premier guarantee®

TECHNICAL MANUAL VERSION 13

The Premier Guarantee Technical Manual Version 13 is produced for the purposes of identifying our technical requirements applicable to the design and construction of buildings to be covered.

Version 13 has been assembled in a more logical 'Building Part' format, which will allow users to find information more easily.

Premier Guarantee has always prided itself on offering flexible solutions to meet Warranty Requirements, and although there is substantial guidance within this Technical Manual, flexibility can still be maintained.

Meeting the Functional Requirements

The Functional Requirements in this Technical Manual, are broken down into three specific requirements covering:

- Workmanship
- Materials
- Design

The Functional Requirements are fundamental issues which must be complied with in all cases to achieve Warranty standards.

Structure of the Technical Manual

This Technical Manual begins with 'General Functional Requirements' which are applicable in all cases i.e. covering all Building Part sections and Appendices (except where noted).

The Manual is then divided into Building Part sections which:

- Include additional Functional Requirements (where necessary), that are specific to that section. These must be read in addition to the 'General Functional Requirements', followed by;
- Guidance which provides suggested solutions for meeting the Functional Requirements*.

*Please Note:
The guidance in the Building Part sections are suggested solutions, if an alternative solution is selected, then this must still meet the Functional Requirements.

All the 'Building Part' sections are listed on the Contents page of this Manual.

The Manual concludes with Appendix Sections, covering guidance for Finishes, Coastal Locations, Materials, Products, and Building Systems, and Warranty requirements for Conversions and Refurbishment projects. These Appendices should be read in conjunction with the 'Building Part' sections, and also contain 'Additional Functional Requirements' that (where necessary) need to be met.

A digital version of this manual, and individual sections, are available on our website should you wish to view digitally, email, or print drawing sheets in A3 format as required.

The difference between Building Control and Warranty

What's the difference between Building Control and Warranty? Why do Warranty Surveyors sometimes ask for more information or more detail, than a Building Control surveyor?

It can be for a number of reasons, whilst it should be remembered that on occasion the Building Control surveyor will, for certain elements, require more information than the Warranty Surveyor, for example smoke control to common areas of an apartment type development. The Building Regulations are statutory requirements; the Approved Documents provide guidance on how these Regulations may be achieved. However, these are minimum standards, derived in the main from building failures. Warranty technical requirements are generally founded on the Building Regulations, but in many instances go into greater depth due to claims experience.

For example:
Basements; a Warranty Surveyor will ask for strict compliance with the British Standard, referred to in the Building Regulations whereas the Building Control Surveyor may only require compliance in principle.

The Building Control Surveyor is interested mainly in compliance on the day that they visit, or at the time that a completion certificate is issued. Warranty Surveyors are generally required to consider the performance on an ongoing basis, therefore have to be satisfied that a basement waterproofing is appropriate for all ground conditions and water table events.

Main Changes in the Technical Manual Version 13

Building Part sections

The previous Chapters have been replaced, and the guidance has now been put together in more logical 'Building Part' sections. This will make the Functional Requirements and the guidance easier to find.

The guidance, which provides suggested solutions*, is now in a 'drawing sheet' format and has been assembled in a logical build order.

Basements

- Additional text added regarding the joint between the below ground waterproofing and the DPC stating that the CSSW design should also take responsibility for this junction.

Ground Floors

- Additional text added on screeds, forming movement joints etc. Information on anhydrite screeds and the treatment of screeds before tiling.
- Further information on underfloor heating used in conjunction with floor screeds.
- Additional new Functional Requirements for Design provided.

Foundations

- Updated guidance added from the 'Good Practice Guides' (available on our website for downloading) has been provided for 'Raft', 'Vibratory Ground Improvement', and 'Engineered Fill' etc.

Drainage

- New Functional Requirement added: Outfall drainage from any sewerage treatment plant or septic tank, should discharge to a suitable outfall that has been given full consent to do so.
- Additional new Functional Requirements for Design provided.

External Walls

- Guidance has been updated to provide further information on the mechanical fixing of copings (traditional masonry cavity walls and timber frame walls).
- Movement joints: Additional section drawing and notes provided regarding concrete bricks.
- A new stepped cavity tray detail has been provided as this is a common high risk area.
- Additional guidance on cavities of fair faced masonry with partial fill insulation. This is for severe exposed locations where the risk of water ingress is increased due to driving rain.
- Timber frame: Additional guidance for Radon barriers where a suspended ground floor is proposed and a solution for venting the sole plate becomes difficult.
- Additional new Functional Requirements for Design provided.

Internal Walls

- Additional new Functional Requirements for Design provided.
- The requirements in Chapter 8.4 of the previous Manual version for providing layouts showing positions of internal compartment walls, floors and other lines of fire resistance in flats and apartments with a floor four or more storeys above the ground, has now changed the height requirement to a building where the floor is 4.5m above ground level.

Windows and Doors

- Further guidance has been issued on nickel sulphide inclusions in glazing and when heat soak testing is required. This is to provide further clarification of our requirements.
- Additional new Functional Requirements for Design provided.

Stairs

- Additional new Functional Requirements for Design provided.

Upper Floors

- Further guidance on timber joist connections with steel beams (to allow for shrinkage in the timbers).
- Notching and drilling guidance updated with a maximum notch depth and max drill diameter now specified.
- Additional guidance added for metal web floor joists and I-joists.
- Additional new Functional Requirements for Design provided.
- The requirements in Chapter 8.4 of the previous Technical Manual for providing layouts showing positions of internal compartment walls, floors and other lines of fire resistance in flats and apartments with a floor four or more storeys above the ground, has now changed the height requirement to a building where the floor is 4.5m above ground level.

Roofs

- Further guidance provided regarding ventilation of batten space when using LR underlay and closefitting roof covering.
- Additional guidance added in regards to where testing of flat roof coverings is required.
- Additional new Functional Requirements for Design provided.

Balconies and Terraces

- Additional guidance added in regards to where testing of coverings to balconies and terraces forming a roof is required.
- Additional new Functional Requirements for Design provided.

Chimneys, Driveways and Paving, Heating Services, Ventilation, Electrical Services and Water Services

- Additional new Functional Requirements for design provided.

Outbuildings

- Additional guidance on fire stopping of garages on party wall lines.

Appendices

- A change from the previous Technical Manual. More general guidance are located in the Appendices relating to: 'Finishes', 'Coastal Locations' (formerly Chapter 13), 'Materials, Products, and Building Systems' (formerly Chapters 2 and 3) and 'Conversions and Refurbishments' (formerly Chapter 12).
- 'Conversions and Refurbishments': Former agricultural buildings of any nature are not considered suitable for cover.

CONTENTS

Workmanship

1. All workmanship must be within the tolerance requirements set out in this Technical Manual.
2. All work is to be carried out by a technically competent person in a workmanlike manner.
3. Concreting shall not take place during cold weather periods where the working temperature is below 2 degrees C or where ground conditions are frozen.

Materials

1. All materials should be stored correctly in a manner that will not cause damage or deterioration of the product.
2. All materials, products and building systems shall be appropriately tested and approved for their intended purpose.
3. The structure shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.
4. Whilst there is and can be no Policy responsibility and/or liability for a roof covering, window and/or door performance life of 60 years or less, roof coverings, windows and/or doors shall be designed and constructed so they have an intended life of not less than 15 years.
5. 'Decorative Claddings': Whilst there is and can be no Policy responsibility and/or liability for a performance life of 60 years or less for a 'cladding' which has a 'decorative function only' (i.e. with the main substrate wall or roof construction, providing the main weatherproof barrier); a 'decorative' type cladding shall be designed and constructed so they have an intended life of not less than 15 years.
6. Timber should be adequately treated or finished to resist insect attacks and be suitable for the position used within the structure. All timber treatment should be in accordance with relevant British standards and Codes of Practice.
7. Timber used in the building to provide support to the structure must be appropriately seasoned to prevent excessive shrinkage and movement.
8. All materials should be suitable for the relative exposure of the building in accordance with the relevant British Standards.

Design

1. The design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
2. Structural elements outside the parameters of regional Building Regulations must be supported by structural calculations provided by a suitably qualified expert.
3. The materials, design and construction must meet the relevant regional Building Regulations.
4. Specialist works must be provided and supported by structural calculations completed by a suitably qualified Engineer where necessary.
5. Reinforced concrete elements must be supported by structural calculations and details produced by a suitably qualified Structural Engineer.
6. Precast structural elements must have structural calculations that prove their adequacy, as endorsed by the manufacturer.
7. Any engineered beams/posts manufactured off-site must have structural calculations endorsed by the manufacturer.
8. Damp proofing works should prevent any external moisture passing into the internal environment of the building.
9. Projects consisting of Non-standard/Modern methods of construction must be supported with evidence of valid independent third party product conformity certification before an offer of Warranty is provided.

Limitations of Functional Requirements

1. These Functional Requirements do not and will not apply to create any policy liability for any remedial works carried out by the contractor or otherwise, nor to any materials used in those remedial works (*not applicable to: 'Ground Conditions' guidance)*.
2. A more stringent tolerance may be stated within an existing National or European standard, however, for the purposes of coverage under the relevant policy, where we have identified a tolerance requirement, this would be deemed suitable to meet our Functional Requirements *(not applicable to: 'Ground Conditions', 'Foundations' and 'Stairs' guidance)*.
3. The guidance provided in each of the Building Part sections is guidance that provides a suggested solution to meeting the Functional Requirements. If an alternative solution is selected, then this must still meet the Functional Requirements.

1.

Tolerances

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

No additional requirements.

Limitations of Functional Requirements

1. A more stringent tolerance may be stated within an existing National or European Standard however, for the purposes of coverage under the relevant policy, where we have identified a tolerance requirement, this would be deemed suitable to meet the requirements of this Technical Manual.
2. We only measure tolerances which are identified within this Technical Manual.
3. These Functional Requirements do not and will not apply to create any policy liability for any remedial works carried out by the contractor or otherwise, nor to any materials used in those remedial works.

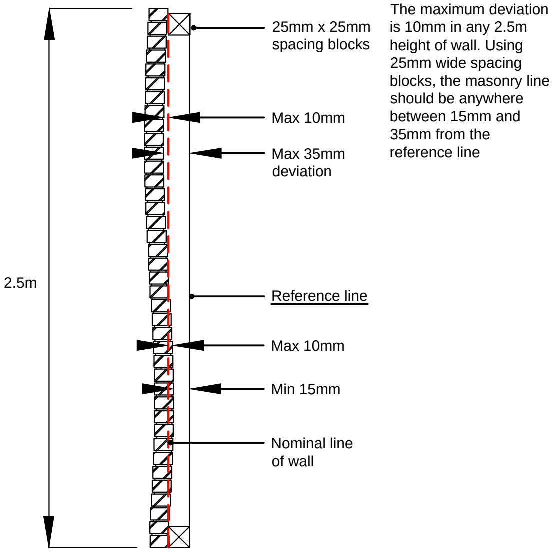
1.

Tolerances

1.1
Tolerances

External walls

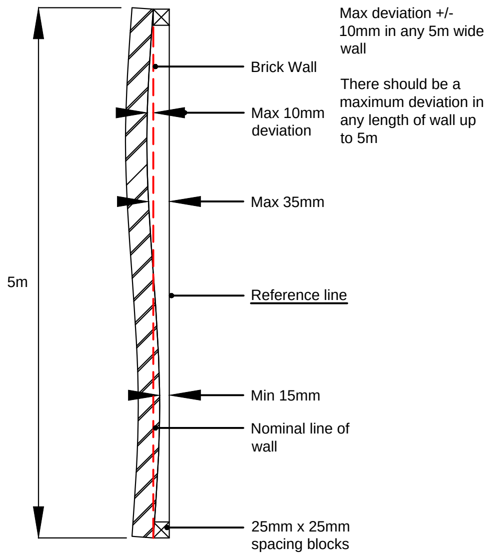
Brickwork: straightness in section



Straightness in section

The maximum deviation is 10mm in any 2.5m height of wall. Using 25mm wide spacing blocks, the masonry line should be anywhere between 15mm and 35mm from the reference line

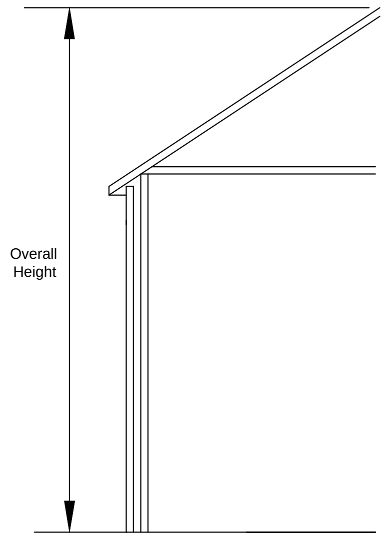
Brickwork: straightness on plan



Brickwork straightness in plan

There should be a 10mm maximum deviation in any length of wall up to 5m

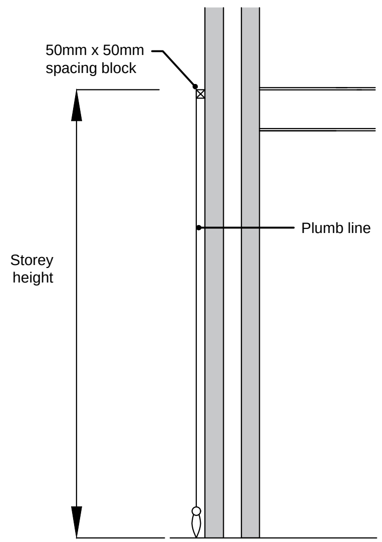
Plumb of wall: overall height



Plumb of wall: overall height

There should be a maximum deviation of 20mm in the overall height of a wall

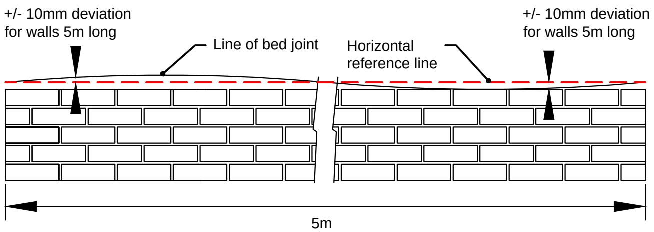
Plumb line of wall: storey height



Plumb of wall: storey height

The maximum deviation is 10mm in a storey height of approximately 2.5m. Using a 50mm wide spacing block, the plumb bob should be between 40mm and 60mm away from the wall

Level of bed joints



A 10mm deviation is suggested for walls 5m long (a pro rata tolerance is applicable for walls less than 5m long), and a 15mm maximum deviation for walls over 5m long. There should be no recurrent variations in the level of the bed joint line

Thickness of bed joint

The thickness of an individual bed joint should not vary from the average of any eight successive joints by more than 5mm.

Perpendicular alignment

Vertical alignments of perpend joints should not deviate from the perpendicular to an extent which impairs the structural stability of the wall.

As a result of the manufacturing process, not all bricks are uniform in length. Therefore, not all perpend joints will align. However, there should be no collective displacement of the perpend joints in a wall.

Rendered walls (plain)

Unless otherwise specified, apply the render coats to produce as flat a surface as possible, and where appropriate check the surface by measuring between the face and any point along a 1.8m straight edge placed against it. The flatness of the rendered finish will depend upon the accuracy to which the background has been constructed, the thickness of the render specified and whether grounds and linings are provided and fixed to a true plane. For render less than 13mm thick, a no tolerance limit is realistic. Significant cracks in the render, or other damage, such as chips and marks greater than 15mm in diameter, are considered unacceptable.

Fair-faced brickwork and blockwork

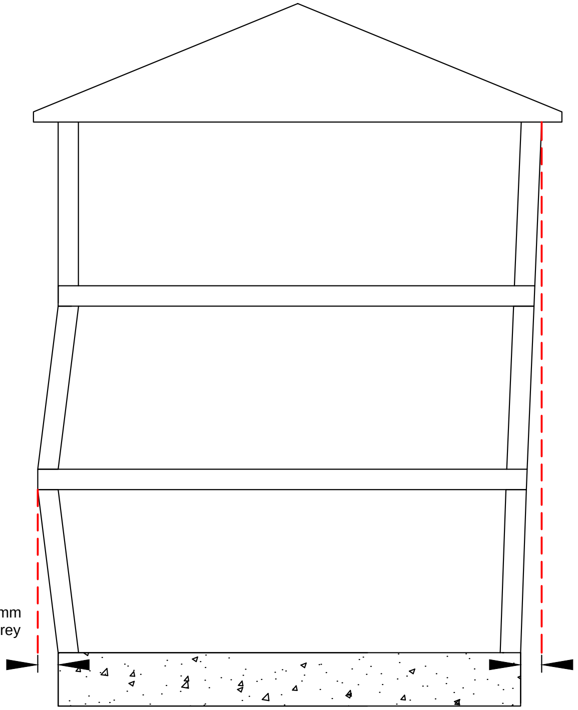
Fair-faced masonry should be completed to a reasonable level, ensuring texture, finish and appearance are consistent. A reasonable appearance for single leaf 102.5mm brick walls should be to have one finished side only. A neat and tidy finish should be applied to the other side. Shrinkage due to drying out could lead to the fracturing of un-plastered blockwork walls, although cracks of up to 3mm are generally normal due to thermal movement and drying shrinkage.

Tile hanging

The uniform appearance is to be maintained for panels of tile hanging, especially at abutments.

Steel frame

Steel frame: wall panel erection tolerances



Site tolerances

It is essential that the accuracy of setting out foundations and ground beams are checked well in advance of materials being delivered to site.

For accurate erection of the frame the following tolerances are required at the level of the base of the wall frame:

- Length of wall frame: +/-10mm in 10m.
- Line of wall frame: +/-5mm from outer face of plate.
- Level of base of wall frame: +/-5mm over complete wall line.

Metal stud framework

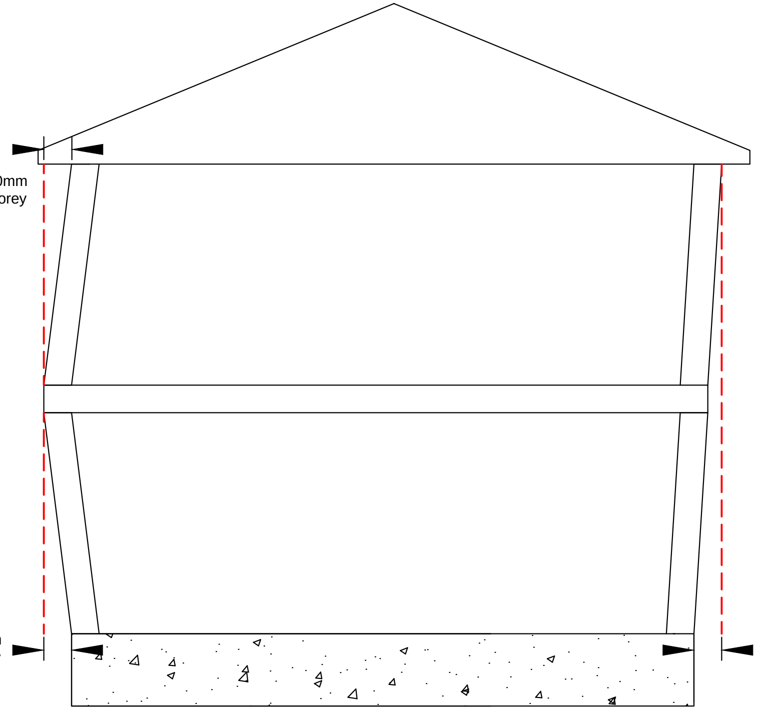
The wall panel usually consists of a head rail, base rail (sole plate) and possibly horizontal noggins at mid-height, together with vertical wall studs.

Vertical tolerances are:

- +/-15mm in overall height of wall 3 storey or;
- +/-10mm in overall height of wall 2 storey or;
- +/-5mm in storey height (approx. 2.5m).

Timber frame

Timber frame: wall panel erection tolerances



Manufacturing tolerances

Based on the tolerances given in prEN 14732 (dated 17/12/2013) wall panels shall be manufactured to the following tolerances:

- Length: +3mm, -3mm.
- Height: +/-2mm.
- Diagonals should be equal, acceptable deviation is +/-5mm.
- Opening dimensions: 0mm, +5mm.

Foundations

It is important that the tight tolerances for timber frame are understood, getting the location and level of the foundation correct is one of the most important parts of the build process. The foundations or upstands that support the timber frame should be set out to the dimensions noted on the timber frame drawings:

- Within +/-10mm in length, width and line.
- Diagonals should be within +/-5mm up to 10m, and +/-10mm more than 10m.
- Levelled to +/-5mm from datum.

Location

Sole plates should:

- Be levelled to +/-5mm from datum.
- Not overhang or be set back from the foundation edge by more than 10mm.
- Be set out within +/-10mm in length and in line within +/-5mm, as defined by the timber frame drawings.
- Diagonals should be within +/-5mm up to 10m, and +/-10mm for more than 10m.

Wall panel erection tolerances

Wall panels should be erected to the following tolerances:

- +/-10mm from plumb per storey height.
- +/-10mm from plumb over the full height of the building.
- +/-3mm from line of sole plate, with maximum +/-5mm deviation from drawing.
- +/-5mm from line at mid height of wall panel.
- Inside faces of adjacent wall panels should be flush.
- Adjacent wall panels should be tightly butted.

Curtain walling

Tolerances

Design should allow for the line, level, plumb and plane of the completed curtain wall to be within the acceptable tolerances of:

- Line: +/-2mm in any one storey height or structural bay width, and +/-5mm overall.
- Level: +/-2mm of horizontal in any one structural bay width, and +/-5mm overall.
- Plumb: +/-2mm of vertical in any one structural bay width, and +/-5mm overall.
- Plane: +/-2mm of the principle plane in any one storey height or structural bay width, and +/-5mm overall.

Rain screen cladding systems

Design should allow for the line, level, plumb and plane of the completed curtain wall to be within the acceptable tolerances of:

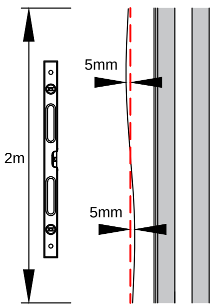
- Line: +/-2mm in any one storey height or structural bay width, and +/-5mm overall.
- Level: +/-2mm of horizontal in any one structural bay width, and +/-5mm overall.
- Plumb: +/-2mm of vertical in any one structural bay width, and +/-5mm overall.
- Plane: +/-2mm of the principle plane in any one storey height or structural bay width, and +/-5mm overall.

Internal walls and ceilings

Walls and ceilings (plastered and dry lined)

There should be no sharp differences of more than 4mm in any 300mm flatness of wall; the maximum deviation is +/-5mm from a 2m straight edge with equal offsets, horizontally and vertically, for all wall and ceiling surfaces.

Flatness of internal wall



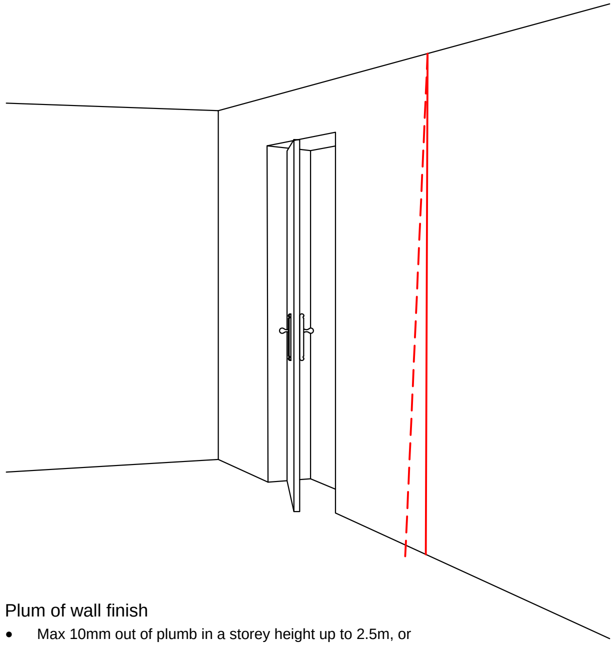
Max deviation +/- 5mm from 2m straight edge with equal offsets, horizontally and vertically

Non load-bearing timber partitions

Partitions should be robust and form a smooth, stable, plane surface to receive decoration:

- Supporting members should be accurately spaced, aligned and levelled.
- The tolerance of horizontal straightness of a partition should be +/-10mm over a 5m length.
- The deviation in vertical alignment of a partition in any storey height should be +/-10mm.

Plum of internal wall



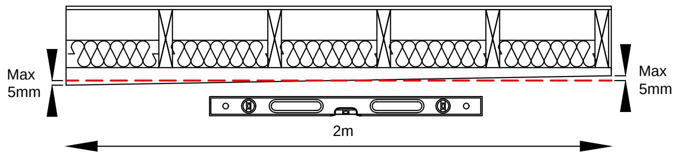
Plum of wall finish

- Max 10mm out of plumb in a storey height up to 2.5m, or
- max 20mm out of plumb for a continuous wall height greater than 2.5m

Junctions

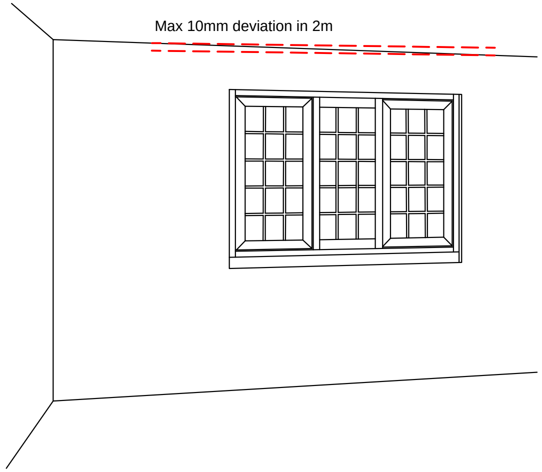
If there are changes in the construction materials used due to shrinkage and the differential movement of materials; small cracks (up to 3mm wide) may become visible in the surface at wall, floor and ceiling junctions.

Flatness of ceiling

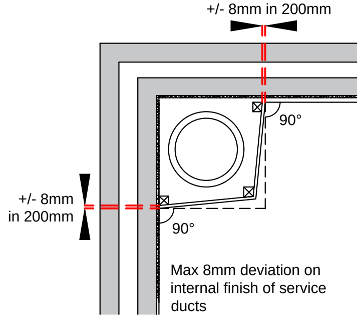


Max +/- 5mm deviation from 2m straight edge with equal offsets

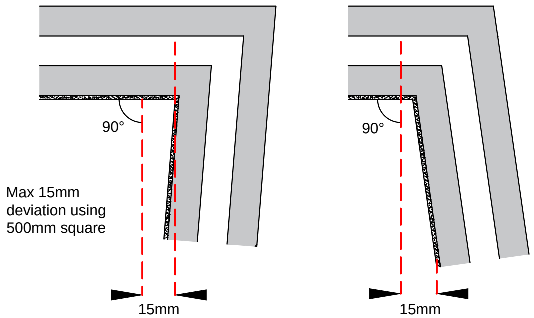
Level of ceiling



Service ducts



Internal corners

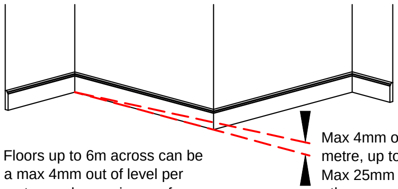


Floors

Level

Floors up to 6m across can be a maximum of 4mm out of level per metre, and a maximum of 25mm overall for larger spans. The effects of normal drying shrinkage on screeded floors could cause some fracturing. Shrinkage of timber floors and staircases is a natural occurrence when drying out, which could result in the squeaking of materials as they move against each other. This again is a natural occurrence, and cannot be eliminated entirely.

Level of floor



Deflection

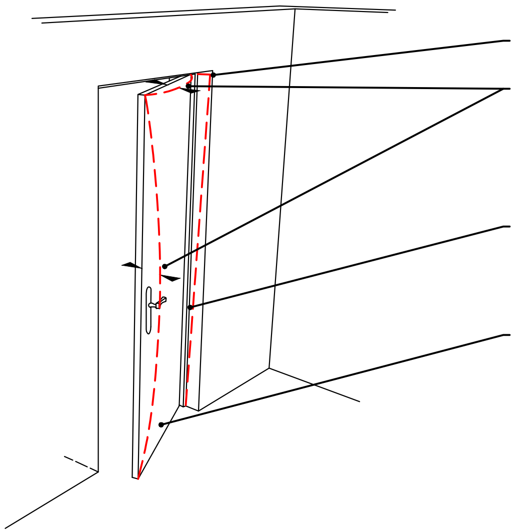
For upper floors (intermediate floors), designers and engineers must observe our tolerances requirements in this Technical Manual for levelness of floors. Although a joist might be designed using British standards or Eurocodes to meet permissible deflections; our tolerances requirement will take precedence.

Doors and Windows

Doors

Reference of +/-3mm maximum deviation in 1m head and sill. The maximum out of level tolerance is 5mm for openings up to 1.5m wide, and 8mm for openings more than 1.5m wide.

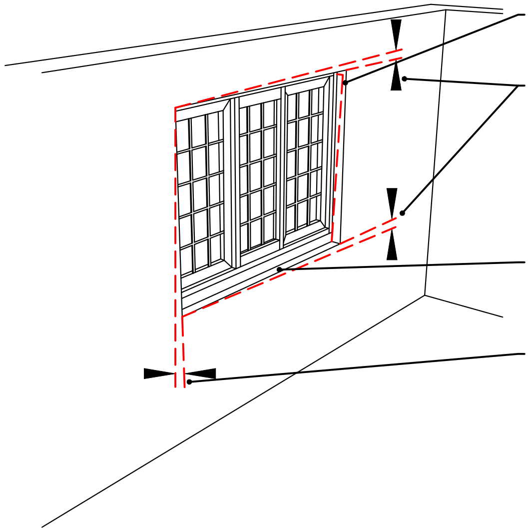
Gaps and distortion in doors



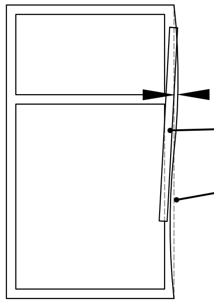
Windows

For square reveals, a maximum +/-8mm deviation off square is applicable for a reveal up to 200mm deep.

Distortion in window reveals



Straightness of external reveals



Glazing

Glass must meet the visual assessment criteria of CWCT Technical Note 35 (TN 35). The total number of faults permitted in a glass unit shall be the sum total of those permitted by the relevant BS EN Standard for each pane of glass incorporated into the unit concerned.

Acceptable faults include:

- Bubbles or blisters.
- Hairlines or blobs.
- Fine scratches not more than 25mm long.
- Minute particles.

When assessing the appearance of glass:

- The viewing distance used shall be the furthest stated in any of the BS EN Standards for the glass types incorporated in the glazed unit. In the event of doubt, the viewing distance shall be 3m.
- The viewing shall commence at the viewing distance, and shall not be preceded by viewing at a closer distance.
- The viewing shall be undertaken in normal daylight conditions, without use of magnification.
- The above does not apply within 6mm of the edge of the pane, where minor scratching is acceptable.

Scratches on doors, windows and frames

Factory-finished door and window components should not have conspicuous abrasions or scratches when viewed from a distance of 0.5m.

- Surface abrasions caused during the building-in process should be removed in accordance with the manufacturer's instructions, which may include polishing out, re-spraying or painting.
- In rooms where there is no daylight, scratches should be viewed in artificial light from fixed wall or ceiling outlets, and not from portable equipment.

TOLERANCES: Finishes and external works

Finishes

Skirtings

It is possible that there will be joints in skirting's on long walls. When viewed from a distance of 2m in daylight, joints will need to show a consistent appearance. It is anticipated that there will be some initial shrinkage of the skirting after occupation of the building.

Finishes and fitted furniture

Fitted furniture with doors and drawers should be aligned vertically, horizontally and in plan. It should also function as designed by the manufacturer. Adjacent doors and/or drawers with any gaps between them should be consistent. At the intersection of adjacent worktops, there should not be a visible change in level.

Painted and varnished surfaces

All surfaces should be reasonably smooth as practicably possible when viewed in daylight from a 2 metre distance and not by shining any artificial light onto the surface. Significant nail holes, cracks and splits should not be seen and should be filled to reduce their visible appearance. Colour, texture and finish should be reasonably consistent and any joints are to be filled where necessary.

Knots in timber

Some seeping of resin from knots is a natural occurrence that may cause paintwork discolouration both internally and externally. The standard will be met providing the Developer finishes the timber in accordance with Functional Requirements.

External Works

Drives and paths: standing water

Surface variation should not exceed +/-10mm from a 2m straight edge with equal offsets. Some fracturing or weathering may also appear if using natural stone due to the make-up of the material. This tolerance applies to principle pathways and driveways to the building that are required to meet the standards of Part M (Access to and use of buildings).

Drainage system covers

Drainage system covers in hard standing areas should line up neatly with the adjacent ground.

2.

Basements

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Basement definition

A basement is defined as a storey or storeys of a building that is constructed partially or entirely below ground. This includes: basement walls, floors and below ground roofs including podium decks.

Workmanship

1. Evidence of certification is required for any work completed by an approved installer.

Materials

No additional requirements.

Design

1. Foundation type and depth must be suitable to resist any movement including that due to the influence of nearby trees.
2. Basements shall be appropriately designed to ensure that they adequately provide a suitable barrier against contaminants, ground gases and ground water.
3. Design details of the basement waterproofing techniques must be provided prior to commencement onsite.
4. All basements must be designed and constructed to meet the requirements of BS 8102: 2009 and achieve a minimum of Grade 2 standard except where defined in the supporting technical guidance.
5. The basement waterproofing design should be completed by a suitably qualified Waterproofing Specialist. The Waterproofing Specialist must take responsibility for the design liability of the waterproofing system and have appropriate professional indemnity cover which covers their business activities. They must also have an understanding of hydrogeology and soil mechanics and hold a relevant professional qualification i.e. Certificated Surveyor in Structural Waterproofing (CSSW).
6. The CSSW (or similar) designer should provide a design philosophy which clearly sets out the desired grade of the environment to be achieved. The design philosophy should clearly set out how the specified design will provide the required environmental grade based on the specific hydrology and ground conditions of the site.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

2.
Basements

2.1
General Requirements

Definition

For the purposes of this guidance, a basement is defined as a storey or storeys of a building that is constructed partially or entirely below ground.

Foundations

All basement foundation structures should be supported by design and structural calculations from a structurally qualified consultant.

Walls below ground

Bricks and blocks below ground

- All basement structures should be supported by design and structural calculations from a structurally qualified consultant.
- The selected bricks should be appropriately durable against saturation in accordance with EN 771-1 and PD 6697.
- Mortars below DPC are exposed to higher saturation and therefore require a higher durability.

For further details on brick, blockwork and mortar classifications for below DPC, please refer to 'Appendix C - Materials, Products, and Building Systems' for suitable brick and blockwork classifications.

If there are sulphates in the ground and/or there is ground water present, confirmation by the manufacturer that the brick or block is suitable for use below ground should be provided.

General Requirements

This section provides guidance on the requirements associated with the design and construction of basements and other below ground structures. Principally, this concerns the process by which the risk of ground water penetration is appraised and addressed so that problems associated with penetration do not occur while consideration is also given to economic construction.

This process and rationale is primarily detailed within BS 8102 (2009) Code of Practice for protection of below ground structures against water from the ground (and other associated design guides). However, further practical guidance on this and compliance with Warranty requirements is included herein.

Limitations of guidance

- This document is not intended as a standalone design guide and does not include full details of what must be considered to comply with BS 8102. Please see the 'Bibliography' at the end of BS 8102:2009 for details of other associated design guides.
- It must also be noted that structural waterproofing design and geotechnical investigations are specialist fields, and while general guidance is provided, advice must be sought from suitably experienced parties. An appropriate structural design must be undertaken by a Chartered Structural Engineer.

General principle of waterproofing design

The approach detailed within BS 8102 involves assessment of a given site to determine the characteristics that influence risk. With the benefit of knowledge gained through this investigation and assessment, suitable designs for dealing with ground water, gases and contaminants can then be devised and constructed.

Design responsibility

- Production of a suitable design is one of the most important aspects of achieving a successful outcome, where the required standard of environment is created within the basement space and maintained in the long term.
- A common assumption in waterproofing is that workmanship is the most 'critical factor' and whilst this is undeniably important, the highest standards of workmanship will not make-up for inadequate design; hence the correct design is the first step in achieving the desired outcome.
- BS 8102 includes a section on the 'design team', which states that the advice of a Geotechnical Specialist be sought for assessment of the geology and hydrogeology, and that a Waterproofing Specialist be included as part of the design team from the earliest stages. This is so that an integrated and practical waterproofing solution is created.
- The Waterproofing Specialist must take responsibility for the design liability of the waterproofing and have appropriate professional indemnity cover which covers their business activities. They must also have an understanding of hydrogeology and soil mechanics and hold a relevant professional qualification i.e. Certificated Surveyor in Structural Waterproofing (CSSW) or similar.
- Designers must have ongoing involvement during the build, maintaining good communication with site management and providing supervision and guidance wherever necessary.

Note: The need for a dedicated Waterproofing Specialist within the design team is intended to reduce the incidence of issues where systems are designed without following the advice and considerations detailed within BS 8102 and associated design guides.

Such scenarios may occur where Project Designers take on the role of Waterproofing Designer without sufficient reference to the stated guides, commonly relying on standard design details and without considering all appropriate factors. Please refer to BS 8102 for a list of requirements that a designer must meet in order to fulfil the Waterproofing Designer role which includes carrying professional indemnity insurance cover appropriate to the project.

Where relying on the use of waterproofing product manufacturer 'standard details', they typically disclaim design responsibility, so it is incumbent on the Waterproofing Design Specialist to ensure that such details are correct and appropriate for the site and structure or offer suitable variation.

The early involvement of a Waterproofing Designer is an important consideration because the waterproofing design typically has an influence on elements of the structural and/or architectural design. Early involvement allows the waterproofing to be duly considered in association with these other aspects and prevents situations where design fees are increased as a result of necessary redesign, or where waterproofing is compromised by working within the constraints of an ill-considered structure relative to achieving the required standard of environment.

Site and risk assessment

The degree of water present within the ground and the propensity for waterlogging to occur over the lifetime of a structure is a principal driver in assessing risk and the degree of waterproofing required. Simplistically, if a basement is constructed into a permanent high water table then the degree of protection will necessarily be greater than a similar structure constructed into a generally dry site.

- An assessment of a site must be based on the results of the site investigation and other site-specific factors.
- Seasonal variations in the water table must be accounted for unless long-term monitoring is undertaken.
- Where standing water levels are not noted during a pre-start site investigation, the drainage characteristics of the ground must receive particular attention.
- Soils with low permeability represent a risk of waterlogging or encouraging a 'perched water table', where water stands temporarily or permanently within the ground against a structure, and arguably this affects more properties with basements versus the true water table level.

Other factors such as topography and orientation, may have an impact on the propensity for pressure to come to bear and should also receive consideration. Further guidance on the drainage characteristics associated with different types of ground is included within the Basement Information Centre publication Basements: Waterproofing - General Guidance to BS 8102: 2009.

Ground gases and contaminants must also be considered within the risk assessment.

Note:

1. While the site investigation forms part of what guides the waterproofing design, an equally important consideration is the intended use of the space and implicit consequences in the event that water penetration occurs. For example, in properties where the consequences of water penetration would be severe, such as in habitable space, suitably low-risk methods must be provided.
2. Whilst in theory it could be assumed that based upon a site investigation, the risk of water pressure ever occurring is low. BS 8102 advises that consideration is given to the effects of climate change and burst water mains and sewers, as well as stating that it should be assumed that there is risk of waterlogging “even where site examination indicated dry conditions”.

In summary:

- The site investigation guides the design, but it should never be assumed that some degree of water pressure will not occur.
- If no site investigation has been undertaken or there is reasonable doubt as to ground water conditions, hydrostatic water pressure to the full height of the below ground structure must be assumed at some point in the life of the structure.
- The Warranty Surveyor may request a copy of the Site Investigation Report, Designer's and associated design rationale.

Water-resisting design

The principle of this is to consider and design for the pressures that the structure and waterproofing must resist based upon the site investigation and risk assessment detailed above. However, it also concerns the means by which the degree of water in the ground can be influenced by design.

Structural resistance

The ability of the structure to provide resistance to the penetration of water has a bearing upon all forms of waterproofing. Retaining walls in plain or reinforced masonry provide comparatively little resistance to the penetration of water under pressure because of the crack pattern associated with the degree of joints (mortar beds) present.

The degree of water excluded by concrete elements (walls and slab) is influenced by the nature of the design and construction. While concrete itself is relatively impermeable, the degree to which water is excluded will be greatly influenced by crack sizes and the detailing of construction joints and service penetrations.

Defects and remedial measures

Within BS 8102, designers are advised to consider the probability that systems may not be installed perfectly and that defects may occur as a result of this, or defects may be present in the supplied materials.

Designing on the assumption that a system will not be totally perfect or free of defects necessitates that consideration is given to the feasibility of repairing those defects, or ensuring that they are of no consequence i.e. where systems are not accessible for repair. Different structures, waterproofing systems and sites have a bearing upon this consideration. For Warranty purposes a Grade 3 environment basement must be designed so that the consideration of reparability is essential.

Strategies for repair of a Grade 1 or 2 environment basement must be considered as part of the design process. Further commentary is provided within each of the specific system type sections.

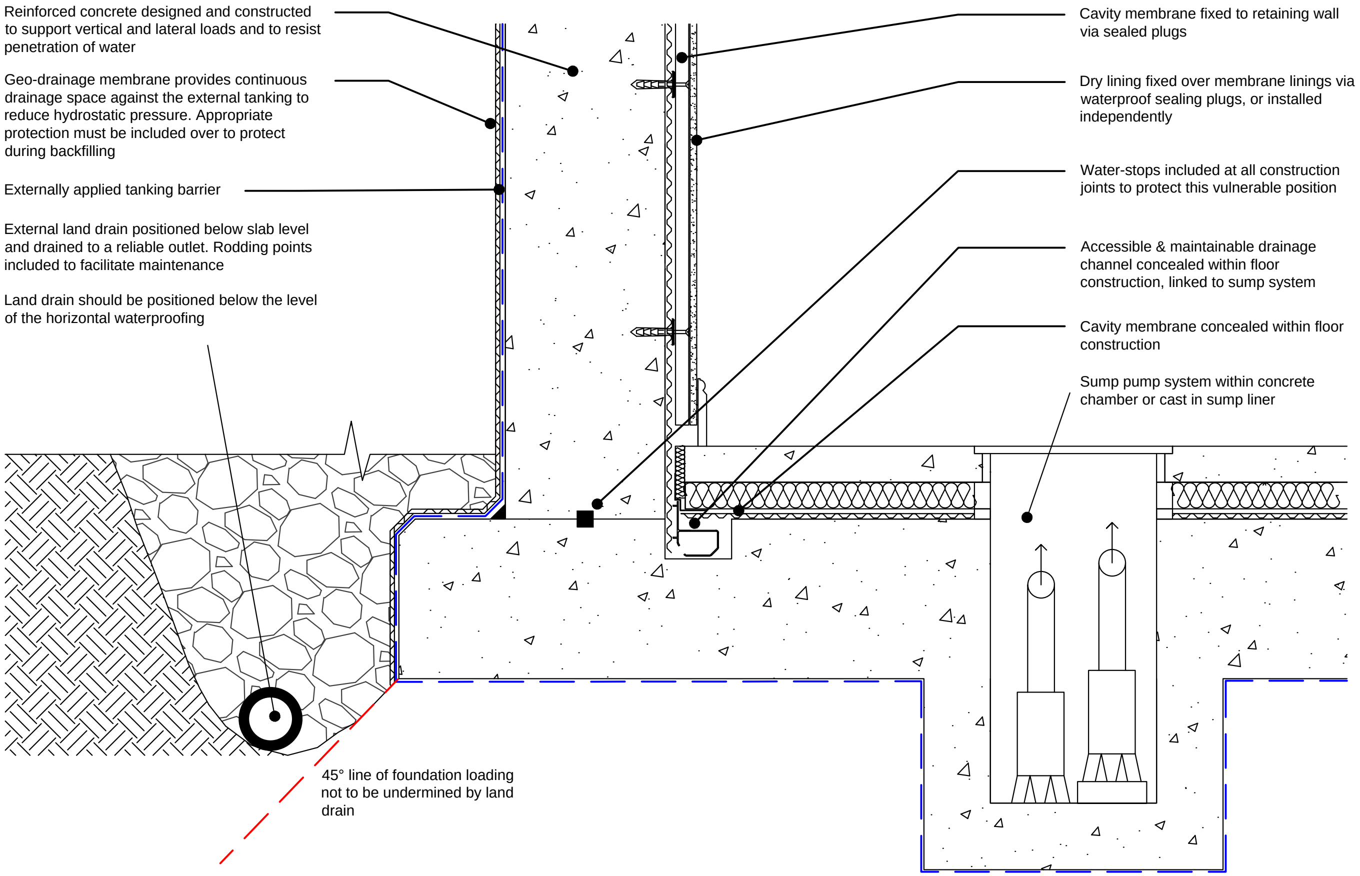
The detail of an appropriate repair strategy may be requested by the Warranty Surveyor in relation to a given waterproofing design.

Forms of waterproofing

BS 8102 defines three forms of waterproofing protection, Type A barrier protection (commonly referred to as 'tanking'), Type B, structurally integral protection and Type C drained protection.

These drawing sheets discuss type A, B, and C protection.

Example of combined waterproofing A, B, and C



Intended use and required standard of environment

Usage dictates the required 'grade' of environment, i.e. how 'dry' a given basement space must be in order to be suitable for a given usage.

The designer must therefore consider how this will be achieved in a particular site and structure. BS 8102: 2009 Table 2 provides three definitions of environmental grades (Grades 1, 2 and 3) as shown in the table below:

Grade	Example of use of structure	Performance level
1	Car parking, plantrooms (excluding electrical equipment), workshops.	Some seepage and damp areas tolerable, dependent on intended use.
2	Plant rooms and workshops requiring a drier environment (than Grade 1), storage areas.	No water penetration acceptable. Damp areas tolerable; ventilation might be required.
3	Ventilated residential and commercial areas including offices, restaurants, leisure centres.	No water penetration acceptable. Ventilation, dehumidification or air conditioning necessary, appropriate to the intended use.

Grades of waterproofing protection

- For Warranty purposes we require all basements to be designed and constructed to a minimum of Grade 2, with Grade 3 being necessary for occupied space. An exception to this is a basement used solely for underground car parking, where a Grade 1 could be accepted. See 'Underground car parking' below for specific guidance.

- Habitable space is Grade 3 where water penetration is unacceptable. Appropriately designed environmental controls such as vapour barriers, insulation, heating, ventilation and dehumidification must be included to control vapour, introduced via occupation sufficiently thereby preventing problems of condensation.

- An example usage for Grade 2 includes store rooms and again, water penetration is not acceptable however, heating and ventilation is not necessarily required, albeit that some degree of ventilation is recommended even in basic storage space, which may otherwise suffer condensation-related dampness.

Underground car parking

In the case of underground car parking with associated underground refuse stores and cycle stores; some seepage, dampness or condensation as well as standing water (from vehicles) is to be expected.

For this type of use, a design by water proofing design specialist to a BS 8102 Grade 1 standard could be accepted. For plant rooms (that do not house items of plant that directly service the building), lifts/escalators, access stairs and lobbies that are associated within an underground car park, a Grade 2 standard is the minimum grade to be expected. A Grade 2 standard is the minimum grade to be expected for plant rooms (that do not house items of plant that directly service the building), lifts/escalators, access stairs and lobbies that are associated within an underground car park.

The degree of seepage or dampness (water tightness) that can be tolerated for this particular end use needs to be established and agreed with all interested parties, including the Warranty Surveyor at the design stage. To assist with quantifying an acceptable level of moisture ingress, the following definitions of water tightness are provided.

- Damp patch: When touched, a damp patch may leave a slight film of moisture on the hand, but no droplets of water or greater degrees of wetness are left on the hand. On a concrete surface a damp patch is discernible from a darkening of the colour of the concrete.
- Beading of water: Beading of water is the state in which individual droplets of water (held by surface tension effects) form on the surface of the wall and adhere to the wall. The water beads do not coalesce and do not flow.
- Weeping of water (seepage): Weeping of water is the state in which droplets of water form on the surface of the wall and coalesce with other droplets. The coalesced water does not remain stationary on the wall surface, but instead flows down the wall.

These are taken from the publication 'Specification for piling and embedded retaining walls'.

Section 2.2.3 of CIRIA Report 139 provides guidance on quantifying the required internal environment and places limits on Grade 1 basements:

It identifies:

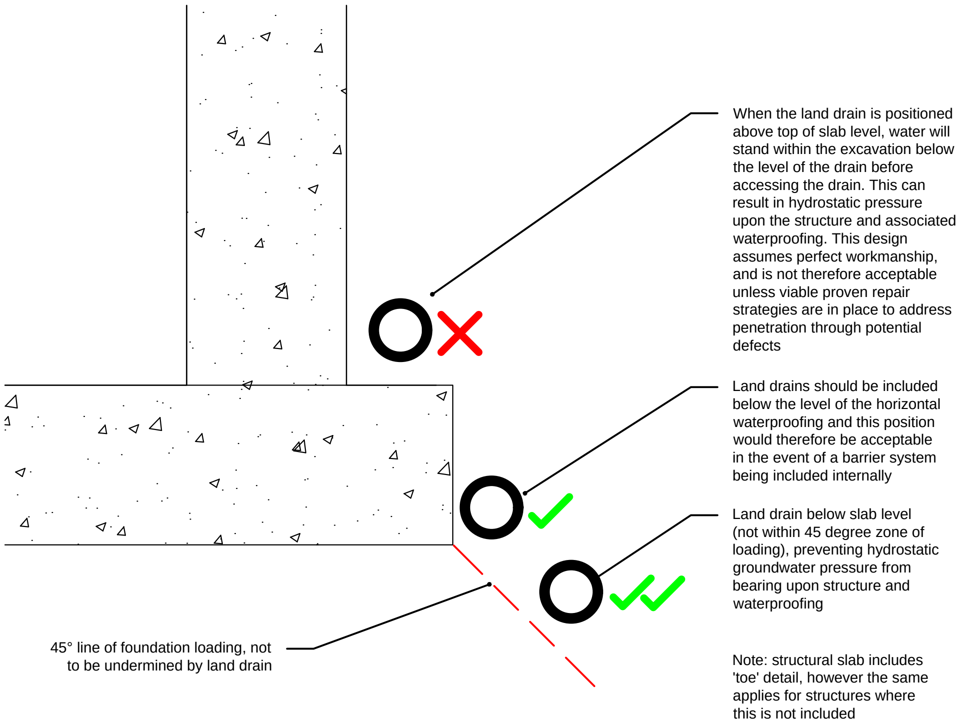
- The functioning of mechanical plant and electrical switchgear is normally unaffected by seepage through walls and floors, provided the water does not impinge directly onto the equipment. However, a wet floor can be hazard to maintenance staff as well as increase the rate of corrosion of steel casings and frames in contact with it. Generally, a raised working area may be desirable and all equipment should be mounted on plinths.
- Atmospheric moisture is unlikely to affect mechanical plant unless it is continually at such a level as to cause an unreasonable fast rate of corrosion. One exception is that air compressors need to be fitted with air-driers if they are to operate in constantly damp conditions. Ferrous pipes, conduits, wall brackets and their fixings etc. will corrode if unprotected.
- Damp air may cause electrical installations to malfunction. Permanently damp conditions may encourage biological degradation of plastic insulation. Ventilation of the plant space is therefore important.
- Water ingress to underground car parks must similarly be controlled. Cars are likely to introduce significant amounts of water on wet days, which should be drained away. There is also the danger of corrosion and discoloration of paintwork on the cars due to seepage through the ceiling slab (podium deck).

Summary of environmental parameters:

- Relative humidity (RH): Items stored in such basements should not normally be unduly affected by high relative humidity. Ventilation provision draws air directly from the atmosphere and conditions equivalent to prevailing atmosphere, RH greater than 65% (normally UK external range), are therefore acceptable.
- Temperature: Grade 1 basement would not normally be heated.
- Dampness: The requirements for dampness will depend on whether the basement is to be decorated in any way and the sensitivity of any electrical equipment to be installed (i.e. light fittings, switches, cable runs/conduits etc.). If the basement is not to be decorated, visible damp patches may be tolerated. A higher waterproofing specification may be required if the walls are to be painted etc. It is normally expected that the construction materials will not be wetter than 85% RH.
- Wetness: Minor seepage would be acceptable through the walls and joints if the basement is not to be decorated.
- The need for drainage within the basement, i.e. channels along perimeter walls and across car parking areas, should also be determined, together with requirements for ventilation.
- Where necessary, consideration should also be given to whether additional protection measures are required to plant and equipment, electrical switchgear, support brackets etc.

Once the most appropriate level of water tightness has been determined, the Waterproofing Specialist should factor this into his design and specify a suitable waterproofing system that will achieve the required level of performance. Full design details and justification of the proposed method of waterproofing must be submitted and approved by the Warranty Surveyor prior to work commencing on site.

Land Drain Positioning & External Drainage



- Where land drains are included this should be in association with a permeable stone backfill compacted in layers, which also encourages water to drain down to the level of the land drains without perching and pressuring the structure.
- The use of maintainable land drains is a necessity when employed in association with some forms of inaccessible/external tanking systems, i.e. where the structure itself provides little resistance. In such cases if it is not feasible to include reliable land drains, alternative methods of waterproofing must be used.

The Warranty Surveyor is to be supplied with design details where external land drainage is included.

Exclusion of surface water

Surfaces external of the basement structure at ground level can act to limit or attenuate penetration into vulnerable positions, i.e. the more permeable excavated and backfilled ground directly around the basement structure. The inclusion of surface and cut-off drains which remove standing water away from the vulnerable areas are also of benefit.

Sub-surface drainage

The use of land drainage can act to remove water from around the structure, thus alleviating pressure and should be considered in all cases to reduce the risk of water ingress where practical.

However, the use of land drainage might not be viable on all sites, examples being:

- Where there is no available location to discharge collected ground water.
- Where high water tables and permeable ground conditions make it impractical to sufficiently remove the quantities of water present.
- Restrictions on the site curtilage due adjacent buildings close to or on the site boundary.
- Draw down, i.e. affecting the stability of other structures by the introduction of a land drain.

Depending on the required 'environment', if land drainage is not feasible, a combination of at least two systems in order to mitigate the risk of water ingress will need to be adopted. The Waterproofing Specialist will be required to provide a solution specific to the site conditions.

Notwithstanding such conditions, the provision of effective land drains is often an economic means of greatly reducing risk and must be included where viable.

The following considerations apply:

- Perforated land drains must be surrounded in clean graded stone and wrapped in a suitable geo-textile filter fabric to reduce the risk of clogging. This is particularly important in fine granular and clay soils where land drains are susceptible to clogging.
- Rodding points must be included (ideally at changes in direction) to facilitate maintenance, which will allow the system to function in the long term (this particularly applies to land drains where there is no viable access for repair). This maintenance should be undertaken at suitable intervals (annually as a minimum), with the detail of this being written into the documentation passed to homeowners.
- Land drains must be positioned at a low enough position to prevent pressure from bearing upon the structure and waterproofing.
- The use of geo-drainage membranes applied to the external face of a retaining wall can provide a continuous drainage space external of the structure, which assists in encouraging water to drain down to the level of the land drains without pressuring the structure.
- Land drains must link to a reliable point of discharge. Where sump pump systems are employed, the implications of power cuts should be considered in that land drains may in such scenarios not function as intended. The effectiveness of battery back-up systems, where employed in sumps servicing land drains, should be considered in relation to assessment of the likely degree of ground water.
- Land drains must not be directly linked to soakaways by gravity, unless it is not possible for water to surcharge, i.e. where the top of the soakaway is below the level of the actual land drains.

2.

Basements

2.2

Waterproofing Systems

Combined protection

This guidance is for the protection Type A tanked (barrier) protection. A combination of forms of waterproofing may need to be employed to substantially lower the risk, and may be necessary where the consequences of failure are particularly great, and/or where difficult site conditions result in an unacceptably high risk when employing a single system.

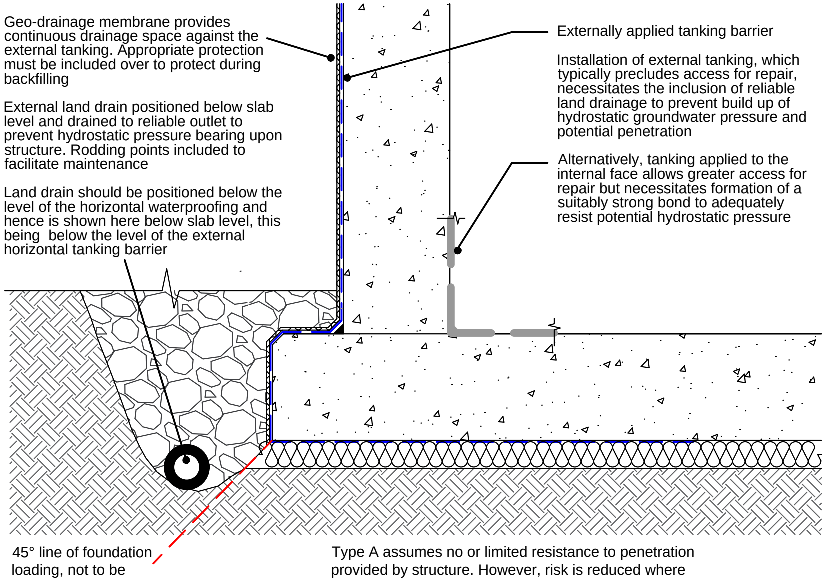
Type A barrier protection

This form of waterproofing relies on the inclusion of a physical barrier material applied on or within the structure, often where the structure itself provides little resistance to the penetration of water.

A variety of considerations apply:

- Suitability of the substrate, primarily applicable where tanking products are applied internally in that the bond between the product and the substrate on which it is applied, must be sufficient to resist hydrostatic ground water pressure.
- The requirement for preparation of substrates to accept tanking mediums.
- Movement which in rigid tanking systems may encourage cracking through which water may penetrate, where pressure comes to bear.
- Loading, where hydrostatic pressure is applied to the structure as a result of exclusion via the tanking medium, i.e. structures must be designed to resist loads applied to them.
- Continuity, in that systems must in virtually all cases be 'continuous'. A gap in a barrier system represents a point at which water under pressure can penetrate.
- 'Buildability', namely whereby sheet membrane products are proposed with the consideration being the practicality of wrapping a flat sheet around complex three dimensional shapes, such as external corners and beneath raft slab thickened toe details.

Type A barrier protection



Commentary on Type A barrier protection

- Whilst BS 8102 advises that 'reparability' must be considered, the use of external adhesive membrane tanking systems on permeable constructions is precluded, unless employed in association with long-term strategies for preventing ground water from pressuring, e.g. serviceable land drains.
- External systems have a greater implication, in that accessibility for repair is typically impractical post-construction and where combined with relatively permeable wall constructions, makes it difficult to confidently determine the point of a defect externally, because water can track within the wall construction to show itself internally at a position not local to the external defect.
- Internal systems have the benefit of greater accessibility meaning that repair is more feasible. Where this system is chosen, the strength of the substrate, its surface preparation and the bond of the waterproofing system are critical considerations and need to be properly considered by the waterproofing specialist.
- The correct use of land drains assists to minimise the potential for hydrostatic pressure coming to bear on to the structure.
- Risk can be lessened by using a 'fully bonded' tanking system, where the bond is such that water cannot track along between the structure and tanking product, in association with a structure of lesser permeability which would allow localised repair to be undertaken.
- Product guarantees, quality assurance schemes and product certification does not negate the Functional Requirement that a waterproofing specialist is required to take responsibility for the design liability of the waterproofing.

Other considerations

Ground gases and contaminants

Aggressive ground conditions may require the inclusion of a suitable ground barrier to protect the structure appropriately. Specialist advice must be sought in respect of dealing with ground gases, and designers are advised to check current standards at the time of construction for suitable guidance.

Existing structures

Waterproofing existing structures differs from new construction in that designers must work within the confines of the existing structure. However, many of the same considerations apply in that the required standard of environment appropriate to usage must be created and maintained in the long term.

Interface with external wall damp proof courses

Whichever type of waterproofing system is deemed appropriate, there must be a continuation provided with the horizontal damp proof courses above ground level. Waterproofing materials used must be compatible with the damp proof course components and adequately lapped and bonded.

The CSSW designer should take responsibility for this junction as part of the tanking design.

Combined protection

This guidance is for the protection Type B structurally integral protection. A combination of forms of waterproofing may need to be employed to substantially lower the risk, and may be necessary where the consequences of failure are particularly great and/or where difficult site conditions result in an unacceptably high risk when employing a single system.

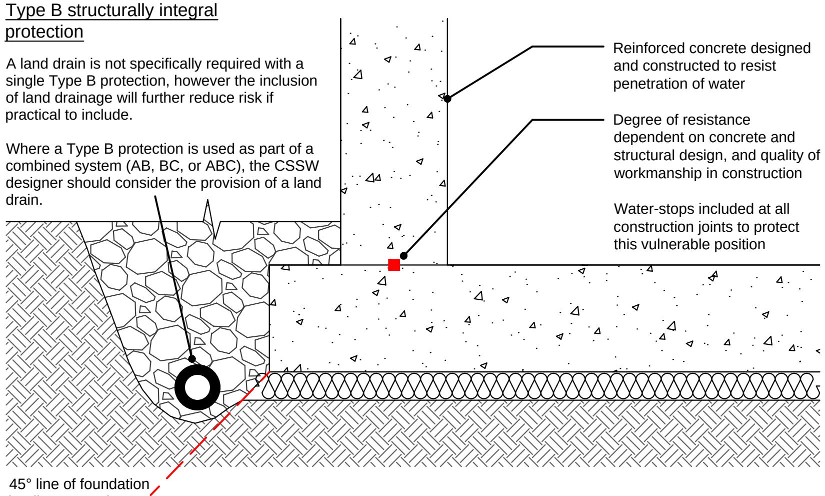
Type B structurally integral protection

Type B also relies on the exclusion of water, but employs the structure itself as opposed to barrier products included on or within it. In the main, as shown in the image below Type B Structurally Integral Protection is formed using reinforced concrete however, this may take several forms.

Type B structurally integral protection

A land drain is not specifically required with a single Type B protection, however the inclusion of land drainage will further reduce risk if practical to include.

Where a Type B protection is used as part of a combined system (AB, BC, or ABC), the CSSW designer should consider the provision of a land drain.



Concrete without additives and including typical levels of steel reinforcement (with cracking <0.3mm); whilst providing good resistance to the penetration of water, will allow seepage given hydrostatic pressure, and as such is not suitable in isolation unless forming basic (non-habitable, non-storage) standards of environment. Further guidance can be found on controlling crack widths in BS EN 1992-3: 2006 and CIRIA publication C:660.

As with any structure that aims to entirely block out water, this must be free of defects which would otherwise allow water to penetrate. In achieving this, the following must be considered:

- Structural design and specification of materials (based in part on-site assessment).
- Water stop detailing at construction joints.
- Service penetration detailing.
- Appropriate specialist site supervision to ensure high standards of workmanship.
- Good placement and compaction.
- Curing.

Particular consideration must be given to the formation of construction joint details, which form a typical weak point in Type B structures. Furthermore, specialist supervision is required on site during construction.

Systems which function by excluding water may not be tested until the ground water pressure comes to bear. Therefore, it is advantageous where external water pressure comes to bear prior to completion, that any areas of penetration can be remedied during construction.

Commentary on Type B protection

- With regard to appraisal of repair, this method has a benefit in that; the point of penetration is typically the point of the defect or pathway through which water penetration occurs. Coupled with the impermeable nature of the structure generally, this allows localised repair to be undertaken via resin injection, grouting and associated repair methods.
- The main consideration is locating the point of any penetration, and it is therefore beneficial where reasonable access to the concrete structure remains viable.
- Product guarantees, quality assurance schemes and product certification does not negate the Functional Requirement that a waterproofing specialist is required to take responsibility for the design liability of the waterproofing.

Other considerations

Ground gases and contaminants

Aggressive ground conditions may require the inclusion of a suitable ground barrier to protect the structure appropriately. Specialist advice must be sought in respect of dealing with ground gases, and designers are advised to check current standards at the time of construction for suitable guidance.

Existing structures

Waterproofing existing structures differs from new construction, in that designers must work within the confines of the existing structure. However, many of the same considerations apply in that the required standard of environment appropriate to usage must be created and maintained in the long term.

Interface with external wall damp proof courses

Whichever type of water proofing system is deemed appropriate, there must be a continuation provided with the horizontal damp proof courses above ground level. Water proofing materials used must be compatible with the damp proof course components and adequately lapped and bonded.

The CSSW designer should take responsibility for this junction as part of the tanking design.

This guidance is for Type C drained protection. A combination of forms of waterproofing may need to be employed to substantially lower the risk, and may be necessary where the consequences of failure are particularly great and/or where difficult site conditions result in an unacceptably high risk when employing a single system.

<u>Type C drained protection</u>

This method of waterproofing differs from Type A and Type B as the structure is employed to limit penetration while an internal drainage system collects and removes any seepage water.

The Structure

- The 'structure' provides the primary resistance to ground water pressure. A Type C drainage system is designed to mitigate the risk by removing any minor water seepage through the structure and in doing so maintains the required internal environment.
- An assessment of the structure is required to ensure it provides the primary level of water resistance by the Waterproofing Specialist.

Internal drainage

The internal drainage system comprises of three elements:

- A drainage channel detail recessed into the floor construction.
- A means of water discharge, which in a basement fully below ground, requires a sump pump system or in a sloping site may be via gravity.
- Vapour barrier drainage membranes included above or internal of the drainage system which isolate the internal environment from the damp substrates behind.

Whilst the drainage channel is intended only to deal with minor seepage water and could alternatively be linked into deeper fixed drains to drain out via gravity, the risks associated with the surcharge of external drains are high and this practice is excluded from Warranty cover.

Drained protection systems are reliant on their ability to remove seepage water and so the mechanism by which water is removed requires careful consideration. The extent of seepage water penetration also has a bearing on the capacity required, with the degree of penetration being influenced by the permeability of the structure and the ground water conditions externally.

Notwithstanding the above, the capacity of such systems to remove water must be adequate to deal with a worst-case scenario and should be engineered with this in mind to provide a suitably low-risk system.

- Sump pump systems must include mechanical redundancy (dual mains powered pumps) to protect against pump failure and also sufficient battery back-up protection to protect in the event of a power cut.
- Each pump within a given system should have independent direct spur RCD/power supply so that in the event of an issue with a pump the others will still have power. Direct spur is advised to prevent accidental turning off by homeowners.
- A Commissioning certificate for the pump system should be provided upon completion.
- Drainage systems typically discharge into surface water gullies at external ground floor level, and an overflow detail must be formed at the point of discharge to allow water to spill out externally in the event of drains blocking or surcharging.
- Systems can drain by gravity to low ground externally, i.e. where properties are part retaining and constructed into sloping sites. As with pumped systems, if connecting to mains drains, an overflow detail must be employed to allow water to spill externally in the event of an issue.
- Internal drained protection systems must include drainage channels local to the external wall floor junctions which facilitates maintenance and allows systems to function and protect in the long term. Where larger footprints are involved, cross floor channels must be included, ideally local to construction joints where the structure is more vulnerable to ground water penetration.

<u>Maintenance</u>

Type C Systems must be maintained annually as a minimum. The detail of this requirement must be included in the documentation provided to the homeowner who will then be responsible for ongoing operation and maintenance of the system. The ongoing maintenance should include:

- The service records of the maintenance of the system.
- Accessibility to drainage channels and sumps are available at all times.
- That the drainage channels and sumps are checked at the service intervals to ensure they are clear and free of any free lime build up.
- Ensure that the electrical supply, battery back-up and alarm systems are fully operational at all times.

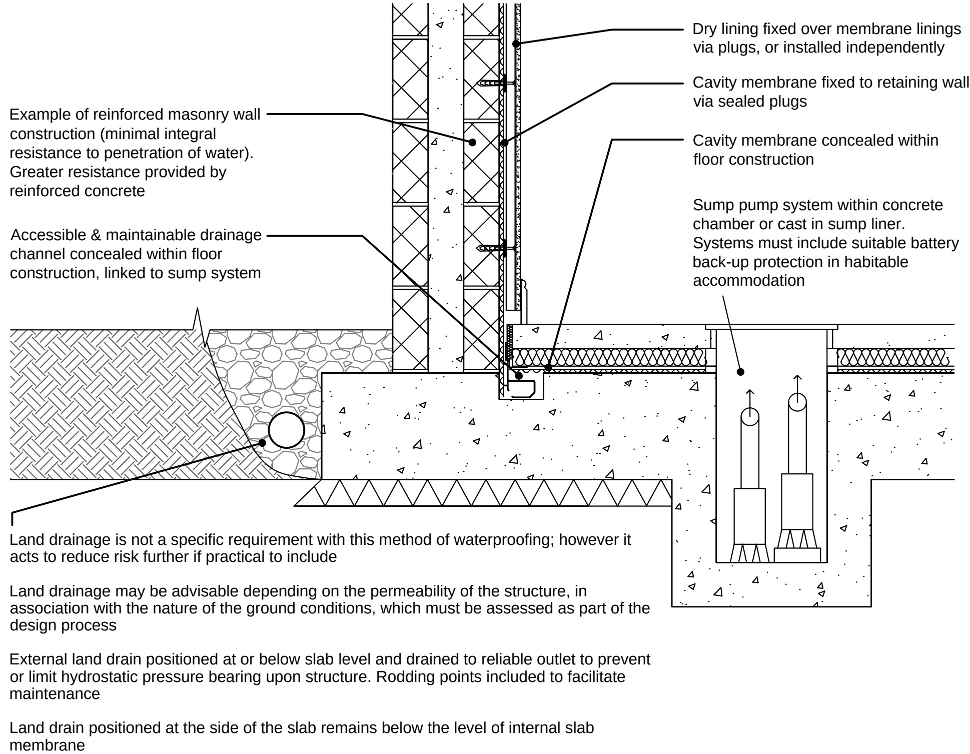
<u>Free lime</u>

Water moving over and through new concrete walls and floors leaches free lime within the early life of the structure, and suitable treatments should be applied to concrete to minimise this.

- The Waterproofing Specialist should provide a specification of the treatments to be used appropriate for the particular construction and made available to the Warranty Surveyor if requested.
- Where basements are formed under existing buildings in conjunction with new under pinning works; the choice of dry packing should be carefully specified and a waterproof expanding type mortar is recommended to help avoid free lime occurrences.
- Substrates should be clean and free of loose or friable materials prior to the application of membrane linings.

<u>General</u>

- Flood testing of a system should be undertaken during construction to check efficiency and that water flows freely to the discharge point. Testing in this manner to prove that the system functions as intended, is a key benefit of this method of waterproofing and must be part of the process.
- Systems creating a habitable space require the inclusion of vapour barrier drainage membranes within the wall and floor construction.
- Where elements of the drained protection system are included within cavities, the cavities must be kept clear of mortar snots and debris.
- Continuity of the structure must be considered because the resistance to water provided by a given structure is reduced by apertures through which water can freely move. Examples could include holes present within existing buildings, or in new construction where land drains are linked to sump pump systems, with the sumps being installed internal of the retaining shell, e.g. in light wells, thus providing a pathway for water to enter.
- Temporary 110v pumps should be included during construction to address water penetration as necessary; 240v systems should be installed and commissioned as soon as viable once the 240v supply is installed.
- Systems must not link directly by gravity to soakaways where any of the previously stated scenarios occur, and because of the danger of backflow of water through the pipes or waterlogging of the local ground above slab/DPM level. However, where such conditions are not present, sump pump systems may be employed to lift water up to ground level externally, discharging into gullies linked to soakaways. This detail should be designed by the Waterproofing Specialist.



<u>Commentary to Type C</u>

In consideration of the repair of defects, the inclusion of drained protection systems internally, generally ensures that systems can be accessed for localised repair. However, this may be lessened where systems are sandwiched within the structure, i.e. within cavities.

- Part of the underlying rationale of drained protection is that water is removed continuously, so that it does not collect and removes pressure upon membrane linings installed over the drainage. If water does not place pressure upon such membranes, then the incidence of any defects within them is generally of no consequence, and so maintaining the efficiency of the drainage in the long term ensures that such defects are negated.
- Product guarantees, quality assurance schemes and product certification does not negate the Functional Requirement that a waterproofing specialist is required to take responsibility for the design liability of the waterproofing.

<u>Other considerations</u>

Ground gases and contaminants

Aggressive ground conditions may require the inclusion of a suitable ground barrier to protect the structure appropriately. Specialist advice must be sought in respect of dealing with ground gases, and designers are advised to check current standards at the time of construction for suitable guidance.

Existing structures

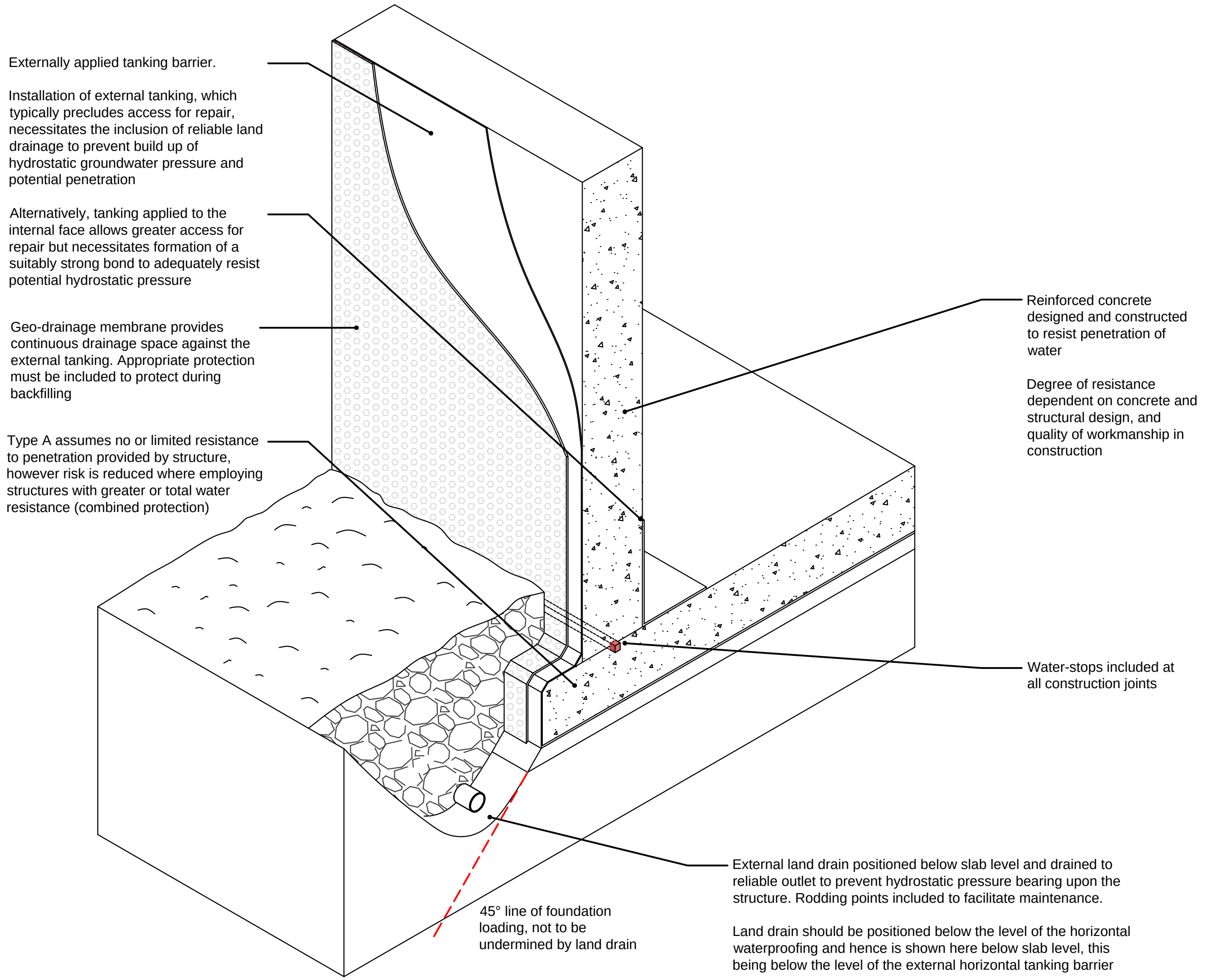
Waterproofing existing structures differs from new construction in that designers must work within the confines of the existing structure. However, many of the same considerations apply in that the required standard of environment appropriate to usage must be created and maintained in the long term.

Interface with external wall damp proof courses

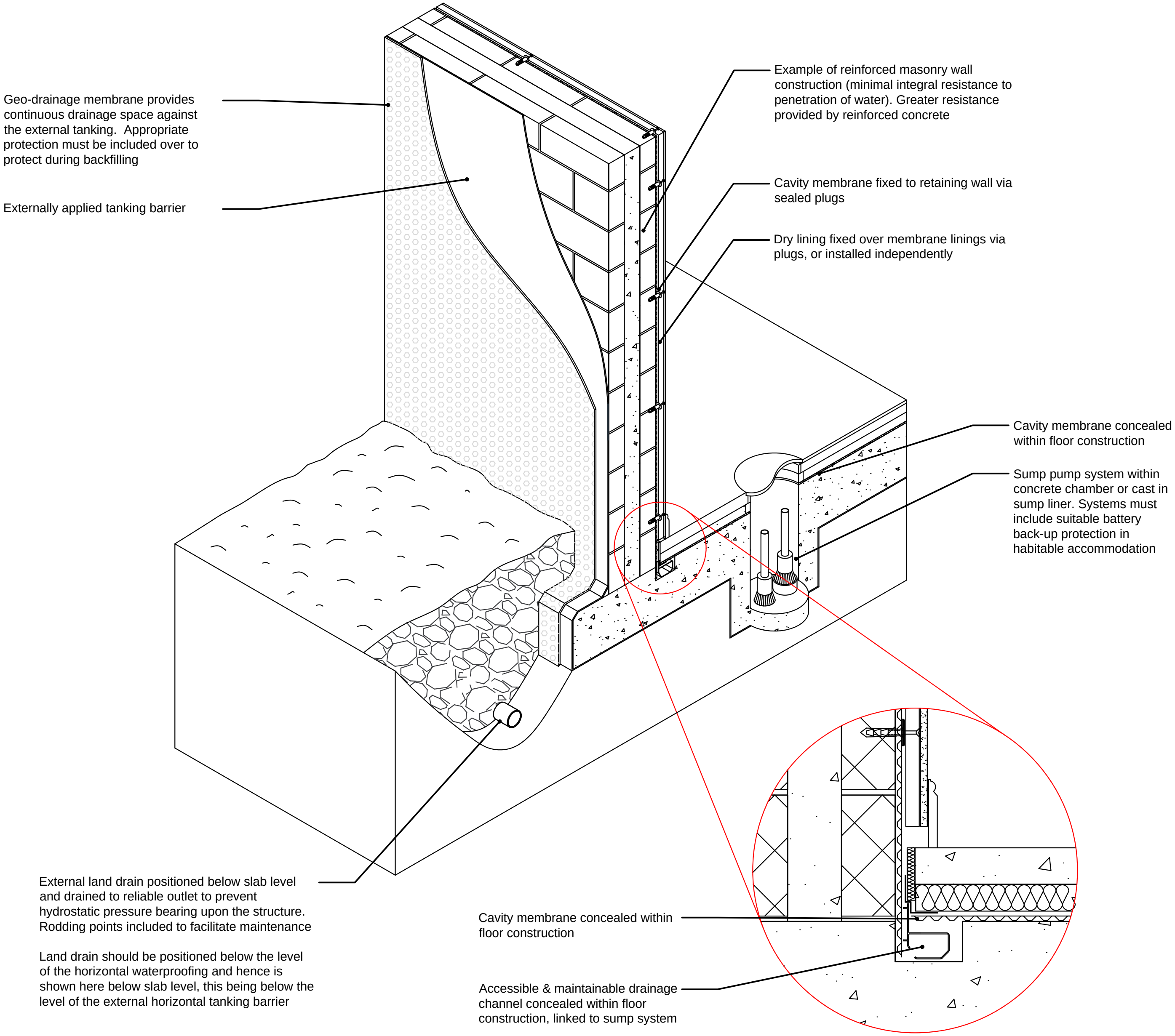
Whichever type of waterproofing system is deemed appropriate, there must be a continuation provided with the horizontal damp proof courses above ground level. Waterproofing materials used must be compatible with the damp proof course components and adequately lapped and bonded.

The CSSW designer should take responsibility for this junction as part of the tanking design.

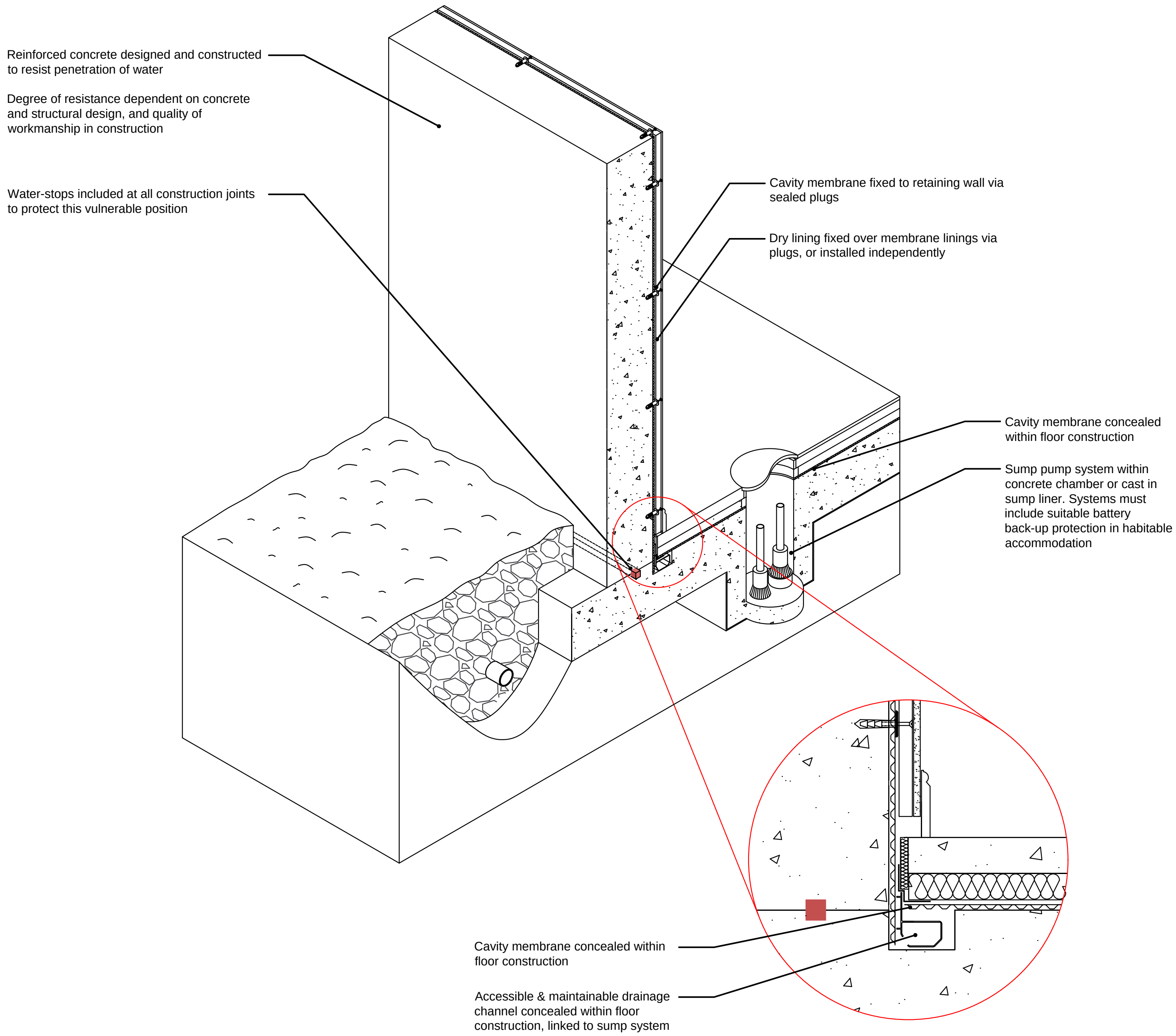
WATERPROOFING SYSTEMS: Typical example of a combined system - Type A+B



WATERPROOFING SYSTEMS: Typical example of a combined system - Type A+C



WATERPROOFING SYSTEMS: Typical example of a combined system - Type B+C



3.

Foundations

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. Ground improvement schemes should be appropriately tested to confirm that the completed works meet design specifications. The testing regime must be agreed with the Warranty Surveyor prior to commencement of work *(applicable to: 'Engineered Fill' and Vibratory Ground Improvement' only)*.
2. The developer shall ensure that adequate quality control procedures are in place. The quality control must identify that site work meets the design intention. All procedures should be auditable and available for inspection *(applicable to: 'Engineered Fill' and 'Vibratory Ground Improvement' only)*.
3. Foundations should be of a suitable depth in order to achieve a satisfactory level of performance.
4. Excavations for foundations shall be accurate in line, width and depth, and suitable for the type of foundation which form the basis of the design.

Materials

No additional requirements.

Design

1. Site Investigation by an appropriately qualified person should be supplied and provide the following information *(applicable to: 'Engineered Fill' and 'Vibratory Ground Improvement' only)*:
    a. Depth of original soil types below the structure.
    b. Details of any filled ground and its suitability to accept ground improvements techniques.
    c. Gas generation or spontaneous combustion from ground conditions.

   The investigation must be endorsed by the Specialist Foundations Contractor.
2. The ground improvement works must meet the relevant regional Building Regulations *(applicable to 'Engineered Fill' and 'Vibratory Ground Improvement' only)*.
3. Foundation type and depth must be suitable to resist movement due to the influence of nearby trees.
4. Piled foundation designs must be supported by structural calculations provided by a suitably qualified expert. Calculations for full piling systems must be provided by, or endorsed by, the piling manufacturer.
5. Raft foundation designs must be supported by structural calculations provided by a suitably qualified expert.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

3.

Foundations

3.1
Mass Fill

MASS FILL: Foundation depths

Limitations of guidance

The following situations are not covered by this guidance:

- Mass filled foundations for buildings other than dwellings.
- Buildings greater than three storeys.
- Foundations on filled ground.
- Mass fill foundations where foundation depths exceed 2.5m.

Design

Mass filled foundations shall be designed to ensure that the building is appropriately supported at all times without excessive settlement. This foundation type should only bear onto original ground if the foundation has been designed by a Structural Engineer and is appropriately reinforced. It is therefore important that site conditions are appropriately assessed prior to the building design. Please refer to the 'Ground Conditions' section.

For 'low rise structures', the foundations should be designed to ensure a maximum settlement of 25mm is not exceeded.

In relation to differential settlements, a design limit for maximum tilt of 1/500 is appropriate. More stringent values may be required due to the particular circumstances (e.g. medium and high rise structures).

Foundations: Trees and Clay

Foundation design should take into account influence from nearby trees. Where construction is to take place in cohesive soils and trees are/were/will be present:

- If the foundation depth is greater than 1.5m, heave protection will be required.
- Where foundation depths exceed 2m, short bored piles with ground beams are recommended. All pile designs should be undertaken by a Chartered structural engineer.
- Foundation depths required to exceed 2.5m are beyond the scope of the online foundation depth calculator and must be a piled engineered solution.

Minimum foundation dimensions

- Mass fill foundations should be of a 600mm minimum width for external walls.
- For single leaf internal walls up to 150mm thick, foundations may be reduced in width to 450mm ensuring that a 150mm projection either side of the internal wall is provided.
- Foundations should be situated centrally below the wall.

Foundation depths

The depth of all foundations should be determined by specific site conditions. All foundations must bear onto virgin stable subsoil and, except where strip foundations are founded on rock. The foundations should have a minimum depth of 450mm, measured from finished ground level to their underside, to avoid the action of frost. This depth however, will commonly need to be increased in areas subject to long periods of frost or in order that loads are transferred to suitable ground.

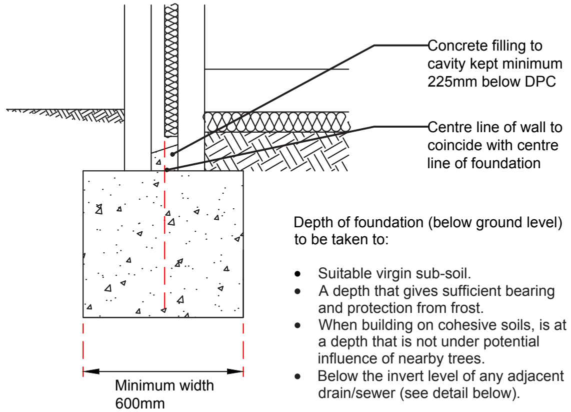
Where trees are situated close to a proposed building founded on a clay soil, the foundation depth/design will be affected; further guidance is available in the 'Foundations - Trees and Clay' section. In clay soils with a plasticity index greater than or equal to 10%, foundations should be taken to a depth where anticipated ground movement will not impair the stability of any part of the building, taking into account the influence of vegetation and trees on or adjacent to the site. The depth to the underside of foundations on clay soils should not be less than 750mm, as measured from finished ground level, and depths may need to be increased in order that loads are transferred to suitable ground.

For minimum depths of foundations in cohesive soils where trees are/were/will be present, please use the online foundation depth calculator. Further guidance can be found in the 'Foundations - Trees and Clay' section.

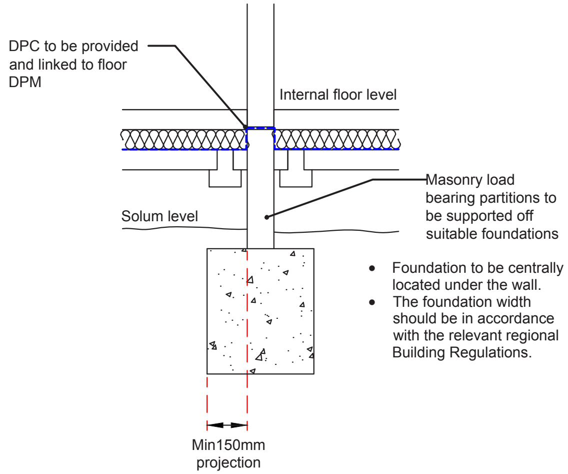
Minimum foundation depths

Modified plasticity index (x)	Volume change potential 40% and greater	Minimum foundation depth (m)
x ≥ 40%	High	1.00
40% > x < 20%	Medium	0.9*
x > 20%	Low	0.75*
Note: *If the modified plasticity index is not confirmed, the minimum foundation depths should be 1m.		

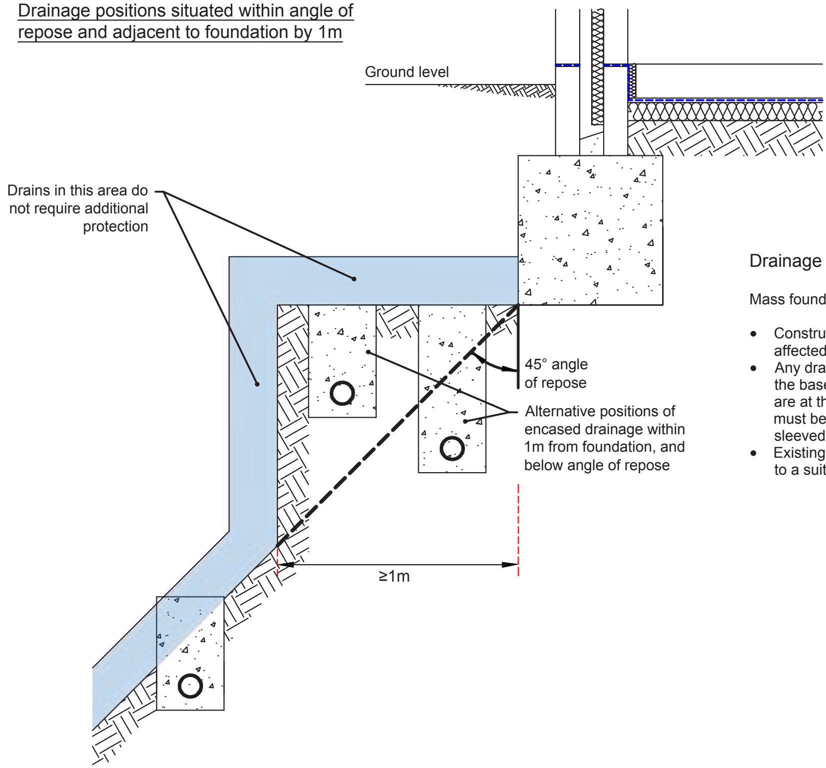
Typical mass filled foundation



Internal wall foundation



Drainage positions situated within angle of repose and adjacent to foundation by 1m



Drainage and other services:

Mass foundations must be:

- Constructed to a depth which will not be affected by nearby drainage or other services.
- Any drain or service pipe must not pass through the base of the foundation. Where such services are at the same level, the base of the foundation must be stepped below and the drain/services sleeved through the substructure wall above.
- Existing ground water drains should be diverted to a suitable outfall.

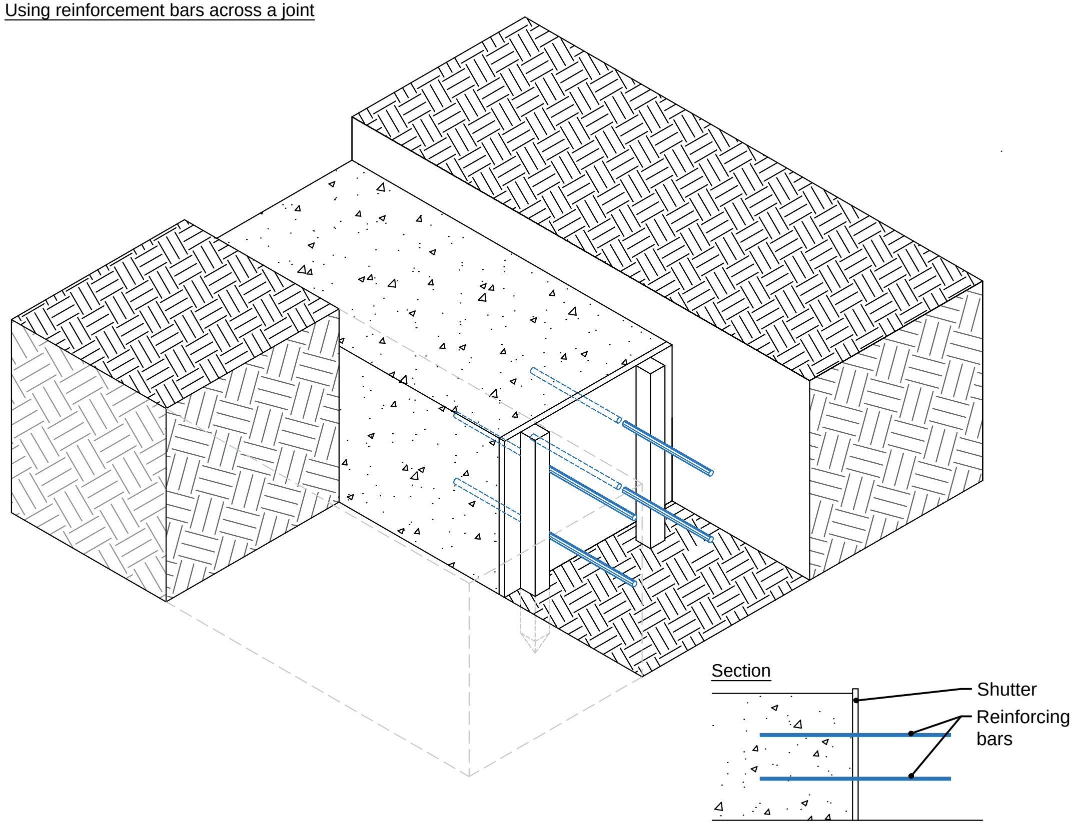
Reinforcing

Mass fill foundations should be reinforced where necessary to suit localised ground conditions. Reinforcement, if needed, should be clean and free from loose rust and should also be placed correctly. Bars, of an appropriate size, should be supported to guarantee that they are 75mm above the base of the foundation, or as indicated in the design. They should be secured at laps and crossings. If in doubt about any soft spots, the engineer's advice should be taken prior to placing the concrete.

Foundation joints

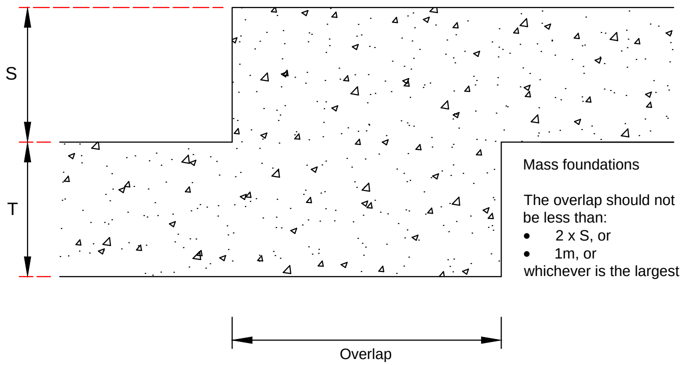
If construction joints are necessary, they should not be positioned within 2m of a corner or junction in the foundation. All shuttering should be removed before work progresses beyond the construction joint.

Using reinforcement bars across a joint



Steps in foundations

Steps in foundations must not be of a greater dimension than the thickness of the foundation. Where foundations are stepped (on elevation), they should overlap by twice the height of the step, or 1m whichever is the largest.



Excavation

- Excavations should be to a depth that gives sufficient bearing and protection from frost damage.
- To avoid damage caused by frost, the depth of the foundation(s) in frost-susceptible ground should be at a minimum of 450mm below ground level. If the finished ground level will be above the existing ground level then, the foundation depth should be calculated from the existing, not finished, ground level.
- Where the depth of mass fill foundations is in excess of 2.5m, they must be designed by a Chartered Structural Engineer in accordance with current British Standards and Codes of Practice. For trench fill, it is imperative to check that the finished foundation level is correct and horizontal. It will be difficult to adjust for discrepancies in the small number of brick courses between foundation and DPC level.
- Prior to concreting, excavations should be 'bottomed out' to remove any debris that may have fallen into the trench; the excavations should be free from water, and if it has been left open for a long period of time, further excavation may be required to a non-weathered strata.

Note: It is important that Health and Safety obligations are met and that excavations are appropriately supported to prevent collapse.

Setting out foundations

The accuracy of setting out foundations should be checked by set controlled trench measurements, including their location relative to site borders and neighbouring buildings. Levels should be checked against benchmarks, where appropriate. In particular, for excavations check:

- Trench widths
- Trench lengths
- Length of diagonals between external corners

Walls should be located centrally upon the foundation, unless specifically designed otherwise. Any discrepancy in dimensions should be reported promptly to the designer. Resulting variations should be distributed to all concerned with site works, including the Warranty Surveyor.

Standards referred to

- BS 8004 Code of Practice for foundations
- BS 5950-1 Structural use of steelwork in buildings
- BS 6399 Loadings for buildings
- BS 8103 Structural design of low rise buildings
- BS 8110 Structural use of concrete

3.

Foundations

3.2
Strip

Limitations of guidance

The following situations are not covered by this guidance:

- Traditional strip foundations for buildings other than dwellings.
- Buildings greater than three storeys.
- Foundations on filled ground.
- Strip foundations where foundation depths exceed 2.5m.

Design

Strip filled foundations shall be designed to ensure that the building is appropriately supported at all times without excessive settlement. This foundation type should only bear onto original ground if the foundation has been designed by a Structural Engineer and is appropriately reinforced. It is therefore important that site conditions are appropriately assessed prior to the building design. Please refer to the 'Ground Conditions' section.

For 'low rise structures', the foundations should be designed to ensure a maximum settlement of 25mm is not exceeded.

In relation to differential settlements, a design limit for maximum tilt of 1/500 is appropriate. More stringent values may be required due to the particular circumstances (e.g. medium and high rise structures).

Foundations: Trees and clay

Foundation design should take into account influence from near-by trees.

- Where construction is to take place in cohesive soils and trees are/were/will be present, and the foundation depth is required (using the online foundation depth calculator) to exceed 1.5m, heave protection will be necessary and strip foundations will not be suitable. Mass fill or short bored piles should be adopted (see the 'Foundations - Mass Fill' and 'Foundations - Piles' guidance).

Minimum foundation dimensions

- Strip foundations should be of a 600mm minimum width for external walls.
- For single leaf internal walls up to 150mm thick, foundations may be reduced in width to 450mm ensuring that a 150mm projection either side of the internal wall is provided.
- The minimum thickness of strip foundations should be 150mm.
- Foundations should be situated centrally below the wall.

Foundation depths

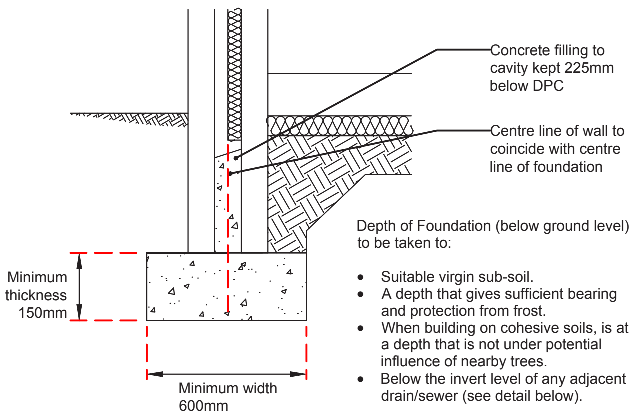
The depth of all foundations should be determined by specific site conditions. All foundations must bear onto virgin stable subsoil and, except where strip foundations are founded on rock. The strip foundations should have a minimum depth of 450mm, measured from finished ground level to their underside, to avoid the action of frost. This depth however, will commonly need to be increased in areas subject to long periods of frost or in order that loads are transferred to suitable ground.

Where trees are situated close to a proposed building founded on a clay soil, the foundation depth/design will require to be assessed by following the recommendations available in the 'Foundations - Trees and Clay' section. In clay soils with a plasticity index greater than or equal to 10%, strip foundations should be taken to a depth where anticipated ground movement will not impair the stability of any part of the building, taking into account the influence of vegetation and trees on or adjacent to the site. The depth to the underside of foundations on clay soils should not be less than 750mm, as measured from finished ground level, and depths may need to be increased in order that loads are transferred to suitable ground.

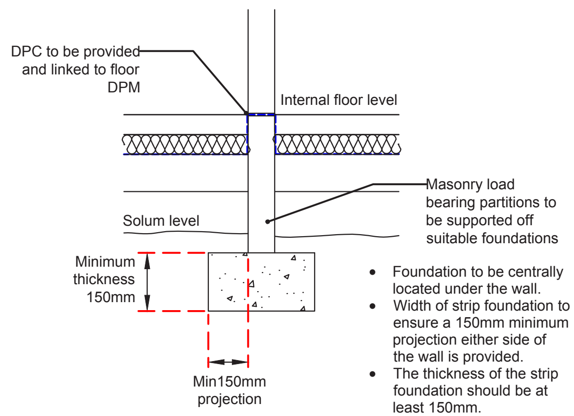
Minimum foundation depths

Modified plasticity index (x)	Volume change potential 40% and greater	Minimum foundation depth (m)
x ≥ 40%	High	1.00
40% > x < 20%	Medium	0.9*
x > 20%	Low	0.75*
Note: *If the modified plasticity index is not confirmed, the minimum foundation depths should be 1m.		

Typical strip foundation

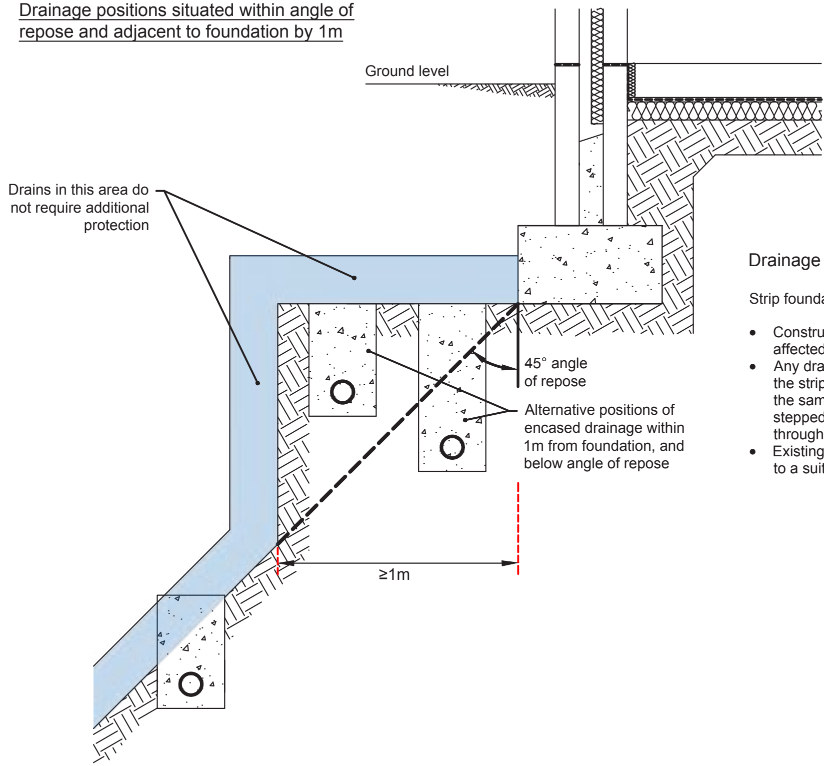


Internal wall foundation



- Foundation to be centrally located under the wall.
- Width of strip foundation to ensure a 150mm minimum projection either side of the wall is provided.
- The thickness of the strip foundation should be at least 150mm.

Drainage positions situated within angle of repose and adjacent to foundation by 1m



Drainage and other services:

Strip foundations must be:

- Constructed to a depth which will not be affected by nearby drainage or other services.
- Any drain or service pipe must not pass through the strip foundation. Where such services are at the same level, the strip foundation must be stepped below and the drain / services sleeved through the substructure wall above.
- Existing ground water drains should be diverted to a suitable outfall.

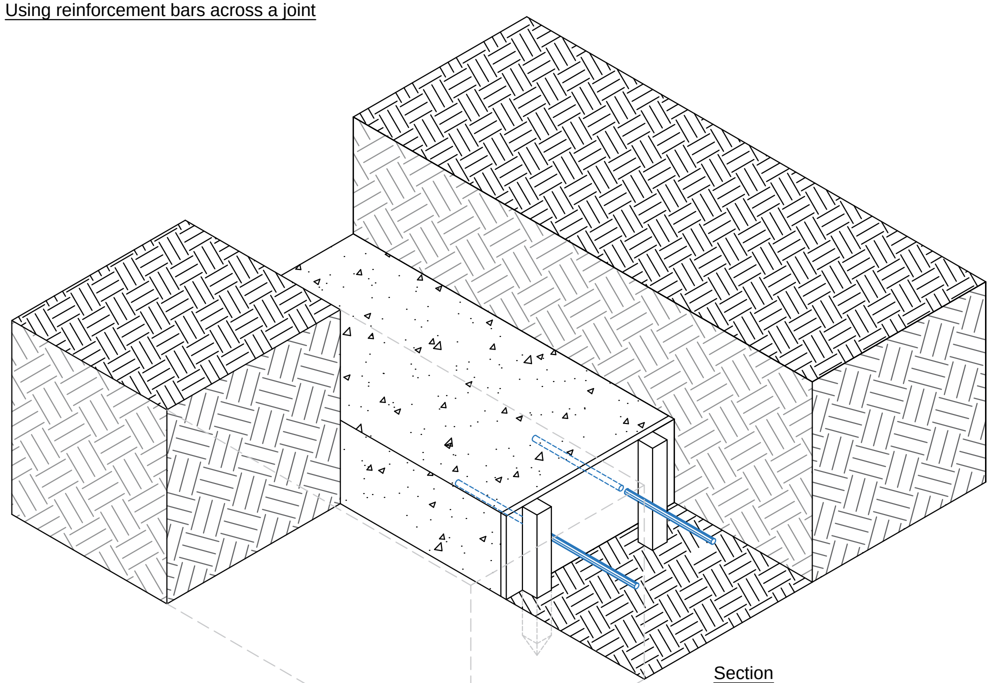
Reinforcing

Strip foundations should be reinforced where necessary to suit localised ground conditions. Reinforcement, if needed, should be clean and free from loose rust and should also be placed correctly. Bars of an appropriate size, should be supported to guarantee that they are 75mm above the base of the foundation, or as indicated in the design. They should be secured at laps and crossings and if in doubt about any soft spots, the engineer's advice should be taken prior to placing the concrete.

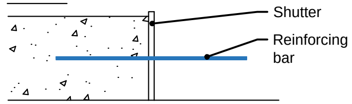
Foundation joints

If construction joints are necessary, they should not be positioned within 2m of a corner or junction in the foundation. All shuttering should be removed before work progresses beyond the construction joint.

Using reinforcement bars across a joint

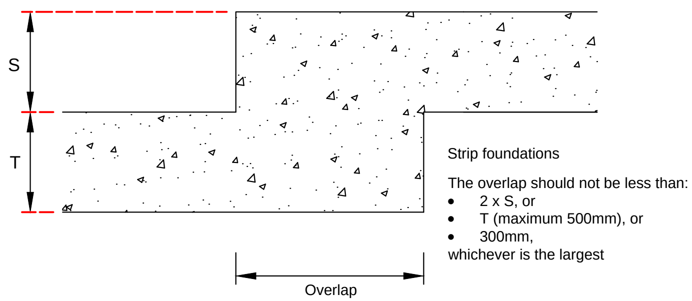


Section



Steps in foundations

Steps in foundations must not be of a greater dimension than the thickness of the foundation. Where foundations are stepped (on elevation), they should overlap by twice the height of the step, or 300mm, whichever is the largest.



Excavation

- Excavation should be to a depth that gives sufficient bearing and protection from frost damage.
- To avoid damage caused by frost, the depth of the foundation(s) in frost-susceptible ground should be at a minimum of 450mm below ground level. If the finished ground level will be above the existing ground level then, the foundation depth should be calculated from the existing, not finished, ground level.
- Where the depth of strip foundations is in excess of 2.5m, they must be designed by a Chartered Structural Engineer in accordance with current British Standards and Codes of Practice.
- Prior to concreting, excavations should be 'bottomed out' to remove any debris that may have fallen into the trench; the excavations should be free from water, and if it has been left open for a long period of time, further excavation may be required to a non-weathered strata.

Note: It is important that Health and Safety obligations are met and that excavations are appropriately supported to prevent collapse.

Setting out foundations

The accuracy of setting out foundations should be checked by set controlled trench measurements, including their location relative to site borders and neighbouring buildings. Levels should be checked against benchmarks, where appropriate. In particular, for excavations check:

- Trench widths
- Trench lengths
- Length of diagonals between external corners

Walls should be located centrally upon the foundation, unless specifically designed otherwise. Any discrepancy in dimensions should be reported promptly to the designer. Resulting variations should be distributed to all concerned with site works, including the Warranty Surveyor.

Standards referred to:

- BS 8004 Code of Practice for foundations
- BS 5950-1 Structural use of steelwork in buildings
- BS 6399 Loadings for buildings
- BS 8103 Structural design of low rise buildings
- BS 8110 Structural use of concrete

3.

Foundations

3.3

Piles

Piled Foundations

Piles are used to transfer loads from buildings to the supporting ground and are utilised in a wide range of applications where conventional strip footings are inappropriate. They are particularly employed where soft or loose soils overlay strong soils or rocks at depths that can be reached conveniently by driving or boring. They are often the most economical type of foundation when very heavy loads must be supported or uplift forces need to be resisted. Large piles are extremely useful for limiting the settlements of large structures on deep stiff clays; smaller versions can provide appropriate foundations for houses and other small buildings on stiff clays liable to shrinkage and swelling. The technique has been in use for many years.

Limitations of guidance

The following situations are beyond the scope of this guidance.

- Innovative foundation systems that do not have third-party approval or accreditation.
- Piling systems where the structural design is not endorsed by the Specialist Piling Contractor.

Foundations: Trees and clay

Foundation design should take into account influence from nearby trees. Where construction is to take place in cohesive soils and trees are/were/will be present:

- Suitable heave precautions should be included in the design details for the protection of the piles and ground beams.
- The piles must be deep enough to cater for heave.

For more information on this, please see the 'Foundations - Trees and Clay' section.

Pile classification

Piles of many different types and methods of installation have been developed to suit the wide variety of soils. Piles generally fall into two main types:

- Bored and dug, including short bored and secant (replacement piles).
- Driven and jacked piles, steel, concrete and timber (displacement piles).

How piling systems work

There are two groupings of piles, based on the way that they transfer loads to the ground:

- End bearing piles derive the greater part of their support from bearing forces at the base. They act largely as columns transferring loads through soft deposits, usually to dense granular soil or rock at the foot of the pile.
- Friction piles on the other hand, develop most of their support from friction between the shaft and the soil, usually firm clay.

Choosing the right piled solution

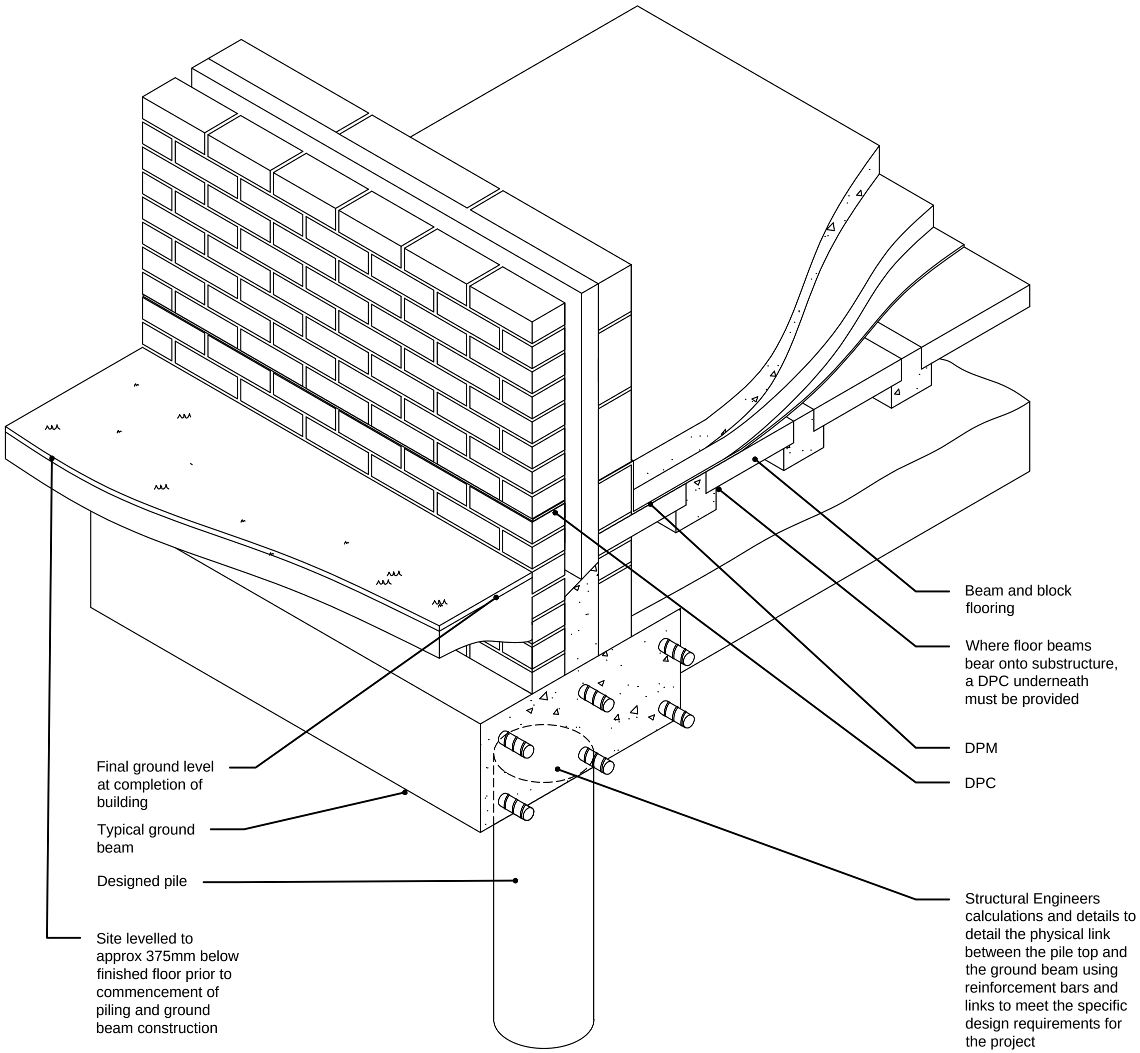
The choice of piling system to support the structure will depend entirely upon the ground conditions. It is important to have the appropriate site investigation works carried out to determine depths of filled ground, the bearing capacity of soils, soil type and any existing workings or services that may clash with pile locations.

Note: For further guidance on ground condition assessments, please refer to the 'Ground Conditions' section.

Analysis of the site investigation report should be completed by a Specialist Piling Contractor and Structural Engineer, as they are best placed to design the most economical piling system.

Piles are particularly appropriate for heave sites (trees removed), for which they are strongly recommended.

Pile layouts can be readily designed to accommodate an individual plot. A good design will seek to achieve cost savings in foundation excavation and materials through incorporation of large ground beam spans between piles and a small number of piles.



Ground beams

The Piling Contractor should take care to ensure that the piles are inserted vertically and pile tops are correctly aligned to support the foundation beams.

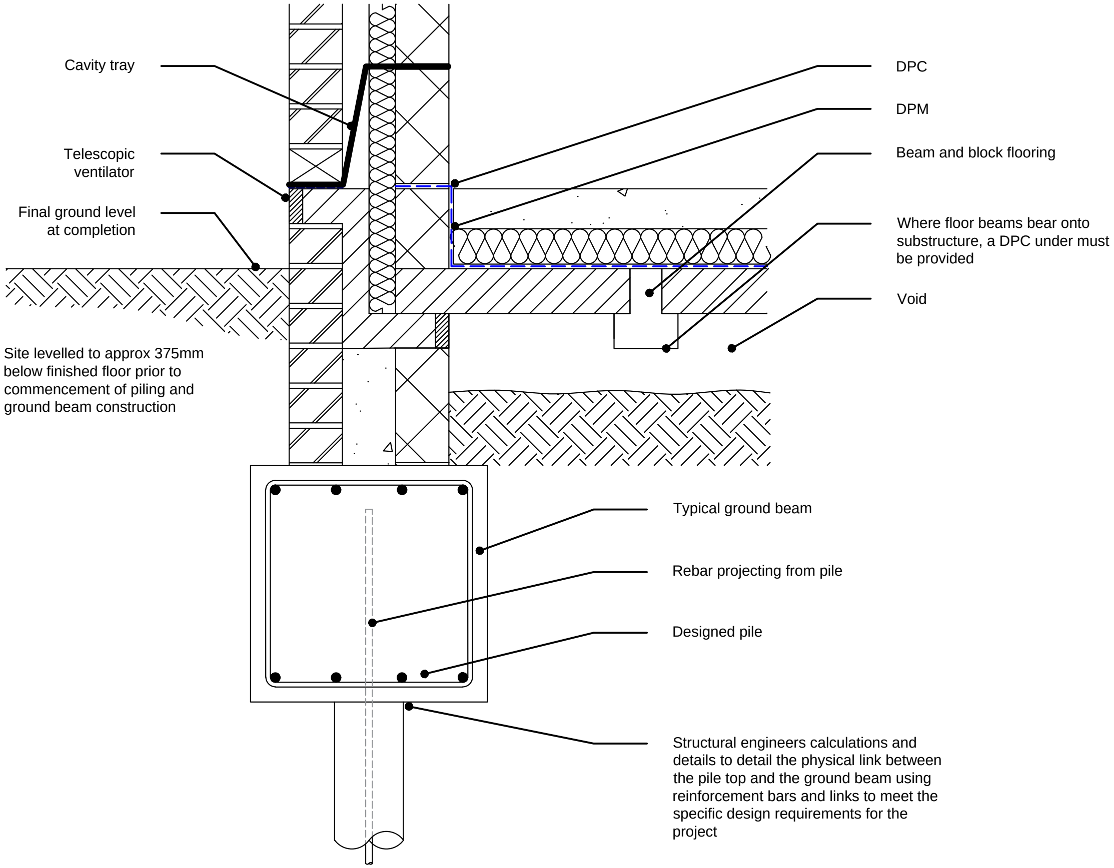
Piles should be capped with an appropriate ground beam system. There should be adequate connections between the beam and the pile to ensure that the loads are transmitted effectively, or that the beams are adequately restrained to the pile to resist uplift on sites that are susceptible to heave. All external, internal, partition and party walls can be accommodated using this system. The ring beam and its connections should be part of the piled foundation design, and should be supported by structural calculations provided by a Structural Engineer.

Pile construction records

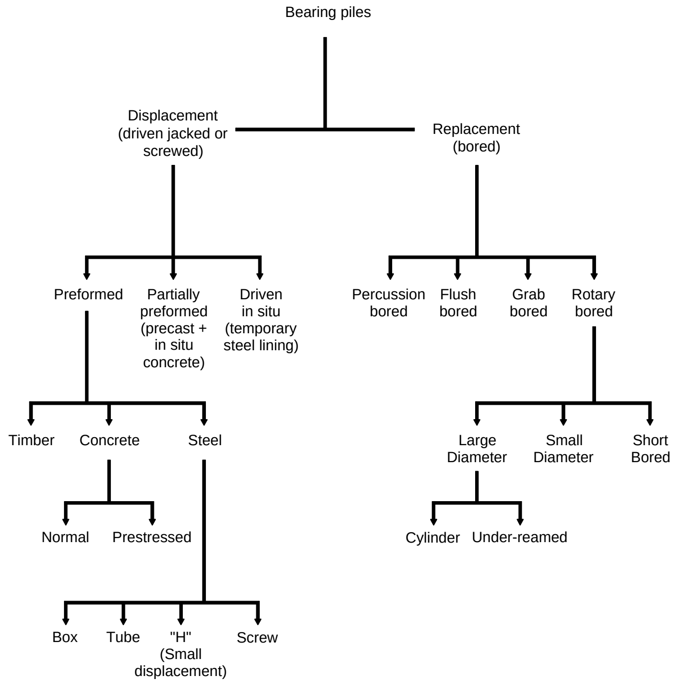
Pile construction records should be made available for all piles installed. The records should include the following information:

- Pile type (driven tube, Continuous Flight Auger (CFA), auger bored, etc.).
- Pile dimensions (diameter or width/breadth).
- Pile depth.
- Driving records from driven piles, including hammer type, weight, drop height, sets, hammer efficiency.
- Pile verticality confirmation, which should be no more than 1:75 from vertical.

For CFA and concrete screw piles, the Warranty Surveyor should be given the computer output for concrete volume and rig performance.



The range of piling types (BRE publication)



Key requirements

The piling scheme shall be designed to clearly demonstrate that the piles are capable of supporting and transferring the foundation design loads safely to known soil strata that are, in turn, capable of supporting the pile loads using the appropriate soil properties obtained from geotechnical testing and contained in the appropriate site investigation report. The piles shall be designed in accordance with BS 8004:2015 and shall ensure that long term settlement does not exceed 10mm or 1:500 (differential, between adjacent piles) at working load and 15mm at 1.5 times working load, unless more stringent criteria are required by the Project Structural Engineer.

Pile installation record sheets shall show clearly that all piles installed have achieved sufficient depth with respect to the pile design calculations. Where there is any doubt concerning the depth of the piles, as a result of any encountered voids or boulders, or there is any other reason to suspect underperformance, the capacity of the questionable piles shall be demonstrated by means of static load testing and it shall be confirmed by the Project Structural Engineer that the piles are fit for purpose.

Technical documentation required

The following documentation shall be submitted to the Warranty Surveyor for assessment. Items 1-5 below should be submitted prior to commencement of piling on site. In the absence of approval, works are proceeding at the Developer's own risk. Items 6-10 below shall be submitted as soon as they become available, prior to construction continuing over the piles.

Prior to commencement on site

1. Desk study, investigative and interpretive Site Investigation Report(s) (to at least 5m below the pile toe) with associated geotechnical testing sufficient for pile design including DS / ACEC requirements for buried concrete, heave and shrinkage.
2. Foundation drawings, pile layouts and pile schedule (with pile reference numbers and loadings).
3. Project Structural Engineer's specification for piling works to include the allowable pile settlements and testing requirements.
4. Calculations demonstrating how the load on each pile was derived.
5. Pile design calculation (for vertical, horizontal, tensile, and heave forces) to geotechnical parameters in the Site Investigation Report and a copy of the pile set design (for driven piles, if applicable). This should include the pile designer's written confirmation that the site investigation is adequate to ensure that the pile design complies with British Standards. This should also include confirmation, justification, type and number of any preliminary and/or working pile load tests required to satisfy the design.

Prior to construction continuing over the piles

6. Pile installation logs (with pile numbers cross-referenced to the pile layout drawing), including details of re-strikes, rock sockets, rig telemetry records, and concrete volume.
7. Concrete mix details and cube test results for the concrete used in the piles with tabulated results similar to that in Concrete Advice Note. No.30 (The Concrete Society) Tables 1 and 3. Delivery records, cross-referenced to the pile layout/numbers, should also be kept for possible future reference.
8. Integrity testing of all concrete piles with interpretive summary and conclusion.
9. Dynamic load testing results (where applicable) with analysis of long-term settlement, interpretive summary and conclusion.
10. Static load test results with interpretive summary and conclusion.

Reference documents

- BS EN 1997-1:2004 + A1:2013 - Eurocode 7: Geotechnical design (EC7)
- BS 8004:2015 - Code of practice for foundations
- BS EN 1997-2:2007 - Ground investigation and testing
- BS 5930: 2015 - Code of practice for ground investigations
- ICE Specification for piling and embedded retaining walls (3rd edition 2016)
- London district surveyors association (LDSA) - Guidance notes for the design of straight shafted bored piles in London clay (2017)

Geotechnical site investigation

A detailed, site specific, interpretive, Phase 2 Geotechnical Site Investigation should take place and be in accordance with BS 5930 / BS EN1997-2 and extend to depths beneath the pile toe of at least 3 x pile diameter or 5m or the smallest plan dimension encompassing the pile group (whichever is the greatest). Refer to 'Published Minimum Requirements for Site Investigation' by the Federation of Piling Specialists (July 2013). Generally, boreholes should be at centres of 10m to 30m for structures and at a minimum of 3 points, but closer borehole spacing's should be used where there are site-specific hazards (e.g. soluble soils, mining features etc.) or where there are large variations in soil properties.

The investigation should include sufficient geotechnical testing throughout the length and beneath the pile to enable an accurate geotechnical design of the pile in accordance with proven design methods.

If the Site Investigation is found to contain insufficient information to verify the proposed design of the piles, additional investigation and testing will be required e.g. by carrying out additional boreholes to the above depth, as considered necessary to establish the required geotechnical parameters.

Pile design

A pile layout drawing and piling schedule should be prepared by the Project Structural Engineer, indicating the pile reference numbers, all loadings to which each pile will be subjected and details of connections between piles and the substructure. Calculations should clearly demonstrate how the load on each pile was derived.

The piles shall be designed in accordance with BS 8004:2015 and shall ensure that long term settlement does not exceed 10mm or 1:500 (differential, between adjacent piles) at working load and 15mm at 1.5 times working load, unless more stringent criteria are required by the Project Structural Engineer.

In all cases, a geotechnical and structural design should be carried out to current standards in order to confirm the required pile length, reinforcement etc. and to reflect the ground conditions as confirmed by the site specific Site Investigation Report. The pile design should prove that the pile can support all expected vertical, horizontal, tensile, heave and negative skin friction forces.

The skin friction adhesion factor (α) should be in accordance with BS 8004:2015 (clause 6.4.1.2.3).

BS 8004:2015 (clause 6.1.1) and BS EN1997-1 (clause 7.4.1) permits pile design to be carried out by:

1. Static pile formulae based on ground parameters from the site investigation and appropriate safety factors, and/or
2. The results of dynamic load tests (provided they have been verified by static tests in comparable situations), and/or
3. Pile driving formula (provided they have been verified by static tests in comparable situations).

If the results of appropriate static load testing are not available for the site, then the 1st option applies. In this case, all driven piles should be installed to the lengths indicated in the static pile design calculation and representative dynamic tests with settlement analysis (e.g. CAPWAP) are carried out (typically 3% to 5% per static pile design), but this may need to be increased if there are any concerns regarding the pile installation or if required by the Project Structural Engineer.

However, if the piles cannot be driven to the lengths indicated in the static pile design (as is often the case), then reliance switches to dynamic tests and/or dynamic formulae, both of which need to be verified by previous evidence of acceptable performance in static load tests on the same type of pile, of similar length and cross section and in similar ground conditions (the static tests don't necessarily need to have been carried out on the particular site), as required by BS 8004:2015.

A pile schedule should be produced indicating the pile numbers (referenced to the drawings), pile loads, pile type and diameter, pile length, required rock socket length, and details of required reinforcement. Piles for new developments should be not less than 150mm diameter or equivalent.

Alternative pile types and design methods

If alternative pile types or non-standard design methods are being considered, please contact the Warranty Surveyor prior to commencement of piling.

Pile design factor of safety

The factor of safety is dependent on the extent of site investigation, design method/code/standard, confidence in the design, the proposed pile load testing regime, and should be in accordance with design method being used.

BS 8004: 2015/EC7 Partial factors depending upon load testing undertaken (for bored or continuous flight auger piles)

Direction of load	Load tests	Partial factor for shaft resistance	Partial factor for base resistance	Model factor
Compression	None	1.6	2.0	1.4
	WPT only	1.4	1.7	1.4
	PPT and WPT	1.4	1.7	1.2
Tension	None	2.0	-	1.4

Alternative factors of safety depending upon load testing undertaken (using traditional approach)

Preliminary Pile Tests (PPT)	Working Pile Tests (WPT)	Typical factor of safety
No	No load testing on WP	3.0
No	Load testing on 1% min of WP	2.5
Yes (rate to be agreed)	Load testing on 1% min of WP	2.0

Note: It is not acceptable to adopt a higher factor of safety in place of an adequately detailed Site Investigation.

The guidelines contained in LDSA guidance should be used for the design of straight shafted bored piles in London clay.

Piling in rock/boulders

If rock sockets are required by the pile design, then the achievement of such sockets during pile installation should be demonstrated. Where there are boulders, it needs to be demonstrated that piles are not founded on, or partly on, boulders. It is advisable to ensure that piles are taken down through strata containing cobbles/boulders. Pre-drilling may be required.

Piling in chalk

Reference should be made to CIRIA PR86 and CIRIA C574 for pile design and installation. Where the risk of solution features as obtained from a Groundsure or Envirocheck hazard map is moderate or high (i.e. not low), probing should be carried out at each pile location in accordance with CIRIA PR86. Piles should be designed to take into account the risk of a solution feature around, adjacent or beneath the pile (refer to clause 7.10.2 of CIRIA C574). Should concrete flows significantly exceed the volume of the pile during installation (suggestive of a solution feature/void), measures should be taken immediately to mitigate the risk e.g. additional probing, deeper piles, relocation of piles, load testing etc.

Piling in ground subject to cavitation

Where the ground is subject to potential cavitation as a result of gypsum dissolution, brine dissolution etc., the pile design and installation should take into account any existing and future cavitation. As such, some form of redundancy may need to be considered within the design to counteract any unknown conditions. As the presence of dissolution features cannot be readily identified during the installation of the piles, it is recommended that probing be undertaken at each pile location. Geophysical investigation or similar is recommended in order to locate existing cavities.

Piling over mine workings

With regard to piling over or near to historical mine workings reference should be made to CIRIA SP32. Piles are not generally suitable unless founded below the grouted horizons. When piling adjacent to existing mine entries, assurance needs to be provided that adequate competent rock is available, that stipulated rock sockets are achieved and that piles will not be affected by any potential future collapse or partial collapse of the mine entry.

Piling in made ground

Piles terminating in, or relying on, made ground are not acceptable.

Pile installation and testing

Piles should be installed and tested to ensure that they meet the design requirements. The Project Structural Engineer shall review all pile installation records and testing results and advise on remedial works to address any unusual results or failures.

Pile installation records (logs)

Copies of the site-recorded pile installation records (logs) shall be provided for each pile indicating the pile number (correctly referenced to the drawing), pile load, pile length, reinforcement details and any sleeving requirements.

For driven piles, the first pile driven should record the number of blows for the first 100mm of each metre of depth, and the set (including dates) achieved during installation and on re-strike should be indicated.

Should driven piles vary considerably in length across short distances, then the pile installation should be immediately re-assessed and details (including subsequent results of further investigation) submitted to the Warranty Surveyor for review. Installing piles to “rig-refusal” or reference to the limitations of the piling rig shall not be accepted as the sole proof of adequacy of the pile length. If the pile static design lengths are not being achieved on site, then static pile load tests may be required in order to ensure compliance with the British Standards and/or carrying out additional site investigation to prove the adequacy of the pile.

Re-strikes shall be carried out on driven piles (typically at a rate of 10%) following a suitable time allowance. If sets have relaxed on re-strike, the adequacy of the piles shall be re-evaluated (e.g. by additional testing).

Rig telemetry should be recorded, stored and provided as a matter of course for projects with continuous flight auger (CFA), sectional flight auger (SFA) or continuous helical displacement (CHD) piles.

Concrete mix and cube test results

Concrete mix details and cube test results for the concrete used in the piles shall be provided with tabulated results, similar to that in Concrete Advice Note No.30 (The Concrete Society) Tables 1 and 3. Delivery records, cross referenced to the pile layout/numbers, should also be kept for possible future reference. The Project Structural Engineer shall review all concrete cube testing results and, in the case of any unusual results or failures, advise on any remedial works proposals necessary.

Pile integrity testing

The integrity of the full depth and cross-section of all CFA, SFA, CHD, bored piles (including retaining walls) should be established by integrity testing using recognised methods. Should integrity testing indicate anomalies, then the Project Structural Engineer should advise on the remedial measures proposed and seek agreement with us. It is recommended that such agreement is obtained prior to work continuing.

Note: Integrity testing should not be considered as replacement for sufficient site investigation or other types of testing, particularly static load testing. 100% of such piles shall be integrity tested.

Dynamic load testing

Dynamic load testing shall be carried out in accordance with BS 8004:2015 and shall include analysis of long term settlements. There should be adequate site investigation to 5m below the pile toe as required by the British Standards.

BS 8004:2015 (clause 6.1.1) & BS EN1997-1 (clause 7.4.1) permits pile design to be carried out by:

1. Static pile formulae based on ground parameters from the site investigation and appropriate safety factors, and/or
2. The results of dynamic tests (provided they have been verified by static load tests in comparable situations), and/or
3. Pile driving formula (provided they have been verified by static load tests in comparable situations).

If the results of appropriate static load testing are not available for the site, then the 1st option applies. In this case, all driven piles should be installed to the lengths indicated in the static pile design and representative dynamic tests with settlement analysis (e.g. CAPWAP) are carried out (typically 3% to 5% per static pile design but this may need to be increased if there are any concerns regarding the pile installation or if required by the Project Structural Engineer).

However, if the piles cannot be driven to the lengths indicated in the static design (as is often the case), then reliance switches to dynamic tests and/or dynamic formulae, both of which need to be verified by previous evidence of acceptable performance in static load tests on the same type of pile, of similar length and cross section and in similar ground conditions (the static tests don't necessarily need to have been carried out on the particular site), as required by BS 8004:2015.

Static load testing

Preliminary Pile Tests (PPT): Maintained load (ML) testing up to the unfactored ultimate resistance (commonly defined as settlement equivalent to 10% of the pile diameter) in accordance with BS 8004, SPERW, or other accepted standards; normally carried out before work starts on site or at the very beginning of a project.

Working Pile Tests (WPT): Maintained load (ML) testing up to at least 1.5 times working load in accordance with BS 8004, SPERW, or other accepted standards. Working Pile Tests shall be carried out at a rate of 1 per 100 piles or part thereof (not less than 1%).

Note: Where there are large variations in substrata revealed either by the Site Investigation or during the construction of piles, load tests should be carried out in each zone and the level of testing reassessed accordingly for each design situation. Similarly, load testing should reflect the various pile lengths and loadings.

If there are queries with regard to anything not covered within this document and/or it is intended that the Site Investigation, pile design, installation or testing is to deviate from the above guidance, then please contact the Warranty Surveyor for agreement prior to commencement.

3.

Foundations

3.4

Raft

Raft foundations

Introduction
A raft foundation consists of a reinforced concrete slab, whose thickness and stiffness are designed to spread the applied wall and column loads over a large area.

For domestic applications, rafts are often built with thickened perimeters to provide protection against frost heave, in which case they are effectively trench fill foundations with integral ground bearing floor slabs. Down stand edge beams also serve to stiffen the foundation's structure.

Rafts are used where it is necessary to limit the load applied to the underlying soil or to reduce the effects of differential foundation movements due to variable soil conditions or variations in loading.

Limitations of guidance
Rafts are not considered an accepted method of foundations where the ground conditions are susceptible to heave or shrinkage (e.g. where trees are present or have been removed). For further clarification, please refer to the 'Foundations - Trees and Clay' section.

Materials
Materials and workmanship should meet the requirements set out in the 'Appendix C - Materials, Products, and Building Systems' section.

Ground conditions
Raft foundations are usually designed for sites with ground conditions with low ground bearing capacity or where there are pockets of filled ground. It is therefore important to complete a suitable Site Investigation to meet the requirements of the 'Ground Conditions' section and ascertain the bearing capacity and suitability of the ground.

Structural design
Structural calculations should be provided by a suitably qualified Structural Engineer, confirming that the raft design is suitable for bearing onto the ground and that the ground bearing capacity safely supports the structure.

Key requirements

The raft foundations shall be designed to clearly demonstrate that the rafts, insulation and any treated ground are capable of supporting and transferring the foundation design loads safely to known soil strata that are, in turn, capable of supporting the loads, using the appropriate soil properties obtained from geotechnical testing and contained in the appropriate Site Investigation report. The rafts shall be designed in accordance with BS 8004:2015 and shall ensure that long term settlement does not exceed 25mm or 1:500 (differential), unless more stringent criteria are required by the Project Structural Engineer.

Technical documentation required

The following documentation shall be submitted to the Warranty Surveyor for assessment.

Please Note: In the absence of approval, works proceed at the Developer's own risk.

1. Site Investigation Reports including site-specific recommendations for raft foundations to ensure long term settlement does not exceed 25mm or 1/500 (differential).
2. Structural drawings:
   a) GA and RC drawings, including a drawing register sheet.
   b) Details of internal and external thickenings to cater for loadings and the effects of frost.
   c) Details of any insulation beneath the raft.
3. Structural calculations:
   a) Demonstrating that the ground bearing pressure does not exceed the allowable value specified in the Site Investigation report. Localised areas of higher bearing pressures (e.g. beneath load-bearing walls, thickenings or point loads) should be considered.
   b) Demonstrating that the raft (i.e. the thickenings, slab and beams) can span a 3 metre 'soft spot' or cantilever 1.5 metres.
   c) Demonstrating the adequacy of any insulation beneath the raft (in relation to loadings, creep and groundwater).
4. Confirmation that all made ground beneath the foundation has / will be removed or treated.
5. Details of engineered granular fill below the raft (including its depth and later extent, ensuring a 45° spread from the edge), along with its compaction specification, testing and validation.
6. Calculations demonstrating how the depth of granular fill has been determined to cater for the effects of heave and shrinkage (if shrinkable soils are present).
7. Details of any ground treatment (e.g. vibro treatment, cement-lime stabilisation etc.).

If there are queries with regard to anything not covered or it is intended to deviate from the above guidance, then please contact the Warranty Surveyor for agreement prior to commencement. Following acceptance of the proposals, please refer back to the Warranty Surveyor if anything is subsequently discovered on site, which affects the design and/or construction of the raft.

Reference Documents

- BS EN 1997-1:2004 + A1:2013 - Eurocode 7: Geotechnical design (EC7).
- BS 8004:2015 - Code of practice for foundations.
- BS EN 1997-2:2007 - Ground investigation and testing.
- BS 5930: 2015 - Code of practice for ground investigations.

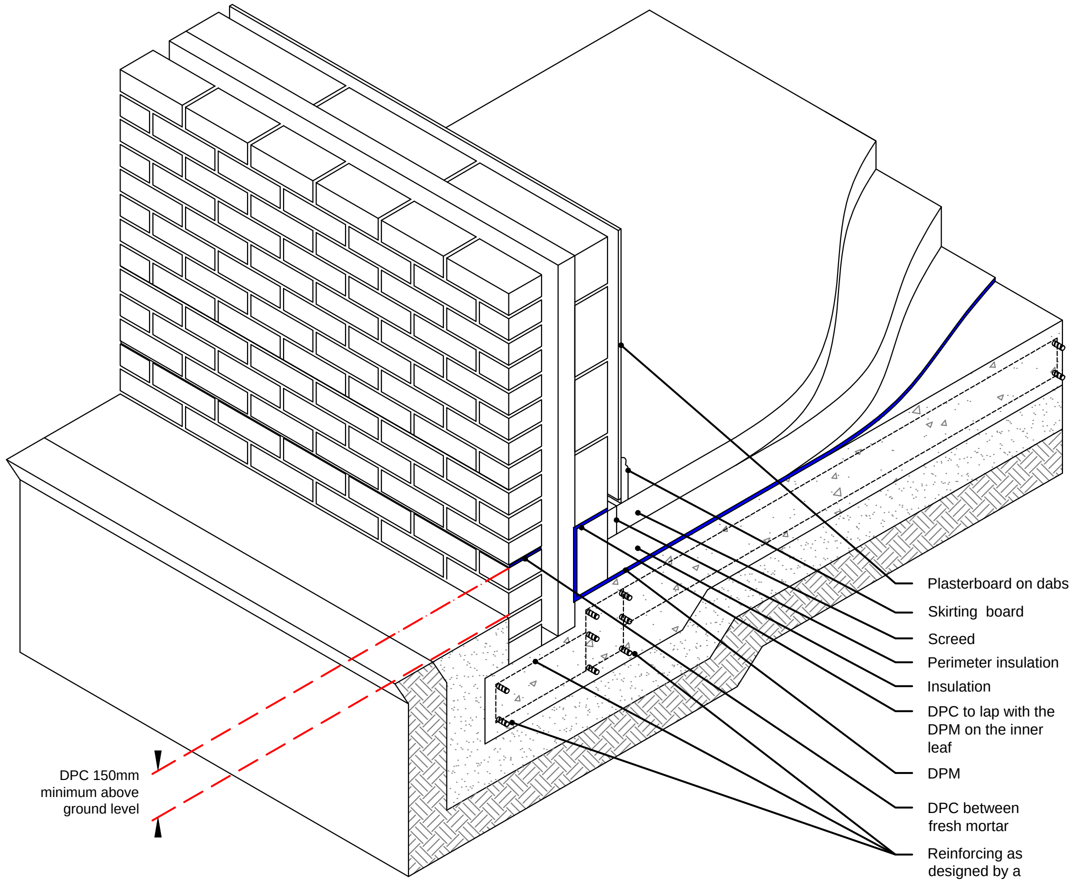
Where thermal insulation products are used below the structural raft they should:

- Meet the requirements of BS EN 1606 Thermal insulation products for building applications.
- Meet BS EN 13163 (for EPS insulation).
- Meet BS EN 13164 (for XPS insulation).
- The Structural Engineer should ensure that the design limits 'compressive creep' to a maximum 2% reduction for a 50/60 years period.
- The insulation product must have third party product approval certification for use below a structural raft foundation (including below external walls).

The design should provide sufficient information to ensure correct installation of the raft and its reinforcing. The minimum recommended information is as follows:

- Plans and details of the proposed raft showing reinforcing positions, etc.
- Structural calculations confirming that the raft is suitable for the proposed loads applied.
- A bar schedule, to be used by the reinforcing steel supplier and installer.

Typical raft foundation



Ducts and sleeving

Any service penetrations that pass through the raft should be appropriately sleeved to protect the service duct. Service duct positions should be planned and indicated on drawings to prevent reinforcing bars from being cut, unless the structural design has catered for this.

Damp proof membranes (DPM), damp proof courses (DPC), and floor finishes

The raft foundation and the junction with the wall should be appropriately constructed to resist ground moisture penetration.

A DPM can be placed beneath the raft, wrapped around the external toe and lapped into the internal DPC. However, this detail can be difficult to implement on-site, and puncturing of the membrane can commonly occur when placing reinforcing. The preferred method is to place the DPM on top of the raft slab beneath the floor insulation or screed.

Stepped membranes

DPM should be continuous where floors are stepped, a waterproof specialist must select an approved waterproof membrane to meet the requirements of BS 8120 to provide a continuous barrier that is compatible with the floor DPM/DPC.

Damp proofing

Damp proof courses (DPC)

DPC's should be of a flexible material that is suitable for its intended use and the DPC should have appropriate third-party certification. Blue brick or slates will not be accepted as a DPC.

DPC's should be laid on a mortar bed and correctly lapped at junctions and corners. The depth of lap should be the same as the width of the DPC.

DPC's should not bridge any cavities unless it is acting as a cavity tray. Where a cavity tray is required (e.g. over a telescopic floor vent) please refer to the 'External Walls' section for cavity tray, weep holes and stop end requirements.

Damp proof membranes (DPM)

A DPM should be provided beneath all ground-supported slabs or cast in-situ reinforced slabs. DPM's should be linked to the DPC and be a minimum 1200g polythene. Other DPM's may be considered if they have appropriate third-party certification and are installed in accordance with the manufacturer's instructions.

Concreting of floors

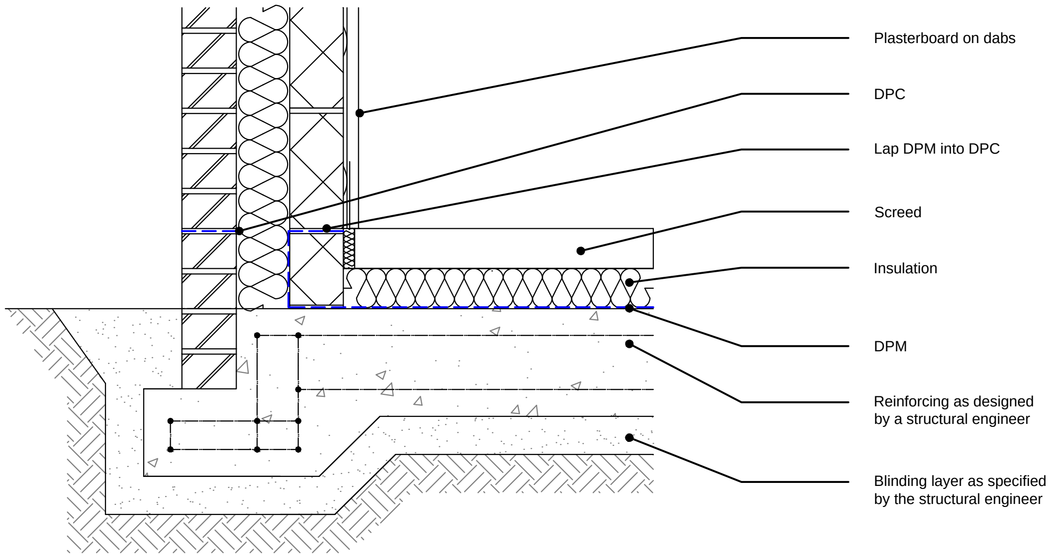
Prior to concreting, any water or debris that may have collected on top of the DPM should be removed. Expansion joints should be provided and constructed in accordance with the Structural Engineers design.

Bricks and blocks below ground

The selected bricks should be appropriately durable against saturation. See 'Appendix C - Materials, Products, and Building Systems' for further guidance.

If there are sulphates in the ground and/or there is ground water present, confirmation by the manufacturer that the brick or block is suitable for use below ground should be provided.

Typical raft foundation design



3.

Foundations

3.5
Engineered Fill

Limitations of guidance

The following situations are beyond the scope of this guidance:

- Where the original ground or sub-strata is unstable or will continue to settle.
- Sites with soft clays with a low bearing capacity (30kN/m2 undrained).
- Filled ground where high levels of voids are anticipated.
- Clay fill, where the water will influence the foundation or where collapse may occur.

Each development site has its own specific characteristics, and where conditions do not clearly fall within the guidance given, clarification should be sought from the Warranty Surveyor or a suitably qualified and experienced expert.

Fill or made ground can be divided into 2 main types:

Engineered Fill: When placed as part of the construction process and carried out to an engineered specification to high standards with good quality control and adequate engineering supervision, then risks can be assessed and may be quite small.

Non-Engineered Fill/Made Ground: Risks associated with sites covered with existing fill are more difficult to assess and short of complete excavation, the risks cannot be fully quantified. Therefore, alternative foundation solutions where loads can be transferred to competent strata are required.

Engineered fill

Generally cohesive/granular homogenous material specifically selected to replace either made ground or infill voids left by other processes is adopted. Fill has been divided into 2 further categories. These are:

- Shallow fill (i.e. less than 2.5m depth below ground level).
- Deep fill (i.e. greater than 2.5m).

For further guidance on foundation types suitable for building on 'Shallow' and 'Deep' fill, please refer to our Warranty good practice guide 'Building on Fill' which can be found on the website.

Design of engineered fill

Careful selection of the material and controlled placement should ensure that the engineered fill forms an adequate foundation material; however, in some circumstances, significant ground movements can occur.

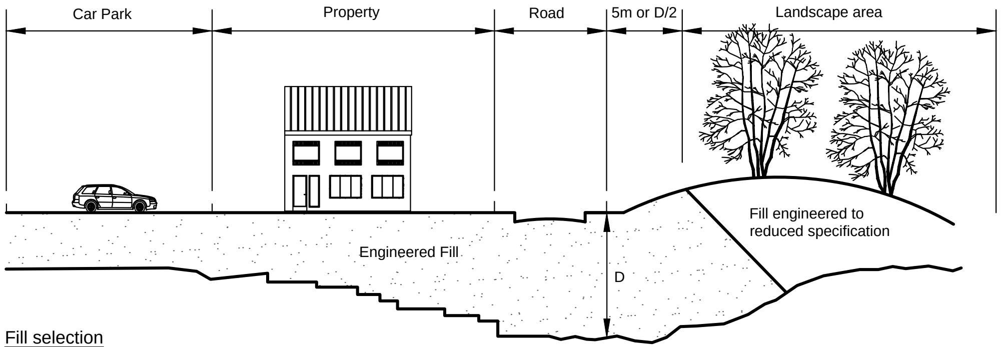
Engineered fill should be designed and placed in accordance with recognised good practice, as noted in the references at the end of this section.

Engineered fills used to produce suitably shaped landforms for structures should be constructed to high standards to minimise the risk of ground movements causing damage to property built on shallow foundations.

In designing and specifying a fill to form a foundation for buildings, the following technical requirements should be established:

- A well-constructed excavation, safely executed, with all soft and hard spots removed and made reasonably dry and well drained.
- Sound fill without undesirable material and capable of compaction as specified, provided with starter and capping layers as necessary.
- Placement and compaction to ensure that the performance of the fill will meet required criteria as a foundation fill.
- Appropriate monitoring; the Designer must ensure that all work can be carried out safely as required by the Health and Safety Executive Construction Design and Management Regulations.

Typical engineered fill construction - Figure 1



Fill selection

Fill should be clearly categorised into material that may and may not be used: unsuitable fill, general fill, restricted fill and special fill. Fill materials must not present an environmental or health hazard.

Unsuitable fill should not be used at any location on the site.

General fill is all material except that which is unsuitable, restricted or special, and is normally the majority of the material used. It may include natural soils as well as some waste products.

Restricted fill is material that would be general fill except that it contains minerals hostile to the built environment. It can include natural materials such as pyritic shales, sulphate-bearing clays and waste materials, including burnt colliery discard and steel slag. Its use is precluded where ground water could rise to the underside of the deepest foundation, or where it is rejected for pollution reasons. For some developments, such as housing with gardens, restricted fills would include fills that are harmful to people.

Special fill is high-quality material, such as well-graded natural sands and gravels, crushed rock or clean demolition rubble. Its use will often have to be reserved for specifically defined purposes, such as a capping layer or backfill to retaining walls. Where possible though, granular soils should be used as general fill since these materials drain readily and consolidate quickly. The smaller the predominant particle size, the longer the potential time required for consolidation under the self-weight of the fill.

Materials considered to be unsuitable for use as fill are:

- Swamp or marsh land materials.
- All organic or part organic materials.
- Materials subject to spontaneous combustion.
- Colliery shales, ironstone shales and similar materials which have the potential for expansion due to oxidation of pyrites.
- Frozen materials or materials which are frost susceptible.
- Any materials which have a higher moisture content than the maximum permitted for such materials as defined in the specification.
- Clays with high plasticity index exceeding 55%.

The following materials require testing to ensure their suitability for use as fill to support structural foundations and slabs, or as backfill to associated trenches:

- Acid wastes.
- Reactive materials.
- Materials that include sulphates (e.g. gypsum).
- Organic materials.
- Toxic materials.
- Materials that cause noxious fumes, rot, undue settlement or damage to surrounding materials.

The sample tests should be carried out by a suitably qualified person and it may be necessary to take a number of samples to identify the material characteristics of the fill accurately.

End product criteria

The greatest threats to successful in-service performance are:

- Collapse settlement due to inundation of dry or inadequately compacted fills.
- Excessive consolidation settlement of wet compressible fill.
- Heave or settlement of clay fill due to climatic changes or vegetation.

These ground movements depend on moisture movement, so by reducing the voids in a fill, the opportunities for excessive in-service movements should be restricted. A maximum allowable air-voids content of 5% is a suitable criterion for most clay fills. However, specifying a 5% air-voids content is insufficient, as this value may easily be achieved by adding water to the fill without increasing compactive effort.

A suitable alternative control method is to specify a minimum acceptable density as a proportion of the maximum dry density measured in a standard laboratory compaction test. Limits on moisture content are also required.

If the fill is too wet, there could be excessive consolidation settlement and if the fill is too dry, it might be vulnerable to collapse compression.

Placing engineered fill

A successful engineered fill requires not only an appropriate specification but also adequate control during placement. All the work must be carried out with due regard to safety, as required by the Construction Design and Management Regulations.

Site preparation and disposition of fill

The site should be cleared of all topsoil and other unsuitable material.

Soft spots and hard spots, such as derelict foundations, should be removed together with ponds and surface water from depressions. Removing water by pumping may be necessary when filling some excavations below the ground water level.

When a variety of material types are used as fill, they should be deposited in horizontal layers across the site. If there is only a limited amount of good granular material, it will be best to use it in layers interspersed between layers of poorer cohesive fill.

The fill thickness should be reasonably constant beneath a structure to minimise differential settlement.

Feather-edges, resulting in foundations set partly on fill and partly on natural ground, should be avoided, and the site worked in such a way that structures are located either directly on natural ground or directly over fill of a consistent thickness.

If fill is to be placed over sloping natural ground, some stepping of the ground may be necessary. Construction over the face of a quarry or an opencast mining high wall should be avoided.

Special measures may have to be taken by providing flexible connections for services at the location of high walls and by thickening construction for service and estate roads.

If the natural ground on which the fill rests is soft and compressible (for example, layers of peat or soft clay), the surface of the fill may settle appreciably and unevenly as a result of the weight of the fill consolidating the soft layers below. This settlement will, of course, be additional to that resulting from the compression of the fill itself.

Sensitive structures may warrant a surface (or capping) layer formed from special fill compacted to more onerous standards than the underlying fill. This should help minimise the differential settlement suffered by the structure.

Where landscaped or other non-load bearing areas form part of a development, they need less compaction than the load-bearing areas. There should be a transition zone around the load-bearing area, as shown in Figure 1.

Fill placement

Fill should be placed in horizontal layers, with each layer separately compacted.

For a given item of plant, compaction performance will be determined by fill layer thickness, fill moisture content and the number of passes of the compaction equipment. There are however, other factors such as the need to avoid excessive handling.

Whenever possible, site trials should be undertaken to determine the correct criteria. Some general information about placing fills is given in BS 6031.

Each layer should be of a thickness that allows the compactive energy to spread throughout the layer, producing the specified fill density and low air-voids content. Loose layers with a thickness greater than 250mm are unlikely to be satisfactory for earth fills compacted to support low rise structures. It may be necessary to use layers of 200mm or less.

Moisture content at the time of placing a fill is fundamental to subsequent performance, particularly where the fill contains a large proportion of fine grained cohesive material. If the fill is too dry, there is the possibility of heave or collapse settlement; if it is too wet, there is the possibility of insufficient strength and high compressibility. It will be difficult to achieve air-voids content of 5% or less when the moisture content is low. In the same way that the addition of too much water can detract from the performance of engineered fill, soil can be over-compacted.

Granular soils and cohesive soils drier than optimum, when rolled excessively, become over-stressed and what should have been a firm compacted surface becomes a loose tilth. This should be avoided whenever possible. Where a fill containing a large proportion of fine grained cohesive material (for example, clay) is used, filling during wet weather should be avoided.

Quality control and testing of fill during placement

Quality control procedures should be implemented to ensure compliance with the specification. The nature of the control procedure will depend on the type of specification adopted.

The end product specification requires an appropriate type and quantity of testing of the fill during placement to ensure that the desired end product is being achieved. Depending upon the type of contract, quality control may be the responsibility of the engineer or of the contractor working under the supervision of the engineer.

Control parameters should be the same as those determined during the site investigation stage. Both design and control parameters must be reproducible, a term that denotes the range within which measurements made on the same fill by different operators using different equipment should agree.

The following are the most significant control parameters:

- Moisture content, in respect of an optimum moisture content established at the Site Investigation stage.
- Dry density, in respect of the already established maximum dry density.
- Air-voids content, which depends on moisture content and dry density.
- Undrained shear strength, which is an alternative to monitoring moisture content and dry density for clay fills.

The laboratory compaction tests and the associated field control tests are suitable for a wide range of fill types and form the most generally applicable approach. For cohesive soils, undrained shear strength forms an alternative basis for specification and control testing. However, different methods of measuring the undrained shear strength, such as the unconfined compression test and the vane test, can give significantly different values. The measured value of cohesion can be sensitive to a detailed test procedure, such as the rate of shearing.

It is important for the method of testing to be strictly specified. Where a cohesive fill contains gravel, it may not be possible to obtain sufficiently undisturbed samples for strength tests. On larger sites, employing in-situ methods, such as the cone penetrometer (BS 1377: Part 9), could be considered.

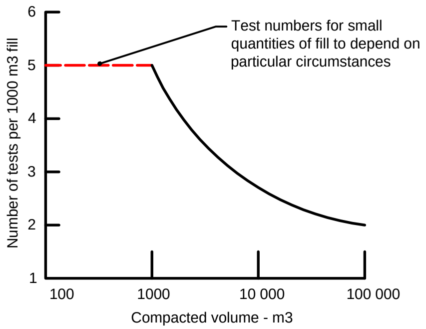
Small sites are generally more difficult to work than large sites, as finished work may be damaged more easily in confined working areas and deficiencies in site preparation usually reflect more readily in poorer quality compaction than on larger sites. Consequently, it is necessary to test more frequently on a small site than on a large one.

A suggested minimum test frequency is presented in Figure 2. However, each site should be judged on its own merits, with careful note taken of any problems revealed during site investigation. In very variable or difficult conditions, more frequent testing may be required. Tests in visually doubtful areas, and re-tests of failed areas, should be carried out in addition to those recommended in Figure 2.

Modern compaction control requires laboratory and field testing during the Site Investigation, and during, and possibly following, the earthworks. The results of this work must be recorded, collated and presented to demonstrate the quality of the operation. The required documentation includes:

- Summary of the specification requirements and the end product in terms of the selected geotechnical parameters for the various fills (based on-site investigation information).
- List of the required suitability tests; one form to be completed for each borrow pit under investigation.
- Suitability test results for each borrow pit.
- List of the required control tests.
- Results of the control tests on each fill type, layer or area, as appropriate.
- A list of post-compaction monitoring requirements.
- The results of post-compaction monitoring; all completed forms should be signed and dated by the person responsible and a list prepared of any required action or remedial work to be carried out.

Figure 2 - Number of tests



Monitoring of fill performance - post compaction

Monitoring provides a check on the performance of the fill after compaction and is particularly important where vulnerable structures are to be built or foundation loading is unusually large. It is also required where the fill is relatively deep or substantial ground water rise within the fill is expected.

Monitoring techniques include:

- Surface levelling stations to measure the settlement of the fill surface.
- Magnet extensometers to measure the settlement of incremental depths of fill.
- Standpipe piezometers to measure the rise in the ground water table in the fill after placement.
- Load tests for direct estimation of settlement of surface layers produced by loadings.

Surface levelling stations are easy to install and very effective. By optical levelling of the stations, measurement can be made of the total vertical movement of the fill upon which they rest, together with any movement of the underlying natural ground. Although this is unlikely to be large if all soft material has been removed prior to compaction.

Levelling stations should be sufficiently robust to resist damage due to construction traffic. A round headed bolt cast into a 1m concrete cube set 300mm into the fill has been found to be effective.

Magnet extensometers are unlikely to be necessary in shallow-depth fill. Standpipes or piezometers will be of advantage if there is reason to suspect that ground water will rise into the fill at any time in the future, with consequent settlement.

Relevant British Standards and guidance documents

Relevant British Standards Codes of Practice and authoritative documents include:

- BS 6031 Code of Practice for earthworks
- BS 1377: Part 9 Methods of tests for soils for civil engineering purposes. In-situ tests
- BS 10175 Investigation of potentially contaminated sites - Code of practice
- BS EN 1991 Actions on structures
- BS EN 14731 Execution of special geotechnical works. Ground treatment by deep vibration
- BS EN 1997-1 General rules
- BS EN 1997-2 Ground investigation and testing
- BS EN ISO 14688 Geotechnical investigation and testing - Identification and classification of soil
- BS EN ISO 14689 Geotechnical investigation and testing - Identification and classification of rock
- BS EN ISO 22476 Geotechnical investigation and testing - Field testing
- BR 391 Specifying vibro stone columns
- Institute of Civil Engineers (ICE) specification for ground treatment: Notes for guidance, 1987
- CIRIA C572: Treated ground: Engineering properties and performance, 2002
- CIRIA C573: A guide to ground treatment, 2002
- BRE 424: Building on fill: Geotechnical aspects
- BRE Information Paper 5/97: Collapse compression on inundation

Introduction

The following guidance outlines recognised good practice in relation to building on fill. The structural design and construction should be in accordance with the Functional Requirements of this Technical Manual and recognised publications from British Standards, Eurocodes, CIRIA, BRE and ICE.

Key requirements

The foundation scheme shall be designed to clearly demonstrate that the foundations are capable of supporting and transferring the design loads safely to known soil strata that can be demonstrated from the appropriate project site investigation reports to be capable of carrying the load, using the appropriate soil properties obtained from geotechnical and load testing.

Groundworks shall be designed and validated by a suitably qualified Chartered Geotechnical Engineer to ensure that settlement will not exceed 25 mm (10mm for piles) or differential settlement tilt greater than 1:500 for low-rise buildings unless more stringent criteria are required by the Project Structural Engineer.

Partial depth foundation solutions where either piles or ground improvement techniques (i.e. vibro stone columns, vibro concrete columns etc.) terminate in the fill material, and do not penetrate to naturally occurring competent strata below, are not acceptable.

Made ground/fill material is inherently variable in nature and unpredictable when considering its settlement properties. Foundations proposing to bear upon made ground /fill as a formation for strip, trench or raft type foundations are unacceptable.

Technical documentation required

The following documentation shall be submitted to the Warranty surveyor for assessment. In the absence of approval, works proceed at the Developer's own risk.

1. Site Investigation Reports including site-specific recommendations for foundations to ensure long term settlement does not exceed 25mm (10mm for piles) or 1/500 (differential).
2. Structural drawings:
   a. Site layout plan including proposed finished floor levels for all plots.
   b. Topographical survey confirming existing ground levels. Subsequent site level surveys indicating areas where earthworks are required to achieve final construction levels. If piling or ground improvement techniques are to be adopted, piling platform and/or vibro platform levels are required.
   a. GA and RC drawings, including a drawing register sheet.
   d. Piling & Vibro layout drawings (if applicable), including a drawing register sheet.
   e. The design of the dwellings should allow a degree of articulation with movement joints sufficient to accommodate the maximum allowable differential settlement above, also at thresholds and service entries.
3. Structural calculations:
   a. Demonstrating that the ground bearing pressure does not exceed the allowable value specified in the Site Investigation Report.
   b. Piled foundation calculations (please refer to the 'Piling Good Practice Guide' available on our website).
   c. Vibro foundation calculations (please refer to the 'Piling Good Practice Guide' available on our website).
4. Earthworks Specification including:
   a. Confirmation that works are supervised by a suitably experienced independent Chartered Geotechnical Engineer.
   b. Proposals for load testing to determine the expected long-term settlement and differential settlement of the fill. Please note: We consider that plate load tests do not confirm the expected long-term performance of the ground.
   c. Allowable bearing pressures, expected settlement and differential settlement.
   d. Consideration of the effects of slag, burnt shale and expansive soils.
   e. Consideration of self-weight settlement of the fill.
   f. Collapse compression analysis in accordance with BRE IP5/97.
   g. Details of any ground treatment (e.g. vibro treatment, cement-lime stabilisation etc.).
5. Geotechnical validation report including:
   a. Confirmation that all made ground and organic matter was removed.
   b. Details of formation levels prior to filling works.
   c. Depths of all cut and fill carried out across the site with levels linked to the original site investigation.
   d. Details demonstrating compliance with Clause 610 of the Specification for Highway Works (for structural fills).
   e. Details and locations of all tests and interpretation by the Geotechnical Engineer.
   f. Confirmation of the bearing capacity achieved by the earthworks and confirmation that long-term settlement will not exceed 25 mm or 1:500 differential settlement.

If there are queries with regard to anything not covered within this document and/or it is intended to deviate from the above guidance, then please contact the Warranty Engineers for agreement prior to commencement. Following acceptance of the proposals, if anything is subsequently discovered on site, which affects the design and/or construction, please contact the Warranty Surveyor immediately.

Reference Documents

- Current Regional Building Regulations
- BS EN 1997-1:2004 + A1:2013 - Eurocode 7: Geotechnical Design (EC7)
- BS 8004:2015 - Code of Practice for Foundations
- BS EN 1997-2:2007 - Ground Investigation and testing
- BS 5930: 2015 - Code of Practice for Ground Investigations
- BS 1377-9:1990 - Methods of test for soils for civil engineering purposes. In-situ tests
- BRE IP 5/97 - Building on Fill: collapse compression on inundation
- BRE Building on Fill 3rd edition: geotechnical aspects
- Department of Transport Specification for Highway Works, Part 2, Series 600 Earthworks
- Warranty Good practice guides, to ensure long term and differential settlement criteria remain compliant:
  - Raft Foundations (Long term settlement 25mm and 1/500 differential)
  - Piling (Long term settlement 10mm and 1/500 differential)
  - Vibro ground improvement (Long term settlement 25mm and 1/500 differential)

Testing

Testing is carried out to confirm that the ground improvement works meet the design criteria. The tests are usually completed to determine the ground bearing capacity.

The engineer shall require the specialist contractor to verify that the ground treatment has been completed to a satisfactory standard. This will usually include carrying out suitable testing to establish the degree of ground improvement, its load-bearing characteristics and settlement potential. These tests may include:

Plate tests

This test will not determine the design but will allow for an assessment of the workmanship on the stone columns. Plate tests should be carried out on stone columns or treated ground at a frequency of at least one test per day per rig.

The plate tests should be carried out with a 600mm diameter plate and minimum test load of 11 tonnes.

Mini zone tests

A mini zone test (dummy footing) can be used as a limited substitute for zone tests. The test should be applied to at least two stone columns and the area of foundation they support. To be useful, mini zone tests should be continued for long enough to establish the presence of creep behaviour.

Mini zone tests (dummy footing) should be carried out at a rate of one test per 1000m2-3000m2 of treated ground, along with penetration tests at a rate of one test for 20-50 stone columns, or one test for not more than 500m2 of treated ground, with a minimum of one test per structural unit. Alternatively, in the absence of penetration tests, one test per ten houses (with a minimum of two tests per site) would suffice.

Zone tests

An isolated pad or strip footing is used to test up to eight stone columns and the intervening ground. Loadings, which should simulate the building loads, are held for 24 hours at predetermined stages to examine creep behaviour.

In-situ tests

Where vibration will improve the ground itself, e.g. granular materials, then in-situ testing is appropriate. The improvement can be assessed when the test results are compared with the in-situ test results recorded during the pre-treatment investigation.

Trial pits

Trial pits can be excavated around trial stone columns to prove that they are fully formed and to the required depth and diameter. This is a destructive test, and allowance should be made accordingly.

On completion of the treatment, the engineer is to confirm that the treated ground has achieved the anticipated condition assumed in the design, and provide evidence in writing to the Warranty Surveyor.

3.

Foundations

3.6

Vibratory Ground Improvement

Introduction

Ground improvement enables sites with poor load-bearing capacity to be strengthened; meaning the loadings of the proposed building can be adequately supported off suitable foundations. The following guidance will be accepted as a satisfactory method of meeting the Functional Requirements of this Technical Manual.

Limitations of guidance

The following situations are beyond the scope of this guidance:

- Where the original ground or sub-strata is unstable or will continue to settle.
- Sites with soft clays with a low bearing capacity (30kN/m^2 undrained).
- Filled ground where high levels of voids are anticipated.
- Clay fill, where the water will influence the foundation or where collapse may occur.

Each development site has its own specific characteristics, and where conditions do not clearly fall within the guidance given, clarification should be sought from the Warranty Surveyor or a suitably qualified and experienced expert.

Vibratory ground improvement

Vibro displacement using vibro stone columns is a method of enhancing ground bearing capacity and limiting settlement. Typical applications include the support of foundations, slabs, hard standings, pavements, tanks or embankments.

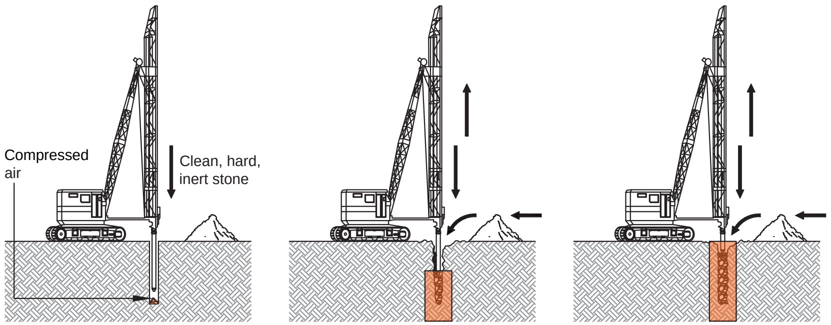
Soft soils can be reinforced to achieve improved specification requirements, whilst slopes can be treated to prevent slip failure, both natural soils and made ground can be improved.

Vibro treatment should be carried out in accordance with the 'Institute of Civil Engineers: 1987 Specification for ground treatment: Notes for guidance' and to a depth sufficient to reach an adequate bearing stratum.

Vibratory techniques

The vibratory process is applied to weak natural soils and filled ground with a view to improving the load-bearing capacity and providing an adequate bearing stratum for the building's foundations. There are two vibratory techniques commonly used in the UK. These are known as the 'dry bottom feed' and 'dry top feed' methods; a third technique, less frequently used in the UK, is known as the 'wet bottom feed' method.

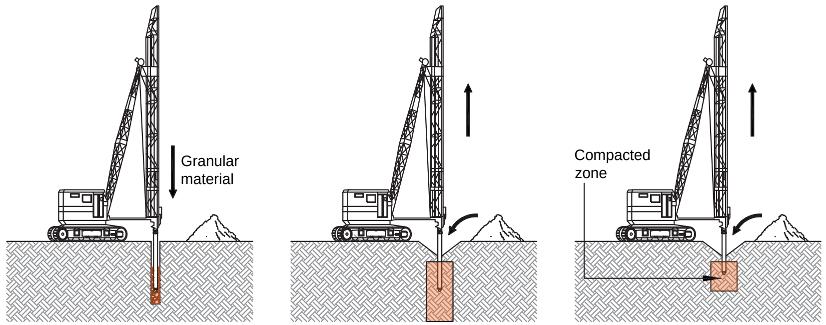
Vibratory techniques: dry bottom feed method



Void is formed as vibrator displaces the ground → Stone backfill is placed into void during withdrawal of vibrator → Continuous stone column formed

The dry bottom feed method is used in weaker soil conditions or where there is a high water table and the borehole is liable to collapse between vibroflot insertions. The vibroflot penetrates using its mass, air flush and vibration, but at design depth, the stone is introduced via a hopper into a pipe fixed to the side of the vibroflot. The stone usually 40mm in size, exits the pipe at the tip of the vibroflot and reaches the bottom of the borehole. The stone is then compacted into the surrounding soil by repeated withdrawal and insertion of the vibroflot.

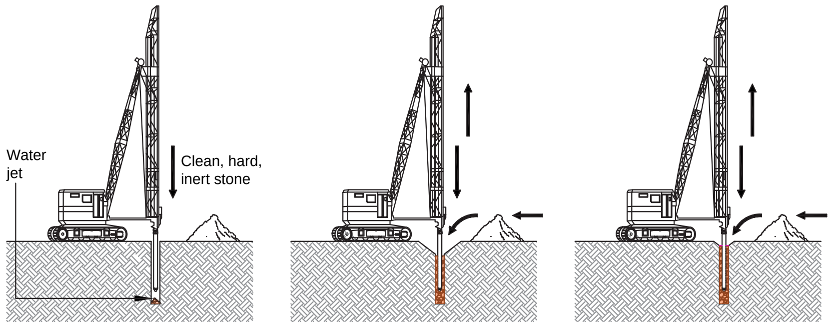
Vibratory techniques: dry top feed method



Vibrator displaces the ground → Granular material is placed into the bore → Existing ground is compacted

In the dry top feed method, the vibroflot penetrates the weak soil or fill again using its mass, air flush and vibration to form a borehole. Once refusal or design depth is reached, the vibroflot is removed and stone fill is introduced into the bore, with the 'charge' typically 500mm-800mm deep. The vibroflot is re-inserted and 'packs' the stone into the surrounding strata. Successive charges of stone are added and compacted, bringing the column up to working level. Typically, the stone grading is 40mm-75mm.

Vibratory techniques: dry top feed method



Void is formed as vibrator displaces the ground → Stone backfill is placed into void during withdrawal of vibrator → Continuous stone column formed

Where the ground contains fines and silts, water jetting from the tip of the vibroflot is used to remove loose materials and form a cavity for charges of stone to be added to replace and densify the soft ground. The carbon footprint of this activity is generally less than with comparable piling solutions.

Key requirements

The scheme shall be designed to clearly demonstrate that the foundations and treatment of the ground with vibro stone columns are capable of supporting and transferring the foundation design loads safely to known natural soil strata that are, in turn, capable of supporting the foundation loads using the appropriate soil properties obtained from geotechnical testing and contained in the appropriate Site Investigation report. The foundations and vibro stone columns shall be designed in accordance with BS 8004:2015 and shall ensure that long term settlement does not exceed 25mm or 1:500 (differential) at working load, unless more stringent criteria are required by the Project Structural Engineer.

Technical documentation required

The following documentation shall be submitted to the Warranty Surveyor for assessment. Items 1-3d should be submitted prior to commencement of vibro treatment on site. In the absence of approval, works are proceeding at the Developer's own risk. Items 3e-3g shall be submitted as soon as they become available, prior to construction continuing over the piles.

1. Geotechnical Site Investigation report with appropriate geotechnical testing.
2. Foundation drawings and design calculations. Strip footings should be designed for the specified bearing pressures and be designed to span between vibro stone columns.
3. Vibro stone columns:
    a. Written confirmation from the vibro designer that the ground conditions are suitable for vibro treatment and that the Site Investigation report is adequate for the purposes of the design and installation of stone columns.
    b. Vibro stone column layout drawings.
    c. Vibro design calculations confirming full-depth of made ground and soft/loose natural strata.
    d. Confirmation of proposed testing regime (i.e. plate and dummy footing tests etc., see notes below). A minimum of 1% of stone columns should be subject to dummy footing test.
    e. Vibro installation logs (with vibro column numbers referenced to the vibro layout drawing). Logs should include date, column number, depth, diameter, weight of stone and surface level. Confirmation of the platform level in relation to the finished floor levels and Site Investigations and details demonstrating that all made ground and soft/loose natural strata.
    f. Copies of all testing carried out (with the locations referenced to the drawings) and interpretation of test results.
    g. Written confirmation from the vibro designer that the as-built installation has achieved the required bearing capacity and settlement characteristics.

Reference Documents

- BS EN 1997-1:2004 + A1:2013 - Eurocode 7: Geotechnical Design (EC7)
- BS 8004:2015 - Code of Practice for Foundations
- BS EN 1997-2:2007 - Ground Investigation and testing
- BS 5930: 2015 - Code of Practice for Ground Investigations

Geotechnical Site Investigation Report

A site specific geotechnical Site Investigation should take place and be in accordance with BS 5930/EC7 and extend into adequate strata beneath the filled or poor-strength strata above. The investigation should include enough geotechnical testing to enable accurate geotechnical design of the vibro stone columns in accordance with proven design methods.

Suitability of ground conditions

Through the process of a Site Investigation, it should first be established by the appointed engineer or suitably qualified specialist that the ground is capable of being improved by a vibratory ground improvement technique. The Site Investigation should determine the depths and properties of the natural materials under the site, including the presence of cavities, mines, rocks or soils that may dissolve or erode when water passes over them.

It should also be established at an early stage whether the site has previously contained any buildings or structures, and whether they have been completely removed, including basement walls, floor slabs, etc. The presence and extent of any existing or redundant services and drains should be investigated, and the associated backfill to the excavations. In addition, the effect that any proposed sustainable drainage system (SuDS) might have on the ground conditions should be identified.

The engineer should supervise the Site Investigation, taking account of the findings of the desk study, and first establish whether there are any contaminated substances or gases present. Data should be gathered using a suitable method for comparison with the site post treatment. Investigations should be made into the presence, level and nature of any ground water, and if it is likely to rise and cause heave or collapse by saturation.

The extent of any areas of made-up ground on the site should be established, including:
- The proportions, compaction and distribution of constituent materials throughout its depth.
- The grading and particle size distribution of fill materials.
- The potential for gas generation from fill materials, and the risk of combustion of natural deposits.

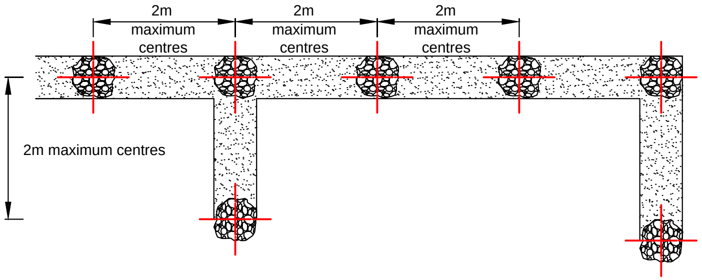
The appointed specialist contractor should be satisfied that the Site Investigation report provides adequate and representative information in order to design the ground improvement. The results of the investigation should be presented to the Warranty Surveyor prior to the commencement of the work.

The developer shall obtain written confirmation from the engineer and specialist contractor that the site is suitable for the proposed ground improvement system, and that all detrimental factors associated with the site and the proposed development have been taken into account.
This is to be made available to the Warranty Surveyor prior to the commencement of any work on the site.

Site workmanship

The specialist contractor should appoint an engineer to supervise the vibratory foundation works at all times and ensure that:
- The required depth and bearing capacity of stone columns are achieved.
- The stone columns are correctly located beneath the proposed foundation and in accordance with design drawings.

The intersection of adjacent reinforced concrete strips



Strip foundations

Foundation drawings and calculations should be prepared by the Structural Engineer indicating the required bearing capacity and settlement characteristics for the purposes of design of vibro stone columns. In general foundations should be designed for maximum settlements of 25mm or differential settlement of 1 in 500 unless more stringent measures are required by the Structural Engineer. Strip foundations should be designed to span between vibro stone columns and must incorporate top and bottom reinforcement. Irrespective of the provision of vibro foundations, regard must be made to the requirements for building strip foundations near trees where heave protection is required. See the 'Foundations - Strip' guidance.

Please note: The vibro treatment must not be affected by the deepening of any foundations.

Vibro Design

The ground must be suitable for vibro treatment (refer to the above mentioned references for details). Vibro stone columns should be designed in accordance with recognised methods (e.g. Priebe) and must extend through the full extent of filled or poor ground and reach natural competent ground. Partial-depth treatment of made ground or poor strength (loose/soft) natural soils is not acceptable.

Vibro Testing

Testing should be carried out across the full site and cover all of the various ground conditions to confirm that the ground improvement works meet the design criteria. The tests are usually completed to determine the ground bearing capacity.

The engineer shall require the specialist contractor to verify that the ground treatment has been completed to a satisfactory standard. This will usually include carrying out suitable testing to establish the degree of ground improvement, its load-bearing characteristics and settlement potential.

Plate Tests should be carried out

- With 600mm diameter plates loaded to 3 times working load or 11 tonnes, whichever is greater.
- At a minimum rate of 1 per 100 vibro stone columns or 1 per rig per day, or a minimum of 2 tests, whichever is greater.
- Note that plate tests do not provide a direct indication of the anticipated settlement of the completed structure and therefore can't be considered as the sole means of load testing.

Dummy Footing Tests should be carried out

- With 1500 x 600mm plates, loaded to at least 1.5 times working load (kN/m^2) for a minimum period of 13 hours.
- At a minimum rate of 1 per 100 stone columns or 1 per 10 houses, whichever is greater.

Penetration Tests should be carried out

- At a rate of 1 per 20-50 stone columns or 1 test for not more than 500m^2, with a minimum of 1 test for each structural unit.
- Penetration tests will not be required if dummy footing tests are carried out at the above rate.

Trial pits

Trial pits can be excavated around trial stone columns to prove that they are fully formed and to the required depth and diameter. This is a destructive test, and allowance should be made accordingly.

On completion of the treatment, the engineer is to confirm that the treated ground has achieved the anticipated condition assumed in the design, and provide evidence in writing to the Warranty Surveyor.

Fill materials

The following materials require testing to ensure their suitability for use as fill to support structural foundations and slabs, or as backfill to associated trenches:

- Acid wastes.
- Reactive materials.
- Materials that include sulphates (e.g. gypsum).
- Organic materials.
- Toxic materials.
- Materials that cause noxious fumes, rot, undue settlement or damage to surrounding materials.

The sample tests should be carried out by a suitably qualified person, and it may be necessary to take a number of samples to identify the material characteristics of the fill accurately.

Sources of fill material

Where the material is of a stable and uniform type from one source, the testing regime may be reduced. However if the material is variable, or from a number of sources, then regular inspections and/or testing may be required.

Recycled aggregate or other building materials, such as crushed brick, should only be used following an inspection by the Warranty Surveyor.

Colliery shale and any other residue from mineral extraction or industrial process bi-products should only be used with specialist approval.

Suitable foundations for sites with improved ground

Foundations on sites with improved ground should either be of a reinforced strip or raft type. Both foundations will require a full design by a Structural Engineer.

For 'low rise structures', the foundations should be designed to ensure a maximum settlement of 25mm is not exceeded.

In relation to differential settlement, a design limit for maximum tilt of 1/500 is appropriate. More stringent values may be required due to the particular circumstances (e.g. medium and high rise structures).

Where foundations bear on cohesive soils or cohesive fill materials, the functional requirements regarding foundations trees and clay should be met. Further guidance can be found in the 'Foundations - Trees and Clay' section.

Relevant British Standards and guidance documents

Relevant British Standards Codes of Practice and authoritative documents include:

- BS 6031 Code of Practice for earthworks.
- BS 1377: Part 9 Methods of tests for soils for civil engineering purposes. In-situ tests.
- BS 10175 Investigation of potentially contaminated sites - Code of Practice.
- BS EN 1991 Actions on structures.
- BS EN 14731 Execution of special geotechnical works. Ground treatment by deep vibration.
- BS EN 1997-1 General rules.
- BS EN 1997-2 Ground investigation and testing.
- BS EN ISO 14688 Geotechnical investigation and testing - Identification and classification of soil.
- BS EN ISO 14689 Geotechnical investigation and testing - Identification and classification of rock.
- BS EN ISO 22476 Geotechnical investigation and testing - Field testing.
- BR 391 Specifying vibro stone columns.
- Institute of Civil Engineers (ICE) Specification for ground treatment: Notes for guidance, 1987.
- CIRIA C572: Treated ground: Engineering properties and performance, 2002.
- CIRIA C573: A guide to ground treatment, 2002.
- BRE 424: Building on fill: Geotechnical aspects.
- BRE Information Paper 5/97: Collapse compression on inundation.

3.

Foundations

3.7

Trees and Clay

Introduction

The following guidance is provided for foundation design when building near trees.

Limitations of guidance

Heave precautions must be incorporated into the foundation design as detailed in this Technical Manual.

The following situations are beyond the scope of this guidance, and will require a site-specific assessment by a suitably qualified and experienced expert:

- Foundations with depths greater than 2.5m within the influence of trees in cohesive soils (note: Mass Fill or Piled Foundations should be adopted).
- Ground with a slope greater than 1:7.
- Manmade slopes, such as embankments and cuttings.
- Underpinning.
- Engineered foundation designs.

Each development site has its own specific characteristics, and where conditions do not clearly fall within the guidance given, clarification should be sought from the Warranty Surveyor or a suitably qualified expert.

Raft foundations

Where a raft foundation is proposed, it must meet the following:

- The foundation depth should be determined using the guidance in this document and the online foundation depth calculator, and;
- If the resulting foundation depth is less than 1.5m deep and no foundation heave protection is required, a raft can be deemed suitable in this location and;
- The raft toe must be at least 600mm below the ground and there should be at least 500mm of compacted stone beneath the toe (i.e. total depth for excavation would be 1100mm or greater).

Note: If the resulting foundation depth required is 1.5m or greater, structural raft foundations are not accepted as a suitable foundation. An alternative foundation design will be required.

Please use the following guidance to determine the required depth of foundations.

Strip foundations

Conventional strip foundations may be constructed practically and economically to a maximum depth of 1.5m. However, strip foundations will not be suitable where heave precautions are required.

Please note: Where building near trees in clay soils; If a required foundation depth is greater than 1.5m, 'heave precautions' in the form of a proprietary compressible material must be placed on all inside surfaces of the peripheral foundations to allow for lateral soil swelling. In this instance strip foundations will not be acceptable and another foundation type should be selected.

The nature of the problem

The roots of all vegetation take water from the soil to make good the water lost from the leaves. If the soil contains clay, it will shrink as it is dried, or swell if it is allowed to rehydrate. If the shrinking or swelling extends below the foundations, they will subside or heave respectively. If the movements are in excess of those that can be tolerated by the building, damage is likely to occur.

Although all vegetation can cause soil drying, the roots of trees extend deeper and further and are thus particularly prone to causing damage. Large shrubs can also root to considerable depths, but their influence is more localised. Herbaceous plants and grass can also cause soil drying down to 1.5m, and require some precautions.

Damage is best avoided by increasing foundation depth to below the level where significant changes in moisture content are likely to occur. Root barriers are not acceptable as an alternative solution.

This guidance defines the depths that are required and the most suitable types of foundations. The extent of soil drying can be variable and unpredictable. If all risk of damage is to be avoided, the required depths would be punitive; instead, the guidance seeks to minimise the risk by striking a balance between the extent of risk and the costs of increasing foundation depth.

The extent of risk depends on:

- The soil.
- The potential for the tree species to cause soil drying.
- The size of the tree.
- The proximity of the tree to the foundations.
- The likely climatic conditions in the locality.

The pile depth required to meet the Structural Engineers design requirements may well exceed the minimum depth required by the foundation depth calculator.

These factors are considered in greater detail in the following sections.

The soil

Soils may be broadly classified into two types:

- Cohesive soils comprise mainly of clay or fine silt particles. When moist they are plastic and can be moulded, and will remain intact if placed into water. As they dry, they will become stiffer, and will eventually crumble if dried beyond a certain point. These soils can potentially cause problems.
- Non-cohesive soils, comprised mainly of sand or with only a proportion of clay or silt, cannot be moulded and will break up if placed in water. They are not subject to significant swelling or shrinkage.

The clay component of cohesive soils can vary widely; very few soils are pure clay, but they contain varying quantities of sand or silt. Clay soils are defined by their particle size (less than two microns), and it is only these clay particles that will shrink or swell. The particles are made-up of a complex molecular lattice structure that is capable of absorbing water, and as it absorbs water the particles will swell, and vice versa. There are many different types of clay with different molecular structures, and all of which have different swelling characteristics. The extent of swelling and shrinkage that can occur will therefore depend on the type of clay particles and the proportion of clay, as opposed to silt or sand, within the soil.

The potential of soil to swell or shrink can be determined by simple tests to determine its plastic limit (the moisture content below which it changes from being plastic and mouldable, and starts to crumble) and liquid limit (the moisture content above which it changes from being plastic, and starts to flow like a liquid). The plastic and liquid limits can be determined by simple laboratory tests in accordance with BS 1377. The difference between the plastic and liquid limits is the plasticity index; the higher the plasticity index, the greater the potential volume changes.

Potential of the tree species to cause soil drying

Tree species differ in the ability of their roots to grow and exploit the available water in a cohesive soil, particularly if it has high clay content. This is commonly referred to as their 'water demand'. Species such as Oak, Poplar and Eucalyptus are deemed as high water demand as they are particularly efficient at exploiting clay soils, rooting to considerable depth. A few species only rarely cause damage and are deemed of low water demand, whilst the majority fall into the moderate category.

Hardwood species tend to have a broad spreading root system, extending considerable distances laterally as well as to depth. By contrast, the influence of most conifers is more localised, but just as deep. A few species (of both hardwoods and conifers) have intermediate characteristics. The guidance takes account of the different patterns of rooting, but it must be emphasised that the distribution of roots can be variable, meaning the guidance should not be taken as indicating a 'zone of influence' of a tree.

Size of tree

The amount of water taken by the roots relates to the leaf area and the vigour of the tree. With open grown trees, height is usually considered the best indicator of leaf area. The greatest water uptake occurs as the tree reaches maturity, and so 'mature height' is the determining factor. Individual trees within a group or row will have a smaller leaf area, but as they compete with each other, the mature height of the individual trees remains the relevant factor.

Although some trees are managed as pollards or are subject to periodic reduction to control their size, unless such treatment can be assured in the future, mature height should be used.

Proximity

The closer the tree, the deeper the potential influence, and the guidance indicates the required foundation depth at any distance. The parts of the foundations closest to the tree require the greatest depth, but if preferred can be stepped down for more distant parts.

Likely climatic conditions

Weather conditions play a major role in determining the extent of soil drying. Hot sunny weather will increase the rate of water uptake by the roots, whereas rainfall during the summer can restore the water that has been taken. As the hottest and driest conditions tend to be in South East England, it has the greatest risk. For other, wetter, parts of the country, the guidance allows for reducing the required foundation depth.

Establishing ground conditions

The British Geological Survey website (www.bgs.ac.uk) can indicate the likely soil conditions in any locality. Enter the postcode to locate the site, and a left click on the location brings up a box that shows the bedrock geology and the superficial deposits (if present). The name of the bedrock or superficial deposits are often sufficient to indicate probable soil conditions (e.g. London Clay or Plateau Gravel), but if not, clicking on the name will bring up further details.

Unless there is clear evidence that a cohesive soil is not present, Site Investigations will be required to determine the soil type to at least the depth of potential influence of adjacent trees. Usually, trial holes are an acceptable method for determining the soil strata, but specialist Site Investigation reports are preferred if available.

Soil samples should be taken from at least two depths, at 1.5m and 2.5m (or the base of the trial hole, whichever is the shallower), and sent to a soil laboratory for determination of plastic and liquid limit (and thus plasticity index). In addition, the moisture content of the samples is usually determined. The highest value of plasticity index should be used for determining foundation depth*. Also see 'Limitations of guidance' at the start of this section.

Identification of trees

Many Local Authorities will require a Tree Survey and Arboricultural Method Statement as part of the planning application. This will usually serve to identify all relevant trees both on and off-site. If a tree survey is not available, assistance with identification of all of the more common trees can be obtained from various websites:

Natural History Museum

www.nhm.ac.uk/nature-online/british-natural-history/urban-tree-survey/identify-trees/tree-key/ index.html

Royal Botanic Gardens, Kew

apps.kew.org/trees

Science and Plants for School

(Particularly useful for winter identification, using twig characteristics)
www-saps.plantsci.cam.ac.uk/trees/index.htm

If a tree cannot be identified, it must be assumed to have high water demand (deep rooting).

Mature height of tree

The mature heights of common tree species are provided in our online foundation depth calculator. Mature height should be used unless an Arboricultural report is obtained, indicating that a lesser height is appropriate for the conditions of the site.

Woodlands, groups or rows with mixed species of trees

Foundation depth should be determined on the basis of the individual tree that requires the greatest depth.

Proximity of tree

Measurement should be taken from the centre of the trunk to the nearest part of the foundations. If preferred, foundations depths can be stepped down at greater distances, by measurement to other locations around the building.

Regional and climatic conditions

The foundation depth calculator will allow for regional and climatic conditions by entering the details of the post code of the proposed site.

Foundation Depth Calculator

Foundation depth* (see also 'Limitations of guidance' at the start of this section) can be determined using the foundation depth calculator found on our website. The depth of foundation is determined by inputting the:

- Plasticity index of soil.
- Tree type (this will determine the water demand of the tree).
- Mature height of the tree will automatically be determined.
- Distance of the relevant tree to the nearest part of foundations and distances elsewhere if stepping foundations.
- Allowance for climatic conditions.

Internal walls should also be taken to a suitable depth to avoid the effects of heave.

Where the foundation depth calculator identifies a minimum depth exceeding 1.5m, raft foundations and strip foundations must not be used. Mass fill or piled foundations must be adopted.

Foundation depths to allow for future tree planting

Where there is a landscape plan specifying future tree planting, foundation depths should be calculated on the basis of the proposed species of tree and its proximity. If no species has been specified, they should be assumed to be moderate water demand.

Even if no tree planting has been specified, it is advisable to allow for reasonable future tree or shrub planting, or for the growth of self-seeded trees or shrubs, as shown in column 2 of Table 1.

If the building design or location is such that no tree planting is likely at any time in the future, minimum foundation depths, as shown in column 3 of the table below, should be used.

Table 1: Minimum foundation depths

Plasticity index	Minimum depth to allow for reasonable future tree/shrub planting (m)	Minimum depth if no future tree/shrub planting likely (m)
>40	1.50	1.00
20-40	1.25	0.90
10-20	1.00	0.75

* Note: Where a minimum depth of 1.5m or greater is required: Strip foundations must not be used. Mass fill or Piled foundations must be adopted.

Foundation design

Depths in excess of 2.5m

Where the required foundation depths, are in excess of 2.5m, foundations must be designed by a suitable expert, i.e. a Chartered Structural Engineer, taking account of the likely effect of soil movement on the foundations and substructure. Short bored piles with ground beams are recommended, and may prove to be the most economical form of construction. Short bored piles are an essential requirement for depths in excess of 3m. See the 'Foundations - Piles' section for further information.

Foundation depths less than 2.5m

Mass fill foundations are likely to be most economic at depths below 1.5m, but can be economic to depths up to 2.5m. However, shored bored piles are recommended.

For foundation depths in excess of 2m, short bored piles with ground beams are recommended. All pile designs should be undertaken by a suitable expert, i.e. a Chartered Structural Engineer. See the 'Foundations - Piles' section for further information.

Heave precautions

Allowance must be made for the probability that any existing tree is likely to die sometime during the life of the building. If the tree has dried the soil prior to the foundations being laid, when it dies (or becomes over-mature) the soil will rehydrate and swell, causing upward or lateral heave movement of the foundations. Severing roots within the footprint of a building foundation will also allow the soil to rehydrate.

If foundation depth is greater than 1.5m, a proprietary compressible material must be placed on all inside surfaces of the peripheral foundations to allow for lateral soil swelling, as shown in the details on the next page. Material is not required on internal foundations (as swelling pressures are likely to be similar on both sides).

For piled foundations greater than 1.5m, a proprietary compressible material must be placed on:

- All inside faces of the external ground beams and,
- The underside face of external and internal ground beams.

The material must be capable of compressing to allow for lateral swelling, in accordance with column 3 of Table 2.

Ground bearing slabs should not be used in ground conditions where heave can occur or where the foundation depth is greater than 1.5m. Under these circumstances, a suspended floor construction should be used (e.g. cast in-situ concrete, precast concrete or timber). This must incorporate either a clear minimum void of a specified depth under the suspended floor or a proprietary compressible material/void former below the underside of the floor construction.

Note: the compressible material/void former must have a third party approval for use in this situation.

The depth of the void should be in accordance with Table 2, or if a compressible material is used, it should be capable of compressing to provide a void of this thickness. The manufacturer's specifications must be checked to establish the actual thickness of compressible material required to both accommodate movement and be able to compress to the dimensions in Table 2.

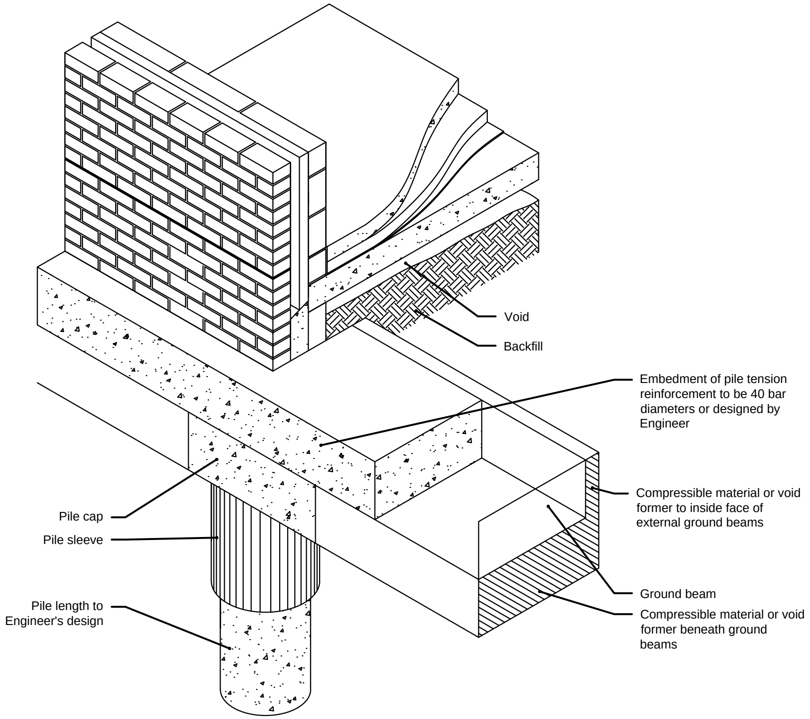
Note: On suspended floors where a minimum void dimension between the oversite level and the ground floor construction should be maintained, the figures in Table 2 should be added to the minimum void depth to ensure that the minimum void depth is maintained after any potential heave has occurred. See the 'Ground Floors' section for further information.

Table 2: Minimum void dimensions for foundations, ground beams, and suspended floor slabs

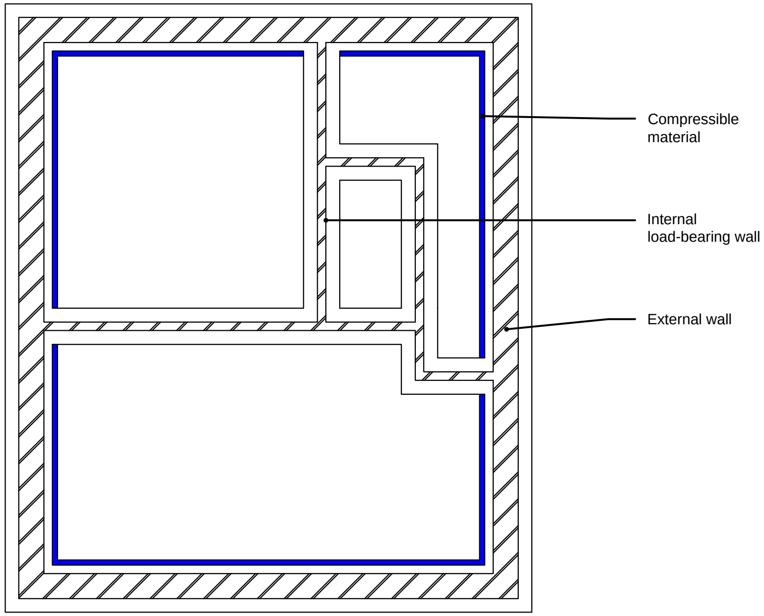
Plasticity index of soil	Required foundation depth (m)	Thickness of void against side of foundation or ground beam (mm)	Depth of void below the underside of edge beam or floor construction (mm) (or minimum resulting thickness of compressible material/void former)
>40	>2.5	Engineer design	
	2.0-2.5	35	100
	1.5-2.0	25	75
20-40	>2.5	Engineer Design	
	2.0-2.5	25	75
	1.5-2.0	25	50
<20	2.0-2.5	-	50
	<2.0	No special precautions	

Typical foundation designs to allow for heave are shown in the following details.

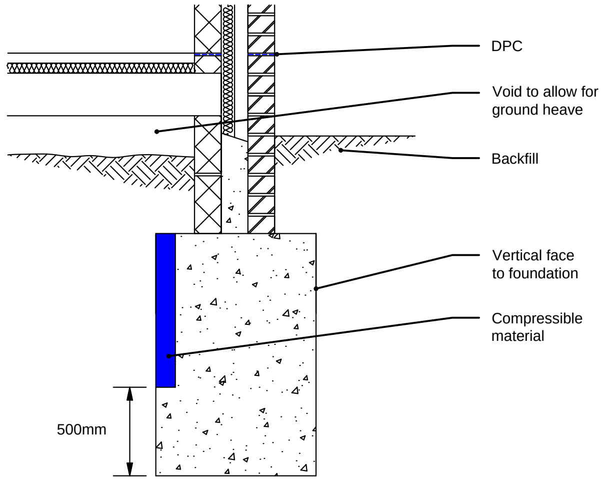
Heave protection - Section through pile and beam foundation



Plan of heave protection to a mass filled foundation



Heave protection - Section through a typical mass filled foundation



Special situations

Trees removed prior to construction

If trees have been removed prior to construction, precautions must be taken against potential rehydration and swelling of the soil. If they have been removed within 12 months of the foundations being laid, the design should be drawn up as if the tree was still present. If the height of the former trees is known, the depth should be determined using actual height. If the identity is not known, it should be assumed to be of high water demand, and if height is not known, it should be assumed to be 20m.

If trees have been removed more than 12 months prior to construction, precautions should be taken in accordance with Table 3.

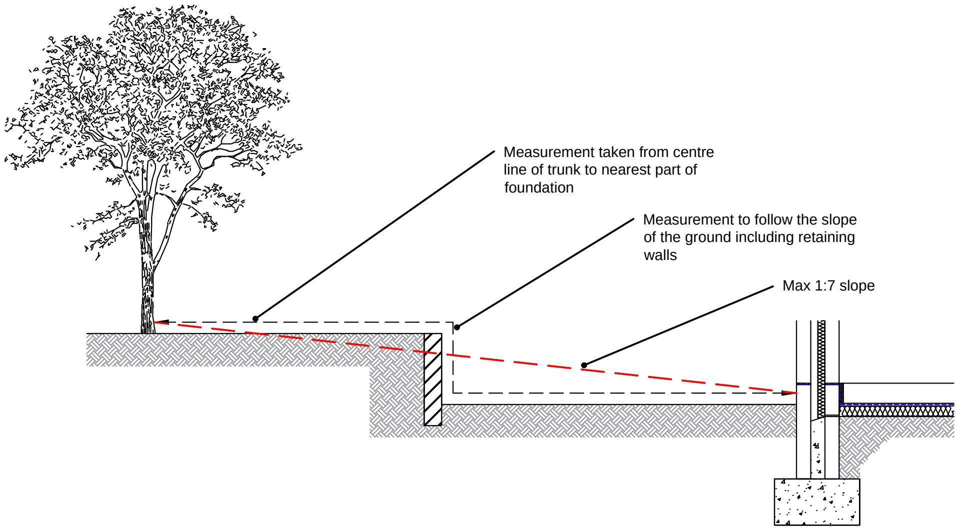
Table 3: Minimum void dimensions for foundations, ground beams, and suspended floor slabs where trees have been removed

Plasticity index	Time since tree felled (years)	Thickness of void against side of foundation or ground beam (mm)	Depth of void below the underside of edge beam or floor construction (mm) (or thickness of compressible material/void former)
>40	2-3	35	100
	4-5	25	75
20-40	2-3	25	75

Sloping sites

If the slope is greater than 1:7, foundations should be engineer designed. For slopes less than 1:7, distance should be measured down the angle of the slope. If there is a retaining wall, include the height of the retaining wall in the distance.

Measuring foundation distance on sloping sites



Changes in level

Changes in ground level (either raising or lowering soil levels) beneath the branch spread of the tree can damage the tree, and should be avoided if possible.

If ground levels are altered in proximity to existing trees that are to remain, the foundation depth should be determined on the basis of the mature height of the tree and original ground level.

If ground levels are altered in proximity to trees that are to be removed, foundation depth should be determined on the basis of the existing height of the tree and original ground level.

Varying foundation depths

As foundation depth depends on the proximity of the tree, the depth* (see also 'Limitations of guidance' at the start of this section) can be reduced in steps with increasing distance. Steps should be in accordance with the 'Foundations - Mass Fill' section.

Protection for drains

In addition to the requirements of the 'Drainage' section, drainage near trees should incorporate additional provisions. Where there is a volume change potential within the ground, the provisions include:

- Increased falls to cater for any ground movement.
- Deeper and wider backfill of granular material.
- A drainage system that is capable of movement should heave and shrinkage occur.
- Drainage pipes should not be encased in concrete.
- Additional clearance is required where drains pass through the structure of a building to allow for additional movement.

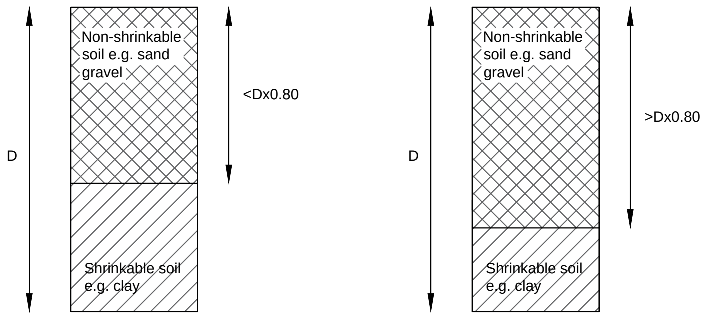
Made-up ground

This refers to land or ground created by filling in a low area with non-original soils or other fill material. Often, such created land is not suitable for building without the use of specialist foundations. If there is high clay content within the made-up ground, specialist foundations may require additional heave protection. It is also important to establish the depth of the made-up ground, because if it is a relatively shallow depth, the original soil below may be cohesive and within the zone of influence of the tree.

Mass fill foundations in non-shrinkable soils overlying shrinkable soils

If non-shrinkable soils such as sand and gravels overlie shrinkable clays, increased foundation depths are not required if the depth of the non-shrinkable soil is greater than 0.8 of the depth, which would be required for the underlying shrinkable soil. See details below for further clarification.

Foundation depth required to be taken down using foundation calculator and plasticity index of underlying clay



4.

Ground Floors

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. Certification is required for any specialists works or systems completed by an approved installer.

Materials

No additional requirements.

Design

1. Ground floors shall be designed and constructed so that they:
    a. Provide a suitable surface for normal dwelling activities;
    b. Are structurally sound;
    c. Are durable and resistant to moisture;
    d. Have an adequate thermal performance;
    e. Prevent the entry of hazardous substances from the ground into the building.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

4.

Ground Floors

4.1

Suspended Beam and Block

Influence of trees and clay

In clay soils if the foundation depth is greater than 1.5m, allowance should be made in the design for heave. This must incorporate either a clear void of a specified minimum depth under the suspended floor, or a proprietary compressible material/void former below the underside of the floor construction. Further guidance can be found in the 'Foundations - Trees and Clay' section.

Precast beam and block floors

Site preparation

All topsoil and organic matter should be removed from beneath the suspended floor. The ground level should be at least the same as the external ground level unless the ground below the floor is free draining.

Alternatively, a DPM linked to the DPC can be provided.

Suitability of beam and block floors

All beam and block flooring systems must have appropriate third-party certification.

The manufacturer's details and specification for the floor must include:

- Structural calculations for the floor indicating depth and centres of the precast floor beams.
- The minimum specification of walls supporting the beam and block floor.
- Specifications for the blocks infilling between the beams, including compressive strength and thickness of the block.

All beam and block floors shall be installed ensuring that the following standards are met:

- Floor beams and blocks are grouted together using cement/sand slurry with a mix ratio of 1:6 respectively.
- The beam and block floor should not be used to support load-bearing walls.
- All walls should be built off an appropriate foundation, as indicated in the 'Foundations' section.
- A suitable mortar bed is required where block work between the floor beams bear onto loadbearing walls, e.g. perimeter walls.
- Holes must not be made through the floor beams and any service penetrations should pass through the holes made in the infill blocks. Any gaps around service penetrations should be filled with concrete (ST3) mix before screeding.

Where beam and block floors are to be installed to areas with higher potential point loads such as garages, additional reinforcing of the screed will be required to distribute loads effectively. This reinforcing should be of at least an 'A' mesh quality, and the screed should be thick enough to give an appropriate depth of cover.

Damp proof courses (DPC)

DPC's should be laid on a mortar bed and correctly lapped at junctions and corners. The depth of lap should be the same as the width of the DPC.

DPC's should be of a flexible material that is suitable for its intended use, and the DPC should have appropriate third-party certification.

DPC's should not bridge any cavities unless it is acting as a cavity tray. Where a cavity tray is required, please refer to the 'External Walls' section for cavity tray, weep holes, and stop end requirements.

Damp proof membranes (DPM)

A DPM should be a minimum thickness of 1200g polythene and linked to the DPC with a minimum 100mm overlap. DPM sheets should be overlapped by at least 300mm. DPM's must be carefully protected where folded up the perimeter walls, and lapped under the DPC particularly at door openings. Temporary protection should be given whilst exposed. The DPM should not be cut at the floor junction as this will prevent correct lapping with the DPC.

Other DPM's may be considered if they have appropriate third-party certification and are installed in accordance with the manufacturer's instructions.

Insulation

The insulation should be installed in accordance with the manufacturer's instructions and be durable enough to withstand the floor loadings and moisture.

Note: A number of insulation products require an additional DPM to protect the surface of the insulation. It is important that this additional membrane is incorporated in these situations.

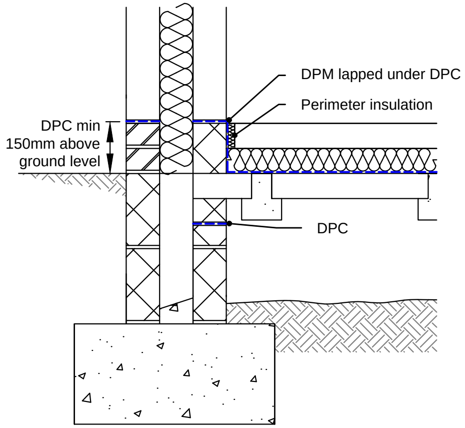
Resistance to ground moisture

The precast beam and block substructure floor shall be designed to prevent water ingress. There are two common methods of achieving this:

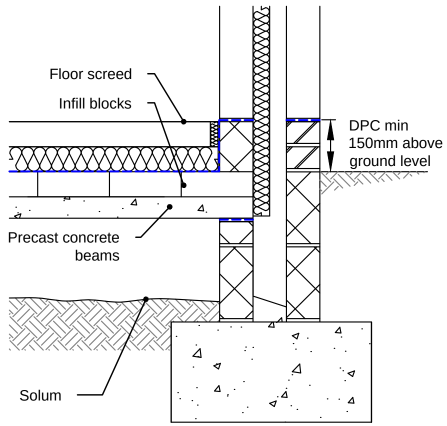
Method 1 - Damp proof membrane (DPM)

- A DPM should be provided beneath the screed or insulation; the floor void beneath the beams should be appropriately vented, ensuring that a cross flow of air between two external walls is achieved.
- The minimum area of ventilation should equate to at least 1500mm2 per metre run of external wall. This roughly equates to an air brick every 3m centres for a typical PVC 225mm x 75mm air brick.
- The ventilated void must have a minimum depth of 150mm from the underside of the floor.

Full fill cavity



Partial fill cavity

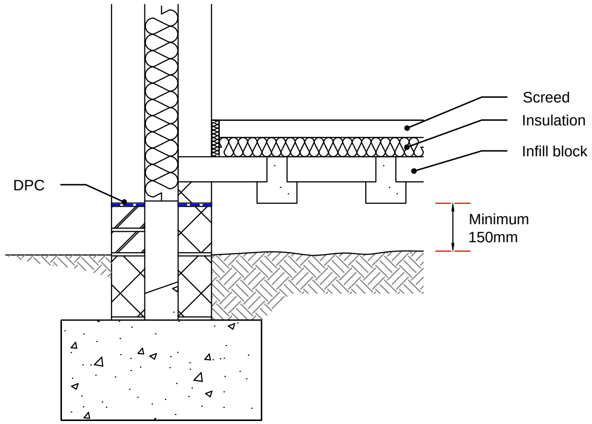


Note: Cavity insulation must be installed to meet the manufacturers installation requirements

Method 2 - No damp proof membrane (DPM)

Where no DPM is incorporated into the precast beam and block floor, the following provisions will apply:

- The beam and block floor must be laid above the DPC.
- The floor void beneath the beams should be appropriately vented to ensure that a cross flow of air between two external walls is achieved.
- The minimum area of ventilation should equate to at least 1500mm2 per metre run of external wall. This roughly equates to an air brick every 3m centres for a typical PVC 225mm x 75mm air brick.
- The ventilated void must have a minimum depth of 150mm from the underside of the floor.
- The solum level must be at the same level as the external ground level.



Note: Cavity insulation must be installed to meet the manufacturers installation requirements

Note: Where the solum level is below the external ground line, a suitable drainage provision to avoid build up of ground water must be provided

Note: If ground conditions consist of clay soils and trees that are, were, or are likely to be present, the void under must allow for heave potential in the solum

Note: At party wall junctions, where required, the floor should have appropriate sound and fire resistance in accordance with the relevant regional Building Regulations

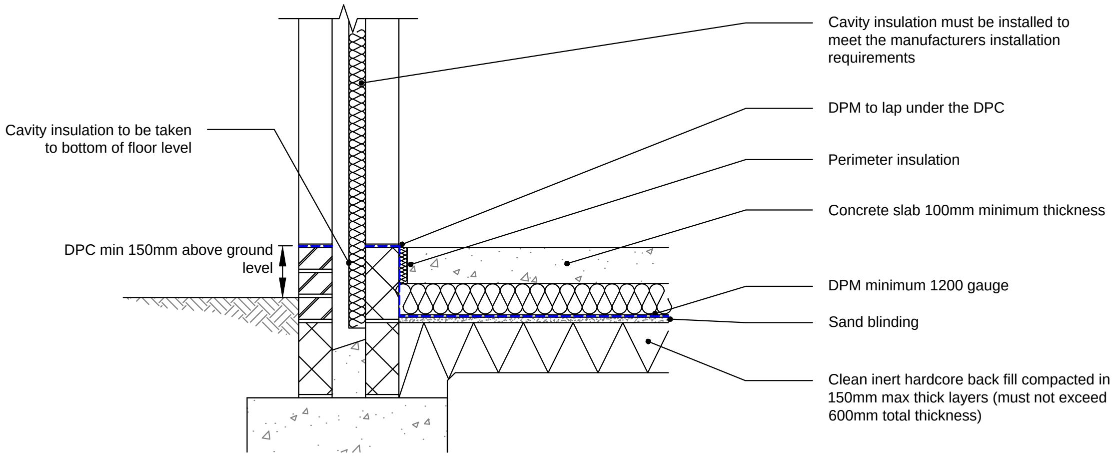
4.

Ground Floors

4.2

Ground Supported Slab

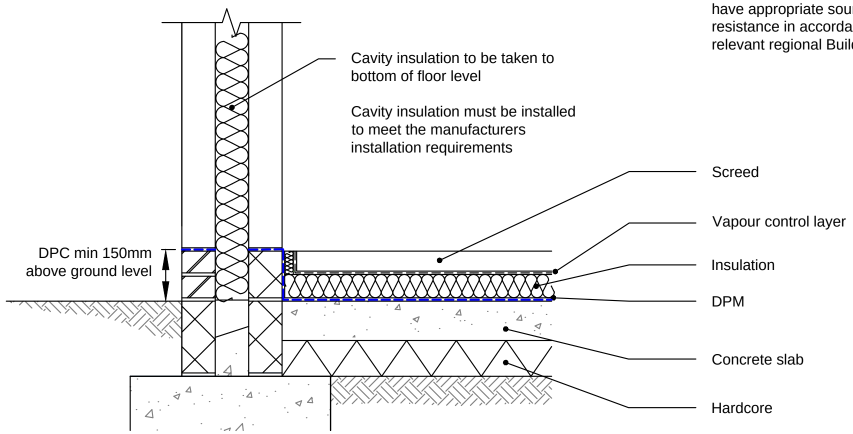
Ground bearing floor - insulation below slab



Note: If ground conditions consist of clay soils and trees that are, were, or are likely to be present, a suspended floor construction should be used

Note: Where required the floor should have appropriate sound and fire resistance in accordance with the relevant regional Building Regulations

Ground bearing floor - insulation above slab



Influence of trees and clay

Ground bearing slabs should not be used in ground conditions where heave can occur or where the foundation depth is greater than 1.5m. Under these circumstances a suspended floor construction should be used.

Site preparation

The ground beneath the floor should be stripped of all topsoil, organic matter or tree roots prior to filling and compaction.

Suitable hard core would include inert quarried material such as limestone or granite. Recycled aggregates may be used, which include crushed concrete or broken brick; however, these must be completely free of contaminants and plaster and should be delivered to site from a supplier that has a quality audit process in place.

Materials available as a result of any site demolition should not be used as hard core beneath floor slabs unless specifically agreed by the Warranty Surveyor and only then if it can be demonstrated that the material is completely free of contaminants and plaster.

Hard core should be placed and compacted in 150mm nominal layers and be fully consolidated using a mechanical compactor. A ground supported concrete floor will not be acceptable where the depth of the hard core exceeds 600mm and an alternative suspended ground floor construction must be used. Hard core material should not be saturated and should be taken to ensure that the new walls are not disturbed by compaction of the hard core.

All services placed under the floor construction must be suitably protected and sleeved where penetrating through the floor slab. DPM's must be correctly sealed around these penetrations.

Damp proof membranes (DPM)

A DPM should be provided beneath all ground-supported slabs. DPM's should be a minimum thickness of 1200g polythene and linked to the DPC with a minimum 100mm overlap. DPM sheets should be overlapped by at least 300mm. DPM's must be carefully protected where folded up the perimeter walls, and lapped under the DPC particularly at door openings. Temporary protection should be given whilst exposed. The DPM should not be cut at the floor junction as this will prevent correct lapping with the DPC.

Membranes should be laid either onto a concrete slab or onto a minimum 5mm sand blinding (if laid below a floor slab).

Other DPM's may be considered if they have appropriate third-party certification and are installed in accordance with the manufacturer's instructions.

Insulation

Insulation that is to be provided to ground floors can be placed either above or below the concrete slab. The insulation should be installed in accordance with the manufacturer's instructions and be durable enough to withstand the floor loadings and moisture.

Note: A number of insulation products require an additional DPM to protect the surface of the insulation. It is important that this additional membrane is incorporated in these situations.

Concreting of floors

Prior to concreting, any water or debris that may have collected on top of the DPM should be removed. Concrete should ideally be ready mixed and be of at least GEN3. Expansion joints should be provided in accordance with 'Appendix C - Materials, Products, and Building Systems' section.

Damp proof courses (DPC)

DPC's should be laid on a mortar bed and correctly lapped at junctions and corners. The depth of lap should be the same as the width of the DPC.

DPC's should be of a flexible material that is suitable for its intended use, and the DPC should have appropriate third-party certification.

DPC's should not bridge any cavities unless it is acting as a cavity tray. Where a cavity tray is required, please refer to the 'External Walls' section for cavity tray, weep holes, and stop end requirements.

4.

Ground Floors

4.3

Suspended Slab

Influence of trees and clay

In clay soils if the foundation depth is greater than 1.5m, allowance should be made in the design for heave. This must incorporate either a clear minimum void of a specified depth under the suspended floor or a proprietary compressible material / void former below the underside of the floor construction. Further guidance can be found in the 'Foundations - Trees and Clay' section.

Damp proof courses (DPC)

DPC's should be of a flexible material that is suitable for its intended use and the DPC should have appropriate third-part certification. Blue brick or slates will not be accepted as a DPC.

DPC's should be laid on a mortar bed and correctly lapped at junctions and corners. The depth of lap should be the same as the width of the DPC.

DPC's should not bridge any cavities unless it is acting as a cavity tray. Where a cavity tray is required (e.g. over a telescopic floor vent) please refer to the 'External Walls' guidance for cavity tray, weep holes, and stop end requirements.

Suspended reinforced in-situ slabs

Structural design

A cast in-situ suspended concrete slab should be designed by a qualified Structural Engineer.

The structural design should include the following information:

- Adequacy of walls that support the concrete slab (intermediate and perimeter walls).
- Suitable thickness, correct durability of concrete and correct provision of reinforcing.
- Provision of anti-crack reinforcing to the perimeter of floors.

Site preparation

The material below the proposed floor slab should be compacted sufficiently to support the slab during the pouring and curing stages. Any backfill material should not contain any organic matter, or contaminants that could react with the concrete or be susceptible to swelling, such as colliery waste.

Damp proof membranes (DPM)

DPM's should be provided beneath all reinforced suspended slab.DPM's should be a minimum thickness of 1200g polythene and linked to the DPC with a minimum 100mm overlap. DPM sheets should be overlapped by at least 300mm. DPM's must be carefully protected where folded up the perimeter walls, and lapped under the DPC particularly at door openings. Temporary protection should be given whilst exposed. The DPM should not be cut at the floor junction as this will prevent correct lapping with the DPC.

Other DPM may be considered if they have appropriate third-party certification and are installed in accordance with the manufacturer's instructions.

Insulation

Insulation that is to be provided to ground floor should be placed above the concrete slab. Insulation should be installed in accordance with the manufacturer's instructions and be durable enough to withstand floor loadings and moisture. A number of insulation products require an additional DPM to protect the surface of the insulation.

Concreting of floors

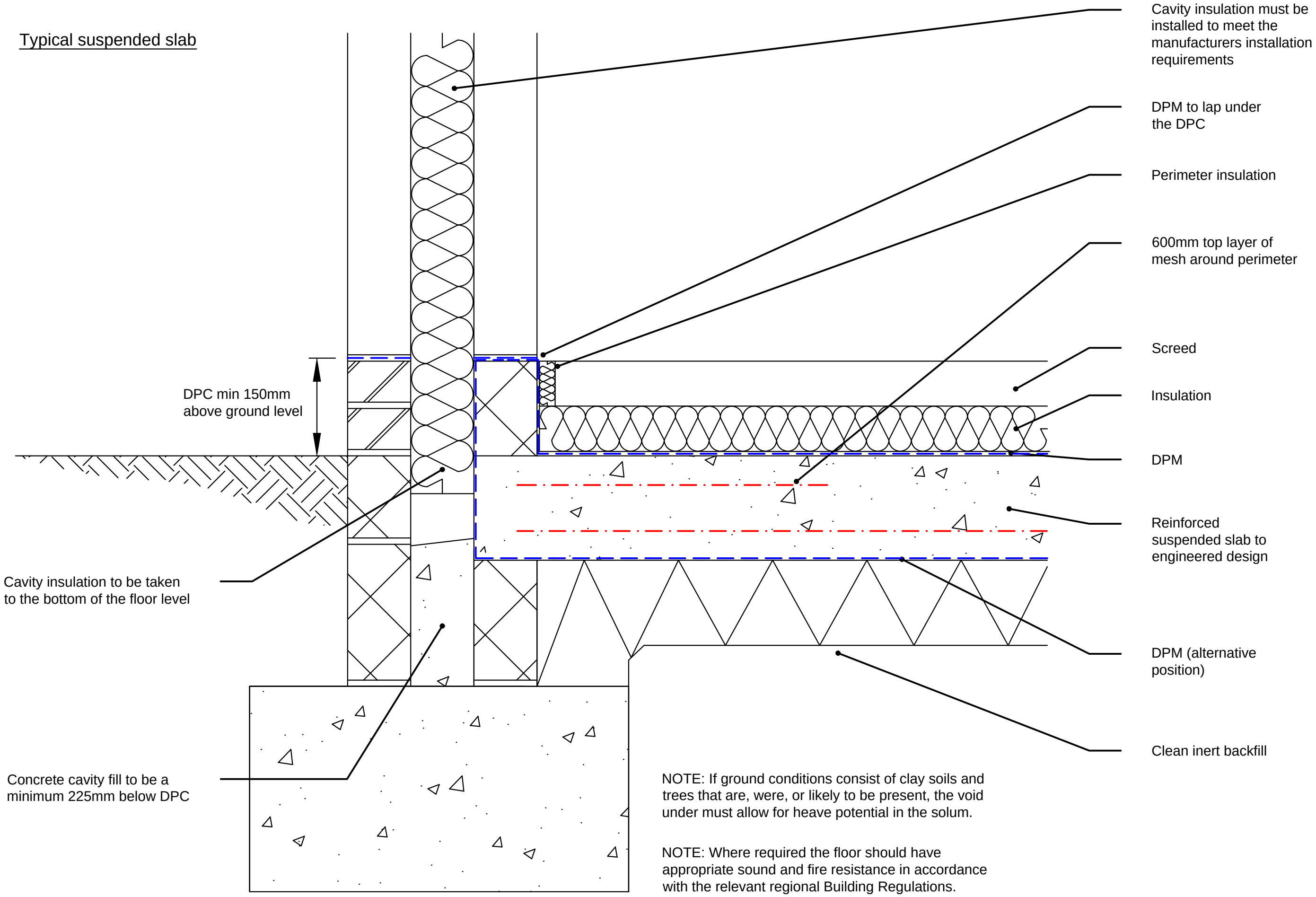
Prior to concreting, any water or debris that may have collected on top of the DPM should be removed.

The depth of concrete will vary depending upon the load conditions and the span of the floor. The overall reinforced concrete slab design should be designed by a suitably qualified Structural Engineer.

- The reinforced concrete should have a minimum strength of RC35 and be ready mixed and delivered on-site.
- Site mixing is not considered suitable for concrete suspended floors.
- The poured concrete should be lightly vibrated and well tamped to ensure that no voids are left within the floor slab.

The floor slab should be appropriately shuttered around its perimeter to enable a cavity to be formed between it and the external wall. The shuttering can be expanded polystyrene (which is removed once the concrete has set) or a proprietary shuttering system.

Typical suspended slab



NOTE: If ground conditions consist of clay soils and trees that are, were, or likely to be present, the void under must allow for heave potential in the solum.

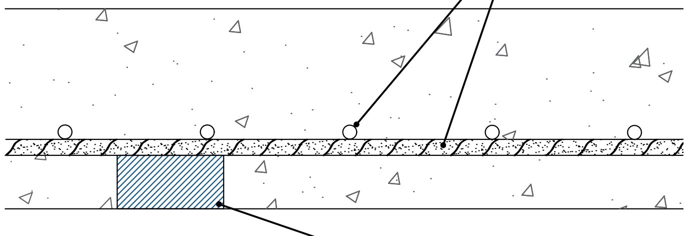
NOTE: Where required the floor should have appropriate sound and fire resistance in accordance with the relevant regional Building Regulations.

Reinforcing

Reinforcing cover

The main reinforcing bars must have a minimum concrete cover of 40mm. Suitable spacers should be provided to support the reinforcing prior to concreting.

Cast in-situ suspended concrete floor - reinforcing cover and support



Standard of fabric reinforcing

Reinforcing fabric should be free from loose rust, oil, grease, mud and any other contaminants that may affect the durability of the concrete. Reinforcing fabric should be of a 'B' mesh grade. This can be identified by the size of the primary and secondary bars. Primary bars are spaced at 100mm centres and secondary bars are placed at 200mm centres, as indicated in Table 1.

Lapping of reinforcing

It is accepted that reinforcing can consist of a number of sheets that can be joined together as identified in Table 2. The depth of cover may need to be increased to maintain minimum cover depending on the thickness of mesh reinforcing. All loose reinforcement that acts as part of the reinforcing layers must be adequately tied together.

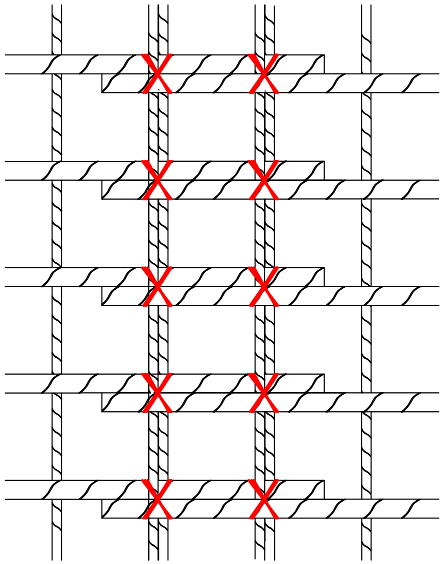
Table 1: Standard 'B' mesh reinforcing details

BS Reference	Primary Bar			Secondary Bar		
	Size (mm)	Spacing of bars (mm)	Area (mm²/m)	Size (mm)	Spacing of bars (mm)	Area (mm²/m)
B1131	12	100	1131	8	200	252
B785	10	100	785	8	200	252
B503	8	100	503	8	200	252
B385	7	100	385	7	200	193
B283	6	100	283	7	200	193
B196	5	100	196	7	200	193

Table 2: Minimum laps for reinforcing

Minimum laps for main reinforcing bars in fabric mesh (1)	
Fabric Type	Minimum lap (mm)
B1131	500
B785	400
B503	350
B385	300
B283	250
B196	200
Note: (1) A minimum lap of 300mm is required for secondary reinforcing bars.	

Typical reinforcing lap



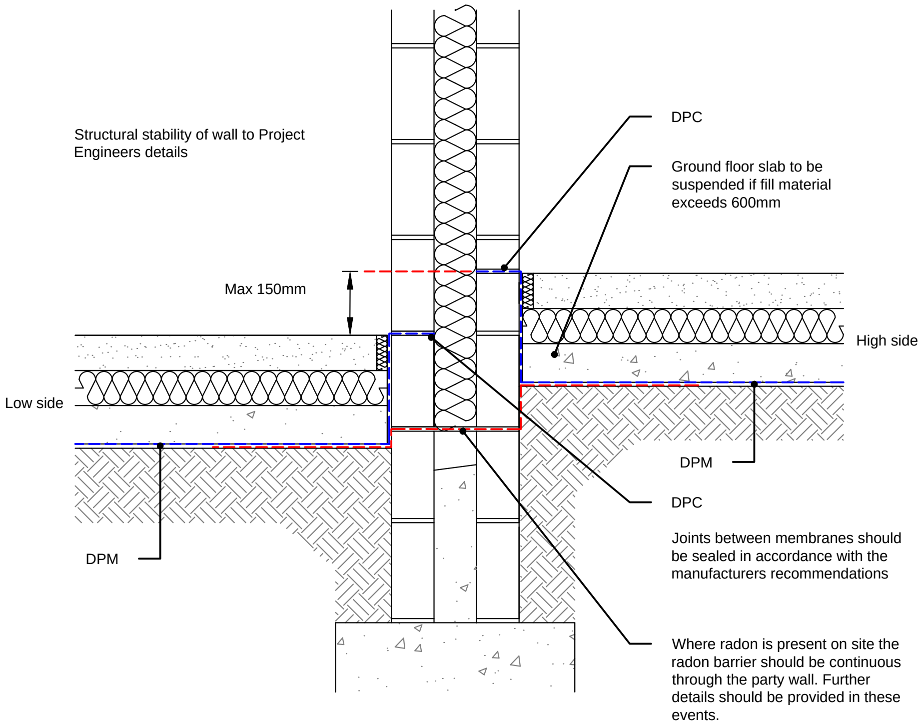
4.

Ground Floors

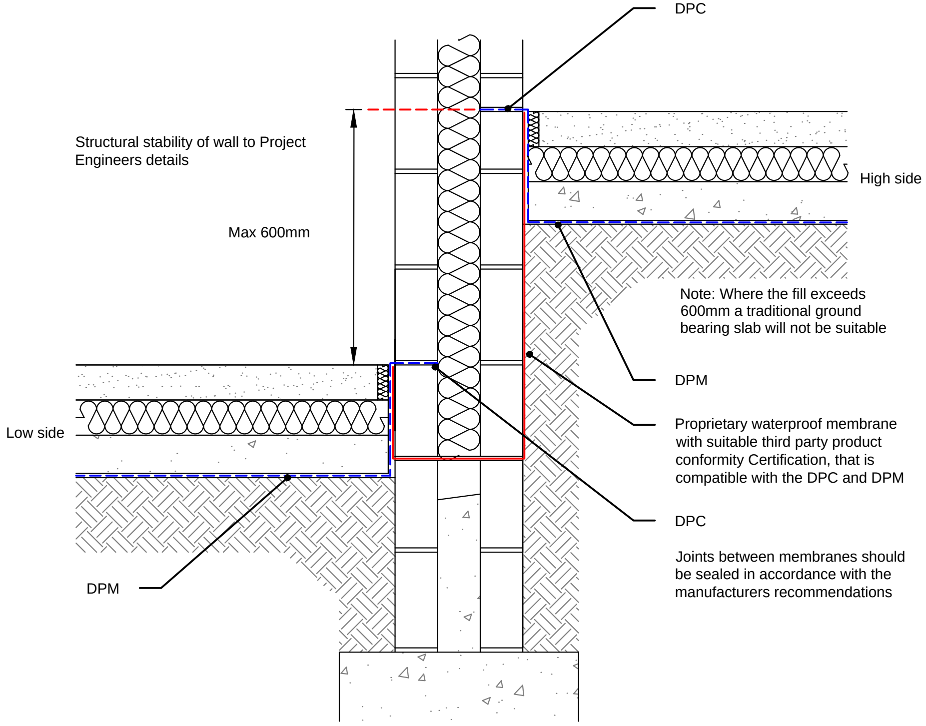
4.4

General Requirements for Concrete Floors

Stepped party walls up to 150mm



Stepped party walls up to 600mm



Stepped party walls up to 150mm

Where the difference between finished floor level (FFL)/DPC does not exceed 150mm and the external ground levels are a minimum of 150mm below DPC in all locations, a waterproofing specialist solution is not required, however in sites where Radon is present it is important that the continuity of the Radon barrier is maintained through the party wall.

Stepped party walls up to 600mm

Where the difference between finished floor level (FFL)/DPC does not exceed 600mm and the external ground levels are a minimum of 150mm below DPC in all locations, a proprietary waterproof membrane with suitable third party product conformity certification, that demonstrates suitability and resistance to hydrostatic pressure, and that is suitable for the site conditions to ensure a grade 3 environment, should be adopted.

Stepped party walls exceeding 600mm

Where the difference between finished floor level (FFL)/DPC exceeds 600mm a waterproofing solution from a CSSW qualified waterproofing specialist should be provided, see the 'Basements' section for further information. The Waterproofing Specialist must take responsibility for the design liability of the waterproofing and have appropriate professional indemnity cover which covers their business activities. They must also have an understanding of hydrogeology and soil mechanics and hold a relevant professional qualification i.e. Certificated Surveyor in Structural Waterproofing (CSSW) or similar.

Floor finishes

Screeding

Traditional floor screeds consist of sand and cement. If the ratios and properties of these screeds are not correctly controlled; cracking, peeling or collapse of the screed will occur (due to being too strong/weak).

Proprietary screeds typically are pre-blended to achieve greater consistency and strength and more suitable over larger areas. As such where the floor area exceeds $50m^2$ only a proprietary screed installed by the screed manufacturers trained installers will be accepted.

Screeds should be fit for purpose, have a suitable finish and be of an appropriate thickness.

Curing

Screeds should be cured naturally and should not be covered for at least three weeks.

Background surfaces

Background surfaces where screeds are being supported should meet the following requirements:

- Bond
  Background surfaces for bonded screeds should provide an adequate mechanical key. If necessary, cement grouting or a bonding agent should be specified to provide adequate adhesion. Where bonded screeds are used, mechanical means of preparing the concrete should be used to create an adequate bond between the substrate and the screed.
- Moisture protection
  The floor design should ensure that moisture from the ground does not enter the dwelling.
- Adequate support
  Substrate structures must be adequately constructed to provide adequate support to the screed. (Note: Timber floor constructions are not suitable to support screeded finishes).
- Screed mix
  Cement and sand screeds should have a mix ratio of between 1:3 and 1:4½.

Proprietary additives should have been assessed and have third-party certification.

The minimum thicknesses of screeds are as follows:

Screed thickness requirements

Surface	Minimum thickness at any point (mm)
Laid monolithically with base	12
Laid and bonded to a set and hardened base	20
Laid on a separating membrane (e.g. 1000g polyethylene)	50
Laid on resilient slabs or quilts (screed reinforced with galvanised wire mesh)	65

Where service pipes are bedded in the screed, the screed should be deep enough to provide at least 25mm of screed cover over service pipes, insulation and reinforcing.

Maximum areas of screed

Screeds should be laid room by room. Unreinforced screeds should have a maximum area of $40m^2$. Expansion joints should be provided and consistent with joints in the floor slab below.

Finishing of screeds

Screed should provide an even surface as appropriate, as defined in the 'Tolerance' section. Concrete floor slabs may be suitably finished to serve directly as a wearing surface without the need for an additional topping, in accordance with the recommendations of BS 8204. If required, surface sealers or hardeners should only be used in accordance with the manufacturer's instructions.

Tiling on anhydrite (liquid) screeds

If an anhydrite screed is used, it must be sealed before the application of any cement based tile adhesive is proposed. Anhydrite screeds can be difficult to identify once laid, if the screed type cannot be identified the screed should be fully sealed as a precaution to prevent the possibility of the tiling adhesive debonding from the screed.

The floor screed should be fully dry before the sealant is applied. The screed drying time will depend on the thickness and type of screed.

A decoupling membrane is also recommended as this can reduce the stress on the tiling layer.

Insulation

Insulation below screeds should have enough compressive strength to support the screed. DPM's should be installed in the correct positions, as indicated by the insulation manufacturer's instructions. Sound insulation should be installed in accordance with the manufacturer's instructions.

Constructing screeds over all substrates:

- Substrates must be level with no pockets or high spots to ensure the thickness of the screed remains even.
- Where screeds are laid over insulation; the insulation must be tightly butted together and level.
- Screeds must be correctly mixed.
- Screeds must not be walked on during the drying period.
- Screeds must not be constructed during cold periods (below 5 degrees).
- Movement joints will be required across door thresholds.
- Movement joints are required if bay sizes exceed $40m^2$ with a maximum of 8m on any one side.
- Movement joints are also required where joints exist or a change of span occurs e.g. beam and block floors.
- The screed must be ready to accept any floor tiling (see guidance below for over insulated substrates).

Drying times

- With cementitious levelling screeds, one day should be allowed for each millimetre of thickness for the first 50 mm, followed by an increasing time for each millimetre above this thickness (BS 8204).
- Polymer modified screeds: strictly follow the manufacturer's specifications and recommendations.
- The developer should keep an accurate record of the screed drying times elapsed before floor tiling is laid and the Warranty surveyor may ask for this information.

Note: The moisture contents of levelling screeds onto which particular floorings are to be laid and methods for measuring moisture content are given in BS 5325, BS 8201, BS 8203 and BS 8425.

Building services

Where building services pass through the screed e.g. underfloor heating, allowance should be made for thermal movement between the screed and the service (so that service pipes can resist chemical attack from the screed).

Additional steps where constructing screeds over concrete substrates

Where a concrete slab is insulated from below and a finishing screed is required to the top surface:

- The concrete substrate slab must be of the correct thickness and not less than 100mm thick.
- Concrete substrate must be adequately dried out and not wet. See drying time guidance.
- Surfaces of hardened in situ concrete bases for bonded screeds should be roughened (Scrabbled) and cleaned to remove laitance and to expose cleanly, but not loosen, the coarse aggregate particles.
- Brushing to remove laitance from a fresh concrete base is inadequate preparation before laying a bonded screed and is not recommended.
- Remove all loose debris, dirt and dust by appropriate means, preferably with vacuum equipment.
- Carry out the preparation of the surface with as little delay as is practicable before the screed is laid so as to reduce the risk of contamination.
- The surface of the prepared slab must be reasonably level to avoid deviations in thickness's of the screed.

Constructing screeds over insulated substrates with under floor heating (UFH) system and tiled floor finishes

1. Provision and construction of movement joints

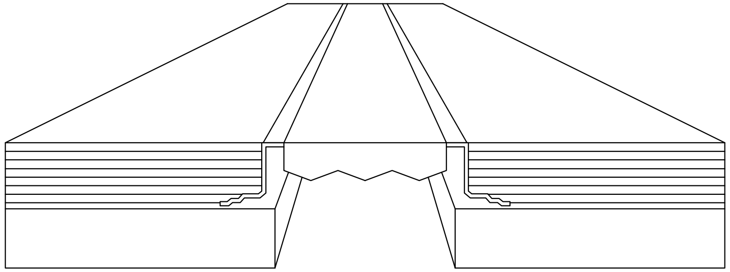
Movement joints should be provided in the floor screed/tiling where floor heating is provided in the following places:

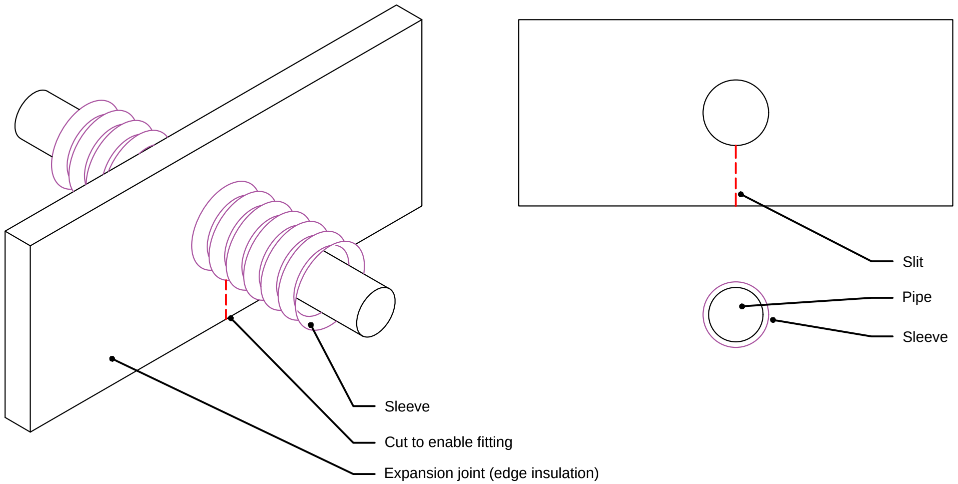
- Between independently controlled heating zones.
- Between heated and unheated areas of screed.
- Additional joints should be considered in areas of high thermal gain e.g. large conservatories or glass atria.

Bay joints should be formed using rigid joint formers where possible, which can be placed during the preparation phase and will remain in place during operation. The joint former should be 5mm lower than the finished screed depth to allow a smooth transition in height between bays.

- All joints in the screed should extend through to any subsequent bonded floor covering.
- Joint positions should be specified prior to the installation of the screed and full consultation between all parties including the main contractor, underfloor heating installer, finished flooring installer and the screed installer should take place to determine appropriate locations.
- Movement joints should be carried through the subfloor to the floor finish and all applied layers terminated either side of the joint.
- The joint should be filled with a suitable flexible filler and a proprietary cover strip applied to cover the joint. Grout must not be used.
- Movement joints should not be bridged by any resilient, textile or other adhered floor finish.
- Movement joint covers may be flush, surface mounted or bedded in mortar and metal, metal with a rubber insert or PVC (see typical detail below).

Typical movement joint covers





2. Provision of edge strip perimeter expansion joint - tile level (floor finish)

When incorporating under floor heating (UFH):

- Screeds should be isolated at all edges, abutments and columns to allow for movement due to thermal loadings.
- The floor screed and tiling (floor finish) manufacturers guidance to be followed particularly when incorporating under-floor heating to determine the minimum thickness of edge strip required to allow for expansion. Typically, between 6-15mm may be required.
- The joint can be concealed by the skirting.
- These joints must be left empty, or else filled with a compressible material.
- Movement joints must not be filled with grout.

3. Screed drying time

- The drying time allowed must be calculated for the proposed depth of screed, taking account of the environmental conditions present e.g. temperature and humidity. Where polymer modified type screeds are being used the manufacturer's requirements must be strictly followed for the actual depth of screed. Surface finishes placed on a screed too early will fail.
- Drying times for polymer modified screeds could potentially be different to cementitious screeds.
- All subcontractors involved with the screed and floor finishes (including installation of underfloor heating systems) must follow the installation requirements and not deviate or change materials.
- The screed should not be walked on until fully cured.

4. UFH testing and commissioning

- Ensure there are no joints in the heating system loops.
- UFH systems should be commissioned before tiling is applied. This will add to the total time before any tiling finish can be applied.
  Note: If floor finishes are installed prior to the UFH being turned on and commissioned, any residual moisture in the floor is driven to the surface of the screed and can potentially cause delamination of the floor finish.
- Pressure testing of the system does not constitute commissioning of the system. The heat source has to be in place and operating in order to deliver the correct temperatures.
- The UFH system must be commissioned in accordance with the manufacturer's recommendations by their approved installers. A commissioning certificate will be required.

5. Moisture testing of the screed where floor tiling is proposed

- Moisture testing should be carried out after the commissioning of the UFH system but before any tiles are laid.
- Where UFH is not installed, moisture testing of the screed should still be carried out before tiling.
- Moisture testing is carried out using a suitable approved method such as a flooring hygrometer or carbide bomb test. Due to the potential inaccuracies of using hygrometers at high humidity levels, a direct measurement should be used such as Carbide Bomb or oven dried sample.
- The base is deemed to be sufficiently dry when the relative humidity, as measured by a surface mounted flooring hygrometer/probe is 75% RH or less. For the use of a flooring hygrometer, reference should be made to Dampness testing in BS 5325, BS 8203, BS 8425 and BS 8201.
- If underfloor heating is present in the base, the heating must be switched off 96 hours prior to any hygrometer test being carried out.
- The hygrometer must be allowed to remain in position until full equilibrium has been established. This is generally considered to be 72 hours but could be longer over thick sections and considerably longer on power floated concrete.

6. Screed preparation for finishes

- The top surface of screeds may require to be scored, sanded or keyed in preparation to accept the primer and floor tiling adhesive.
- Sanding, keying etc. of the screed surface allows the penetration of primers. It also provides a “key” for the adhesive to grip onto.
- The surface must then be cleared of dirt and debris prior to primers being applied.
- Any primers and adhesives must not be applied until the screed has fully hardened and dried out. Drying times vary depending on the type of screed.
- Surfaces to be tiled should be rigid, dimensionally stable, flat with no dips and rises, sound, clean and free from laitance, paints, salts, grease, dust and any contamination which may prevent adhesion.

7. Application of the flexible tiling adhesive using double gluing technique

Tile fixing should be carried out in accordance with BS 5385 and BS 8000 Codes of Practice for the installation of wall and floor tiles.

- The tiling manufacturer's specifications for fixing should be followed, e.g. travertine tiles may require double gluing. Large sized tiles may also require this fixing method.
- Double gluing (applying adhesive to the underside of the tile and also the substrate) may be necessary.
- The adhesive must be used to the manufacturer's recommendations.
- The adhesive will require to be compressed by the tile to ensure full adhesion.
- Large voids must be avoided when fixing tiles.
- Floors should not be opened to traffic until the adhesive has hardened.

8. Full contact of the tile and adhesive

- The adhesive will require to be compressed by the tile to ensure full adhesion and solid bedding without creating voids.
- Thin-bed method with adhesive and notched trowel: Verify that there is full contact between the adhesive and the piece base.

9. Adhering to the manufacturers' process during the installation of the flooring

All the relevant manufacturers recommendations should be followed which will identify timelines to adhere i.e:

- Removing the laitance by sanding to provide a key for the primer and/or adhesive.
- Commissioning the underfloor heating before tiling commenced.
- Allowing the UFH system to cool down for at least 48 hours before tiling commences.
- Moisture testing to confirm the dryness of the screed before tiling commenced.
- Ensuring the time from screed completion to tiling commencement is calculated and adhered to.
- Ensure the tiling adhesive is allowed to set before the tiling is walked on (typically 12 -24 hours dependent on environment conditions).
- Ensure the UFH system is not turned on for at least 48 hours after the tiling is completed.
- If an anhydrite screed is used, it must be sealed before the application of a cement based tile adhesive if proposed in conjunction with a tiled floor surface covering.

10. Exceeding the Maximum 27°C floor temperature

The underfloor heating system must be correctly commissioned to ensure temperature fluctuations are avoided and potential damage to the floor finishes.

BS 8203 Code of Practice for the Installation of Resilient Floor coverings states: When used with many flooring materials underfloor heating can cause problems if the temperature at the interface between the subfloor and flooring exceeds 27°C, or is subject to rapid fluctuations in temperature.

Where a resilient floor covering is proposed: 'the temperature should never exceed the agreed maximum of 27°C at the underside of the floorcovering (the adhesive line).

Note: UFH designers may refer to this as the 'interface' temperature.

Please Note: BS EN 1264 - 2 refers to a max 29°C however for Warranty purposes a maximum 27°C is to be followed.

11. End user information

End users must be aware of how to use an UFH system, as these need to be operated differently than other heating systems both for in use and to avoid damage to screeds and finishes.

4.

Ground Floors

4.5

Suspended Timber

Influence of trees and clay

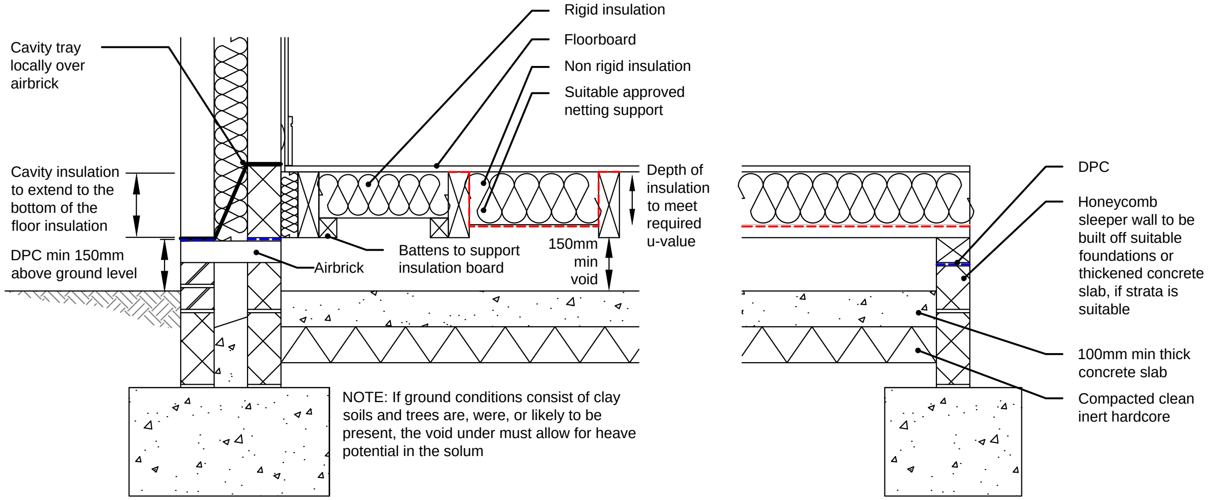
In clay soils if the foundation depth is greater than 1.5m, allowance should be made in the design for heave. This must incorporate either a clear minimum void of a specified depth under the suspended floor. Further guidance can be found in the 'Foundations - Trees and Clay' section.

Durability of suspended timber floors

To prevent the decay of timber joists, the suspended timber floor should be constructed in such a way that:

- All joists and wall plates are above the DPC level.
- A minimum void of 150mm is provided between the joists and oversite.
- Air bricks are provided to give adequate cross ventilation to the floor void.
- Joists have adequate bearings and do not protrude into the cavity.

Suspended timber ground floor - perpendicular to wall



Floor joists

All floor joists must be of a suitable durability and strength grade (minimum C16), be of the correct size and stress grade and be laid at the correct specified centres as indicated on plans and specifications. The joists should have consistent dimensions and be securely nailed to timber wall plates.

Joists at the junction with the external and party walls should be supported on suitable joist hangers and be adequately strutted at mid-span.

Floor joists can be supported internally by sleeper walls. Sleeper walls should be built off an adequate foundation if the ground is of suitable bearing strata, or can be built of a reinforced thickened slab where designed by a Chartered Structural Engineer.

Sub floor ventilation requirements

To prevent decaying floor joists, sub-floor ventilation must be provided and give a free cross flow of air. External air bricks should be provided in two opposing walls and must meet the provision detailed in Table 1.

Table 1: Suspended timber floors: minimum cross ventilation provision

Floor area of building (m²)	Minimum ventilation provision (mm²)
40	20,000
60	30,000
80	40,000
100	50,000
120	60,000
140	70,000
160	80,000

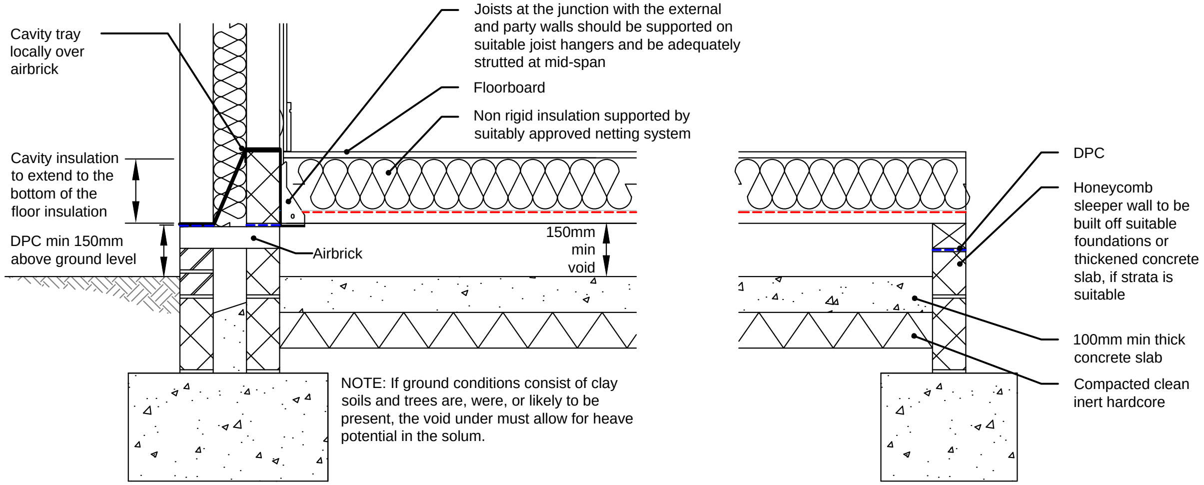
Air bricks should be evenly spaced along the two opposing walls that meet the ventilation provision. Typical ventilation areas for various types of air bricks are identified in Table 2.

Table 2: Typical air brick net ventilation area capabilities (ventilation rates vary between different manufacturers)

Air brick type	Dimensions WxH (mm)	Net area (mm²)
Clay air brick square holes	225x75	1400
	225x150	4300
	225x225	6400
Clay air brick louvred	225x150	2000
	225x225	6400
PVC air brick	225x75	4645

The cross flow of air must not be interrupted by internal walls or low hanging insulation. All internal walls must have air bricks to allow the free flow of air, or be built using a honeycomb technique.

Suspended timber ground floor - bearing onto an external wall



Damp proof courses (DPC)

Damp Proof Courses should be of a flexible material that is suitable for its intended use and the DPC should have appropriate third-part certification. Blue brick or slates will not be accepted as a DPC.

DPC should be laid on a mortar bed and correctly lapped at junctions and corners. The depth of lap should be the same as the width of the DPC.

DPC should not bridge any cavities unless it is acting as a cavity tray. Where a cavity tray is required (e.g. over a telescopic floor vent) please refer to the 'External Walls' section for cavity tray, weep holes, and stop end requirements.

Stepped floors

For lower ground floors on sloping sites and semi basements timber suspended ground floors are not recommended.

Concrete oversite

A suitable oversite should be provided at least 150mm below the timber suspended floor.

The oversite should be either:

- 100mm thick concrete over-site (GEN 3) on well-compacted hard core, or;
- 50mm thick concrete over-site on a 1200g DPM laid on 25mm sand blinding and well-compacted hard core.

For sites that are susceptible to gas migrations, the oversite should incorporate gas protection measures designed by a suitable specialist.

Where the joists are supported on joist type hangers

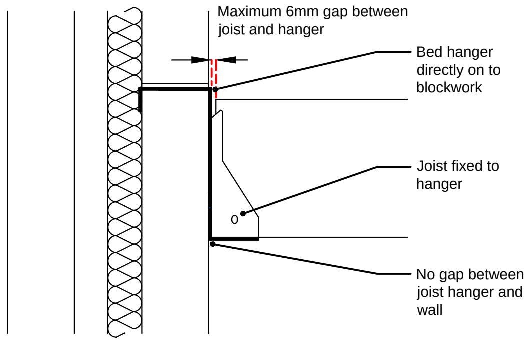
It is necessary to ensure that:

- The hanger is bedded directly on the masonry and there is no gap between the hanger back-plate and the face of the masonry.
- At least 450mm of masonry is provided above the hanger or as per manufacturer's requirements.
- Hangers are spaced at centres of floor joists included in the design.
- The hanger is suitable for the loadings and masonry strength.

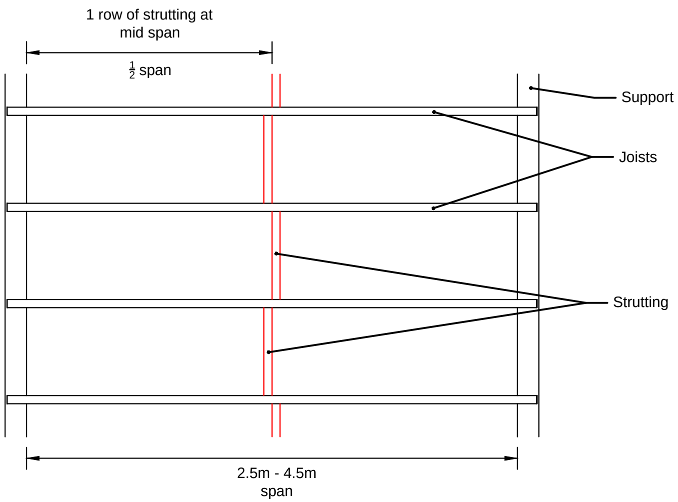
Do not:

- Apply load while the mortar is still green and has not gained sufficient strength.
- Use brick courses in block walls under joist hangers as the thermal insulation of the wall may be reduced unless similar units to the blocks are used.

Typical restraint type joist hanger

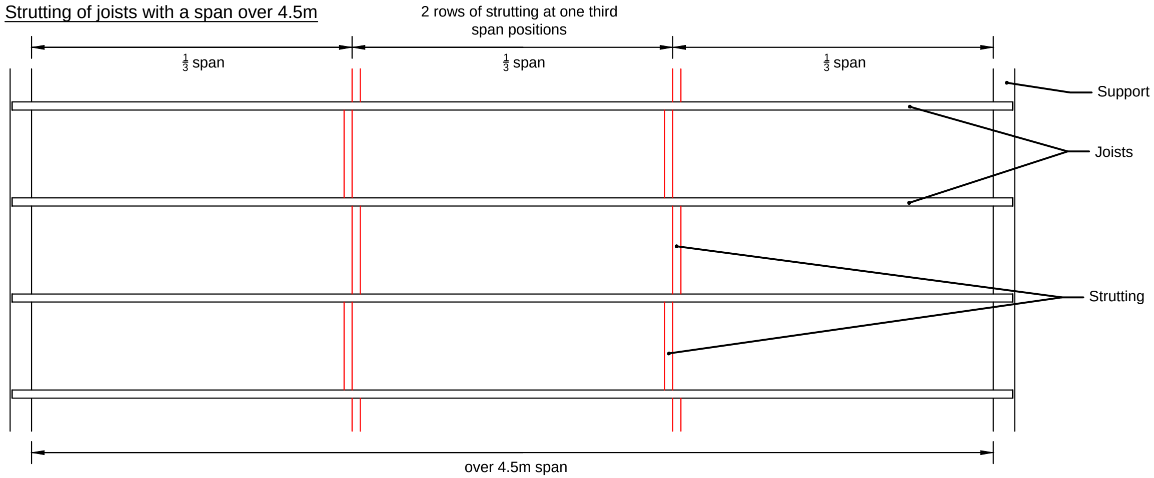


Strutting of joists with a span between 2.5m and 4.5m



Where the span of a floor joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with Figure 3 of BS 8103-3: 2009 or by a proprietary system.

Strutting of joists with a span over 4.5m



Where the span of a floor joist or flat roof joist is more than 4.5m, two rows of strutting at 1/3rd the span position will be necessary

Strutting or bridging of solid timber floor joists

Where the span of a floor joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with Figure 3 of BS 8103-3: 2009 or by a proprietary system.

Timber strutting can be in the form of solid bridging of at least 38mm basic thickness and with a depth equal to at least three-quarters of the depth of the joists; or it can consist of herringbone strutting with members of at least 38mm by 38mm basic size. Herringbone strutting should not be used where the distance between the joists is more than approximately three times the depth of the joists.

Deflection of floors

For timber floors (intermediate floors), designers and engineers must observe our tolerance requirements for levelness of floors. Please refer to the 'Tolerances' section for further guidance.

There may be an instance where a joist might be designed to meet permissible deflections within a relevant British Standard; however, our tolerance requirements will take precedence.

Floor Joists

For advice on 'sizing of certain timber members in floors for dwellings', the Designer should refer to the following sources:

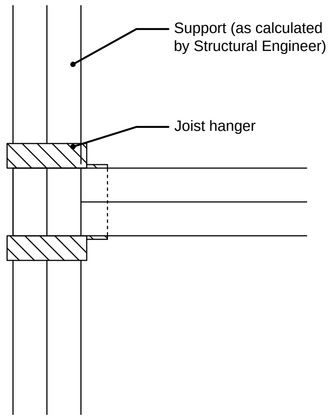
- Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. Published by TRADA. Note: Reference should be made to the version of the TRADA document current at the time of construction of the floor / timber or roof.
- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995-1: 2004+A1, Eurocode 5 design of timber structures. General: Common rules and rules for buildings.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

It is essential that joists are not overloaded during construction. Joints in joists should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

Typical trimming detail (plan)

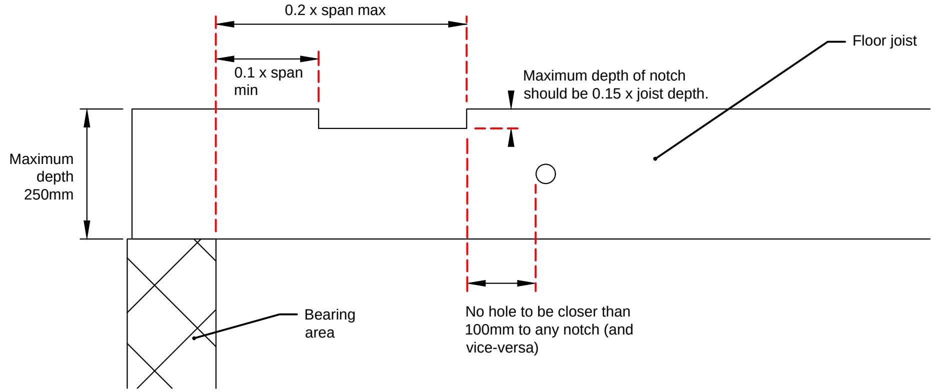


Joists should have a minimum end bearing of 90mm, unless joist hangers are used, where a 35mm bearing is acceptable (subject to the manufacturer's details).

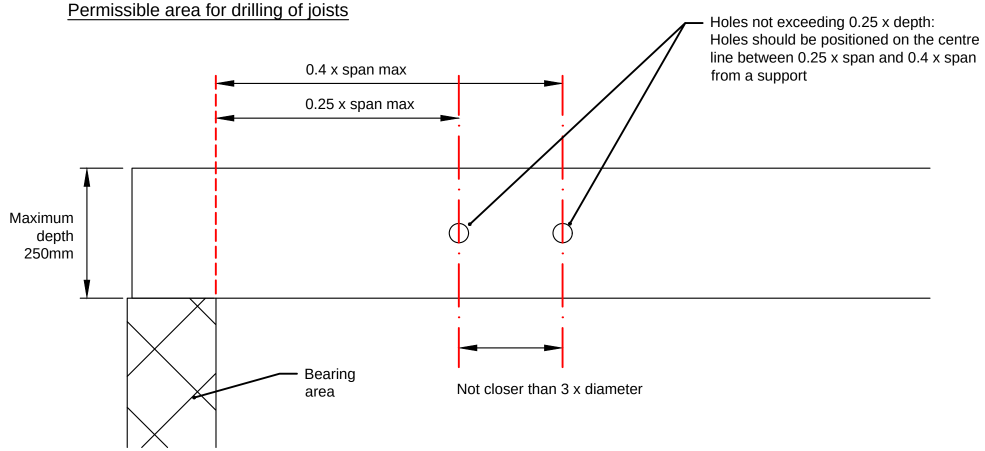
Double joists should be bolted together at 600mm centres using minimum 10mm diameter bolts with large washers that will prevent the bolt head and nut from penetrating the joist. It is recommended that the bolting of double joists is along the centre line of joists. Suitably sized trimmer joists shall be provided around floor openings.

Trimmed openings may be needed around chimneys. Solid trimmed joists may be supported using either joist hangers or a structurally designed connection; timber trimmers around openings should consist of at least two members and be designed by a Structural Engineer.

Permissible area for notching of joists



Permissible area for drilling of joists



Notching and drilling in solid timber joists basic guide

Requirements for notching and drilling of solid timber joists (further guidance can be found in BS 8103, TRADA span tables, BS EN 1996 and PD 6693 - 1), this guidance is for joists up to 250mm deep, notching and drilling for joists exceeding this depth should be designed by a Structural Engineer.

Notches: Notches should be made in between 0.1 and 0.2x span. Notches should be no deeper than 0.15x depth of the joists in this area. e.g. For a 250mm deep joist, the maximum notch depth should not exceed 35mm.

Holes: Holes should be drilled on the centre line of the joist. Holes should be between 0.25 and 0.4 x the span. Holes should be a maximum diameter of 0.25x the joists depth and kept apart by at least 3x the diameter. The maximum hole diameter should not exceed 65mm.

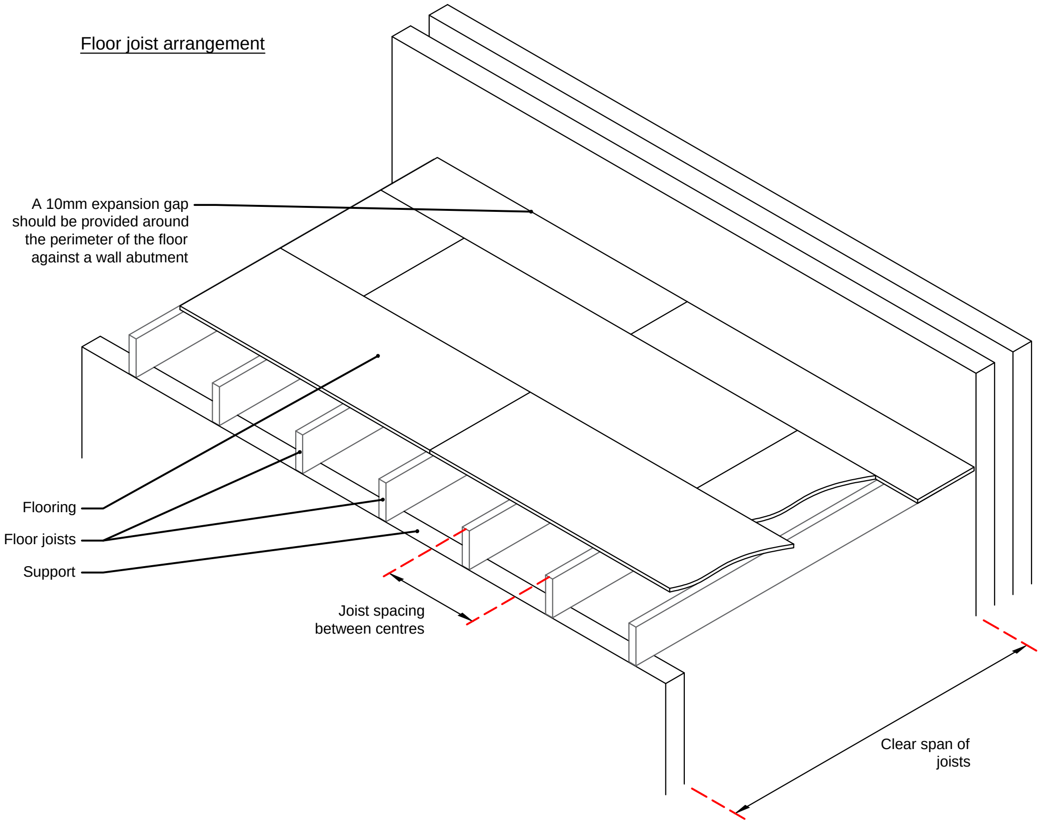
Note: Notches and holes should be a minimum of 100mm apart.

The table below gives an indication of the areas in a joist which are suitable for notching and drilling.

Typical permissible zones for notching and drilling of solid timber joists

Span (m)	**Notches to be taken out only within these zones (m)**		**Holes only to be drilled within these zones (m)**	
1.5	0.15	0.30	0.375	0.6
2	0.2	0.4	0.5	0.8
2.5	0.25	0.5	0.625	1
3.0	0.3	0.6	0.75	1.2
3.5	0.35	0.7	0.875	1.4
4	0.4	0.8	1	1.6
4.5	0.45	0.9	1.125	1.8
5	0.5	1	1.25	2

Floor joist arrangement



Insulation

Suitable provision for insulation should be provided to meet the relevant local Building Regulations.

The insulation should be installed in accordance with the manufacturer's instructions, be suitable for the intended use and adequately supported between the floor joists.

Floor boarding

Suitable floor boards and decking include tongue and grooved softwood flooring, with a maximum moisture content at the time of fixing of between 6 -19% in accordance with BS 8103 - 3 2009. (See Table A1 in Annex A of the standard which gives a range of moisture content for softwood flooring, dependent on the intensity of the heating to be provided in the building e.g. where under floor heating is provided the maximum moisture content of the floor must be limited to 6 -8%, whereas in an unheated building the maximum moisture content of the floor is 15 - 19%). All boards must be double nailed or secret nailed to each joist using nails that are at least three times the depth of the board. The boards must have a minimum thickness, as indicated in the table below.

Softwood floor boarding: Minimum thickness and centres of support

Finished board thickness (mm)	Maximum centres of joist (mm)	Typical nail fixings (mm)
15	Max 450	45mm lost head nail
18	Max 600	60mm lost head nail

Particle boarding

Acceptable particle boards consist of Oriented Strand Board (OSB) or chipboard. Chipboard should be tongue and grooved and all joints glued. The boards should be laid so that the shortest length is laid parallel to the span. OSB boards should be type 3 or 4 to BS EN 300, and should be laid with the major axis at right angles to the joists (the major axis is indicated on the OSB board by a series of arrows).

Particle boards should be either screwed or nailed to the joists at 250mm centres. Nails should be annular ring shanks that are at least three times the depth of the board.

A 10mm expansion gap should be provided around the perimeter of the floor against a wall abutment.

Particle floor boarding: Minimum thickness and centres of support

Thickness (mm) (chipboard)	Thickness (mm) (OSB)	Maximum span (mm)	Typical nail fixing (mm)
18 and 19	15	450	60mm annular ring shank
22	18 and 19	600	65mm annular ring shank

Floor coverings should be fixed in accordance with BS8103 - 3.

Fire resistance

Where required the floor should have appropriate fire resistance in accordance with the relevant regional Building Regulations.

Sound insulation and air tightness

Due to the construction methods, it is more likely to be difficult to demonstrate satisfactory levels of air tightness and sound insulation for suspended timber ground floors. In ensuring that a reasonable level of air tightness and sound resistance is achieved, the following provisions should be incorporated:

- All joists to be supported off proprietary joist hangers at the junction with party walls and external perimeter walls.
- Floor boarding to be sealed against the wall using a sealant or proprietary tape.
- Internal floors shall where necessary, have adequate resistance to the transmission of sound transmission to meet the requirements of the regional Building Regulations.
- The resilient layers where required should be fitted as per manufacturers instructions.
- The resilient layer and subsequent floor makeup should be suitable to support the design loads, any point loads or additional loading may have special requirements.

Floor finishes

For guidance on floor finishes onto the floor boarding, please refer to 'Appendix A - Finishes'.

5.

Drainage

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. Drainage works should be carried out by competent operatives.
2. Drainage systems should be laid strictly in accordance with the design.

Materials

1. Drainage materials must meet a recognised standard such as a Eurocode or British Standard.
2. Below ground drainage systems should be backfilled with suitable materials so as not to cause any damage to the drain by loading or crushing.

Design

1. The outfall drainage from any sewerage treatment plant or septic tank, should discharge to a suitable outfall that has been given full consent to do so, in writing from the Environment Agency (England and Wales), NIEA (Northern Ireland) or Local Authority (Scotland). This consent should clearly allow the discharge to occur for a minimum period of 15 years.
2. Drainage layouts and systems must be supported by a full design package identifying drainage diameter sizes, gradients and outfalls.
3. Drainage design must meet the relevant regional Building Regulations.
4. All drainage services - shall be designed, constructed and installed so that they:
   a. Do not adversely affect the structural stability of the building;
   b. Prevent the entry of hazardous ground substances, external moisture or vermin;
   c. Are constructed using non-hazardous materials;
   d. Are durable and robust;
   e. Are safe and convenient in use.
5. In addition to point 4 above: Above ground foul and storm water drainage systems - shall be designed and constructed so that:
   a. Liquid and solid waste may be discharged safely and efficiently;
   b. They are accessible for inspection and cleaning;
   c. Foul air is prevented from entering the building;
   d. The risk of blockages is reduced;
   e. They are adequately vented;
   f. Noise transmission from pipes and appliances is reduced to a minimum.
6. In addition to point 4: Below ground foul and surface water drainage shall be designed and constructed so that it:
   a. Safely and effectively conveys the discharges to a suitable outfall;
   b. Is accessible for inspection and cleaning;
   c. Reduces to a minimum the risk of blockages;
   d. Is adequately vented.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

5.

Drainage

5.1

Above Ground - Foul Drainage

Provision of information

Design drawings for above ground drainage services will need to include:

- Location of sanitary fittings.
- Drainage runs.
- Position of ventilation to the foul drain.
- Position of rodding access points.
- Specification of drainage pipes and supports.
- Location and size of cold water storage cisterns.
- Location and size of hot water storage cylinder.
- Hot and cold water pipe runs.

Above ground soil and waste drainage systems

Drainage shall be designed, constructed and installed so that:

- Pipework should be designed to meet the requirements of relevant Regional Building Regulation requirements or BS EN 12056-Parts 1, 2, and 5, and be installed following the guidance in BS 8000 - 13.
- Connected to a suitable underground foul drainage system.
- The materials and components used for sanitary pipework, e.g. pipes, fittings and fixing accessories, should conform to appropriate European Standards or European Technical Assessments (ETAS). Where no relevant European Standard or ETA exists, British Standards or British Board of Agrement Certificates should be used.
- Sanitary pipework should be installed in accordance with manufacturer's recommendations.
- Pipework used externally must be suitable for exposure to sunlight without early degradation. Proof of use for external exposure must be provided.
- Do not adversely affect the structural stability of the building.
- Prevent the entry of hazardous ground substances, external moisture or vermin.
- Are constructed using non-hazardous materials.
- Are safe and convenient in use.

All above ground plumbing systems need to be designed to allow the unobstructed flow of waste water from an appliance to the underground drainage system. To achieve this, the points below should be noted at the design and installation stages:

- Provide rodding access facilities at all changes of direction.
- Avoid bends, connections and changes of direction in the wet part of the above ground drainage system.
- Pipe sizes are adequate to take the expected rate of discharge and load at suitable gradients with the minimum of direction changes.
- 75mm deep seal traps should always be used, except:
  - On a WC where a 50mm depth of water seal can be used, or
  - Where an appliance on the ground floor discharges directly into a trapped gully.
- Pipe sizes should not exceed the dimensions for diameter against pipe length.
- Pipes should be laid at gradient 1:80 or better and adequately supported to prevent sagging and back falls.
- Sanitary pipework must be adequately supported (see Table 1).
- Provision for expansion in the pipework must be given both in vertical pipes and branch/waste pipes.(see Table 2).

- Any admittance valve fitted to the system should be located above the highest flood level of any appliance connected to that stack pipe.
- Enclosures to air admittance valves should be adequately ventilated.
- The highest point of a drainage system (head of run) should always be vented to the external air.
- A soil or ventilation pipe should extend at least 900mm above an opening if it is less than 3m away from an opening into the building.
- The drains are adequately protected from ground loads and movement in the building structure.
- Drains and pipes passing through the external waterproof envelope of the building or through the underground walls must be suitably sealed to prevent vermin ingress and dampness
- Sound insulation will be necessary where soil pipes pass through room's enroute to the underground connection. This can be achieved by:
  - Encasing the pipework within a boxed in framework with a minimum 15 kg/m2 board covering or
  - Wrapping the pipework with mineral wool fibre at least 25mm thick, throughout the height of the pipe - up to the highest ceiling level.

Table 1: Maximum distance between sanitary pipe supports

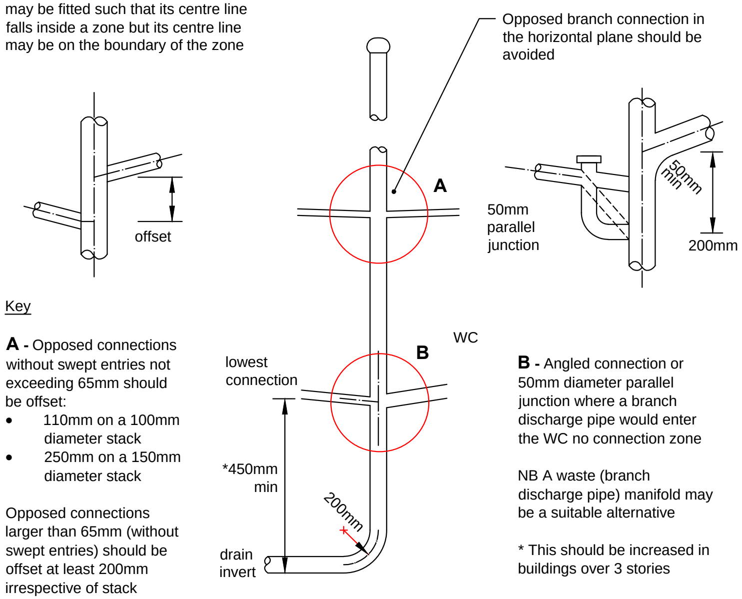
Pipe material	Normal pipe size (mm)	Vertical pipes (m)	Low gradient pipes (m)
Plastics (any type)	32 to 40 50 75 to 100 150	1.2 1.2 1.8 1.8	0.5 0.6 0.9 1.2
Cast iron	All sizes	3.0	3.0
Copper	25 32 to 40 50 65 to 100	2.4 3.0 3.0 3.7	1.8 2.4 2.7 3.0
Galvanised steel	25 32 40 to 50 65 to 75 100	3.0 3.0 3.7 4.6 4.6	2.4 2.7 3.0 3.7 4.0

Table 2: Design for thermal movement in runs of waste pipes

Fitting type	Movement provision
Push fit	Push fit joints should be assembled with clearance for expansion. Check expected movement and relate to number of joints
Solvent-welded joints	Provide 'push-fit' couplings at calculated intervals, but not exceeding 1.8m
Notes: 1. The manufacturer's recommendations should be followed in respect of provision of movement (Polypropylene pipe work can expand more than UPVC pipework for the same length). 2. Ensure 'push-fit' joints are lubricated before assembly with specified lubricant that is approved for the pipe type. (Boss white is not permitted to make joints in plastics pipework). 3. Sleeve wastes through walls to permit pipe movement.	

Position of connections to soil stacks

A branch creates a no connection zone on a stack. No other branch may be fitted such that its centre line falls inside a zone but its centre line may be on the boundary of the zone



Key

A - Opposed connections without swept entries not exceeding 65mm should be offset:

- 110mm on a 100mm diameter stack
- 250mm on a 150mm diameter stack

Opposed connections larger than 65mm (without swept entries) should be offset at least 200mm irrespective of stack diameter. Unopposed connections may be at any position

B - Angled connection or 50mm diameter parallel junction where a branch discharge pipe would enter the WC no connection zone

NB A waste (branch discharge pipe) manifold may be a suitable alternative

* This should be increased in buildings over 3 stories

Openings for pipes in fire resisting floors and walls

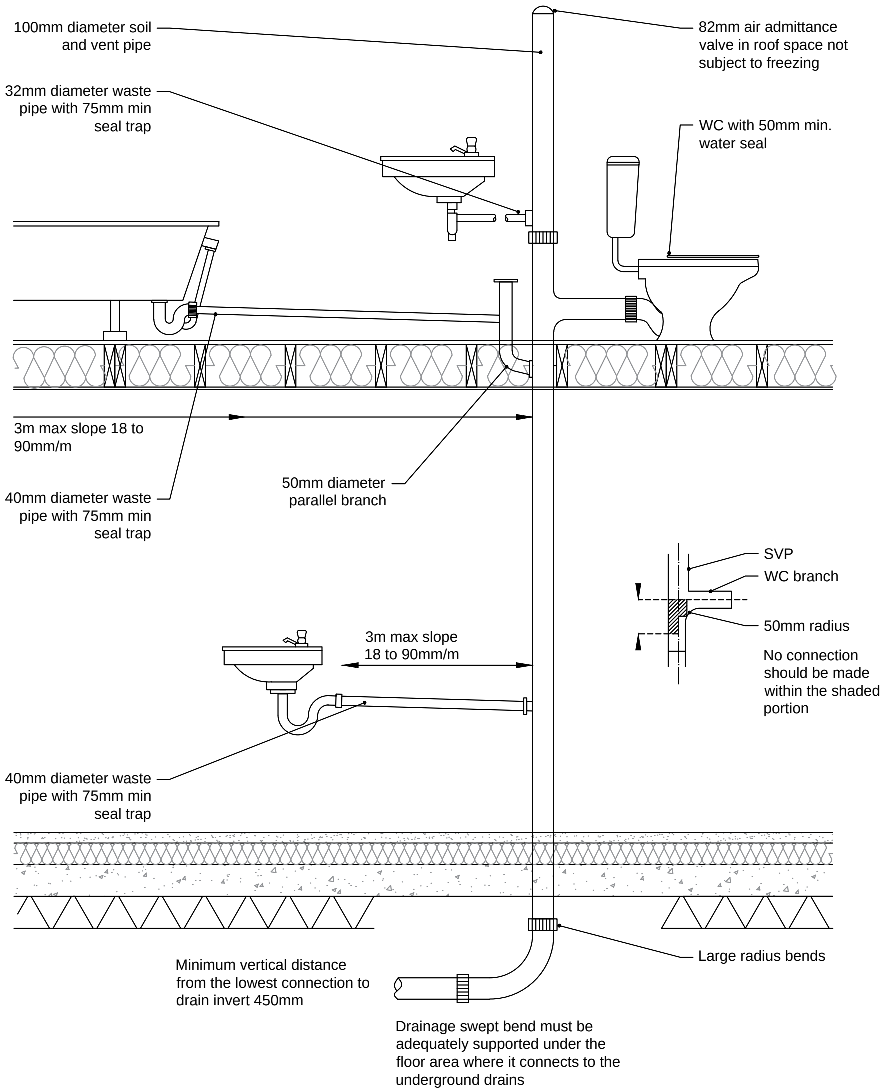
Pipes which pass through fire resisting floors and walls (unless in a protected shaft) shall:

a) Have an approved proprietary sealing system that has a UKAS accredited test to prove it will maintain the fire resistance of the floor/wall. Note: It should only be installed as per the Test requirements, or

b) Where an approved proprietary sealing system is not used; the pipes penetrating the fire resisting floor/wall should be restricted in diameter to a maximum size shown in the relevant regional Building Regulations and fire stopping used around the pipe, or

c) A sleeving system with a maximum 160mm internal diameter is used as specified in the relevant regional Building Regulations.

Single stack system: Air admittance valves



Air admittance valves

Air admittance valves provide a means of ventilation to the drainage system to prevent the loss of water seals in traps. They are suitable for use in buildings, e.g. bungalows, houses, multi-storey flats, and they only allow air to enter the drainage system. Their use does not avoid the need to ventilate the drainage system adequately.

Where air admittance valves are used to terminate soil pipes, they should comply with Building Standards. Admittance valves must have a current third party product approval and be used within the scope of that approval certificate.

Valves within the building should be:

- Positioned in areas that are not liable to freezing.
- Positioned in areas with adequate ventilation. Note, where the pipes and valve are boxed in, adequate means of ventilation will be required by means of grilles or gaps. The amount of ventilation provided should be at least 2500mm2 or whatever specified by the manufacturer.
- Accessible for maintenance.

If the discharge stack provides the only ventilation to septic tanks or cesspits, the connecting drain is subject to periodic surcharging or is fitted with intercepting traps, air admittance valves are not suitable for providing ventilation in these circumstances.

Sanitary fittings

Wash basins (WHB), baths, bidets, shower trays:

- Should be securely fixed with appropriate non rusting fixings.
- Floors should be capable of carrying the weight of the appliance.
- Excessive packing must be avoided.
- Must be connected to the drainage system and where applicable an appropriate water supply.

Where WC's, WHB's, baths and shower units are installed; where tiling is installed around these appliances, flexible waterproof mould resisting flexible sealant should be used to accommodate any movement between the appliance and tiles.

Baths and shower units should be correctly supported so that when in use the fittings will not deflect excessively and pull on the mastic seal.

Floor joists should be doubled up under the bath locations. Where heavier baths (e.g. cast iron baths or similar) are proposed, the floor joists must be designed to take the additional loadings and joist feet located over the joists.

Additional requirements where the development is within a coastal location

Where developments fall under the coastal location definition (see 'Appendix B - Coastal Locations') the following additional requirements should be met, and where elements of the sanitary drainage may be subject to the outside atmosphere, the following conditions will apply.

Corrosion

The materials should be suitably protected against corrosion, see 'Appendix C - Materials, Products, and Building Systems' for further information.

Fixings:

External fixings that are exposed to weathering, moisture and corrosive environments or applications where concentrations of corrosive agents may accumulate should be made from high grade austenitic stainless steel (e.g. A4) or a protective coating suitable for the corrosion category described in the table 'the classification of environmental corrosion conditions' in 'Appendix C - Materials, Products, and Building Systems'.

Durability

External soil and waste pipes must be suitable for the environmental conditions. Please refer to the manufacturer's specifications to confirm durability. Discolouration of dark plastic goods may be unavoidable in coastal locations.

Whilst the durability range is not a 'guarantee time', consideration has to be made to the Warranty Functional Requirements: If the component does not form part of the structure (e.g. drainage pipes and fittings), then a minimum 15 year service life will be required (please refer to the Functional Requirement wording for clarification). Otherwise, 60 years' service life is required if forming part of the structure (e.g. lintels over drainage openings in walls).

Due to the environment, certain materials and particularly the finishes may require on-going maintenance in order to keep a satisfactory finish e.g. external SVP. In these circumstances it will be the building owner's responsibility to ensure that regular maintenance of exposed components and finishes is undertaken to ensure they perform correctly. Maintenance plans will need to be in place during the lifetime of the building to ensure premature failure of coatings or components is avoided.

5.

Drainage

5.2
Above Ground - Storm Drainage

Provision of information

Design drawings for storm water gutters and downpipes will need to include:

- Areas of roof drained to each gutter.
- Downpipe and/or drainage hopper positions from roof.
- Positions of hazards e.g. Flues, opening windows/doors.
- Location of below ground storm drainage connections.
- Will drainage have to go internally of the building.
- Rodding access provision.
- Downpipe outlet positions - avoiding potential water ingress/splashing of external walls etc.

Provision of gutters and downpipes

Drainage shall be designed, constructed and installed so that:

- Roof water gutters and downpipes designed to meet the requirements of relevant Regional Building Regulation requirements and BS EN 12056-3.
- Connected to a suitable underground drainage system.
- Materials and components for rainwater goods, e.g. gullies, pipes, fittings and fixing accessories, should conform to appropriate European Standards or European Technical Assessments (ETAS). Where no relevant European Standard or ETA exists, British Standards or British Board of Agrement Certificates should be used.
- Rainwater goods should be installed in accordance with manufacturer's recommendations.
- Pipework used externally must be suitable for exposure to sunlight without early degradation. Proof of use for external use must be provided.
- Do not adversely affect the structural stability of the building.
- Prevent the entry of hazardous ground substances, external moisture or vermin.
- Are constructed using non-hazardous materials.
- Are safe and convenient in use.

When designing roof drainage systems it is normally impracticable to guard against very infrequent extremely heavy rainfall events. The design should achieve a balance between the cost of the roof drainage system and the frequency and consequences of flooding. The effective design area of a drained roof / balcony area should be determined using Table 1.

If the roof area is greater than 6m2, a roof will need to be provided with rainwater gutters and rainwater downpipes (RWP) that meet the minimum size requirements shown in Table 2.

Where a roof area is less than 6m2, thought should also be provided to the provision of rainwater drainage of such roof areas e.g. dormer roofs so as to ensure rainwater will be effectively disposed and not cause potential for damage and resulting water ingress into the building. Note: Roof areas e.g. flat roofs, which are less than 6m2 will still require to be laid to a fall.

Table 1: Calculation of roof area

Type of surface area	Effective design area
Balcony areas	Plan area
Flat roof plan	Area of roof
30° roof pitch plan	Area x 1.29
45° roof pitch plan	Area x 1.5
60° roof pitch plan	Area x 1.87
Pitched roof over 70° or any wall	Elevational area x 0.5

Table 2: Gutter sizes and outlet sizes

Max effective roof area (m²)	Gutter size (mm diameter)	RWP outlet size (mm diameter)	Flow capacity (litres/sec)
6	-	-	-
18	75	50	0.38
37	100	63	0.78
53	115	63	1.11
65	125	75	1.37
103	150	89	2.16

Gutters

- Gutters should be laid to a nominal gradient of between 1mm over 1 metre and 3 mm over 1 metre where practicable.
- The gradient of an eaves gutter shall not be so steep that the gutter drops below the level of the roof to such an extent that water discharging from the roof will pass over the front edge of the gutter.
- Gutters must be adequately supported and not sag: Fascia or rafter brackets should be typically no more than 1 metre apart or as recommended by the manufacturer.
- Additional support for gutters will be required at angles, corners, and outlet positions.
- Gutters should be laid so that any overflow in excess of the design capacity - caused by extreme conditions such as above normal rainfall, will be discharged clear of the building. On flat roofs, balconies, valley gutters and parapet gutters, additional outlets may be necessary.
- In areas where snow lies on roofs, the front edge of the gutter should not be higher than the projected line of the roof, unless snow guards or other precautions are used.

General requirements for above ground storm drainage

The above ground storm system needs to be designed to allow the unobstructed flow of storm water from the drained roof area to the underground drainage system. To achieve this, the points below should be noted at the design and installation stages:
.

- Pipe and gutter sizes should be adequate to take the expected rate of discharge, and are laid at suitable gradients with the minimum of direction changes.
- Discharge of gutters into downpipes can be substantially improved by the careful location of downpipes:
  - Locating downpipes at end quarter positions will double the flow capacity if more than one downpipe is required.
  - The downpipe should be located within 200mm of the change in direction in order to maintain the flow capacity of the gutter where changes in the line of the gutter occur.
- Where the design incorporates valley gutters or parapet gutters, the design should be carried out in accordance with BS EN 12056.
- Ensure that joints in gutters, gutter outlets and downpipes are sealed in accordance with the manufacturer's recommendations.
- Gutters and downpipes must be installed to allow for thermal movement. Joint gaps must be to the manufacturers recommendations.
- Downpipes must be installed plumb and supported at regular centres throughout the height of the pipework.
- Outlets should be correctly positioned relative to gullies.
- Sanitary pipework must not be connected/discharge into the storm drainage system.
- Pipework shall not reduce in diameter in the direction of flow, except in the case of siphonic systems.
- Siphonic roof drainage systems should be designed in accordance with BS EN 12056-3.
- Where there is no alternative to a rainwater pipe discharging on to a lower roof, a pipe shoe should be fitted to divert water away from the building. Special shoes are available where necessary to reduce splashing.
- Where rainwater pipes discharge on to a lower roof, the covering of the roof should be reinforced at the point where the pipe shoe discharges.
- Where a rainwater downpipe discharges into a gully, it should terminate below the gully grating but above the water seal, preferably by the use of a back inlet.

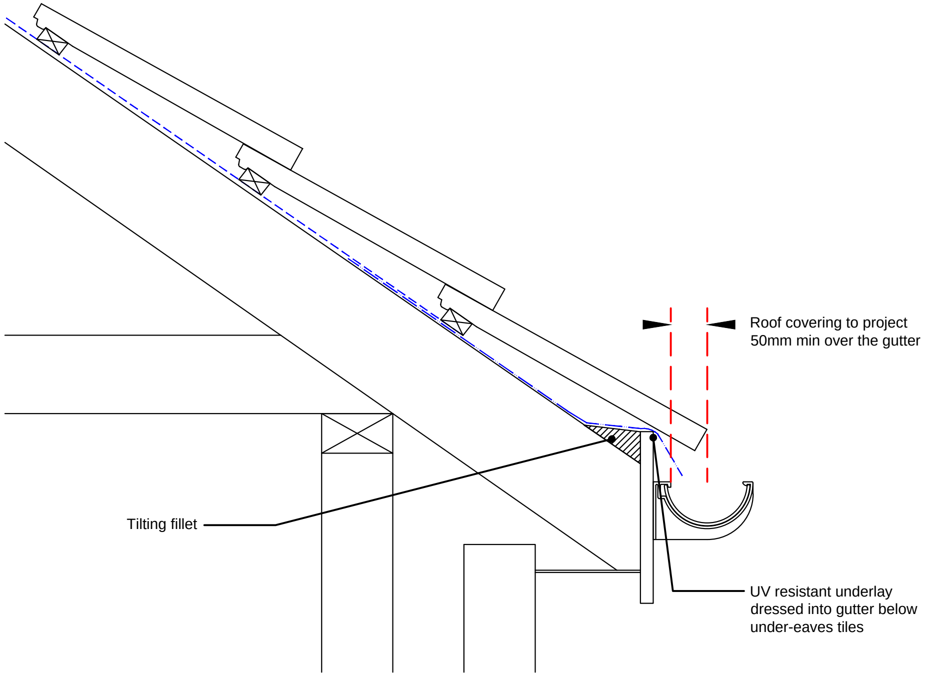
Additional requirements for pitched roofs:
(Please also refer to the 'Roofs - Pitched' guidance)

- Gutters should be fixed with the centre line vertically below the edge of the roof covering. Pitched roof UV resistant underlay should dress over the gutter.
- Gutters must be designed to deal with concentrated loads e.g. from nearby downpipes discharging water from higher level roof areas such as dormers.

Ensure gutters are:

- Adequately supported to prevent sagging.
- Laid to a fall towards the outlets.
- Have stop ends fitted.

Tile edge over gutter centre line



Additional requirements for flat roofs and balconies
(Please also refer to the 'Flat Roofs' and 'Balconies and Terraces' guidance)

- To ensure effective drainage of the 'roof area', balcony decking or other finish laid over the water proof roof covering must not restrict water flow to the rainwater outlets e.g. decking supports must not be laid across the fall of the roof.
- Flat roofs and balconies must be designed and constructed to have a finished fall (allowing for deflection in the construction) of no less than 1:80.
- The roof area should fall away from a wall that contains any door/window opening and a minimum upstand of 150mm provided between the waterproof decking and the underside of the opening.
- Tapered insulation and 'crickets' must only be designed and manufactured by the insulation manufacturer (not cut to fall on site).

Rainwater outlets must be:

- Recessed and not stand proud above the flat roof water proof covering; to ensure water will flow freely into the outlet.
- Be accessible for maintenance (any decking above the outlet must easily be removable).
- Sized and be of sufficient numbers and position to deal with the local rainfall intensity in accordance with BS EN 12056-3.
- There must be 2 outlets (or one outlet plus one overflow) where the flat roof/balcony has an upstand to all sides.
- Drainage from roof gardens should enable inspection and access to the outlet and shall incorporate means of excluding soil and debris from entering the roof drainage system.
- Drainage outlets formed through parapet walls must be constructed with secondary protection to prevent water ingress into the wall structure.
- Drainage outlets formed through parapet walls in timber framed construction where the outer leaf is masonry; Must allow for shrinkage in the timber frame i.e. the frame will settle but the outer leaf will not, therefore a backfall could result in the outlet.

Additional requirements where the development is within a coastal location

Where developments fall under the coastal location definition (see 'Appendix B - Coastal Locations') the following additional requirements should be met, and where elements of the surface water drainage may be subject to the outside atmosphere, the following conditions will apply.

Corrosion
The materials should be suitably protected against corrosion, see 'Appendix C - Materials, Products, and Building Systems' for further information.

Fixings:
External fixings that are exposed to weathering, moisture and corrosive environments or applications where concentrations of corrosive agents may accumulate should be made from high grade austenitic stainless steel (e.g. A4) or a protective coating suitable for the corrosion category described in the table 'the classification of environmental corrosion conditions' in 'Appendix C - Materials, Products, and Building Systems'.

Durability
External surface water drainage components must be suitable for the environmental conditions. Please refer to the manufacturer's specifications to confirm durability. Discolouration of dark plastic goods may be unavoidable in coastal locations.

Whilst the durability range is not a 'guarantee time', consideration has to be made to the Warranty Functional Requirements: If the component does not form part of the structure (e.g. drainage pipes and fittings), then a minimum 15 year service life will be required (please refer to the Functional Requirement wording for clarification). Otherwise, 60 years' service life is required if forming part of the structure (e.g. lintels over drainage openings in walls).

Due to the environment, certain materials and particularly the finishes may require on-going maintenance in order to keep a satisfactory finish e.g. gutters and downpipes. In these circumstances it will be the building owner's responsibility to ensure that regular maintenance of exposed components and finishes is undertaken to ensure they perform correctly. Maintenance plans will need to be in place during the lifetime of the building to ensure premature failure of coatings or components is avoided.

Openings for pipes in fire resisting floors and walls

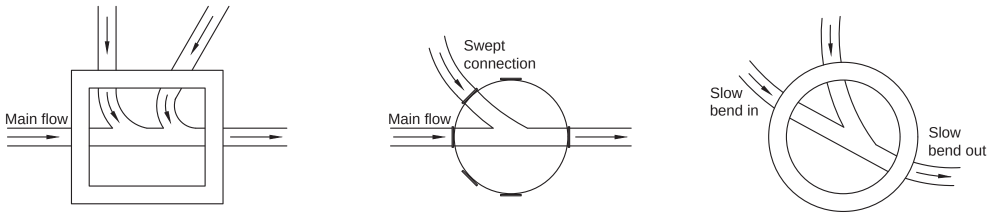
Where stormwater pipes are installed within the building
Pipes which pass through fire resisting floor/walls (unless in a protected shaft) shall:

a. Have an approved proprietary sealing system that has a UKAS accredited test to prove it will maintain the fire resistance of the floor/wall. Note: It should only be installed as per the Test requirements, or
b. Where an approved proprietary sealing system is not used; the pipes penetrating the fire resisting floor/wall should be restricted in diameter to a maximum size shown in the relevant regional Building Regulations and fire stopping used around the pipe, or
c. A sleeving system with a maximum 160mm internal diameter is used as specified in the relevant regional Building Regulations.

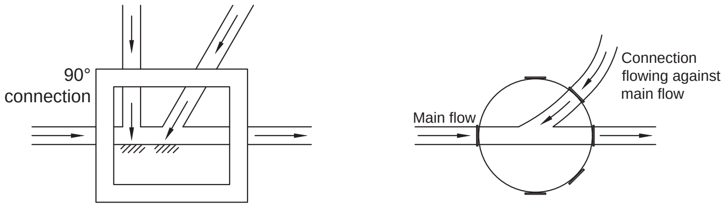
5.
Drainage

5.3
Below Ground - General Requirements

Swept connections into flow of drains - **Acceptable**



Connections against flow of main drain - **Not Acceptable**



Access and connections

Suitable access must be provided to every length of drain to allow rodding access to deal with potential blockages.

Depending on the depth and position of the drain, one of the following should be provided:

- Rodding eye - capped extensions of pipes.
- Access chamber - small chambers on (or an extension of) the pipes but not with an open channel.
- Inspection chamber - chambers with working space at ground level.
- Manhole - deep chambers with working space at drain level.

The installation of access points must not impede the flow of waste and allow connections onto main runs to be in the direction of flow and not against it.

Additional requirements for drains near trees

Drainage near trees should incorporate additional provisions where there is a volume change potential within the ground. The provisions include:

- Increased falls to cater for any ground movement.
- Deeper and wider backfill of granular material.
- A drainage system that is capable of movement should heave and shrinkage occur.
- Drainage pipes should not be encased in concrete.
- Additional clearance is required where drains pass through the structure of a building to allow for additional movement.

Access points must be provided:

- On or near the head of each drain run, and
- At a bend and change of gradient, and
- At a junction unless each run can be cleared from an access point (some junctions can only be rodded through from one direction).

Minimum dimensions for access fittings, inspection chambers and manholes can be referenced in the guidance supporting the relevant regional Building Regulations.

Construction of access points should be with one of the following materials (see table 2) and must be capable of containing the foul water under working and test conditions.

Inspection chambers and manholes should have removable non-ventilating covers of durable material (such as cast iron, cast or pressed steel, precast concrete or plastics) and be of a suitable strength for its location e.g. access points on driveways will require heavier duty covers than those in a garden.

Small lightweight covers should be secured to deter unauthorised access.

Access points within buildings should have mechanically fixed airtight covers.

Drainage system covers

Drainage system access point covers in hard standing areas should be level with the adjacent ground level.

Access covers in garden areas should not be covered over by the soil/turf.

Table 2: Materials for access points

Materials - access pipe	**British Standard**
Inspection chambers and manholes:	
Clay bricks and blocks	BS 3921
Vitrified clay	BS EN 295, BS 65
Concrete - precast	BS 5911
Concrete - insitu	BS 8110
Plastics	BS 7158
Rodding eyes and access fittings (excluding frames and covers)	As pipes ETA or Third party product approval certificates

General back fill

In normal circumstances, the excavated material from the trench will be appropriate for backfilling above the chosen material. General backfill materials must be free from:

- Boulders.
- Building rubble.
- Timber.
- Vegetable matter.

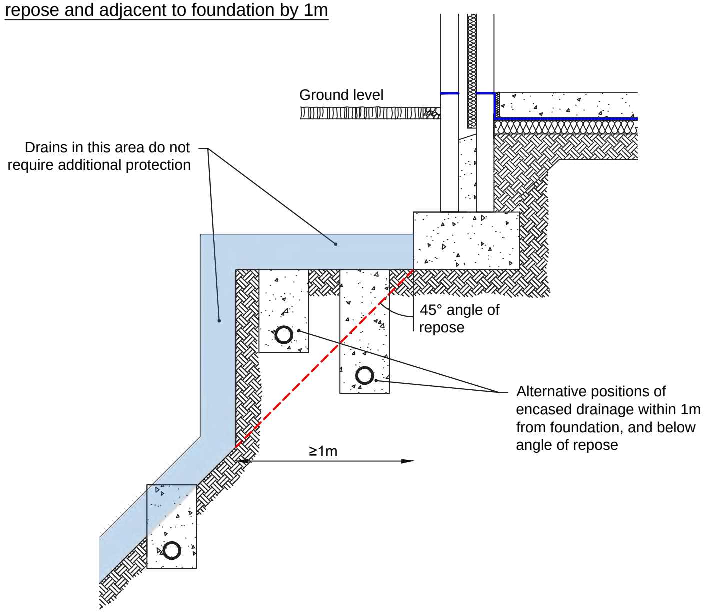
Backfill needs to be positioned in layers not deeper than 300mm, and must be well compacted. When compacted backfill is at least 450mm above the crown of the pipe, only mechanical compacting should be used.

Drain protection adjacent to foundations

Drains are to be located so that foundation loads are not transmitted to pipes. Where drainage trenches are located near to foundations, foundation depths should be increased or the drain re-routed further from the foundations.

The trench should be filled with concrete to an appropriate level where the bottom of a trench is below foundation level.

Drainage positions situated within angle of repose and adjacent to foundation by 1m

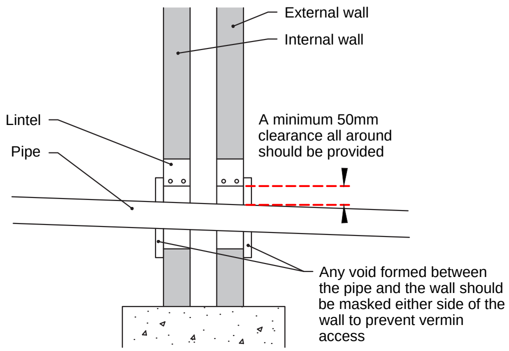


Drains and services passing through walls

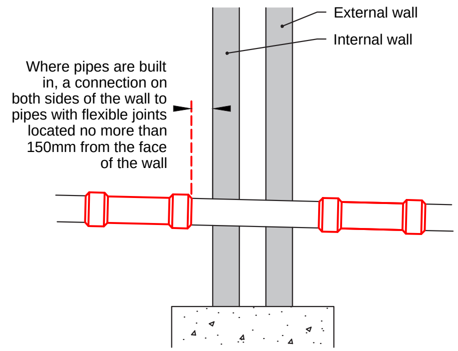
Walls should accommodate movement where drains pass through substructure by:

- Providing a minimum 50mm clearance all around.
- A sleeve with a 50mm clearance.
- (If built in) A connection on both sides of the wall to pipes with flexible joints located no more than 150mm from the face of the wall.
- Any void formed between the pipe and the wall should be masked either side of the wall to prevent vermin access.

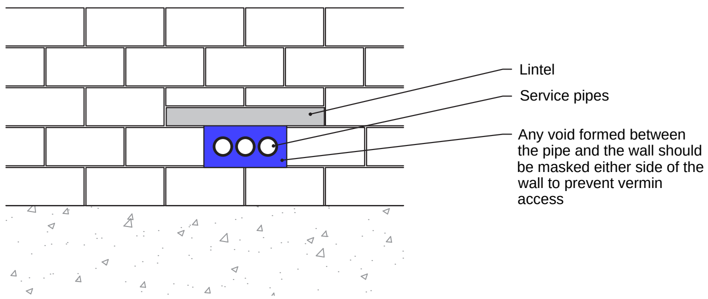
Linteled opening over pipes



Flexible jointed pipes (rockers) either side of built in pipe



Linteled opening for service pipes



5.

Drainage

5.4

Below Ground - Foul Drainage - to Mains Sewer

Provision of information

Design drawings for below ground foul drainage will need to include:

- Location of sanitary fittings.
- Position of soil stacks.
- Location of foul drain connections and drainage runs.
- Location of inspection chambers and rodding points.
- Location of suitable outfall.

Below ground foul drainage systems

Drainage shall be designed, constructed and installed so that:

- Foul drainage systems should be designed to meet the requirements of relevant regional Building Regulation requirements or BS EN 752 and be installed following the guidance in BS 8000-14.
- Discharges to a suitable outfall which is:
  - Sewer maintained by the Local sewerage undertaker or
  - A suitable private foul drainage/sewer system (1) that leads to an adopted sewer.

  Note: (1) Connections to private foul drainage systems will require agreement of the owners of such drain/sewer.
- Materials and components used for foul water drainage systems, e.g. pipes, fittings and fixing accessories, inspection chambers etc. should conform to appropriate European Standards or European Technical Assessments (ETAs). Where no relevant European Standard or ETA exists, British Standards or British Board of Agrement Certificates should be used.
- Pipework, fittings, inspection chambers etc. should be installed in accordance with manufacturer's recommendations.
- Drains and pipework etc. must be durable and suitable for use underground.
- The installation of drainage/pipework does not adversely affect the structural stability of the building.
- Prevent the entry of hazardous ground substances, external moisture or vermin.
- Are constructed using non-hazardous materials.
- Are safe and convenient in use.

All below ground foul drainage systems need to be designed to allow the unobstructed flow of waste water to a suitable approved outfall. To achieve this, the points below should be noted at the design and installation stages:

- Foul water drainage systems only take foul waste from a property or properties and will include waste water from sinks, toilets, showers, baths, dishwashers and washing machines. These systems discharge into Local Authority sewers, then pass through sewage treatment plants. Storm water should be discharged to a separate storm water disposal system so as to avoid treatment plants treating large volumes of storm water needlessly.
- Drainage from impervious surfaces such as drives, paths and hard standings must drain to a suitable rain water drainage system.
- The drainage system, including manholes, gullies, pipe connections, etc. should be protected from damage throughout the course of the construction works.
- Drainage trench excavations should be taken down to solid ground, but when this is not possible, the drainage system should be designed to accommodate any movement and made-up with a well-compacted backfill to the required formation levels.
- Where ground movement is likely to occur, flexible drainage systems should be provided, e.g. filled sites, mining areas and sites with shrinkable clay.
- Where possible, avoid passing adjacent to tree roots. Adequate precautions should be taken where this cannot be avoided, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer.

Installation of underground drains

The depths of drains and the protection provided over them needs to be adapted to the traffic normal for the location, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer. Requirements are as follows:

- Pipes should be laid to an even gradient (see table 1), and significant changes in gradient should be combined with an access point.
- Pipes should be laid in straight lines, but may be laid to slight curves, providing the length of drain can be effectively cleaned by the use of rods.
- Connections should be to inspection chambers or manholes, but connections to junctions are acceptable if access is provided to clear blockages. In all cases, discharge should be in the direction of flow.
- Bends should be positioned in, or adjacent to, terminal fittings, inspection chambers or manholes, and at the foot of discharge stacks. Bends should have as large a radius as practicable.
- The system should be ventilated at or near the head of each main drain to allow free passage of air throughout; the maximum length of any branch serving a single appliance being 6m, and for a group of appliances, 12m.
- Where appliances are not fitted with integral traps at the point of discharge, a trap must be provided using either a trapped gully or low back trap.

Table 1: Recommended minimum gradient of drains

Peak flow (litres/sec)	Pipe size (mm)	Minimum gradient	Maximum capacity (litres/sec)
<1	75 100	1:40 1:40	4.1 9.2
>1	75 100 150	1:80 1:80 (1) 1:150 (2)	2.8 6.3 15
Notes: (1) Minimum of 1 WC (2) Minimum of 5 WC's			

5.

Drainage

5.5

Below Ground - Foul Drainage - to Septic Tank

Provision of information

Design drawings for below ground foul drainage will need to include:

- Location of sanitary fittings.
- Position of soil stacks.
- Location of foul drain connections and drainage runs.
- Location of inspection chambers and rodding points.
- Location of suitable outfall.

Below ground foul drainage systems

Drainage shall be designed, constructed and installed so that:

- Foul drainage systems should be designed to meet the requirements of relevant regional Building Regulation requirements or BS EN 752:2017 and be installed following the guidance in BS 8000-14.
- Discharges to a suitable outfall which is:
  - For septic tanks: the ground conditions and water table movements must be suitable to allow the installation. Percolation tests will be required and the Warranty Surveyor given the opportunity to appraise.
  - Has consent by the Environment Agency (England and Wales) NIEA (Northern Ireland) or Local Authority (LA) in Scotland; to allow discharge to or near a watercourse or river.

  Note: Consent from the EA, NIEA or LA means a clear confirmation in writing that they will allow discharge to the designated outfall for the period of Warranty cover.

- Materials and components used for foul water drainage systems, e.g. pipes, fittings and fixing accessories, inspection chambers, septic tanks etc. should conform to appropriate European Standards or European Technical
- Assessments (ETAs). Where no relevant European Standard or ETA exists, British Standards or British Board of
- Agrement Certificates should be used.
- Pipework, fittings, inspection chambers, septic tanks etc. should be installed in accordance with manufacturer's recommendations.
- Drains and associated pipework etc. must be durable and suitable for use underground.
- The installation of drainage or pipework does not adversely affect the structural stability of the building.
- Prevent the entry of hazardous ground substances, external moisture or vermin.
- Are constructed using non-hazardous materials.
- Are safe and convenient in use.

All below ground foul drainage systems need to be designed to allow the unobstructed flow of waste water to a suitable approved outfall. To achieve this, the points below should be noted at the design and installation stages:

- Foul water drainage systems only take foul waste from a property or properties and will include waste water from sinks, toilets, showers, baths, dishwashers and washing machines. These systems discharge into septic tank. Storm water should be discharged to a separate storm water disposal system so as to avoid septic tanks treating large volumes of storm water needlessly.
- Drainage from impervious surfaces such as drives, paths and hard standings must drain to a suitable rain water drainage system.
- The drainage system, including manholes, gullies, pipe connections, etc. should be protected from damage throughout the course of the construction works.
- Drainage trench excavations should be taken down to solid ground, but when this is not possible, the drainage system should be designed to accommodate any movement and made-up with a well-compacted backfill to the required formation levels.
- Where ground movement is likely to occur, flexible drainage systems should be provided, e.g. filled sites, mining areas and sites with shrinkable clay.
- Where possible, avoid passing adjacent to tree roots. Adequate precautions should be taken where this cannot be avoided, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer.

Installation of underground drains

The depths of drains and the protection provided over them needs to be adapted to the traffic normal for the location, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer. Requirements are as follows:

- Pipes should be laid to an even gradient (see table 1), and significant changes in gradient should be combined with an access point.
- Pipes should be laid in straight lines, but may be laid to slight curves, providing the length of drain can be effectively cleaned by the use of rods.
- Connections should be to inspection chambers or manholes, but connections to junctions are acceptable if access is provided to clear blockages. In all cases, discharge should be in the direction of flow.
- Bends should be positioned in, or adjacent to, terminal fittings, inspection chambers or manholes, and at the foot of discharge stacks. Bends should have as large a radius as practicable.
- The system should be ventilated at or near the head of each main drain to allow free passage of air throughout; the maximum length of any branch serving a single appliance being 6m, and for a group of appliances, 12m.
- Where appliances are not fitted with integral traps at the point of discharge, a trap must be provided using either a trapped gully or low back trap.

Table 1: Recommended minimum gradient of drains

Peak flow (litres/sec)	Pipe size (mm)	Minimum gradient	Maximum capacity (litres/sec)
<1	75 100	1:40 1:40	4.1 9.2
>1	75 100 150	1:80 1:80(1) 1:150(2)	2.8 6.3 15
Notes: (1) Minimum of 1 WC (2) Minimum of 5 WC's			

Septic tank systems - treatment plants

If you are not on main line drainage then you will have either a septic tank or cesspit; ordinarily, the foul waste will run to one of the above tanks while the rain water is usually kept separate to help the action of bacteria and enzymes in the tank. The outfall from the septic tank should either run to a designed drainage field or possibly straight to a river or brook; you will often find the rain water system tapped onto the outlet of a septic tank to help dilute any effluent that may pass through the system.

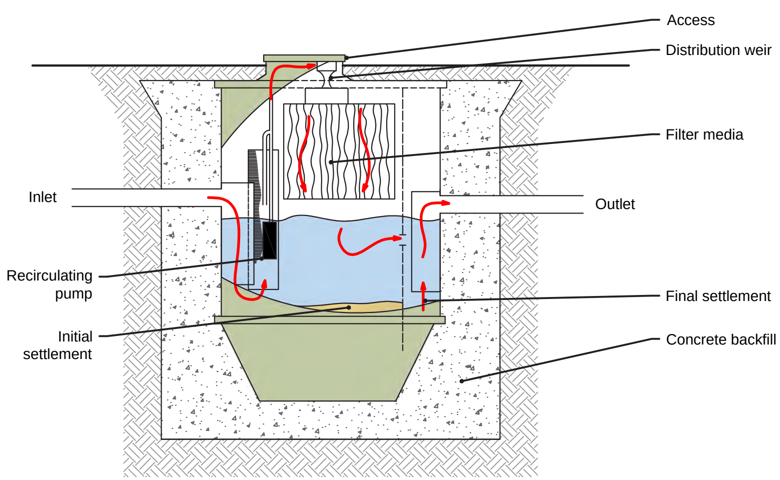
Any septic tank or other sewerage treatment system that is intended to have an outfall to a water course should have full consent to do so, in writing from the Environment Agency (England and Wales), NIEA (Northern Ireland) or Local Authority (Scotland). This consent should clearly allow the discharge to occur for a minimum period of 15 years and should be made available upon request.

Storm water should not discharge into the septic tank or water treatment plant and should be directed to a suitably designed soakaway or sewer.

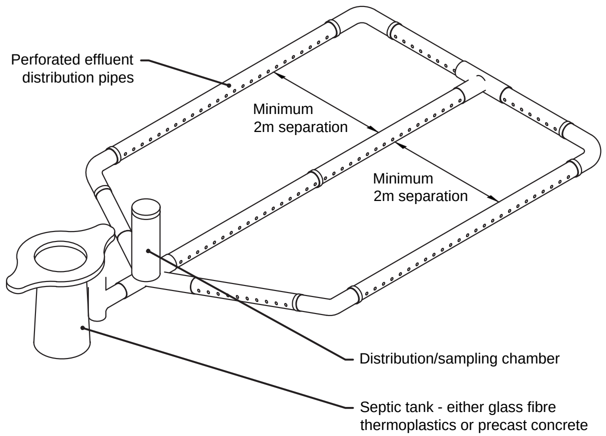
Percolation drainage fields for treatment and outfall drainage plants should not be situated uphill of dwellings.

Where the septic tank or treatment plant discharges to a soakaway, drainage field or mound suitable percolation tests should be provided in conjunction with the drainage design. The test should be carried out with at least two trail holes. The average figure from the tests should be taken. The test should not be carried out during abnormal weather conditions such as heavy rain, severe frost or drought.

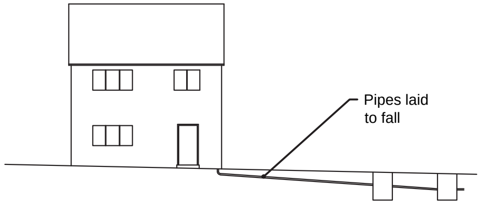
Typical sewage treatment plant



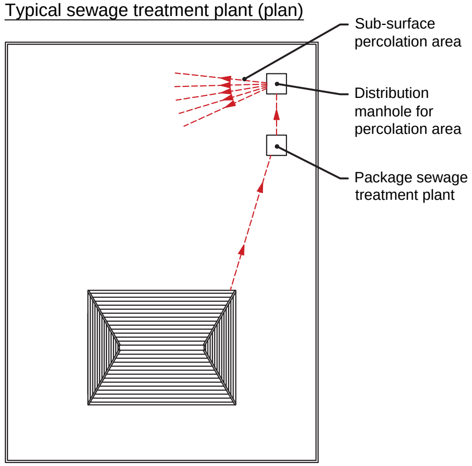
Drainage field



Typical sewage treatment plant (section)



Typical sewage treatment plant (plan)



Septic tanks

Septic tanks should only be used in conjunction with a form of secondary treatment (e.g drainage field, drainage mound or constructed wetland).

Septic tanks should be sited at least 7m from any habitable parts of the building and perfferability downslope. Septic tanks should have a minimum capacity of at least 2,700 litres below the level of the inlet, for up to 4 users. The size should be increased by at least 180 litres for each additional user.

Where they are to be emptied using a tanker, the septic tank should be sited within 30m of a vehicle access provided that the invert access does not exceed 3m below the level of vehicle access. Where the depth of the invert access exceed 3m this distance may need to be reduced.

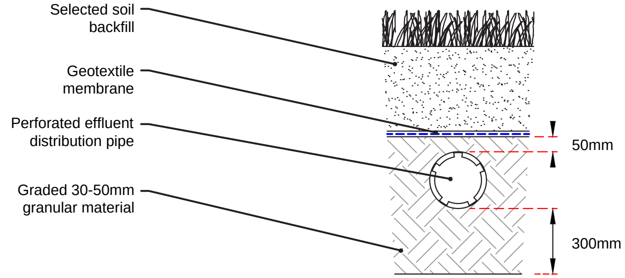
Where possible tanks should not be located beneath vehicle access points unless adequate precautions are undertaken.

Septic tanks should be designed and constructed in accordance with the relevant regional Building Regulations.

Drainage fields and drainage mounds

A drainage field or mound serving a wastewater treatment plant or septic tank should be located:

- At least 10m from any watercourse or permeable drain.
- At least 50m from the point of abstraction of any ground water supply and not in any zone 1 groundwater protection zone.
- At least 15m from any building.
- Sufficiently far from any other drainage fields, drainage mounds or soakaways so that the overall soakage capacity of the ground is not exceeded.



Packaged treatment plants

- The discharge from the waste water treatment plant should be sited at least 10m away from watercourses and any other buildings.
- Treatment plants should be type tested in accordance with BS 7781.
- Where packaged treatment plants require power to operate it should be able to adequately function without power for up to 6 hours or have uninterruptible power supply.
- Packaged treatment plants should have suitable 3rd party accreditation.

5.

Drainage

5.6

Below Ground - Storm Drainage - to Mains Sewer

Provision of information

Design drawings for below ground storm drainage will need to include:

- Location of rainwater down pipes.
- Location of slotted drainage channel systems.
- Location of drainage runs.
- Location of inspection chambers and rodding points.
- Location of suitable approved/tested outfall.

Below ground storm drainage systems

Drainage shall be designed, constructed and installed so that:

- Storm drainage systems should be designed to meet the requirements of relevant regional Building Regulation requirements or BS EN 752 and be installed following the guidance in BS 8000-14.
- Discharges to a suitable outfall which is:
  - A soakaway or other infiltration system if ground conditions (1) and site location permit, or
  - A watercourse that has consent by the Environment Agency (England and Wales) NIEA (Northern Ireland) or Local Authority (LA) in Scotland; to allow or limit the rate of discharge. Consent from the EA, NIEA or LA means a clear confirmation in writing that they will allow discharge to the designated outfall for the period of Warranty cover, or
  - Sewer maintained by the Local sewerage undertaker, or
  - A suitable private storm drainage/sewer system (2) that leads to an adopted sewer.

  Note:
  (1) For soakaways: the ground conditions and water table movements must be suitable to allow the installation to function correctly all year round. Percolation tests will be required and the Warranty Surveyor given the opportunity to appraise the results before the installation goes ahead.
  (2) Connections to private storm drainage systems will require agreement of the owners of such drain/sewer.
- Materials and components used for storm water drainage systems, e.g. pipes, fittings and fixing accessories, inspection chambers etc. should conform to appropriate European Standards or European Technical Assessments (ETAs). Where no relevant European Standard or ETA exists, British Standards or British Board of Agrement Certificates should be used.
- Pipework, fittings, inspection chambers, etc. should be installed in accordance with manufacturer's recommendations.
- Drains and pipework etc. must be durable and suitable for use underground.
- The installation of drainage/pipework does not adversely affect the structural stability of the building.
- Prevent the entry of hazardous ground substances, external moisture or vermin.
- Are constructed using non-hazardous materials.
- Are safe and convenient in use.

All below ground storm drainage systems need to be designed to allow the unobstructed flow of storm water to a suitable approved/tested outfall. To achieve this, the points below should be noted at the design and installation stages:

- Storm water drainage systems only take storm/surface water from a property or properties and will include water from roofs, drives, paths and certain hard standing areas. These systems discharge into Local Authority sewers, soakaways or water courses. Foul drainage must not be connected to these systems.
- Impervious surfaces can drain to a permeable area within the garden providing it is free draining.
- The storm drainage system must be designed for the rainfall intensities as recommended in the applicable regional Building Regulations. This should include allowance for where hard standing areas are also being drained into the storm water drains.
- Silt traps should be incorporated where hard standings are being drained into the storm system to avoid build-up of material in the underground drains.
- Oil interceptors should be should be installed on car parks, or other areas where there is likely to be leakage or spillage of oil.
- The drainage system, including manholes, gullies, pipe connections, etc. should be protected from damage throughout the course of the construction works.
- Drainage trench excavations should be taken down to solid ground, but when this is not possible, the drainage system should be designed to accommodate any movement and made-up with a well-compacted backfill to the required formation levels.
- Where ground movement is likely to occur, flexible drainage systems should be provided, e.g. filled sites, mining areas and sites with shrinkable clay.
- Where possible, avoid passing adjacent to tree roots. Adequate precautions should be taken where this cannot be avoided, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer.

Installation of underground drains

The depths of drains and the protection provided over them needs to be adapted to the traffic normal for the location, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer. Requirements are as follows:

- Pipes should be laid to an even gradient (see table 1), and significant changes in gradient should be combined with an access point.
- Pipes should be laid in straight lines, but may be laid to slight curves, providing the length of drain can be effectively cleaned by the use of rods.
- Connections should be to inspection chambers or manholes, but connections to junctions are acceptable if access is provided to clear blockages. In all cases, discharge should be in the direction of flow.
- Bends should be positioned in, or adjacent to, terminal fittings, inspection chambers or manholes, and at the foot of discharge stacks. Bends should have as large a radius as practicable.

Table 1: Minimum gradient of drains

Pipe diameter (mm)	Minimum gradient
100	1:80
150	1:150

5.

Drainage

5.7
Below Ground - Storm Drainage - to Soakaway

Provision of information

Design drawings for below ground storm drainage will need to include:

- Location of rainwater downpipes.
- Location of slotted drainage channel systems.
- Location of drainage runs.
- Location of inspection chambers and rodding points.
- Location of soakaways.

Below ground storm drainage systems

Drainage shall be designed, constructed and installed so that:

- Storm drainage systems should be designed to meet the requirements of relevant regional Building Regulation requirements or BS EN 752 and be installed following the guidance in BS 8000-14.
- Discharges to a suitable outfall which is:
  - A soakaway or other infiltration system if ground conditions and site location permit, or
  - A soakaway or other infiltration system if ground conditions and site location permit. For soakaways: the ground conditions and water table movements must be suitable to allow the installation to function correctly all year round. Percolation tests will be required and the Warranty Surveyor given the opportunity to appraise the results before the installation goes ahead.
- Materials and components used for storm water drainage systems, e.g., pipes, fittings and fixing accessories, inspection chambers etc. should conform to appropriate European Standards or European Technical Assessments (ETAs). Where no relevant European Standard or ETA exists, British Standards or British Board of Agrement Certificates should be used.
- Pipework, fittings, inspection chambers, etc. should be installed in accordance with manufacturer's recommendations.
- Drains and pipework etc. must be durable and suitable for use underground.
- The installation of drainage/pipework does not adversely affect the structural stability of the building.
- Prevent the entry of hazardous ground substances, external moisture or vermin.
- Are constructed using non-hazardous materials.
- Are safe and convenient in use.

All below ground storm drainage systems need to be designed to allow the unobstructed flow of storm water to a suitable approved/tested outfall. To achieve this, the points below should be noted at the design and installation stages:

- Storm water drainage systems only take storm/surface water from a property or properties and will include water from roofs, drives, paths and certain hard standing areas. These systems discharge into Local Authority sewers, soakaways or water courses. Foul drainage must not be connected to these systems.
- Impervious surfaces can drain to a permeable area within the garden providing it is free draining.
- The storm drainage system must be designed for the rainfall intensities as recommended in the applicable regional Building Regulations. This should include allowance for where hard standing areas are also being drained into the storm water drains.
- Silt traps should be incorporated where hard standings are being drained into the storm system to avoid build-up of material in the underground drains.
- Oil interceptors should be should be installed on car parks, or other areas where there is likely to be leakage or spillage of oil.
- The drainage system, including manholes, gullies, pipe connections, etc., should be protected from damage throughout the course of the construction works.
- Drainage trench excavations should be taken down to solid ground, but when this is not possible, the drainage system should be designed to accommodate any movement and made-up with a well-compacted backfill to the required formation levels.
- Where ground movement is likely to occur, flexible drainage systems should be provided, e.g. filled sites, mining areas and sites with shrinkable clay.
- Where possible, avoid passing adjacent to tree roots. Adequate precautions should be taken where this cannot be avoided, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer.

Layout of land drains

Drain runs on sloping sites need to be positioned perpendicular to the fall of the site.
Land drains should be positioned adjacent to paths, drives and outbuildings. The pipe soffit should be positioned at least 400mm below the finished ground level, and the backfill consolidated to the same degree of compaction as the adjacent soil.

Soakaways

Soakaways are a simple way of dispersing surface and storm water in circumstances where connection to the storm water sewer system is not feasible or unnecessary. A soakaway is basically a system that loses water rather than collects water. Soakaways are part of the Sustainable Urban Drainage Systems (SuDS) technologies that handle storm water at the source rather than leading it into the public sewer systems.

Developments proposing to use other types of Sustainable Urban Drainage Systems (SuDS) should follow the guidance found in '*SuDS Manual*' (a design manual published by CIRIA). The developer should also confirm if the Planning consent for the project imposes any additional requirements which may impact on the design of the sustainable drainage systems (SuDS).
Any surface water drain, soakaway or other infiltration system (including a SuDS system) which is intended to discharge to a water course should have Environment Agency consent to discharge.

Soakaways can only be considered in permeable conditions. A suitable site must be:

- In a location lower than the area being drained.
- At least 5m away from any building (BS 8301).
- Situated so that it will not saturate the foundations of any structure.
- Situated so that the base of any soakaway/infiltration system is permanently above the water table.
- Situated far enough away from other soakaways/infiltration systems to ensure that the capacity of those other systems and the ground itself is not impaired.
- Situated so that there is no risk of contamination from pollutants.

Installation of underground drains

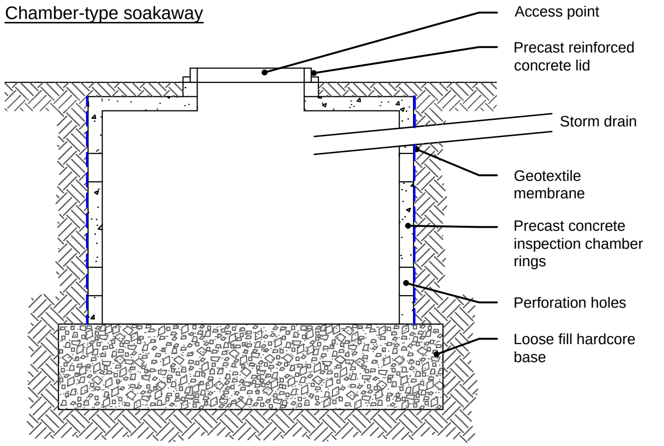
The depths of drains and the protection provided over them needs to be adapted to the traffic normal for the location, in accordance with the recommendations of the relevant Building Control body and the pipe manufacturer. Requirements are as follows:

- Pipes should be laid to an even gradient (see table 1), and significant changes in gradient should be combined with an access point.
- Pipes should be laid in straight lines, but may be laid to slight curves, providing the length of drain can be effectively cleaned by the use of rods.
- Connections should be to inspection chambers or manholes, but connections to junctions are acceptable if access is provided to clear blockages. In all cases, discharge should be in the direction of flow.
- Bends should be positioned in, or adjacent to, terminal fittings, inspection chambers or manholes, and at the foot of discharge stacks. Bends should have as large a radius as practicable.

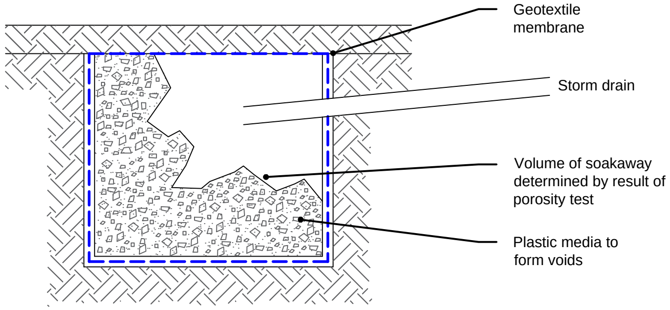
Table 1: Minimum gradient of drains

Pipe diameter (mm)	Minimum gradient
100	1:80
150	1:150

Chamber-type soakaway



Typical soakaway design



Typical soakaway design

For sites where chalk is prevalent, the CIRIA C574 Engineering in Chalk 2002 publication gives the following recommendations:

Concentrated ingress of water into the chalk can initiate new dissolution features, particularly in low-density chalk, and destabilise the loose backfill of existing ones. For this reason, any soakaways should be sited well away from foundations for structures or roads, as indicated below:

- In areas where dissolution features are known to be prevalent, soakaways should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations.
- Where the chalk is of low density, or its density is not known, soakaways should be sited at least 10m away from any foundations.
- For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipe work.
- As the chalk is a vitally important aquifer, the Environment Agency and Local Authority must be consulted when planning soakaway installations where chalk lies below the site, even where it is mantled with superficial deposits.

6.

External Walls

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. Certification is required for any specialist works and/or systems completed by an approved installer.
2. Cavities should be clear from mortar droppings to prevent moisture ingress.
3. Masonry walls should not be constructed in extreme weather conditions.

Materials

1. Timber frame elements should be appropriately protected to keep components dry.
2. Materials should be suitable for the relative exposure of the building in accordance with relevant British Standards.
3. Steel frames should be appropriately treated to prevent corrosion.

Design

1. The materials design and construction of external walls (including claddings), must meet the relevant regional Building Regulations.
2. Surfaces that will be subjected to water from the use of a showerhead, including over a bath should be tiled or have an appropriate alternative water-resistant finish.
3. Steel frame structures must be supported by structural calculations completed by a suitably qualified engineer. The design and construction must meet the relevant Building Regulations.
4. Where render external cladding is proposed as the waterproof envelope to the building, the backing materials/substrate wall, must be confirmed as suitable for the proposed render mix and/or system for the wind driven rain exposure zone.
5. External walls shall be designed and constructed so that they:
    a. Are structurally sound;
    b. Have adequate resistance to the effects of fire and will resist the spread of fire to adjacent buildings;
    c. Are durable and resistant to weather and ground moisture;
    d. Have an adequate thermal performance;
    e. Provide suitable surfaces to receive a range of finishes;
    f. Resist flanking sound transmission where adjacent to separating walls.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

6.

External Walls

6.1

Traditional Masonry Cavity Wall - Brick Clad

Structural design of walls

A method of meeting the requirements of the Warranty is to design and construct walls to the relevant Building Regulations depending on the region. For example, in England and Wales, the masonry units should be built in accordance with Approved Document A (Structure). Alternatively, justification of design by a Chartered Structural Engineer can be used as a solution.

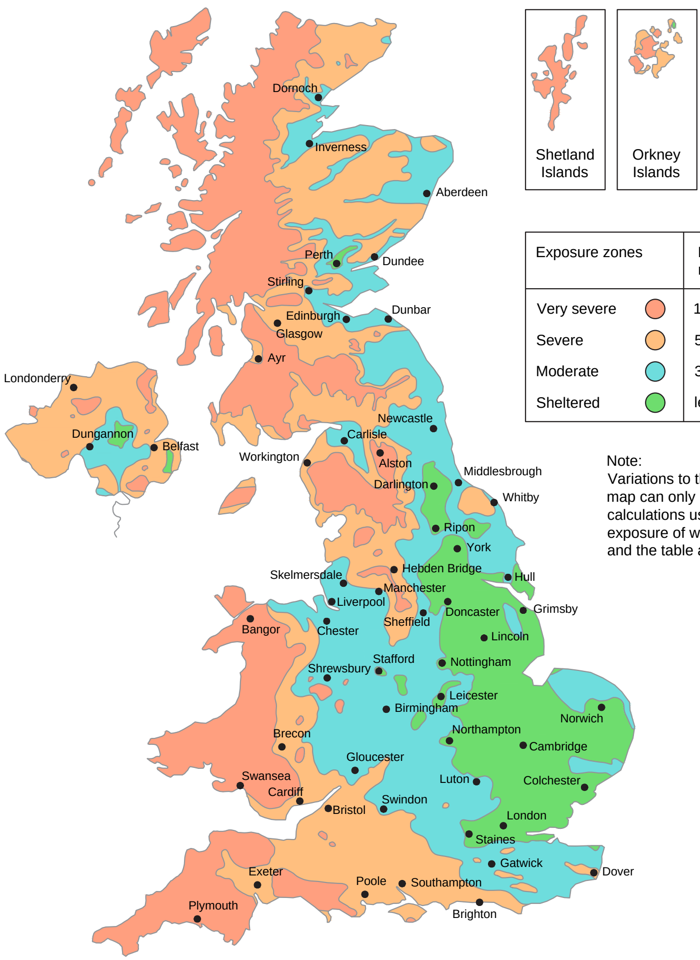
Dealing with areas of high exposure to frost and wind-driven rain

The design and construction of masonry cavity walls should be suitable for the site specific exposure location.

Wind-driven rain

To ascertain the risk relating to wind-driven rain, the following should be determined:

- The exposure to wind-driven rain, using the image below 'Map showing exposure to wind-driven rain categories'.
- The correct type of construction, including the correct application of insulation.
- The correct level of workmanship and design detailing, particularly around window and door openings.



Exposure zones	Exposure to wind driven rain (litres/m² per spell)
Very severe	100 or more
Severe	56.5 to less than 100
Moderate	33 to less than 56.5
Sheltered	less than 33

Note:
Variations to the exposure shown on the map can only be made by site-specific calculations using BS 8104 "Assessing exposure of walls to wind driven rain" and the table above.

The suitability of full fill cavity insulation in exposure locations

The following table outlines the minimum cavity widths for full fill insulation types in varying exposure locations. Full fill cavity wall insulation is not suitable for very severe exposure zones.

Suitable cavity wall construction depending on exposure, for use with full fill cavity insulation

		Minimum insulation thickness (mm)		
Exposure category	**Suitable wall construction**	**Built-in insulation**	**Retro-fill (other than UF foam)**	**UF foam**
Very Severe (Exposure zone 4)	Any wall with impervious cladding	50	50	50
	Fair-faced masonry with impervious cladding to all walls above ground storey	100	100	N/A
	Any wall fully rendered (2)	75	75	N/A
	Fair-faced masonry (1)	N/A	N/A	N/A
Severe (Exposure zone 3)	Any wall with impervious cladding or render (2)	50	50	50
	Fair-faced masonry with impervious cladding or render (2) to all walls above ground storey	50	75	50
	Fair-faced masonry (1)	75	75	N/A
Moderate (Exposure zone 2)	Any wall with impervious cladding or render (2)	50	50	50
	Fair-faced masonry with impervious cladding or render (2) to all walls above ground storey	50	50	50
	Fair-faced masonry	50	75	75
Sheltered (Exposure zone 1)	Any wall with impervious cladding or render.	50	50	50
	Fair-faced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fair-faced masonry	50	50	50

Notes:
- (1) In very severe exposure locations, fair-faced masonry with full fill cavity insulation is not permitted
- (2) Render on an external leaf of clay bricks (F2, S1 or F1, S1 designation bricks BS EN 771) in ***severe*** or *very severe* exposures is not permitted where the cavity is to be fully filled with insulation.
- This table covers walls where the external leaf does not exceed 12m in height.
- The exposure category of the building is determined by its location on the map showing categories of exposure to wind-driven rain (see also BRE Report 262).
- Fair-faced masonry includes clay, calcium silicate and concrete bricks and blocks and dressed natural stone laid in an appropriate mortar, preferably with struck, weathered or bucket handle joints. Cavity walls of random rubble or random natural stone should not be fully filled.
- Recessed mortar joints should not be used.

Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

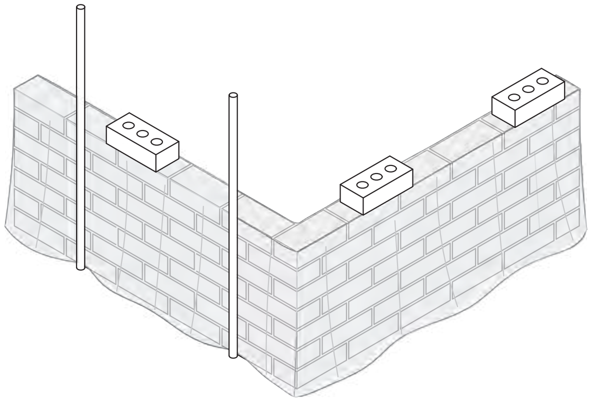
Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.

Masonry walls

Protection
All new masonry work should be protected during construction by covering it to ensure that walls are not allowed to become saturated by rainwater, dry out too quickly in hot weather, are protected against frost attack, the risk of efflorescence and line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

Protection of masonry



Working in adverse weather

Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in 'Appendix C - Material, Products, and Building Systems'.

During prolonged periods of hot weather, when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e. engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Exposure
Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further information can be found in 'Appendix C - Material, Products, and Building Systems'.

Colour variation of bricks
There is usually a variation in the colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations
Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength, helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure, which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention/collection has been found to exist in the perforations.

Efflorescence
Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use.
- Protecting the head of newly constructed work with some form of cover to prevent saturation.

Frost attack
Frost-resistant bricks should be used in areas that are prone to prolonged periods of frost.

If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Mortar

General
A mortar type above DPC should be chosen in accordance with the guidance given in the 'External Walls' and 'Appendix C - Material, Products, and Building Systems' sections, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and/or air entraining plasticisers may be added to cement in accordance with the manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching
Keep batching and mixing equipment clean to avoid contamination with materials used previously, mortar should be mixed by machine, or use ready mixed retarded mortars.

Mixing
Mortar should be carefully and consistently proportioned and then thoroughly mixed using a mechanical mixer, except for very small quantities.

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

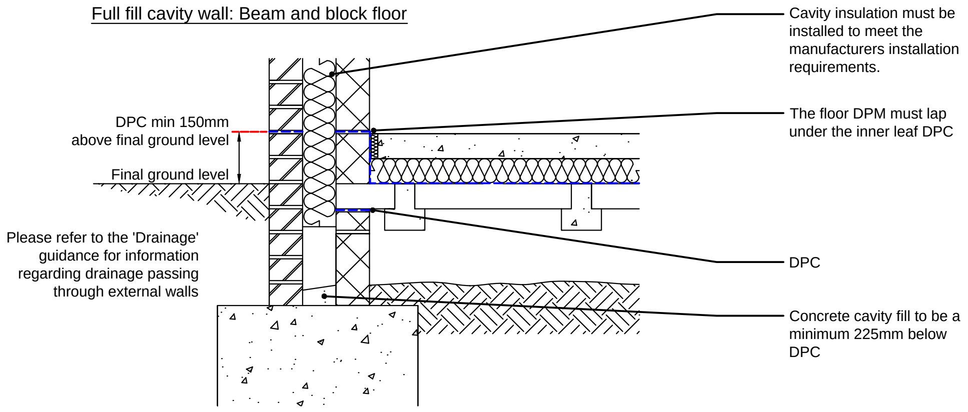
Key points: Construction below DPC

1. Brickwork and blockwork must be selected to have suitable durability for its use in the wall construction in accordance with BS EN 771-1 and PD 6697.
2. Mortars below DPC are exposed to higher levels of saturation and therefore require higher durability classification (see BS EN 998-2).
3. Cavities below ground should be filled with concrete ensuring there is a minimum gap of 225mm between DPC and the top of concrete.
4. Concrete for cavities should be GEN 1 grade and a consistence class S3.
5. External ground levels should be a minimum of 150mm below DPC.
6. The compressive strength of the masonry units must meet the requirements of the relevant regional Building Regulations.

Damp proof courses (DPC)

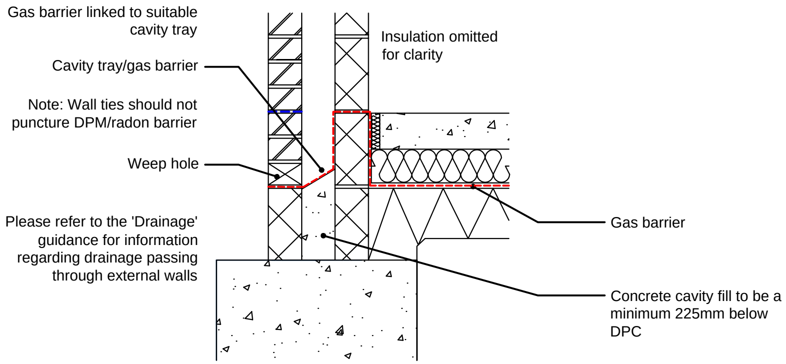
1. DPCs should be of a flexible material, be suitable for the intended use, the DPC should have appropriate 3rd party certification. The installation specification of DPC's should follow good design practice in accordance with BS 8215.
2. Blue bricks or slate will not be accepted as a DPC.
3. DPC's should be laid on a mortar bed and correctly lapped at junction and corners. The depth of the lap should be the same width as the DPC.
4. The DPC should not bridge any cavity unless it is acting as a cavity tray where a cavity is required (e.g over a telescopic floor vent).
5. Damp proof membranes should be lapped with the DPC a minimum overlap of 100mm. DPM's should be at least a minimum 1200 gauge thickness.

Full fill cavity wall: Beam and block floor

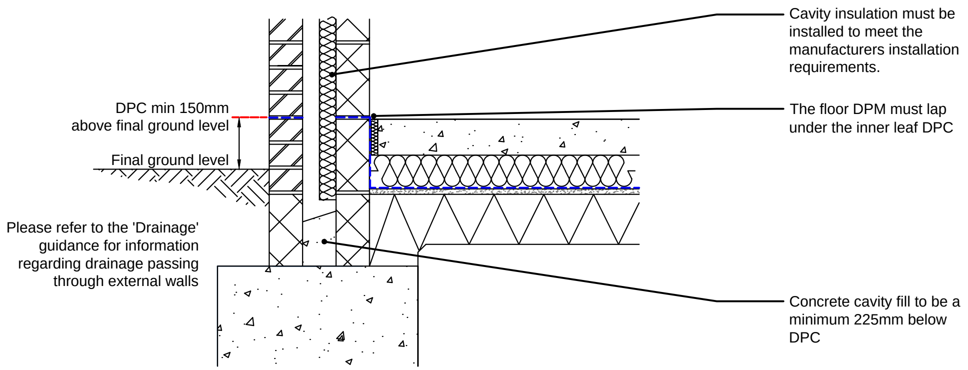


Note: For very severe exposure locations, fair faced masonry with a full fill cavity insulation is not permitted. A partial fill insulation will be necessary

Typical gas barrier arrangement: Traditional ground bearing slab



Partial fill cavity wall: Traditional ground bearing slab



Cavities

A traditional masonry wall should be constructed using an inner and outer leaf, and a cavity should be provided between them, which meet the following provisions:

- The cavity should have a minimum width of 50mm.
- It is to be kept clear from mortar snots to ensure the cavity is not bridged.
- The two leaves should be appropriately tied.
- The cavity can be fully or partially insulated, depending on exposure to wind driven rain. For partial fill insulation, a minimum clear residual cavity of 50mm should always be provided. Further information can be found in BS 8104.
- A 75mm minimum residual cavity will be required to partial fill insulated cavities in very severe exposure locations.
- For very severe exposure locations, fair faced masonry with a full fill cavity insulation is not permitted. A partial fill insulation will be necessary.

Brick suitability

- Facing bricks must have a suitable level of durability and particular attention should be paid to the bricks resistance to frost and moisture.
- Bricks should be capable of supporting proposed loads.
- Bricks should comply with BS EN771 and PD 6697.
- Frost resistant bricks should be used in areas of prolonged frost.

Internal skin (blockwork)

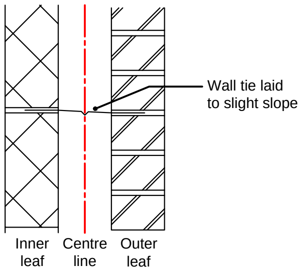
- The blockwork should be capable of supporting the proposed loads and achieve the required thermal performance.
- The blockwork should have appropriate compressive strength in accordance with the Building Regulations.
- The blockwork should comply with BS EN771 and PD 6697.

Cavity Barriers

Cavity barriers should be provided in the external cavity at all compartment walls and floor junctions.

Cavity barriers should have suitable third party accreditation.

Wall tie provision



Wall ties

Wall ties should meet the following provisions:

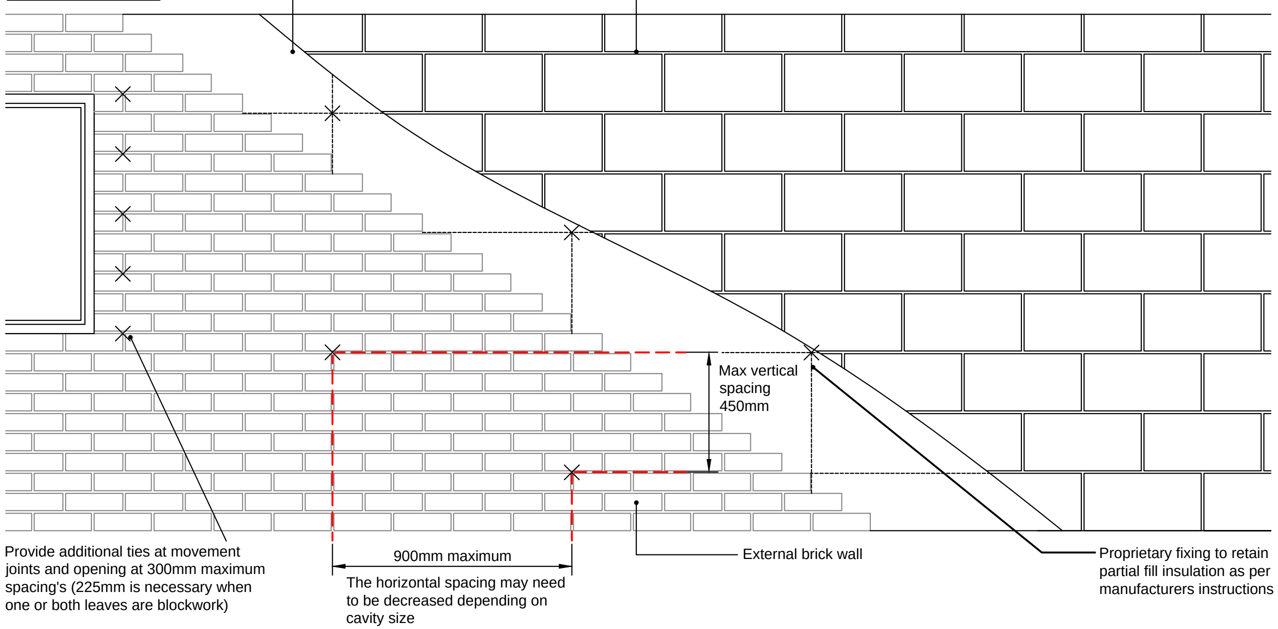
- Wall ties should be to BS EN 845-1 or have appropriate third party certification.
- The overall length of the wall ties must be long enough to ensure there is at least a 62.5mm overlap onto each leaf of masonry, so that it will achieve a 50mm minimum length of bedding onto the mortar.
- Wall ties should be laid to a slight fall towards the outer leaf and have the ability to hold insulation against an internal leaf for partial fill scenarios.
- Where a partial fill cavity insulation solution is proposed, a 50mm minimum residual cavity is to be provided.
- Wall ties should be in a staggered in a diamond pattern.
- Wall ties should be installed at a minimum density in accordance with BS EN 1996 -1-1: 2015 NA. This should not be less than 2.5 ties per m2 and may increase with cavity width.
- Wall ties should be spaced so that the minimum density is not less than 2.5 ties per M2.

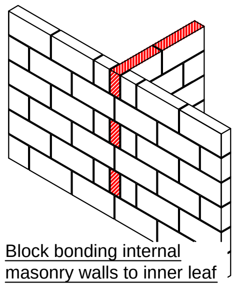
Thermal insulation

Thermal insulation for cavity walls should be inserted to a high standard of workmanship to avoid poor insulation performance and to prevent dampness migrating to the inside of the building:

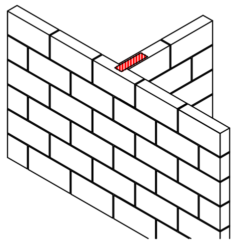
- Insulation should have appropriate third party certification and be installed in accordance with the manufacturers instructions.
- Insulation should not be cut or pierced to accommodate wall ties, unless increased centres at reveals or expansion joints are required. The wall ties should coincide with insulation joints.
- Partial fill insulation should be clipped or retained to the inner leaf using proprietary fixings in conjunction with wall ties.
- For full fill cavities, mortar joints to facing brickwork should not be recessed.

Spacing of wall ties





Block bonding internal masonry walls to inner leaf



Block bonding internal walls to inner leaf using ties

Bonding internal walls to external cavity walls

Bonded walls in brickwork are comparatively easy to construct, but this can be more difficult with blockwork, so either:

- Tooth every alternative course, or butt and tie.
- Where blocks are of a different density, always use a butted joint; party walls carry the separating wall through and butt up the inner leaf using a proprietary bed joint, reinforcement or suitable ties at each block course.

Wall ties

Wall ties should meet the provisions detailed in this section, including the following:

- Stainless steel wall ties should always be used.
- It is important to note that only BS EN 845-1 type wall ties or specifically manufactured (and tested) party wall ties are permitted in cavity separating walls between dwellings to reduce the transfer of sound.

Suitability and spacing of wall ties

Wall tie spacing

Unfilled or fully filled cavities		**Spacing of ties**	
Width of cavity	Recommended tie	Horizontal	Vertical
50mm to 75mm wide	Butterfly Double triangle Vertical twist Proprietary ties	900mm	450mm (increased to 300mm at reveals and movement joints)
75mm to 100mm wide	Double triangle Vertical twist	900mm	450mm (increased to 300mm at reveals and movement joints)
100mm to 150mm wide	Vertical twist	750mm	450mm (increased to 300mm at reveals and movement joints)
Greater than 150mm	Wall tie specification and design to be provided by a Chartered Structural Engineer, or in accordance with appropriate third-party certification. Design will be determined by location and site-specific conditions.		

Proprietary ties are to have appropriate third-party certification.

Proprietary insulation retaining clips compatible with the tie should be used where the cavity is partially filled.

Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in the table below. The first joint from a return should be no more than half the dimension indicated in the table.

Movement joints below the DPC should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm centres should be provided on each side of movement joints.

Compressible filler, such as polyurethane foam, should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

When sealants are used in proximity with stone it is important to select a non-oil-based sealant to help prevent any staining to the stone.

Elastic sealants (Type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

Where a backing material is used, the following must be considered:
- The material is compatible with the sealant.
- It will not adhere to the sealant, preventing cracking within the sealant.
- Provides sufficient density to allow the sealant to be applied.
- Allows sufficient flexibility so not to impede lateral movement (compressible to about 50% of its original thickness), fibreboard is not acceptable.

The use of bed joint reinforcement may allow the distance between expansion joints to be increased, however this should be designed by a Structural Engineer.

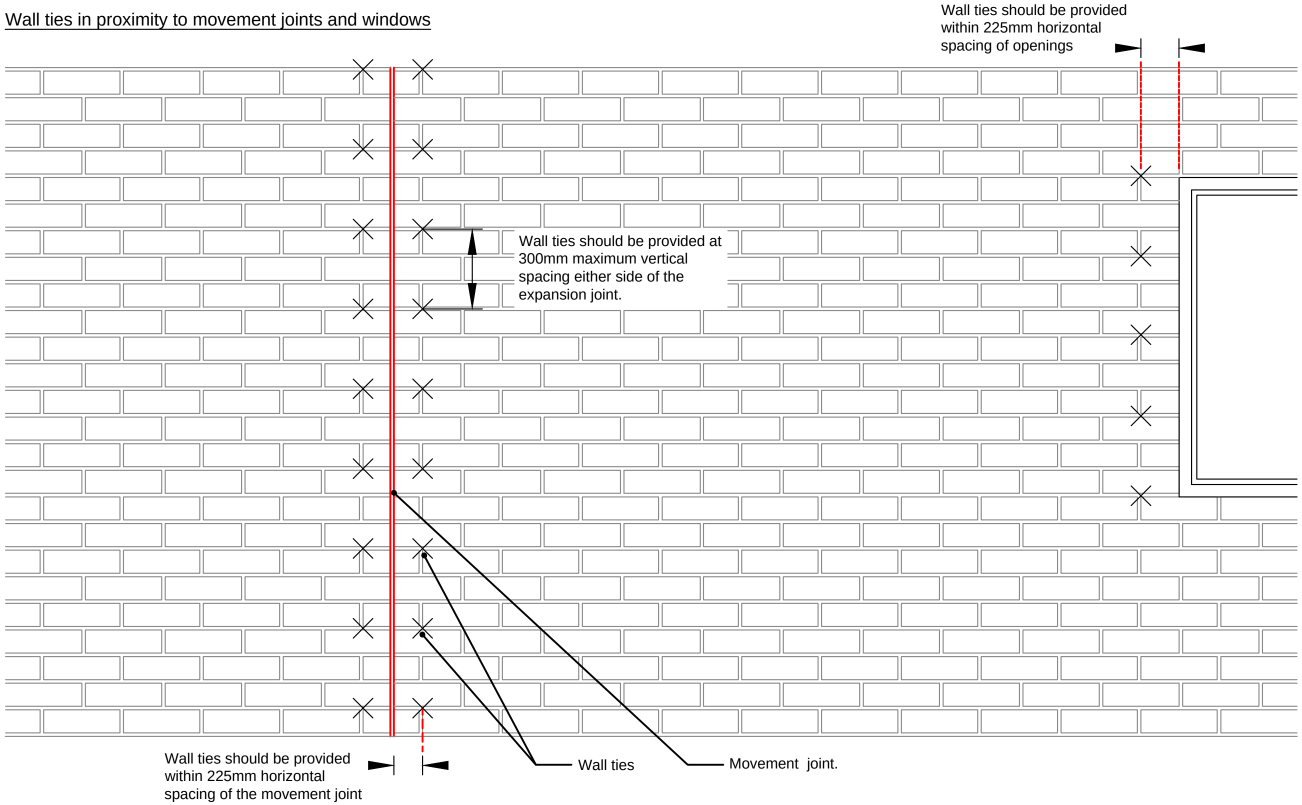
Spacing of expansion joints

Material	**Normal spacing**	**Joint thickness**
Clay brickwork	12m (spacing up to 15m may be possible if sufficient restraint is provided - consult designer)	15mm
Calcium silicate	7.5-9m	10mm
Concrete brickwork (1)	6m	10mm
Note: It is not normally necessary to provide movement joints to the internal leaf of cavity walls, but it should be considered for rooms with unbroken lengths of wall in excess of 6m. The first joint from a return should be not more than half the dimension indicated in the table. Movement joints are not acceptable in solid party or separating walls; however, where cavity wall construction is adopted, offset movement joints with a solid rubber compressible strip may be acceptable. (1) Where openings are over 1.5m, masonry bed joint reinforcement should be considered		

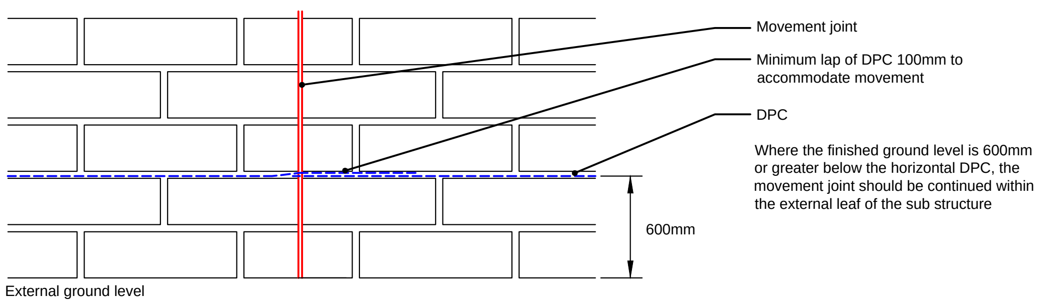
Movement joints

- Vertical movement joints should be provided in accordance with this Technical Manual and the manufacturers guidance.
- Wall ties should be provided at 300mm maximum vertical spacing either side of the expansion joint, and within 225mm horizontal spacing of the movement joint.
- Compressible filler, such as polyurethane foam, should be used to form the joint.
- Fibre board or cork board are not suitable materials for forming movement joints.
- The joint should be sealed to prevent water penetration.
- It is not normally necessary to provide movement joints to internal leaf of cavity walls, but should be considered where rooms occur with unbroken lengths of wall in excess of 6m.

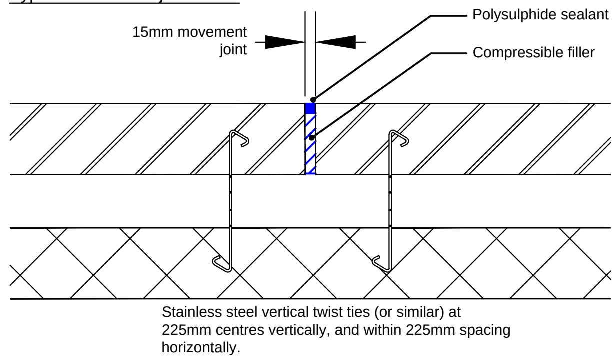
Wall ties in proximity to movement joints and windows



Movement joints below DPC



Typical movement joint detail



New elements connecting to existing structures

Where residential developments are attached to existing buildings, and the existing elements form part of the new structure; these must meet the Functional Requirements of the Warranty. The details below give some guidance on the minimum information and standards required to meet the Functional Requirements.

Party wall

It is highly likely that improvements to an existing wall are necessary to meet the requirements of the Warranty. This may include underpinning, injected DPC and internal linings.

Where a wall is shared by two or more owners, the requirements of the Party Wall etc. Act may apply. This is separate legislation with different requirements to the Building Regulations or Warranty requirement.

Further guidance on the Party Wall etc. Act can be found on the Planning Portal website www.planningportal.gov.uk

Separating walls

The separating wall between the new and existing building must meet the relevant requirements of the Building Regulations.

The existing walls should prove to be structurally stable and resistant to water penetration.

Existing foundations

The existing foundations and wall structure must be suitable to support any proposed increased loading resulting from the construction of the new building.

Foundations to the existing wall should be exposed and assessed for suitability to support additional loadings. It is important to protect existing foundations at all times, and care must be taken not to 'undermine' existing foundations when clearing the site or reducing levels.

Where existing foundations require underpinning, a design by a Chartered Structural Engineer should be provided and approved by the Warranty Surveyor prior to work commencing on-site.

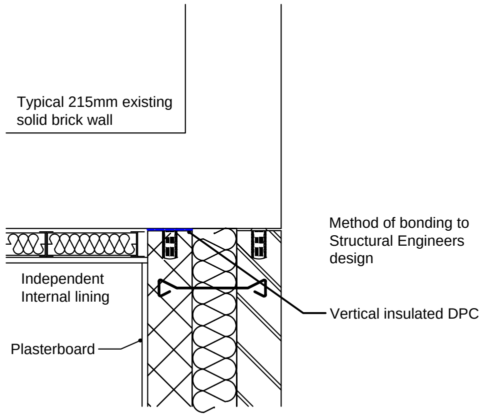
The existing wall should also be appraised to determine whether it is structurally stable and suitable to support additional loadings.

New wall junctions

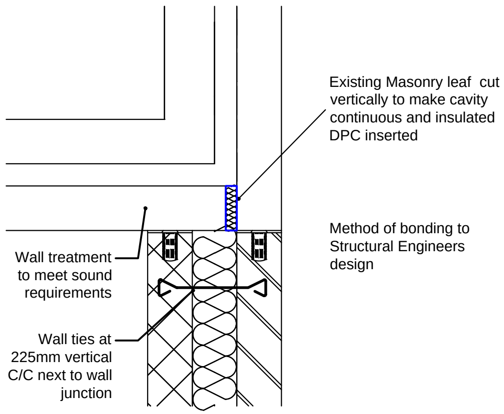
The junction of the new walls to the existing walls must ensure that dampness cannot track back into the new building or the existing building.

The detailing of this junction is critical to ensure that moisture ingress does not occur between the new and existing walls. Typical acceptable details are indicated below.

Bonding new walls to existing solid masonry wall



Bonding new walls to existing masonry cavity wall



Damp Proof Course (DPC)

An effective DPC should be present in the existing wall, linked to the new DPC and damp proof membrane (DPM) of the new building.

Acceptable existing DPCs are considered as:

- A continuous felt or proprietary DPC material.
- A chemically injected DPC supported by an insurance-backed guarantee.
- A slate DPC is considered acceptable if the existing wall incorporates an independent wall lining system to the inner face of the new building.

The new DPC should lap the existing DPC by at least 100mm.

Existing and new structure junctions

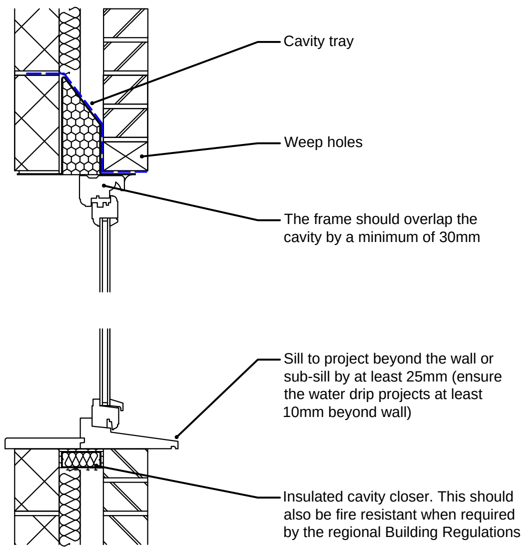
At the junction of the existing and new structures, detailing should allow for differential movement without cracking. Any settlement should be limited to 2mm-3mm, which would not normally adversely affect the roof covering.

In order to prevent excessive differential movement, the new building should have the same foundation type as the existing building. Where the foundation types are different, e.g. new building pile and beam, existing building traditional strip foundation, the new building should be completely independent of the existing building.

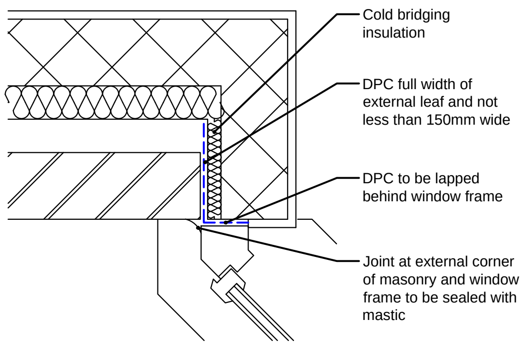
Window and door installations

Please refer to the 'Windows and Doors' section for installation requirements of frames including maximum gaps and fixings.

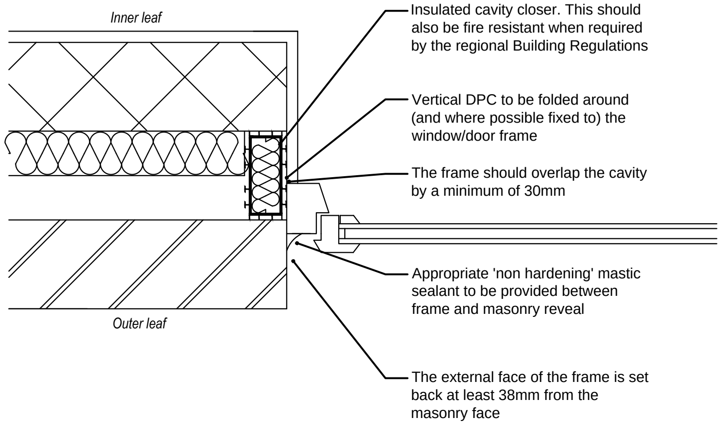
Typical vertical section through window opening



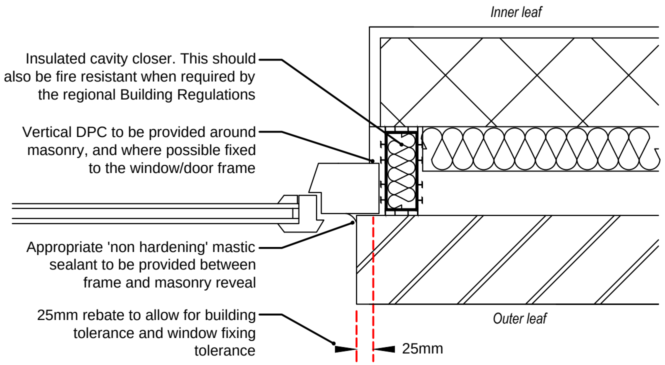
Bay window detail



Typical window reveal detail (normal exposure)



Typical rebated window frame detail for areas of very severe exposure



When installing window/door frames in a checked rebate, allow for the frame to be deeper:

- To accommodate the 25mm rebate, and
- To allow for opening lights to open clear of the masonry/render.

Windows and doors

In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap.

A suitable DPC must be provided at all window and door openings to prevent the passage of damp to the internal finishes. A third party certified cavity closure may be used.

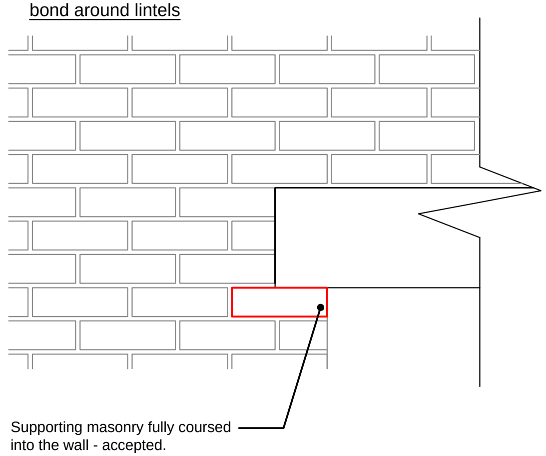
Lintels

- The lintel should be the correct length and width for the opening and cavity width, the bearing length should be at least 150mm.
- Do not let masonry overhang lintels by more than 25mm.
- Continuity of the masonry bond should be maintained at supports for beams and lintels.
- Lintels should be insulated to prevent excessive thermal bridging.

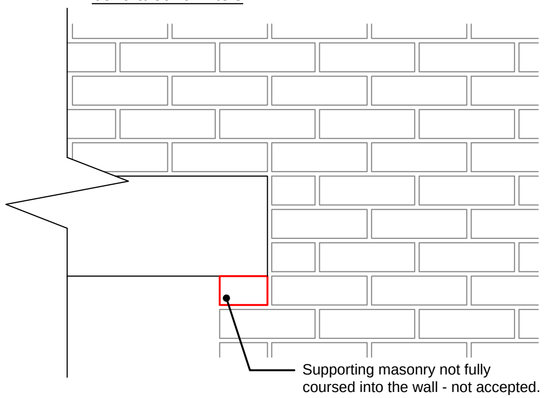
Do not:

- Support lintels and beams on short lengths of cut blocks or make-up pieces.
- Apply load to lintels or beams before the masonry supporting has hardened.

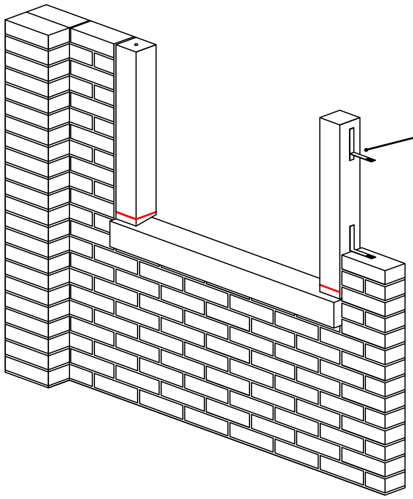
Correct method of brick bond around lintels



Incorrect method of brick bond around lintels



Stone jamb mullion fixing to walls

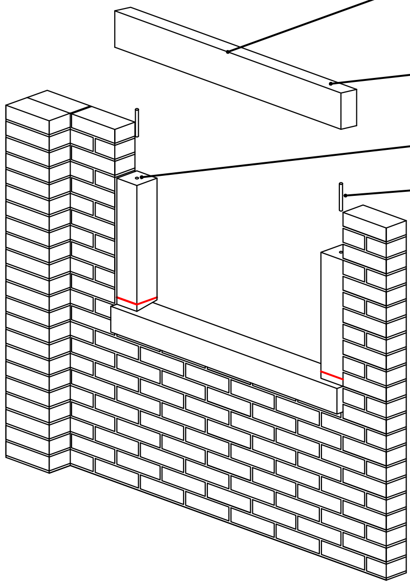


Stone jambs, mullions, and heads should not project into the cavity and insulated cavity closers should be inserted to prevent cold bridging (see typical window opening sections)

Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame-type cramps can also be used to give extra stability at jambs

Mortar:
The mortar for use with stone should comply with the relevant British Standards for sand, lime, and cement as set out in BS 5390

Joining stone jambs to sills and head



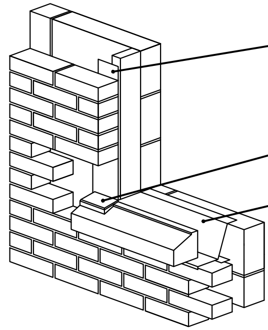
Cavity Trays

When stone heads are being used, it is advisable to double up the cavity trays - with one above the stone head to provide stop-ends and weep-holes

Cast stone jambs and mullions

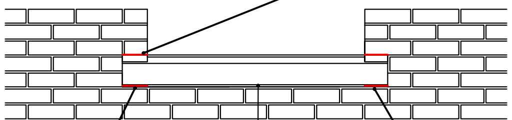
Stainless steel dowels in the sides of jambs should be bedded into adjacent mortar joints as the masonry is constructed

Stone sill with insulated cavity closer



Note: The insulated cavity closer should also be fire resistant when required by the relevant Building Regulations

Stone sill



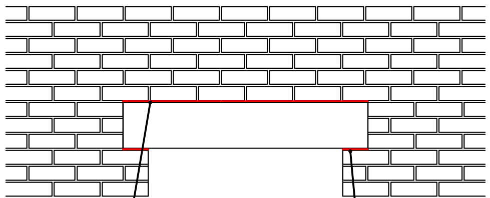
Sills

The DPC should be overlapped by the vertical DPC at the jambs and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off, and then a DPC laid over. The open section below the sill should be sealed with a flexible material only on completion of the structure.

To control water penetration through joints in window surrounds, e.g. at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

Stone head



Cast stone heads

A cavity tray must be provided above all heads as this not only discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head as well as a soft joint between the top of the head and the steel support lintel.

Cast stone heads should be manufactured in accordance with BS 1217, confirmation of this should be provided to the Warranty Surveyor upon request.

Cast stone window/door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement e.g. where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated or the cast stone should be flexibly jointed.

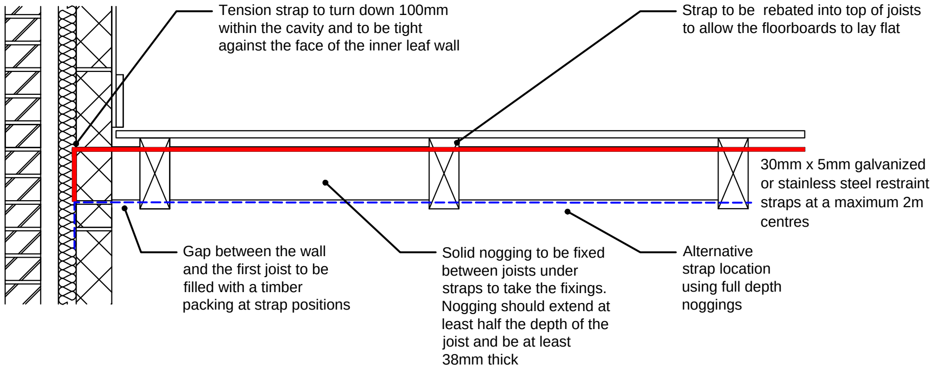
Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

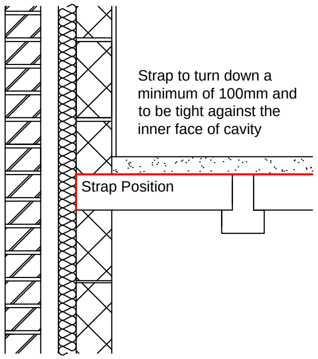
Restraint can be provided by:

- Lateral restraint straps.
- Restraint type joist hangers.
- Other forms of restraint proven by a Chartered Engineer.

Lateral restraint of walls (timber floors)



Lateral restraint of walls (beam and block floors)



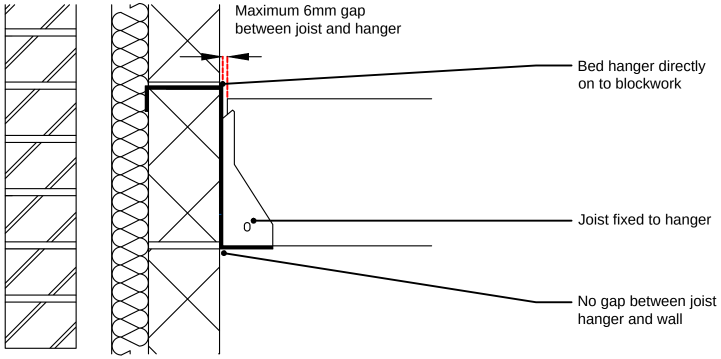
Lateral restraint straps

Floors, including timber, block and beam, and roofs should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanised or stainless steel restraint straps at a maximum 2m centres (please refer to the 'Upper Floors' section for further guidance). Straps need not be provided to floors at, or about, the same level on each side of a supported wall and at the following locations:

Timber floors in two storey buildings where:

- Joists are at maximum 1.2m centres and have at least 90mm bearing on supported walls or 75mm bearing on to a timber wall plate.
- Carried by the supported wall by restraint type joist hangers as described in BS 5268: 7.1.
- Concrete floors with minimum 90mm bearing on supported wall.

Typical restraint type joist hanger



Restraint type hangers

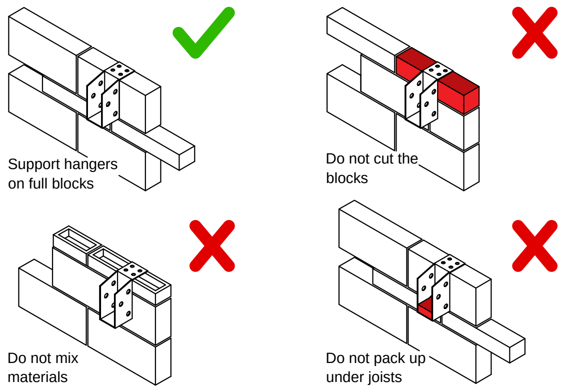
It is necessary to ensure that:

- The hanger is bedded directly on the masonry and there is no gap between the hanger back-plate and the face of the masonry.
- At least 450mm of masonry is provided above the hanger.
- Hangers are spaced at centres of floor joists included in the design.
- The hanger is suitable for the loadings and masonry strength.

Do not:

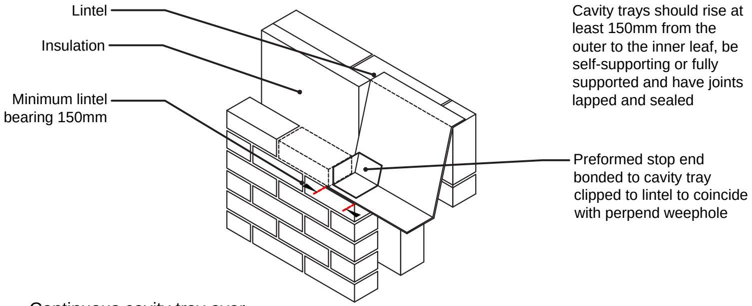
- Apply load while the mortar is still green and has not gained sufficient strength.
- Use brick courses in block walls under joist hangers as the thermal insulation of the wall may be reduced unless similar units to the blocks are used.

Correct use of hangers

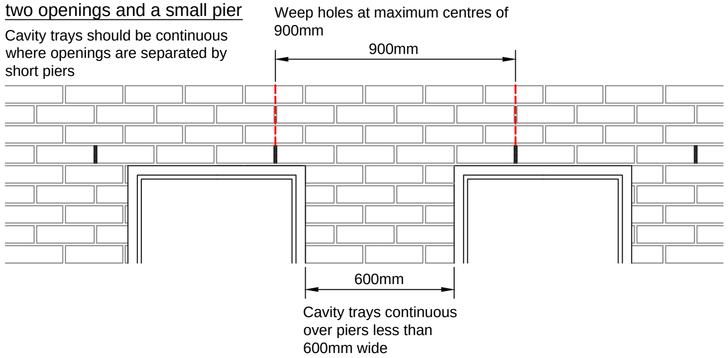


TRADITIONAL MASONRY CAVITY WALL - BRICK CLAD: Cavity trays

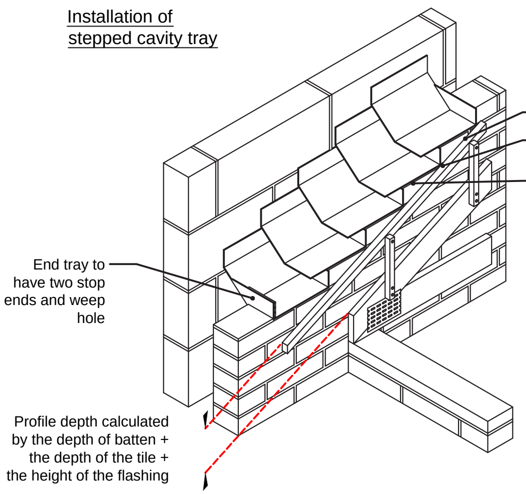
Stop end to cavity tray



Continuous cavity tray over two openings and a small pier



Installation of stepped cavity tray



Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of buildings with steps and staggers. A proprietary cavity tray system should be used, or alternatively, a suitable tanking system. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g. attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape over the lower roof covering. For masonry, lead cover flashings should be linked into the cavity tray (lapped in below).

Cavity trays

Cavity trays, associated weep-holes and stop-ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- Cavity trays are to be provided to comply with relevant regional Building Regulations.
- At all interruptions likely to direct rain water across the cavity, such as rectangular ducts, lintels and recessed meter boxes.
- Above cavity insulation that is not taken to the top of the wall, unless that area of wall is protected by impervious cladding.
- Above lintels in walls in exposure zones 4 and 3, and in zones 2 and 1 where the lintel is not corrosion-resistant and not intended to function as its own cavity tray.
- Continuously above lintels where openings are separated by short piers.
- Above openings where the lintel supports a brick soldier course.

Ring beams or floor slabs that partially bridge the cavity, e.g. when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray, especially when full fill cavity insulation is employed.

Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level. When the wall is to be cavity filled, it is advisable to reduce this spacing.

At least two weep-holes must be provided to drain cavity trays above openings.

Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind-driven rain (including ground level).

Stop-ends

Cavity trays should have water tight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, so that a stop to the structural cavity of at least 75mm high is provided. Normally, the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

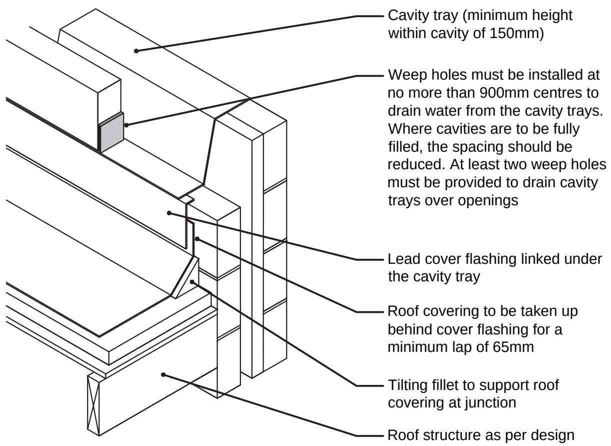
Other perforations of the building envelope

Proprietary elements, such as ventilators, soil pipes, etc. which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

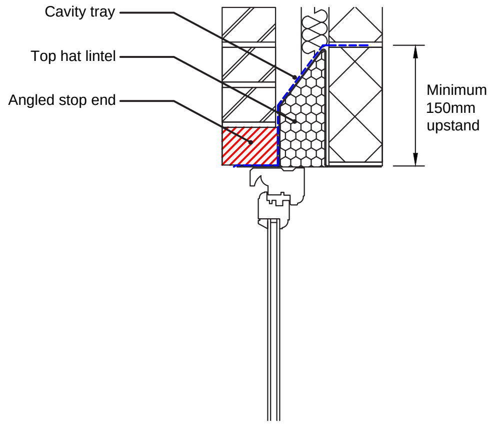
Proprietary cavity wall systems

At stepped and lower storey abutments and around corners in low rise cavity masonry walls a proprietary cavity tray system should be used.

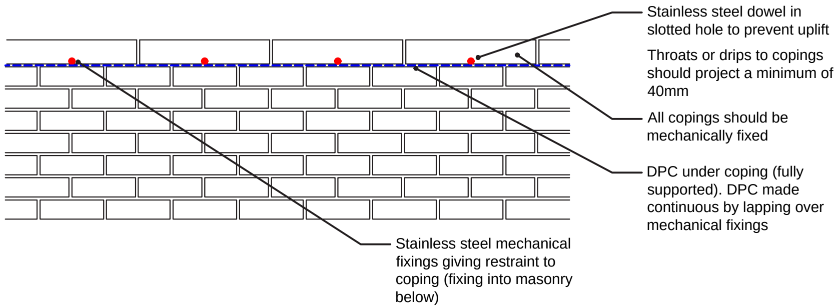
Flat roof abutment cavity tray construction



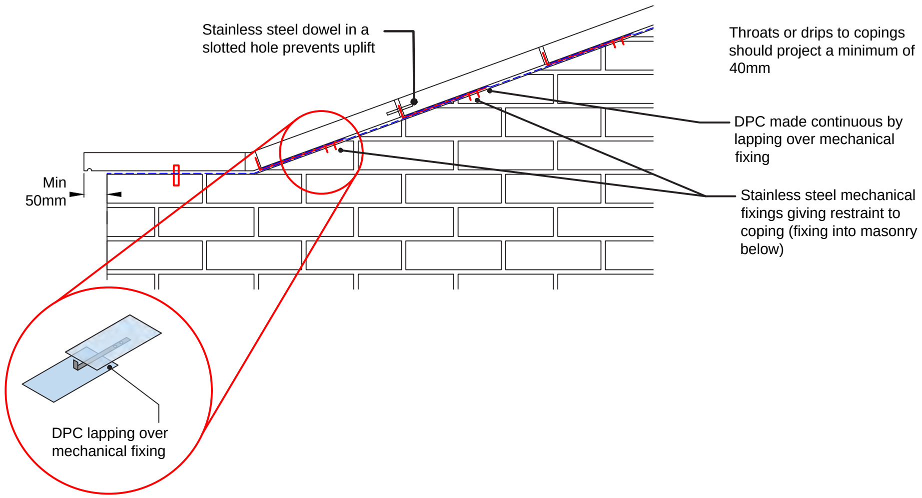
Stop end in relation to cavity tray and lintel



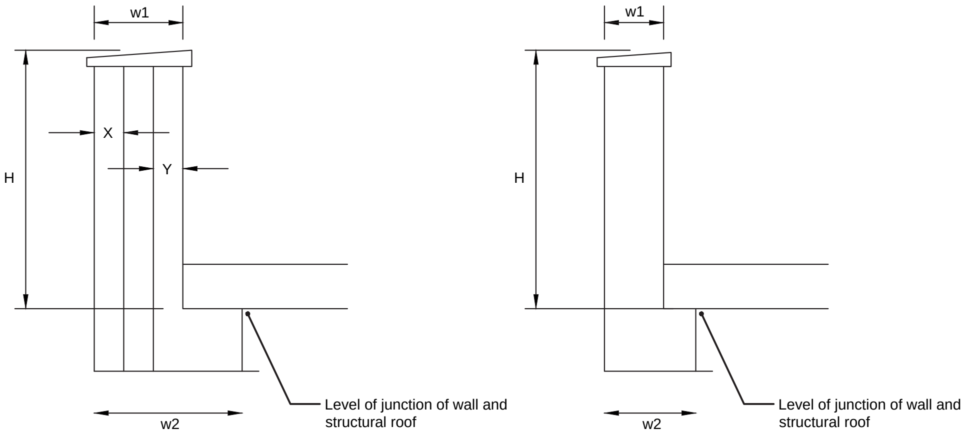
Fixing of copings onto horizontal parapets



Fixing of copings to sloping parapets

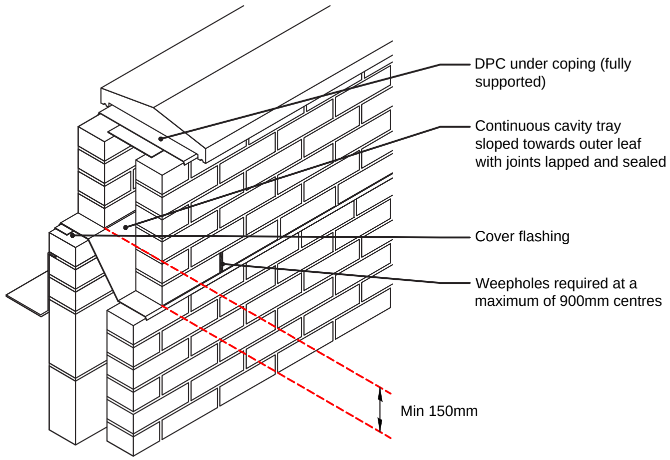


Maximum height of parapet walls (to be read in conjunction with the table below)



Wall type	Thickness (mm)	Parapet height to be no more than (mm)
Cavity wall	x + y equal or less than 200 x + y greater than 200 equal or less than 250	600 860
Solid wall	w1 = 150 w1 = 190 w1 = 215	600 760 860
Note: w1 should be less than w2 - as shown above		

Parapet wall detail

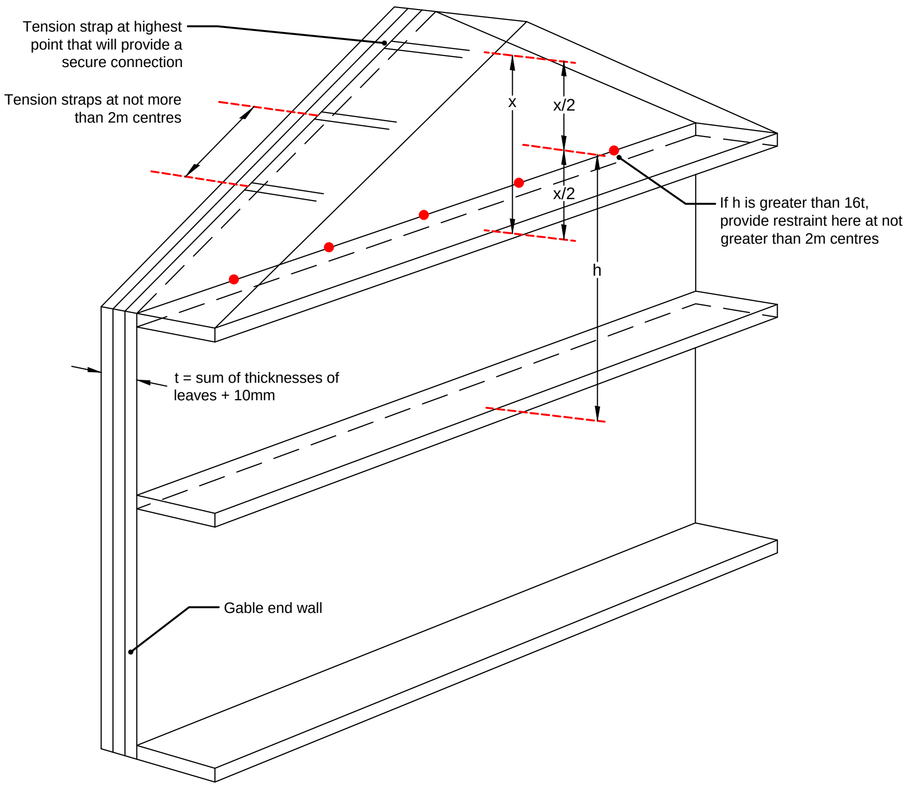


Parapets

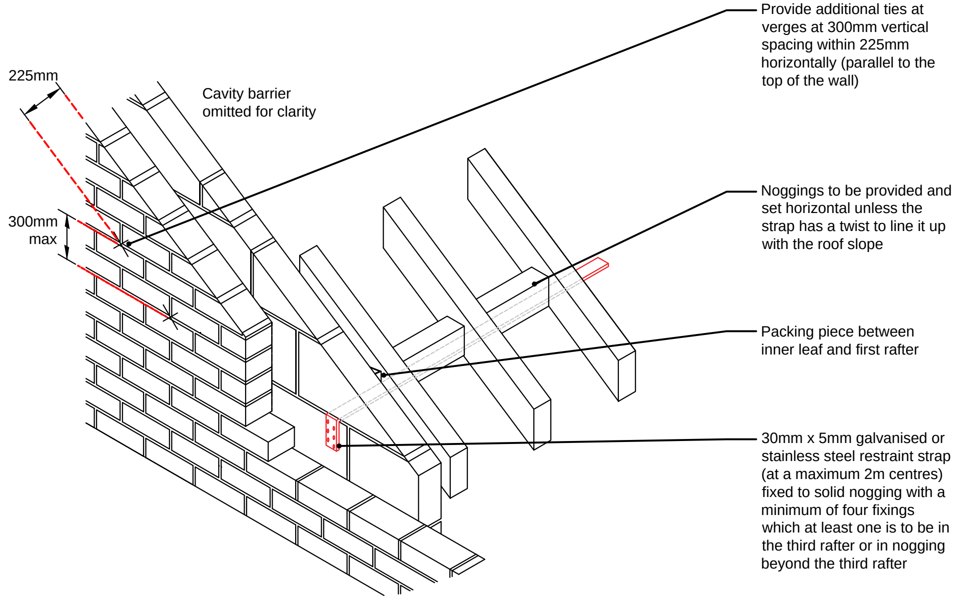
- The materials used in construction of the parapets details should be suitable for the location and exposure.
- Where possible, the use of raking parapets should be avoided due to need for high standards of detailing and workmanship required to prevent the ingress of moisture.
- In very severe exposure zones, it is recommended that parapet construction is avoided altogether.
- Throats or drips to copings of parapets and chimneys should project beyond the finished faces by a minimum of 40mm distance to throw water clear.

TRADITIONAL MASONRY CAVITY WALL - BRICK CLAD: Lateral restraint of walls

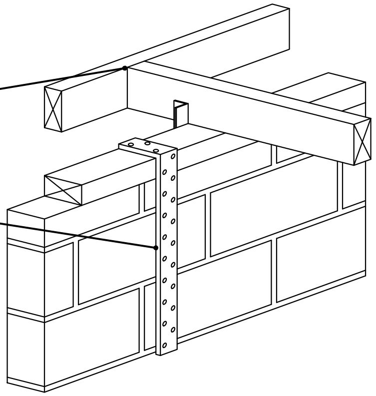
Tension strap location



Rafter/gable wall detail

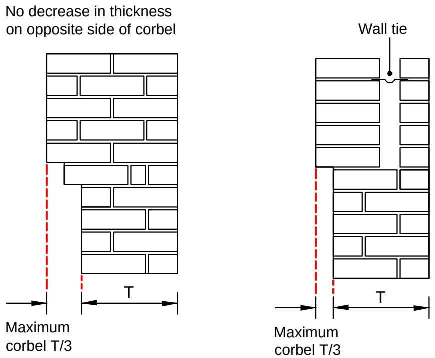


Vertical strapping at eaves - flat roofs



Corbelling

The extent of corbelling of masonry should not exceed that indicated in the below detail, unless supported or reinforced. Reinforced corbels should be designed by a Charted Structural Engineer.



Restraint of Walls

Walls should be adequately restrained at floors, ceilings, and verges in accordance with the relevant Building Regulations.

Restraints can be provided by:

- Restraint type joist hangers.
- Lateral restraint straps.
- Other forms of restraint proven by a Charted Engineer.

Insulation

Insulation should extend to the full height of the gable wall.

Chimneys

If the chimney is in a severe exposure zone the cavity should extend around the outside of the stack and be continuous up to roof level, as per BS 5628, Part 3. Where the chimney breast is gathered in, the lower projecting masonry should be protected with a suitable capping and cavity trays. A 50mm cavity at the back of the chimney breast is maintained to prevent rainwater penetration.

Further guidance can be found in the 'Chimneys and Flues' section.

6.

External Walls

6.2

Traditional Masonry Cavity Wall - Rendered Masonry Clad

Structural design of walls

A method of meeting the requirements of the Warranty is to design and construct walls to the relevant Building Regulations depending on the region. For example, in England and Wales, the masonry units should be built in accordance with Approved Document A (Structure). Alternatively, justification of design by a Chartered Structural Engineer can be used as a solution.

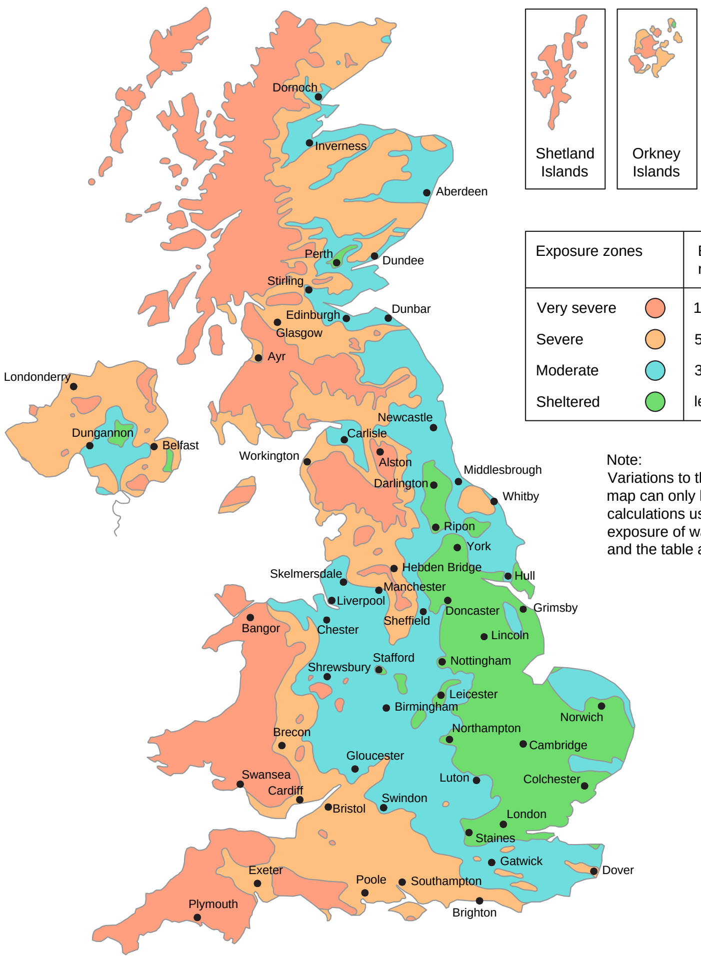
Dealing with areas of high exposure to frost and wind-driven rain

The design and construction of masonry cavity walls should be suitable for the site specific exposure location.

Wind-driven rain

To ascertain the risk relating to wind-driven rain, the following should be determined:

- The exposure to wind-driven rain, using the image below 'Map showing exposure to wind-driven rain categories'.
- The correct type of construction, including the correct application of insulation.
- The correct level of workmanship and design detailing, particularly around window and door openings.



Exposure zones	Exposure to wind driven rain (litres/m² per spell)
Very severe	100 or more
Severe	56.5 to less than 100
Moderate	33 to less than 56.5
Sheltered	less than 33

Note:
Variations to the exposure shown on the map can only be made by site-specific calculations using BS 8104 "Assessing exposure of walls to wind driven rain" and the table above.

The suitability of full fill cavity insulation in exposure locations

The following table outlines the minimum cavity widths for full fill insulation types in varying exposure locations. Full fill cavity wall insulation in fully rendered walls on concrete blockwork should be a minimum of 75mm.

Suitable cavity wall construction depending on exposure, for use with full fill cavity insulation

		Minimum insulation thickness (mm)		
Exposure category	**Suitable wall construction**	**Built-in insulation**	**Retro-fill (other than UF foam)**	**UF foam**
Very Severe (Exposure zone 4)	Any wall with impervious cladding	50	50	50
	Fair-faced masonry with impervious cladding to all walls above ground storey	100	100	N/A
	Any wall fully rendered (2)	75	75	N/A
	Fair-faced masonry (1)	N/A	N/A	N/A
Severe (Exposure zone 3)	Any wall with impervious cladding or render (2)	50	50	50
	Fair-faced masonry with impervious cladding or render (2) to all walls above ground storey	50	75	50
	Fair-faced masonry (1)	75	75	N/A
Moderate (Exposure zone 2)	Any wall with impervious cladding or render (2)	50	50	50
	Fair-faced masonry with impervious cladding or render (2) to all walls above ground storey	50	50	50
	Fair-faced masonry	50	75	75
Sheltered (Exposure zone 1)	Any wall with impervious cladding or render.	50	50	50
	Fair-faced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fair-faced masonry	50	50	50

Notes:
- (1) In very severe exposure locations, fair-faced masonry with full fill cavity insulation is not permitted
- (2) Render on an external leaf of clay bricks (F2, S1 or F1, S1 designation bricks BS EN 771) in ***severe*** or *very severe* exposures is not permitted where the cavity is to be fully filled with insulation.
- This table covers walls where the external leaf does not exceed 12m in height.
- The exposure category of the building is determined by its location on the map showing categories of exposure to wind-driven rain (see also BRE Report 262).
- Fair-faced masonry includes clay, calcium silicate and concrete bricks and blocks and dressed natural stone laid in an appropriate mortar, preferably with struck, weathered or bucket handle joints. Cavity walls of random rubble or random natural stone should not be fully filled.
- Recessed mortar joints should not be used.

Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.

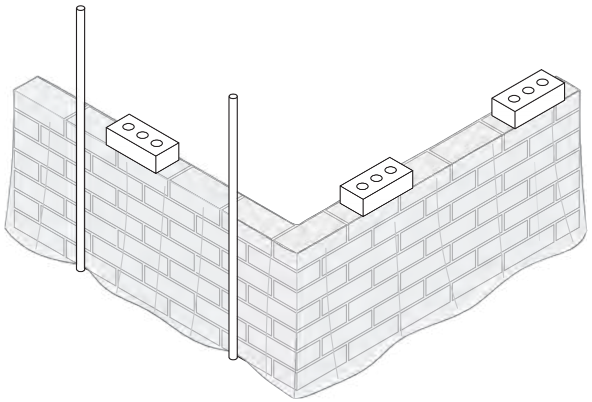
Masonry walls

Protection

All new masonry work should be protected during construction by covering it to ensure that walls are not allowed to become saturated by rainwater or dry out too quickly in hot weather, are protected against frost attack, the risk of efflorescence and line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

Protection of masonry



Working in adverse weather

Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in 'Appendix C - Material, Products, and Building Systems'.

During prolonged periods of hot weather, when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e. engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Brick and block suitability

Exposure

Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further information can be found in 'Appendix C - Material, Products, and Building Systems'.

Colour variation of bricks below DPC

There is usually a variation in the colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations

Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength, helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure, which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention/collection has been found to exist in the perforations.

Efflorescence

Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use.
- Protecting the head of newly constructed work with some form of cover to prevent saturation.

Frost attack

Frost-resistant bricks should be used in areas that are prone to prolonged periods of frost.

If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Mortar

General

A mortar type above DPC should be chosen in accordance with the guidance given in the 'External Walls' and 'Appendix C - Material, Products, and Building Systems' sections, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and/or air entraining plasticisers may be added to cement in accordance with the manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching

Keep batching and mixing equipment clean to avoid contamination with materials used previously, mortar should be mixed by machine, or use ready mixed retarded mortars.

Mixing

Mortar should be carefully and consistently proportioned and then thoroughly mixed using a mechanical mixer, except for very small quantities.

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

Non-rendered blockwork

All external blockwork should be rendered or otherwise finished with a cladding that is appropriately durable, unless the block manufacturer can provide third-party certification confirming that the blockwork can be left unfinished, or finished in an alternative way.

Key points: Construction below DPC

1. Brickwork and blockwork must be selected to have suitable durability for its use in the wall construction in accordance with BS EN 771-1 and PD6697.
2. Mortars below DPC are exposed to higher levels of saturation and therefore require higher durability classification (see BS EN 998-2).
3. Cavities below ground should be filled with concrete ensuring there is a minimum gap of 225mm between DPC and the top of concrete.
4. Concrete for cavities should be GEN 1 grade and a consistence class S3.
5. External ground levels should be a minimum of 150mm below DPC.
6. The compressive strength of the masonry units must meet the requirements of the relevant regional Building Regulations.

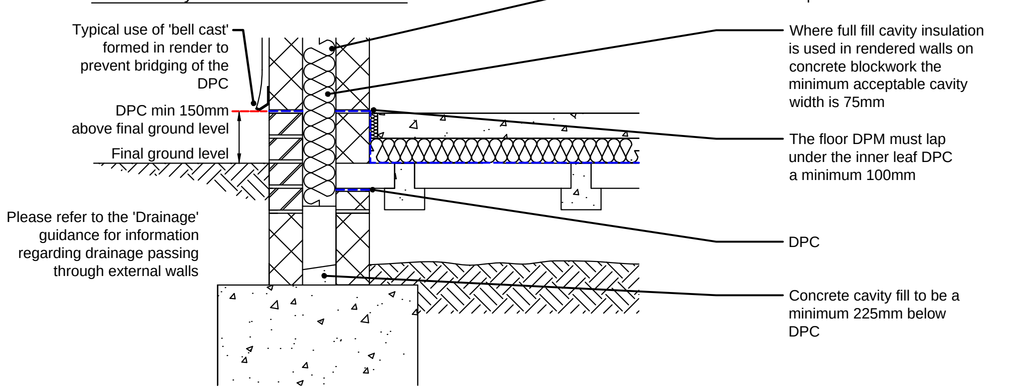
Damp proof courses (DPC)

1. DPCs should be of a flexible material, be suitable for the intended use, the DPC should have appropriate 3rd party certification. The installation specification of DPC's should follow good design practice in accordance with BS 8215.
2. Blue bricks or slate will not be accepted as a DPC.
3. DPC's should be laid on a mortar bed and correctly lapped at junction and corners. The depth of the lap should be the same width as the DPC.
4. The DPC should not bridge any cavity unless it is acting as a cavity tray where a cavity is required (e.g over a telescopic floor vent).
5. Damp proof membranes should be lapped with the DPC a minimum overlap of 100mm. DPM's should be at least a minimum 1200 gauge thickness.

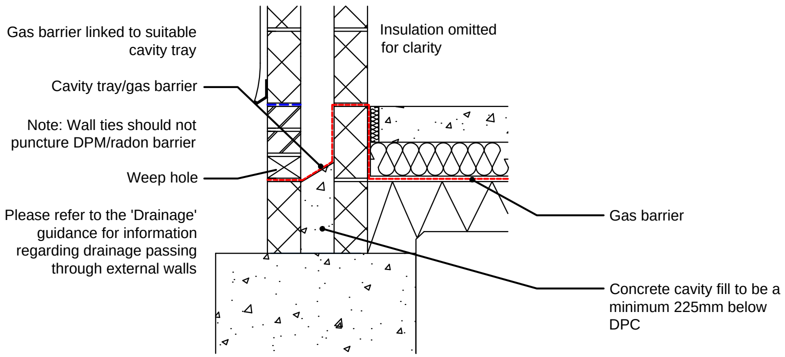
Rendering

1. Rendering below DPC should only be carried out using a specialist render manufacturer's specification. No render system should bridge the DPC and a proprietary uPVC bead or stainless steel bead should be used above and below where the renders meet at the DPC.
2. DPC should extend through the rendering system on between the bellcast beads or render stop system.
3. For bellcasts, uPVC beads or stainless steel beads are acceptable.

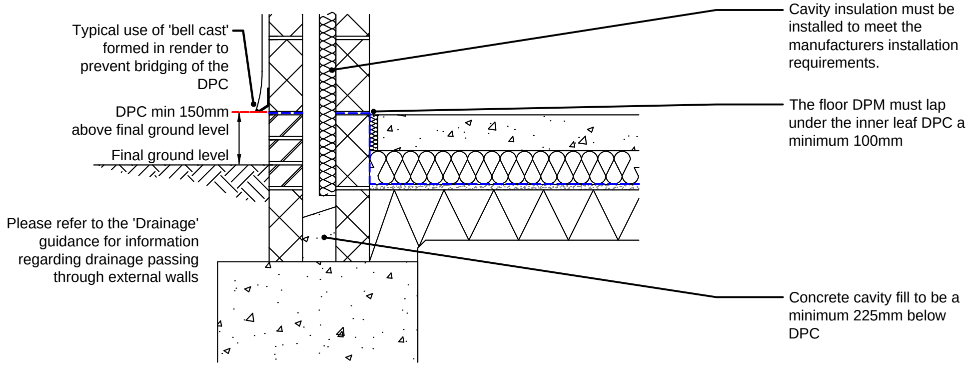
Full fill cavity wall: Beam and block floor



Typical gas barrier arrangement: Traditional ground bearing slab



Partial fill cavity wall: Traditional ground bearing slab



Cavities

A traditional masonry wall should be constructed using an inner and outer leaf, and a cavity should be provided between them, which meet the following provisions:

- The cavity should have a minimum width of 50mm.
- It is to be kept clear from mortar snots to ensure the cavity is not bridged.
- The two leaves should be appropriately tied.
- The cavity can be fully or partially insulated, depending on exposure to wind driven rain.
- For partial fill insulation, a minimum clear cavity of 50mm should always be provided. Further information can be found in BS 8104.

Masonry suitability

- Facing masonry must have a suitable level of durability and particular attention should be paid to the masonry's resistance to frost and moisture.
- Masonry should be capable of supporting proposed loads.
- Masonry should comply with BS EN 771 and PD6697.
- Frost resistant masonry should be used in areas of prolonged frost.

Internal skin (blockwork)

- The blockwork should be capable of supporting the proposed loads and achieve the required thermal performance.
- The blockwork should have appropriate compressive strength in accordance with the Building Regulations.
- The blockwork should comply with BS EN 771 and PD6697.

Cavity Barriers

Cavity barriers should be provided in the external cavity at all compartment walls and floor junctions.

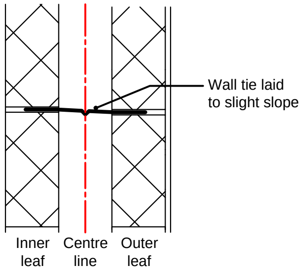
Cavity barriers should have suitable third party accreditation.

Bonding internal walls to external cavity walls

Bonded walls in brickwork are comparatively easy to construct, but this can be more difficult with blockwork, so either:

- Tooth every alternative course, or butt and tie.
- Where blocks are of a different density, always use a butted joint; party walls carry the separating wall through and butt up the inner leaf using a proprietary bed joint, reinforcement or suitable ties at each block course.

Wall tie provision



Wall ties

Wall ties should meet the following provisions:

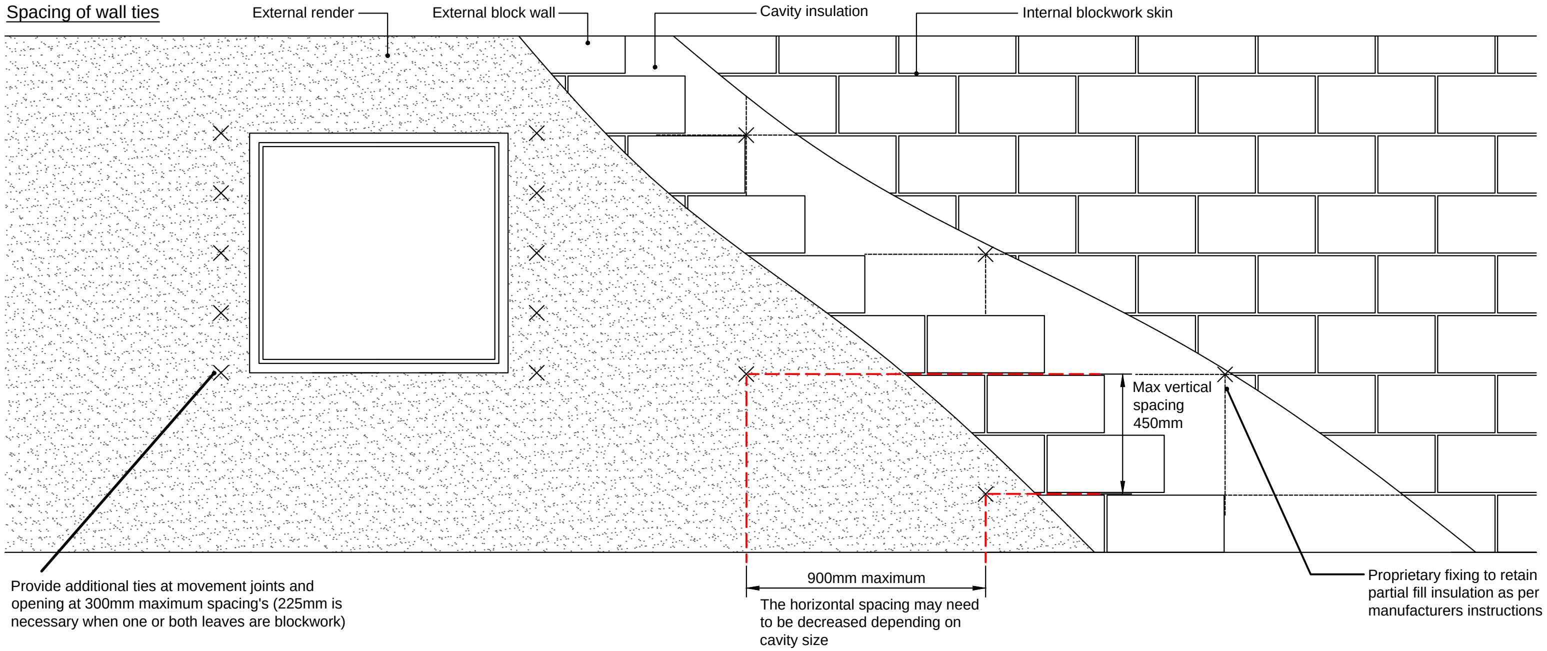
- Wall ties should be to BS EN 845-1 or have appropriate third party certification.
- The overall length of the wall ties must be long enough to ensure there is at least a 62.5mm overlap onto each leaf of masonry, so that it will achieve a 50mm minimum length of bedding onto the mortar.
- Wall ties should be laid to a slight fall towards the outer leaf and have the ability to hold insulation against an internal leaf for partial fill scenarios
- Where a partial fill cavity insulation solution is proposed, a 50mm minimum residual cavity is to be provided.
- Wall ties should be in a staggered in a diamond pattern.
- Wall ties should be installed at a minimum density in accordance with BS EN 1996 -1-1: 2015 NA. This should not be less than 2.5 ties per m2 and may increase with cavity width.

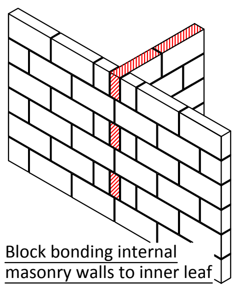
Thermal insulation

Thermal insulation for cavity walls should be inserted to a high standard of workmanship to avoid poor insulation performance and to prevent dampness migrating to the inside of the building:

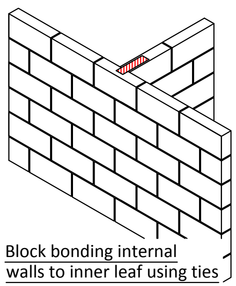
- Cavity wall insulation must have an independent third party product approval and only be used as detailed in the third party product certification.
- Insulation should not be cut or pierced to accommodate wall ties, unless increased centres at reveals or expansion joints are required.
- The wall ties should coincide with insulation joints.
- Partial fill insulation should be clipped or retained to the inner leaf using proprietary fixings in conjunction with wall ties.
- 'Render on an external leaf of clay bricks (F2, S1 or F1, S1 designation bricks BS EN 771) in *severe* or *very severe* exposures is not permitted where the cavity is to be fully filled with insulation. Partial fill cavity insulation should be adopted'.

Spacing of wall ties





Block bonding internal masonry walls to inner leaf



Block bonding internal walls to inner leaf using ties

Rendering

- Rendering should be in accordance with BS EN 13914-1:2005 and workmanship in accordance with BS 8000.
- Traditional hand mixed rendering is not accepted. Only a pre-blended bagged render system will be accepted as a suitable render system.
- Where a specialist render system is being used, the system should have a third party accreditation such as a BBA or ETA certification, and backed up with a manufacturer's specification.

Masonry background

The walls which are to be rendered should be examined for excessive moisture content prior to rendering and suitable to receive rendering. Rendering should only be completed if the outside temperature is at least 2°C. There should be no frost within the construction and rendering should not take place where freezing weather conditions are expected before curing.

Ensure that all joints are finished flush with the surface to avoid shade variations.

The wall construction should not include dissimilar materials that may increase the potential of cracking due to differential thermal movement and effects that the different suction that each type of background material may create.

To control suction, always apply a specialist sealer key coat or suitable render preparatory coat. Allow a minimum of 48 hours for the key coat to fully dry before applying the next coat.

Wall ties

Wall ties should meet the provisions detailed in this section, including following:

- Stainless steel wall ties should always be used.
- It is important to note that only BS EN 845-1 type wall ties or specifically manufactured (and tested) party wall ties are permitted in cavity separating walls between dwellings to reduce the transfer of sound.

Suitability and spacing of wall ties

Wall tie spacing

Unfilled or fully filled cavities		**Spacing of ties**	
Width of cavity	Recommended tie	Horizontal	Vertical
50mm to 75mm wide	Butterfly Double triangle Vertical twist Proprietary ties	900mm	450mm (increased to 300mm at reveals and movement joints)
75mm to 100mm wide	Double triangle Vertical twist	900mm	450mm (increased to 300mm at reveals and movement joints)
100mm to 150mm wide	Vertical twist	750mm	450mm (increased to 300mm at reveals and movement joints)
Greater than 150mm	Wall tie specification and design to be provided by a Chartered Structural Engineer, or in accordance with appropriate third-party certification. Design will be determined by location and site-specific conditions.		

Proprietary ties are to have appropriate third-party certification.

Proprietary insulation retaining clips compatible with the tie should be used where the cavity is partially filled.

Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in the table below. The first joint from a return should be no more than half the dimension indicated in the table.

The movement joints must be continued through the render construction and an appropriate weather resistant seal provided to prevent moisture ingress to behind the render finish.

Movement joints below the DPC should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm centres should be provided on each side of movement joints.

Compressible filler, such as polyurethane foam, should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

When sealants are used in proximity with stone it is important to select a non-oil-based sealant to help prevent any staining to the stone.

Elastic sealants (Type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

Where a backing material is used, the following must be considered:

- The material is compatible with the sealant.
- It will not adhere to the sealant, preventing cracking within the sealant.
- Provides sufficient density to allow the sealant to be applied.
- Allows sufficient flexibility so not to impede lateral movement (compressible to about 50% of its original thickness), fibreboard is not acceptable.

The use of bed joint reinforcement may allow the distance between expansion joints to be increased, however this should be designed by a Structural Engineer.

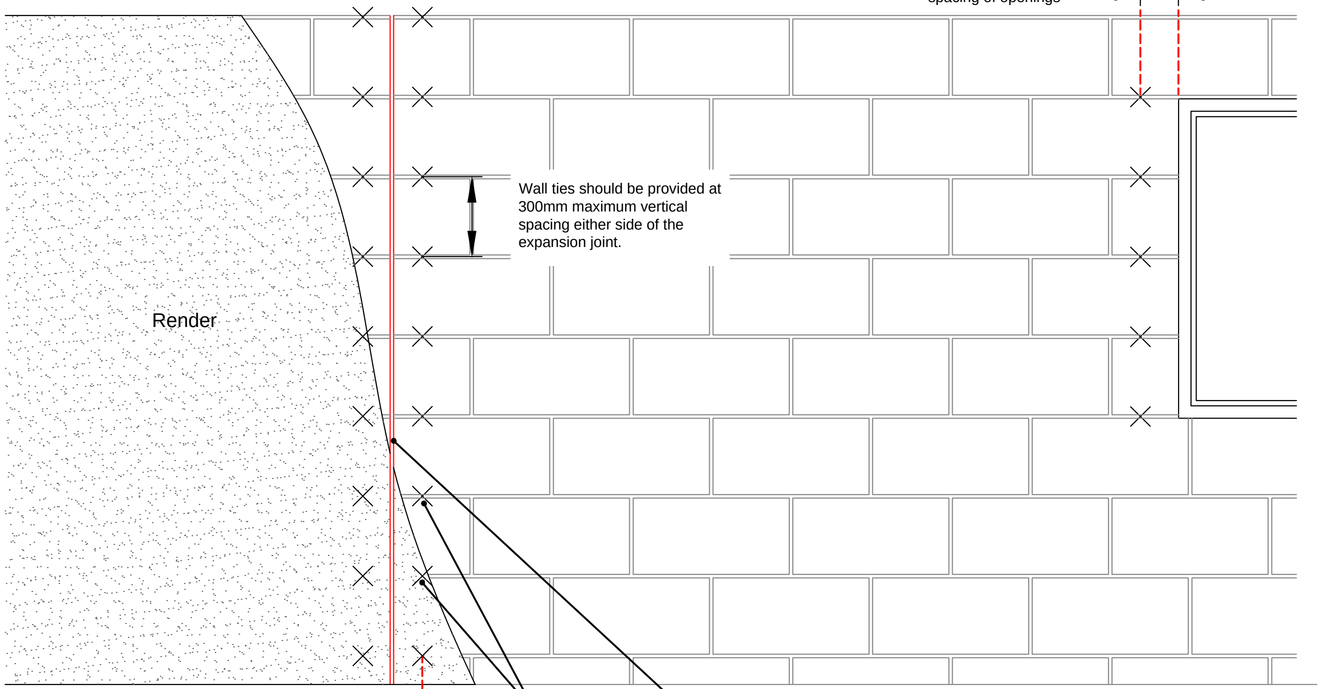
Spacing of expansion joints

Material	**Normal spacing**	**Joint thickness**
Concrete blockwork (used in outer leaf)	6m	10mm
Note: It is not normally necessary to provide movement joints to the internal leaf of cavity walls, but it should be considered for rooms with unbroken lengths of wall in excess of 6m. The first joint from a return should be not more than half the dimension indicated in the table. Movement joints are not acceptable in solid party or separating walls; however, where cavity wall construction is adopted, offset movement joints with a solid rubber compressible strip may be acceptable.		

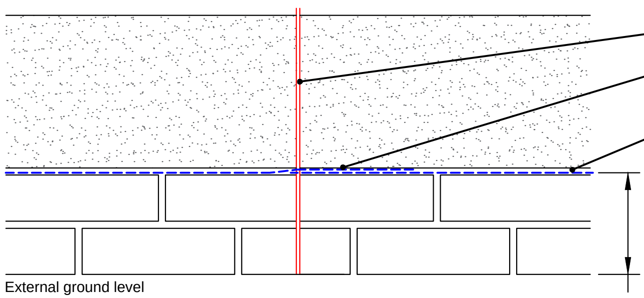
Movement joints

- Vertical movement joints should be provided in accordance with this Technical Manual and the manufacturers guidance.
- Wall ties should be provided at 300mm maximum spacing either side of the expansion joint, and within 225mm horizontal spacing of the movement joint.
- Compressible filler, such as polyurethane foam, should be used to form the joint.
- Fibre board and cork board are not suitable materials for forming movement joints.
- The joint should be sealed to prevent water penetration.
- It is not normally necessary to provide movement joints to internal leaf of cavity walls, but should be considered where rooms occur with unbroken lengths of wall in excess of 6m.
- The movement joint should continue through the render finish.

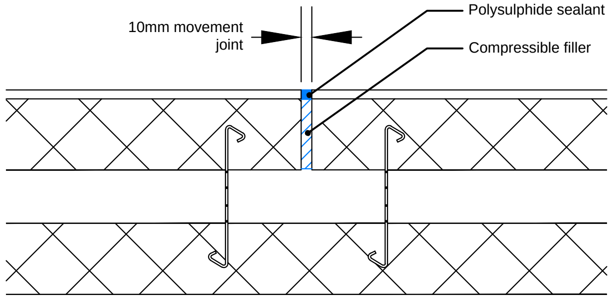
Wall ties in proximity to movement joints and windows



Movement joints below DPC



Typical movement joint detail



Render

Rendering should be in accordance with BS EN 13914-1:2005 and workmanship in accordance with BS 8000. In particular the following should be considered:

With traditional renders the quality of the sands used and design mix is as critical as is the reliance on good mixing techniques by the applicator.

Poor mixing ratios and low quality materials is often the reason traditional renders fail. For the purposes of this Warranty, traditional hand mix using standard sand and cement is not accepted. Only a pre-blended bagged render system will be accepted as a suitable render system that has a third party accreditation such as a BBA or ETA certification, and backed up with a manufacturer's specification.

Where a specialist render system is being used the following conditions must be met:

1) The product approval is based on the details and limitations of use described in a 'current' approved ETA, BBA, BRE etc. or other UKAS certified system specific to the relevant substrate being applied too. A copy of the certificate documents are to be supplied.

2) For masonry substrates (e.g. solid brickwork, blockwork, concrete, terracotta, stone etc.) the masonry should be adequately prepared and be of a thickness which would resist damp ingress to the internal finishes based on the recommendations of BS 5628 Part 3 2005 for the given exposure zone. Please note: Where the thickness of the masonry is less than that recommended in BS 5268, is a single skin construction or is in a very severe exposure zone or coastal location, then the requirements of condition 3 (below) must also be met.

3) For all render installations (including brick slip system applications) on all substrates types located in an exposure zone where the wind driven rain is expected to be more than 75litres per m²: A 10 year 'insurance backed' manufacturer's system guarantee is required, together with a full project specific specification that has also been accepted and approved by the Warranty provider. The proposal will require full system details to deal with all junctions, openings etc. together with other project specific requirements provided by the render system company. The render system will need to be installed by a registered and carded installer who has been approved and accredited by the render system manufacturer before work commences.

In all instances where a render system manufacturer's guarantee is required, full project specification and details are to be obtained from the render system manufacturer before any installation commences to ensure that conformity is met. Once work commences, the installation must be inspected and signed off by a render system representative throughout the installation stage, and at completion of the installation and confirm that the specification has been met.
The render system together with the backing wall to which they are applied should satisfactorily resist the passage of moisture to the inside of the building.

General render conditions (using pre-blended bagged render)

Weather conditions

- For exposure zones where the wind driven rain is expected to be more than 75 litres per m² (classed as very severe) then checked reveals will be required. The render applied to the reveal must be of the same thickness as the wall render with an appropriate corner beading provided. A suitable non hardening' mastic sealant must also be provided between window / door frame and masonry reveal.
- Protection must be provided when applying renders in rain or other inclement weather. Application should cease in temperature below 5°C or where rapid freezing is considered to be a potential threat.
- When applying in hot weather it is advisable that work coincides with the shaded areas of the building. During longer periods of hot and dry weather, it may be appropriate and necessary to apply an even mist spray of clean water to the substrate before application, and to surface finish for a couple of days afterwards subject to site and weather conditions.
- Cement products should not be applied to substrates which are frost laden or which have recently been subject to prolonged rain.
- Do not render onto saturated substrates as this may affect the bond strength and cause lime bloom (discolouration), salts to occur and patchiness due to uneven suction.
- Local weather and site conditions must be taken into account by the applicator before any cement product is applied.
- Care must be taken to protect cement and synthetic products soon after the application from rapid freezing and heavy rainfall. For other drying conditions i.e. where there is direct exposure to sunlight or drying winds, the render may require to be protected from the elements. This process is important to ensure complete hydration of the products can take place.
- Where an application is not covered in these conditions further advice from the render manufacturer must be sought and submit a suitable manufacturer's specification to the Warranty provider for approval.

Application

- 15mm is considered the minimum finished thickness of render applied to a masonry wall, either as a single spray coat or as a two coat hand application. Where structures are located in very severe weather rating locations or within coastal locations, the depth of render may need to be increased to a minimum of 20mm and a specialist manufacturer's specification will be required to support this.
- Please note: 5-6mm is considered the minimum finished thickness of render for applications of specialist insulated render systems. The render thickness will need to be increased where structures are located in very severe weather rating locations, or within coastal locations and a specialist manufacturer's specification will be required to support this; approved by the Warranty provider.
- When ashlar detailing is required, it is recommended that a minimum depth to the back of the ashlar cut should be no less than 15mm and 20 - 25mm for applications in very severe exposure zones or within coastal locations. To achieve this depth, it will require the finished thickness of the main render to be increased to accommodate this feature.
- Abutments between cement render and other cladding materials or components should be weather tight and allow for differential movement.
- Any joints in the wall where movement may occur should be continued through the rendering.
- Render should not bridge the Damp Proof Course (DPC) and must be finished onto a durable render stop profile such as a proprietary uPVC bead or stainless steel bead.
- Renders will be reinforced as a minimum with an appropriate certified alkaline resistant fibreglass mesh at corners of all openings and penetrations. For substrates that are prone to movement, an appropriate certified alkaline resistant fibreglass mesh will need to be incorporated throughout the substrate.
- Where different materials are being rendered over, the incorporation of an appropriate certified alkaline resistant fibreglass mesh will be necessary to assist with the possibilities of differential movement. The mesh must extend sufficiently over the different materials to resist against differential movement.
- Renders installed between pedestrian level and 6.0m above ground level will be designed to accommodate higher maintenance and impact loads in accordance with Table 2 of BS 8200.
- All surfaces must be clean, suitably dry and free from anything that may interfere with the adhesion of the material to be applied. The manufacturer's product data sheets should be followed including the manufacturer's surface preparation and suitability checks in full.
- All blockwork mortar joints are to be flush pointed and should be fully cured before the application of the render.
- The quantity of material required for a given area should be of the same batch number or if not the different batches must be thoroughly mixed together to avoid shade variations.
- Full masking must be used to give protection to adjacent areas of work, windows, doors etc. and to give clean straight edges. It should be removed immediately after the finishing coat has dried.
- Carefully remove splashes of material, in particular from glass or aluminium immediately as they may etch the surface and leave a permanent mark.

Materials

- Ensure the render being used is suitable for the substrate and is not too strong. Due to shrinkage differentials, avoid applying a thin base coat and a thicker top coat application, as the shrinkage values of a thicker top coat could cause the render to delaminate from the base coat. The same effect is also caused by applying a very hard render over a softer base coat.
- External rendering should comply as a minimum with BS EN 13914-1:2005 but should also conform with the specialist render manufacturers recommendations.
- Rendering products should be stored separately from other building and concreting sands.
- For bellcasts, other beads, and stops; uPVC bead or stainless steel bead is acceptable.
- Only clean water should be used for mixing.

Masonry background requirements

The walls which are to be rendered should be examined for excessive moisture content prior to rendering. This is particularly important where the masonry background has no upper limit on its soluble salts content, e.g. N designation clay bricks.

A specialist render system and mortar should be employed for parapets, chimneys, retaining walls and walls below DPC level with this masonry background type.

Ensure that all joints are finished flush with the surface to avoid shade variations.

To minimise the potential for differential thermal movement and effects that the different suction that each type of background material may create; the section of walling to receive the render should be constructed using the same type and density of material throughout.

When rendering is required to be applied to wet masonry substrates, a specialist sealer key coat prior to applying the main coat of render should be applied, to control suction and reduce the impact of lime blooming occurring through the render. The key coat should provide a sound substrate and be compatible with the subsequent render system.

For high absorption e.g. lightweight blockwork, common bricks etc. and smooth dense substrates (such as engineering bricks); direct rendering is not acceptable, as the moisture can be extracted by the substrate from the wet render which affects its curing and bonding capability, or it does not bond to the substrate respectively.

To control suction, always apply a specialist sealer key coat or suitable render preparatory coat. Allow a minimum of 48 hours for the key coat to fully dry before applying the next coat.

For highly exposed areas of construction:

- The backs surfaces of parapets should not be rendered using a standard render system. Either:
  a) Use suitable fair faced masonry to the roof elevation and incorporate cavity trays linked to the roof flashing, or
  b) Use a specialist render system designed to combat movement and provide robust weatherproofing.
  Note: horizontal surfaces of Parapets should not be rendered, they should be protected by a suitable capping system.
- Throats or drips to copings of parapets and chimneys should project beyond the finished faces to throw water clear.
- Rendering to chimneys should only be carried out where the masonry contains little or no sulphates. An appropriate specialist sealer/bonding key coat should be applied prior to applying the main coat of render. A proprietary alkaline resistant mesh should be embedded throughout the render, the key coat should provide a sound substrate and be compatible with the subsequent render system.
- As before; horizontal DPC and Damp Proof Membranes (DPM) must not be bridged.
- Rendering below DPC should only be carried out using a specialist render manufacturer's specification. No render system should bridge the DPC and a proprietary uPVC bead or stainless steel bead should be used above and below where the renders meet at the DPC.

Other construction detailing

Ensure that drips and throating to sills, coping, etc. project beyond the face of the finished render above the DPC.

Notwithstanding wind loadings, the larger the eaves overhang, the better. This will provide protection to the top joint of the render panel where it meets the roof and prevent rain water getting behind the render.

Angles, stop beads and jointing sections should be secured with drilled or shot-fired fixings, and not with gypsum plaster. Fixing of external render beads on masonry backgrounds with an adhesive is also acceptable, providing the render manufacturer can provide a full specification on fixing the beads including:

- The adhesive to be used.
- Type of fixing e.g. dabs or continuous bead.
- Curing times.
- Specification of the beads used.

Under no circumstances should the beads or profiles be bonded using a solvent based adhesive.

Check whether the rendering can be applied directly onto the wall, or whether any preparatory treatment is required in accordance with the manufacturer's instructions.

The surface should be checked for suction by dampening the wall with clean water.

In accordance with a Structural Engineers requirements, cracking of the substrate could be significantly reduced by introducing a specialist proprietary bed joint reinforcement within the mortar joints. Ideally this should be applied throughout the building during construction and in accordance with the substrate manufacturer's recommendations. Ensure that the reinforcement is continuous and joints are lapped in accordance with the manufacturer's requirements (generally 450 - 500mm laps and continued around corners). Specialist corner units are likely to be required, check with the manufacturer.

Introducing reinforcement at weak points such as above and below window and door openings is strongly recommended as a minimum requirement in all applications, as it will greatly assist in minimising cracking to these areas

Vertical and horizontal flatness

Rendering should have a maximum vertical and horizontal deviation from flatness of +/-10mm in 5m, and is measured in a similar way to straightness on plan and plumb of masonry. See the 'Tolerances' section for further information.

New elements connecting to existing structures

Where residential developments are attached to existing buildings, and the existing elements form part of the new structure; these must meet the Functional Requirements of the Warranty. The details below give some guidance on the minimum information and standards required to meet the Functional Requirements.

Party Walls

It is highly likely that improvements to an existing wall are necessary to meet the requirements of the Warranty. This may include underpinning, injected DPC and internal linings.

Where a wall is shared by two or more owners, the requirements of the Party Wall etc. Act may apply. This is separate legislation with different requirements to the Building Regulations or Warranty requirement.

Further guidance on the Party Wall etc. Act can be found on the Planning Portal website www.planningportal.gov.uk

Separating walls

The separating wall between the new and existing building must meet the relevant requirements of the Building Regulations.

Existing foundations

The existing foundations and wall structure must be suitable to support any proposed increased loading resulting from the construction of the new building.

Foundations to the existing wall should be exposed and assessed for suitability to support additional loadings. It is important to protect existing foundations at all times, and care must be taken not to 'undermine' existing foundations when clearing the site or reducing levels.

Where existing foundations require underpinning, a design by a Chartered Structural Engineer should be provided and approved by the Warranty Surveyor prior to work commencing on-site.

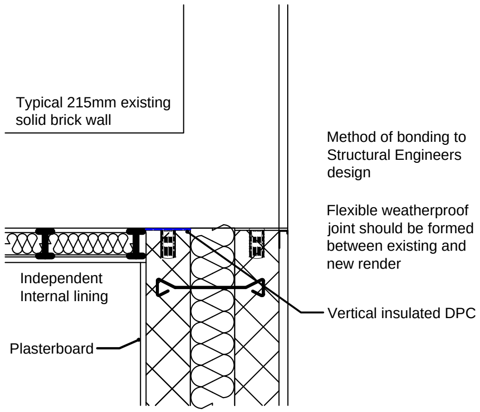
The existing wall should also be appraised to determine whether it is structurally stable and suitable to support additional loadings.

New wall junctions

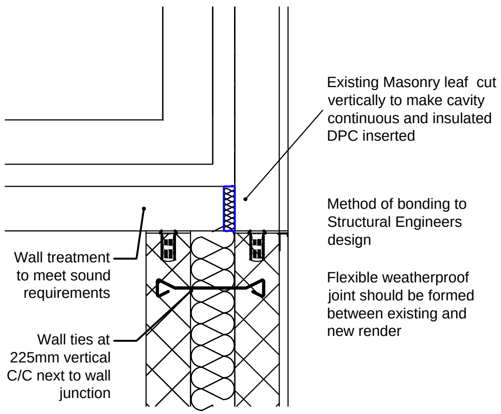
The junction of the new walls to the existing walls must ensure that dampness cannot track back into the new building or the existing building.

The detailing of this junction is critical to ensure that moisture ingress does not occur between the new and existing walls. Typical acceptable details are indicated below.

Bonding new walls to existing solid masonry wall



Bonding new walls to existing masonry cavity wall



Damp Proof Course (DPC)

An effective DPC should be present in the existing wall, linked to the new DPC and damp proof membrane (DPM) of the new building.

Acceptable existing DPCs are considered as:

- A continuous felt or proprietary DPC material.
- A chemically injected DPC supported by an insurance-backed guarantee.
- A slate DPC is considered acceptable if the existing wall incorporates an independent wall lining system to the inner face of the new building.

The new DPC should lap the existing DPC by at least 100mm.

Existing and new structure junctions

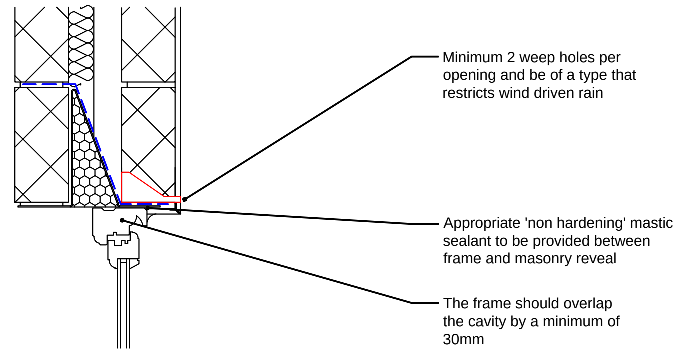
At the junction of the existing and new structures, detailing should allow for differential movement without cracking. Any settlement should be limited to 2mm-3mm, which would not normally adversely affect the roof covering.

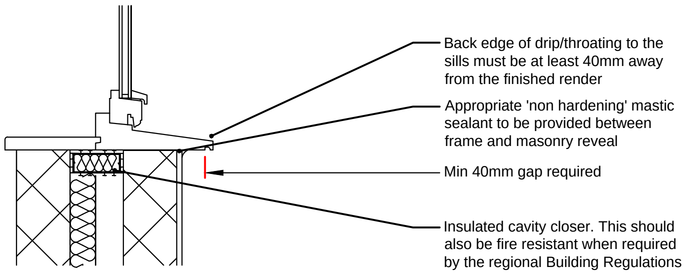
In order to prevent excessive differential movement, the new building should have the same foundation type as the existing building. Where the foundation types are different, e.g. new building pile and beam, existing building traditional strip foundation, the new building should be completely independent of the existing building.

Window and door installations

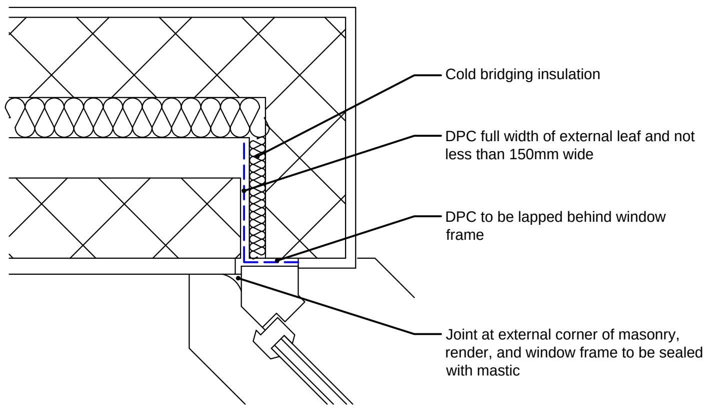
Please refer to the 'Windows and Doors' section for installation requirements of frames including maximum gaps and fixings.

Typical vertical section through window opening

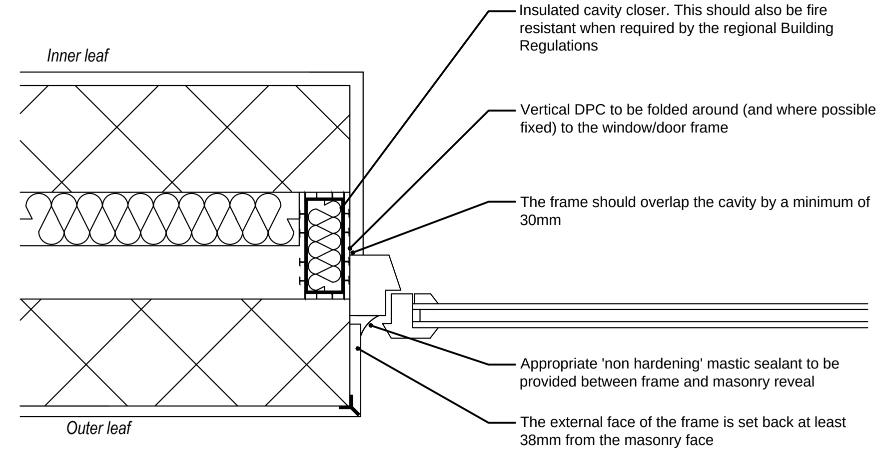




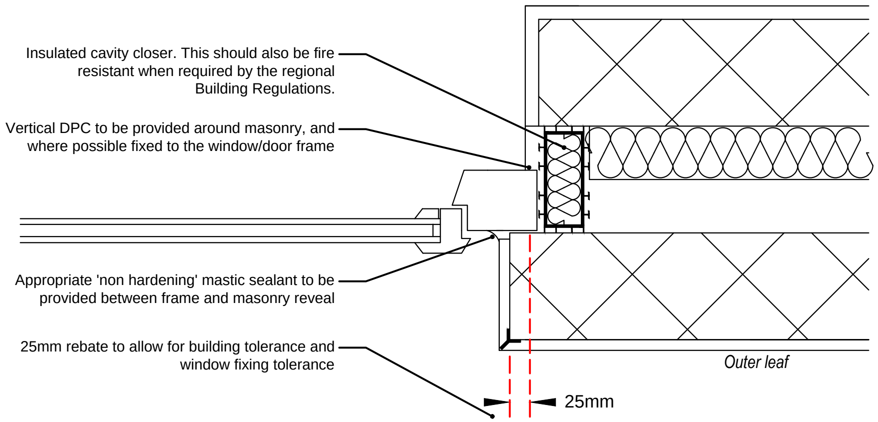
Bay window detail



Typical window reveal detail (normal exposure)



'Checked rebate' detail areas of very severe exposure



When installing window/door frames in a checked rebate, allow for the frame to be deeper:

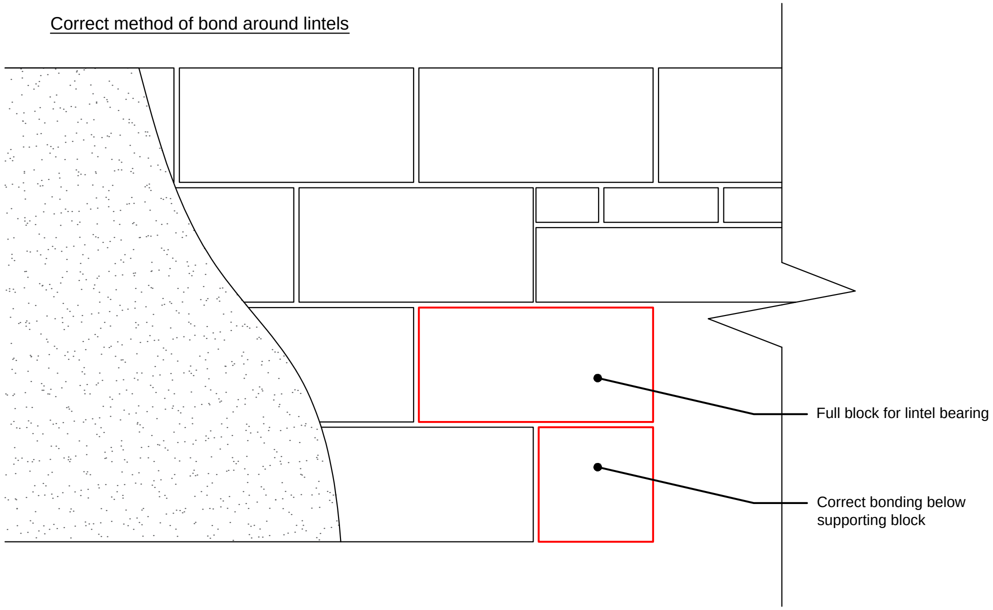
- To accommodate the 25mm rebate, and
- To allow for opening lights to open clear of the masonry/render.

Windows and doors

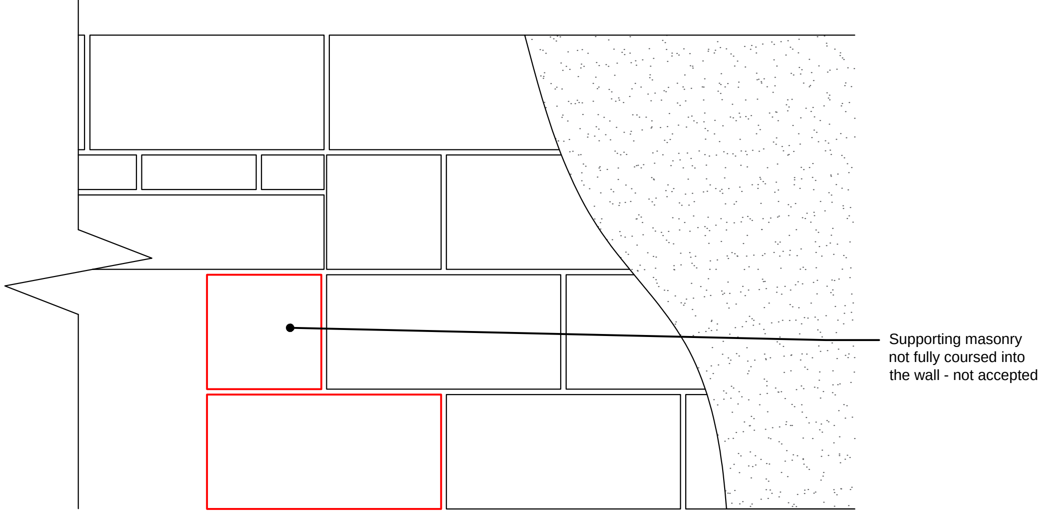
In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap.

A suitable DPC must be provided at all window and door openings to prevent the passage of damp to the internal finishes. A third party certified cavity closure may be used.

Correct method of bond around lintels



Incorrect method of bond around lintels



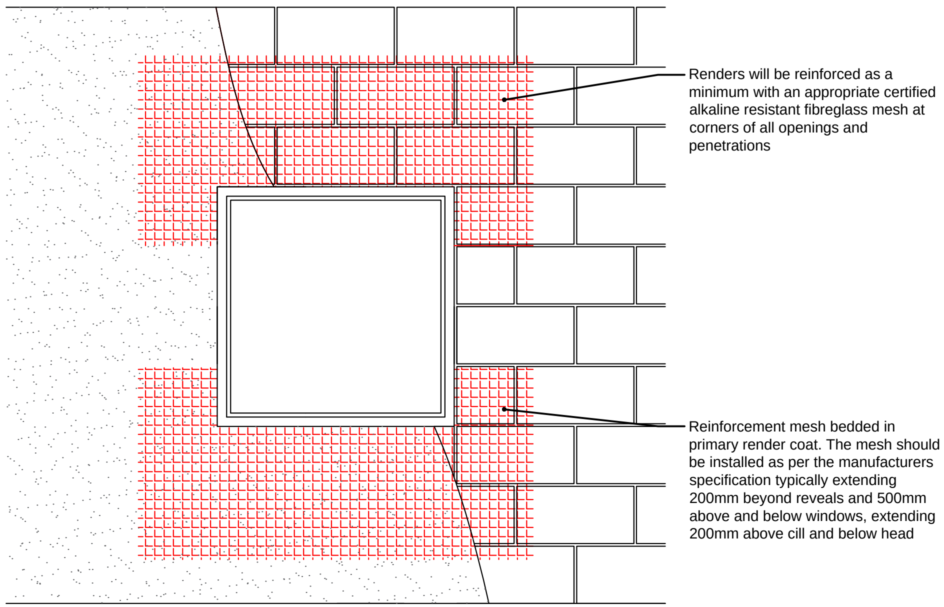
Lintels

- The lintel should be the correct length and width for the opening and cavity width, the bearing length should be at least 150mm.
- Do not let masonry overhang lintels by more than 25mm.
- Continuity of the masonry bond should be maintained at supports for beams and lintels.
- Lintels should be insulated to prevent excessive thermal bridging.

Do not:

- Support lintels and beams on short lengths of cut blocks or make-up pieces.
- Apply load to lintels or beams before the masonry supporting has hardened.

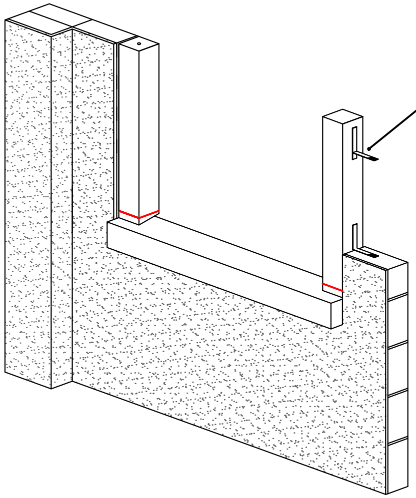
Typical mesh reinforcement around openings



Rendering adjacent to openings

- For bellcasts and other beads uPVC beads or stainless steel beads are acceptable.
- Renders will be reinforced as a minimum with an appropriate certified alkaline resistant fibreglass mesh at corners of all openings and penetrations. For substrates that are prone to movement, an appropriate certified alkaline resistant fibreglass mesh will need to incorporated throughout the substrate.
- Ensure that drips and throating to sills, coping, etc. project a minimum of 40mm beyond the face of the finished render above the DPC.

Stone jamb mullion, fixing to walls

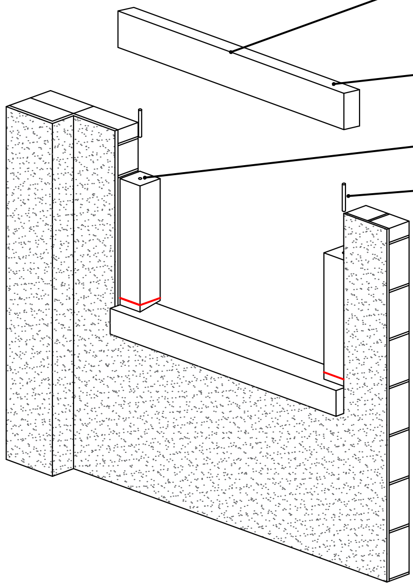


Stone jambs, mullions, and heads should not project into the cavity and insulated cavity closers should be inserted to prevent cold bridging (see typical window opening sections)

Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame-type cramps can also be used to give extra stability at jambs

Mortar:
The mortar for use with stone should comply with the relevant British Standards for sand, lime, and cement as set out in BS 5390

Joining stone jambs to sills and head



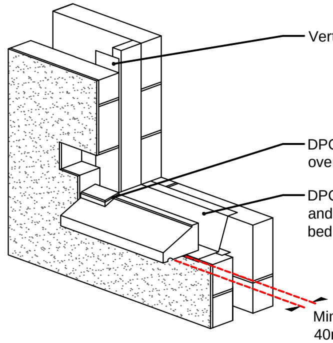
Cavity Trays

When stone heads are being used, it is advisable to double up the cavity trays - with one below the stone head and to provide stop-ends and weep-holes. Weep holes to be of a type to restrict wind driven rain

Cast stone jambs and mullions

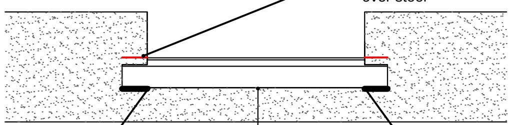
Stainless steel dowels in the sides of jambs should be bedded into adjacent mortar joints as the masonry is constructed

Stone sill with insulated cavity closer



Note: The insulated cavity closer should also be fire resistant when required by the relevant Building Regulations

Stone sill



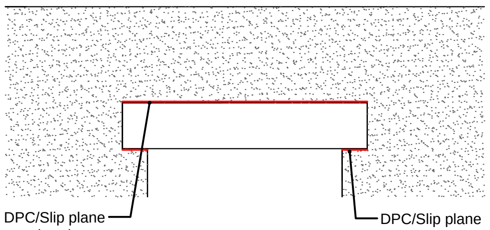
Sills

The DPC should be overlapped by the vertical DPC at the jambs and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off, and then a DPC laid over. The open section below the sill should be sealed with a flexible material only on completion of the structure.

To control water penetration through joints in window surrounds, e.g. at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

Stone head



Render

Ensure that drips and throating to sills etc project beyond the face of the finished render above the DPC by a minimum of 40mm. Rendering around window/door openings to be reinforced with mesh.

Cast stone heads

A cavity tray must be provided above all heads as this not only discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head as well as a soft joint between the top of the head and the steel support lintel.

Cast stone heads should be manufactured in accordance with BS 1217, confirmation of this should be provided to the Warranty Surveyor upon request.

Cast stone window/door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement e.g. where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated or the cast stone should be flexibly jointed.

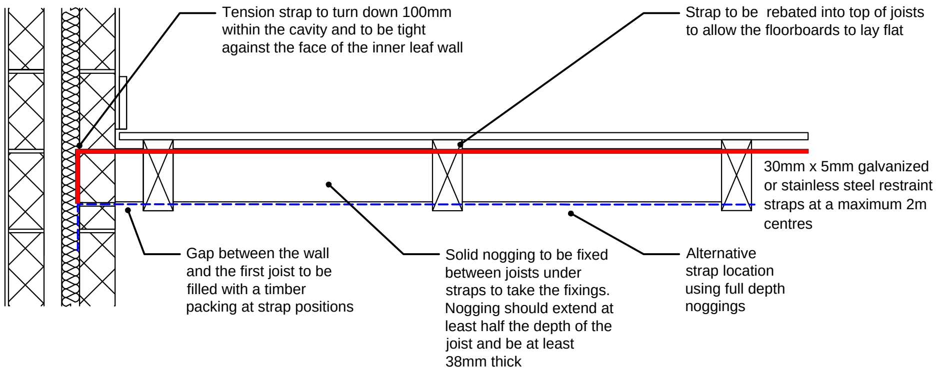
Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

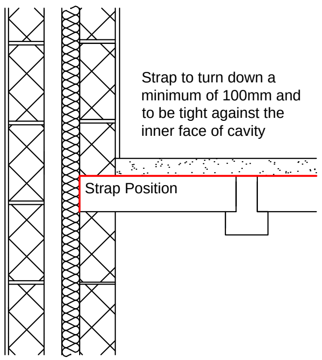
Restraint can be provided by:

- Lateral restraint straps.
- Restraint type joist hangers.
- Other forms of restraint proven by a Chartered Engineer.

Lateral restraint of walls (timber floors)



Lateral restraint of walls (beam and block floors)



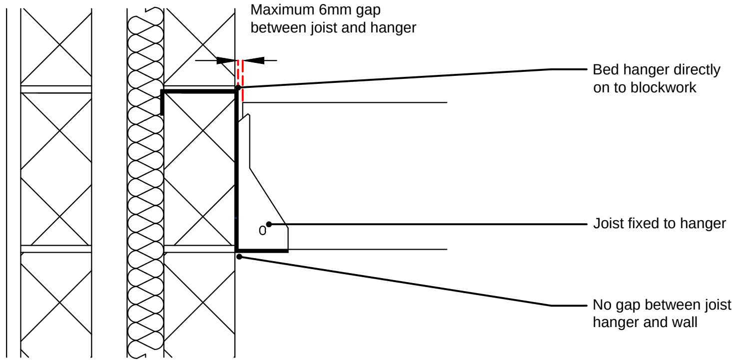
Lateral restraint straps

Floors, including timber, block and beam, and roofs should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanised or stainless steel restraint straps at a maximum 2m centres (please refer to the 'Upper Floors' section for further guidance). Straps need not be provided to floors at, or about, the same level on each side of a supported wall and at the following locations:

Timber floors in two storey buildings where:

- Joists are at maximum 1.2m centres and have at least 90mm bearing on supported walls or 75mm bearing on to a timber wall plate.
- Carried by the supported wall by restraint type joist hangers as described in BS 5268: 7.1.
- Concrete floors with minimum 90mm bearing on supported wall.

Typical restraint type joist hanger



Restraint type hangers

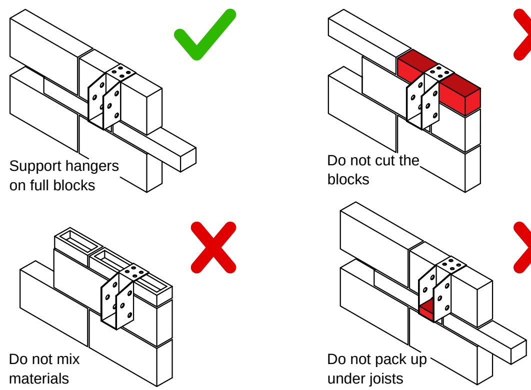
It is necessary to ensure that:

- The hanger is bedded directly on the masonry and there is no gap between the hanger back-plate and the face of the masonry.
- At least 450mm of masonry is provided above the hanger.
- Hangers are spaced at centres of floor joists included in the design.
- The hanger is suitable for the loadings and masonry strength.

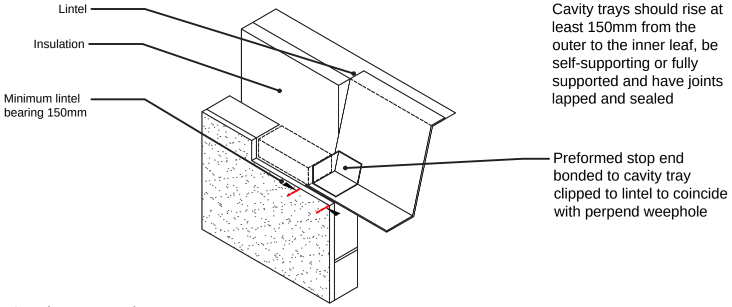
Do not:

- Apply load while the mortar is still green and has not gained sufficient strength.
- Use brick courses in block walls under joist hangers as the thermal insulation of the wall may be reduced unless similar units to the blocks are used.

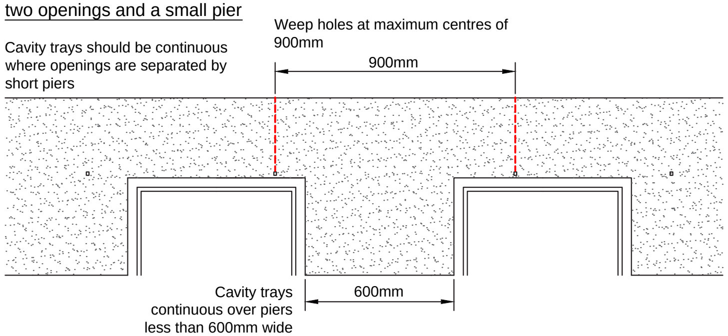
Correct use of hangers



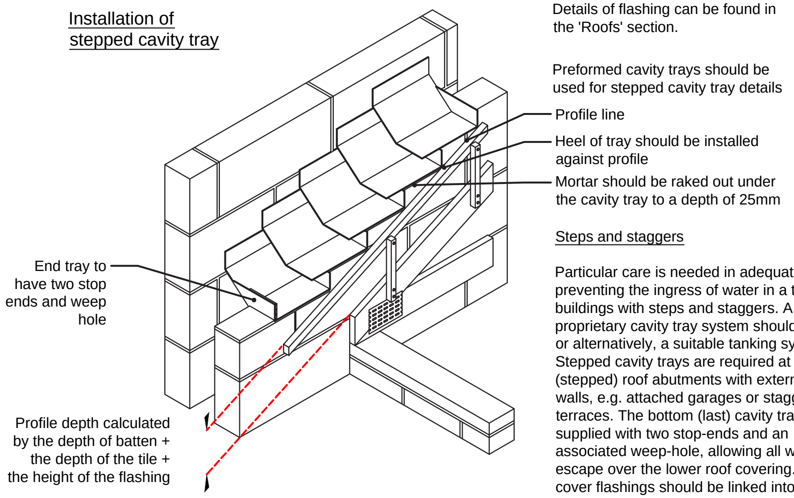
Stop end to cavity tray



Continuous cavity tray over two openings and a small pier



Installation of stepped cavity tray



Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of buildings with steps and staggers. A proprietary cavity tray system should be used, or alternatively, a suitable tanking system. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g. attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape over the lower roof covering. A lead cover flashings should be linked into the cavity tray (lapped in below).

Cavity trays

Cavity trays, associated weep-holes and stop-ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- Cavity trays are to be provided to comply with relevant regional Building Regulations.
- At all interruptions likely to direct rain water across the cavity, such as rectangular ducts, lintels and recessed meter boxes.
- Above cavity insulation that is not taken to the top of the wall, unless that area of wall is protected by impervious cladding.
- Above lintels in walls in exposure zones 4 and 3, and in zones 2 and 1 where the lintel is not corrosion-resistant and not intended to function as its own cavity tray.
- Continuously above lintels where openings are separated by short piers.
- Above openings where the lintel supports a brick soldier course.

Ring beams or floor slabs that partially bridge the cavity, e.g. when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray, especially when full cavity insulation is employed.

Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level. When the wall is to be cavity filled, it is advisable to reduce this spacing.

At least two weep-holes must be provided to drain cavity trays above openings.

Where the wall is externally coated with a 'High Performance' polymer modified factory manufactured render system, the weep-holes are not deemed necessary for cavity wall construction. However, weepholes will still be required in high risk areas such as lower roof abutments or parapet walls.
Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind-driven rain (including ground level).

Stop-ends

Cavity trays should have water tight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, so that a stop to the structural cavity of at least 75mm high is provided. Normally, the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

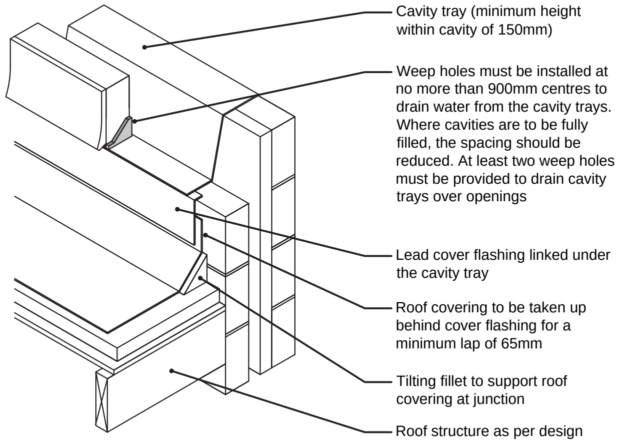
Other perforations of the building envelope

Proprietary elements, such as ventilators, soil pipes, etc. which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

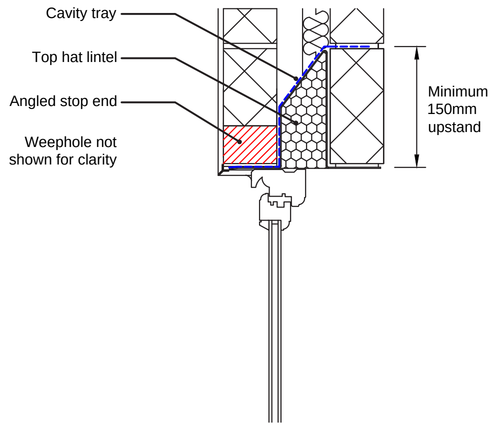
Proprietary cavity tray systems

At stepped and lower storey abutments and around corners in low rise cavity masonry walls a proprietary cavity tray system should be used.

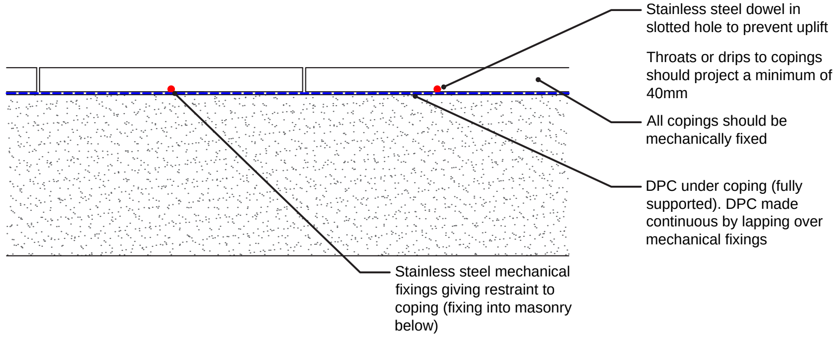
Flat roof abutment cavity tray construction



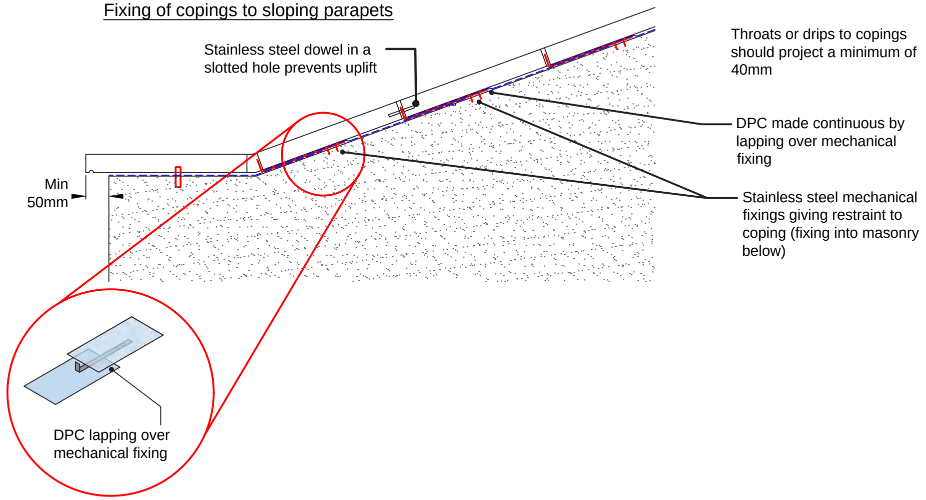
Stop end in relation to cavity tray and lintel



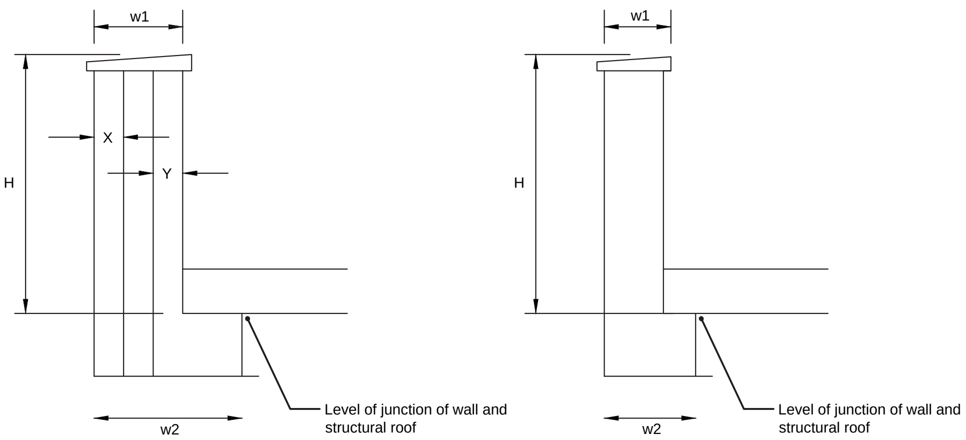
Fixing of copings onto horizontal parapets



Fixing of copings to sloping parapets

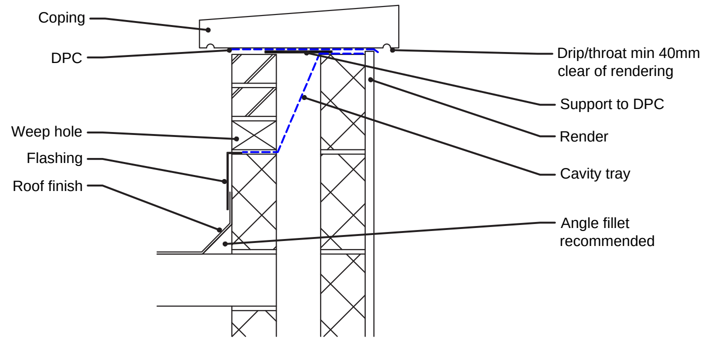


Maximum height of parapet walls (to be read in conjunction with the table below)



Wall type	Thickness (mm)	Parapet height to be no more than (mm)
Cavity wall	x + y equal or less than 200 x + y greater than 200 equal or less than 250	600 860
Solid wall	w1 = 150 w1 = 190 w1 = 215	600 760 860
Note: w1 should be less than w2 - as shown above		

Parapet wall detail



Parapets

- The materials used in construction of the parapets details should be suitable for the location and exposure.
- Where possible, the use of raking parapets should be avoided due to need for high standards of detailing and workmanship required to prevent the ingress of moisture.
- In very severe exposure zones, it is recommended that parapet construction is avoided altogether.

Render in highly exposed areas of construction

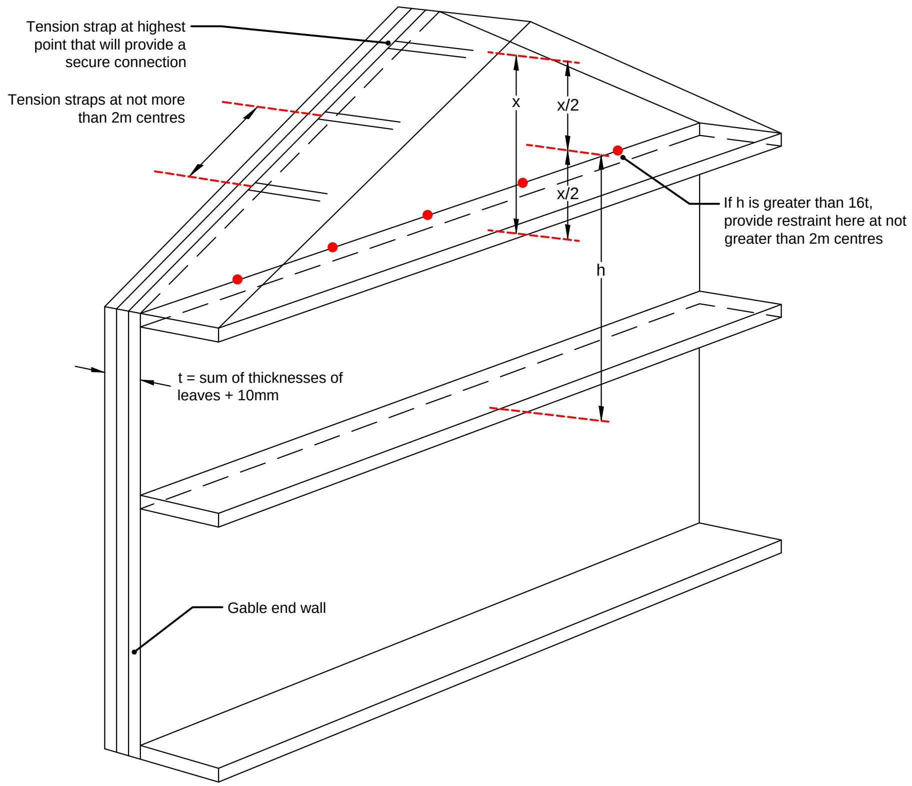
A specialist render system and mortar should be employed for parapets, chimneys, retaining walls and walls below DPC level with this masonry background type.

It is recommended that;

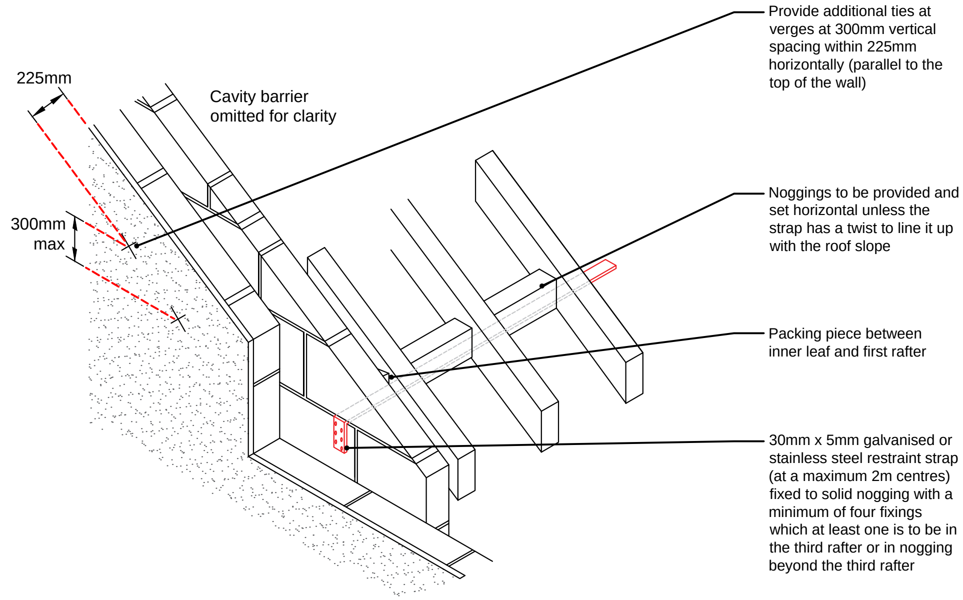
- The backs and exposed horizontal surfaces of parapets are not rendered using a standard render system. Use a specialist render system designed to combat movement and provide robust weatherproofing.
- Throats or drips to copings of parapets and chimneys should project beyond the finished faces by a minimum of 40mm distance to throw water clear.
- Rendering to chimneys should only be carried out where the masonry contains little or no sulphates. An appropriate specialist sealer / bonding key coat should be applied prior to applying the main coat of render. A proprietary alkaline resistant mesh should be embedded throughout the render, the key coat should provide a sound substrate and be compatible with the subsequent render system.

TRADITIONAL MASONRY CAVITY WALL - RENDERED MASONRY CLAD: Lateral restraint of walls

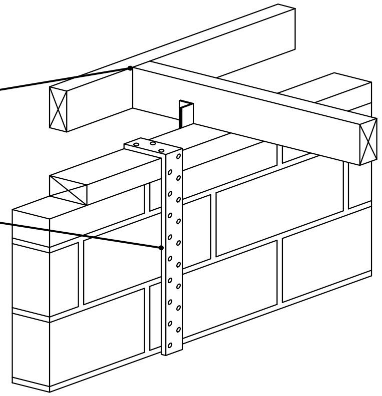
Tension strap location



Rafter/gable wall detail

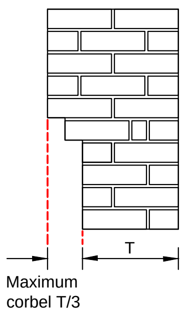


Vertical strapping at eaves - flat roofs



Corbelling

The extent of corbelling of masonry should not exceed that indicated in the below detail, unless supported or reinforced. Reinforced corbels should be designed by a Charted Structural Engineer.



Restraint of Walls

Walls should be adequately restrained at floors, ceilings, and verges in accordance with the relevant Building Regulations.

Restraints can be provided by:

- Restraint type joist hangers
- Lateral restraint straps
- Other forms of restraint proven by a Charted Engineer

Insulation

Insulation should extend to the full height of the gable wall.

Chimneys

If the chimney is in a severe exposure zone the cavity should extend around the outside of the stack and be continuous up to roof level, as per BS 5628, Part 3. Where the chimney breast is gathered in, the lower projecting masonry should be provided with a suitable capping and cavity trays. A 50mm cavity at the back of the chimney breast is maintained to prevent rainwater penetration.

A specialist render system and mortar should be employed for parapets, chimneys, retaining walls and walls below DPC level.

Further guidance can be found in the 'Chimneys and Flues' section.

Eaves detailing for rendered walls

The eaves detail should extend past the masonry to provide protection to the top joint of the render and prevent rainwater percolating behind the render.

6.

External Walls

6.3

Timber Frame - Brick Clad

Introduction

This Guidance refers to 'conventional' timber frame open panel* systems made off-site under factory conditions. Such panel systems are required to be manufactured and erected on-site under quality assured systems and be either Silver or Gold members of the Structural Timber Association or BM TRADA registered.

*Open panel systems are defined as systems which may include the external breather membrane and sheathing board, insulation internally between the studs and a transparent Vapour Control Layer (VCL) which is left unfixed in order that the connections between panels can be viewed upon inspection.

Timber frame panels which arrive to site with additional elements e.g. external cladding or a non-transparent VCL will need to undergo our in house Warranty Approval process.

Timber frame external walls are generally considered to consist of load-bearing solid timber studs at regular centres with insulation between them, lined with a structural sheathing board, breather membrane, drained cavity and cladding. A VCL and fire-resistant linings are provided to the internal finishes.

Alternatively, any timber frame kit, system or wall panel that has been approved via the Warranty product approval process will be acceptable.

Structural design

Wind, roof and floor loads should be considered in the design and all timber frame structures shall be designed in accordance with Eurocode 5. Structures designed in accordance with BS 5268 may still be acceptable, although these standards have now been superseded by Eurocode 5.

General specifications

Bespoke timber frame open panel systems that do not have such QA procedures as the 'conventional' timber frame open panel systems described in this document will need either third-party accreditation or independent Structural Engineer supervision and monitoring of the installation, erection and completion (sign off) of the system. All load-bearing timbers will have to be preservative treated in accordance with BS 8417 according to their position within the frame, and evidence of treatment must be provided.

The structural engineer must confirm, in writing prior to sign off, that the timber frame system has been installed:
- In accordance with the design.
- In accordance with the structural calculations provided.
- All structural timbers are appropriately preservative treated in accordance with BS 8417.
- That a trained contractor, experienced in the erection of timber frame panels, has been employed.

Green air dried or seasoned oak is not acceptable for use in external wall, window/door construction, frame or internal wall or roof constructions, regardless of whether it forms part of the waterproof envelope or not. Projects incorporating 'green Oak' will not be acceptable for Warranty cover. Green Oak is defined for Warranty purposes as 'Oak that has been freshly cut or air dried'.

Certified kiln dried Oak with a certified moisture content of 12% may be acceptable for parts of the structure where the oak does not form part of the waterproof envelope, or movement in the oak frame will not affect the waterproof envelope.

Structurally Insulated Panels (SIPs) are a form of stressed skin composite panel. Only systems with independent third-party certification will meet the Warranty requirements.

Quality assurance

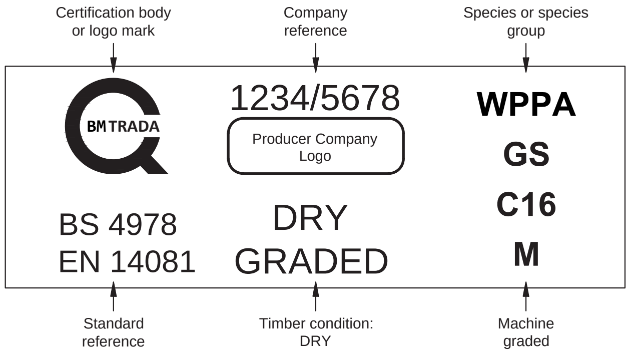
All timber frame Designers, Manufacturers, and Erectors should possess current certification from at least one of the following quality assurance schemes:
- BM TRADA QMark for timber frame.
- Gold or Silver member of the Structural Timber Association.
- ISO 9001 to cover the manufacture of the timber frame panels.
- CE Marking when EN 14732 is published.
- Other relevant third party quality assurance scheme.

Timber specifications

Grading of structural timber
All structural timber whether machine or visually graded shall be graded in accordance with BS EN 14081: Timber structures - Strength graded structural timber with rectangular cross section.

All load-bearing solid timber studs, rails, binders and sole plates should be of a minimum dry graded C16.

Typical grading stamp



Treatment of structural timber

All load-bearing timber components shall be either naturally durable or treated in accordance with BS 8417: Preservation of wood code of practice. Sole plates and load-bearing timber studwork are considered to be in 'Use Class 2'. Sole plates are normally considered to be included in 'Service Factor Code C', while load-bearing timber studwork is included in 'Service Factor Code B'.

All structural timber should be treated with a preservative suitable for the 'Use Class' and 'Service Factor' applicable to its use.

Where treated timber is cut, the exposed end will not be protected by the original preservative treatment. When treated timbers are cut in the factory or on site, the cut ends shall be re-treated with a preservative compatible with the original treatment used, this treatment should be coloured to allow easy checking on site.

Manufacture

Timber
All structural timber components should be specified in accordance with this Technical Manual.

Panel moisture content
All structural timber components should be at a moisture content of 20% or less at the time of manufacture. Once panels are manufactured, they should either be stored in a covered storage area, or loosely covered with a water proof sheet material.

Manufacturing tolerances
Based on the tolerances given in prEN 14732 (dated 17/12/2013) wall panels shall be manufactured to the following tolerances:

- Length: +3mm, -3mm.
- Height: +/-2mm.
- Diagonals should be equal, acceptable deviation is +/-5mm.
- Opening dimensions: 0mm, +5mm.

Studs
Wall panels should be designed to minimise thermal bridging. Gaps between studs within the wall panel and at wall panel junctions should be large enough to allow the installation of insulation.

Site preparation and erection

Pre-commencement
To allow the building to be constructed as designed all necessary drawings, specifications and fixing schedules shall be provided to site before work commences.

Foundations
It is important that the tight tolerances for timber frame are understood, getting the location and level of the foundation correct is one of the most important parts of the build process.

The foundations or upstands that support the timber frame should be set out to the dimensions noted on the timber frame drawings:

- Within +/-10mm in length, width and line.
- Diagonals should be within +/-5mm up to 10m, and +/-10mm more than 10m.
- Levelled to +/-5mm from datum.

Timber frame delivery and storage
Timber frame components should be:

- Carefully unloaded to avoid damage or distortion of components.
- Stored off the ground on an adequate number of level bearers.
- Loosely covered with a waterproof membrane to allow protection from moisture while allowing ventilation if they are not to be used for a prolonged period.
- Unwrapped if tightly bound in polythene and loosely recovered with a waterproof membrane to allow ventilation.
- Below 20% moisture content.
- Confirmed as square by sample checking for equal diagonal measurements, lengths and heights.

Timber frame erection

Wall panel erection tolerances
Wall panels should be erected to the tolerances as per the 'Tolerances' section:

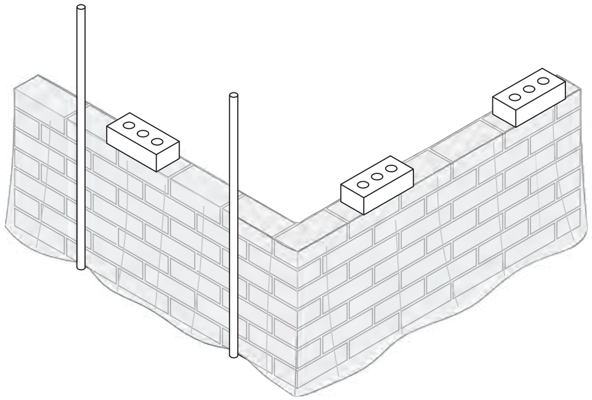
- +/-10mm from plumb per storey height.
- +/-10mm from plumb over the full height of the building.
- +/-3mm from line of sole plate, with maximum +/-5mm deviation from drawing.
- +/-5mm from line at mid height of wall panel.
- Inside faces of adjacent wall panels should be flush.
- Adjacent wall panels should be tightly butted.

Masonry walls

Protection
All new masonry work should be protected during construction by covering it to ensure that walls are not allowed to become saturated by rainwater, dry out too quickly in hot weather, are protected against frost attack, the risk of efflorescence and line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

Protection of masonry



Working in adverse weather

Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in 'Appendix C - Material, Products, and Building Systems'.

During prolonged periods of hot weather, when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e. engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Exposure
Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further information can be found in 'Appendix C - Material, Products, and Building Systems'.

Colour variation of bricks
There is usually a variation in the colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations
Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength, helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure, which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention/collection has been found to exist in the perforations.

Efflorescence
Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use.
- Protecting the head of newly constructed work with some form of cover to prevent saturation.

Frost attack
Frost-resistant bricks should be used in areas that are prone to prolonged periods of frost.

If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Mortar

General
A mortar type above DPC should be chosen in accordance with the guidance given in the 'External Walls' and 'Appendix C - Material, Products, and Building Systems' sections, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and/or air entraining plasticisers may be added to cement in accordance with the manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching
Keep batching and mixing equipment clean to avoid contamination with materials used previously, mortar should be mixed by machine, or use ready mixed retarded mortars.

Mixing
Mortar should be carefully and consistently proportioned and then thoroughly mixed using a mechanical mixer, except for very small quantities.

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

Dealing with areas of high exposure to frost and wind-driven rain

The design and construction of external walls should be suitable for the site specific exposure location.

Wind-driven rain

To ascertain the risk relating to wind-driven rain, the following should be determined:

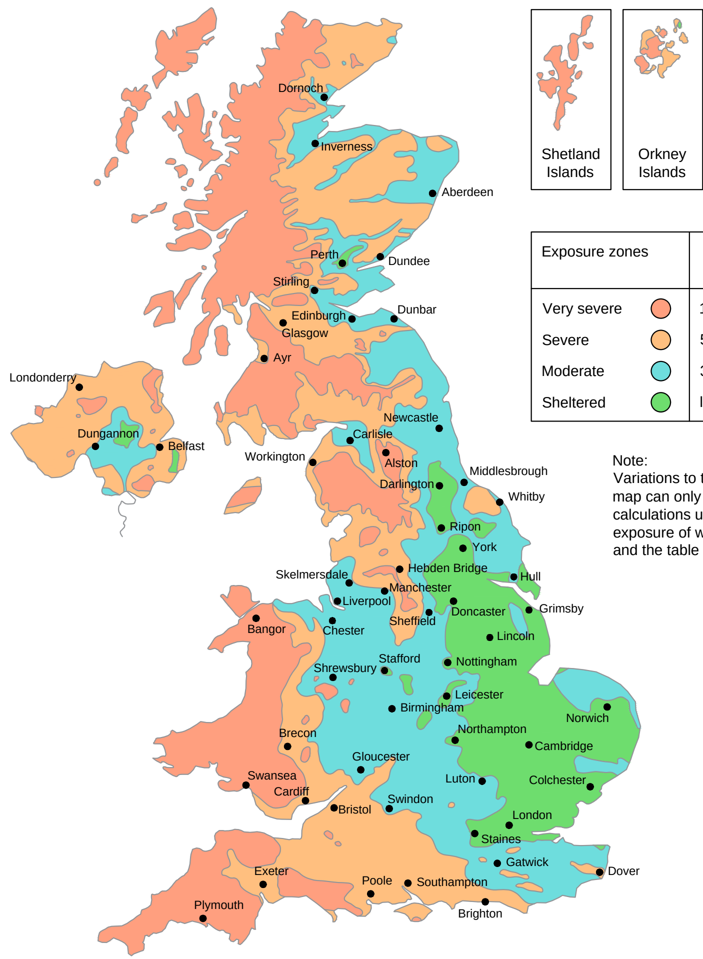
- The exposure to wind-driven rain.
- The correct type of construction, including the correct application of insulation.
- The correct level of workmanship and design detailing, particularly around window and door openings.

Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.



Exposure zones		Exposure to wind driven rain (litres/m^2 per spell)
Very severe	(red)	100 or more
Severe	(orange)	56.5 to less than 100
Moderate	(blue)	33 to less than 56.5
Sheltered	(green)	less than 33

Note:
Variations to the exposure shown on the map can only be made by site-specific calculations using BS 8104 "Assessing exposure of walls to wind driven rain" and the table above.

Key points: Construction below DPC

1. Brickwork and blockwork must be selected to have suitable durability for its use in the wall construction in accordance with BS EN 771-1 and PD6697.
2. Mortars below DPC are exposed to higher levels of saturation and therefore require higher durability classification (see BS EN 998-2).
3. Cavities below ground should be filled with concrete ensuring there is a minimum gap of 225mm between DPC and the top of concrete.
4. Concrete for cavities should be GEN 1 grade and a consistence class S3.
5. External ground levels should be a minimum of 150mm below DPC.
6. The compressive strength of the masonry units must meet the requirements of the relevant regional Building Regulations.

Damp proof courses (DPC)

1. DPC's should be of a flexible material, be suitable for the intended use, the DPC should have appropriate 3rd party certification. The installation specification of DPC's should follow good design practice in accordance with BS 8215.
2. Blue bricks or slate will not be accepted as a DPC.
3. DPC's should be laid on a mortar bed and correctly lapped at junction and corners. The depth of the lap should be the same width as the DPC.
4. The DPC should not bridge any cavity unless it is acting as a cavity tray where a cavity is required (e.g over a telescopic floor vent).
5. Damp proof membranes should be lapped with the DPC, DPM, and VCL by a minimum overlap of 100mm.

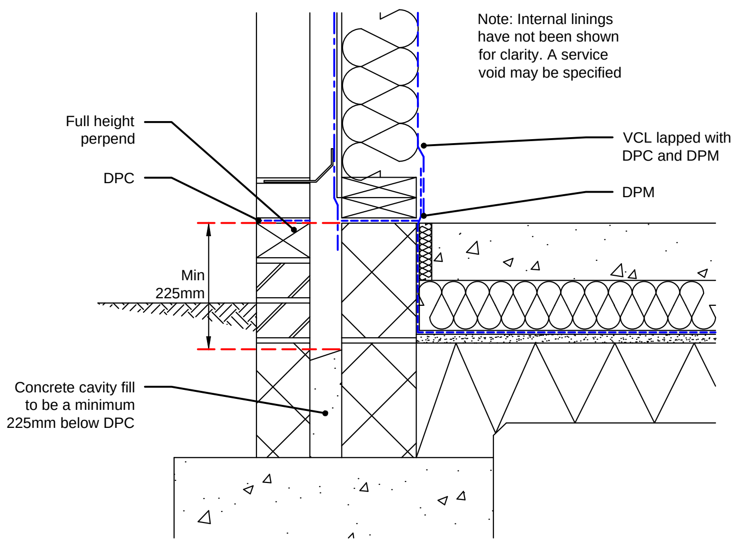
Drainage and ventilation

Cavity drainage and ventilation in masonry cladding should:

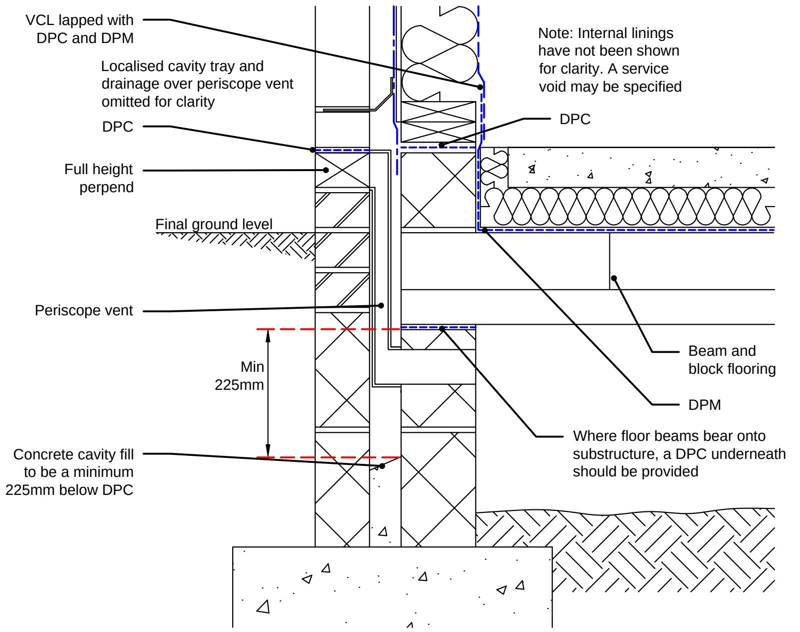
- Be provided with the use of full height open perpends at a maximum of 1350mm centres or equivalent open area.
- Be fitted in the brick or block course below the lowest timber sole plate above external finished ground level and below DPC.
- Maintain a clear cavity with care taken to reduce mortar droppings at the base of the wall.

Weep-holes alone are unsuitable for timber frame construction, and open perpends should be used. Proprietary open perpends should be used. Proprietary open perpend inserts are available with insect screening incorporated. Their equivalent open area must be considered and installation centres reduced accordingly.

Ground supported floor - no sub floor ventilation



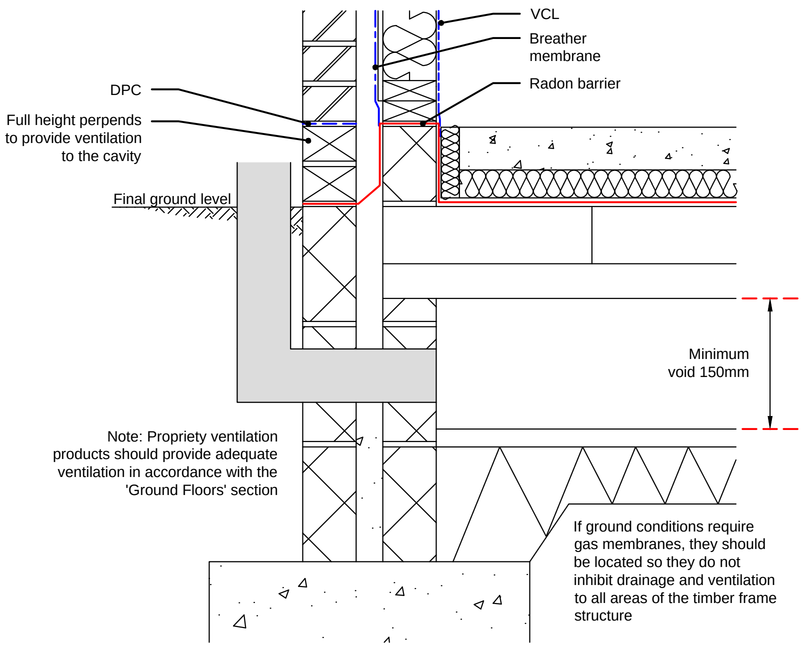
Suspended floor with ventilation provision



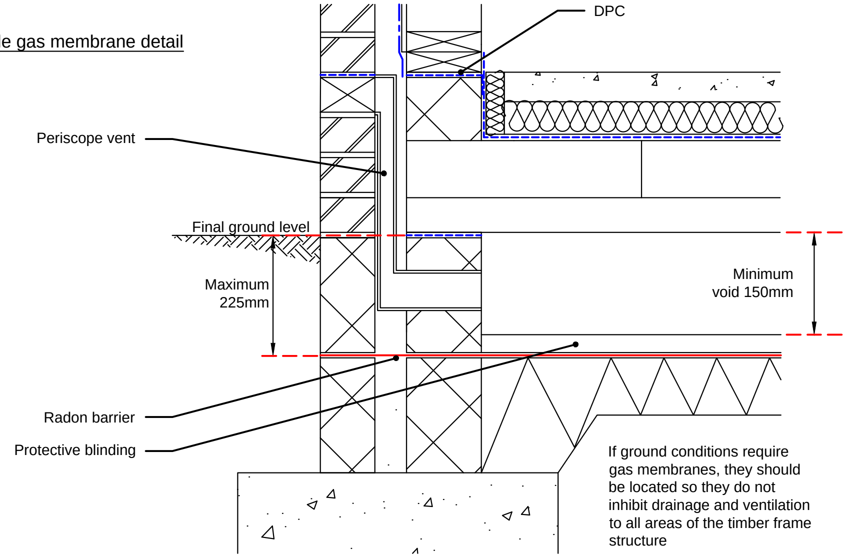
Ventilation for timber frame structures

It is important that whilst setting out the walls below ground that suitable forethought is given to the subsequent construction above DPC. The cavity should be constructed so that the appropriate widths are achieved in line with the appropriate relevant regional Building Regulations and our Warranty requirements. For timber frame structures early consideration of ventilation and drainage is key. Radon barriers should be positioned in such a way to not impair or restrict ventilation to any part on the timber frame structure.

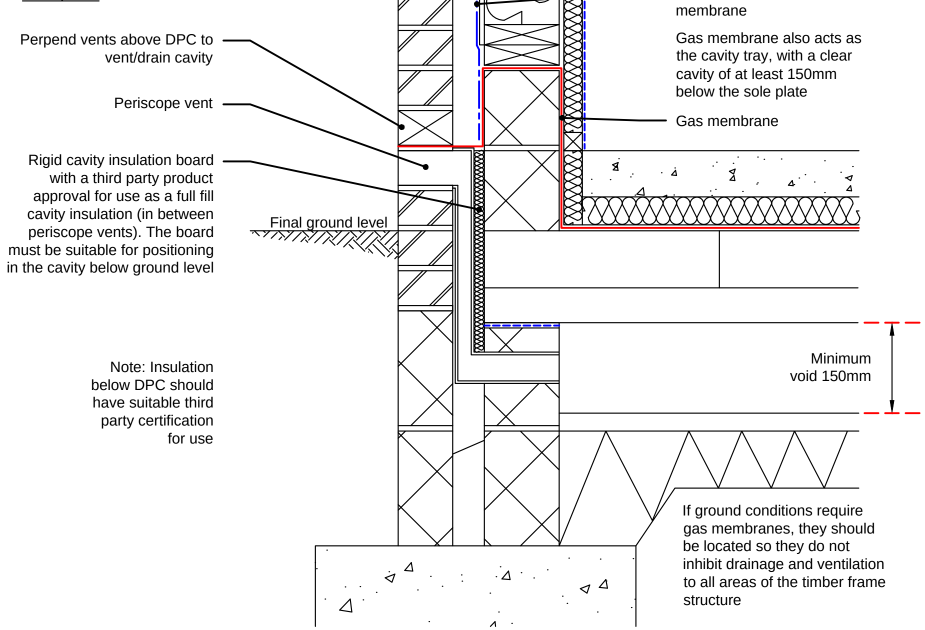
Possible gas membrane detail



Possible gas membrane detail



Possible gas membrane detail with raised sole plate



Sole plates

The sole plate is the first structural timber component installed on site. Its purpose is to set out the building, transfer loads to the foundations and provide a level base for erecting the wall panels. All structural timber should be located at least 150mm above finished external ground level, except for localised ramping (incorporating satisfactory drainage and ventilation detailing) for level threshold requirements.

The sole plate should be accurately levelled, located, and securely fixed to the substructure as specified by the Structural Engineer. Where no sole plate is specified, the following guidance applies equally to wall panel bottom rails. Timber sole plates should be preservative treated in accordance with BS 8417. Further information on timber treatment can be found in 'Appendix C - Materials, Products, and Building Systems'.

Location

Sole plates should:

- Be located so that all structural timber is at least 150mm above external ground level. The use of a masonry foundation kerb upstand may be an appropriate method to achieve this.
- Be levelled to +/-5mm from datum.
- Not overhang or be set back from the foundation edge by more than 10mm.
- Be set out within +/-10mm in length and in line within +/-5mm, as defined by the timber frame drawings.
- Diagonals should be within +/-5mm up to 10m, and +/-10, for more than 10m.

Note: Internal and party wall timber sole plates should not be installed below internal finished floor level.

Damp Proof Course (DPC)

A DPC should:

- Be located directly below all timber sole plates.
- Overlap at DPC junctions by at least 100mm.
- Be located flush to the outside edge of the sole plate.

Fixings

Fixings should:

- Be installed to the Structural Engineers specification.
- Not damage the substructure or sole plates during installation.
- Be placed to provide adequate lateral restraint at door openings.
- Be specified with consideration for use with gas membranes where appropriate.
- Sole plates should be fixed to foundations with shot fired nails, proprietary sole plate fixings, anchors, brackets, or straps, as specified by a Structural Engineer.
- All sole plate fixings and holding down products should be austenitic stainless steel. If stainless steel straps are used, they should be grade 1.4301 steel to BS EN 10088 and isolated from the studs with neoprene gaskets or similar.

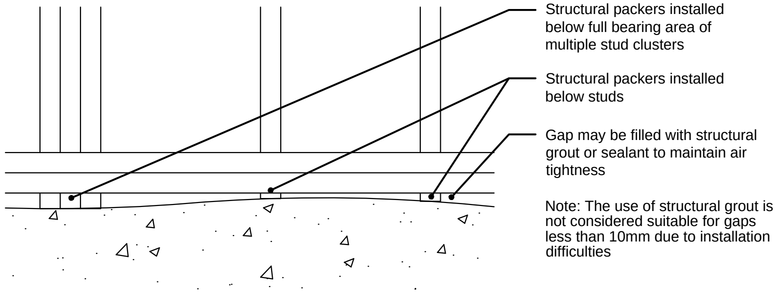
Ventilation

Regardless of the cladding system used, a cavity with provision for drainage and ventilation should be provided between the cladding and the timber frame ensuring that adequate ventilation provision is provided to all areas of the timber frame including the sole plate.

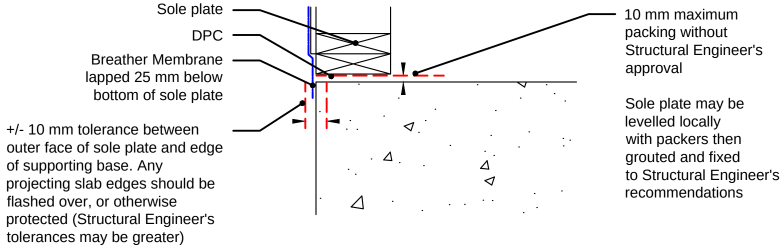
Packing

Structural shims or grout may be required under sole plates to level them and transfer vertical load. Longer fixings may be needed to allow for the size of the gap.

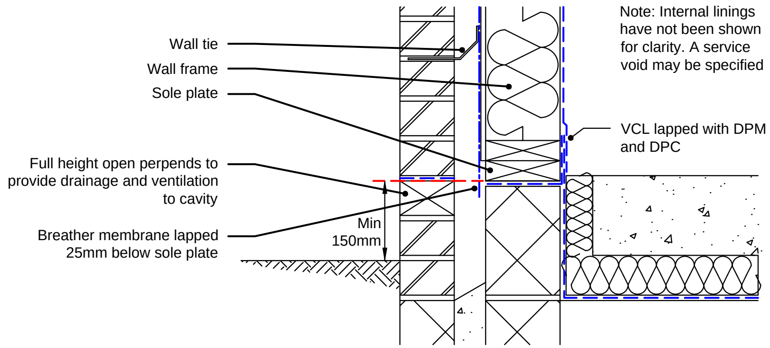
Packing of sole plates



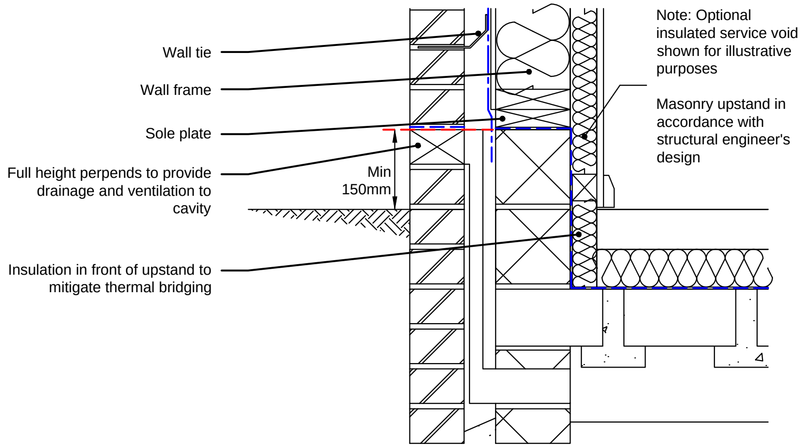
Locating sole plates



Sole plate/foundation junctions



Kerb upstand to allow level threshold



Timber frame wall panels

Timber frame external wall panels shall:

- Be manufactured in accordance with the Structural Engineer's design.
- Consist of solid timber studs and rails.
- Have studs at a maximum of 600mm centres.
- Be braced with a structural sheathing board.

Fixings and junctions

All fixings are to be installed to the Structural Engineer's specification.

Unless otherwise justified:

- Junctions of wall panels and sole plates/head binders should not occur together.
- Head binder laps should wherever possible occur over a stud, preferably at least 600mm from the panel junction.
- Wall panel to wall panel connections should be a maximum of 300mm centres.
- Bottom rail to sole plate fixings should be one or two per stud bay.
- Wall panels should be adequately braced during erection to maintain tolerances.
- Disproportionate collapse components and fixings must be installed if specified.
- Multiple stud clusters must be installed to the full width of point load-bearings.
- Point loads must be transferred down through wall panels and floor zones to foundations.
- Walls manufactured off-site must be fixed together as specified.
- Special considerations should be given to protecting closed panels from exposure to moisture during delivery, storage and erection.
- Engineered timber components should not be exposed to moisture for longer periods than those stated by the manufacturer.
- Roof trusses/rafters should be adequately fixed to wall panels.
- Floor joists should be nailed down to wall panels.
- If no head binder is present, floor joists must bear directly over studs.
- Waistbands and alignment of floors over walls should remain within tolerances for wall panels.

Timber framing components and structural sheathing boards may be fixed with:

- Nails
- Staples

Nail fixings should be:

- Austenitic stainless steel
- Galvanised
- Sherardized

Staple fixings should be austenitic stainless steel or similar.

Openings

All openings including doors, windows, flues and ventilation ducts should be designed and constructed to maintain structural performance.

Vapour Control Layer (VCL)

A continuous VCL with a minimum vapour resistance of 250 MN.s/g or 0.25 Pa/m2 should be located on or near the warm side of the thermal insulation.

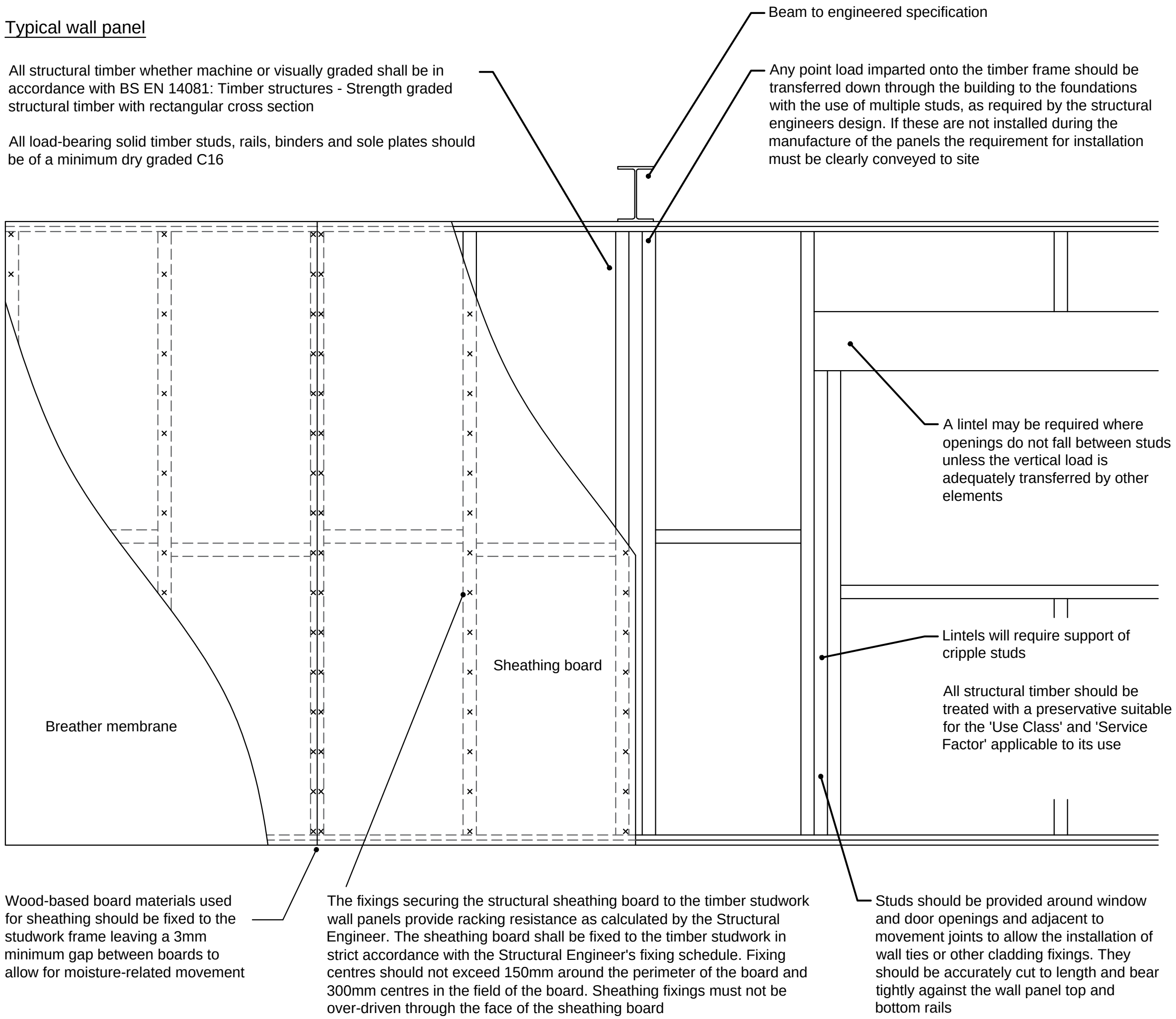
Sheathing boards

Sheathing boards are fixed to the timber frame in order to provide racking resistance to the structure.

Structural sheathing board materials may be any of the following:

- Orientated strand board (OSB).
- Plywood.
- Impregnated soft board.
- Other board material with suitable third-party certification.
- All wood-based panel products should comply with BS EN 13986: Wood-based panels for use in construction - characteristics, evaluation of conformity and marking.
- OSB should be grade 3 or 4 in accordance with BS EN 300: Oriented Strand Boards (OSB) - Definitions, classification and specifications.
- Plywood should be at least Class 2 Structural in accordance with BS EN 636: Plywood Specifications.
- Impregnated soft boards should be Type SB.HLS in accordance with BS EN 622-4: Fibreboards, specifications and requirements for soft boards.

Typical wall panel



TIMBER FRAME - BRICK CLAD: Breather membrane, drilling of studs, and services

Breather membrane

A breather membrane is a water-resistant moisture vapour permeable membrane used to provide temporary weather protection during construction, and secondary protection from moisture once the building is complete.

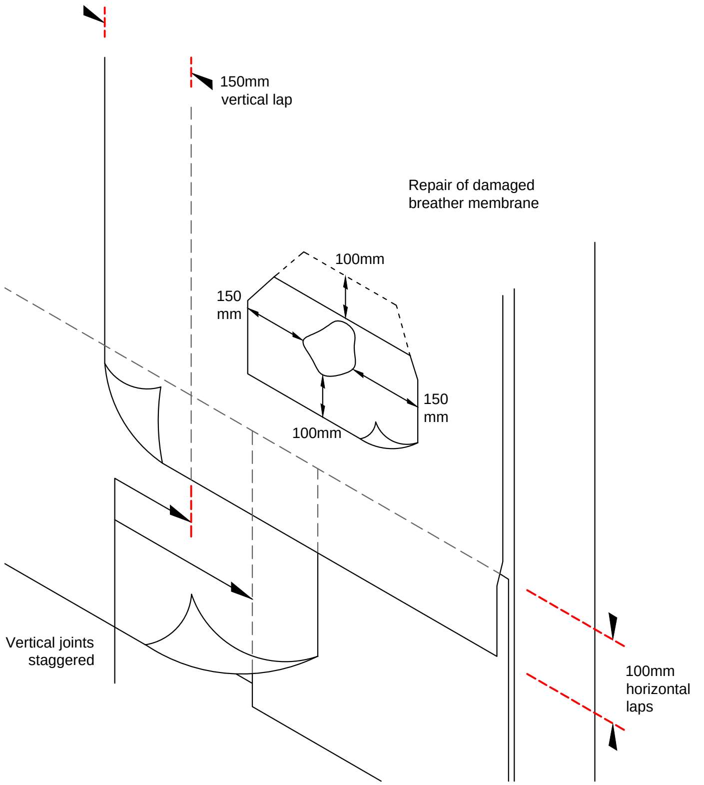
The timber frame structure should always be protected by a breather membrane facing the external wall cavity.

Breather membranes should be:

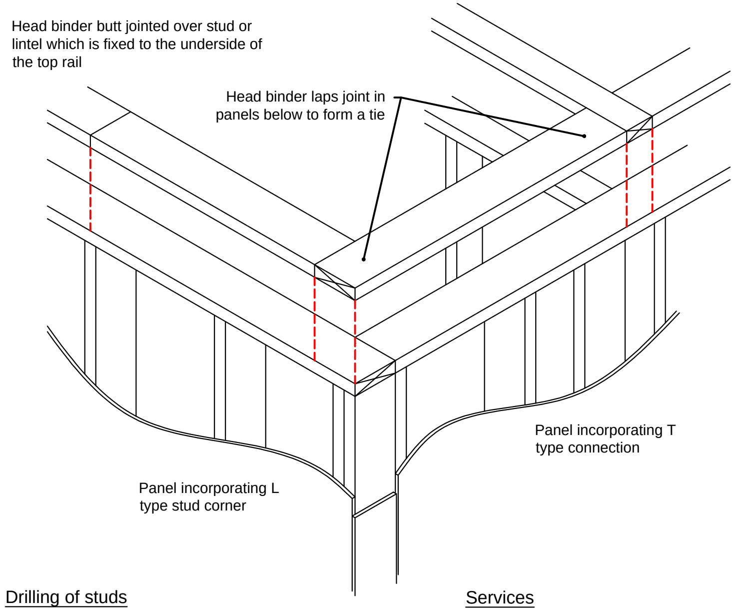
- Minimum Class W2 or better in accordance with BS EN 13859: Flexible sheets for waterproofing - Definitions and characteristics of underlays.
- Securely fixed to protect the outside face of the timber frame structure with austenitic stainless steel staples.
- Placed on the outside of the timber structure and any external insulation adjacent to the external wall cavity.
- Lapped to deflect moisture away from the timber frame structure.
- Trimmed to leave 25mm lap below the lowest timber sole plate.
- Repaired if damaged.

Breather membranes should be lapped by a minimum of 100mm at horizontal joints, and a minimum of 150mm at vertical joints. If breather membranes are trimmed flush with the edges of wall panels, additional strips of breather membrane, at least 300mm wide, should be supplied and site fixed over panel junctions. The location of solid timber studs should be clearly marked on the outer face of the breather membrane to ensure that cladding fixings are installed into solid timber.

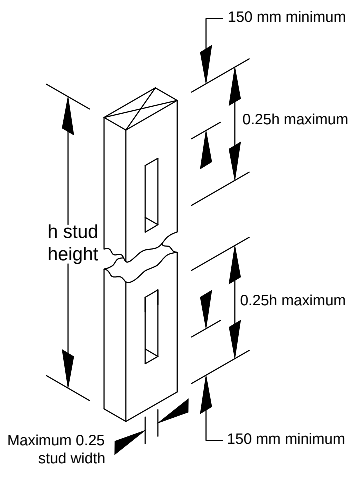
Lapping and repair of breather membrane



Head binder lapping - Timber frame



Drilling of studs



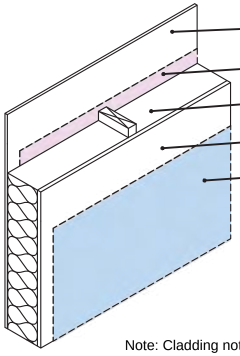
Drilling on centre line only. Hole diameters not greater than 0.25 stud width and hole centres not closer than 4d (d = hole diameter)

Services

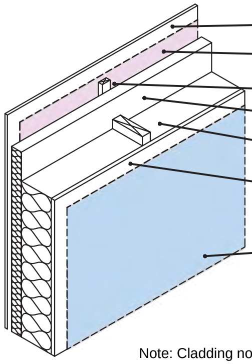
In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Electrical services are to be rated for their location with consideration for insulation.
- Wet services are not to be installed on the cold side of the insulation.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face stud.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.

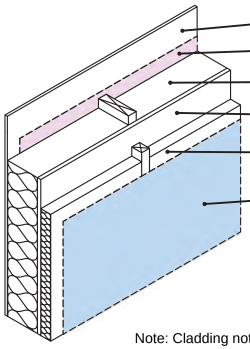
Conventional wall with insulation between studs



Continuous internal insulation



Continuous external insulation



Insulation materials

Insulation materials should be chosen with consideration for their breathability and interaction with the timber frame.

Thermal insulation products typically used are:

- Mineral fibre (glass or rock).
- Wood fibre/wool.
- Blown cellulose.

Other insulation materials may be used subject to relevant third-party certification.

Insulation may be specified in any or all of the following locations:

- Between the load-bearing studs.
- On the outside of the timber frame.
- On the inside of the timber frame.

Insulation installed to the outside of the timber frame structure should have third-party certification for this application and retain a minimum of a clear 50mm cavity. The outer layer of insulation should also be covered with a breather membrane adjacent to the cavity.

External walls should be subject to U-Value and condensation risk calculations. A wall build up will be considered satisfactory if there is no calculated risk of surface or interstitial condensation at any time of the year, and it fulfils the minimum national requirement for thermal performance.

Special consideration should be given to condensation risk where non-breathable insulation products are installed on the outside of the timber frame structure. Joints between foil faced external insulation boards, must not be taped as this forms a vapour control layer on the cold side of the insulation.

Depending on the specification of insulation materials to be added to the structural frame, timber battens may be required to support the insulation or allow fixing of plasterboard linings, or external cladding.

Insulation

If insulation is specified between external walls studs all voids shall be filled with insulation to maintain the thermal envelope of the building. When noggins or boards are installed between studs to support services or heavy fittings the void behind them shall be fully insulated.

Insulation should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight, as wet insulation can retain moisture. If closed panel timber frame is specified, additional care must be taken to protect the panels from exposure to moisture during construction, with moisture content checks carried out before full closure.

Note: The above also applies equally to insulated party wall cavities.

Insulation installed within the cavity

If external wall insulation is to be used:

- Insulation should be installed in a manner to maintain its stated performance by minimising gaps that lead to thermal bridging and air washing.
- Installation should be covered with a breather membrane to ensure that external wall cavity moisture does not become trapped in or between the insulation and the timber frame.
- Cavity trays should be fixed and lapped over the cavity facing breather membrane to deflect cavity moisture away from the timber frame.
- Allowance should be made for differential movement to occur at floor zones.
- Cavity barriers should be tightly fitting; depending on the type of insulation used, cavity barriers may need to pass through the insulation, back to solid timber within the timber frame structure behind and remain effective in a fire.
- It should not retain or transmit moisture to cause the timber structure to exceed 20% moisture content.
- Stud locator marks should be transferred onto the outer face of the breather membrane adjacent to the external wall cavity.
- Wall ties should transfer loads to the timber frame structure. To achieve this, wall ties will typically need to be installed through the external insulation rather than bearing onto it.
- Joints between foil faced insulation boards must not be taped.

Vapour control layer (VCL)

A VCL is a moisture vapour-resistant material located on, or near, the warm side of the thermal insulation.
Its purpose is to:

- Restrict the passage of moisture vapour through the structure of the wall.
- Mitigate the risk of interstitial condensation.

The VCL should have a minimum vapour resistance of 250 MN.s/g or 0.25 Pa/m2. It is also typically used as an air tightness layer.

The VCL may take the form of:

- A vapour control plasterboard comprising a metallised polyester film bonded to the back face of the plasterboard.*
- A minimum 125 micron thick (500 gauge) polythene sheet.
- A third-party approved proprietary vapour control membrane product.

*Vapour control plasterboard should only be used subject to a condensation risk analysis demonstrating the suitability of the wall build up.

Subject to a favourable condensation risk analysis, a novel or reverse wall construction may not require the use of a high moisture vapour-resistant vapour control membrane.

A VCL should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight.

Installation of a VCL

A sheet membrane (polythene or proprietary) VCL should be:

- Securely fixed to and cover all areas of the timber frame external walls, including all sole plates, head binders, and lapped/sealed fully into window/door reveals.
- Lapped and sealed by at least 100mm at joints.
- Lapped and sealed over studs, rails or noggins.
- Sealed around service penetrations.
- Lapped and sealed with DPM/DPC at the junction with the ground floor/foundation by a minimum of 100mm.

Note: Small holes in the VCL should be sealed with a suitable self-adhesive tape. If a proprietary membrane is being used, the manufacturer's proprietary sealing tape should be used. Larger holes should be re-covered to lap over adjacent studs and rails.

Vapour control plasterboard should be:

- Fixed in accordance with the plasterboard manufacturer's installation guidance.
- Tightly cut and fitted around service penetrations.
- Discarded if the vapour control backing is damaged.

Wall linings

The internal lining of the timber frame wall may be required to perform four functions:

- Provide the finish or a substrate to accept the finish on the inner face of the wall.
- Contribute to the racking resistance of the wall.
- Contribute to the fire resistance of the wall.
- Contribute to the acoustic performance of the wall.

Wall linings are typically:

- Gypsum plasterboard.
- Fibre reinforced gypsum board.
- Cement bonded particle board.

Lining materials must satisfy all relevant performance criteria, e.g. fire resistance, acoustic performance and have relevant third-party certification.

Plasterboard

Installation

In order to provide the specified period of fire resistance, the plasterboard must:

- Protect all areas of the timber frame structure.
- Have all edges supported by timber studs or rails.
- Be fixed in accordance with the plasterboard manufacturer's guidance.
- Be cut and tightly fit around service penetrations.
- Have junctions of wall and ceiling linings detailed to maintain continuity.
- Be installed using the specified number of layers to achieve the required fire resistance.
- Have all joints staggered when installing multiple layers.

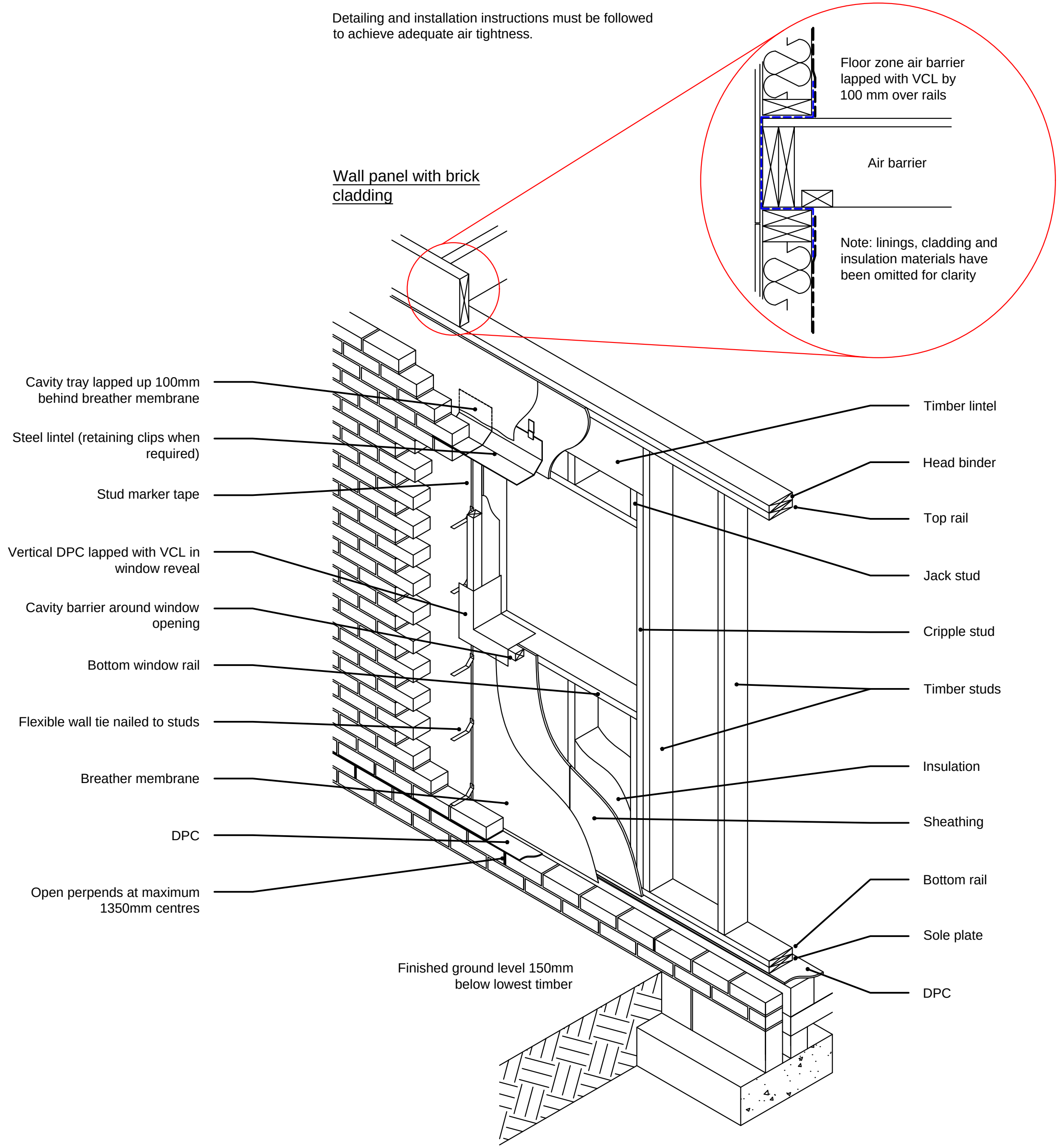
When fixing plasterboard linings:

- Each layer must be fully and independently fixed.
- Fixings of the correct length and centres should be installed in accordance with the plasterboard manufacturer's installation instructions.
- Walls requiring plasterboard to provide racking resistance should be clearly identified with plasterboard installed to the Structural Engineer's specification or the plasterboard manufacturer's specification, whichever is more onerous.

Air leakage

Detailing and installation instructions must be followed to achieve adequate air tightness.

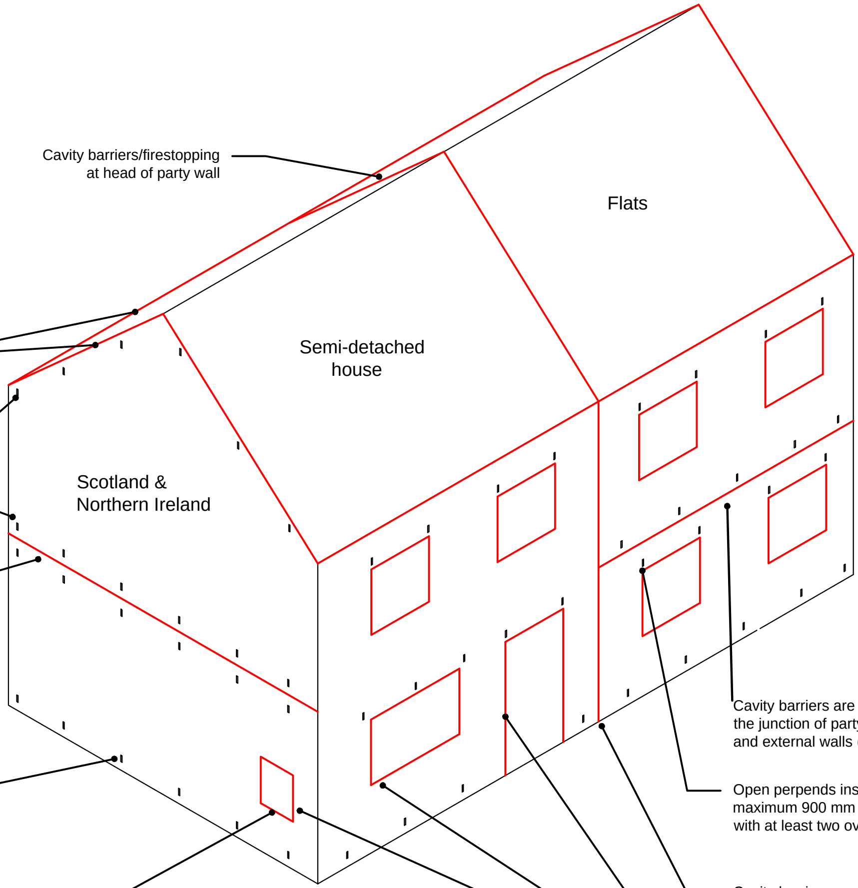
Wall panel with brick cladding



Locations of cavity barriers and open perpends

Note: Lightweight cladding systems will require a cavity barrier along the bottom of the cavity

Note: Cavity barriers may also be required between walls and floors within the building, consult National Regulations for further guidance



Cavity barrier locations

In England and Wales, cavity barriers shall be installed:

- At the edges of all cavities including around openings, e.g. windows and doors.
- Between an external cavity wall and a compartment wall or compartment floor.
- Around meter boxes in external walls.
- Around service penetrations in external walls e.g. extract duct or boiler flue.
- To sub-divide extensive cavities; please refer to National Regulations for specific requirements.

Cavity barrier installation

Cavity barriers shall be installed:

- So they fully close the cavity.
- So the ends are tightly butted (or adequately lapped in accordance with the manufacturers instructions) to form a continuous barrier.
- Backed by solid timber studs, rails or floor joist at least 38mm wide.
- In accordance with manufacturer or independent certifier's guidance.

A cavity tray should be proved directly above a horizontal cavity barrier and lapped at least 100mm behind the breather membrane (except at eaves and verges).

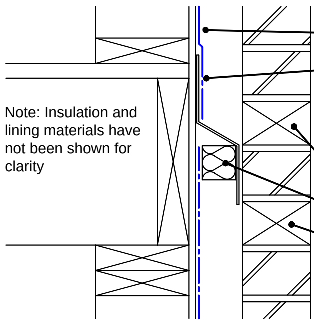
Cavity barriers are required to prevent the spread of smoke and flame within concealed spaces.

Cavity barriers may be constructed from:

- Steel at least 0.5mm thick.
- Timber at least 38mm thick.
- Proprietary 3rd party approved mineral wool product.
- Calcium silicate, cement-based or gypsum-based board at least 12mm thick.
- An independently assessed and certified proprietary product.

Timber cavity barriers should be protected from masonry cladding by the use of a DPC. The cavity face of the barrier should be left uncovered to allow drainage and ventilation of the timber. The use of timber cavity barriers around openings allows for effective sealing to be installed between them and the opening frame.

Cavity tray above horizontal cavity barrier



Masonry cladding

Timber frame external walls should be finished externally with a cladding system, which may take the form of masonry or a lightweight rainscreen system. Regardless of the cladding system used, all external wall claddings should be separated from the timber frame structure by a drained and ventilated cavity. In some locations, for example close to boundaries, national regulations require claddings to provide fire resistance to the structure from the outside in. Where a masonry cladding is proposed the vertical loadings from the masonry cladding must not be supported by the timber frame structure.

Self supporting masonry claddings

Self supporting masonry claddings should be connected to the timber frame using walls ties, wall ties should meet the following provisions:

- Comply with BS EN 845: Specification for ancillary components for masonry, ties, tension straps, hangers, and brackets.
- Be constructed from austenitic stainless steel.
- Accommodate all anticipated differential movement.
- The overall length of the wall ties must be of adequate length to provide a minimum 50mm clear cavity and ensure there is at least a 62.5mm overlap onto the leaf of the masonry so that it will achieve a 50mm minimum length of bedding on the mortar.
- Be installed into solid timber studs, not just through sheathing.
- Additional studs should be provided in the timber frame structure for wall ties at vertical movement joints and around openings in the masonry cladding.
- Angled to drain moisture away from the timber frame even after differential movement has occurred.
- Installed at a maximum of 300mm centres vertically and 225mm horizontally around openings and movement joints.
- Installed within 225mm of the head of the wall.
- Wall tie density: For buildings up to three storeys in height wall ties should be installed at a minimum density of 4.4/m² (a maximum of 375mm vertically with studs at 600mm centres and a maximum of 525mm vertically where studs are at 400mm centres). A tie density of 4.4 ties/m2 may be suitable for buildings on flat sites within towns and cities anywhere in the UK, except the north western fringes of Scotland and Ireland (where the basic wind speed exceeds 25 m/sec) and any areas where the site is at an altitude of 150 m or more above sea level. An increased wall tie density may be required in exposed locations or for buildings higher than three storeys in height, the actual performance required for each site location or building should be determined by a suitably qualified Structural Engineer.

Cavity drainage and ventilation in masonry cladding should:

- Be provided with full height open perpends at a maximum of 1350mm centres or equivalent open area.
- Be provided in the brick or block course below the lowest timber sole plate above external finished ground level and below DPC.
- Be provided to ensure drainage and ventilation to each external wall concealed space directly above horizontal cavity barriers/trays.
- Be installed over openings in the external wall cavity e.g. windows and doors at a maximum of 900mm centres.
- Maintain a minimum 50mm clear cavity with care taken to reduce mortar droppings at the base of the wall.

Weep-holes alone are unsuitable for timber frame construction, and open perpends should be used. Proprietary open perpend inserts are available with insect screening incorporated. Their equivalent open area must be considered and installation centres reduced accordingly.

Cavity drainage and ventilation should provide an open area of not less than 500mm² per metre run:

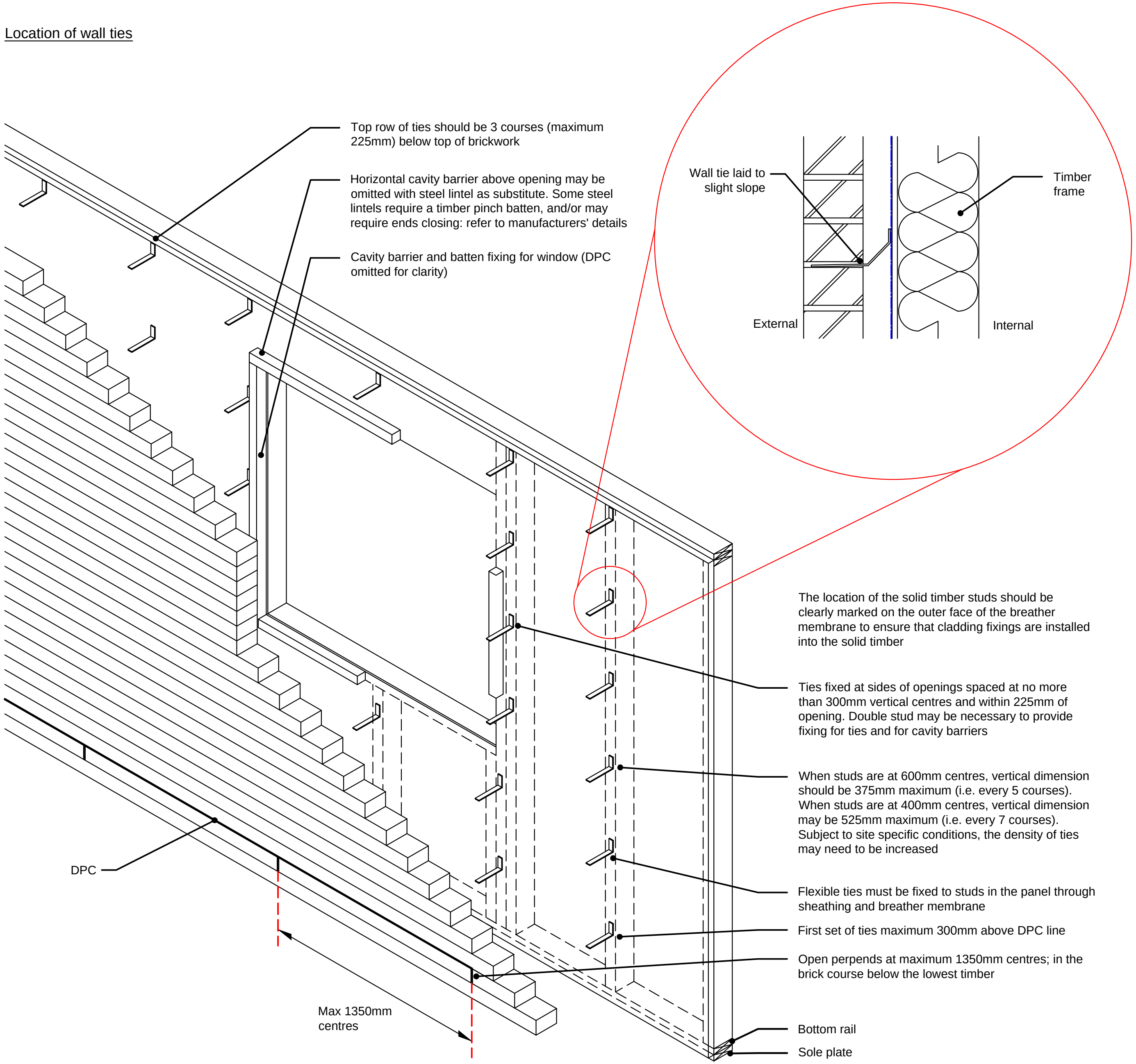
- At the base of the external wall concealed space.
- Above horizontal cavity barriers/trays.
- Over openings in the external wall cavity, e.g. windows and doors.
- Allowing differential movement to occur while retaining an adequate gap.
- With openings protected by a mesh to prevent the passage of insects.

Masonry cladding - Brick suitability

- Facing bricks must have a suitable level of durability and particular attention should be paid to the bricks resistance to frost and moisture.
- Bricks should be capable of supporting proposed loads.
- Bricks should comply with BS EN771 and PD 6697.
- Frost resistant bricks should be used in areas of prolonged frost.

Further guidance is available in 'Appendix C - Materials, Products, and Building Systems'.

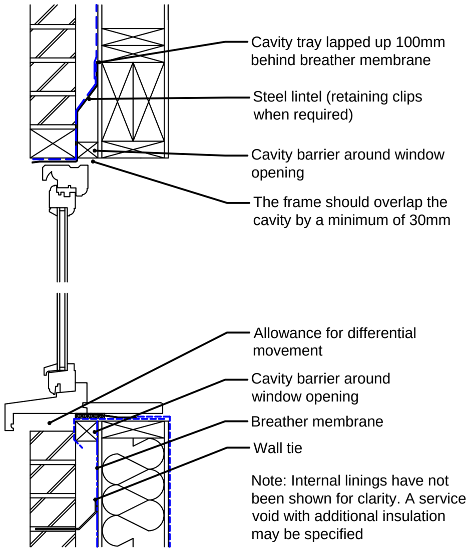
Location of wall ties



Window and door installations

Please refer to the 'Windows and Doors' guidance for installation requirements of frames including maximum gaps and fixings.

Typical vertical section through window opening



Openings

All openings including doors, windows, flues and ventilation ducts, should be designed and constructed to maintain:

Fire performance:

- Internal reveals require equal fire resistance to the rest of the structure.
- Window fixing straps should not compromise the integrity of any fire-resistant reveal linings.
- Cavity barriers should be installed in the external wall cavity around the perimeter of openings.
- If profiled steel lintels are used as cavity barriers, triangular gaps behind lintels, which occur at each end, should be closed with careful positioning of adjacent cavity barriers.

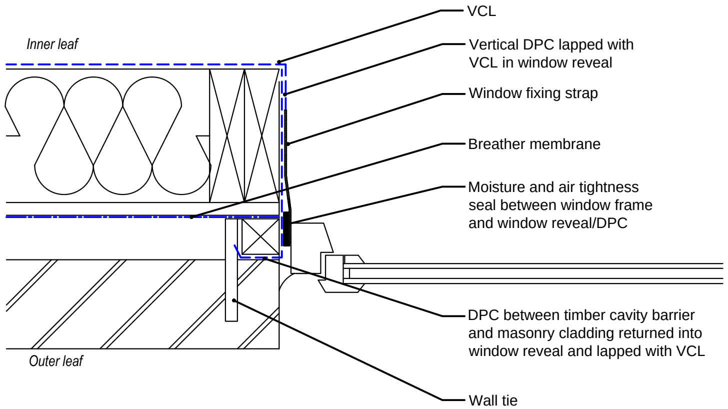
Acoustic performance:

- Seal gaps between timber frame wall and the element being installed into the opening.
- The element being installed into the opening may have a minimum acoustic requirement.

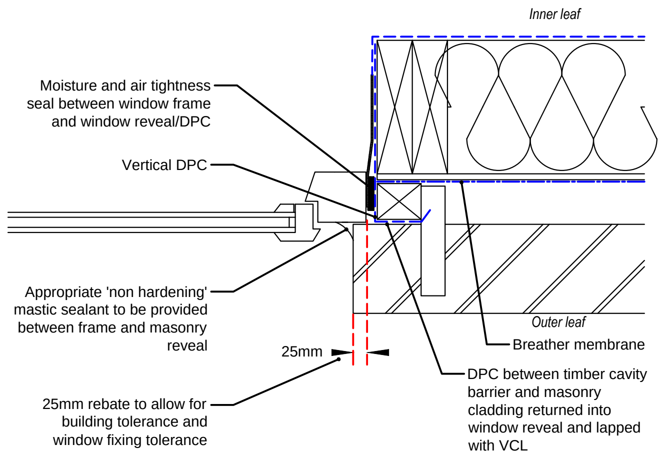
Weather tightness and thermal performance, including thermal bridging and air tightness:

- The element being installed into the opening is likely to have a minimum thermal performance.
- Seal gaps between the timber frame wall and the element being installed into the opening to provide thermal performance, weather tightness and air tightness.
- Cavity trays should be installed over the heads of all openings and lapped behind the breather membrane by a minimum of 100mm. A flashing may be acceptable for some types of claddings.
- Lap cavity barrier DPC with internal VCL around openings. Where no DPC is used, breather membrane should be lapped with internal VCL.

Typical window reveal detail (normal exposure)



Typical rebated window frame detail for areas of very severe exposure



When installing window/door frames in a checked rebate, allow for the frame to be deeper:

- To accommodate the 25mm rebate, and;
- To allow for opening lights to open clear of the masonry/render.

Windows and doors

In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap.

For further information on windows and doors please refer to the 'Windows and Doors' section.

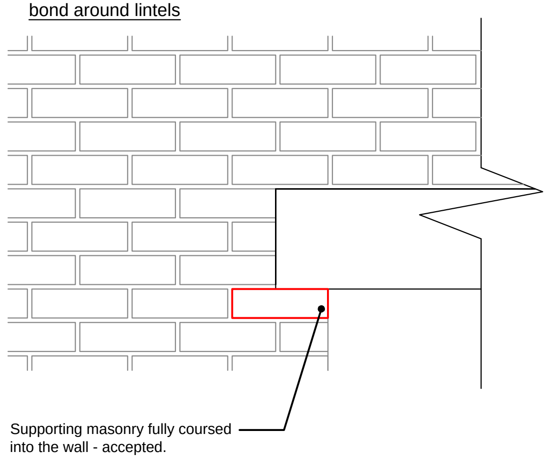
Lintels

- The lintel should be the correct length and width for the opening and cavity width, the bearing length should be at least 150mm.
- Do not let masonry overhang lintels by more than 25mm.
- Continuity of the masonry bond should be maintained at supports for beams and lintels.

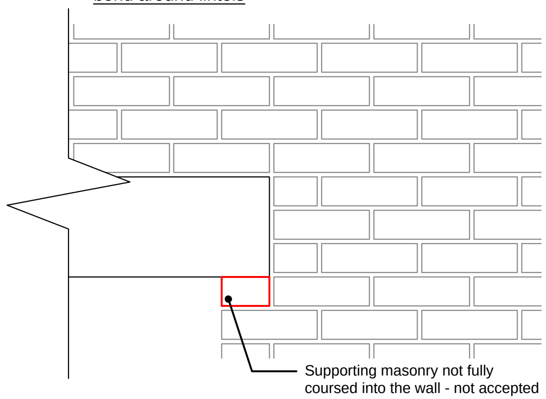
Do not:

- Support lintels and beams on short lengths of cut blocks or make-up pieces.
- Apply load to lintels or beams before the masonry supporting has hardened.

Correct method of brick bond around lintels

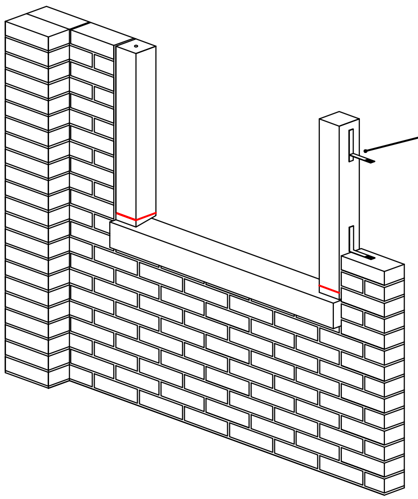


Incorrect method of brick bond around lintels



TIMBER FRAME - BRICK CLAD: Feature stone surrounds to openings

Stone jamb mullion fixing to walls

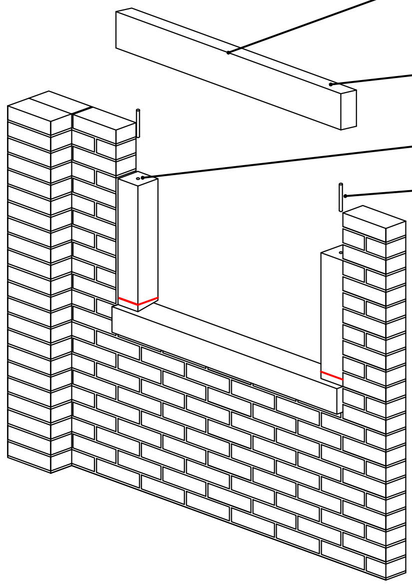


Stone jambs, mullions, and heads should not project into the cavity and insulated cavity closers should be inserted to prevent cold bridging (see typical window opening sections)

Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame-type cramps can also be used to give extra stability at jambs

Mortar:
The mortar for use with stone should comply with the relevant British Standards for sand, lime, and cement as set out in BS 5390

Joining stone jambs to sills and head



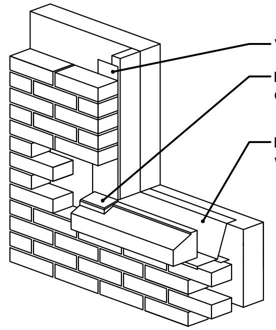
Cavity Trays

When stone heads are being used, it is advisable to double up the cavity trays - with one above the stone head to provide stop-ends and weep-holes

Cast stone jambs and mullions

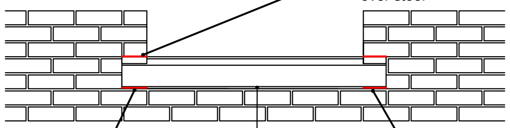
Stainless steel dowels in the sides of jambs should be bedded into adjacent mortar joints as the masonry is constructed

Stone sill with insulated cavity closer



Note: The insulated cavity closer must also be fire resistant unless an additional method of fire resisting cavity closure is also provided that meets Building Regulations.

Stone sill



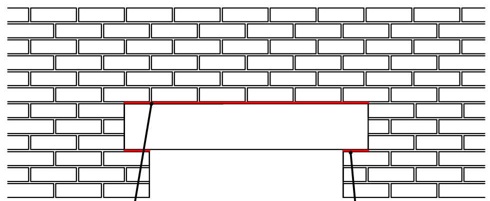
Sills

The DPC should be overlapped by the vertical DPC at the jambs and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off, and then a DPC laid over. The open section below the sill should be sealed with a flexible material only on completion of the structure.

To control water penetration through joints in window surrounds, e.g. at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

Stone head



Cast stone heads

A cavity tray must be provided above all heads as this not only discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head as well as a soft joint between the top of the head and the steel support lintel.

Cast stone heads should be manufactured in accordance with BS 1217, confirmation of this should be provided to the Warranty Surveyor upon request.

Cast stone window/door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement e.g. where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated or the cast stone should be flexibly jointed.

Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in the table below. The first joint from a return should be no more than half the dimension indicated in the table.

Movement joints below the Damp Proof Course (DPC) should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm vertical centres, and 225mm horizontally, should be provided on each side of movement joints.

Compressible filler, such as polyurethane foam, should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

When sealants are used in proximity with stone it is important to select a non-oil-based sealant to help prevent any staining to the stone.

Elastic sealants (type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

Where a backing material is used, the following must be considered:

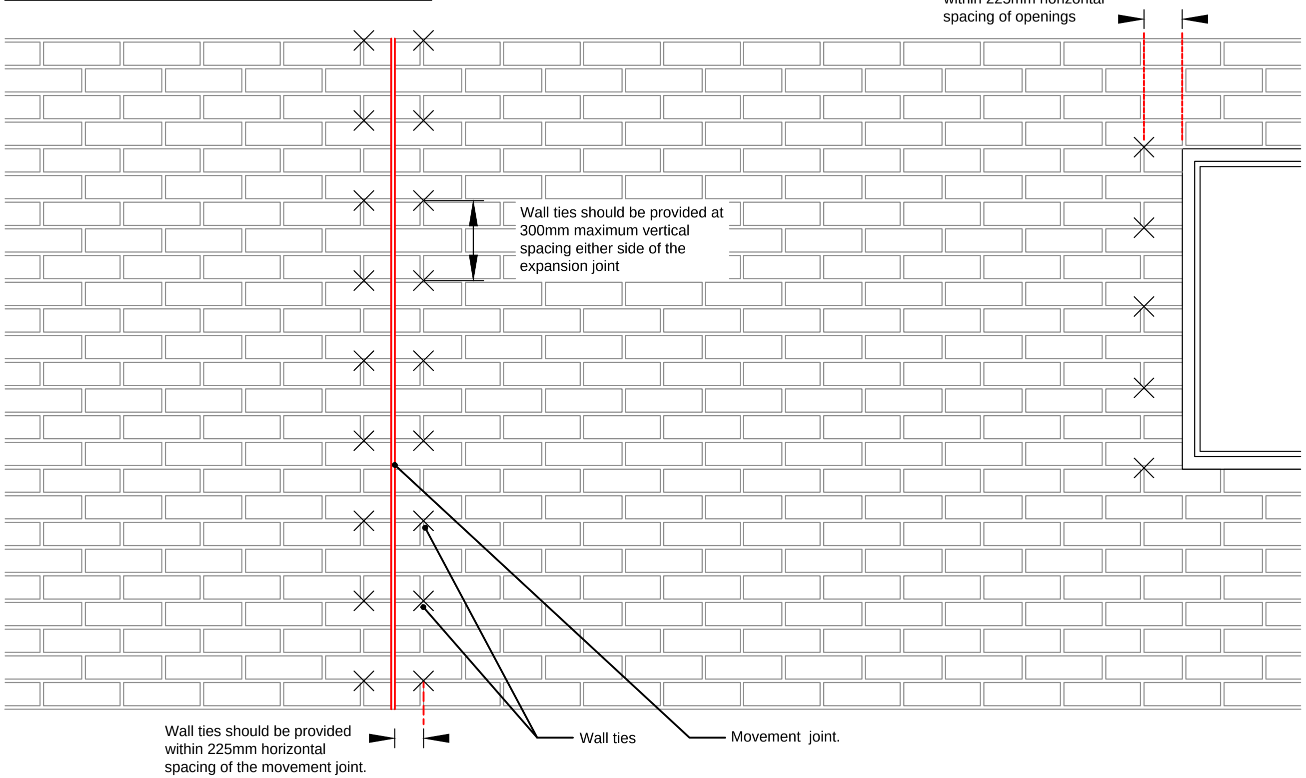
- The material is compatible with the sealant.
- It will not adhere to the sealant, preventing cracking within the sealant.
- Provides sufficient density to allow the sealant to be applied.
- Allows sufficient flexibility so not to impede lateral movement (compressible to about 50% of its original thickness), fibreboard is not acceptable.

The use of bed joint reinforcement may allow the distance between expansion joints to be increased, however this should be designed by a Structural Engineer.

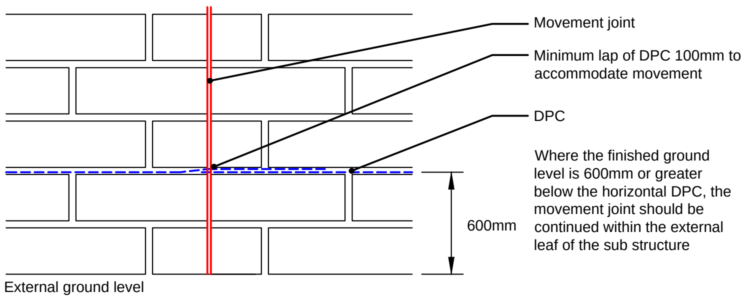
Spacing of expansion joints

Material	Normal spacing	Joint thickness
Clay brickwork	12m (spacing up to 15m may be possible if sufficient restraint is provided - consult designer)	15mm
Calcium silicate	7.5-9m	10mm
Concrete brickwork (1)	6m	10mm
Note: The first joint from a return should be not more than half the dimension indicated in the table. (1) Where openings are over 1.5m, masonry bed joint reinforcement should be considered		

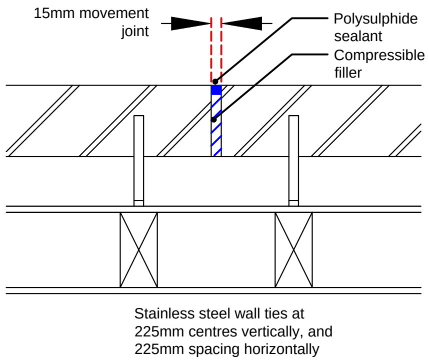
Wall ties in proximity to movement joints and windows



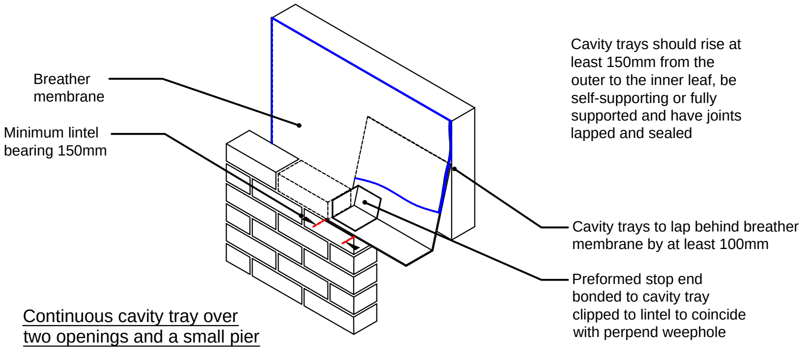
Movement joints below DPC



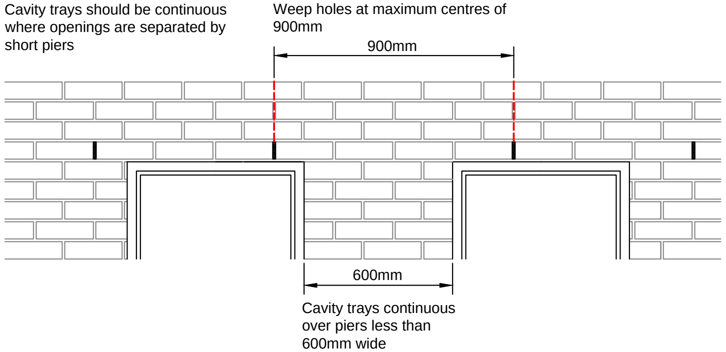
Typical movement joint detail



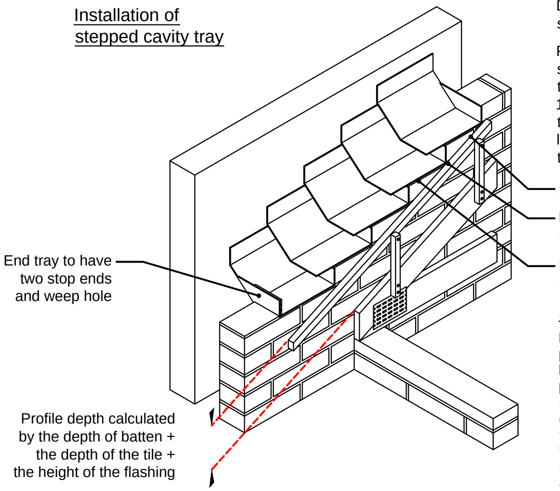
Stop end to cavity tray



Continuous cavity tray over two openings and a small pier



Installation of stepped cavity tray



Details of flashing can be found in the 'Roofs' section

Preformed cavity trays should be used for stepped cavity tray details. Stepped cavity trays to lap behind breather membrane by at least 100mm. Additional measures may be needed to ensure the breather membrane adequately laps the tray to prevent moisture ingress behind the stepped cavity tray

Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of buildings with steps and staggers. A proprietary cavity tray system should be used. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g. attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape over the lower roof covering. For masonry, lead cover flashings should be linked into the cavity tray (lapped in below)

Cavity trays

Cavity trays, associated weep-holes and stop-ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- Cavity trays are to be provided to comply with relevant regional Building Regulations.
- At all interruptions likely to direct rain water across the cavity, such as rectangular ducts, lintels and recessed meter boxes.
- Above cavity insulation that is not taken to the top of the wall, unless that area of wall is protected by impervious cladding.
- Above lintels in walls in exposure zones 4 and 3, and in zones 2 and 1 where the lintel is not corrosion-resistant and not intended to function as its own cavity tray.
- Continuously above lintels where openings are separated by short piers.
- Above openings where the lintel supports a brick soldier course.

Ring beams or floor slabs that partially bridge the cavity, e.g. podium decks or when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray.

Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level.

At least two weep-holes must be provided to drain cavity trays above openings.

Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind-driven rain (including ground level).

Stop-ends

Cavity trays should have water tight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, so that a stop to the structural cavity of at least 75mm high is provided. Normally, the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

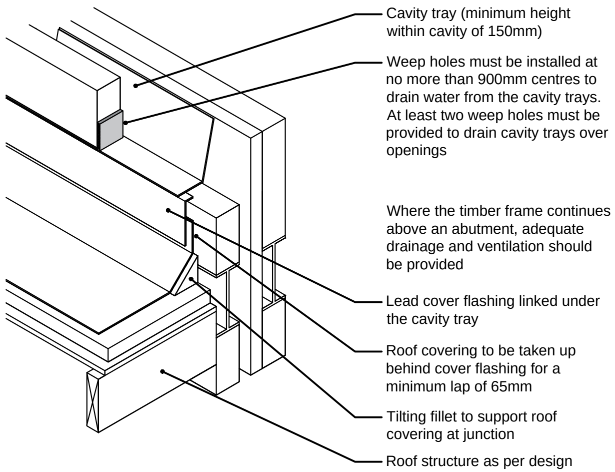
Other perforations of the building envelope

Proprietary elements, such as ventilators, soil pipes, etc. which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

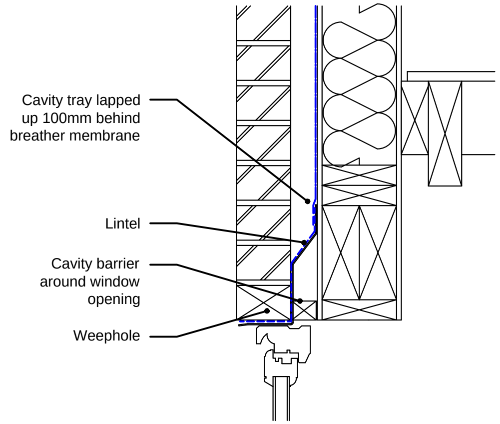
Proprietary cavity tray systems

At stepped and lower storey abutments, and around corners in low rise external walls, a proprietary cavity tray system should be used.

Flat roof abutment cavity tray construction



Cavity tray and lintel



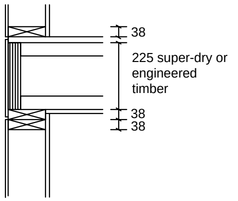
Differential movement at floor zones

Differential vertical movement occurs as a result of compression, closing of gaps and shrinkage of the timber frame structure and occurs during the first 24 months following completion. Shrinkage occurs across the grain and is due to a reduction in the moisture content of timber elements. The shrinkage of plates, rails, binders, floor and roof joists should be considered. The building should be designed to ensure that differential movement occurs evenly to external elevations and the internal structure.

Anticipated differential movement can be calculated using the allowance of 1mm for every 38mm of horizontal cross grain timber. As solid timber joists contribute significantly to anticipated differential movement, engineered timber joists should be considered where it is desirable to reduce differential movement.

Appropriate allowances must be made for differential movement to occur without damage to the building.

Engineered Timber

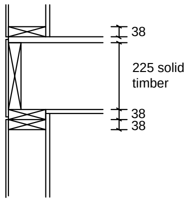


225 mm engineered timber = 2 - 3 mm differential movement depending on tightness of build.

Expect 6 mm movement per storey, or 7 mm per storey if a locator plate is used on upper stories.

Note: when super-dry timber or engineered timber platform frame ground floor is used, add 3 - 4 mm (depending on tightness of build) to the differential movement allowances quoted.

Solid Timber



225 mm solid timber = 6 mm differential movement.

Expect 9 mm movement per storey, or 10 mm per storey if a locator plate is used on upper stories.

Note: when solid timber platform frame ground floor is used, add 7 mm to the differential movement allowances quoted.

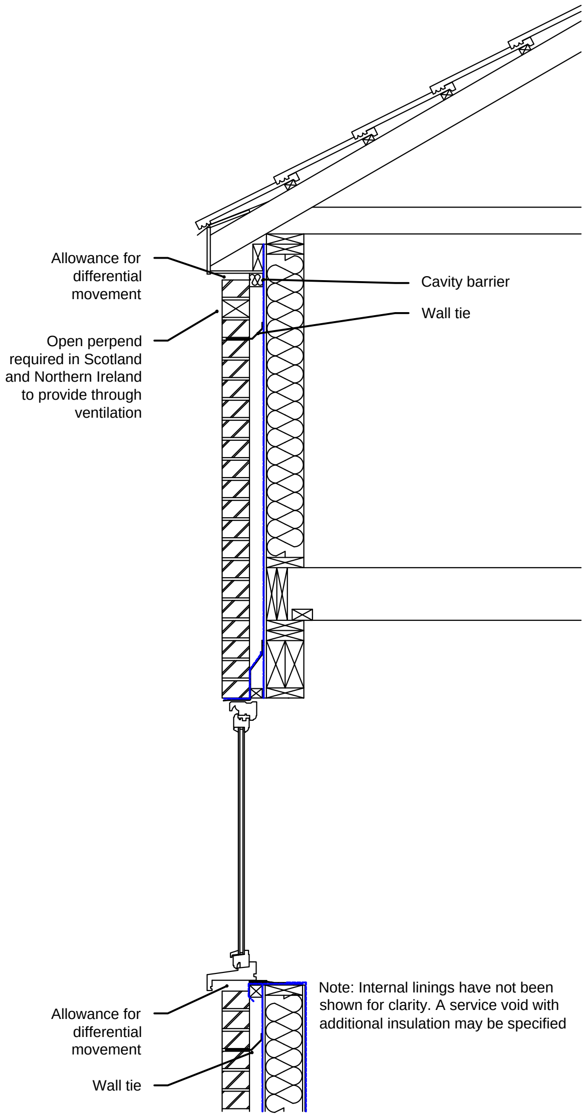
If fillers or seals are to be installed into differential movement gaps their fully compressed dimension, considering the area of the seal and force required to compress it, must be added to calculate gap size. Materials should be chosen to provide an effective weather tight seal dependent on whether they are to be subjected to compression, expansion, or shear forces. Cover strips may also be used.

Self supporting claddings (masonry)

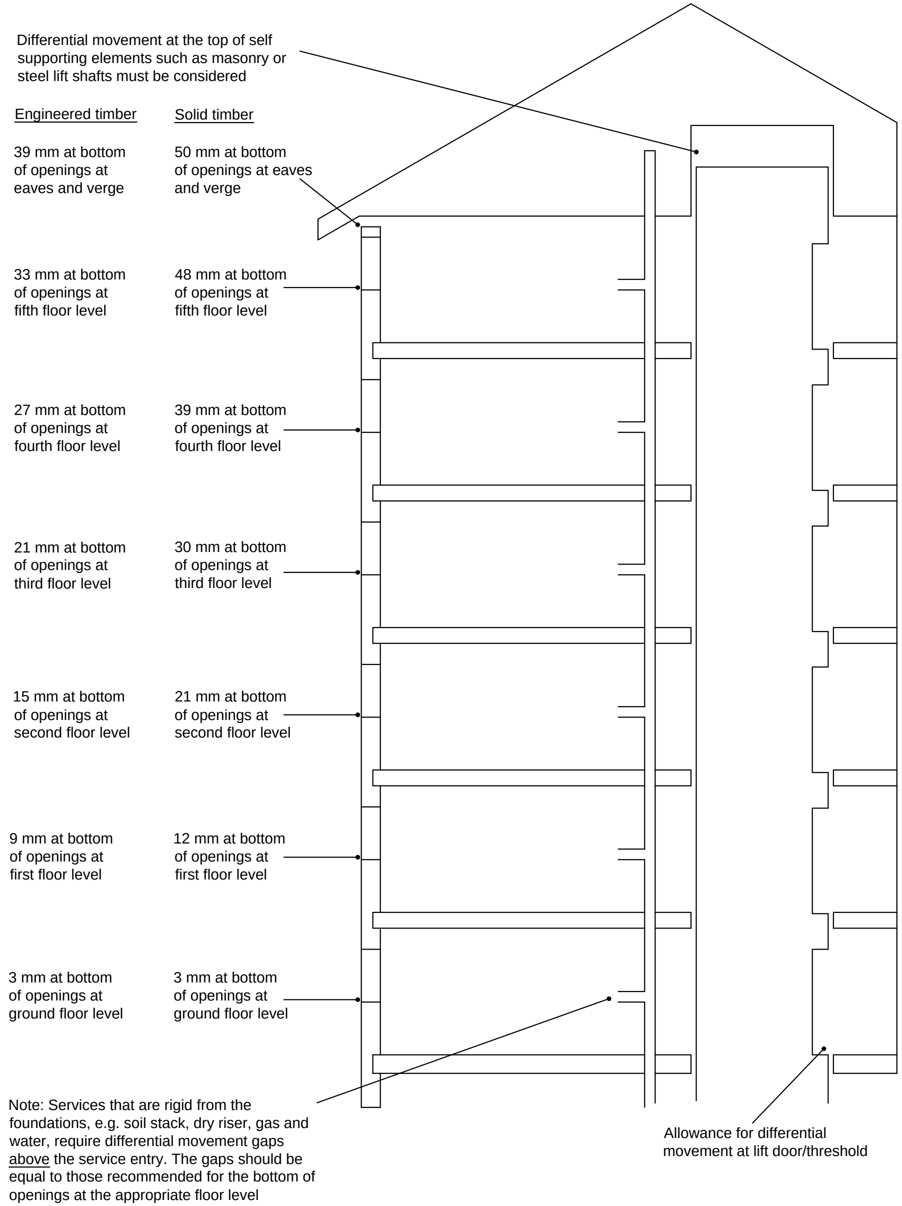
Any material or component attached to the timber superstructure that overhangs the brick or blockwork (e.g. cladding attached to the timber frame, window sills, roof eaves, and verges) or projects through the masonry (e.g. balcony supports, flues, extractor fan vents, or overflow pipes) should have a clear gap beneath and at the top of the masonry cladding to allow differential movement to take place, thus avoiding damage to the components or cladding.

Gap sizes should allow for anticipated differential movement while allowing for drainage and ventilation requirements. Insect infestation should be avoided by using screens to cover gaps exceeding 4mm.

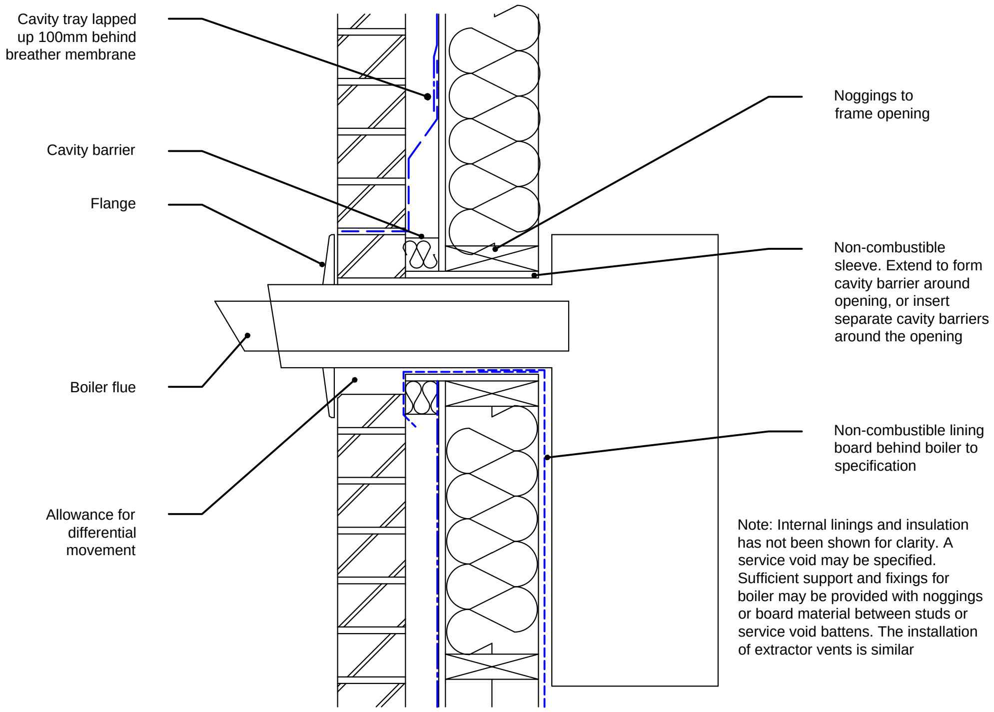
Allowance for differential movement



Anticipated differential movement

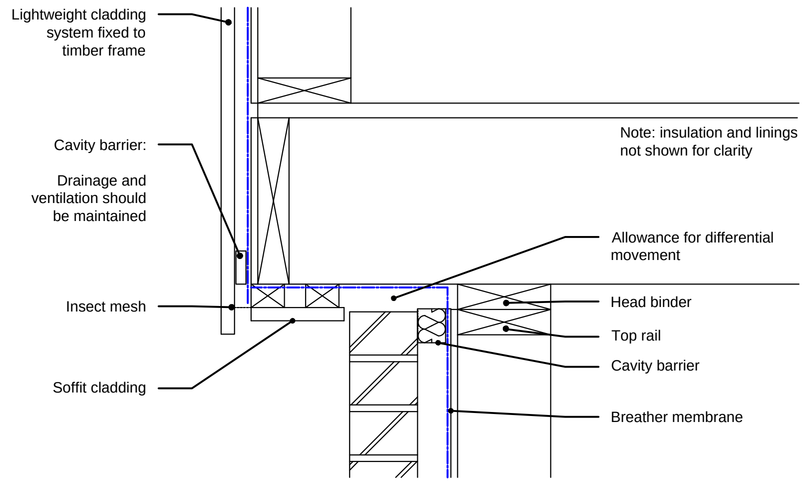


Differential movement at services

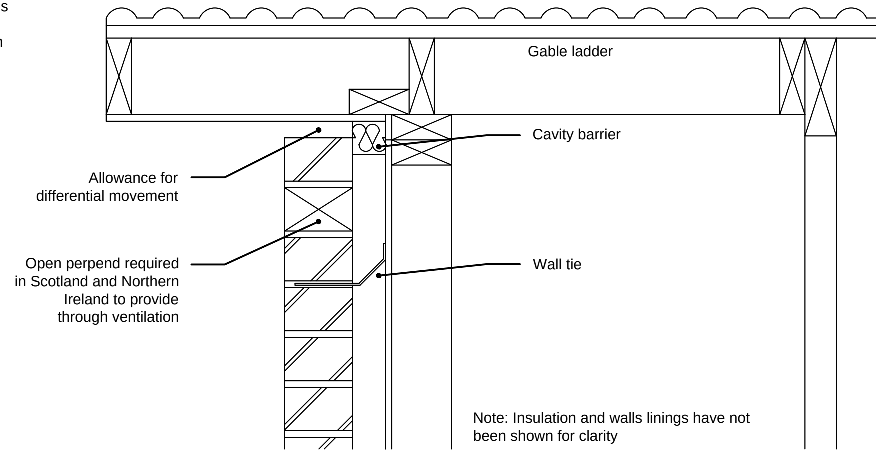


Note: Internal linings and insulation has not been shown for clarity. A service void may be specified. Sufficient support and fixings for boiler may be provided with noggings or board material between studs or service void battens. The installation of extractor vents is similar

Differential movement at cantilevered overhang



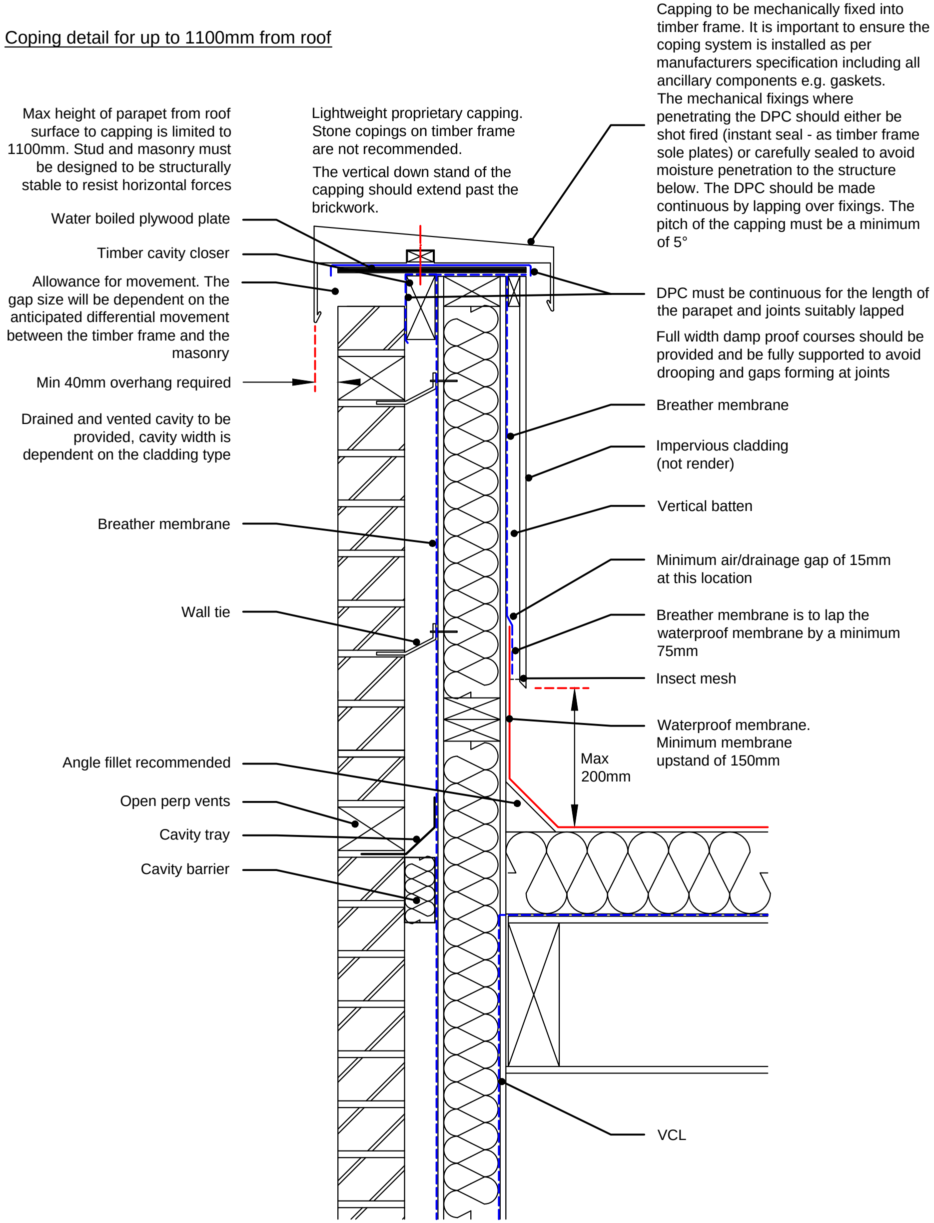
Differential movement at verge



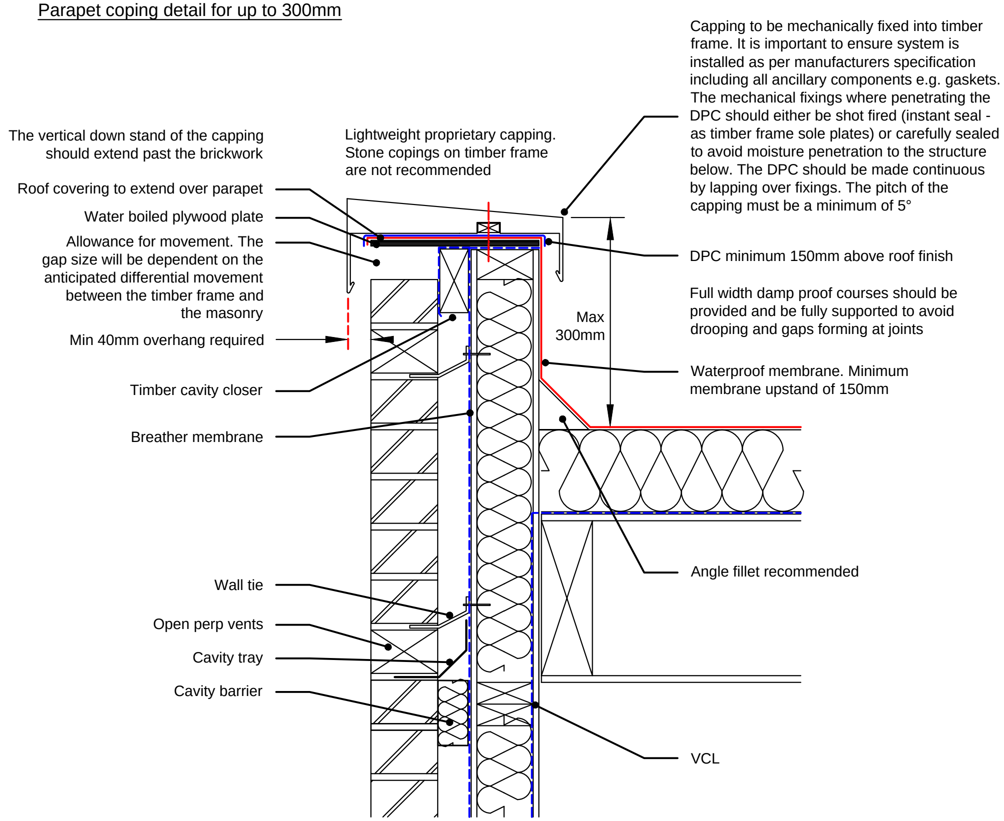
Services

Rigid services within the timber frame structure also require an equal allowance for differential movement, as shown. Examples include copper gas and water pipes, dry risers, internal downpipes, SVP's, and blockwork lift shafts. While gap allowances externally are allowed below, for example, a sill, when a branch comes off a rigid stack internally, the gap needs to be left above a service to allow the timber frame to drop around it.

Coping detail for up to 1100mm from roof



Parapet coping detail for up to 300mm

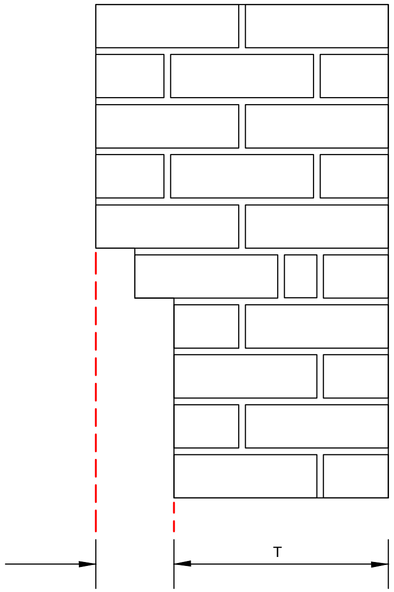


Parapets

- The parapet should be designed to accommodate differential movement, remain structurally stable, and allow suitable structural support of the lightweight coping.
- The coping should be mechanically fixed to the timber frame and the fixings should be suitable for the exposure and anticipated wind loadings.
- If the capping is secret fixed, each capping piece should be provided with at least 2 security fixings.

Feature brick corbelling

The extent of corbelling of masonry should not exceed that indicated in the below detail, unless supported or reinforced. Reinforced corbels should be designed by a Charted Structural Engineer.



Gable spandrel panels

The gable spandrel panel should be suitably designed to transmit loads to the roof structure and down through the timber frame.

It is important that gable spandrel panels are designed to transmit these loads to the roof structure via lateral restraints and vertically down to the timber frame. A full design with structural calculations be provided.

The timber frame designer should provide details of the lateral resistant to the gable spandrel panel, including details of the restraint used and the fixings should be provided.

General references used in this section

- BS EN 1995-1-1: 2004+A1: 2008 Eurocode 5 Design of timber structures. General: Common rules and rules for buildings.
- BS 5268-2: 2002 Structural use of timber. Code of Practice for permissible stress design, materials and workmanship.
- BS 5268-3: 2006 Structural use of timber. Code of Practice for trussed rafter roofs.
- BS 5268-4 Section 4.1: 1978 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.1 Recommendations for calculating fire resistance of timber members.
- BS 5268-4 Section 4.2: 1990 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.2 Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions.
- BS 5268-6.1: 1996 Structural use of timber. Code of Practice for timber frame walls. Dwellings not exceeding seven storeys.
- BS 5268-6.2: 2001 Structural use of timber. Code of Practice for timber frame walls. Buildings other than dwellings not exceeding four storeys.
- BS EN 14081-1: 2005 Timber structures. Strength graded structural timber with rectangular cross section. General requirements.
- BS 8417: 2003 Preservation of timber. Recommendations.
- BS EN 13986: 2006 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking.
- BS EN 300: 2006 Orientated strand boards (OSB). Definitions, classification and specifications.
- BS EN 636: 2003 Plywood. Specifications.
- BS EN 622-4: 2009 Fibreboards - Specifications. Requirements for softboards.
- BS EN 622-3: 2004 Fibreboards - Specifications. Requirements for medium boards.
- BS EN 622-2: 2004 Fibreboards - Specifications. Requirements for hardboards.
- BS 4016: 1997 Specification for flexible building membranes (breather type).
- BS EN 845-1: 2003+A1: 2008 Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets.
- EN 14732: 2011 Timber structures. Prefabricated wall, floor and roof elements. Requirements Draft for comment.

6.

External Walls

6.4
Timber Frame - Rendered Masonry Clad

Introduction

This Guidance refers to 'conventional' timber frame open* panel systems made off-site under factory conditions. Such panel systems are required to be manufactured and erected on-site under quality assured systems and be either Silver or Gold members of the Structural Timber Association or BM TRADA registered.

*Open panel systems are defined as systems which may include the external breather membrane and sheathing board, insulation internally between the studs and a transparent Vapour Control Layer (VCL) which is left unfixed in order that the connections between panels can be viewed upon inspection.

Timber frame panels which arrive to site with additional elements e.g. external cladding or a non-transparent VCL will need to undergo our in house Warranty Approval process.

Timber frame external walls are generally considered to consist of load-bearing solid timber studs at regular centres with insulation between them, lined with a structural sheathing board, breather membrane, drained cavity and cladding. A VCL and fire-resistant linings are provided to the internal finishes.

Alternatively, any timber frame kit, system or wall panel that has been approved via the Warranty product approval process will be acceptable.

Structural design

Wind, roof and floor loads should be considered in the design and all timber frame structures shall be designed in accordance with Eurocode 5. Structures designed in accordance with BS 5268 may still be acceptable, although these standards have now been superseded by Eurocode 5.

General specifications

Bespoke timber frame open panel systems that do not have such QA procedures as the 'conventional' timber frame open panel systems described in this document will need either third-party accreditation or independent Structural Engineer supervision and monitoring of the installation, erection and completion (sign off) of the system. All load-bearing timbers will have to be preservative treated in accordance with BS 8417 according to their position within the frame, and evidence of treatment must be provided.

The structural engineer must confirm, in writing prior to sign off, that the timber frame system has been installed:
- In accordance with the design.
- In accordance with the structural calculations provided.
- All structural timbers are appropriately preservative treated in accordance with BS 8417.
- That a trained contractor, experienced in the erection of timber frame panels, has been employed.

Green air dried or seasoned oak is not acceptable for use in external wall, window/door construction, frame or internal wall or roof constructions, regardless of whether it forms part of the waterproof envelope or not. Projects incorporating 'green Oak' will not be acceptable for Warranty cover. Green Oak is defined for Warranty purposes as 'Oak that has been freshly cut or air dried'.

Certified kiln dried Oak with a certified moisture content of 12% may be acceptable for parts of the structure where the oak does not form part of the waterproof envelope, or movement in the oak frame will not affect the waterproof envelope.

Structurally Insulated Panels (SIPs) are a form of stressed skin composite panel. Only systems with independent third-party certification will meet the Warranty requirements.

Quality assurance

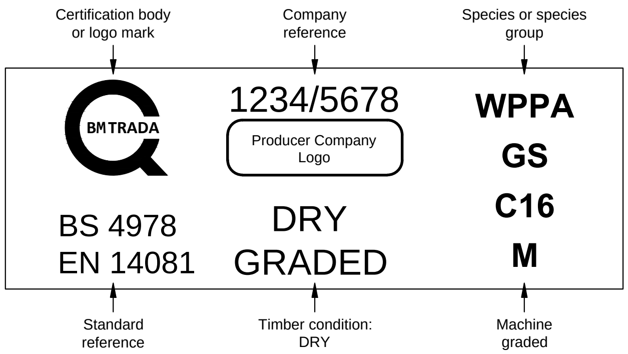
All timber frame Designers, Manufacturers, and Erectors should possess current certification from at least one of the following quality assurance schemes:
- BM TRADA QMark for timber frame.
- Gold or Silver member of the Structural Timber Association.
- ISO 9001 to cover the manufacture of the timber frame panels.
- CE Marking when EN 14732 is published.
- Other relevant third party quality assurance scheme.

Timber specifications

Grading of structural timber
All structural timber whether machine or visually graded shall be graded in accordance with BS EN 14081: Timber structures - Strength graded structural timber with rectangular cross section.

All load-bearing solid timber studs, rails, binders and sole plates should be of a minimum dry graded C16.

Typical grading stamp



Treatment of structural timber

All load-bearing timber components shall be either naturally durable or treated in accordance with BS 8417: Preservation of wood code of practice. Sole plates and load-bearing timber studwork are considered to be in 'Use Class 2'. Sole plates are normally considered to be included in 'Service Factor Code C', while load-bearing timber studwork is included in 'Service Factor Code B'.

All structural timber should be treated with a preservative suitable for the 'Use Class' and 'Service Factor' applicable to its use.

Where treated timber is cut, the exposed end will not be protected by the original preservative treatment. When treated timbers are cut in the factory or on site, the cut ends shall be re-treated with a preservative compatible with the original treatment used, this treatment should be coloured to allow easy checking on site.

Manufacture

Timber
All structural timber components should be specified in accordance with this Technical Manual.

Panel moisture content
All structural timber components should be at a moisture content of 20% or less at the time of manufacture. Once panels are manufactured, they should either be stored in a covered storage area, or loosely covered with a water proof sheet material.

Manufacturing tolerances
Based on the tolerances given in prEN 14732 (dated 17/12/2013) wall panels shall be manufactured to the following tolerances:

- Length: +3mm, -3mm.
- Height: +/-2mm.
- Diagonals should be equal, acceptable deviation is +/-5mm.
- Opening dimensions: 0mm, +5mm.

Studs
Wall panels should be designed to minimise thermal bridging. Gaps between studs within the wall panel and at wall panel junctions should be large enough to allow the installation of insulation.

Site preparation and erection

Pre-commencement
To allow the building to be constructed as designed all necessary drawings, specifications and fixing schedules shall be provided to site before work commences.

Foundations
It is important that the tight tolerances for timber frame are understood, getting the location and level of the foundation correct is one of the most important parts of the build process.

The foundations or upstands that support the timber frame should be set out to the dimensions noted on the timber frame drawings:

- Within +/-10mm in length, width and line.
- Diagonals should be within +/-5mm up to 10m, and +/-10mm more than 10m.
- Levelled to +/-5mm from datum.

Timber frame delivery and storage
Timber frame components should be:

- Carefully unloaded to avoid damage or distortion of components.
- Stored off the ground on an adequate number of level bearers.
- Loosely covered with a waterproof membrane to allow protection from moisture while allowing ventilation if they are not to be used for a prolonged period.
- Unwrapped if tightly bound in polythene and loosely recovered with a waterproof membrane to allow ventilation.
- Below 20% moisture content.
- Confirmed as square by sample checking for equal diagonal measurements, lengths and heights.

Timber frame erection

Wall panel erection tolerances
Wall panels should be erected to the tolerances as per the 'Tolerances' section:

- +/-10mm from plumb per storey height.
- +/-10mm from plumb over the full height of the building.
- +/-3mm from line of sole plate, with maximum +/-5mm deviation from drawing.
- +/-5mm from line at mid height of wall panel.
- Inside faces of adjacent wall panels should be flush.
- Adjacent wall panels should be tightly butted.

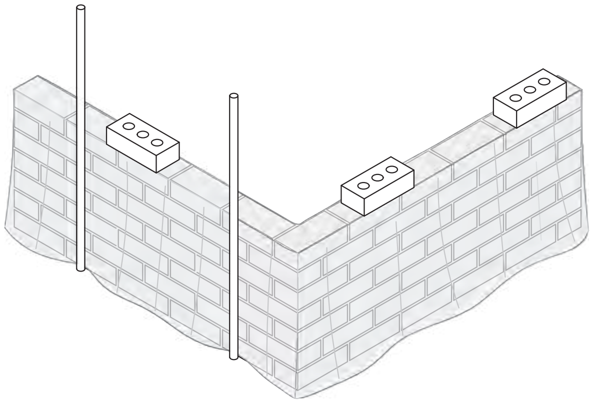
Masonry walls

Protection

All new masonry work should be protected during construction by covering it to ensure that walls are not allowed to become saturated by rainwater or dry out too quickly in hot weather, are protected against frost attack, the risk of efflorescence and line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

Protection of masonry



Working in adverse weather

Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in 'Appendix C - Material, Products, and Building Systems'.

During prolonged periods of hot weather, when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e. engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Exposure

Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further information can be found in 'Appendix C - Material, Products, and Building Systems'.

Colour variation of bricks below DPC

There is usually a variation in the colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations

Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength, helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure, which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention/collection has been found to exist in the perforations.

Efflorescence

Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use.
- Protecting the head of newly constructed work with some form of cover to prevent saturation.

Frost attack

Frost-resistant bricks should be used in areas that are prone to prolonged periods of frost.

If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Mortar

General

A mortar type above DPC should be chosen in accordance with the guidance given in the 'External Walls' and 'Appendix C - Material, Products, and Building Systems' sections, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and/or air entraining plasticisers may be added to cement in accordance with the manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching

Keep batching and mixing equipment clean to avoid contamination with materials used previously, mortar should be mixed by machine, or use ready mixed retarded mortars.

Mixing

Mortar should be carefully and consistently proportioned and then thoroughly mixed using a mechanical mixer, except for very small quantities.

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

Brick and block suitability

Non-rendered blockwork

All external blockwork should be rendered or otherwise finished with a cladding that is appropriately durable, unless the block manufacturer can provide third-party certification confirming that the blockwork can be left unfinished, or finished in an alternative way.

Dealing with areas of high exposure to frost and wind-driven rain

The design and construction of external walls should be suitable for the site specific exposure location.

Wind-driven rain

To ascertain the risk relating to wind-driven rain, the following should be determined:

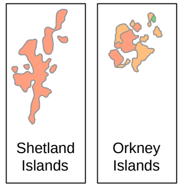
- The exposure to wind-driven rain.
- The correct type of construction, including the correct application of insulation.
- The correct level of workmanship and design detailing, particularly around window and door openings.

Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5Km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.



Exposure zones		Exposure to wind driven rain (litres/m^2 per spell)
Very severe	(red)	100 or more
Severe	(orange)	56.5 to less than 100
Moderate	(blue)	33 to less than 56.5
Sheltered	(green)	less than 33

Note:
Variations to the exposure shown on the map can only be made by site-specific calculations using BS 8104 "Assessing exposure of walls to wind driven rain" and the table above.

Key points: Construction below DPC

1. Brickwork and blockwork must be selected to have suitable durability for its use in the wall construction in accordance with BS EN 771-1 and PD 6697.
2. Mortars below DPC are exposed to higher levels of saturation and therefore require higher durability classification (see BS EN 998-2).
3. Cavities below ground should be filled with concrete ensuring there is a minimum gap of 225mm between DPC and the top of concrete.
4. Concrete for cavities should be GEN 1 grade and a consistence class S3.
5. External ground levels should be a minimum of 150mm below DPC.
6. The compressive strength of the masonry units must meet the requirements of the relevant regional Building Regulations.

Damp proof courses (DPC)

1. DPC's should be of a flexible material, be suitable for the intended use, the DPC should have appropriate 3rd party certification. The installation specification of DPC's should follow good design practice in accordance with BS 8215.
2. Blue bricks or slate will not be accepted as a DPC.
3. DPC's should be laid on a mortar bed and correctly lapped at junction and corners. The depth of the lap should be the same width as the DPC.
4. The DPC should not bridge any cavity unless it is acting as a cavity tray where a cavity is required (e.g over a telescopic floor vent).
5. Damp proof membranes should be lapped with the DPC, DPM, and VCL by a minimum overlap of 100mm.

Rendering

1. Rendering below DPC should only be carried out using a specialist render manufacturer's specification. No render system should bridge the DPC and a proprietary uPVC bead or stainless steel bead should be used above and below where the renders meet at the DPC.
2. DPC should extend through the rendering system in between the bellcast beads or render stop system.
3. For bellcasts, uPVC beads or stainless steel beads are acceptable.

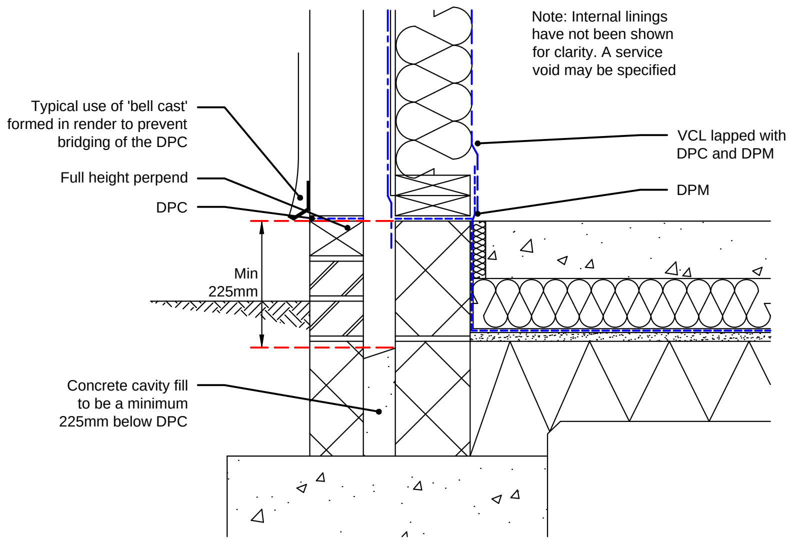
Drainage and ventilation

Cavity drainage and ventilation in masonry cladding should:

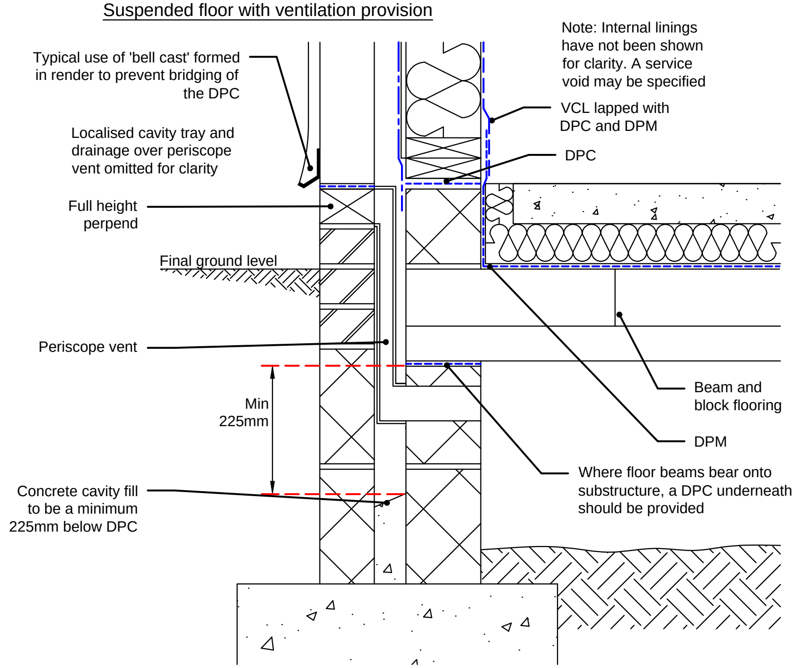
- Be provided with the use of full height open perpends at a maximum of 1350mm centres or equivalent open area.
- Be fitted in the brick or block course below the lowest timber sole plate above external finished ground level and below DPC.
- Maintain a clear cavity with care taken to reduce mortar droppings at the base of the wall.

Weep-holes alone are unsuitable for timber frame construction, and open perpends should be used. Proprietary open perpends should be used. Proprietary open perpend inserts are available with insect screening incorporated. Their equivalent open area must be considered and installation centres reduced accordingly.

Ground supported floor - no sub floor ventilation



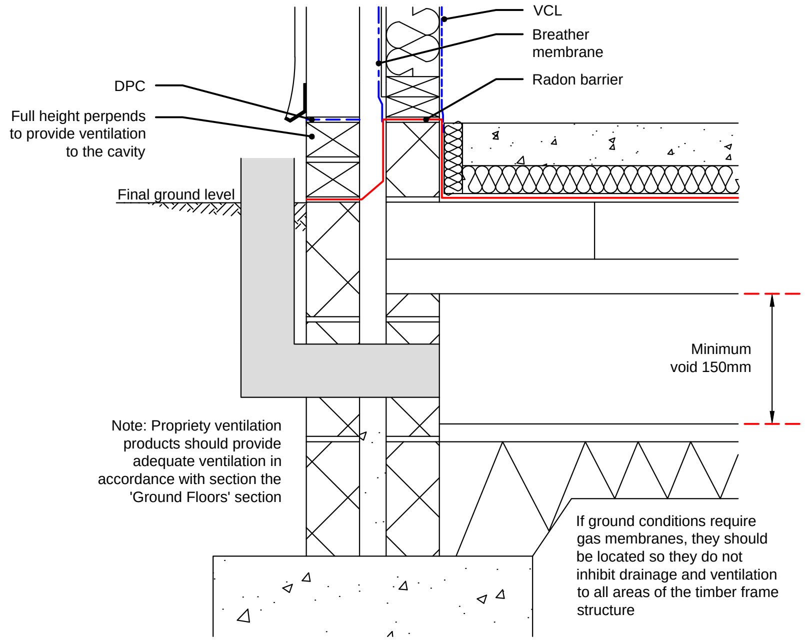
Suspended floor with ventilation provision



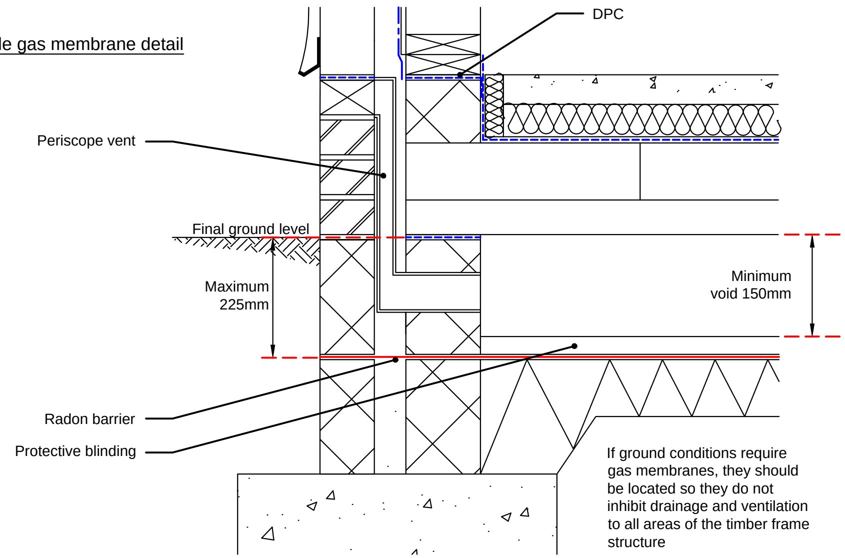
Ventilation for timber frame structures

It is important that whilst setting out the walls below ground that suitable forethought is given to the subsequent construction above DPC. The cavity should be constructed so that the appropriate widths are achieved in line with the appropriate relevant regional Building Regulations and our Warranty requirements. For timber frame structures early consideration of ventilation and drainage is key. Radon barriers should be positioned in such a way to not impair or restrict ventilation to any part on the timber frame structure.

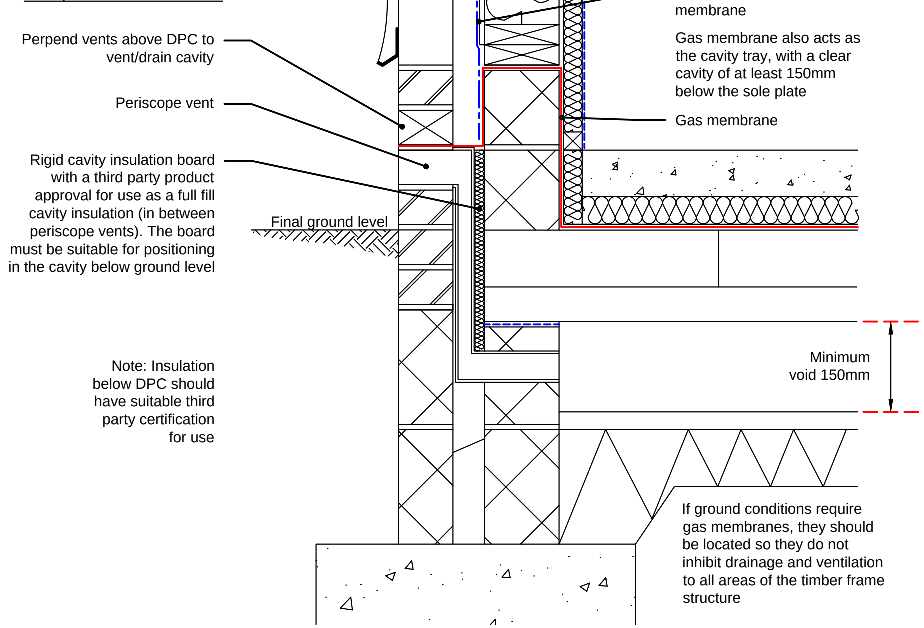
Possible gas membrane detail



Possible gas membrane detail



Possible gas membrane detail with raised sole plate - Timber frame



Sole plates

The sole plate is the first structural timber component installed on site. Its purpose is to set out the building, transfer loads to the foundations and provide a level base for erecting the wall panels. All structural timber should be located at least 150mm above finished external ground level, except for localised ramping (incorporating satisfactory drainage and ventilation detailing) for level threshold requirements.

The sole plate should be accurately levelled, located, and securely fixed to the substructure as specified by the Structural Engineer. Where no sole plate is specified, the following guidance applies equally to wall panel bottom rails. Timber sole plates should be preservative treated in accordance with BS 8417. Further information on timber treatment can be found in 'Appendix C - Materials, Products, and Building Systems'.

Location

Sole plates should:

- Be located so that all structural timber is at least 150mm above external ground level. The use of a masonry foundation kerb upstand may be an appropriate method to achieve this.
- Be levelled to +/-5mm from datum.
- Not overhang or be set back from the foundation edge by more than 10mm.
- Be set out within +/-10mm in length and in line within +/-5mm, as defined by the timber frame drawings.
- Diagonals should be within +/-5mm up to 10m, and +/-10, for more than 10m.

Note: Internal and party wall timber sole plates should not be installed below internal finished floor level.

Damp Proof Course (DPC)

A DPC should:

- Be located directly below all timber sole plates.
- Overlap at DPC junctions by at least 100mm.
- Be located flush to the outside edge of the sole plate.

Fixings

Fixings should:

- Be installed to the Structural Engineers specification.
- Not damage the substructure or sole plates during installation.
- Be placed to provide adequate lateral restraint at door openings.
- Be specified with consideration for use with gas membranes where appropriate.
- Sole plates should be fixed to foundations with shot fired nails, proprietary sole plate fixings, anchors, brackets, or straps, as specified by a Structural Engineer.
- All sole plate fixings and holding down products should be austenitic stainless steel. If stainless steel straps are used, they should be grade 1.4301 steel to BS EN 10088 and isolated from the studs with neoprene gaskets or similar.

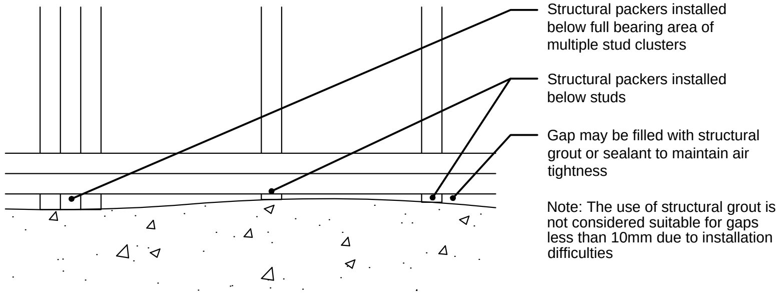
Ventilation

Regardless of the cladding system used, a cavity with provision for drainage and ventilation should be provided between the cladding and the timber frame ensuring that adequate ventilation provision is provided to all areas of the timber frame including the sole plate.

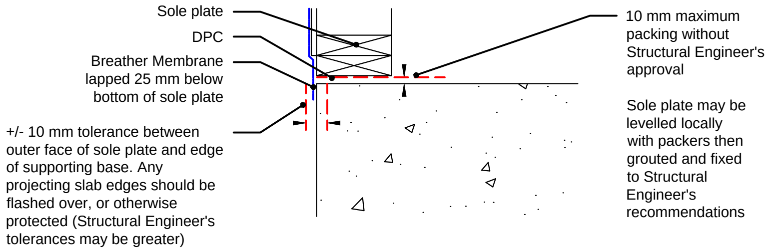
Packing

Structural shims or grout may be required under sole plates to level them and transfer vertical load. Longer fixing may be needed to allow for the size of the gap.

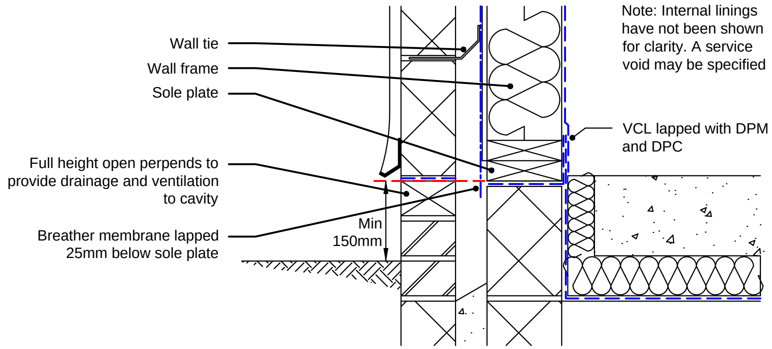
Packing of sole plates



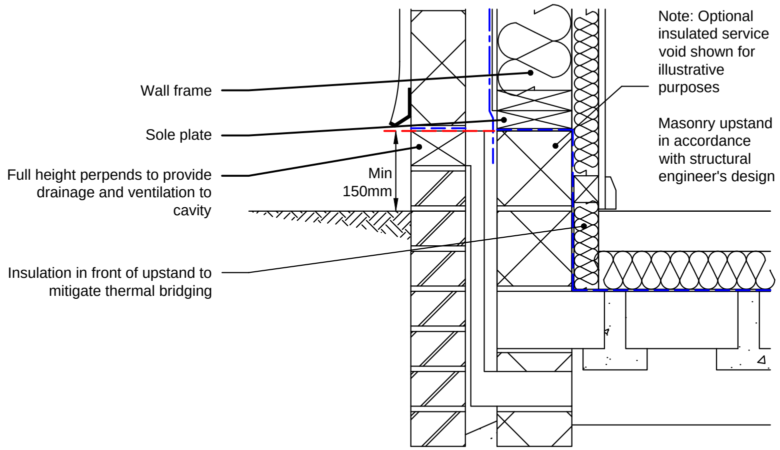
Locating sole plates



Sole plate/foundation junctions



Kerb upstand to allow level threshold



Timber frame wall panels

Timber frame external wall panels shall:

- Be manufactured in accordance with the Structural Engineer's design.
- Consist of solid timber studs and rails.
- Have studs at a maximum of 600mm centres.
- Be braced with a structural sheathing board.

Fixings and junctions

All fixings are to be installed to the Structural Engineer's specification.

Unless otherwise justified:

- Junctions of wall panels and sole plates/head binders should not occur together.
- Head binder laps should wherever possible occur over a stud, preferably at least 600mm from the panel junction.
- Wall panel to wall panel connections should be a maximum of 300mm centres.
- Bottom rail to sole plate fixings should be one or two per stud bay.
- Wall panels should be adequately braced during erection to maintain tolerances.
- Disproportionate collapse components and fixings must be installed if specified.
- Multiple stud clusters must be installed to the full width of point load-bearings.
- Point loads must be transferred down through wall panels and floor zones to foundations.
- Walls manufactured off-site must be fixed together as specified.
- Special considerations should be given to protecting closed panels from exposure to moisture during delivery, storage and erection.
- Engineered timber components should not be exposed to moisture for longer periods than those stated by the manufacturer.
- Roof trusses/rafters should be adequately fixed to wall panels.
- Floor joists should be nailed down to wall panels.
- If no head binder is present, floor joists must bear directly over studs.
- Waistbands and alignment of floors over walls should remain within tolerances for wall panels.

Timber framing components and structural sheathing boards may be fixed with:

- Nails
- Staples

Nail fixings should be:

- Austenitic stainless steel
- Galvanised
- Sherardized

Staple fixings should be austenitic stainless steel or similar.

Openings

All openings including doors, windows, flues and ventilation ducts should be designed and constructed to maintain structural performance.

Vapour Control Layer (VCL)

A continuous VCL with a minimum vapour resistance of 250 MN.s/g or 0.25 Pa/m2 should be located on or near the warm side of the thermal insulation.

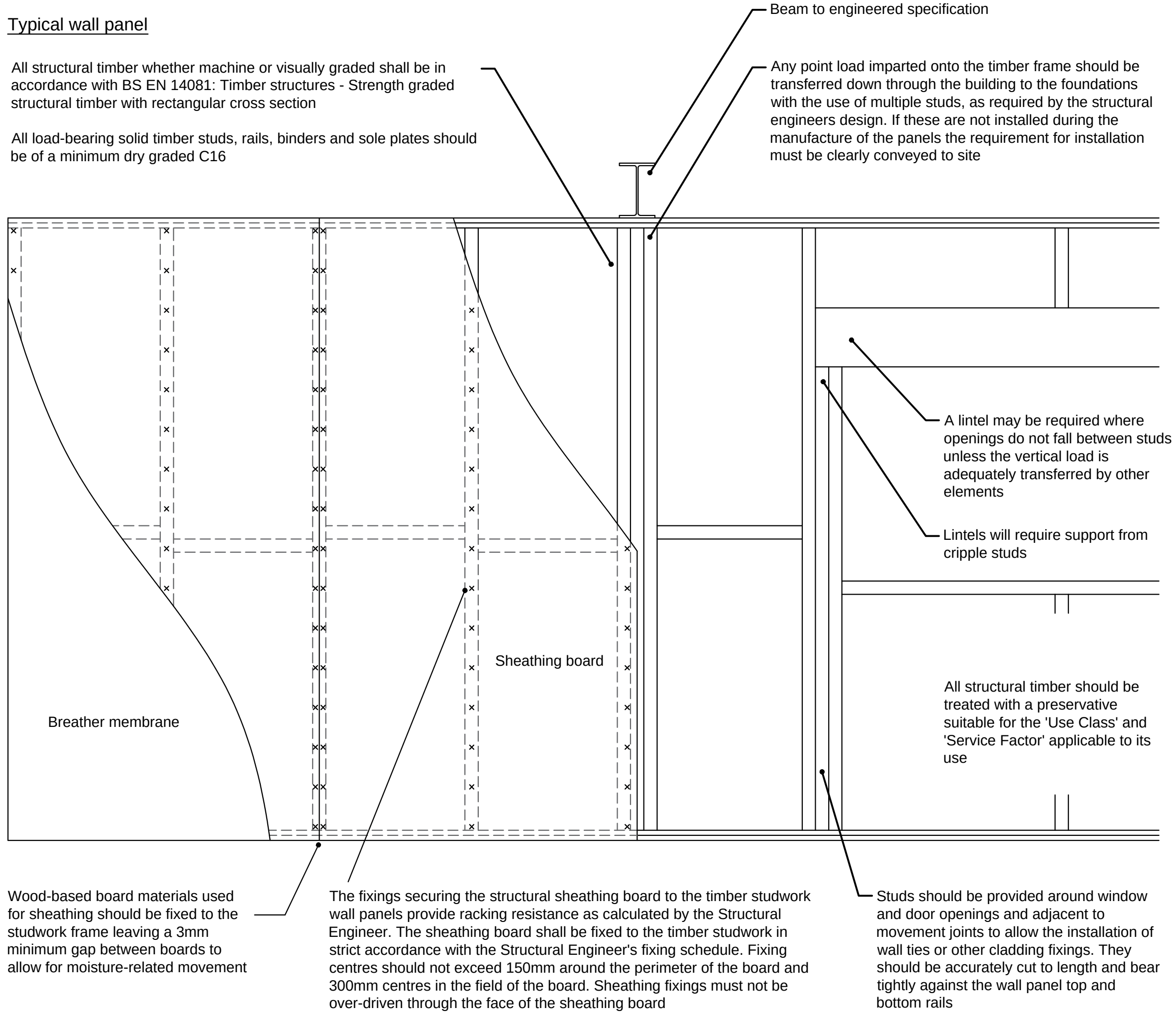
Sheathing boards

Sheathing boards are fixed to the timber frame in order to provide racking resistance to the structure.

Structural sheathing board materials may be any of the following:

- Orientated strand board (OSB).
- Plywood.
- Impregnated soft board.
- Other board material with suitable third-party certification.
- All wood-based panel products should comply with BS EN 13986: Wood-based panels for use in construction - characteristics, evaluation of conformity and marking.
- OSB should be grade 3 or 4 in accordance with BS EN 300: Oriented Strand Boards (OSB) - Definitions, classification and specifications.
- Plywood should be at least Class 2 Structural in accordance with BS EN 636: Plywood Specifications.
- Impregnated soft boards should be Type SB.HLS in accordance with BS EN 622-4: Fibreboards, specifications and requirements for soft boards.

Typical wall panel



Breather membrane

A breather membrane is a water-resistant moisture vapour permeable membrane used to provide temporary weather protection during construction, and secondary protection from moisture once the building is complete.

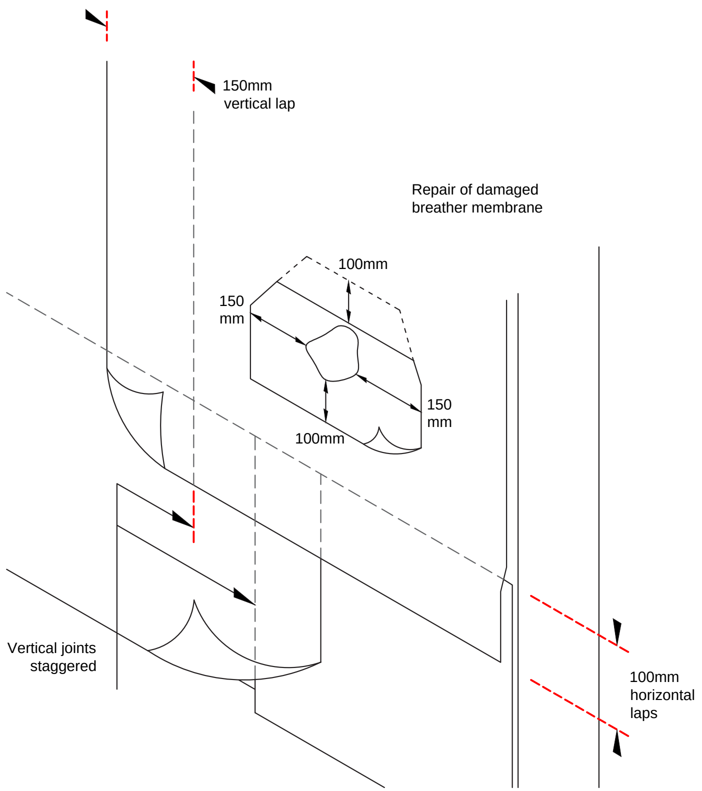
The timber frame structure should always be protected by a breather membrane facing the external wall cavity.

Breather membranes should be:

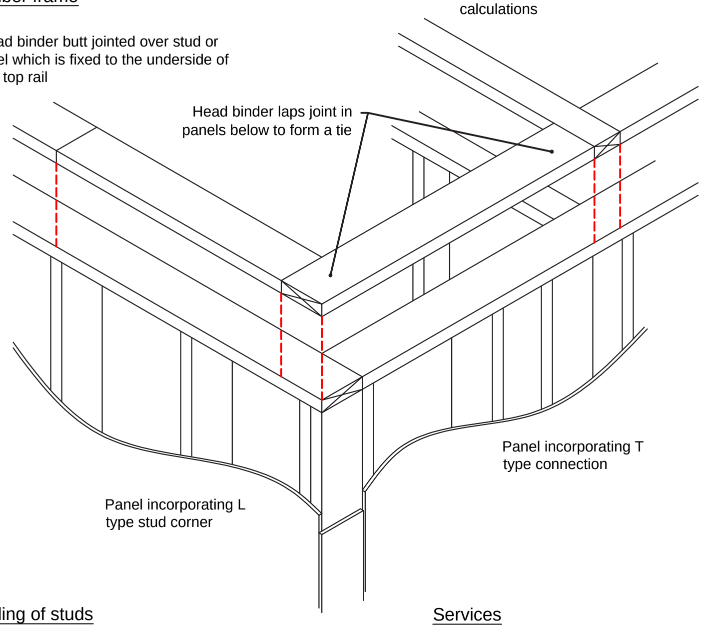
- Minimum Class W2 or better in accordance with BS EN 13859: Flexible sheets for waterproofing - Definitions and characteristics of underlays.
- Securely fixed to protect the outside face of the timber frame structure with austenitic stainless steel staples.
- Placed on the outside of the timber structure and any external insulation adjacent to the external wall cavity.
- Lapped to deflect moisture away from the timber frame structure.
- Trimmed to leave 25mm lap below the lowest timber sole plate.
- Repaired if damaged.

Breather membranes should be lapped by a minimum of 100mm at horizontal joints, and a minimum of 150mm at vertical joints. If breather membranes are trimmed flush with the edges of wall panels, additional strips of breather membrane, at least 300mm wide, should be supplied and site fixed over panel junctions. The location of solid timber studs should be clearly marked on the outer face of the breather membrane to ensure that cladding fixings are installed into solid timber.

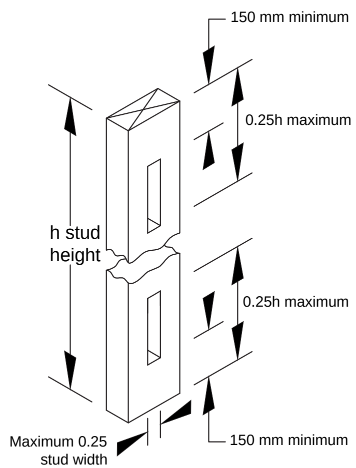
Lapping and repair of breather membrane



Head binder lapping - Timber frame



Drilling of studs



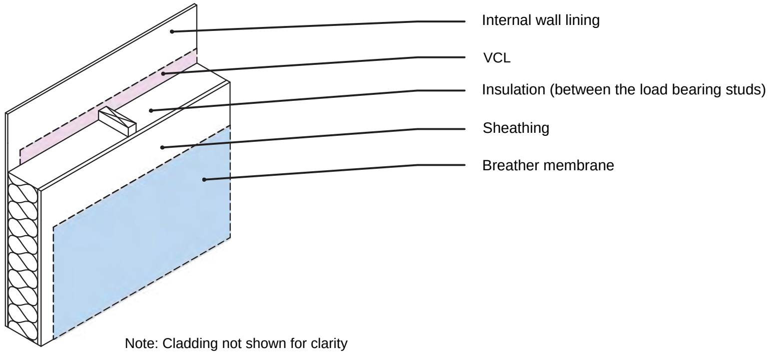
Drilling on centre line only. Hole diameters not greater than 0.25 stud width and hole centres not closer than 4d (d = hole diameter)

Services

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

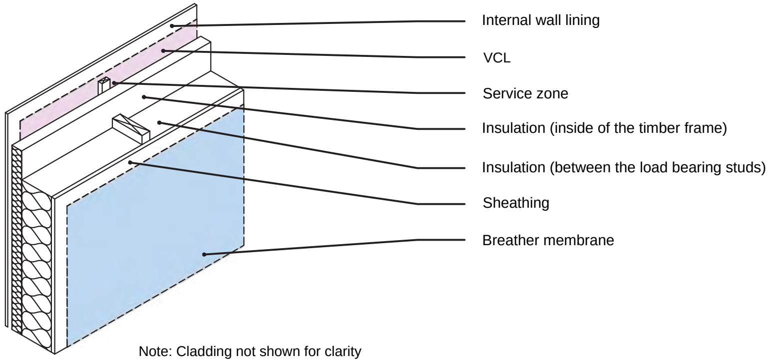
- The routing and termination of services should not affect the fire resistance of the structure.
- Electrical services are to be rated for their location with consideration for insulation.
- Wet services are not to be installed on the cold side of the insulation.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face stud.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.

Conventional wall with insulation between studs



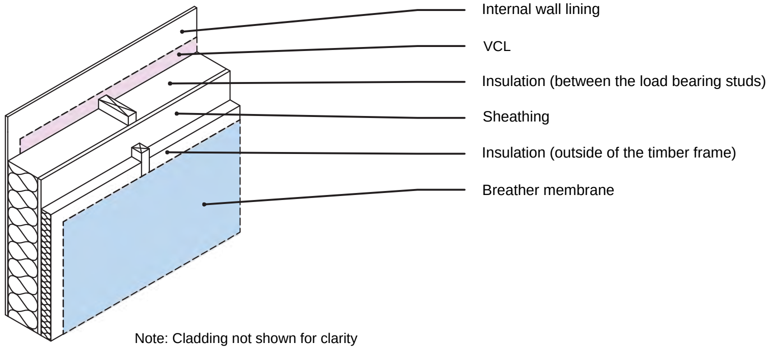
Note: Cladding not shown for clarity

Continuous internal insulation



Note: Cladding not shown for clarity

Continuous external insulation



Note: Cladding not shown for clarity

Insulation materials

Insulation materials should be chosen with consideration for their breathability and interaction with the timber frame.

Thermal insulation products typically used are:

- Mineral fibre (glass or rock).
- Wood fibre/wool.
- Blown cellulose.

Other insulation materials may be used subject to relevant third-party certification.

Insulation may be specified in any or all of the following locations:

- Between the load-bearing studs.
- On the outside of the timber frame.
- On the inside of the timber frame.

Insulation installed to the outside of the timber frame structure should have third-party certification for this application and retain a minimum of a clear 50mm cavity. The outer layer of insulation should also be covered with a breather membrane adjacent to the cavity.

External walls should be subject to U-Value and condensation risk calculations. A wall build up will be considered satisfactory if there is no calculated risk of surface or interstitial condensation at any time of the year, and it fulfils the minimum National requirement for thermal performance.

Special consideration should be given to condensation risk where non-breathable insulation products are installed on the outside of the timber frame structure. Joints between foil faced external insulation boards, must not be taped as this forms a vapour control layer on the cold side of the insulation.

Depending on the specification of insulation materials to be added to the structural frame, timber battens may be required to support the insulation or allow fixing of plasterboard linings, or external cladding.

Insulation

If insulation is specified between external walls studs all voids shall be filled with insulation to maintain the thermal envelope of the building. When noggins or boards are installed between studs to support services or heavy fittings the void behind them shall be fully insulated.

Insulation should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight, as wet insulation can retain moisture. If closed panel timber frame is specified, additional care must be taken to protect the panels from exposure to moisture during construction, with moisture content checks carried out before full closure.

Note: The above also applies equally to insulated party wall cavities.

Insulation installed within the cavity

If external wall insulation is to be used:

- Insulation should be installed in a manner to maintain its stated performance by minimising gaps that lead to thermal bridging and air washing.
- Installation should be covered with a breather membrane to ensure that external wall cavity moisture does not become trapped in or between the insulation and the timber frame.
- Cavity trays should be fixed and lapped over the cavity facing breather membrane to deflect cavity moisture away from the timber frame.
- Allowance should be made for differential movement to occur at floor zones.
- Cavity barriers should be tightly fitting; depending on the type of insulation used, cavity barriers may need to pass through the insulation, back to solid timber within the timber frame structure behind and remain effective in a fire.
- It should not retain or transmit moisture to cause the timber structure to exceed 20% moisture content.
- Stud locator marks should be transferred onto the outer face of the breather membrane adjacent to the external wall cavity.
- Wall ties should transfer loads to the timber frame structure. To achieve this, wall ties will typically need to be installed through the external insulation rather than bearing onto it.
- Joints between foil faced insulation boards must not be taped.

Vapour control layer (VCL)

A VCL is a moisture vapour-resistant material located on, or near, the warm side of the thermal insulation.
Its purpose is to:

- Restrict the passage of moisture vapour through the structure of the wall.
- Mitigate the risk of interstitial condensation.

The VCL should have a minimum vapour resistance of 250 MN.s/g or 0.25 Pa/m2. It is also typically used as an air tightness layer.

The VCL may take the form of:

- A vapour control plasterboard comprising a metallised polyester film bonded to the back face of the plasterboard.*
- A minimum 125 micron thick (500 gauge) polythene sheet.
- A third-party approved proprietary vapour control membrane product.

*Vapour control plasterboard should only be used subject to a condensation risk analysis demonstrating the suitability of the wall build up.

Subject to a favourable condensation risk analysis, a novel or reverse wall construction may not require the use of a high moisture vapour-resistant vapour control membrane.

A VCL should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight.

Installation of a VCL

A sheet membrane (polythene or proprietary) VCL should be:

- Securely fixed to and cover all areas of the timber frame external walls, including all sole plates, head binders, and lapped/sealed fully into window/door reveals.
- Lapped and sealed by at least 100mm at joints.
- Lapped and sealed over studs, rails or noggins.
- Sealed around service penetrations.
- Lapped and sealed with DPM/DPC at the junction with the ground floor/foundation by a minimum of 100mm.

Note: Small holes in the VCL should be sealed with a suitable self-adhesive tape. If a proprietary membrane is being used, the manufacturer's proprietary sealing tape should be used. Larger holes should be re-covered to lap over adjacent studs and rails.

Vapour control plasterboard should be:

- Fixed in accordance with the plasterboard manufacturer's installation guidance.
- Tightly cut and fitted around service penetrations.
- Discarded if the vapour control backing is damaged.

Wall linings

The internal lining of the timber frame wall may be required to perform four functions:

- Provide the finish or a substrate to accept the finish on the inner face of the wall.
- Contribute to the racking resistance of the wall.
- Contribute to the fire resistance of the wall.
- Contribute to the acoustic performance of the wall.

Wall linings are typically:

- Gypsum plasterboard.
- Fibre reinforced gypsum board.
- Cement bonded particle board.

Lining materials must satisfy all relevant performance criteria, e.g. fire resistance, acoustic performance and have relevant third-party certification.

Plasterboard

Installation

In order to provide the specified period of fire resistance, the plasterboard must:

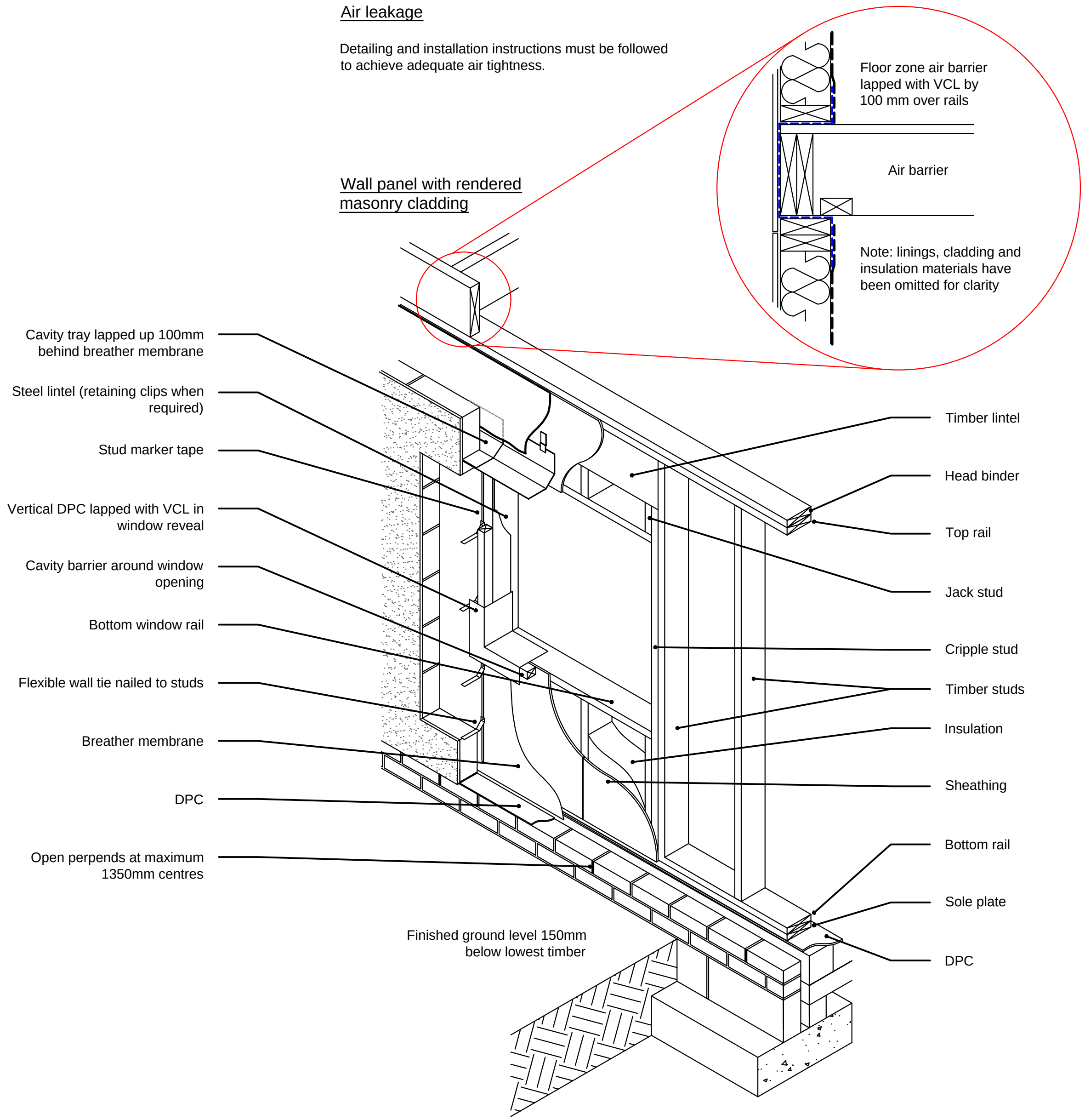
- Protect all areas of the timber frame structure.
- Have all edges supported by timber studs or rails.
- Be fixed in accordance with the plasterboard manufacturer's guidance.
- Be cut and tightly fit around service penetrations.
- Have junctions of wall and ceiling linings detailed to maintain continuity.
- Be installed using the specified number of layers to achieve the required fire resistance.
- Have all joints staggered when installing multiple layers.

When fixing plasterboard linings:

- Each layer must be fully and independently fixed.
- Fixings of the correct length and centres should be installed in accordance with the plasterboard manufacturer's installation instructions.
- Walls requiring plasterboard to provide racking resistance should be clearly identified with plasterboard installed to the Structural Engineer's specification or the plasterboard manufacturer's specification, whichever is more onerous.

Air leakage

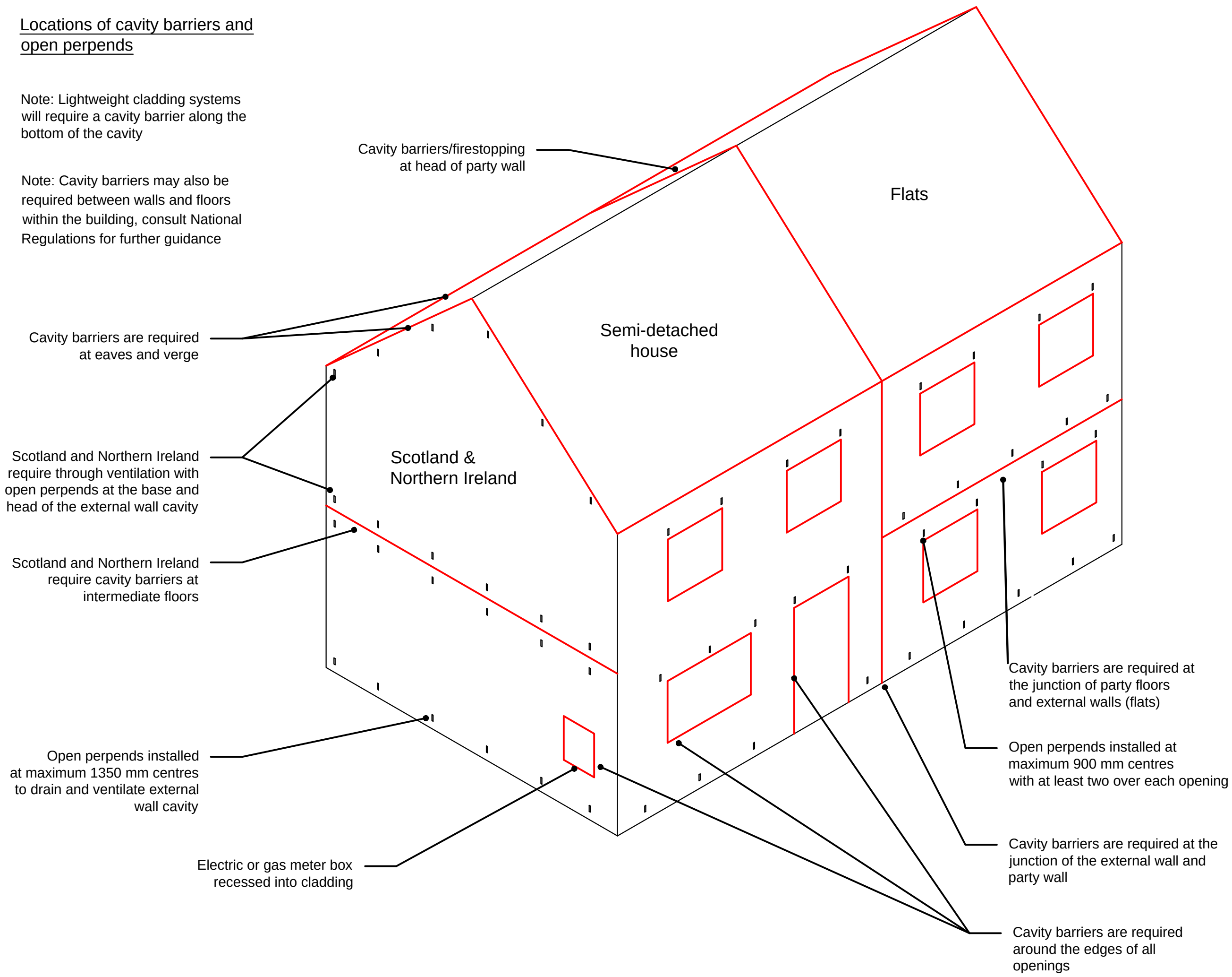
Detailing and installation instructions must be followed to achieve adequate air tightness.



Locations of cavity barriers and open perpends

Note: Lightweight cladding systems will require a cavity barrier along the bottom of the cavity

Note: Cavity barriers may also be required between walls and floors within the building, consult National Regulations for further guidance



Cavity barrier locations

In England and Wales, cavity barriers shall be installed:

- At the edges of all cavities including around openings, e.g. windows and doors.
- Between an external cavity wall and a compartment wall or compartment floor.
- Around meter boxes in external walls.
- Around service penetrations in external walls e.g. extract duct or boiler flue.
- To sub-divide extensive cavities; please refer to National Regulations for specific requirements.

Cavity barrier installation

Cavity barriers shall be installed:

- So they fully close the cavity.
- So the ends are tightly butted (or adequately lapped in accordance with the manufacturers instructions) to form a continuous barrier.
- Backed by solid timber studs, rails or floor joist at least 38mm wide.
- In accordance with manufacturer or independent certifier's guidance.

A cavity tray should be proved directly above a horizontal cavity barrier and lapped at least 100mm behind the breather membrane (except at eaves and verges).

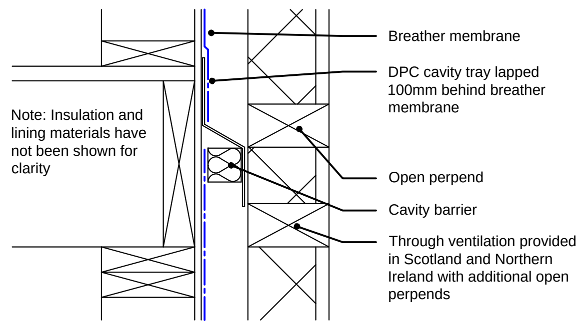
Cavity barriers are required to prevent the spread of smoke and flame within concealed spaces.

Cavity barriers may be constructed from:

- Steel at least 0.5mm thick.
- Timber at least 38mm thick.
- Polythene sleeved mineral wool.
- Calcium silicate, cement-based or gypsum-based board at least 12mm thick.
- An independently assessed and certified proprietary product.

Timber cavity barriers should be protected from masonry cladding by the use of a DPC. The cavity face of the barrier should be left uncovered to allow drainage and ventilation of the timber. The use of timber cavity barriers around openings allows for effective sealing to be installed between them and the opening frame.

Cavity tray above horizontal cavity barrier



Render

Rendering should be in accordance with BS EN 13914-1:2005 and workmanship in accordance with BS 8000. In particular the following should be considered:

With traditional renders the quality of the sands used and design mix is as critical as is the reliance on good mixing techniques by the applicator.

Poor mixing ratios and low quality materials is often the reason traditional renders fail. For the purposes of this Warranty, traditional hand mix using standard sand and cement is not accepted. Only a pre-blended bagged render system will be accepted as a suitable render system that has a third party accreditation such as a BBA or ETA certification, and backed up with a manufacturer's specification.

Where a specialist render system is being used the following conditions must be met:

1) The product approval is based on the details and limitations of use described in a 'current' approved ETA, BBA, BRE etc. or other UKAS certified system specific to the relevant substrate being applied too. A copy of the certificate documents are to be supplied.

2) For masonry substrates (e.g. solid brickwork, blockwork, concrete, terracotta, stone etc.) the masonry should be adequately prepared and be of a thickness which would resist damp ingress to the internal finishes based on the recommendations of BS 5628 Part 3 2005 for the given exposure zone. Please note: Where the thickness of the masonry is less than that recommended in BS 5268, is a single skin construction or is in a very severe exposure zone or coastal location, then the requirements of condition 3 (below) must also be met.

3) For all render installations (including brick slip system applications) on all substrates types located in an exposure zone where the wind driven rain is expected to be more than 75 litres per m²: A 10 year 'insurance backed' manufacturer's system guarantee is required, together with a full project specific specification that has also been accepted and approved by the Warranty provider. The proposal will require full system details to deal with all junctions, openings etc. together with other project specific requirements provided by the render system company. The render system will need to be installed by a registered and certified installer who has been approved and accredited by the render system manufacturer before work commences.

In all instances where a render system manufacturer's guarantee is required, full project specification and details are to be obtained from the render system manufacturer before any installation commences to ensure that conformity is met. Once work commences, the installation must be inspected and signed off by a render system representative throughout the installation stage, and at completion of the installation and confirm that the specification has been met.
The render system together with the backing wall to which they are applied should satisfactorily resist the passage of moisture to the inside of the building.

General render conditions (using pre-blended bagged render)

Weather conditions

- For exposure zones where the wind driven rain is expected to be more than 75 litres per m² (classed as very severe) then checked reveals will be required. The render applied to the reveal must be of the same thickness as the wall render with an appropriate corner beading provided. A suitable non hardening' mastic sealant must also be provided between window/door frame and masonry reveal.
- Protection must be provided when applying renders in rain or other inclement weather. Application should cease in temperature below 5°C or where rapid freezing is considered to be a potential threat.
- When applying in hot weather it is advisable that work coincides with the shaded areas of the building. During longer periods of hot and dry weather, it may be appropriate and necessary to apply an even mist spray of clean water to the substrate before application, and to surface finish for a couple of days afterwards subject to site and weather conditions.
- Cement products should not be applied to substrates which are frost laden or which have recently been subject to prolonged rain.
- Do not render onto saturated substrates as this may affect the bond strength and cause lime bloom (discolouration), salts to occur and patchiness due to uneven suction.
- Local weather and site conditions must be taken into account by the applicator before any cement product is applied.
- Care must be taken to protect cement and synthetic products soon after the application from rapid freezing and heavy rainfall. For other drying conditions i.e. where there is direct exposure to sunlight or drying winds, the render may require to be protected from the elements. This process is important to ensure complete hydration of the products can take place.
- Where an application is not covered in these conditions further advice from the render manufacturer must be sought and submit a suitable manufacturer's specification to the Warranty provider for approval.

Application

- 15mm is considered the minimum finished thickness of render applied to a masonry wall, either as a single spray coat or as a two coat hand application. Where structures are located in very severe weather rating locations or within coastal locations, the depth of render may need to be increased to a minimum of 20mm and a specialist manufacturer's specification will be required to support this.
- Please note: 5-6mm is considered the minimum finished thickness of render for applications of specialist insulated render systems. The render thickness will need to be increased where structures are located in very severe weather rating locations, or within coastal locations and a specialist manufacturer's specification will be required to support this; approved by the Warranty provider.
- When ashlar detailing is required, it is recommended that a minimum depth to the back of the ashlar cut should be no less than 15mm and 20 - 25mm for applications in very severe exposure zones or within coastal locations. To achieve this depth, it will require the finished thickness of the main render to be increased to accommodate this feature.
- Abutments between cement render and other cladding materials or components should be weather tight and allow for differential movement.
- Any joints in the wall where movement may occur should be continued through the rendering.
- Render should not bridge the Damp Proof Course (DPC) and must be finished onto a durable render stop profile such as a proprietary uPVC bead or stainless steel bead.
- Renders will be reinforced as a minimum with an appropriate certified alkaline resistant fibreglass mesh at corners of all openings and penetrations. For substrates that are prone to movement, an appropriate certified alkaline resistant fibreglass mesh will need to be incorporated throughout the substrate.
- Where different materials are being rendered over, the incorporation of an appropriate certified alkaline resistant fibreglass mesh will be necessary to assist with the possibilities of differential movement. The mesh must extend sufficiently over the different materials to resist against differential movement.
- Renders installed between pedestrian level and 6.0m above ground level will be designed to accommodate higher maintenance and impact loads in accordance with Table 2 of BS 8200.
- All surfaces must be clean, suitably dry and free from anything that may interfere with the adhesion of the material to be applied. The manufacturer's product data sheets should be followed including the manufacturer's surface preparation and suitability checks in full.
- All blockwork mortar joints are to be flush pointed and should be fully cured before the application of the render.
- The quantity of material required for a given area should be of the same batch number or if not the different batches must be thoroughly mixed together to avoid shade variations.
- Full masking must be used to give protection to adjacent areas of work, windows, doors etc. and to give clean straight edges. It should be removed immediately after the finishing coat has dried.
- Carefully remove splashes of material, in particular from glass or aluminium immediately as they may etch the surface and leave a permanent mark.

Materials

- Ensure the render being used is suitable for the substrate and is not too strong. Due to shrinkage differentials, avoid applying a thin base coat and a thicker top coat application, as the shrinkage values of a thicker top coat could cause the render to delaminate from the base coat. The same effect is also caused by applying a very hard render over a softer base coat.
- External rendering should comply as a minimum with BS EN 13914-1:2005 but should also conform with the specialist render manufacturers recommendations.
- Rendering products should be stored separately from other building and concreting sands.
- For bellcasts, other beads, and stops; uPVC bead or stainless steel bead is acceptable.
- Only clean water should be used for mixing.

Masonry background requirements

The walls which are to be rendered should be examined for excessive moisture content prior to rendering. This is particularly important where the masonry background has no upper limit on its soluble salts content, e.g. N designation clay bricks.

A specialist render system and mortar should be employed for parapets, chimneys, retaining walls and walls below DPC level with this masonry background type.

Ensure that all joints are finished flush with the surface to avoid shade variations.

To minimise the potential for differential thermal movement and effects that the different suction that each type of background material may create; the section of walling to receive the render should be constructed using the same type and density of material throughout.

When rendering is required to be applied to wet masonry substrates, a specialist sealer key coat prior to applying the main coat of render should be applied, to control suction and reduce the impact of lime blooming occurring through the render. The key coat should provide a sound substrate and be compatible with the subsequent render system.

For high absorption e.g. lightweight blockwork, common bricks etc. and smooth dense substrates (such as engineering bricks); direct rendering is not acceptable, as the moisture can be extracted by the substrate from the wet render which affects its curing and bonding capability, or it does not bond to the substrate respectively.

To control suction, always apply a specialist sealer key coat or suitable render preparatory coat. Allow a minimum of 48 hours for the key coat to fully dry before applying the next coat.

For highly exposed areas of construction:

- The backs surfaces of parapets should not be rendered using a standard render system. Either:
  a) Use suitable fair faced masonry to the roof elevation and incorporate cavity trays linked to the roof flashing, or
  b) Use a specialist render system designed to combat movement and provide robust weatherproofing.
  Note: horizontal surfaces of Parapets should not be rendered, they should be protected by a suitable capping system.
- Throats or drips to copings of parapets and chimneys should project beyond the finished faces to throw water clear.
- Rendering to chimneys should only be carried out where the masonry contains little or no sulphates. An appropriate specialist sealer/bonding key coat should be applied prior to applying the main coat of render. A proprietary alkaline resistant mesh should be embedded throughout the render, the key coat should provide a sound substrate and be compatible with the subsequent render system.
- As before; horizontal DPC and Damp Proof Membranes (DPM) must not be bridged.
- Rendering below DPC should only be carried out using a specialist render manufacturer's specification. No render system should bridge the DPC and a proprietary uPVC bead or stainless steel bead should be used above and below where the renders meet at the DPC.

Other construction detailing

Ensure that drips and throating to sills, coping, etc. project beyond the face of the finished render above the DPC.

Notwithstanding wind loadings, the larger the eaves overhang, the better. This will provide protection to the top joint of the render panel where it meets the roof and prevent rain water getting behind the render.

Angles, stop beads and jointing sections should be secured with drilled or shot-fired fixings, and not with gypsum plaster. Fixing of external render beads on masonry backgrounds with an adhesive is also acceptable, providing the render manufacturer can provide a full specification on fixing the beads including:

- The adhesive to be used.
- Type of fixing e.g. dabs or continuous bead.
- Curing times.
- Specification of the beads used.

Under no circumstances should the beads or profiles be bonded using a solvent based adhesive.

Check whether the rendering can be applied directly onto the wall, or whether any preparatory treatment is required in accordance with the manufacturer's instructions.

The surface should be checked for suction by dampening the wall with clean water.

In accordance with a Structural Engineers requirements, cracking of the substrate could be significantly reduced by introducing a specialist proprietary bed joint reinforcement within the mortar joints. Ideally this should be applied throughout the building during construction and in accordance with the substrate manufacturer's recommendations. Ensure that the reinforcement is continuous and joints are lapped in accordance with the manufacturer's requirements (generally 450 - 500mm laps and continued around corners). Specialist corner units are likely to be required, check with the manufacturer.

Introducing reinforcement at weak points such as above and below window and door openings is strongly recommended as a minimum requirement in all applications, as it will greatly assist in minimising cracking to these areas

Vertical and horizontal flatness

Rendering should have a maximum vertical and horizontal deviation from flatness of +/-10mm in 5m, and is measured in a similar way to straightness on plan and plumb of masonry. See the 'Tolerances' section for further information.

Masonry cladding

Timber frame external walls should be finished externally with a cladding system, which may take the form of masonry or a lightweight rainscreen system. Regardless of the cladding system used, all external wall claddings should be separated from the timber frame structure by a drained and ventilated cavity. In some locations, for example close to boundaries, National Regulations require claddings to provide fire resistance to the structure from the outside in. Where a masonry cladding is proposed the vertical loadings from the masonry cladding must not be supported by the timber frame structure.

Self supporting masonry claddings

Self supporting masonry claddings should be connected to the timber frame using walls ties, wall ties should meet the following provisions:

- Comply with BS EN 845: Specification for ancillary components for masonry, ties, tension straps, hangers, and brackets.
- Be constructed from austenitic stainless steel.
- Accommodate all anticipated differential movement.
- The overall length of the wall ties must be of adequate length to provide a minimum 50mm clear cavity and ensure there is at least a 62.5mm overlap onto the leaf of the masonry so that it will achieve a 50mm minimum length of bedding on the mortar.
- Be installed into solid timber studs, not just through sheathing.
- Additional studs should be provided in the timber frame structure for wall ties at vertical movement joints and around openings in the masonry cladding.
- Angled to drain moisture away from the timber frame even after differential movement has occurred.
- Installed at a maximum of 300mm centres vertically and 225mm horizontally around openings and movement joints.
- Installed within 225mm of the head of the wall.
- Wall tie density: For buildings up to three storeys in height wall ties should be installed at a minimum density of 4.4/m² (a maximum of 375mm vertically with studs at 600mm centres and a maximum of 525mm vertically where studs are at 400mm centres). A tie density of 4.4 ties/m2 may be suitable for buildings on flat sites within towns and cities anywhere in the UK, except the north western fringes of Scotland and Ireland (where the basic wind speed exceeds 25 m/sec) and any areas where the site is at an altitude of 150 m or more above sea level. An increased wall tie density may be required in exposed locations or for buildings higher than three storeys in height, the actual performance required for each site location or building should be determined by a suitably qualified Structural Engineer.

Cavity drainage and ventilation in masonry cladding should:

- Be provided with full height open perpends at a maximum of 1350mm centres or equivalent open area.
- Be provided in the brick or block course below the lowest timber sole plate above external finished ground level and below DPC.
- Be provided to ensure drainage and ventilation to each external wall concealed space directly above horizontal cavity barriers/trays.
- Be installed over openings in the external wall cavity e.g. windows and doors at a maximum of 900mm centres.
- Maintain a minimum 50mm clear cavity with care taken to reduce mortar droppings at the base of the wall.

Weep-holes alone are unsuitable for timber frame construction, and open perpends should be used. Proprietary open perpend inserts are available with insect screening incorporated. Their equivalent open area must be considered and installation centres reduced accordingly.

Where partial fill cavity insulation is to be used the same width of clear cavity is to be maintained in addition to the insulation depth.

Cavity drainage and ventilation should provide an open area of not less than 500mm² per metre run:

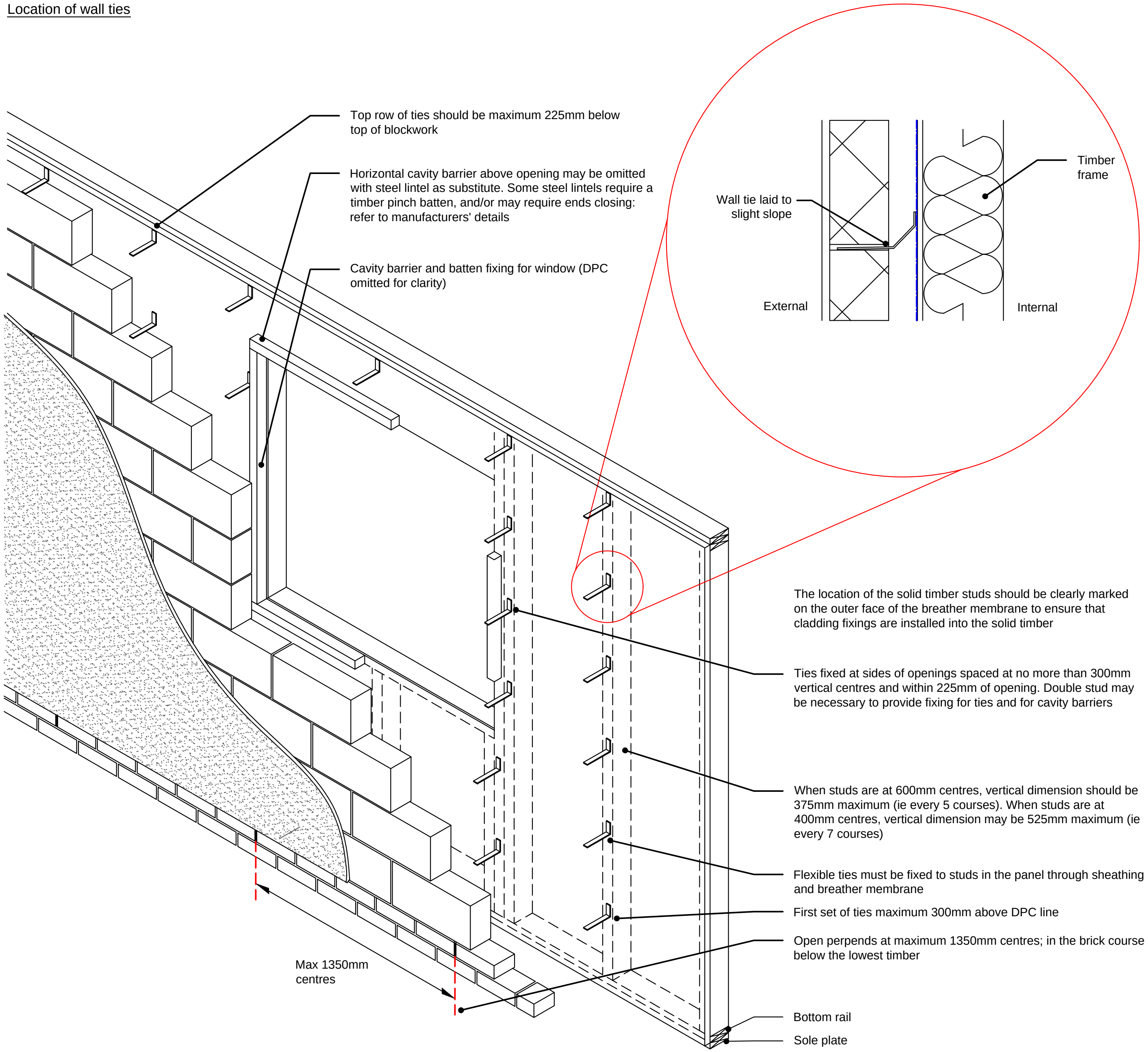
- At the base of the external wall concealed space.
- Above horizontal cavity barriers/trays.
- Over openings in the external wall cavity, e.g. windows and doors.
- Allowing differential movement to occur while retaining an adequate gap.
- With openings protected by a mesh to prevent the passage of insects.

Masonry cladding - Masonry suitability

- Facing bricks must have a suitable level of durability and particular attention should be paid to the bricks resistance to frost and moisture.
- Bricks should be capable of supporting proposed loads.
- Bricks should comply with BS EN771 and PD 6697.
- Frost resistant bricks should be used in areas of prolonged frost.

Further guidance is available in 'Appendix C - Materials, Products, and Building Systems'.

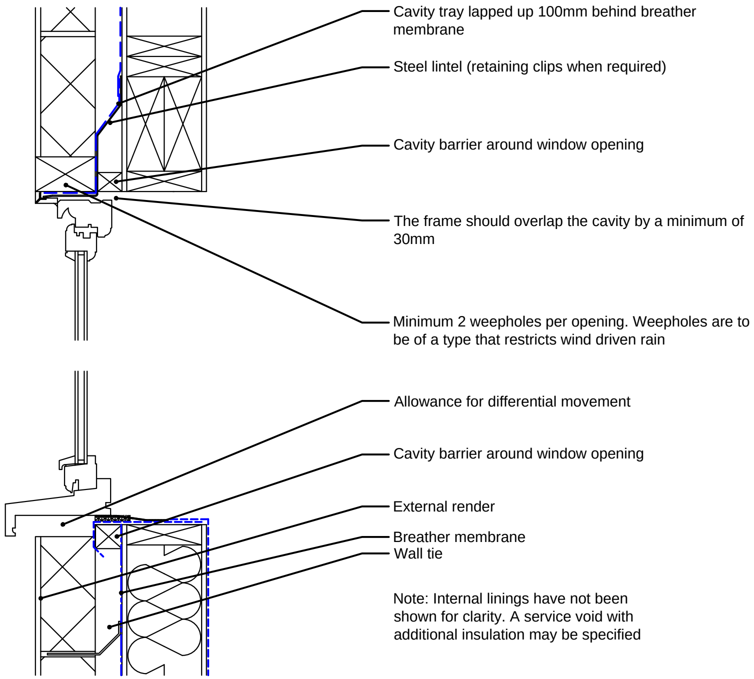
Location of wall ties



Window and door installations

Please refer to the 'Windows and Doors' guidance for installation requirements of frames including maximum gaps and fixings.

Typical vertical section through window opening



Openings

All openings including doors, windows, flues and ventilation ducts, should be designed and constructed to maintain:

Fire performance:

- Internal reveals require equal fire resistance to the rest of the structure.
- Window fixing straps should not compromise the integrity of any fire-resistant reveal linings.
- Cavity barriers should be installed in the external wall cavity around the perimeter of openings.
- If profiled steel lintels are used as cavity barriers, triangular gaps behind lintels, which occur at each end, should be closed with careful positioning of adjacent cavity barriers.

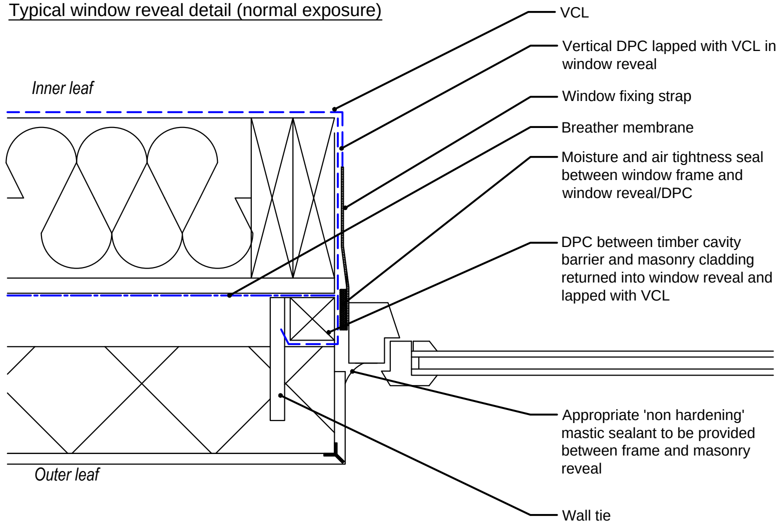
Acoustic performance:

- Seal gaps between timber frame wall and the element being installed into the opening.
- The element being installed into the opening may have a minimum acoustic requirement.

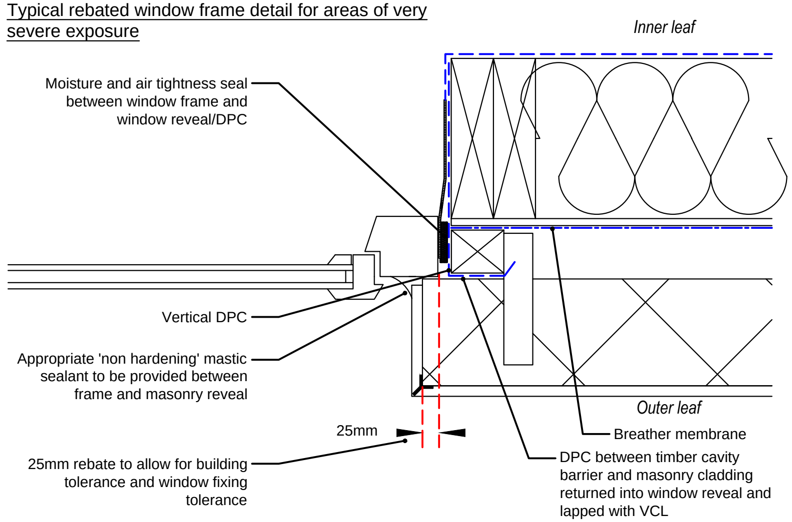
Weather tightness and thermal performance, including thermal bridging and air tightness:

- The element being installed into the opening is likely to have a minimum thermal performance.
- Seal gaps between the timber frame wall and the element being installed into the opening to provide thermal performance, weather tightness and air tightness.
- Cavity trays should be installed over the heads of all openings and lapped behind the breather membrane by a minimum of 100mm. A flashing may be acceptable for some types of claddings.
- Lap cavity barrier DPC with internal VCL around openings. Where no DPC is used, breather membrane should be lapped with internal VCL.

Typical window reveal detail (normal exposure)



Typical rebated window frame detail for areas of very severe exposure



When installing window/door frames in a checked rebate, allow for the frame to be deeper:

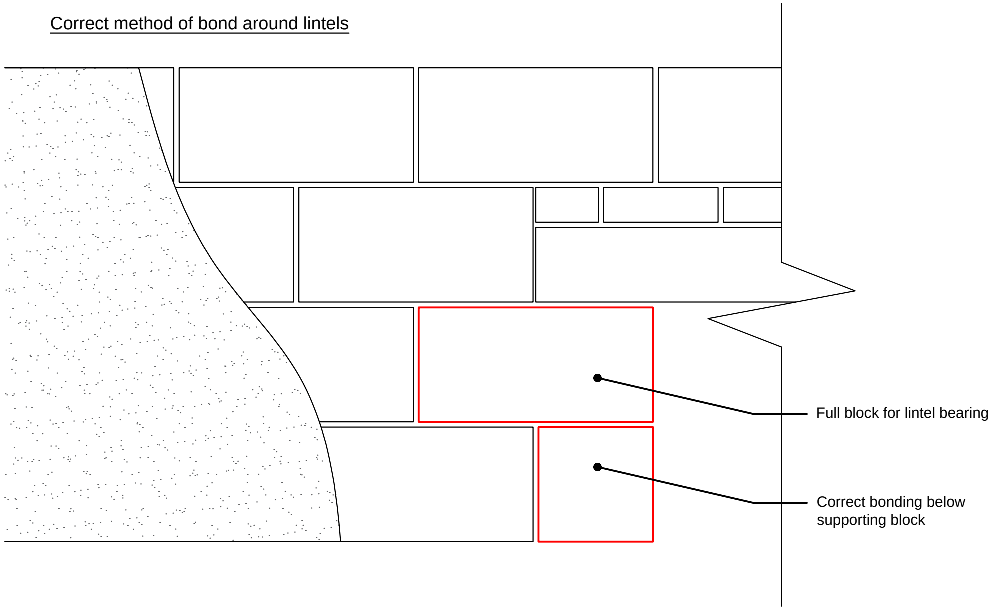
- To accommodate the 25mm rebate, and;
- To allow for opening lights to open clear of the masonry/render.

Windows and doors

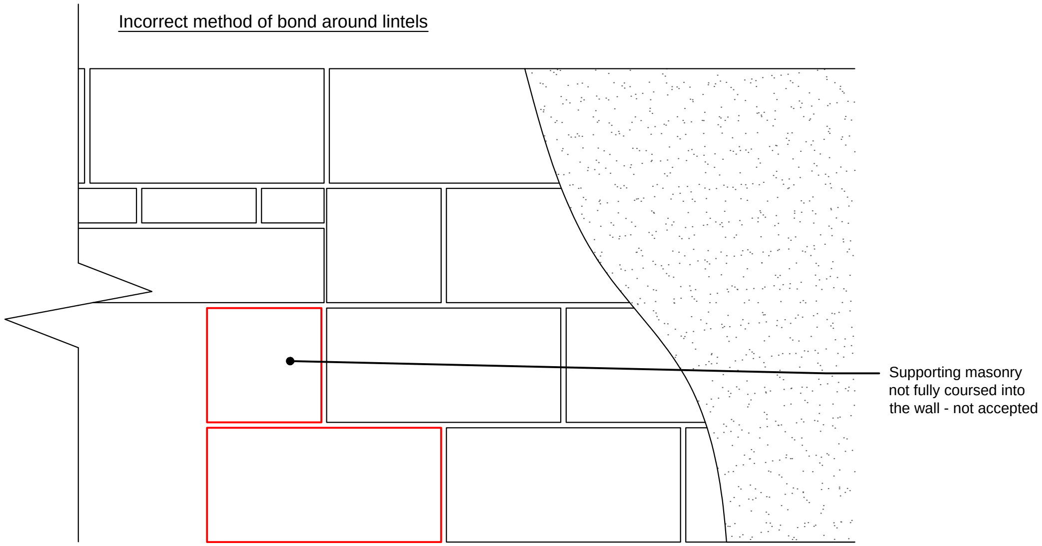
In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap.

For further information on windows and doors please refer to the 'Windows and Doors' section.

Correct method of bond around lintels



Incorrect method of bond around lintels



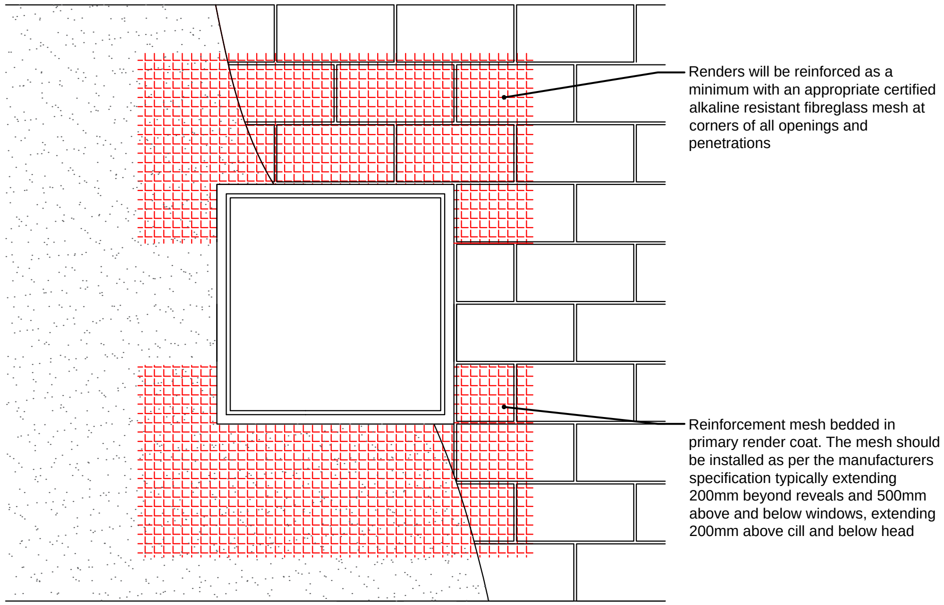
Lintels

- The lintel should be the correct length and width for the opening and cavity width, the bearing length should be at least 150mm.
- Do not let masonry overhang lintels by more than 25mm.
- Continuity of the masonry bond should be maintained at supports for beams and lintels.

Do not:

- Support lintels and beams on short lengths of cut blocks or make-up pieces.
- Apply load to lintels or beams before the masonry supporting has hardened.

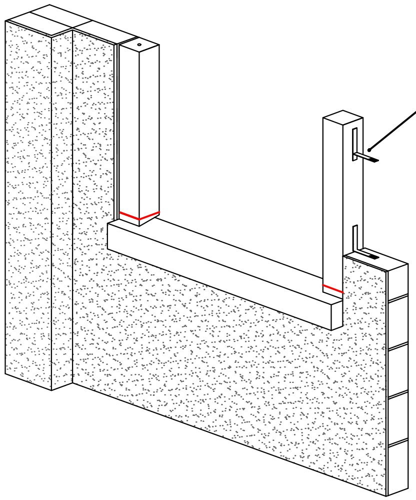
Typical mesh reinforcement around openings



Rendering adjacent to openings

- For bellcasts and other beads uPVC beads or stainless steel beads are acceptable.
- Renders will be reinforced as a minimum with an appropriate certified alkaline resistant fibreglass mesh at corners of all openings and penetrations. For substrates that are prone to movement, an appropriate certified alkaline resistant fibreglass mesh will need to incorporated throughout the substrate.
- Ensure that drips and throating to sills, coping, etc. project a minimum of 40mm beyond the face of the finished render above the DPC.

Stone jamb mullion, fixing to walls

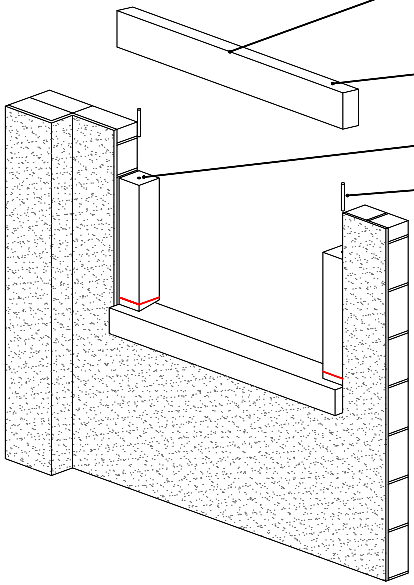


Stone jambs, mullions, and heads should not project into the cavity and insulated cavity closers should be inserted to prevent cold bridging (see typical window opening sections)

Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame-type cramps can also be used to give extra stability at jambs

Mortar:
The mortar for use with stone should comply with the relevant British Standards for sand, lime, and cement as set out in BS 5390

Joining stone jambs to sills and head



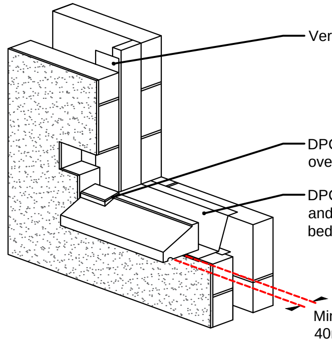
Cavity Trays

When stone heads are being used, it is advisable to double up the cavity trays - with one below the stone head and to provide stop-ends and weep-holes. Weep holes to be of a type to restrict wind driven rain

Cast stone jambs and mullions

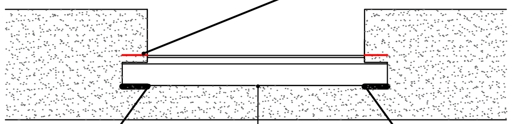
Stainless steel dowels in the sides of jambs should be bedded into adjacent mortar joints as the masonry is constructed

Stone sill with insulated cavity closer



Note: The insulated cavity closer must also be fire resistant unless an additional method of fire resisting cavity closure is also provided that meets Building Regulations

Stone sill



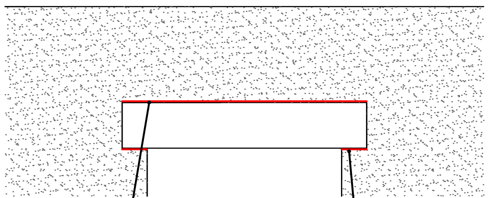
Sills

The DPC should be overlapped by the vertical DPC at the jambs and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off, and then a DPC laid over. The open section below the sill should be sealed with a flexible material only on completion of the structure.

To control water penetration through joints in window surrounds, e.g. at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

Stone head



Render

Ensure that drips and throating to sills etc project beyond the face of the finished render above the DPC by a minimum of 40mm. Rendering around window/door openings to be reinforced with mesh.

Cast stone heads

A cavity tray must be provided above all heads as this not only discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head as well as a soft joint between the top of the head and the steel support lintel.

Cast stone heads should be manufactured in accordance with BS 1217, confirmation of this should be provided to the Warranty Surveyor upon request.

Cast stone window/door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement e.g. where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated or the cast stone should be flexibly jointed.

Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in the table below. The first joint from a return should be no more than half the dimension indicated in the table.

The movement joints must be continued through the render construction and an appropriate weather resistant seal provided to prevent moisture ingress to behind the render finish.

Movement joints below the Damp Proof Course (DPC) should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm vertical centres, and 225mm horizontally, should be provided on each side of movement joints.

Compressible filler, such as polyurethane foam, should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

When sealants are used in proximity with stone it is important to select a non-oil-based sealant to help prevent any staining to the stone.

Elastic sealants (type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

The following must be considered:

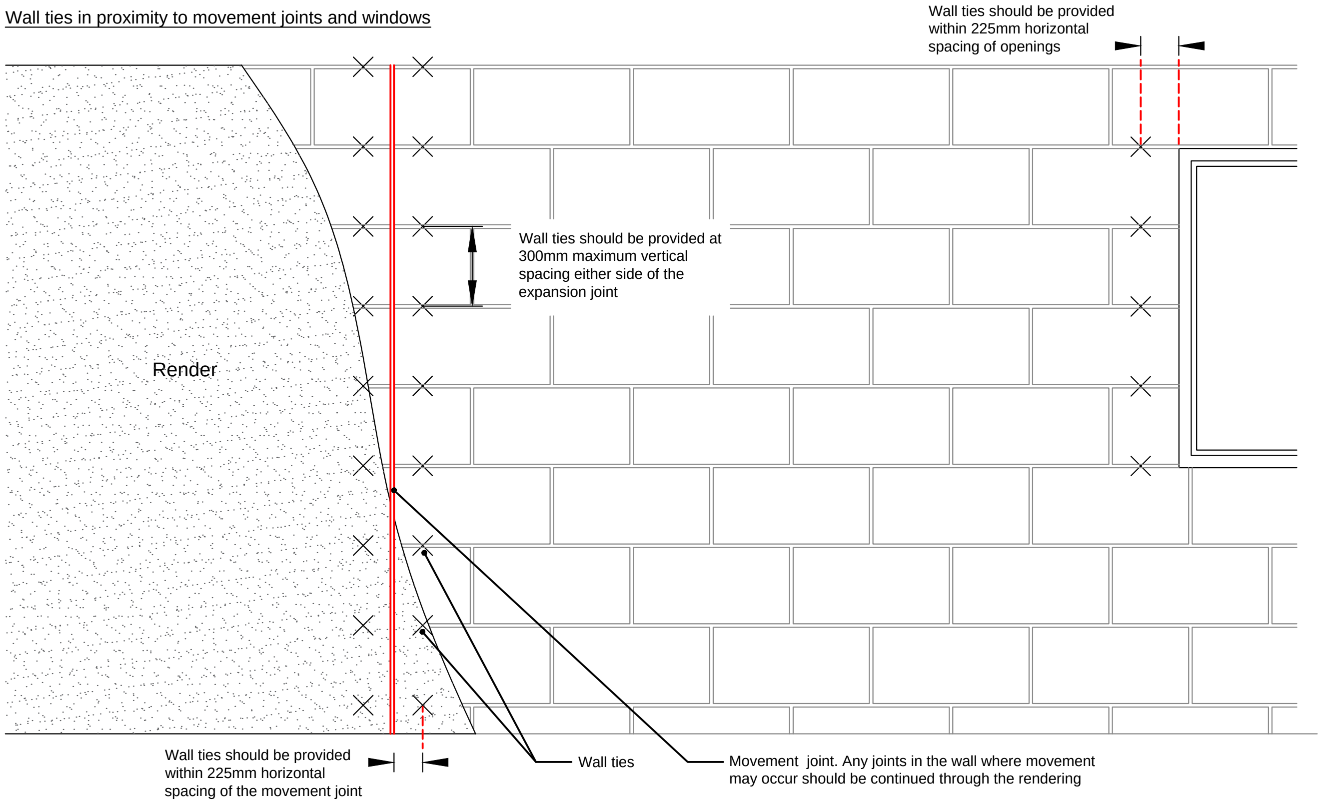
- The material is compatible with the sealant.
- It will not adhere to the sealant, preventing cracking within the sealant.
- Provides sufficient density to allow the sealant to be applied.
- Allows sufficient flexibility so not to impede lateral movement (compressible to about 50% of its original thickness), fibreboard is not acceptable.

The use of bed joint reinforcement may allow the distance between expansion joints to be increased, however this should be designed by a Structural Engineer.

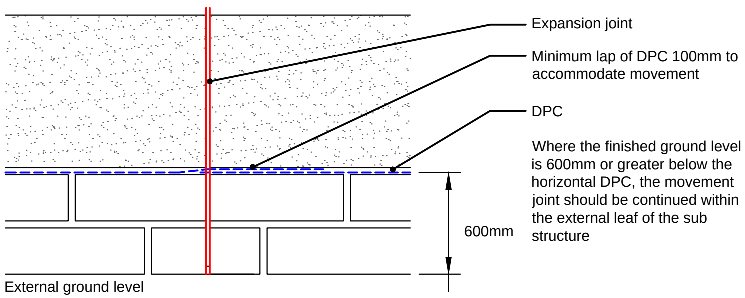
Spacing of expansion joints

Material	Normal spacing	Joint thickness
Concrete blockwork (used in outer leaf)	6m	10mm
Note: The first joint from a return should be not more than half the dimension indicated in the table.		

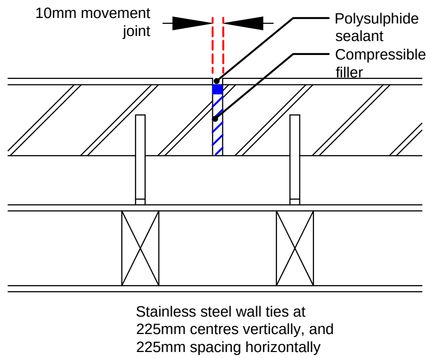
Wall ties in proximity to movement joints and windows



Movement joints below DPC

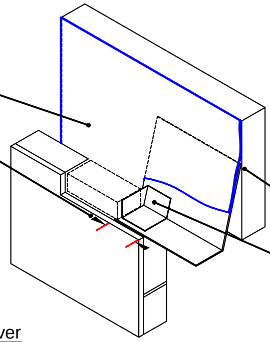


Typical movement joint detail



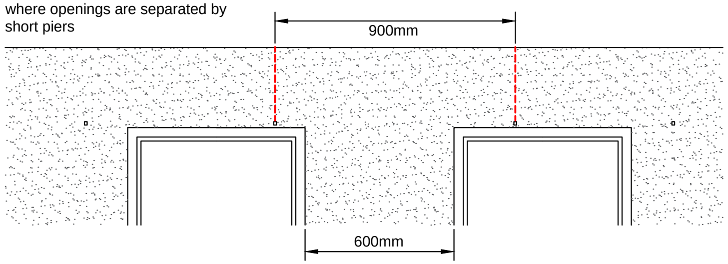
6.4.18 TIMBER FRAME - RENDERED MASONRY CLAD: Cavity trays

Stop end to cavity tray

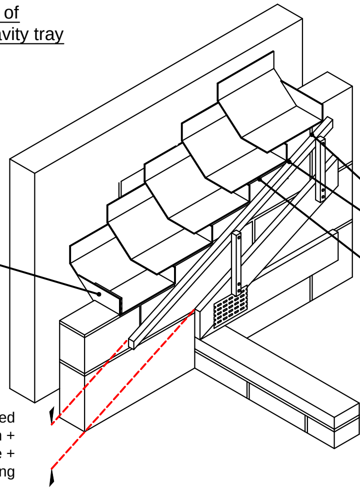


Continuous cavity tray over two openings and a small pier

Cavity trays should be continuous where openings are separated by short piers



Installation of stepped cavity tray



Details of flashing can be found in the 'Roofs' section

Preformed cavity trays should be used for stepped cavity tray details. Stepped cavity trays to lap behind breather membrane by at least 100mm. Additional measures may be needed to ensure the breather membrane adequately laps the tray to prevent moisture ingress behind the stepped cavity tray

Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of dwellings with steps and staggers. A proprietary cavity tray system should be used. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g. attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape over the lower roof covering. For masonry, lead cover flashings should be linked into the cavity tray (lapped in below)

Cavity trays

Cavity trays, associated weep-holes and stop-ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- Cavity trays are to be provided to comply with relevant regional Building Regulations.
- At all interruptions likely to direct rain water across the cavity, such as rectangular ducts, lintels and recessed meter boxes.
- Above cavity insulation that is not taken to the top of the wall, unless that area of wall is protected by impervious cladding.
- Above lintels in walls in exposure zones 4 and 3, and in zones 2 and 1 where the lintel is not corrosion-resistant and not intended to function as its own cavity tray.
- Continuously above lintels where openings are separated by short piers.
- Above openings where the lintel supports a brick soldier course.

Ring beams or floor slabs that partially bridge the cavity, e.g. podium decks or when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray.

Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level.

At least two weep-holes must be provided to drain cavity trays above openings.

Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind-driven rain (including ground level).

Stop-ends

Cavity trays should have water tight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, so that a stop to the structural cavity of at least 75mm high is provided. Normally, the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

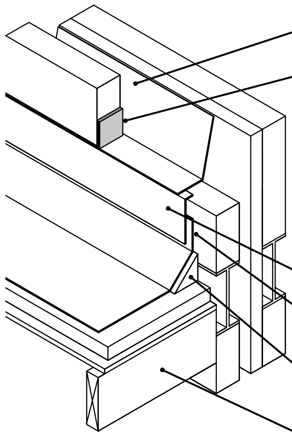
Other perforations of the building envelope

Proprietary elements, such as ventilators, soil pipes, etc. which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

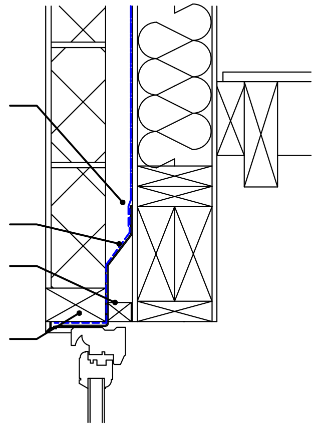
Proprietary cavity tray systems

At stepped and lower storey abutments, and around corners in low rise external walls, a proprietary cavity tray system should be used.

Flat roof abutment cavity tray construction



Cavity tray and lintel



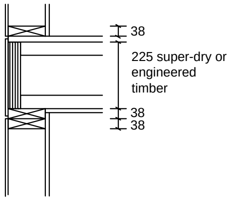
Differential movement at floor zones

Differential vertical movement occurs as a result of compression, closing of gaps and shrinkage of the timber frame structure and occurs during the first 24 months following completion. Shrinkage occurs across the grain and is due to a reduction in the moisture content of timber elements. The shrinkage of plates, rails, binders, floor and roof joists should be considered. The building should be designed to ensure that differential movement occurs evenly to external elevations and the internal structure.

Anticipated differential movement can be calculated using the allowance of 1mm for every 38mm of horizontal cross grain timber. As solid timber joists contribute significantly to anticipated differential movement, engineered timber joists should be considered where it is desirable to reduce differential movement.

Appropriate allowances must be made for differential movement to occur without causing damage to the building.

Engineered Timber

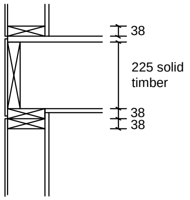


225 mm engineered timber = 2 - 3 mm differential movement depending on tightness of build.

Expect 6 mm movement per storey, or 7 mm per storey if a locator plate is used on upper stories.

Note: when super-dry timber or engineered timber platform frame ground floor is used, add 3 - 4 mm (depending on tightness of build) to the differential movement allowances quoted.

Solid Timber



225 mm solid timber = 6 mm differential movement.

Expect 9 mm movement per storey, or 10 mm per storey if a locator plate is used on upper stories.

Note: when solid timber platform frame ground floor is used, add 7 mm to the differential movement allowances quoted.

If fillers or seals are to be installed into differential movement gaps their fully compressed dimension, considering the area of the seal and force required to compress it, must be added to calculate gap size. Materials should be chosen to provide an effective weather tight seal dependent on whether they are to be subjected to compression, expansion, or shear forces. Cover strips may also be used.

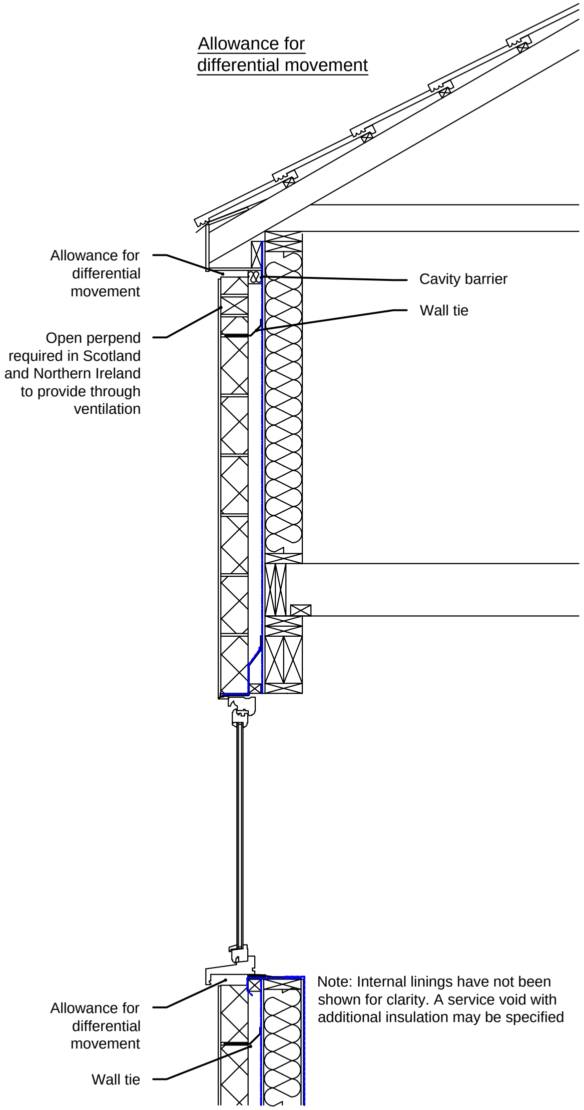
Self supporting claddings (masonry)

Any material or component attached to the timber superstructure that overhangs the brick or blockwork (e.g. cladding attached to the timber frame, window sills, roof eaves, and verges) or projects through the masonry (e.g. balcony supports, flues, extractor fan vents, or overflow pipes) should have a clear gap beneath and at the top of the masonry cladding to allow differential movement to take place, thus avoiding damage to the components or cladding.

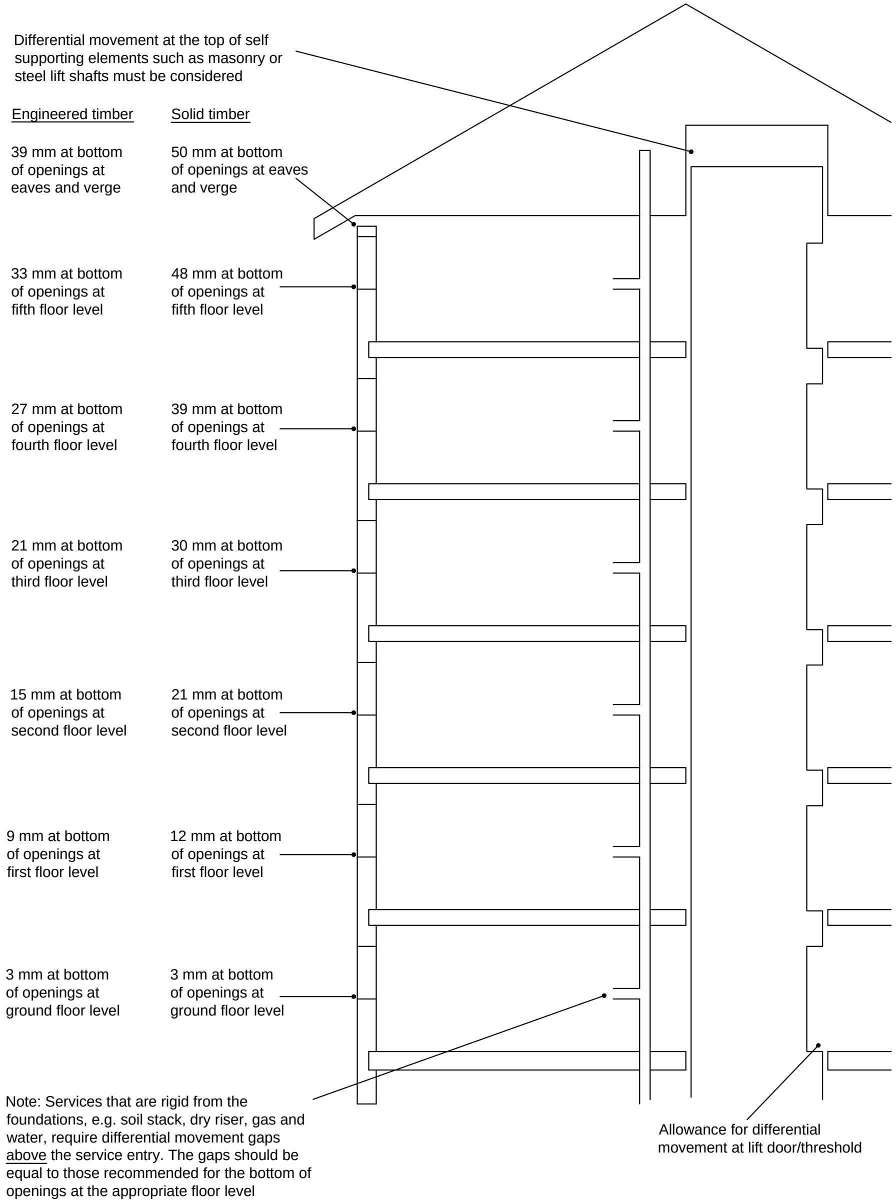
Masonry cladding should not be supported on the timber frame structure.

Gap sizes should allow for anticipated differential movement while allowing for drainage and ventilation requirements. Insect infestation should be avoided by using screens to cover gaps exceeding 4mm.

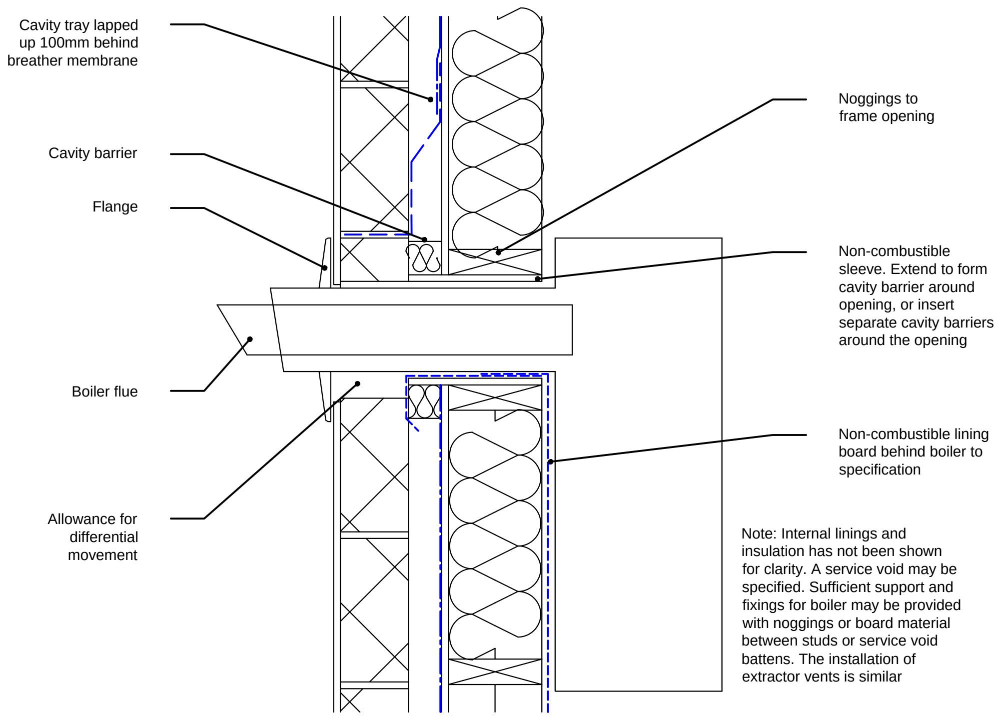
Allowance for differential movement



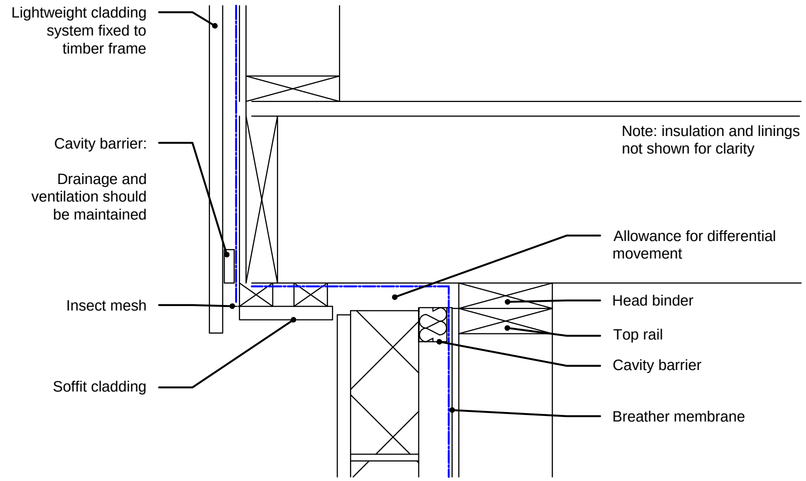
Anticipated differential movement



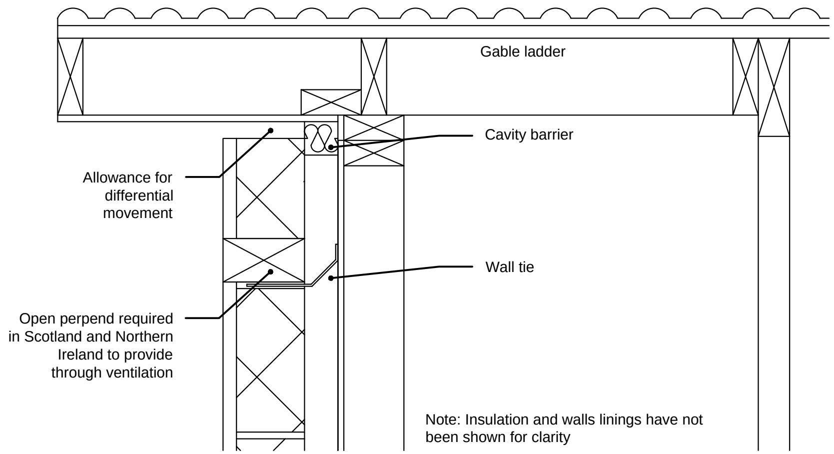
Differential movement at services



Differential movement at cantilevered overhang



Differential movement at verge



Services

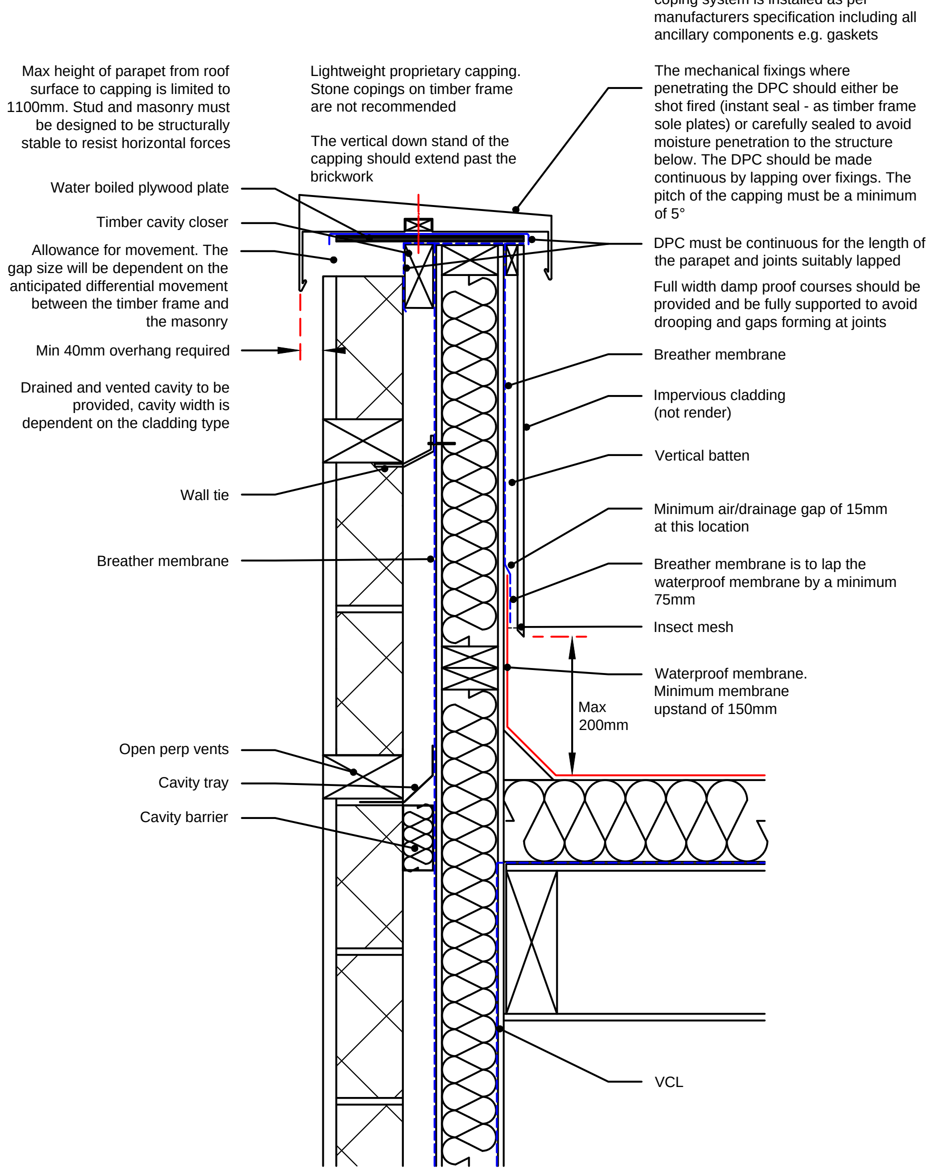
Rigid services within the timber frame structure also require an equal allowance for differential movement, as shown. Examples include copper gas and water pipes, dry risers, internal downpipes, SVP's, and blockwork lift shafts. While gap allowances externally are allowed below, for example, a sill, when a branch comes off a rigid stack internally, the gap needs to be left above a service to allow the timber frame to drop around it

Eaves detailing for rendered walls

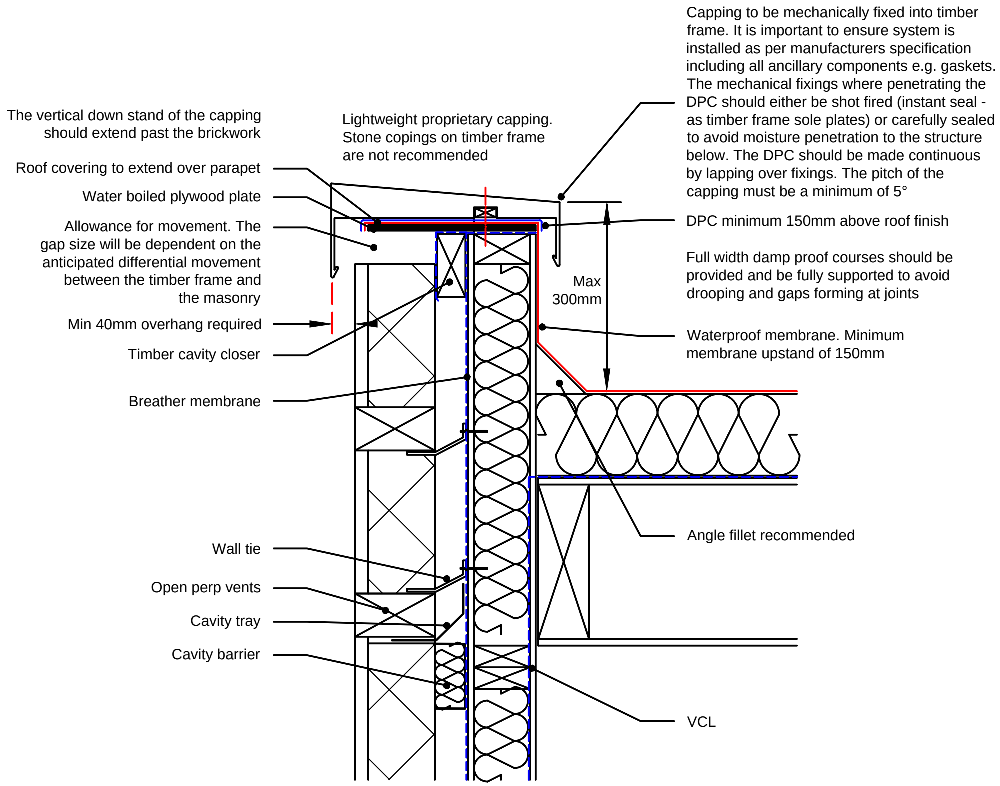
The eaves detail should extend past the masonry to provide protection to the top joint of the render and prevent rainwater percolating behind the render.

6.4.21 TIMBER FRAME - RENDERED MASONRY CLAD: Parapet construction

Coping detail for up to 1100mm from roof



Parapet coping detail for up to 300mm

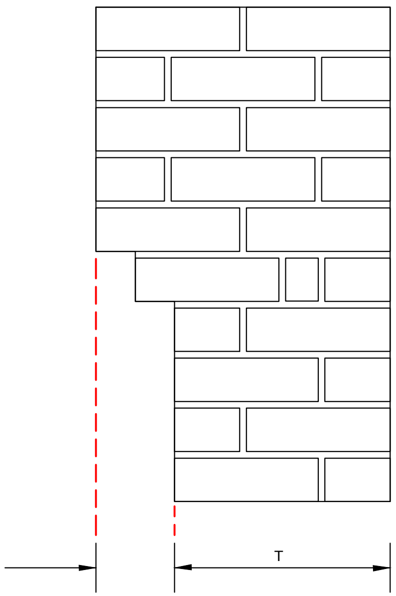


Parapets

- The parapet should be designed to accommodate differential movement, remain structurally stable, and allow suitable structural support of the lightweight coping.
- The coping should be mechanically fixed to the timber frame and the fixings should be suitable for the exposure and anticipated wind loadings.
- If the capping is secret fixed, each capping piece should be provided with at least 2 security fixings.

Feature brick corbelling

The extent of corbelling of masonry should not exceed that indicated in the below detail, unless supported or reinforced. Reinforced corbels should be designed by a Charted Structural Engineer



Gable spandrel panels

The gable spandrel panel should be suitably designed to transmit loads to the roof structure and down through the timber frame.

It is important that gable spandrel panels are designed to transmit these loads to the roof structure via lateral restraints and vertically down to the timber frame. A full design with structural calculations be provided.

The timber frame designer should provide details of the lateral resistant to the gable spandrel panel, including details of the restraint used and the fixings should be provided.

General references used in this section

- BS EN 1995-1-1: 2004+A1: 2008 Eurocode 5 Design of timber structures. General: Common rules and rules for buildings.
- BS 5268-2: 2002 Structural use of timber. Code of Practice for permissible stress design, materials and workmanship.
- BS 5268-3: 2006 Structural use of timber. Code of Practice for trussed rafter roofs.
- BS 5268-4 Section 4.1: 1978 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.1 Recommendations for calculating fire resistance of timber members.
- BS 5268-4 Section 4.2: 1990 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.2 Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions.
- BS 5268-6.1: 1996 Structural use of timber. Code of Practice for timber frame walls. Dwellings not exceeding seven storeys.
- BS 5268-6.2: 2001 Structural use of timber. Code of Practice for timber frame walls. Buildings other than dwellings not exceeding four storeys.
- BS EN 14081-1: 2005 Timber structures. Strength graded structural timber with rectangular cross section. General requirements.
- BS 8417: 2003 Preservation of timber. Recommendations.
- BS EN 13986: 2006 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking.
- BS EN 300: 2006 Orientated strand boards (OSB). Definitions, classification and specifications.
- BS EN 636: 2003 Plywood. Specifications.
- BS EN 622-4: 2009 Fibreboards - Specifications. Requirements for softboards.
- BS EN 622-3: 2004 Fibreboards - Specifications. Requirements for medium boards.
- BS EN 622-2: 2004 Fibreboards - Specifications. Requirements for hardboards.
- BS 4016: 1997 Specification for flexible building membranes (breather type).
- BS EN 845-1: 2003+A1: 2008 Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets.
- EN 14732: 2011 Timber structures. Prefabricated wall, floor and roof elements. Requirements Draft for comment.

6.

External Walls

6.5

Timber Frame - Directly Applied Claddings

Claddings supported on the timber frame

Claddings supported on the timber frame should be connected to it on vertical treated timber battens, or a carrier system, to form a drained and ventilated cavity to all areas of the external timber frame wall. These should be fixed into structural timber not just through the sheathing and to the Structural Engineer's specification.

Cavity drainage and ventilation should provide an open area of not less than 500mm^2 per metre run:

- At the base of the external wall concealed space.
- Above horizontal cavity barriers/trays.
- Over openings in the external wall cavity, e.g. windows and doors.
- Allowing differential movement to occur while retaining an adequate gap.
- With openings protected by a mesh to prevent the passage of insects.

Minimum cavity widths

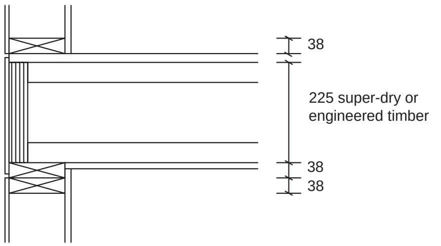
Timber frame external wall minimum cavity widths	
Masonry	50mm
Render on unbacked lath	50mm
Render on backed lath or board	25mm
Timber	19mm
Tile hanging	25mm

Differential movement at floor zones - timber frame

Appropriate allowances must be made for differential movement to occur without causing damage to the building.

Differential vertical movement occurs as a result of compression, closing of gaps and shrinkage of the timber frame structure and occurs during the first 24 months following completion. Shrinkage occurs across the grain and is due to a reduction in the moisture content of timber elements. The shrinkage of plates, rails, binders, floor and roof joists should be considered. The building should be designed to ensure that differential movement occurs evenly to external elevations and the internal structure.

Engineered Timber

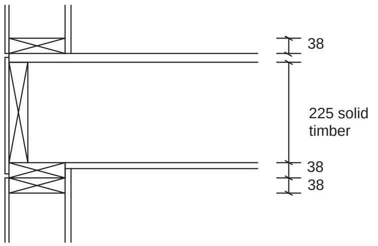


225 mm engineered timber = potentially 2-3 mm differential movement depending on tightness of build.

Expect 6 mm movement per storey, or 7 mm per storey if a locator plate is used on upper stories.

Note: when super-dry timber or engineered timber platform frame ground floor is used, add 3 - 4 mm (depending on tightness of build) to the differential movement allowances quoted.

Solid Timber



225 mm solid timber = potentially 6 mm differential movement.

Expect 9 mm movement per storey, or 10 mm per storey if a locator plate is used on upper stories.

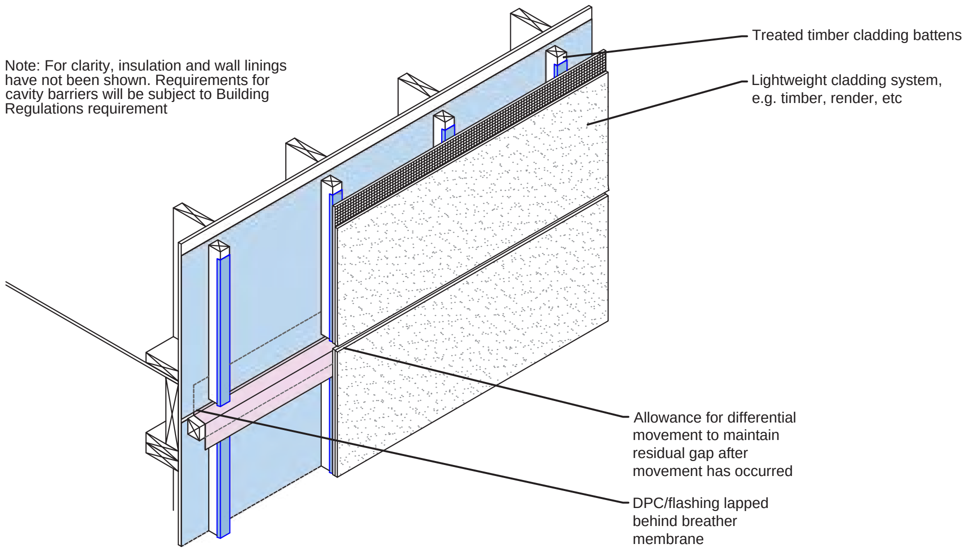
Note: when solid timber platform frame ground floor is used, add 7 mm to the differential movement allowances quoted.

Anticipated differential movement can be calculated using the allowance of 1mm for every 38mm of horizontal cross grain timber. As solid timber joists contribute significantly to anticipated differential movement, engineered timber joists should be considered where it is desirable to reduce differential movement.

If fillers or seals are to be installed into differential movement gaps their fully compressed dimension, considering the area of the seal and force required to compress it, must be added to calculate gap size. Materials should be chosen to provide an effective weather tight seal dependent on whether they are to be subjected to compression, expansion, or shear forces. Cover strips may also be used.

Horizontal cross grain timber and construction gaps are concentrated at floor zones and this is where the majority of movement occurs. Vertical timber battens or other rigid cladding support systems should not span over the floor zones of timber frame buildings. Gaps should be provided to accommodate anticipated differential movement and the compressed size of any filler. Unlike self-supporting claddings, movement is not cumulative but should be calculated individually for each floor zone using the formula above of 1mm for every 38mm of horizontal cross grain timber.

Differential movement at floor zone with cladding supported on timber frame



Gap sizes should allow for anticipated differential movement while allowing for drainage and ventilation requirements. Insect infestation should be avoided by using screens to cover gaps exceeding 4mm.

Render

Rendering should be in accordance with BS EN 13914-1:2005 and workmanship in accordance with BS 8000. In particular the following should be considered:

With traditional renders the quality of the sands used and design mix is as critical as is the reliance on good mixing techniques by the applicator.

Poor mixing ratios and low quality materials is often the reason traditional renders fail. For the purposes of this Warranty, traditional hand mix using standard sand and cement is not accepted. Only a pre-blended bagged render system will be accepted as a suitable render system that has a third party accreditation such as a BBA or ETA certification and backed up with a manufacturer's specification.

Where a specialist render system is being used the following conditions must be met:

1) The product approval is based on the details and limitations of use described in a 'current' approved ETA, BBA, BRE etc. or other UKAS certified system specific to the relevant substrate being applied too. A copy of the certificate documents are to be supplied.

2) For timber supporting structures, a drained cavity is required. A manufacturer's fully detailed project specific render system specification must be provided, which should include:

   - Details of a suitable third party product approved external grade render board.
   - Details of preventing water penetration to the frame and internal finishes at all junctions, openings etc.
   - Other project specific requirements including specification of fixings suitable for the environment, breather membranes, allowance for movement due to shrinkage, appropriate weather seals at movement joints, adequate protection to rendering at cills, parapets etc.
   - The installation should be completed by a competent, registered and certified installer that has been approved and accredited by the render system manufacturer before work commences.
   - Where the specification is in a high exposure zone or coastal location, then the requirements of condition 3 (below) must also be met.

Note: Non drained cavity cladding constructions for timber frame external walls would not meet the Warranty requirements of this Technical Manual.

3) For all render installations (including brick slip system applications) on all substrate types located in an exposure zone where the wind driven rain is expected to be more than 75 litres per m²: A 10 year 'insurance backed' manufacturer's system guarantee is required, together with a full project specific specification that has also been accepted and approved by the Warranty provider. The proposal will require full system details to deal with all junctions, openings etc. together with other project specific requirements provided by the render system company. The render system will need to be installed by a registered and certified installer who has been approved and accredited by the render system manufacturer before work commences.

In all instances where a render system manufacturer's guarantee is required, full project specification and details are to be obtained from the render system manufacturer before any installation commences to ensure that conformity is met. Once work commences, the installation must be inspected and signed off by a render system representative throughout the installation stage and at completion of the installation and confirm that the specification has been met.

The render system together with the backing wall to which they are applied should satisfactorily resist the passage of moisture to the inside of the building.

General render conditions (using pre-blended bagged render)

Weather conditions

- For exposure zones where the wind driven rain is expected to be more than 75 litres per m² (classed as very severe) then checked reveals will be required. The render applied to the reveal must be of the same thickness as the wall render with an appropriate corner beading provided. A suitable non hardening' mastic sealant must also be provided between window / door frame and masonry reveal.
- Protection must be provided when applying renders in rain or other inclement weather. Application should cease in temperature below 5°C or where rapid freezing is considered to be a potential threat.
- When applying in hot weather it is advisable that work coincides with the shaded areas of the building.
- Cement products should not be applied to substrates which are frost laden or which have recently been subject to prolonged rain.
- Do not render onto saturated substrates as this may affect the bond strength.
- Local weather and site conditions must be taken into account by the applicator before any cement product is applied.
- Care must be taken to protect cement and synthetic products soon after the application from rapid freezing and heavy rainfall. For other drying conditions i.e. where there is direct exposure to sunlight or drying winds the render may require to be protected from the elements. This process is important to ensure complete hydration of the products can take place.
- Where an application is not covered in these conditions further advice from the render manufacturer must be sought and submit a suitable manufacturer's specification to the Warranty provider for approval.

Application

- Please note: 5-6mm is considered the minimum finished thickness of render for applications of specialist insulated render systems. The render thickness will need to be increased where structures are located in very severe weather rating locations or within coastal locations and a specialist manufacturer's specification will be required to support this; approved by the Warranty provider.
- Abutments between cement render and other cladding materials or components should be weather tight and allow for differential movement.
- Any joints in the wall where movement may occur should be continued through the rendering.
- Render should not bridge the damp proof course (DPC) and must be finished onto a durable render stop profile such as a proprietary uPVC bead or stainless steel bead.
- Renders will be reinforced as a minimum with an appropriate certified alkaline resistant fibreglass mesh at corners of all openings and penetrations. For substrates that are prone to movement, an appropriate certified alkaline resistant fibreglass mesh will need to be incorporated throughout the substrate.
- Renders installed between pedestrian level and 6.0m above ground level will be designed to accommodate higher maintenance and impact loads in accordance with Table 2 of BS 8200.
- All surfaces must be clean, suitably dry and free from anything that may interfere with the adhesion of the material to be applied. The manufacturer's product data sheets should be followed including the manufacturer's surface preparation and suitability checks in full.
- The quantity of material required for a given area should be of the same batch number or if not the different batches must be thoroughly mixed together to avoid shade variations.
- Full masking must be used to give protection to adjacent areas of work, windows, doors etc. and to give clean straight edges. It should be removed immediately after finishing coat has dried.
- Carefully remove splashes of material, in particular from glass or aluminium immediately as they may etch the surface and leave a permanent mark.

Materials

- Ensure the render being used is suitable for the substrate and is not too strong. Due to shrinkage differentials, avoid applying a thin base coat and a thicker top coat application as the shrinkage values of a thicker top coat could cause the render to delaminate from the base coat. The same effect is also caused by applying a very hard render over a softer base coat.
- External rendering should comply as a minimum with BS EN 13914-1:2005 but should also conform with the specialist render manufacturers recommendations.
- Rendering products should be stored separately from other building and concreting sands.
- For bellcasts, other beads, and stops; uPVC bead or stainless steel bead is acceptable.
- Only clean water should be used for mixing.

Timber frame background

A drained and vented cavity should be provided behind the render system on timber frame construction. The render board should have the capability to be directly rendered. It should not be a wood based board or cement particle board unless confirmed by a UKAS or European equivalent third party product approval body that confirms it is acceptable for use in the conditions proposed. It should also not be a board that is not approved by the render system manufacturer.

For metal lathing, these should be a proprietary BBA, BRE etc. or ETA certified non-corrosive mesh system and must be fully installed in accordance with the mesh system manufacturers details to vertical battens at the stud centres.

The minimum size of the cavity should be 19mm for both the render board or metal lathing applications. Unless proven otherwise, all applications should be used with a water-resistant membrane. When the render board or metal lathing system is unbacked, the minimum cavity should be 50mm. A DPC should be provided between unbacked render and timber battens.

When using external render board you should:

- Fix with the manufacturer's recommended non-corrosive fixings and all in accordance with the manufacturer's installation details, ensuring the vertical board joints are staggered and do not follow directly in line with window, door reveals and other openings.
- Take care to ensure there are no gaps between the boards and appropriate weather seals are incorporated against walls and frames.
- Ensure the boards are cut neat and square; follow the building lines and the screw heads are recessed just below the surface.
- Take particular note of movement joint and fire break requirements and specific application details.
- Ensure all door, window and other openings are fully sealed using an appropriate manufacturer's weatherproof system to provide a primary weather barrier and to resist to movement.

Battens should be either 25mm x 38mm or 50mm x 50mm, preservative treated (BS 8417 or equivalent, hazard class 2) and fixed at spacing's recommended in BS EN 13914-1: 2005. Fixings and preservatives should be compatible.

Battens should be fixed to each stud with annular ring nails of length at least twice the batten thickness plus the sheathing thickness. Nails should be hot dipped galvanised stainless steel or equally durable.

Cavity barriers

Where cavity barriers are required, they should be correctly fitted without gaps, the cavity filled and fixed with stainless steel staples or equally durable fixings, the settlement joints below the external frames and soffits must be maintained.

Render systems which include a cavity as a secondary defence system should also incorporate cavity barriers within the cavity to prevent the spread of fire. The cavity barriers should not obstruct more than 50% of the cavity and should be installed to the internal leaf to retain its ability to drain. The cavity barrier must activate and fully close the cavity when exposed to fire.

Movement joints

Where cement render spans across an intermediate floor zone in timber frame construction, allow for differential movement due to timber shrinkage by incorporating a movement joint. Vertical movement joints should also be provided at maximum 5m centres.

Other construction detailing

Ensure that drips and throating to sills, coping, etc. project beyond the face of the finished render above the DPC.

Notwithstanding wind loadings, the larger the eaves overhang the better. This will provide protection to the top joint of the render panel where it meets the roof and prevent rain water getting behind the render.

Angles, stop beads and jointing sections should be secured with drilled or shot-fired fixings, and not with gypsum plaster.

Vertical and horizontal flatness

Rendering should have a maximum vertical and horizontal deviation from flatness of +/-10mm in 5m, and is measured in a similar way to straightness on plan and plumb.

6.

External Walls

6.6

Light Gauge Steel Frame

Building regulations

All steel frame construction should meet the relevant regional Building Regulations.

Light steel frame systems

Offsite manufactured systems for low rise buildings, must be provided with either independent UKAS or equivalent third party system approval or the system has been evaluated by the Steel Construction Institute (SCI) and also endorsed by our Warranty. Any external wall make up incorporating external cladding, must meet our Warranty requirements in respect of weather resistance.

Steel frame - General design requirements

The structural design should be in accordance with BS EN 1993-1-3:2006, and imposed loads should be calculated in accordance with BS EN 1991, including:

- Dead loads.
- Imposed loads.
- Wind loads.

Steel and fixings should be suitable for the design and adequately protected against corrosion.

Galvanised strip steel should be designated either grade S280GD or 350GD to BS EN 10346.

Where light steel frame ring beams or floor joists are used in ground floors these should be a minimum of 150mm above ground level and be galvanised to a minimum 450g/m^2. Alternately where 150mm between ground level (or waterproofing layer of a flat roof, balcony or terrace) and the lowest steel or base rail cannot be guaranteed, e.g at localised areas for level access the steel should be galvanised to a minimum 600g/m^2.

Load-bearing walls should be designed to support and transfer loads to foundations safely and without undue movement.

Wall panels may provide resistance to racking forces using one or more of the following techniques:

- Internal bracing.
- Cross flat bracing.
- External sheathing board.
- Internal sheathing board.
- Rigid frame action.

The design should detail how joints between the wall panels and other elements are to be securely fixed:

- To the structure.
- To adjacent panels.
- To the floors and roof.

The design should ensure that the structure is adequately protected from the effects of moisture.

Exterior claddings should be compatible with the steel frame. Suspended floors should be designed to support and transmit loads safely to the supporting structure without undue deflection.

Services should be adequately protected from damage, walls and floors should resist the spread of fire. Internal walls and floors should be designed to resist the passage of sound adequately.

Metal stud framework

The wall panel usually consists of a head rail, base rail (sole plate) and possibly horizontal noggins at mid-height, together with vertical wall studs:

- Recommended site connections include self-drilling, self-tapping screws or 10mm-12mm diameter grade 4.6 bolts. Welding is not recommended on-site.
- Workmanship should comply with BS 8000: 5.
- Framed walls should be accurately aligned, plumb, level without twist and securely fixed to adjacent elements.

Vertical tolerances are:

- +/-15mm in overall height of wall 3 storey, or
- +/-10mm in overall height of wall 2 storey, or
- +/-5mm in storey height (approx. 2.5m).

A lintel should be provided where one or more studs is cut or displaced to form an opening. A lintel is not required where an opening falls between studs. Non-load bearing walls should have adequate strength and support.

Non-load bearing walls should not bridge movement joints in the main structure. A movement joint should be constructed between the frame and any chimney flue or lift shaft to prevent load transfer. Cavity barriers and fire stops should be provided in accordance with relevant Building Regulations, and steel joists should be spaced at centres no greater than 600mm.

Cutting holes for services on-site is not recommended, but where essential should be carried out with specialist tools. The maximum size of rectangular holes should not exceed 40% of the overall section, and length should not exceed 60% of the overall section or be the depth of the section apart. No holes should be closer than 1.5 times the depth of the section to the end of the member, notches are not acceptable.

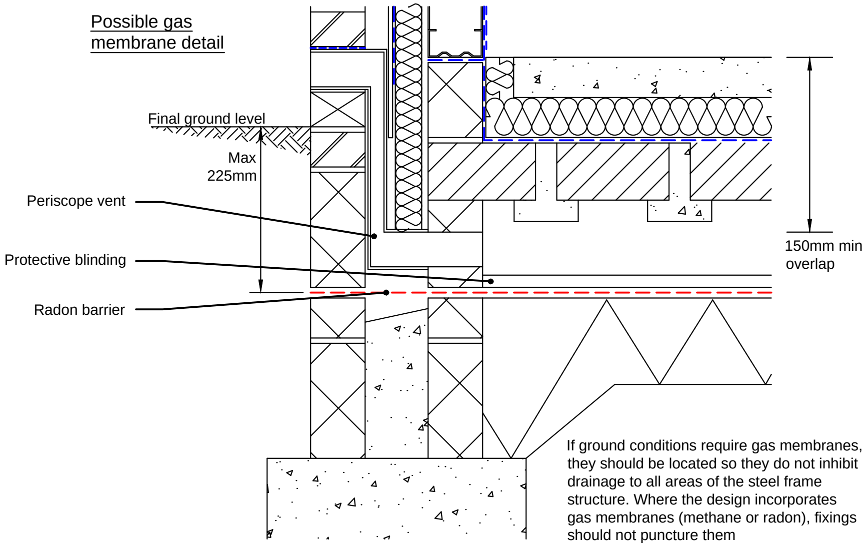
Key points: Construction below DPC

1. Brickwork and blockwork below DPC level must be selected to have suitable durability for its use in the wall construction in accordance with BS EN 771-1 and PD 6697.
2. Mortars below DPC are exposed to higher levels of saturation and therefore require higher durability classification (see BS EN 998-2).
3. Cavities below ground should be filled with concrete ensuring there is a minimum gap of 225mm between DPC and the top of concrete.
4. Concrete for cavities should be GEN 1 grade and a consistence class S3.
5. External ground levels should be a minimum of 150mm below DPC.
6. The compressive strength of the masonry units must meet the requirements of the relevant regional Building Regulations.

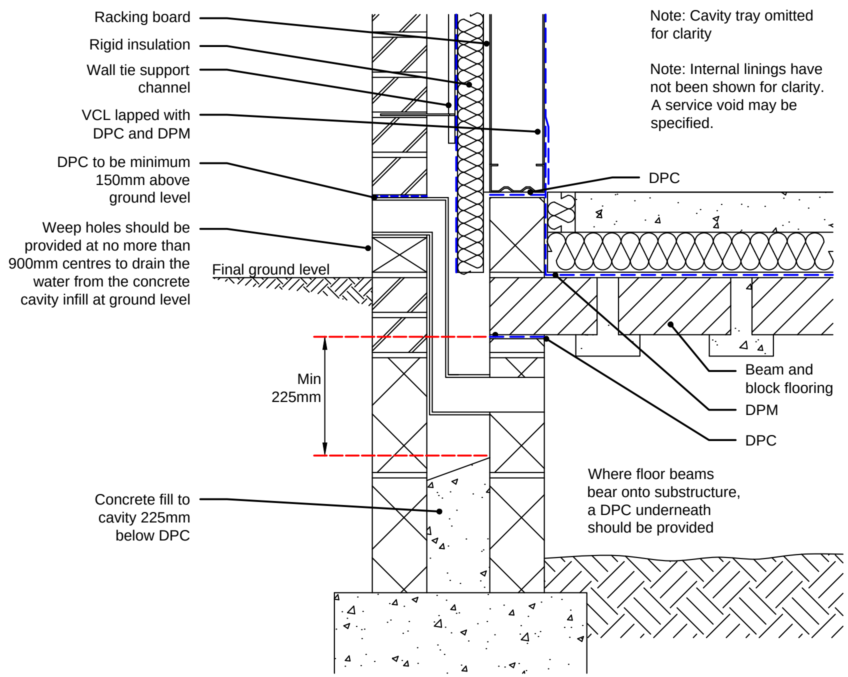
Damp proof courses (DPC)

1. DPC's should be of a flexible material, be suitable for the intended use, and should have appropriate 3rd party certification. The installation specification of DPC's should follow good design practice in accordance with BS 8215.
2. Blue bricks or slate will not be accepted as a DPC.
3. DPC's should be laid on a mortar bed and correctly lapped at junction and corners. The depth of the lap should be the same width as the DPC.
4. The DPC should not bridge any cavity unless it is acting as a cavity tray (e.g over a telescopic floor vent). Please refer to the cavity tray details for further information.
5. Damp proof membranes (DPM) should be lapped with the DPC, and VCL by a minimum overlap of 100mm.

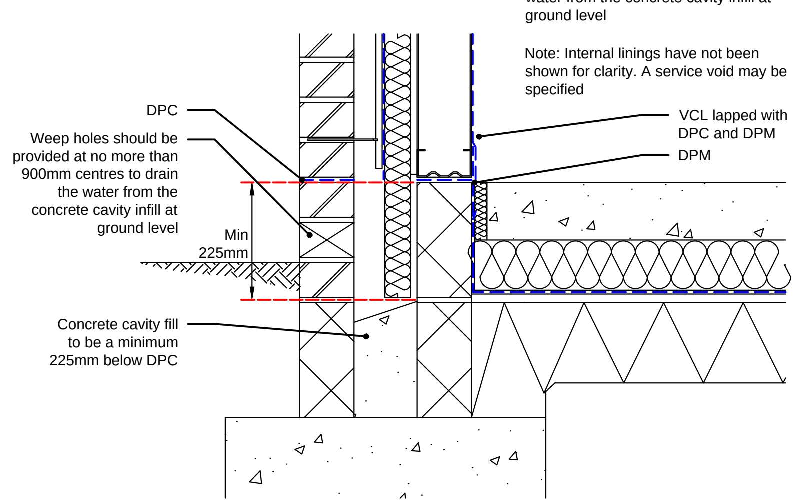
Possible gas membrane detail



Suspended floor with ventilation provision



Ground supported floor - no sub floor ventilation



Site tolerances

It is essential that the accuracy of setting out foundations and ground beams are checked well in advance of materials being delivered to site.

For accurate erection of the frame the following tolerances are required at the level of the base of the wall frame:

- Length of wall frame: +/-10mm in 10m.
- Line of wall frame: +/-5mm from outer face of plate.
- Level of base of wall frame: +/-5mm over complete wall line.

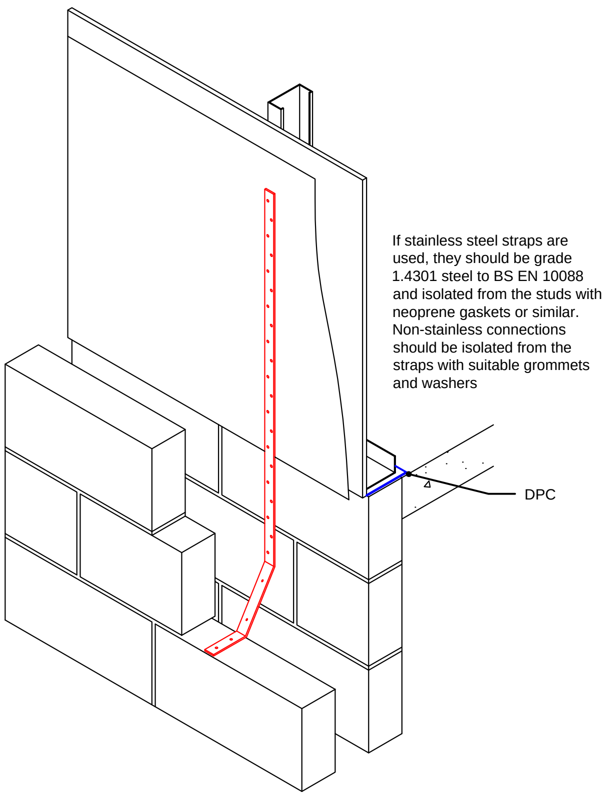
Some packing may be needed to achieve the required tolerances.

Fixing of frames to substructures

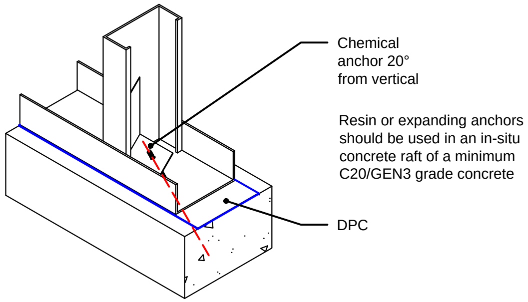
The oversite DPM should be attached to the side of the slab and returned under the DPC on which the frame is placed. The DPC/DPM detail requires careful attention to prevent the cavity being bridged and providing a ledge for mortar droppings.

Holding down anchors may be galvanised, or preferably stainless steel straps that are fixed to the stud wall and attached to masonry supports or concrete foundation, or holding down bolts fixed to the concrete slab.

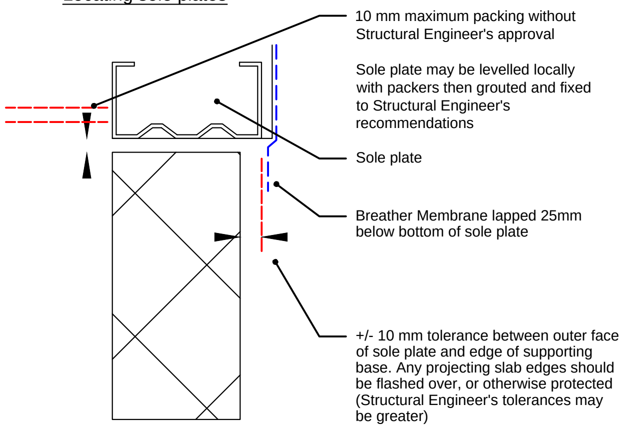
Example of holding down strap



Example of frame anchors

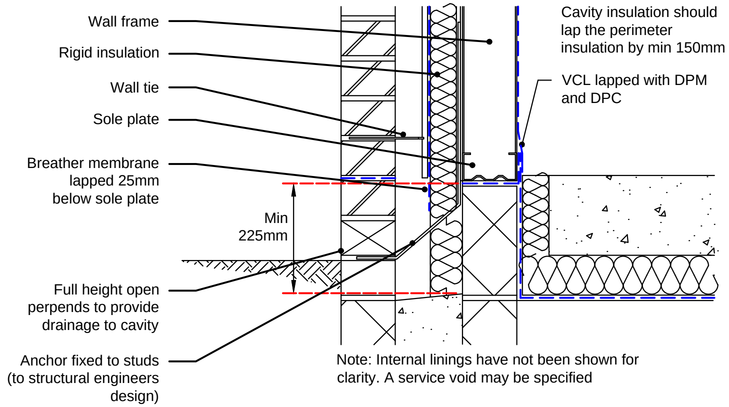


Locating sole plates



The metal frame should be located entirely above DPC level. Where this is not possible at level entrance ramps to the principal entrance door to dwellings only; a thickness of corrosion protection equivalent to Z460 galvanising or a suitable bituminous coating could be applied to all components below DPC level. However, the access ramp should only be limited to the entrance door area only (not the entire perimeter) and provision for a slotted drainage and the ramp should be provided with a gradient away from the door (see the 'Windows and Doors' section for level threshold guidance). It is recommended that the inner leaf DPC is turned up approximately 30mm above the screed to protect the bottom of the studs from construction moisture and spillage, and weep-holes are provided at 900mm centres to drain cavities at ground level.

Sole plate/foundation junctions

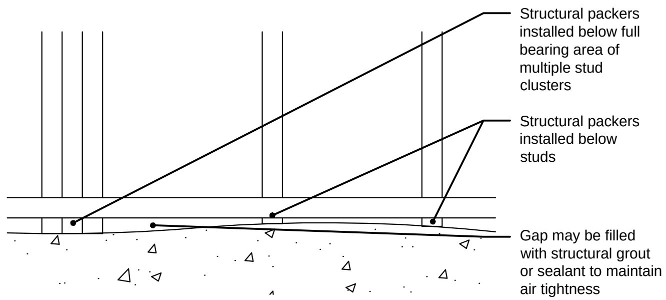


Packing under the steel frame

Structural shims or grout may be required under the steel frames to level them and transfer vertical load. Longer frame to foundation fixing may be needed to allow for the size of the gap.

- Less than 10mm; pack under each steel with pre-galvanised steel shims.
- 10mm-20mm; pack under each steel with steel shims and grout over length of sole plate.
- Over 20mm; refer to Frame Designer.

Packing of sole plates



Thermal insulation

Rigid thermal insulation material should be fixed to the outside face of the steel studs to create a 'warm frame' construction.

Insulation installed to the outside of the steel frame structure should have third-party certification for this application and retain a minimum of a clear 50mm cavity.

The outer layer of insulation should also be covered with a breather membrane adjacent to the cavity.

External walls should be subject to U-Value and condensation risk calculations. A wall build up will be considered satisfactory if there is no calculated risk of surface or interstitial condensation at any time of the year, and it fulfils the minimum National Requirement for thermal performance. Special consideration should be given to condensation risk where non breathable insulation products are installed on the outside of the steel frame structure. Joints between foil faced external insulation boards, must not be taped as this forms a vapour control layer on the cold side of the insulation.

Where the condensation risk has been assessed and shown to be negligible additional insulation may be placed between the studs. The additional insulation should be placed in contact with the studs to minimise air gaps and prevent local condensation.

The following are acceptable:

- Mineral wool to BS EN 13162*
- FR (flame retardant) grade expanded polystyrene to BS EN 13163
- FR (flame retardant) grade extruded polystyrene to BS EN 13164
- Rigid polyurethane foam and polyisocyanurate to BS EN 13166
- Cellular glass to BS EN 13167*

*Compressible insulation for use between the metal studwork

Breather membranes

A breather membrane should be provided to the 'cold side' of the steel frame. Breather membranes should be capable of allowing water vapour from within the frame to pass out into the cavity and protect the sheathing and frame from external moisture. These should be:

- Vapour-resistant to less than 0.6MNs/g when calculated from the results of tests carried out in accordance with BS 3177 at 25°C, and with a relative humidity of 75%.
- Capable of resisting water penetration.
- Self-extinguishing.
- Durable.
- Adequately strong when wet to resist site damage.
- Type 1 to BS 4016 in areas of *very severe* exposure to wind-driven rain.

If foil faced insulation is not used, then an independent breather membrane should be provided to the 'cold side' of the insulation.

Breather membranes should be lapped by a minimum of 100mm at horizontal joints, and a minimum of 150mm at vertical joints. If breather membranes are trimmed flush with the edges of wall panels, additional strips of breather membrane, at least 300mm wide, should be supplied and site fixed over panel junctions. The location of steel studs should be clearly marked on the outer face of the breather membrane to ensure that cladding fixings are installed into steel studs.

Vapour control layers (VCL)

A vapour control layer should be provided to the warm side of the steel frame. VCL's resist the passage of water vapour from within the dwelling and should be a minimum of 500-gauge polyethylene sheet or vapour control plasterboard*. The vapour resistance (not resistivity) of the vapour control material should not be less than 250 MNs/g or 0.25 Pa/m^2.

*Vapour control plasterboard should only be used subject to a condensation risk analysis demonstrating the suitability of the wall build up.

Installation

A sheet membrane vapour control layer (VCL) should be:

- Lapped and sealed by at least 100mm at joints.
- Lapped over studs, rails or noggins.
- Sealed around service penetrations.
- Lapped and sealed fully into window and door reveals.
- Lapped and sealed with DPM/DPC at the junction with the ground floor/foundation.
- Able to accommodate differential movements.

Small holes in the VCL should be sealed with a suitable self-adhesive tape. Larger holes should be re-covered with new laps located over adjacent studs and rails.

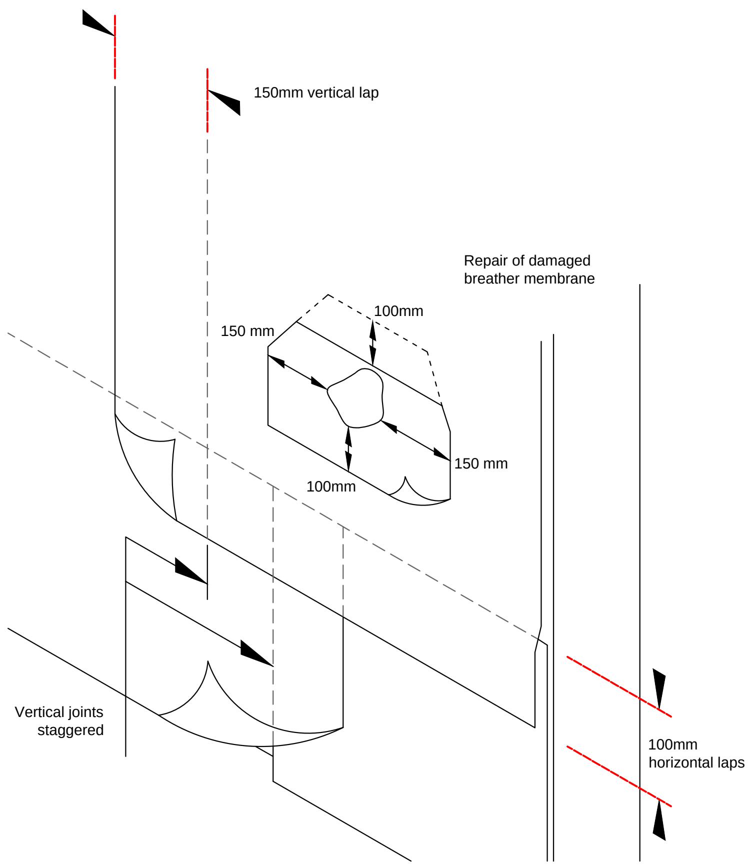
Plasterboard

Plasterboard should be to BS 1230 and not less than:

- 9.5mm for stud spacing up to 450mm, or
- 12.5mm for stud spacing up to 600mm.

To provide fire resistance fire rated boards should be used and installed in accordance with the manufacturer's instructions.

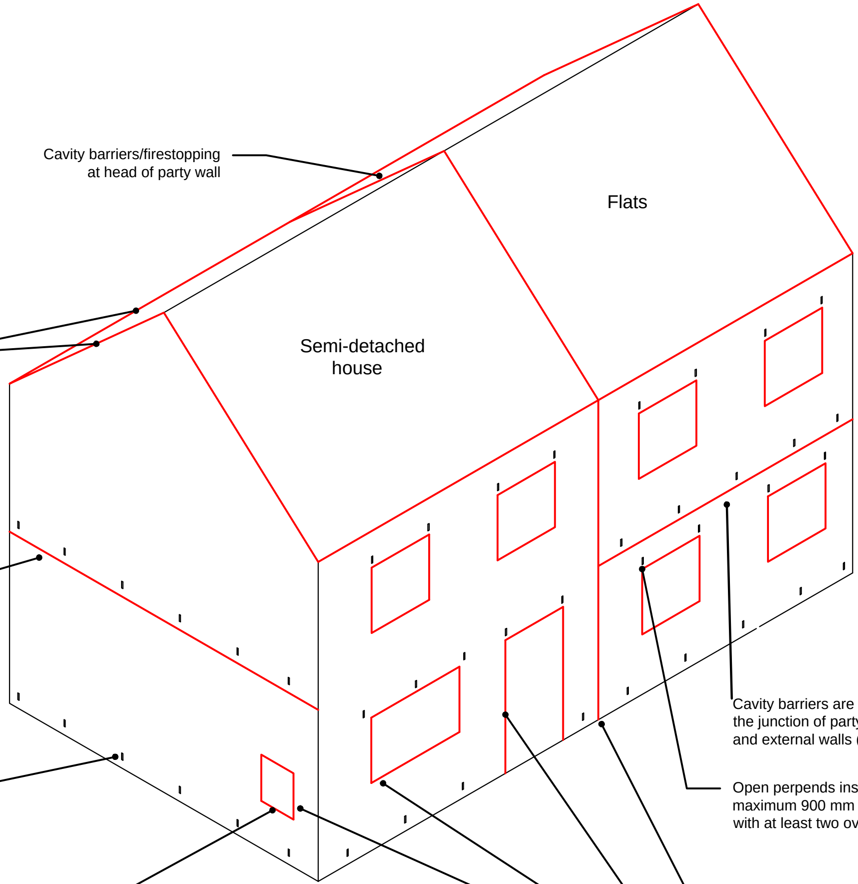
Lapping and repair of breather membrane



Locations of cavity barriers and open perpends

Note: Lightweight cladding systems will require a cavity barrier along the bottom of the cavity

Note: Cavity barriers may also be required between walls and floors within the building, consult National Regulations for further guidance



Note: Scotland and Northern Ireland may require additional drainage and ventilation to the cavity, please see the regional Building regulations for further guidance.

Cavity barrier locations

In England and Wales, cavity barriers shall be installed:

- At the edges of all cavities including around openings, e.g. windows and doors.
- Between an external cavity wall and a compartment wall or compartment floor.
- Around meter boxes in external walls.
- Around service penetrations in external walls e.g. extract duct or boiler flue.
- To sub-divide extensive cavities; please refer to National Regulations for specific requirements.

Cavity barrier installation

Cavity barriers shall be installed:

- So they fully close the cavity.
- So the ends are tightly butted (or adequately lapped in accordance with the manufacturers instructions) to form a continuous barrier.
- Backed by studs, rails or floor joist.
- In accordance with manufacturer or independent certifier's guidance.

A cavity tray should be proved directly above a horizontal cavity barrier and lapped at least 100mm behind the breather membrane (except at eaves and verges).

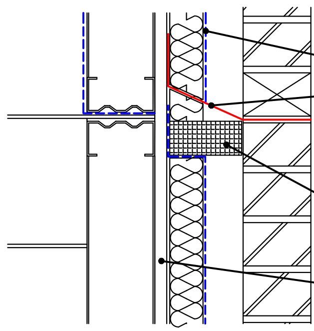
Cavity barriers are required to prevent the spread of smoke and flame within concealed spaces.

It is important that cavity barriers should extend through PIR insulation.

Cavity barriers may be constructed from:

- Steel at least 0.5mm thick.
- Timber at least 38mm thick.
- Proprietary 3rd party approval mineral wool product.
- Calcium silicate, cement-based or gypsum-based at least 12mm thick.
- An independently assessed and certified proprietary product.

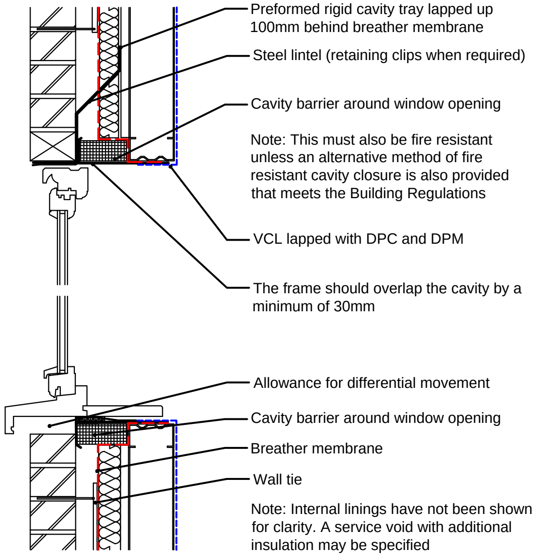
Cavity tray above horizontal cavity barrier - Steel frame



Window and door installations

Please refer to the 'Windows and Doors' guidance for installation requirements of frames including maximum gaps and fixings.

Typical vertical section through window opening



In this instance the steel frame has been shown with an external sheathing board

Openings

All openings including doors, windows, flues and ventilation ducts, should be designed and constructed to maintain:

Fire performance:

- Internal reveals require equal fire resistance to the rest of the structure.
- Window fixing straps should not compromise the integrity of any fire-resistant reveal linings.
- Cavity barriers should be installed in the external wall cavity around the perimeter of openings.
- If profiled steel lintels are used as cavity barriers, triangular gaps behind lintels, which occur at each end, should be closed with careful positioning of adjacent cavity barriers.

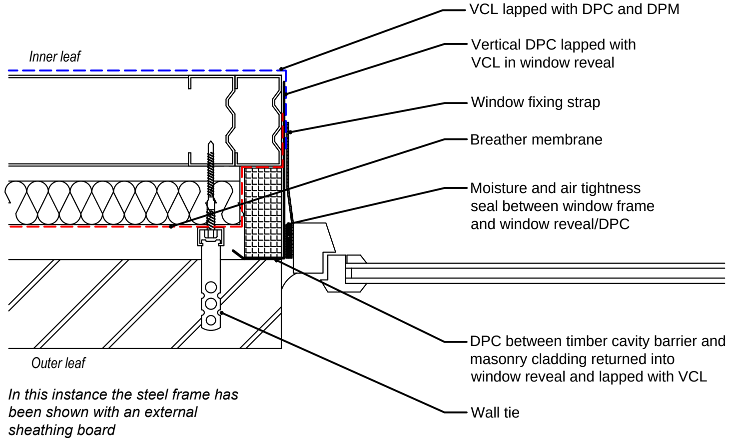
Acoustic performance:

- Seal gaps between steel frame wall and the element being installed into the opening.
- The element being installed into the opening may have a minimum acoustic requirement.

Weather tightness and thermal performance, including thermal bridging and air tightness:

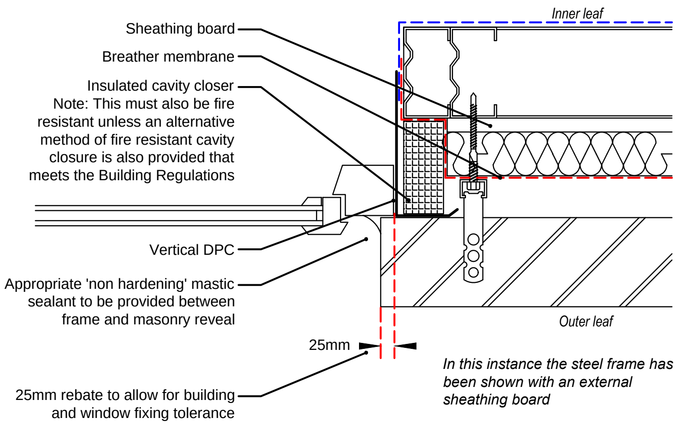
- The element being installed into the opening is likely to have a minimum thermal performance.
- Seal gaps between the steel frame wall and the element being installed into the opening to provide thermal performance, weather tightness and air tightness.
- Cavity trays should be installed over the heads of all openings, lapped behind the breather membrane by a minimum of 100mm. A flashing may be acceptable for some types of claddings.
- Lap cavity barrier DPC with internal VCL around openings. Where no DPC is used, breather membrane should be lapped with internal VCL.

Typical window reveal detail (normal exposure)



In this instance the steel frame has been shown with an external sheathing board

Typical rebated window frame detail for areas of very severe exposure



In this instance the steel frame has been shown with an external sheathing board

When installing window/door frames in a checked rebate, allow for the frame to be deeper:

- To accommodate the 25mm rebate, and;
- To allow for opening lights to open clear of the masonry/render.

Windows and doors

In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap.

For further information on windows and doors please refer to the 'Windows and Doors' section.

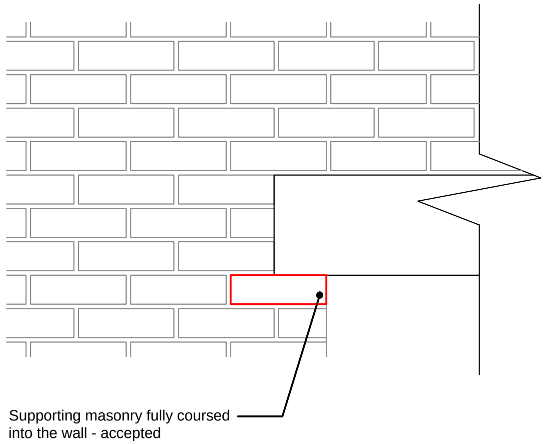
Lintels

- The lintel should be the correct length and width for the opening and cavity width, the bearing length should be at least 150mm.
- Do not let masonry overhang lintels by more than 25mm.
- Continuity of the masonry bond should be maintained at supports for beams and lintels.
- Lintels should be insulated to prevent excessive thermal bridging.

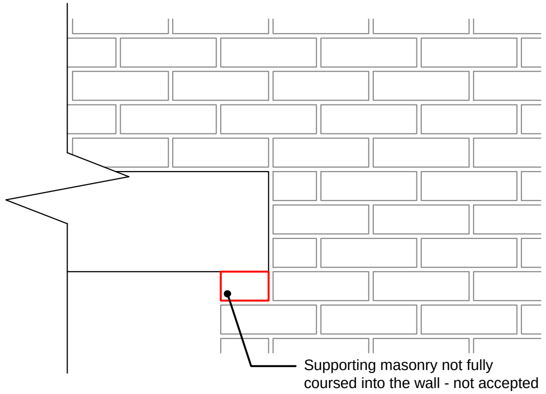
Do not:

- Support lintels and beams on short lengths of cut blocks or make-up pieces.
- Apply load to lintels or beams before the masonry supporting has hardened.

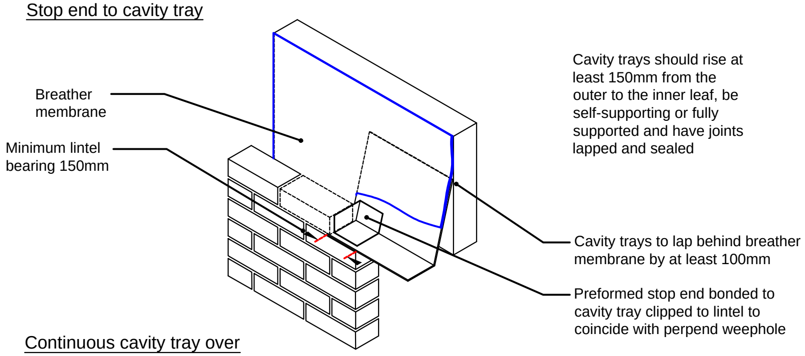
Correct method of brick bond around lintels



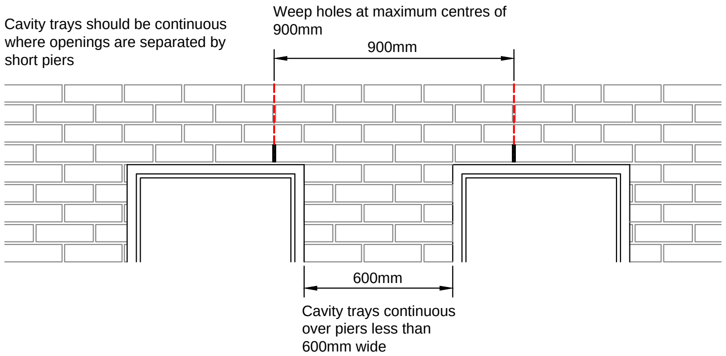
Incorrect method of brick bond around lintels



Stop end to cavity tray



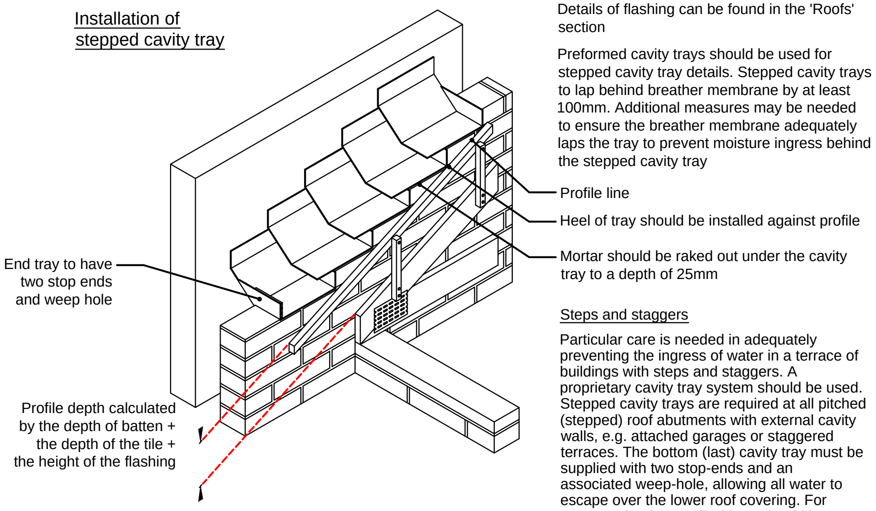
Continuous cavity tray over two openings and a small pier



Installation of stepped cavity tray

Details of flashing can be found in the 'Roofs' section

Preformed cavity trays should be used for stepped cavity tray details. Stepped cavity trays to lap behind breather membrane by at least 100mm. Additional measures may be needed to ensure the breather membrane adequately laps the tray to prevent moisture ingress behind the stepped cavity tray



Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of buildings with steps and staggers. A proprietary cavity tray system should be used. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g. attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape over the lower roof covering. For masonry, lead cover flashings should be linked into the cavity tray (lapped in below)

Cavity trays

Cavity trays, associated weep-holes and stop-ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- Cavity trays are to be provided to comply with relevant regional Building Regulations.
- At all interruptions likely to direct rain water across the cavity, such as rectangular ducts, lintels and recessed meter boxes.
- Above cavity insulation that is not taken to the top of the wall, unless that area of wall is protected by impervious cladding.
- Above lintels in walls in exposure zones 4 and 3, and in zones 2 and 1 where the lintel is not corrosion-resistant and not intended to function as its own cavity tray.
- Continuously above lintels where openings are separated by short piers.
- Above openings where the lintel supports a brick soldier course.

Ring beams or floor slabs that partially bridge the cavity, e.g. podium decks or when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray.

Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level. At least two weep-holes must be provided to drain cavity trays above openings.

Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind-driven rain (including ground level).

Stop-ends

Cavity trays should have water tight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, so that a stop to the structural cavity of at least 75mm high is provided. Normally, the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

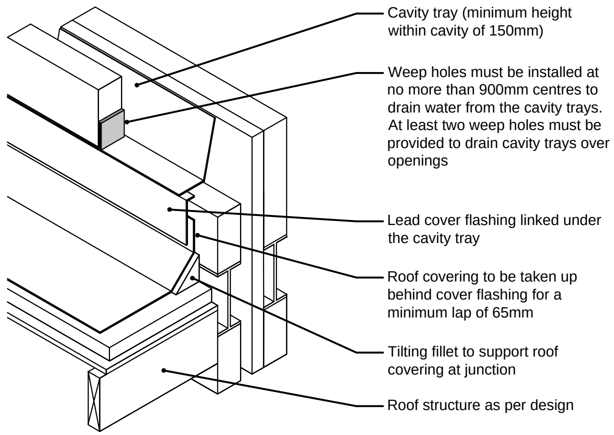
Other perforations of the building envelope

Proprietary elements, such as ventilators, soil pipes, etc. which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

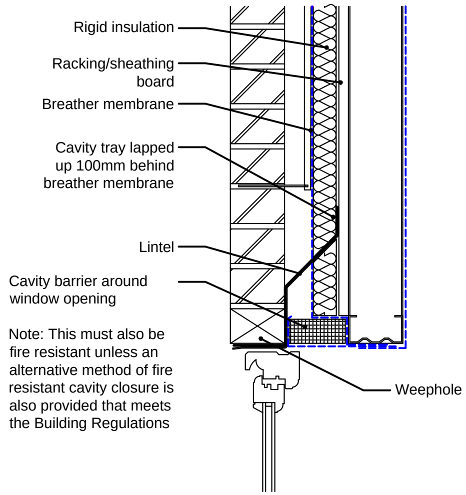
Proprietary cavity tray systems

At stepped and lower storey abutments, and around corners in low rise external walls, a proprietary cavity tray system should be used.

Flat roof abutment cavity tray construction



Cavity tray and lintel



LIGHT GAUGE STEEL FRAME: Exposure category of sites and suitability of masonry

Dealing with areas of high exposure to frost and wind-driven rain

The design and construction of masonry cavity walls should be suitable for the site specific exposure location.

Frost attack
Frost-resistant bricks should be used in areas that are prone to prolonged periods of frost.

If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Wind-driven rain
To ascertain the risk relating to wind-driven rain, the following should be determined:

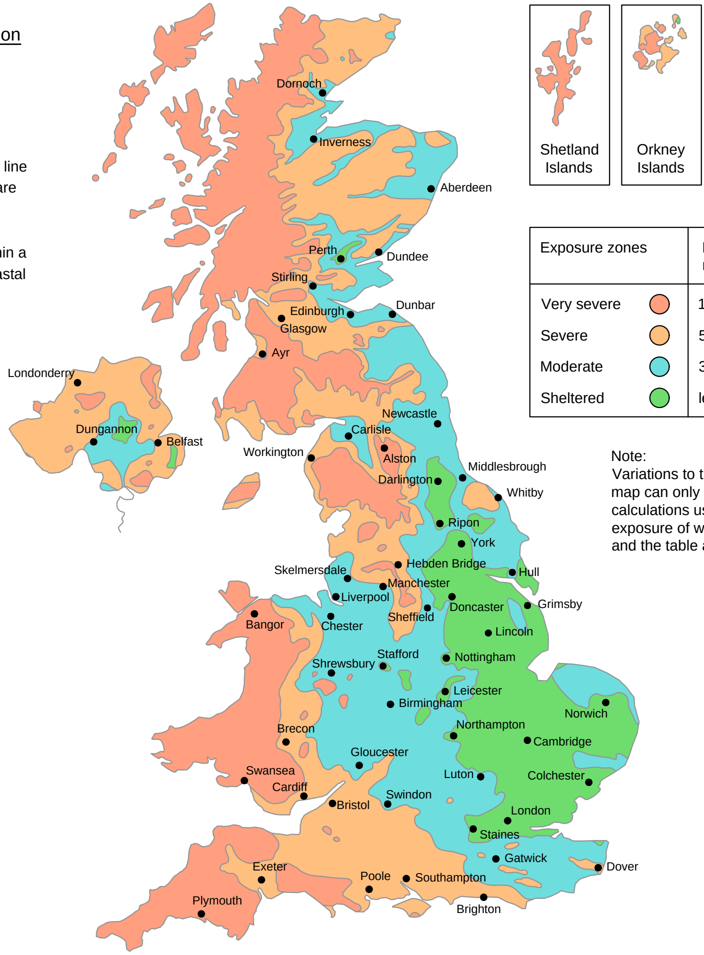
- The exposure to wind-driven rain.
- The correct type of construction, including the correct application of insulation.
- The correct level of workmanship and design detailing, particularly around window and door openings.

Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.



Exposure zones	Exposure to wind driven rain (litres/m^2 per spell)
Very severe	100 or more
Severe	56.5 to less than 100
Moderate	33 to less than 56.5
Sheltered	less than 33

Note:
Variations to the exposure shown on the map can only be made by site-specific calculations using BS 8104 "Assessing exposure of walls to wind driven rain" and the table above.

Brick and block suitability

Exposure
Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further information can be found in 'Appendix C - Material, Products, and Building Systems'.

Colour variation of bricks
There is usually a variation in the colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations
Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength, helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure, which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention/collection has been found to exist in the perforations.

Efflorescence
Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use.
- Protecting the head of newly constructed work with some form of cover to prevent saturation.

Mortar suitability

General
A mortar type should be chosen in accordance with the guidance given in the 'External Walls' and 'Materials, Products, and Building Systems' sections, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and/or air entraining plasticisers may be added to cement in accordance with the manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching
Keep batching and mixing equipment clean to avoid contamination with materials used previously, mortar should be mixed by machine, or use ready mixed retarded mortars.

Mixing
Mortar should be carefully and consistently proportioned and then thoroughly mixed using a mechanical mixer, except for very small quantities.

Masonry cladding to steel frames

Protection
All new masonry work should be protected during construction by covering it to ensure that walls are not allowed to become saturated by rain water or dry out too quickly in hot weather, are protected against frost attack, the risk of efflorescence and line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

Working in adverse weather

Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in 'Appendix C - Material, Products, and Building Systems'.

During prolonged periods of hot weather, when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e. engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Wall ties

Wall ties should meet the following provisions:

- The wall ties should be tested to BS EN 845-1 and carry a CE marking. The wall tie manufacturer should provide a site specific fixing schedule, which details the centres of the fixings, the type of fixings and the spacing of the wall ties. The wall tie systems should be tested to BS EN 845-1 and carry a CE marking.
- External skin of brick should be attached to the metal frame with either epoxy coated galvanized ties or austenitic stainless steel ties (to DD140, BS 12, BS 5268, BS 8200).
- Ties are normally fixed in vertical channels, these channels are then fixed through the sheathing board or insulation board to the light gauge steel frame with stand-off screws (screws should be isolated from the channels with neoprene or similar washers).
- The wall tie rails, ties, and fixings, should come as a 'kit' supplied by the manufacturer. Wall tie systems made up from off the shelf products will not be acceptable for Warranty.
- The wall tie system 'channels' should be fixed to ensure the fixings go into the centre line of the steel frame studs.
- If insulation is to be placed on the cavity face of the steel frame it should be rigid insulation and be compatible with the manufactures requirements of the wall tie rail system. Rigid insulation should not be taped.
- The wall tie length should be long enough to achieve the minimum overlap of the external masonry skin as specified by the manufacturer. This should not be less than 50mm.
- For steel frame external masonry walls, a 50mm minimum residual cavity is to be provided.
- Ties should be spaced at jambs of openings, a maximum of 300mm vertically within 225mm of the masonry reveal. Additional studs may be needed to achieve this.
- Ties should be inclined away from the frame.
- Ties should be fixed to the studs, not the sheathing.
- Ties should accommodate differential movement between the frame and the cladding.

Cavities

A masonry cladding to a steel frame must have a separating cavity that meets the following provisions:

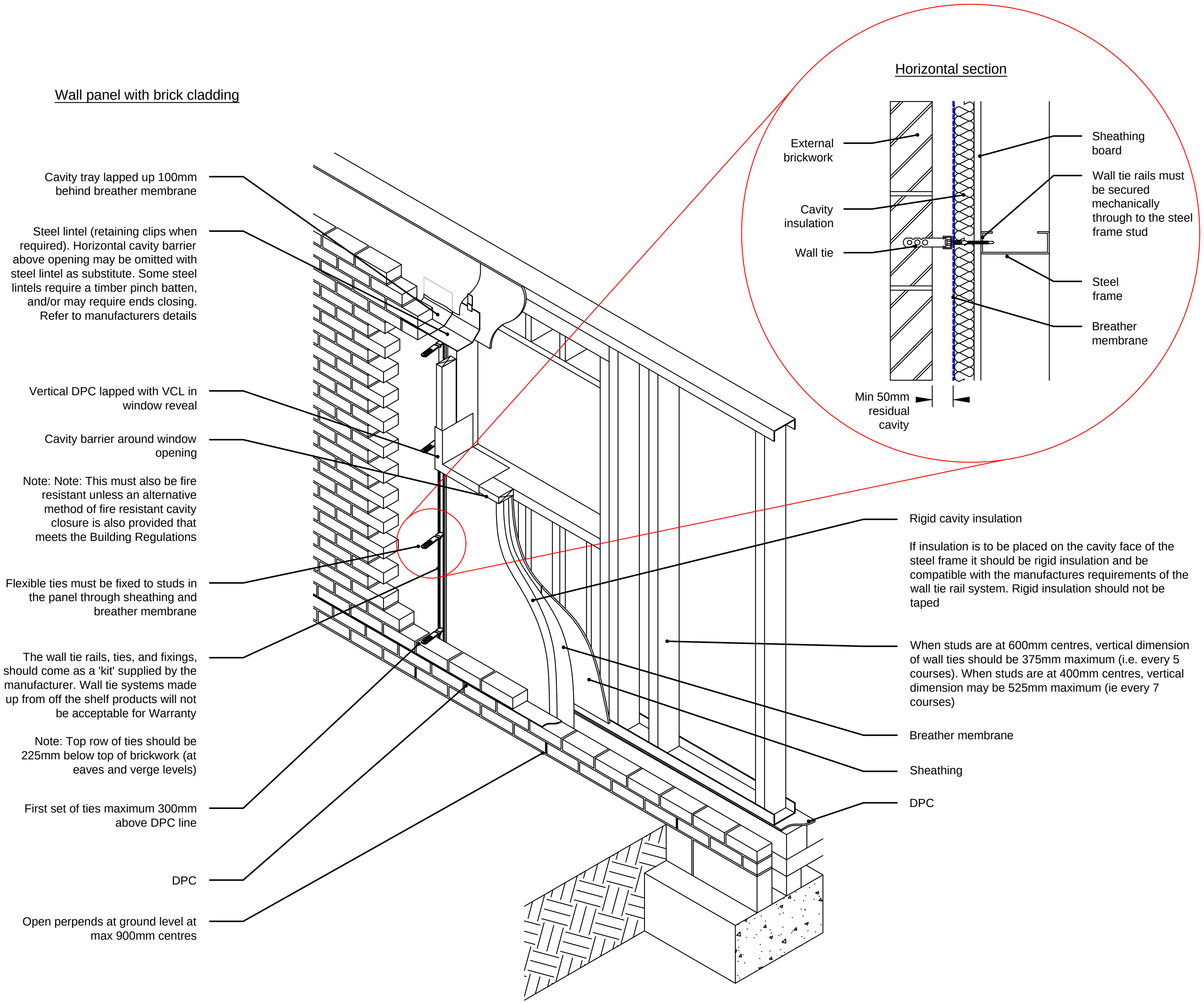
- The cavity should have a minimum width of 50mm.
- It is to be kept clear from mortar 'snots' to ensure cavity is not bridged.
- An approved wall tie system to tie the masonry leaf to the steel frame must be provided.

Brick suitability

- Facing bricks must have a suitable level of durability and particular attention should be paid to the bricks resistance to frost and moisture.
- Bricks should be capable of supporting proposed loads.
- Bricks should comply with BS EN 771 and PD6697.
- Frost resistant bricks should be used in areas of prolonged frost.

Masonry cladding

- Cavity trays must be provided above all cavity barriers, windows and door openings, etc.
- Cavity trays should extend 150mm either side of the door or window openings and have stopped-ends.
- A continuous cavity tray should be provided where intermediate floors meet the external wall.
- Soft joints should be provided to allow for differential movement. A gap of 1mm per metre of masonry should be provided at openings and soffits.
- All brick support angles should be installed by the manufacturer or specialist contractor.



Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in the table below. The first joint from a return should be no more than half the dimension indicated in the table.

Movement joints below the DPC should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm vertical centres, and 225mm horizontally, should be provided on each side of movement joints.

Compressible filler, such as polyurethane foam, should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

When sealants are used in proximity with stone it is important to select a non-oil-based sealant to help prevent any staining to the stone.

Elastic sealants (type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

Where a backing material is used, the following must be considered:

- The material is compatible with the sealant.
- It will not adhere to the sealant, preventing cracking within the sealant.
- Provides sufficient density to allow the sealant to be applied.
- Allows sufficient flexibility so not to impede lateral movement (compressible to about 50% of its original thickness), fibreboard is not acceptable.

The use of bed joint reinforcement may allow the distance between expansion joints to be increased, however this should be designed by a Structural Engineer.

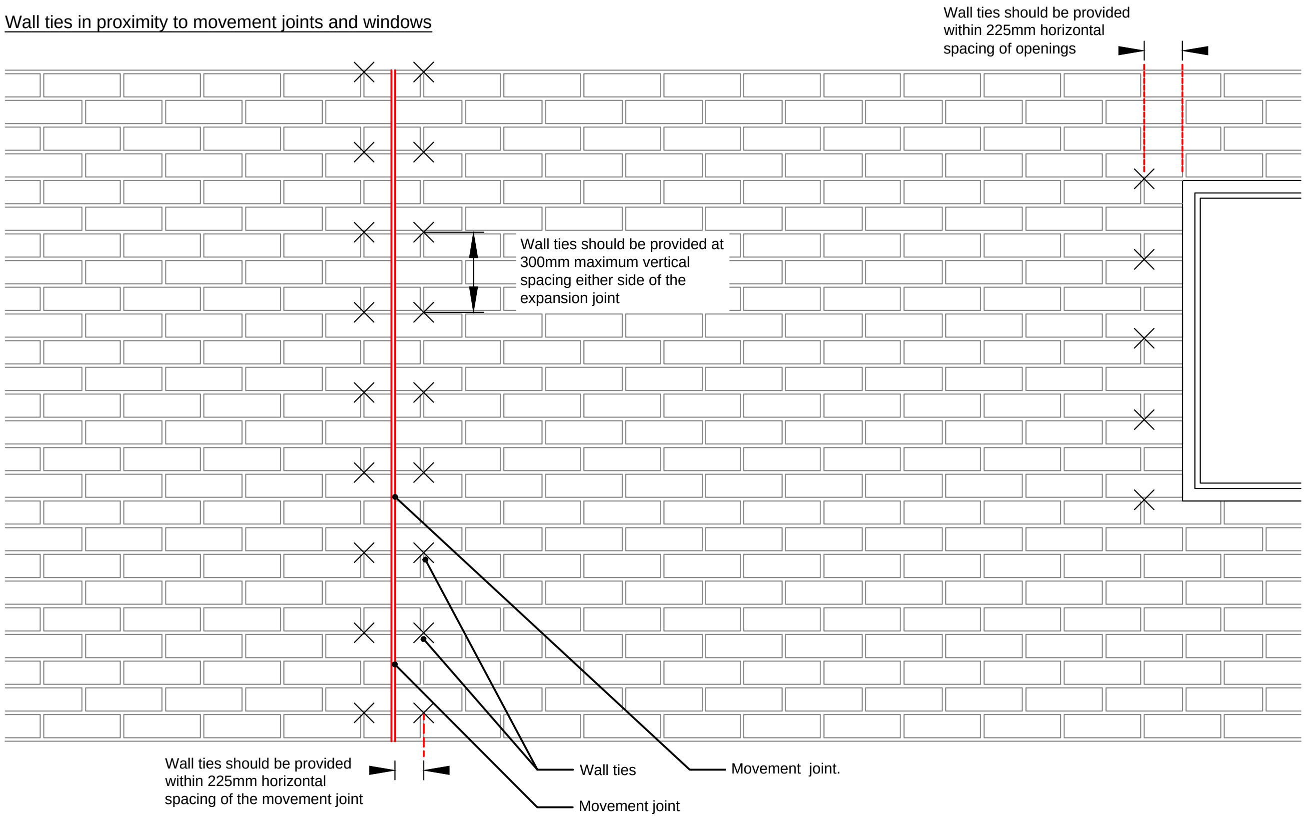
Spacing of expansion joints

Material	Normal spacing	Joint thickness
Clay brickwork	12m (spacing up to 15m may be possible if sufficient restraint is provided - consult designer)	15mm
Calcium silicate	7.5-9m	10mm
Concrete brickwork (1)	6m	10mm
Concrete blockwork (used in outer leaf)	6m	10mm

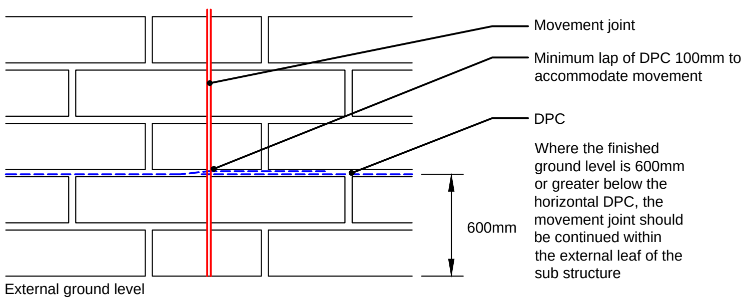
Note:
The first joint from a return should be not more than half the dimension indicated in the table.

(1) Where openings are over 1.5m, masonry bed joint reinforcement should be considered

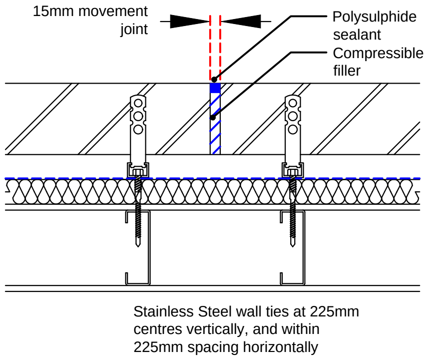
Wall ties in proximity to movement joints and windows



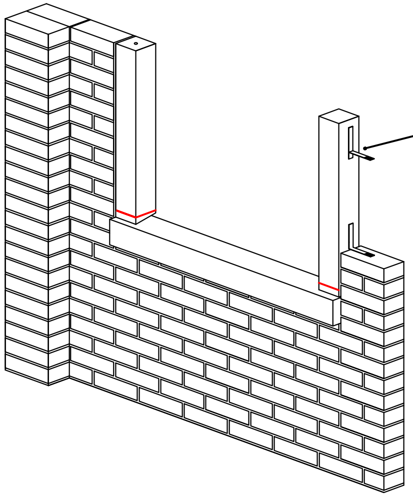
Movement joints below DPC



Typical movement joint detail



Stone jamb mullion fixing to walls

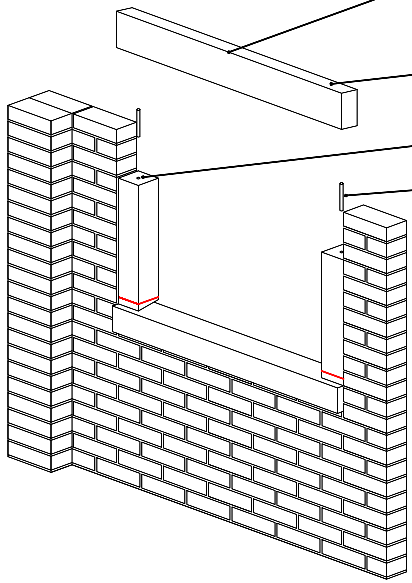


Stone jambs, mullions, and heads should not project into the cavity and insulated cavity closers should be inserted to prevent cold bridging (see typical window opening sections)

Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame-type cramps can also be used to give extra stability at jambs

Mortar:
The mortar for use with stone should comply with the relevant British Standards for sand, lime, and cement as set out in BS 5390

Joining stone jambs to sills and head



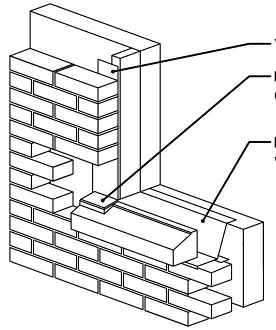
Cavity Trays

When stone heads are being used, it is advisable to double up the cavity trays - with one above the stone head to provide stop-ends and weep-holes

Cast stone jambs and mullions

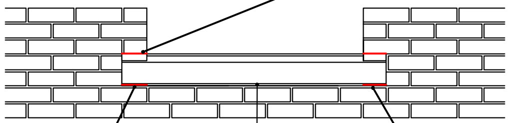
Stainless steel dowels in the sides of jambs should be bedded into adjacent mortar joints as the masonry is constructed

Stone sill with insulated cavity closer



Note: The insulated cavity closer must also be fire resistant unless an additional method of fire resisting cavity closure is also provided that meets Building Regulations.

Stone sill



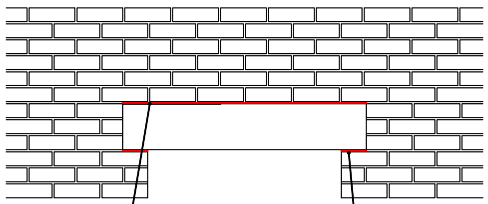
Sills

The DPC should be overlapped by the vertical DPC at the jambs and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off, and then a DPC laid over. The open section below the sill should be sealed with a flexible material only on completion of the structure.

To control water penetration through joints in window surrounds, e.g. at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

Stone head



Cast stone heads

A cavity tray must be provided above all heads as this not only discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head as well as a soft joint between the top of the head and the steel support lintel.

Cast stone heads should be manufactured in accordance with BS 1217, confirmation of this should be provided to the Warranty Surveyor upon request.

Cast stone window/door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement e.g. where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated or the cast stone should be flexibly jointed.

Claddings

More traditional claddings can include, amongst others, timber boarding, plywood and tile hanging. These types of cladding should be fixed to battens and suitably attached at stud positions. For further details, refer to the 'External Walls - Claddings' section and the manufacturer's recommendations.

Minimum cavity widths

Steel frame external wall minimum cavity widths	
Masonry	50mm
Render on unbacked lath	50mm
Render on backed lath or board	25mm
Timber	19mm
Tile hanging	25mm

Render

Render on metal lath combined with a breather membrane should also be fixed to battens attached to studs.

Rendering should be in accordance with BS EN 13914-1:2005 and workmanship in accordance with BS 8000. In particular the following should be considered:

- With traditional renders the quality of the sands used and design mix is as critical as is the reliance on good mixing techniques by the applicator.
- Poor mixing ratios and low quality materials is often the reason traditional renders fail. For the purposes of this guidance, traditional hand mix using standard sand and cement is not accepted. Only a pre-blended bagged render system will be accepted as a suitable render system that has a third party accreditation such as a BBA or ETA certification and backed up with a manufacturer's specification.

Where a specialist render system is being used the following conditions must be met:

1) The product approval is based on the details and limitations of use described in a 'current' approved ETA, BBA, BRE etc. or other UKAS certified system specific to the relevant substrate being applied too. A copy of the certificate documents are to be supplied.

2) For steel framed supporting structures, a drained cavity is required. A manufacturer's fully detailed project specific render system specification must be provided, which should include:

   - Details of a suitable third party product approved external grade render board.
   - Details of preventing water penetration to the frame and internal finishes at all junctions, openings etc.
   - Other project specific requirements including specification of fixings suitable for the environment, breather membranes, allowance for movement due to shrinkage, appropriate weather seals at movement joints, adequate protection to rendering at cills, parapets etc.
   - The installation should be completed by a competent, registered and certified installer that has been approved and accredited by the render system manufacturer before work commences.
   - Where the specification is in a high exposure zone or coastal location, then the requirements of condition 3 (below) must also be met.

   Note: Non drained cavity cladding constructions for steel frame external walls would not meet the Warranty requirements of this Technical Manual.

3) For all render installations (including brick slip system applications) on all substrates types located in an exposure zone where the wind driven rain is expected to be more than 75 litres per m²: A 10 year 'insurance backed' manufacturer's system guarantee is required, together with a full project specific specification that has also been accepted and approved by the Warranty provider. The proposal will require full system details to deal with all junctions, openings etc. together with other project specific requirements provided by the render system company. The render system will need to be installed by a registered and certified installer who has been approved and accredited by the render system manufacturer before work commences.

In all instances where a render system manufacturer's guarantee is required, full project specification and details are to be obtained from the render system manufacturer before any installation commences to ensure that conformity is met. Once work commences, the installation must be inspected and signed off by a render system representative throughout the installation stage and at completion of the installation and confirm that the specification has been met.

The render system together with the backing wall to which they are applied should satisfactorily resist the passage of moisture to the inside of the building.

Other claddings should only be used if they are provided with an acceptable third-party accreditation certificate.

General render conditions (using pre-blended bagged render)

Weather conditions

- For exposure zones where the wind driven rain is expected to be more than 75 litres per m² (classed as very severe) then checked reveals will be required. The render applied to the reveal must be of the same thickness as the wall render with an appropriate corner beading provided. A suitable non hardening' mastic sealant must also be provided between window / door frame and masonry reveal.
- Protection must be provided when applying renders in rain or other inclement weather. Application should cease in temperature below 5°C or where rapid freezing is considered to be a potential threat.
- When applying in hot weather it is advisable that work coincides with the shaded areas of the building. During longer periods of hot and dry weather it may be appropriate and necessary to apply an even mist spray of clean water to the substrate before application and to surface finish for a couple of days afterwards subject to site and weather conditions.
- Cement products should not be applied to substrates which are frost laden or which have recently been subject to prolonged rain.
- Do not render onto saturated substrates as this may affect the bond strength and cause lime bloom (discolouration), salts to occur and patchiness due to uneven suction.
- Local weather and site conditions must be taken into account by the applicator before any cement product is applied.
- Care must be taken to protect cement and synthetic products soon after the application from rapid freezing and heavy rainfall. For other drying conditions i.e. where there is direct exposure to sunlight or drying winds the render may require to be protected from the elements. This process is important to ensure complete hydration of the products can take place.
- Where an application is not covered in these conditions further advice from the render manufacturer must be sought and submit a suitable manufacturer's specification to the Warranty provider for approval.

Application

- 15mm is considered the minimum finished thickness of render applied to a masonry wall, either as a single spray coat or as a two coat hand application. Where structures are located in very severe weather rating location or within coastal locations, the depth of render may need to be increased to a minimum of 20mm and a specialist manufacturer's specification will be required to support this.
- Please note: 5-6mm is considered the minimum finished thickness of render for applications of specialist insulated render systems. The render thickness will need to be increased where structures are located in very severe weather rating locations or within coastal locations and a specialist manufacturer's specification will be required to support this and approved by the Warranty provider.
- When ashlar detailing is required, it is recommended that a minimum depth to the back of the ashlar cut should be no less than 15mm and 20 - 25mm for applications in very severe exposure zones or within coastal locations. To achieve this depth, it will require the finished thickness of the main render to be increased to accommodate this feature.
- Abutments between cement render and other cladding materials or components should be weather tight and allow for differential movement.
- Any joints in the wall where movement may occur should be continued through the rendering.
- Render should not bridge the damp proof course (DPC) and must be finished onto a durable render stop profile such as a proprietary uPVC bead or stainless steel bead.
- Renders will be reinforced as a minimum with an appropriate certified alkaline resistant fibreglass mesh at corners of all openings and penetrations. For substrates that are prone to movement, an appropriate certified alkaline resistant fibreglass mesh will need to incorporated throughout the substrate.
- Where different materials are being rendered over, the incorporation of an appropriate certified alkaline resistant fibreglass mesh will be necessary to assist with the possibilities of differential movement. The mesh must extend sufficiently over the different materials to resist against differential movement.
- Renders installed between pedestrian level and 6.0m above ground level will be designed to accommodate higher maintenance and impact loads in accordance with Table 2 of BS 8200.
- All surfaces must be clean, suitably dry and free from anything that may interfere with the adhesion of the material to be applied. The manufacturer's product data sheets should be followed including the manufacturer's surface preparation and suitability checks in full.
- All blockwork mortar joints are to be flush pointed and should be fully cured before the application of the render.
- The quantity of material required for a given area should be of the same batch number or if not the different batches must be thoroughly mixed together to avoid shade variations.
- Full masking must be used to give protection to adjacent areas of work, windows, doors etc. and to give clean straight edges. It should be removed immediately after finishing coat has dried.
- Carefully remove splashes of material, in particular from glass or aluminium immediately as they may etch the surface and leave a permanent mark.

Materials

- Ensure the render being used is suitable for the substrate and is not too strong. Due to shrinkage differentials, avoid applying a thin base coat and a thicker top coat application as the shrinkage values of a thicker top coat could cause the render to delaminate from the base coat. The same effect is also caused by applying a very hard render over a softer base coat.
- External rendering should comply as a minimum with BS.EN 13914-1:2005 but should also conform with the specialist render manufacturers recommendations.
- Rendering products should be stored separately from other building and concreting sands.
- For bellcasts, other beads, and stops: uPVC bead or stainless steel bead is acceptable.
- Only clean water should be used for mixing.

Cavity barriers

Where cavity barriers are required, they should be correctly fitted without gaps, the cavity filled and fixed with stainless steel staples or equally durable fixings, the settlement joints below the external frames and soffits must be maintained.

Render systems which include a cavity as a secondary defence system should also incorporate cavity barriers within the cavity to prevent the spread of fire. The cavity barriers should not obstruct more than 50% of the cavity and should be installed to the internal leaf to retain its ability to drain. The cavity barrier must activate and fully close the cavity when exposed to fire.

Movement joints

Where cement render spans across an intermediate floor zone in timber frame construction, allow for differential movement by incorporating a movement joint. Vertical movement joints should also be provided at maximum 5m centres.

Render boards on light gauge steel frame

A drained and vented cavity should be provided behind the render system on light gauge steel frame construction. The render board should have the capability to be directly rendered to. It should not be a wood based board or cement particle board unless confirmed by a UKAS or European equivalent third party product approval body that confirms it is acceptable for use in the conditions proposed. It should also not be a board that is not approved by the render system manufacturer.

For metal lathing, these should be a proprietary BBA, BRE etc. or ETA certified non-corrosive mesh system and must be fully installed in accordance with the mesh system manufacturer to vertical battens at the stud centres.

The minimum size of the cavity should be 19mm for both the render board or metal lathing applications. Unless proven otherwise, all applications should be used with a water-resistant membrane. When the render board or metal lathing system is unbacked, the minimum cavity should be 50mm. A DPC should be provided between unbacked render and timber battens.

When using external render board you should:

- Fix with the manufacturer's recommended non-corrosive fixings and all in accordance with the manufacturer's installation details, ensuring the vertical board joints are staggered and do not follow directly in line with window, door reveals and other openings.
- Take care to ensure there are no gaps between the boards and appropriate weather seals are incorporated against walls and frames.
- Ensure the boards are cut neat and square; follow the building lines and the screw heads are recessed just below the surface.
- Take particular note of movement joint and fire break requirements and specific application details.
- Ensure all door, window and other openings are fully sealed using an appropriate manufacturer's weatherproof system to provide a primary weather barrier and to resist to movement.

Battens should be either 25mm x 38mm or 50mm x 50mm, preservative treated (BS 8417 or equivalent, hazard class 2) and fixed at spacing's recommended in BS EN 13914-1: 2005. Fixings and preservatives should be compatible.

Battens should be fixed to each stud with annular ring nails of length at least twice the batten thickness plus the sheathing thickness. Nails should be hot dipped galvanised stainless steel or equally durable.

6.

External Walls

6.7

Claddings

Curtain walling

General

Curtain walling systems should have third-party certification confirming satisfactory assessment, and comply with the requirements of the CWCT Standard for Systemised Building Envelopes, including the following sections:

- Part 1: Scope, terminology, testing and classification.
- Part 2: Loadings, fixings and movement.
- Part 3: Air, water and wind resistance.
- Part 4: Operable components, additional elements and means of access.
- Part 5: Thermal, moisture and acoustic performance.
- Part 6: Fire performance.
- Part 7: Robustness, durability, tolerances and workmanship.
- Part 8: Testing.

The CWCT Standard provides detailed guidance on performance and testing.

Dead and live loads should be transferred safely to the building structure without undue permanent deformation or deflection of any component.

Imposed loads should be calculated in accordance with BS EN 1991. Movement should be accommodated without any reduction in performance.

Fixings and supports should be designed to accommodate specified loads and take account of the product manufacturer's recommendations.

CE marking is to be provided for all curtain walling covered by EN 13830 in buildings constructed after July 2013, and will therefore include the following curtain wall types:

- Stick construction.
- Unitised construction.
- Double skin walls.
- Structural sealant glazing.
- Bolted glazing.

The completed system should incorporate cavity barriers and firestops and resist the spread of fire in accordance with the relevant Building Regulations.

The completed curtain wall system should resist the passage of water to the inside of the building allowing free drainage, not trapping water and should have:

- External and internal air and water seals.
- Drained and ventilated glazing rebates.

Sealants should be specified in accordance with BS 6213 or BS EN 15651 and the performance determined by BS EN 11600 and the manufacturer's recommendations.

The system should be designed to minimise the risk of surface and interstitial condensation by the use of thermal breaks and a continuous vapour control layer. It should be designed to resist the passage of airborne and impact sound within the building with particular attention given to flanking transmission at:

- The edges of separating floors.
- The outer edges of separating walls.
- The outer edges of partition walls.
- The junctions with roof constructions and parapets.

Where curtain wall members run uninterrupted past floor slabs and partition walls, consideration must be given to structure-borne sound (impact sound).

The system should comply with BS 7671 requirements for electrical installations for electrical continuity and earth bonding, where it is required to form part of a lightning protection system it must be designed to comply with the requirements of BS 6651.

The risk of bimetallic corrosion should be avoided through the isolation of dissimilar metals. Fixings and finishes to curtain walling must take into account the location and corrosion category to ensure corrosion is avoided. Aluminium components must be robustly isolated from cementitious products to mitigate corrosion.

The curtain wall system should not include materials liable to infestation attack by micro-organisms, fungi, insects or vermin.

Packing of brackets to achieve surface tolerance is only permitted in accordance with the manufacturer's recommendations, and shall not exceed the maximum depth stated in the designer's calculations.

All packers for brackets supporting or restraining the curtain wall must be metal.

Testing

The curtain wall system will have either been tested and provided with a classification given in BS EN 13830, or if the curtain walling is of a custom design, it would be tested to an appropriate standard of CWCT sequence A or B testing by an independent UKAS accredited test facility to ensure that the system meets or exceeds the weather performance classification for the building taking into account the design parameters and project location.

Pull-out or destructive testing of anchors should be carried out in accordance with BS 5080 and the Construction Fixings Association Guidance Note, Procedure for Site Testing Construction Fixings.

The number of fixings to be assessed must be agreed on a project by project basis, as an understanding of the scope and size of the project would determine the number of fixings tested. In addition, if there are varying types of fixings then each type should be tested. If the fixing is the same but the structure varies, then each type of structure should be tested.

BS 5080 requires 5 tests per type, however if a very large project is proposed, this could be increased to give more assurance on installation, e.g. every floor, one per side (e.g. North / East/ South/West). The scope and number of tests must be agreed with the Warranty Surveyor at the commencement of the project, to allow sufficient time for testing to be planned in advance and made available to the Warranty Surveyor when completed.

Site testing for water penetration of the joints to windows and doors in accordance with the CWCT test methods is recommended to check the site workmanship of the building envelope as constructed. See CWCT Technical Note No. 41 for guidance on site hose testing.

Tolerances

Design should allow for the line, level, plumb and plane of the completed curtain wall to be within the acceptable tolerances of:

- Line: +/-2mm in any one storey height or structural bay width, and +/-5mm overall.
- Level: +/-2mm of horizontal in any one structural bay width, and +/-5mm overall.
- Plumb: +/-2mm of vertical in any one structural bay width, and +/-5mm overall.
- Plane: +/-2mm of the principle plane in any one storey height or structural bay width, and +/-5mm overall.

Insulated render systems

These are systems applied to the exterior walls of existing or new buildings, comprising of an insulant and a weather protective finish, of which there are three main types:

- Traditional renders and finishes.
- Thin coat renders and synthetic finishes.
- Pre-formed cladding materials.

All insulated render systems must have appropriate third-party certification and a full manufacturer's specification suitable for the substrate must be provided. Ensure all building criteria's are maintained, e.g. drained cavities should not be blocked, the use of timber supports and blocks within the insulated render system should not be used unless absolutely necessary. Ensure all fixtures and fittings which penetrate the insulation system e.g. flues, ventilation pipes, water pipes etc. are appropriately sleeved and fully sealed in accordance with the system manufacturer's recommendations.

All the render and cladding guidance/information stated in this section must be adhered to when applying an insulated render system.

The insulation type for the structure and application should be suitable for the intended purpose and, when required should be keyed to receive the desired base coat and reinforcement. The insulated render system should be designed to minimise the risk of interstitial condensation and the effects of thermal bridging. A condensation risk analysis should be carried out in accordance with BS 5250 to ensure the building fabric meets the required performance standard. If a vapour control layer is required then this must be installed to the warm side of the insulation and the type must be approved and suitable for the application.

In accordance with the render system manufacturer's recommendations appropriate trims should be provided at openings, corners, angles and interfaces etc. Reinforcement mesh should be accommodated throughout the base coat application with additional reinforcement to vulnerable areas and corners of openings etc. If there are any concerns regarding straight line joints or other areas where there are unusual constructions requirements an additional layer of mesh should be installed to these locations.

The dead and live loads should be transferred safely to the buildings structure without deformation or deflection of any component. Ensure the insulation continues around openings and other penetrations to maintain the thermal benefits.

Movement within the insulated render system should be accommodated without any reduction in performance.

Movement joints in the backing substrate should be accommodated through and by the insulated render system and formed in accordance with the manufacturer's recommendations.

When required an approved proprietary fixing should be used in accordance with the design requirements calculated. This generally consists of a minimum of 5 fixings per full insulation board / 8/m² elsewhere with additional fixings to corners and reveals. A pull out test report confirming fixing type and length will be required in accordance with the Construction Fixings Association and made available to the Warranty Provider.

Proprietary preparation works

- Ensure all fixings, cables, fence posts, light fitting, satellite dishes and other ancillary fittings and fixtures are temporarily removed to enable the easy application of the insulated render system.
- Remove existing and provide temporary downpipes, avoid allowing the temporary downpipes to spill water over the render system.
- If required reset all drainage gulley's to accommodate the insulation system thickness.
- If required ensure that any gap around the window and door frames is correctly sealed against rain penetration before application of the insulated render system.

Where an insulated render system is used as a cladding to a timber or light gauged steel framed structure a drainage cavity will be required. A suitable breather membrane must also be provided to protect the sheathing board and framing system from water penetration reaching the internal finishes.

Timber cladding

Timber and boards for exterior use should be of a durable species, with sapwood excluded, or preservative treated by pressure impregnation using preservatives suitable for use in hazard Class 3 in compliance with BS 8417:2003, or equivalent. Further guidance on the durability of timber is provided in 'Appendix C - Materials, Products, and Building Systems'.

Where timber boarding or plywood spans across an intermediate floor zone in a timber frame construction, allow for differential movement caused through timber shrinkage by incorporating a movement joint.

Where cavity barriers are required, they should be correctly fitted without gaps, fill the cavity and be fixed with stainless steel staples or equally durable fixings.

Abutments between cladding and other weather-resisting elements should be neatly made, weather tight and allow for differential movement. Workmanship should comply with BS 8000:5.

Timber boarding

Timber boarding should be at least 16mm thick, and allowance for moisture movement in boarding should be achieved by making tongues, joints or overlaps at least 10% of the board width.

Timber boarding should be battened off the supporting background to provide a minimum 19mm cavity for draining and venting board.

Battens should be a minimum of 38mm wide, preservative treated and at maximum 600mm centres. A breather membrane should always be installed. Battens on timber frame should be fixed to each stud (and not to the sheathing) with annular ring nails of length at least twice the batten thickness plus the sheathing thickness (or plain shank nails of length 2.5 times the batten thickness plus the sheathing thickness).

Boards should be fixed to battens by face or secret nailing with annular ring nails at least twice the board thickness or plain shank nails at least 2.5 times the board thickness.

Butt joints at board ends should occur at battens. Nails should be either hot dipped galvanised, stainless steel or equally durable. Aluminium nails should not be used with timber treated with a preservative containing copper. Galvanised nails should not be used with Western Red Cedar.

Rainscreen cladding systems

A rainscreen cladding system consists of a multi-layer construction of materials which is designed to provide a barrier to the weather on new or existing buildings. The typical build-up would consist of a supporting airtight and water tight backing wall and rainscreen system.

The rainscreen should comprise of supporting brackets fixed to the backing wall, insulation between the brackets, a breather membrane, carrier support rails fixed to the brackets, a ventilated and drained cavity and the rainscreen panels.

Rainscreen systems should have third-party certification confirming satisfactory assessment and comply with the requirements of the CWCT Standard for Systemised Building Envelopes. The collation of individual testing of components does not provide an overall performance of the rainscreen system or backing wall.

Dead and live loads should be transferred safely to the building structure without undue permanent deformation or deflection of any component. Imposed loads should be calculated in accordance with BS EN 1991 and movement should be accommodated without any reduction in performance. Fixings and supports should be designed to accommodate specified loads and take account of the product manufacturer's recommendations.

Rainscreen panels are generally lightweight and vulnerable to impact damage. The rainscreen must be able to resist impacts without causing safety hazards. Testing and classification to CWCT Technical Note 75 and 76 may be required to demonstrate the rainscreen's material impact performance.

Design should allow for the line, level, plumb and plane of the completed rainscreen cladding to be within the acceptable tolerances of:

- Line: +/-2mm in any one storey height or structural bay width, and +/-5mm overall.
- Level: +/-2mm of horizontal in any one structural bay width, and +/-5mm overall.
- Plumb: +/-2mm of vertical in any one structural bay width, and +/-5mm overall.
- Plane: +/-2mm of the principle plane in any one storey height or structural bay width, and +/-5mm overall.

Cavity barriers within a ventilated rainscreen system must be appropriately selected, suitable for use and be aligned with the compartment wall and floor. The cavity behind a rainscreen is deemed to be a moist zone and materials selected must not corrode, deteriorate or affect the performance of the cavity barrier during its design life. The minimum design width of the cavity wall will be determined by the panel joint type, i.e. whether it is sealed, closed, labyrinth, baffled or open. Horizontal cavity barriers must allow for drainage and ventilation in the rainscreen cavity and a gap of 50% of the cavity width must be retained in front of the open state cavity barrier.

Rainscreen systems and their materials must comply with the Building Regulations Approved Document B.

Vertical tiling and slating

Vertical slating with fibre cement slates

Fibre cement slates can be fixed to vertical surfaces and provides an attractive and weatherproof cladding on both timber frame and masonry constructions.

The following guidance notes apply to this detail:

- Use counter battens over masonry construction (38mm x 25mm minimum) to reduce direct fixing. Special masonry fixings may be required.
- Slate-and-a-half should be used in alternate courses at internal and external corners and adjacent to openings.
- Use Code 3 lead soakers to weather internal and external corners.
- Fix slates by two nails and one rivet, and slate-and-a-half by three nails and two rivets.
- Code 4 lead cover flashings should be used above and below openings, in accordance with Lead Sheet Association recommendations.

Vertical tiling with plain tiles

Plain tiling is an excellent, weather proof and attractive cladding to the vertical walls of any building.

Feature and ornamental tiles may also be used with normal plain tiles to create decorative patterns. Fibre cement slates can also be used for vertical cladding.

- Use counter battens over masonry construction (38mm x 25mm minimum) to reduce direct fixing. Special masonry fixings may be required.
- Ensure tiling details do not interfere with the opening of windows and doors.
- Lead flashings and soakers should be used around openings, in accordance with Lead Sheet Association details.
- Use double course of tiles at eaves, by laying first course of eaves/tops tiles with course of full tiles laid over.
- At the top of a wall or under a sill, use a course of eaves/tops tile laid over a course of full tiles. Dress a Code 4 lead cover flashing over by 100mm.
- Use internal and external angle tiles at all 90° corners. Purpose-made 135° angle tiles are also available. For other angles, close mitre tiles and use Code 3 lead soakers.
- All tiles should be twice nailed.

Further guidance on tiles and slates can be found in the 'Roofs' section.

7. Internal Walls

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part sections as follows:

Workmanship

1. Fire stopping and cavity barriers are to be completed by a third-party approved contractor for all flats and apartments with a floor 4.5m above ground level.

Materials

1. Fire stopping and cavity barrier materials are to have relevant third-party certification confirming suitability in its application.

Design

1. Internal walls (including separating walls) shall be designed and constructed so that they:
   a. Are structurally sound;
   b. Have adequate resistance to the effects of fire and surface spread of flame, in accordance with relevant regional Building Regulations.
   c. Are durable and resistant to moisture;
   d. Provide suitable surfaces to receive a range of finishes.
2. Separating walls shall be designed and constructed so that they:
   a. Have adequate resistance to the spread of fire between buildings;
   b. Have adequate resistance to the passage of sound between buildings to meet the relevant requirements of the Building Regulations.
3. Separating walls between the dwelling area and garage within a Housing Unit shall be designed and constructed so that they:
   a. Have adequate resistance to the spread of fire between garage, and dwelling area;
   b. Have an adequate thermal performance.
4. Internal surfaces that will be subjected to water from the use of a showerhead over a bath should be tiled or have an appropriate alternative water-resistant finish.
5. Layouts indicating the positions of compartment walls/floors and other lines of fire resistance must be provided for all flats and apartments with a floor 4.5m above ground level and must demonstrate compliance with regional Building Regulations.

Limitations of Functional Requirements

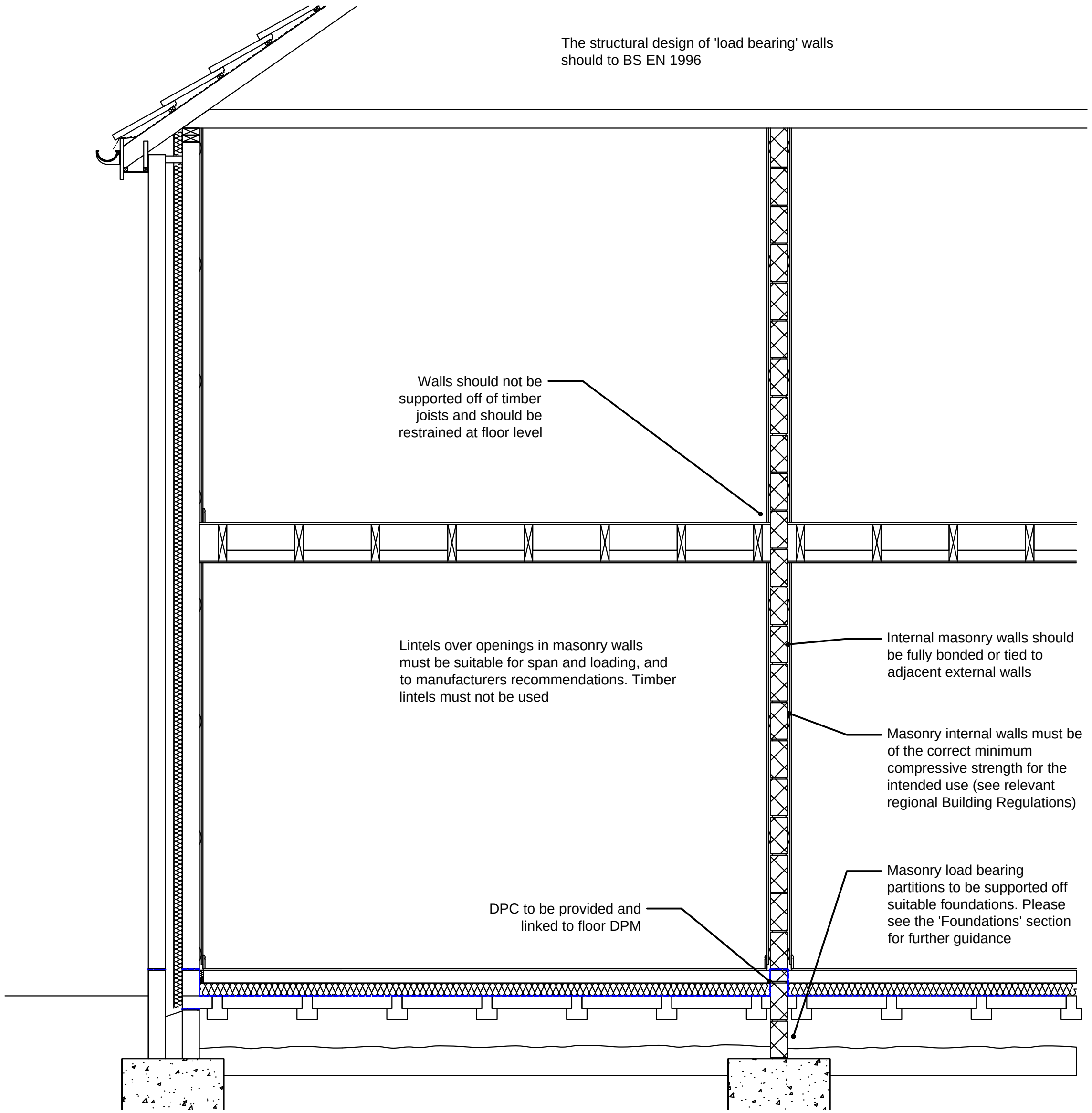
1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

7.

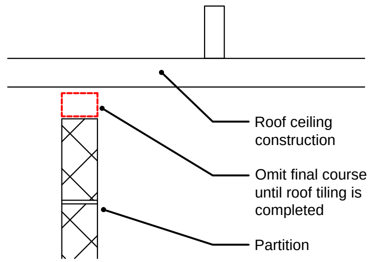
Internal Walls

7.1

Masonry



Internal non-loadbearing walls



It is advisable to erect non-load bearing walls after the roof tiling has been completed thus allowing deflection to take place under dead load, thereby reducing the risk of cracking appearing in the ceiling finishes. If partitions are of brick or block, then alternatively the final course can be omitted until roof tiling has been completed.

Damp proof course (DPC) and damp proof membrane (DPM)

Where an internal wall is built off a foundations continuity of the DPM must be achieved.

The internal wall should have a DPC, which is at least the width of the internal wall and linked with the DPM by a minimum of 100mm.

Note:

1. Internal partitions should not be supported by compressible layers forming part of a floating floor unless suitable for that purpose.
2. Internal partitions between bedrooms or rooms containing WC's and other rooms, must achieve adequate sound resistance.
3. Internal masonry partitions should have a minimum density of 600kg/m^3 and finished both sides with 13mm of plaster.

Additional requirements may apply for Building Regulations compliance. Please refer to the relevant regional Building Regulations.

Internal masonry walls

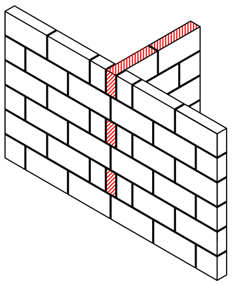
Foundations
Below ground, load-bearing walls must be supported using a suitable foundation. Where the upper floors are supported by a suitable beam or lintel, the load should be adequately transferable to the foundations. All structural masonry walls should be provided with foundations.

Compressive strength
The varying strengths of bricks and blocks mean that they have to be chosen in accordance with the proposed use of the building. The recommended strengths of bricks and blocks to be used in buildings up to three storeys high are found in 'Appendix C - Materials, Products, and Building Systems' and the relevant regional Building Regulations.

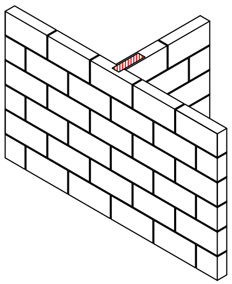
Lateral restraint
Lateral restraint is to be provided for load-bearing walls and separating walls at each floor level and the ceiling level below a roof.

Bonding and tying
Where a separating wall abuts an external wall, they may be tied or bonded together. Tied joints should be formed using expanded metal strip, wall ties or equivalent fixings, at maximum 300mm vertical centres.

Block bonding internal masonry walls to inner leaf



Block bonding internal walls to inner leaf using ties



The external wall cavity needs to be closed at the junction with the separating wall with a flexible cavity stop, but not if the cavity is fully filled with built-in insulation (where permitted).

Beams and lintels

Beams and lintels shall be satisfactory for their purpose.

Items to be taken into account include:

- Loads and spans are in accordance with the manufacturer's recommendations.
- Wall and cavity thicknesses.
- Bearing capacity of the masonry supporting the lintel or beam.

Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used on a project in a coastal location, please follow the requirements for additional corrosion protection 'Appendix B - Coastal Locations'.

Materials

Concrete or steel lintels are appropriate for use in masonry walls; support for masonry should not be provided by timber lintels.

Concrete lintels should extend beyond each end of openings in masonry as follows:

Minimum bearing lengths of lintels

Span (m)	Minimum length of bearing (mm)
Up to 1.2	100
Over 1.2	150

Steel lintels should comply with the manufacturers installation guidance.

Where structurally necessary, provide padstones under the bearings of lintels and beams.

Non-load bearing partitions shall have acceptable strength and be adequately supported.

Method of supporting partitions

Masonry partitions should be supported on one of the following:

- A suitable foundation.
- Other masonry partitions or walls (wherever conceivable, the design of buildings should be such that the first floor masonry partitions are an extension of those on the ground floor).
- Structural concrete floors.
- Steel or concrete beams.

It may be necessary to use padstones at bearings where steel or concrete beams are to be used.

Masonry partitions should not be supported by timber joists or beams.

Allowance for the probable deflection of floors at the head of partitions is required to prevent the partition becoming load-bearing. Allowance should be given in the design for the relatively flexible nature of the timber and the rigid nature of masonry.

Walls and partitions that are supported off structural floors, should not be built directly off a compressible layer forming part of a floating floor system.

Sound insulation

Internal walls shall, where necessary, have adequate resistance to the transmission of sound.

All separating walls in England and Wales may be built in accordance with Robust Details and meet the requirements for Resistance to the passage of sound in the relevant Regional Building Regulations. Compliance with the relevant Building Regulations can be demonstrated by either:

Pre-completion testing

Pre-completion testing (PCT) is required in the following situations:

- To all new build properties (including rooms for residential purposes), other than when the Developer has registered and built in accordance with Robust Details.
- Where the sound insulation construction is in accordance with the guidance given in the relevant regional Building Regulations for resistance to the passage of sound.
- Where the building is not built in accordance with the relevant regional Building Regulations.
- The requirements of the Robust Details system have not been met.

or

Robust details

The use of robust details as a means of providing adequate sound insulation applies only to party walls and floors between different dwellings or flats. It is approved by Robust Details Ltd.

The robust design details are available in a handbook, which can be purchased from:

Robust Details Ltd, Unit 14, Shenley Pavilions, Chalkdell Drive, Shenley Wood, Milton Keynes, MK5 6LB
Tel 0870 240 8210

www.robustdetails.com

Robust Details Ltd may undertake monitoring to check on the performance achieved in practice.

Wall ties for cavity separating walls

To provide structural stability, the two leaves of a masonry cavity separating wall should normally be tied together.

Sound transmission across the cavity should be limited by the type of tie and spacing.

Ties should be specified in accordance with the System Designer's recommendations for separating walls. The type of tie and spacing should limit sound transmission across the cavity.

To limit sound transmission, metal tie straps should be:

- No more than 3mm thick.
- Fixed below ceiling level.
- Spaced at least 1.2m apart horizontally.

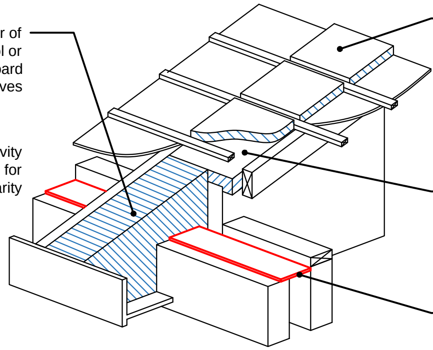
Thicker ties, fixed at ceiling level or more closely spaced, will increase sound transmission through the cavity.

Chases in party walls

Chases in masonry walls for service pipes and cables should be avoided. Where unavoidable, chases should:

- only be made in solid masonry (not hollow blocks).
- a horizontal chase must not exceed 1/6 the thickness of the single leaf.
- a vertical chase must not exceed 1/3 the thickness of the wall.
- Electric sockets should be staggered either side of a party wall.

Fire stopping at roof level between party walls



Fire stopping should be provided in accordance with the relevant regional Building Regulations.

- Party/separating walls should be finished 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.

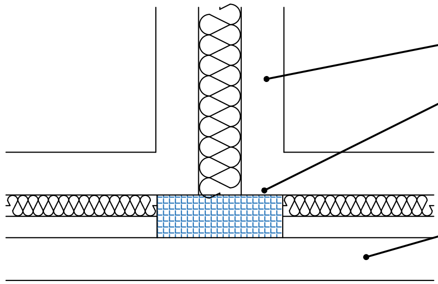
Fire resistance

Typically, in buildings, a half-hour or one-hour fire-resistance from both sides is required to satisfy the relevant regional Building Regulations with regard to fire separation between buildings and/or compartments within buildings.

Compartment walls that are common to two or more buildings should run the full height of the building in a continuous vertical plane and should be continued through the roof space.

Where a compartment wall meets another external wall or floor junction fire resistance should be maintained.

Fire stopping within the cavity on the party wall line



Minimum masonry thickness to achieve fire resistance

Material	½ hour FR	1 hour FR
Brick	90mm thickness	90mm thickness
Block	90mm thickness	90mm thickness

All internal, separating and compartment walls should have the fire resistance required by the relevant regional Building Regulations.

Penetrations in fire resisting masonry construction must be designed to meet the requirements of the Building Regulations.

Fire stopping in apartments and flats with a floor over 4.5m will have additional requirements. Please see 'Internal Walls - General Requirements - Cavity Barrier and Fire Stopping' for further guidance.

Single party wall spandrel panels on masonry walls in a cold roof space

Spandrel panel construction

Spandrel panels are generally a softwood structural frame with head and soleplates with vertical studs at 600 centres. The typical section sizes are 47mm x 72mm where joints are plated and 38mm x 89mm where joints are nailed. The designer should provide supporting calculations for the design of the spandrel panel upon request.

Fire resistance

Fire resistance should be provided on a site-by-site basis; however generally for party walls a minimum of 60 minutes' fire resistance from both sides is required. Plasterboard should be fixed at a minimum of 300 centres with plasterboard screws, the screws should penetrate a minimum of 25mm into the timber studs, and joints of the plasterboard should be over timber studs or noggins and staggered.

In the case of a fire the party wall the spandrel panels should be designed to remain in place should one side of the roof structure be burnt away, as a result party wall spandrel panels should be restrained from both sides.

Party wall spandrel panels for ease of handling may consist of a number of panels, it is important that these panels are suitably jointed as not to impair the required fire resistance of the panel. Fire stopping should also be provided above the panel between the roofing membrane and in between the battens, the fire stopping should continue into the boxed soffits.

General considerations

Below are some general considerations for party wall spandrel panels:

- Fire resistance should be provided on a site-by-site basis; however generally for party walls a minimum of 60 minutes, should be achieved.
- Plasterboard should be fixed at a minimum of 300 centres with plasterboard screws, the screws should penetrate a minimum of 25mm into the timber studs, joints of the plasterboard should be over timber studs or noggins and staggered.
- Spandrel panels should provide suitable sound resistance. In a cold roof where masonry party walls are used in conjunction with a single piece panel, the masonry walls should extend a minimum of 300mm above the ceiling line and incorporate suitable fire stopping to close the cavity. Party walls should be constructed in accordance with robust details or sound tested.
- Party wall spandrel panels should be fixed to the head of the wall this can be achieved with the use of vertical restraint straps at centres specified by the designer. These are typically placed at a minimum of 1200mm centres and face fixed to coincide with stud positions. The strap length should ensure a minimum of two fixings into the panel framework and three fixings into the blockwork, into a minimum of 2 blocks (See figure 5).
- The panel should also be restrained at roof level this should be on both sides of the panel and should be in accordance with the design typically at 2m centres. Common methods of achieving this are; fixing a timber ledger to the face of the spandrel panel to at least 2 vertical studs and fixing a timber to the top of the timber ledger, which extends back over a minimum of three trusses at 2m centres. Or using restraint straps at 2m centres (this may commonly need to be increased to 1.8m centres to coincide with the vertical studs) fixed to vertical studs within the panel and extending back over three trusses, these straps should be supported by noggins in between the truss (see figure 1 and 2). The restraint should not impair the fire resistance of the panel.
- As with a masonry cavity, fire stopping should be provided at the head of the spandrel panel and be continuous into the soffit area (see figure 3).

Acoustic requirements

Spandrel panels should meet the regional Building Regulations. If robust details are being used it is important that the construction of the party wall is in conjunction with the robust details.

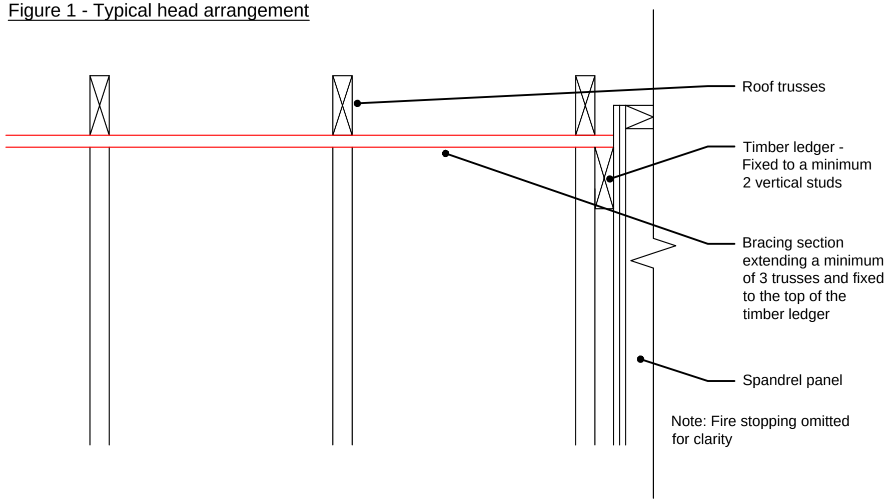
Weather protection

Any impervious weather protection should be removed sufficiently to allow the panels to breathe.

Fire stopping

Fire stopping is required between the top of the spandrel panel and the roof covering and in the batten space. It is important that the fire stopping is extended into any boxed eaves. Where the spandrel panel is sat on a masonry wall fire stopping is required between the panel and the wall.

Figure 1 - Typical head arrangement



Head restraint may be achieved through timber bracing. Requirements for the spandrel panel head restraint are as follows:

- Lateral bracing at a maximum 2m centres.
- Minimum bracing section 25mm x 100mm, fixed using 2 x 3.35 x 65mm galvanised wire nails to top edge of the timber ledger.
- Timber ledger minimum section 45mm x 72mm and minimum length 900mm.
- Timber ledger screw-fixed with minimum 100mm-long screws to at least two vertical studs within the panel.
- Lateral bracing should be fixed to a minimum of three trusses. (Note: 3.1mm machine nails may be used in lieu of 3.35mm standard wire nails).

Figure 2 - Alternate head arrangement

Head restraint may be achieved through metal restraint straps. Requirements for the spandrel panel head restraint are as follows:

- Lateral bracing to be fitted at apex and along rafters and ceiling joists maximum two-metre centres (no more than 1.25m centres for dwellings over three storeys or over two storeys in Scotland).
- Minimum 38mm x 63mm noggings fixed between at least three trusses.
- Metal restraint strap fixed to noggings with eight 3.75mm x 30mm square twisted nails evenly spaced.
- End of metal restraint strap to be screw-fixed to studwork within spandrel with minimum 50mm-long screws.

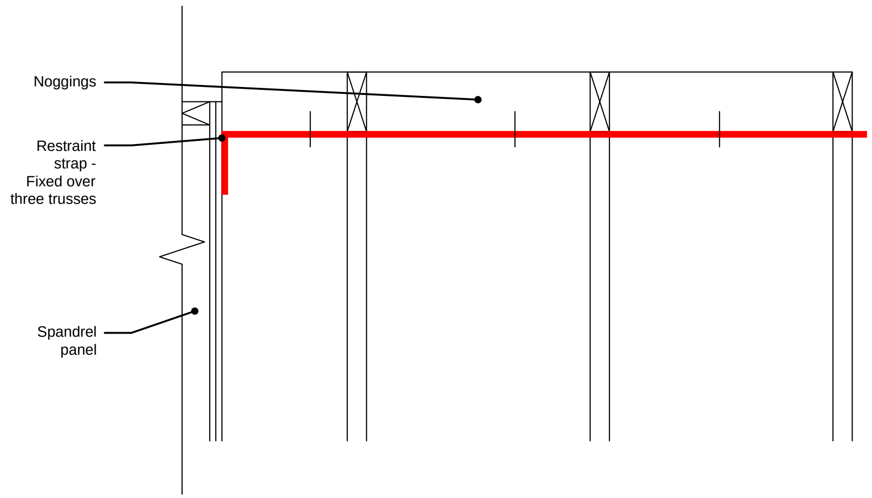
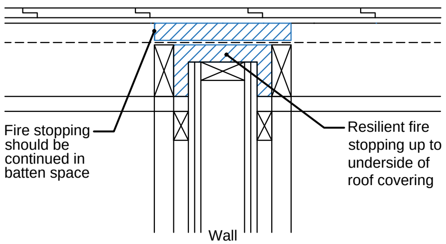
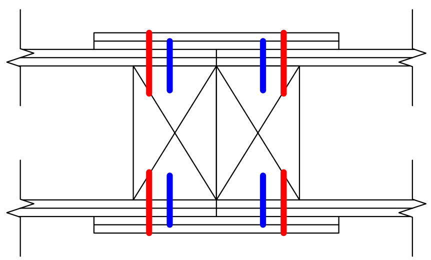


Figure 3 - Fire stopping at the head of the panel



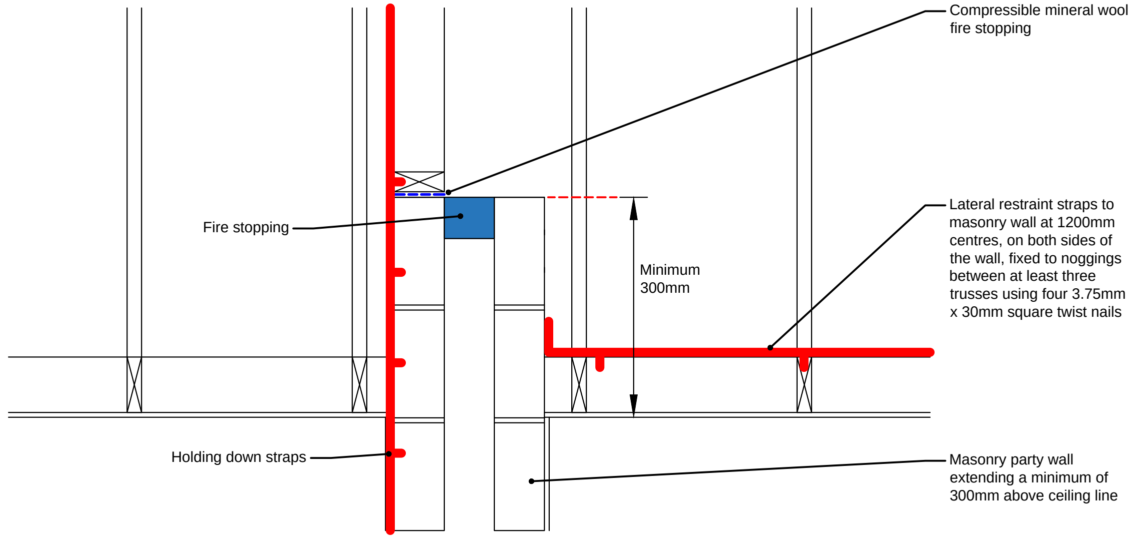
- Spandrel head at a minimum of 50mm below the truss head.
- Mineral wool quilt placed below the underlay felt as a fire stop. Fire stopping should continue into boxed eaves.
- Mineral wool quilt placed above underlay felt and laid between battens from eaves to ridge.

Figure 4 - Panel connections



- Joints should be backed by timber
- Where panels are butt jointed cover strip should be fitted. The correct lapping must be to the manufactures requirements to achieve adequate fire resistance, generally the cover strip should be a minimum of 150mm wide.
- The cover strips should provide the same fire resistance as the rest of the wall.
- Each cover strip should be independently fixed and the joints of the cover strip should be staggered.
- Fixings should penetrate the timber by a minimum of 25mm.

Figure 5 - Foot detail of a single panel party wall spandrel panel on a masonry wall



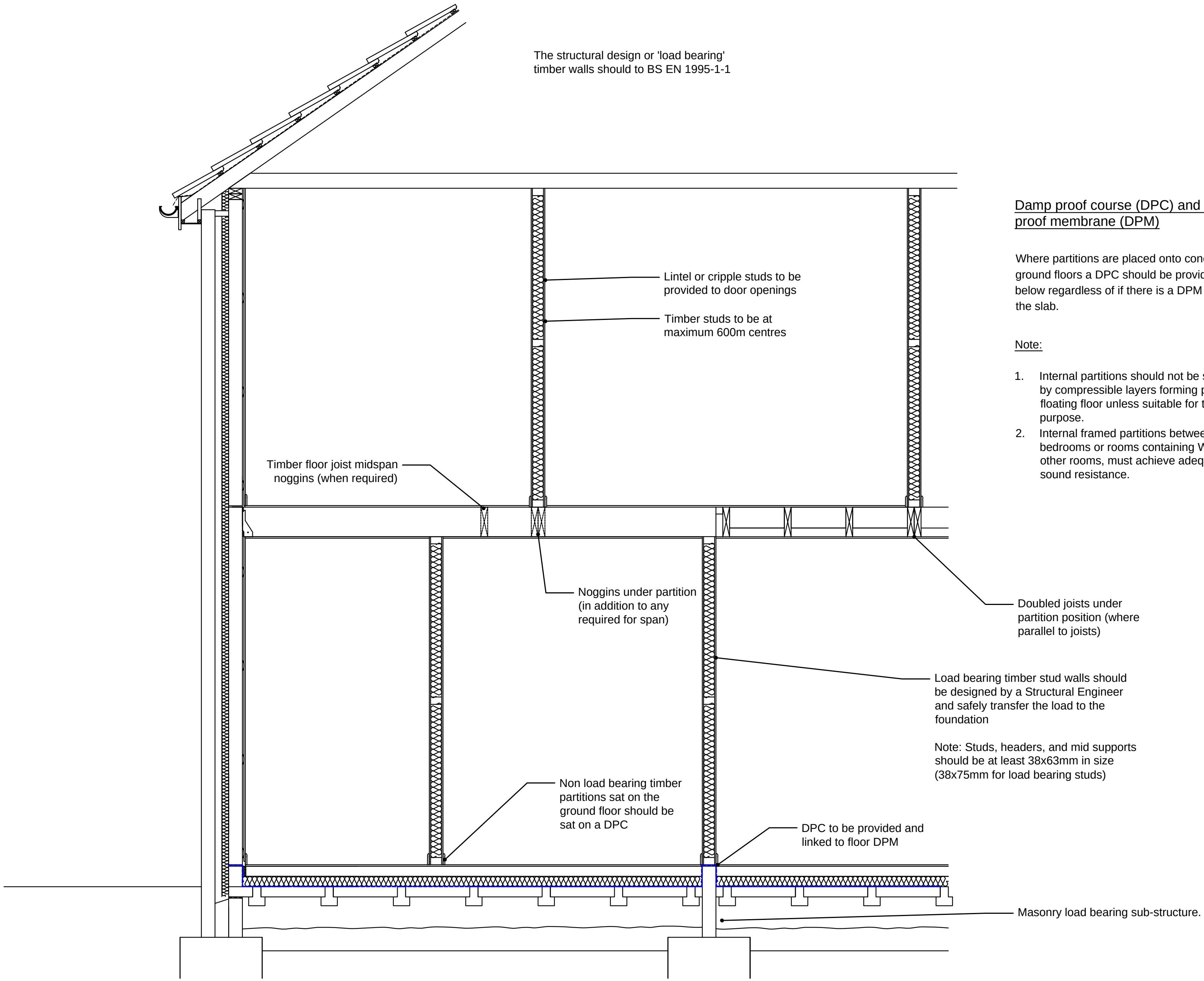
- The masonry should extend a minimum of 300mm above the ceiling line.
- The blockwork should provide continuous support for the panel.
- The masonry cavity should be fire stopped.
- The bottom edge of the panel should be sealed with a compressible rock fibre quilt.
- Holding down straps should be provided to the spandrel panel at a minimum of 1200mm centres and face fixed to coincide with stud positions.
- The holding down strap length should ensure a minimum of two fixings into the panel framework and three fixings into the blockwork into a minimum of 2 blocks.
- Restraint should be provided to the top of the masonry party wall using lateral restraint straps at 1200mm centres, on both sides of the wall, fixed to noggings between at least three trusses using a minimum of four 3.75mm x 30mm square twist nails. The straps should be fixed to wall with a minimum of three fixings.

7.

Internal Walls

7.2

Timber Stud



Damp proof course (DPC) and damp proof membrane (DPM)

Where partitions are placed onto concrete ground floors a DPC should be provided directly below regardless of if there is a DPM beneath the slab.

Note:

1. Internal partitions should not be supported by compressible layers forming part of a floating floor unless suitable for that purpose.
2. Internal framed partitions between bedrooms or rooms containing WC's and other rooms, must achieve adequate sound resistance.

Load-bearing timber walls and partitions

Load-bearing timber internal walls are to be designed to provide support and transfer loads to foundations safely and without undue movement.

The structural design of load-bearing timber walls should be in accordance with BS EN 1995-1-1.

Structural timber should be specified according to the strength classes, e.g. C16 or C24.

Load-bearing partitions should be designed by a Structural Engineer.

Structural elements

Typically, individual studs, sills and head plates are to be 38mm x 75mm. Larger timber section sizes are required to achieve satisfactory levels of fire resistance. Studs should be spaced at maximum 600mm centres.

Lintels and studs

A lintel and cripple studs are to be provided to any opening other than where the stud spacing is not affected. Traditionally, multiple studs will be used to support multiple joists.

Where internal walls are made-up of panels, structural continuity is to be maintained, for example through the use of a continuous top binder.

Framing joints need to be secured with a minimum of two nails per joint.

Beams and lintels

Beams and lintels shall be satisfactory for their purpose.

Items to be taken into account include:

- Loads and spans are in accordance with the manufacturer's recommendations.
- Wall thicknesses.
- Bearing capacity of the wall construction supporting the lintel or beam.

Partition construction

The following partition constructions are satisfactory:

- Timber stud partitions using studs, sills and head plates nominally 63mm x 38mm. Studs should be spaced to suit the thickness of plasterboard used, as follows:
  - Maximum 450mm spacing for 9.5mm boards.
  - Maximum 600mm spacing for 12.5mm-20mm boards.

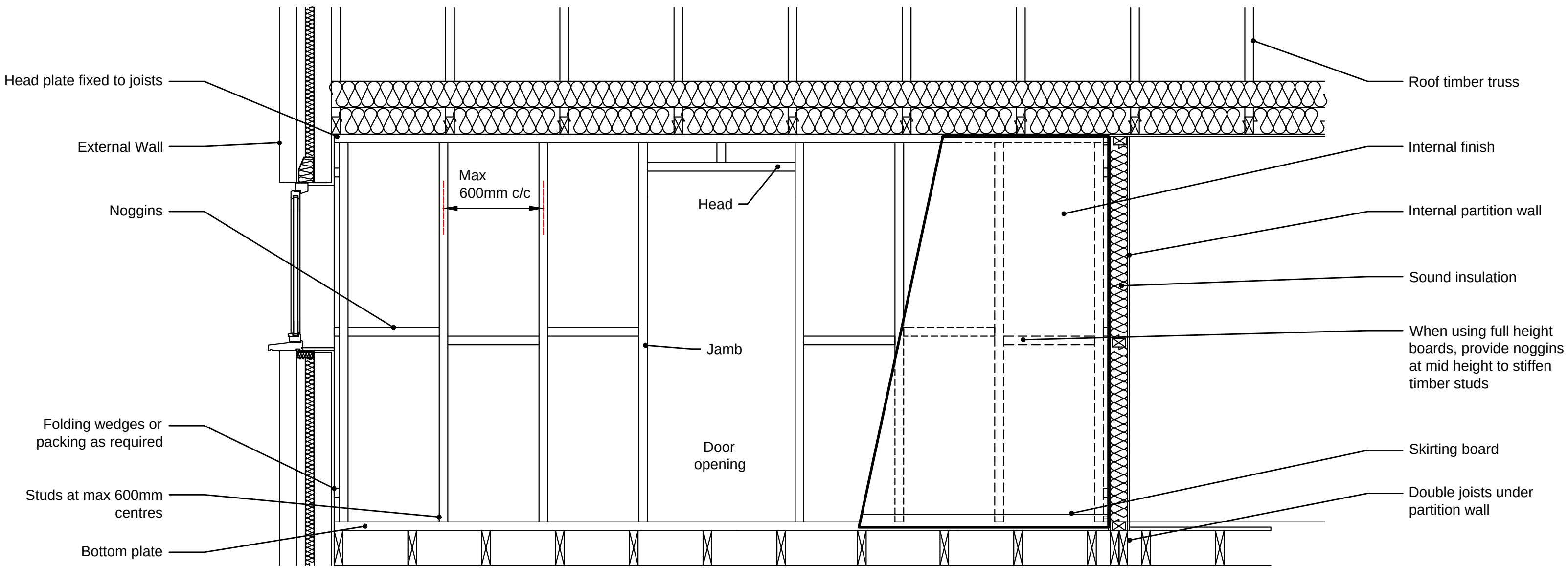
Non load-bearing timber partitions

Partitions should be robust and form a smooth, stable, plane surface to receive decoration:

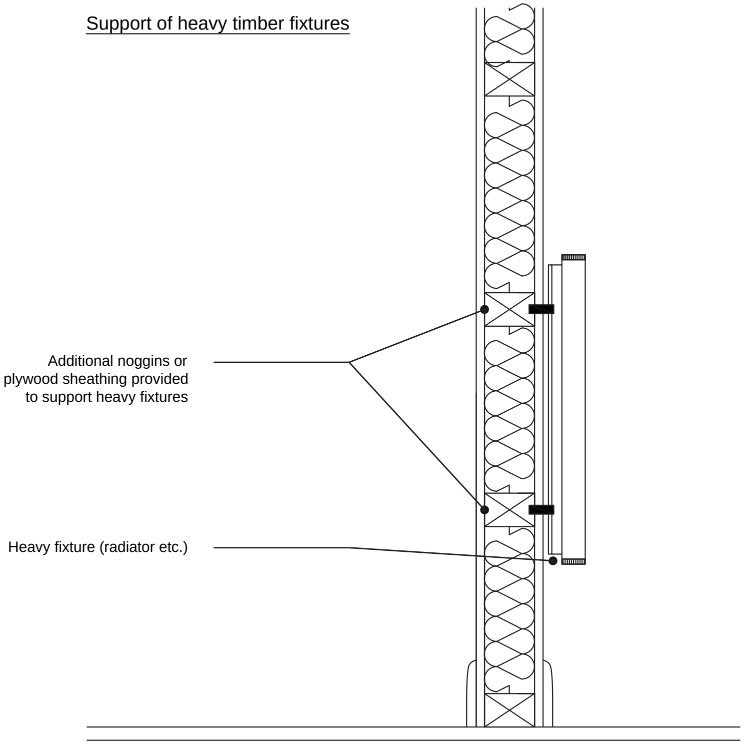
- Supporting members should be accurately spaced, aligned and levelled.
- The tolerance of horizontal straightness of a partition should be +/-10mm over a 5m length.
- The deviation in vertical alignment of a partition in any storey height should be +/-10mm.
- Timbers supporting plasterboard should be regularised and have a moisture content not greater than 20% at the time of erection (lower moisture contents can reduce incidents of nail popping and other effects of shrinkage).

Stud partitions should be no less than 38mm wide and no less than 63mm thick (up to a maximum partition height of 2.4m), and 89mm thick up to a maximum partition height of 3m. However, in order to accommodate tolerances for plasterboard fixing, a minimum width of 44mm is recommended.

Timber stud partitions

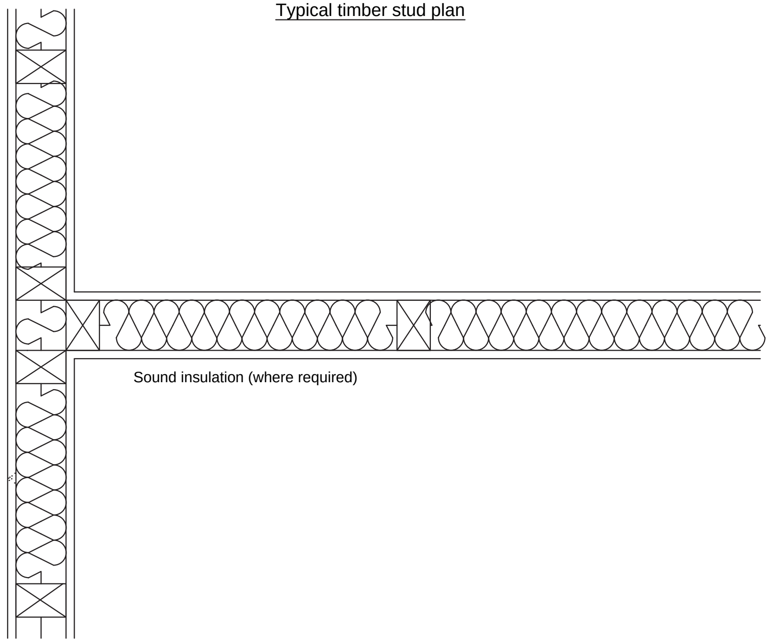


Support of heavy timber fixtures



Where partitions are to support heavy items such as radiators or kitchen cupboards, additional noggins should be provided within the stud partition to accommodate fixings.

Typical timber stud plan



Method of supporting partitions

Walls and partitions are to be supported by the structural floor, only if the material is specifically manufactured for that purpose; it is not to be supported by a floating floor that incorporates a compressible layer.

Extra noggins or joists should be specified where stud partitions or proprietary plasterboard partitions are supported by a timber floor, unless it can be shown that the deck can transfer the load without undue movement. Allowance for the probable deflection of floors at the head of partitions is required to prevent the partition becoming load-bearing.

Head and sole plates should consist of single length members fixed to the building structure at no less than 600mm centres.

Partitions should be located on double joists when parallel to floor joist span and nailed to 50mm x 50mm noggins fixed between ceiling joists at 600mm centres when parallel to ceiling joist span. For short lengths of partitions (1.2m maximum), blocking between joists at 600mm centres may be used. Intersecting head and sole plates should be skew nailed together.

Timber members should be fixed together with a minimum of 2 No. 75mm long x 2.65mm diameter nails. Proprietary partitions of plasterboard, strawboard or other material must be detailed and constructed in accordance with the manufacturer's recommendations.

Walls and partitions that are supported off structural floors, should not be built directly off a compressible layer forming part of a floating floor system.

Internal plastering

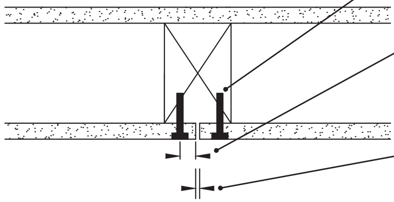
Internal plastering should comply with BS EN 3914-2.

Plasterboard should be to BS EN 520: Gypsum plasterboards - Definitions, requirements and test methods.

Plasterboard thickness should be:

- 9.5mm for stud spacing up to 450mm.
- 12.5mm for stud spacing up to 600mm.

Fixing of plasterboard to studs at joint positions



Plasterwork

This guidance covers all plastered finishes to walls and ceilings. The workmanship of plastered finishes should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

Substrate and background

Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 8481: 2006.

Where the background has a mix of varying materials, e.g. blockwork and brickwork, expanded metal should be provided to prevent differential movement in the plaster finish.

Plaster mixes

Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

Minimum plaster thickness

The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified, and be of a suitable quality so that a decorative finish can be applied. Please refer to the 'Tolerances' section.

Plastering of plasterboard walls

Plasterboard walls should be skimmed to provide a suitable and durable finish. A minimum of one coat is required.

Support of plasterboard

Supports for plasterboard should be designed so that the following span limits are not exceeded.

Plasterboard joints and fixings

Board thickness	Timber support centres (mm)	Intermediate noggins required
9.5mm	400mm	No
	450mm	Yes
12.5mm	400mm	No
	450mm	No
	600mm	Yes
15mm	600mm	No

When fixing plaster boarding:

- Fix with decorative side out to receive joint treatment or a skim plaster finish.
- Lightly butt boards together and never force boards into position.
- Install fixings no closer than 13mm from cut edges and 10mm from bound edges.
- Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper.
- Stagger horizontal and vertical board joints between layers by a minimum of 600mm.
- Locate boards to the centre line of framing where this supports board edges or ends. Fix to timber studs using dry-wall screws.
- When dry lining, plasterboard can be fixed to walls using adhesive dabs or by screwing to timber battens.

Note: Where adhesive dabs are used, the plasterboard manufacturers recommendations must be followed.

Alternatively, a proprietary wall system can be used, providing it has full third-party accreditation. Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve building air tightness.

Minimum periods of fire resistance

Material	½ hour FR	1 hour FR
Plasterboard on timber	12.5mm board on both sides of framing	Two layers of 12.5mm board on both sides of framing or proprietary fire boards (typically 12.5mm-15mm) on both sides of framing
Plasterboard on laminated wall	12.5mm laminated on both sides of 19mm board	Refer to manufacturers recommendations

All internal, separating and compartment walls should have the fire resistance required by the relevant regional Building Regulations.

Sound insulation

Internal walls shall, where necessary, have adequate resistance to the transmission of sound.

All separating walls in England and Wales may be built in accordance with Robust Details and meet the requirements for resistance to the passage of sound in the relevant regional Building Regulations.

Compliance with the relevant Building Regulations can be demonstrated by either:

Pre-completion testing

Pre-completion testing (PCT) is required in the following situations:

- To all new build properties (including rooms for residential purposes), other than when the Developer has registered and built in accordance with Robust Details.
- Where the sound insulation construction is in accordance with the guidance given in the relevant regional Building Regulations for resistance to the passage of sound.
- Where the building is not built in accordance with the relevant regional Building Regulations.
- The requirements of the Robust Details system have not been met.

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Robust Details Ltd may undertake monitoring to check on the performance achieved in practice.

Method of supporting partitions

Walls and partitions are to be supported by the structural floor only if the material is specifically manufactured for that purpose; it is not to be supported by a floating floor that incorporates a compressible layer.

Extra noggins or joists should be specified where stud partitions or proprietary plasterboard partitions are supported by a timber floor, unless it can be shown that the deck can transfer the load without undue movement.

Allowance for the probable deflection of floors at the head of partitions is required to prevent the partition becoming load-bearing.

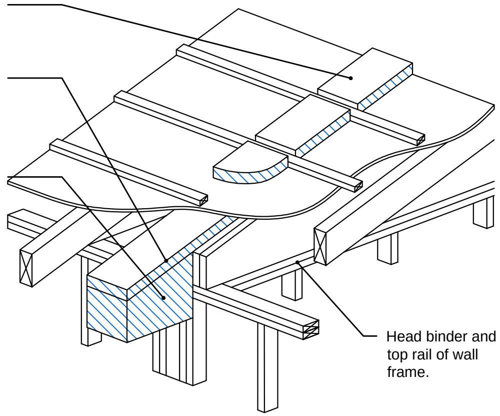
Sound resistance

Sound insulation

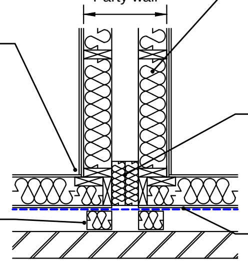
Internal walls shall, where necessary, have adequate resistance to the transmission of sound.

All separating walls in England and Wales may be built in accordance with Robust Details and meet the requirements for resistance to the passage of sound in the relevant regional Building Regulations.

Fire stopping at roof level between party walls



Fire stopping within the cavity on the party wall line



Electrical sockets in party walls

Electrical sockets within the party walls should be avoided where possible, where this is not possible the fire and sound resistance of the walls should be maintained.

Sockets should not be installed back to back in party walls. Please see the 'Electrical Services' section for further guidance.

Fire stopping

Where separating walls and compartment walls meet a roof, further guidance can be found in the 'Roofs' section.

Penetrations in walls that are required to have fire resistance must be designed to meet the requirements of the Building Regulations. Fire stopping in apartments and flats with a floor over 4.5m will have additional requirements. Please see 'Internal Walls - General Requirements - Cavity Barriers and Fire Stopping' for further guidance.

Fire stopping should be provided in accordance with the relevant regional Building Regulations.

- Party/separating walls should be finished 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.

Fire resistance

Typically, in dwellings, a half-hour or one-hour fire-resistance is required to satisfy the relevant regional Building Regulations with regard to fire separation between dwellings and/or compartments within dwellings.

Compartment walls that are common to two or more buildings should run the full height of the building in a continuous vertical plane and should be continued through the roof space.

Where a compartment wall meets another external wall or floor junction fire resistance should be maintained.

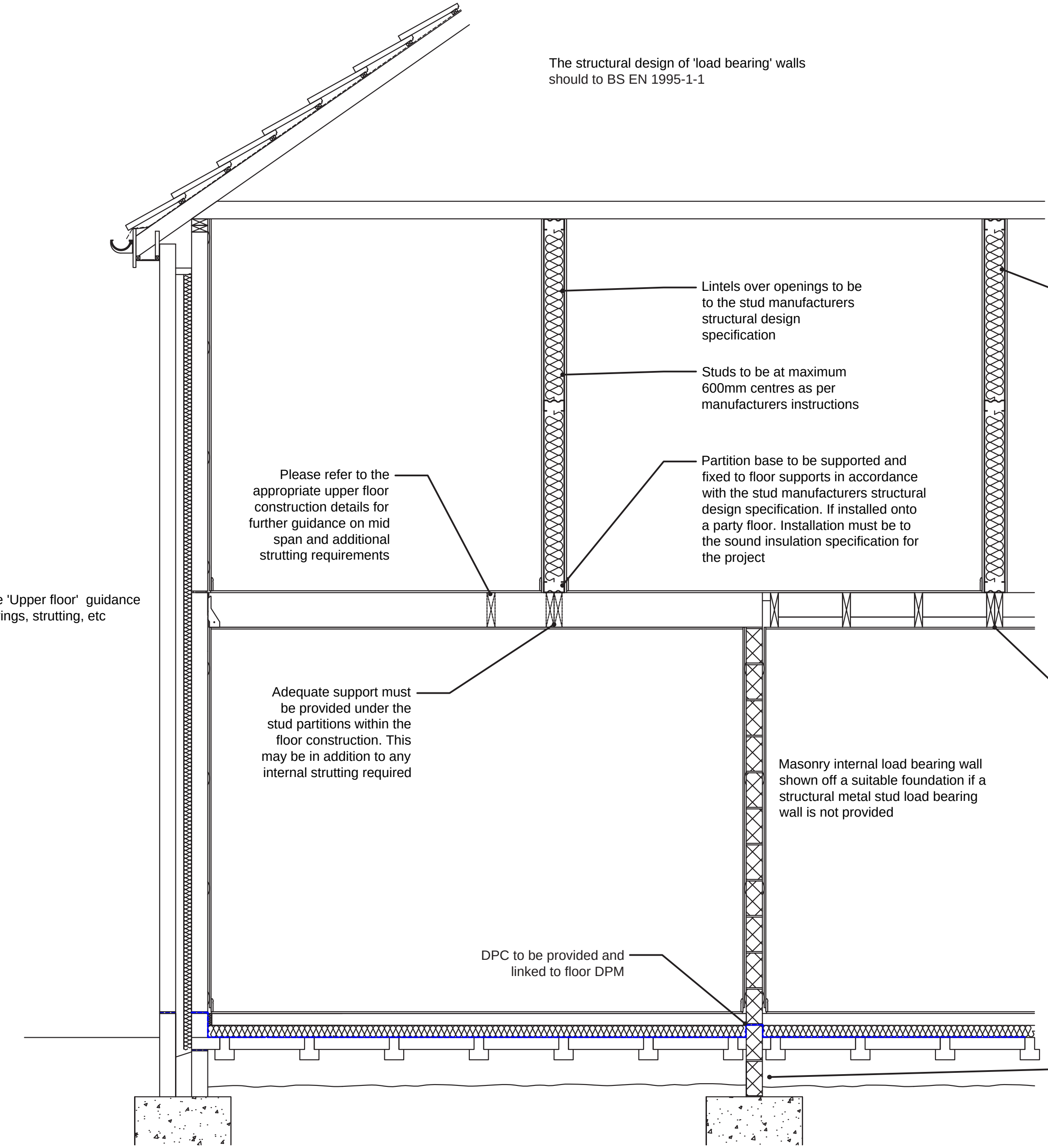
All internal, separating and compartment walls should have the fire resistance required by the relevant regional Building Regulations.

Penetrations in walls that are required to have fire resistance must be designed to meet the requirements of the Building Regulations.

7.

Internal Walls

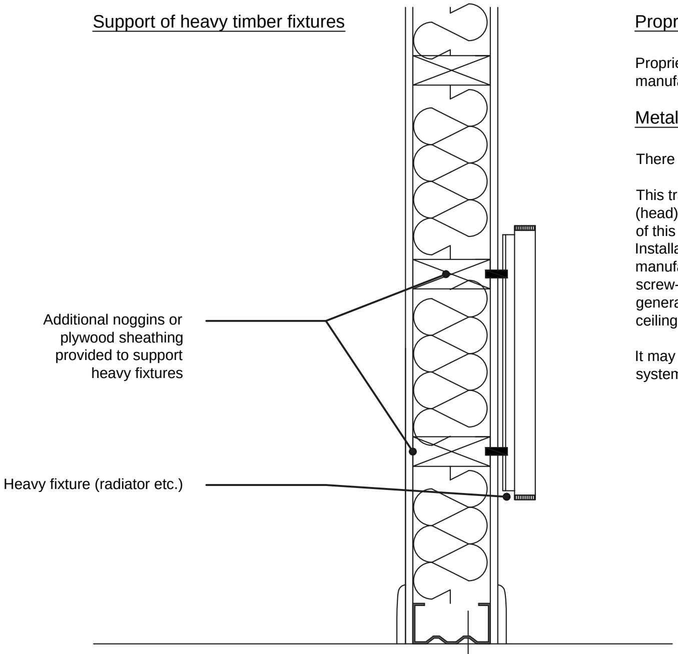
7.3
Metal Stud



Metal stud system

There are a number of proprietary systems on the market. This traditionally consists of U-shaped channels that act as ceiling (head), base plates (tracks) and the vertical studs. The advantage of this system is that it is lightweight, versatile and quick to erect. Installation should always be carried out in accordance with the manufacturer's instructions. Plasterboard coverings are screw-fixed to the metal studs, with the perimeter studs/tracks generally being mechanically fixed to the surrounding walls, ceilings and floors.
It may be necessary to provide earth-bonding to the metal stud system.

Support of heavy timber fixtures



Where additional loads will be applied to the walls e.g. radiators or kitchen cabinets, these may require additional strengthening support as per the manufacturers guidance.

Proprietary systems

Proprietary systems are to be specified in accordance with the manufacturer's recommendations.

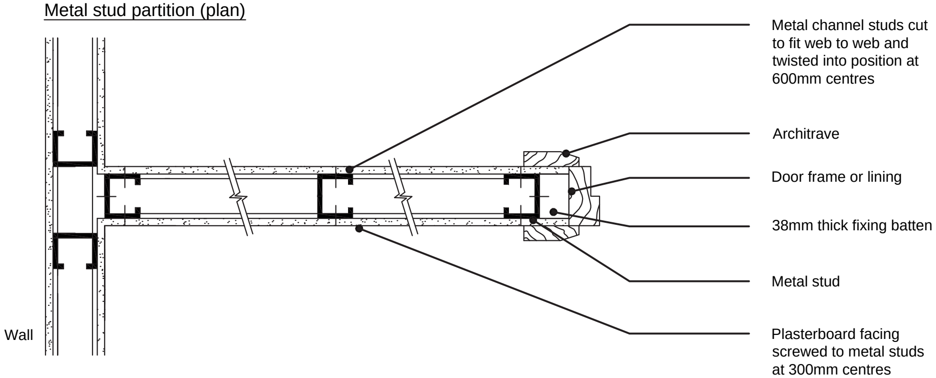
Metal stud system

There are a number of proprietary systems on the market.

This traditionally consists of U-shaped channels that act as ceiling (head), base plates (tracks) and the vertical studs. The advantage of this system is that it is lightweight, versatile and quick to erect. Installation should always be carried out in accordance with the manufacturer's instructions. Plasterboard coverings are screw-fixed to the metal studs, with the perimeter studs/tracks generally being mechanically fixed to the surrounding walls, ceilings and floors.

It may be necessary to provide earth-bonding to the metal stud system.

Metal stud partition (plan)



Method of supporting partitions

Walls and partitions are to be supported by the structural floor only if the material is specifically manufactured for that purpose; it is not to be supported by a floating floor that incorporates a compressible layer.

Extra noggins or joists should be specified where stud partitions or proprietary plasterboard partitions are supported by a timber floor, unless it can be shown that the deck can transfer the load without undue movement.

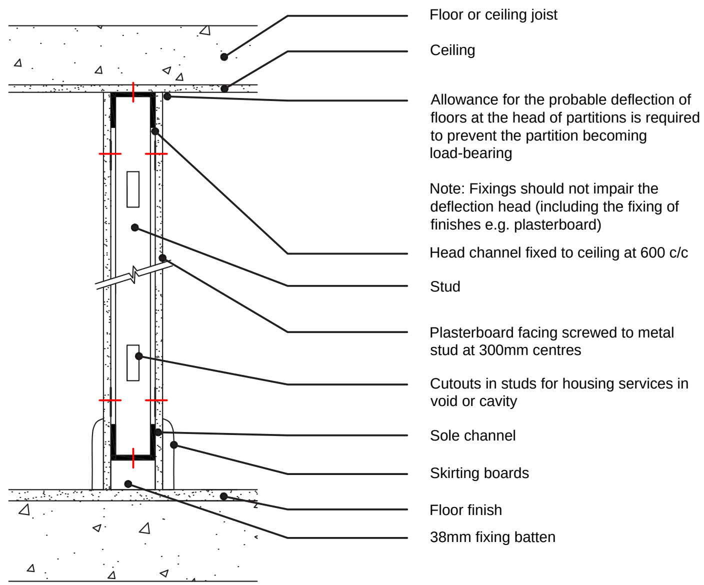
Allowance for the probable deflection of floors at the head of partitions is required to prevent the partition becoming load-bearing.

Head and sole plates should consist of single length members fixed to the building structure at no less than 600mm centres.

Partitions should be located on double joists when parallel to floor joist span and nailed to 50mm x 50mm noggins fixed between ceiling joists at 600mm centres when parallel to ceiling joist span. For short lengths of partitions (1.2m maximum), blocking between joists at 600mm centres may be used. Intersecting head and sole plates should be fixed in accordance with the manufacturers recommendations.

Proprietary partitions of plasterboard, strawboard or other material must be detailed and constructed in accordance with the manufacturer's recommendations.

Metal stud partition



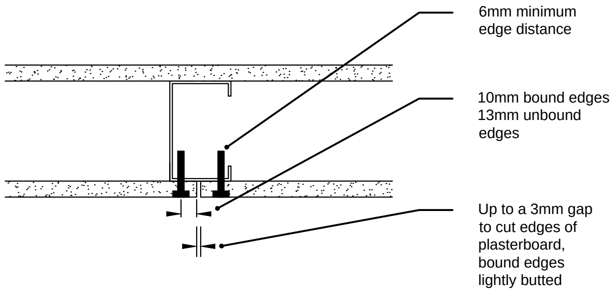
Internal plastering

Internal plastering should comply with BS EN 3914-2.

Plasterboard should be to BS EN 520: Gypsum plasterboards - Definitions, requirements and test methods.

Plasterboard thickness should be:
- 9.5mm for stud spacing up to 450mm.
- 12.5mm for stud spacing up to 600mm.

Fixing of plasterboard to studs at joint positions



Plasterwork

This guidance covers all plastered finishes to walls and ceilings. The workmanship of plastered finishes should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

Substrate and background

Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 8481:2006.

Where the background has a mix of varying materials, e.g. blockwork and brickwork, expanded metal should be provided to prevent differential movement in the plaster finish.

Plaster mixes

Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

Minimum plaster thickness

The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified, and be of a suitable quality so that a decorative finish can be applied. Please refer to the 'Tolerances' section.

Plastering of plasterboard walls

Plasterboard walls should be skimmed to provide a suitable and durable finish. A minimum of one coat is required.

Support of plasterboard

Supports for plasterboard should be designed so that the following span limits are not exceeded.

Plasterboard joints and fixings

Board thickness	Timber support centres (mm)	Intermediate noggins required
9.5mm	400mm	No
	450mm	Yes
12.5mm	400mm	No
	450mm	No
	600mm	Yes
15mm	600mm	No

When fixing plaster boarding:

Fix with decorative side out to receive joint treatment or a skim plaster finish.
- Lightly butt boards together and never force boards into position.
- Install fixings no closer than 13mm from cut edges and 10mm from bound edges.
- Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper.
- Stagger horizontal and vertical board joints between layers by a minimum of 600mm.
- Locate boards to the centre line of framing where this supports board edges or ends.
- Fix metal studs using dry-wall screws.
- When dry lining, plasterboard can be fixed to walls using adhesive dabs or by screwing to metal battens.

Note: Where adhesive dabs are used, the plasterboard manufacturers recommendations must be followed.

Alternatively, a proprietary wall system can be used, providing it has full third-party accreditation. Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve building air tightness.

Minimum periods of fire resistance

All internal, separating and compartment walls should have the fire resistance required by the relevant Regional Building Regulations.

Sound insulation

Internal walls shall, where necessary, have adequate resistance to the transmission of sound.

All separating walls in England and Wales may be built in accordance with Robust Details and meet the requirements for resistance to the passage of sound in the relevant regional Building Regulations. Compliance with the relevant Building Regulations can be demonstrated by either:

Pre-completion testing

Pre-completion testing (PCT) is required in the following situations:

- To all new build properties (including rooms for residential purposes), other than when the Developer has registered and built in accordance with Robust Details.
- Where the sound insulation construction is in accordance with the guidance given in the relevant regional Building Regulations for resistance to the passage of sound.
- Where the building is not built in accordance with the relevant regional Building Regulations.
- The requirements of the Robust Details system have not been met.

or

Robust details

The use of robust details as a means of providing adequate sound insulation applies only to party walls and floors between different dwellings or flats. It is approved by Robust Details Ltd.

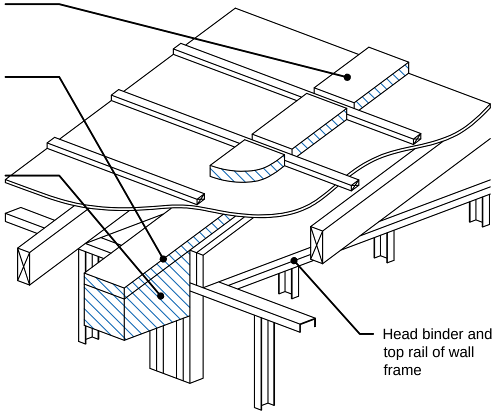
The robust design details are available in a handbook, which can be purchased from:

Robust Details Ltd, 14 Shenley Pavilions, Chalkdell Drive, Shenley Wood, Milton Keynes, MK5 6LB
Tel 0870 240 8210

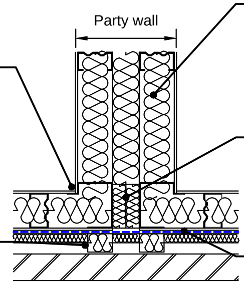
www.robustdetails.com

Robust Details Ltd may undertake monitoring to check on the performance achieved in practice.

Fire stopping at roof level between party walls



Fire stopping within the cavity on the party wall line (plan)



Electrical sockets in party walls

Electrical sockets within the party walls should be avoided where possible, where this is not possible the fire and sound resistance of the walls should be maintained.

Sockets should not be installed back to back in party walls. Please see the 'Electrical Services' section for further guidance.

Fire stopping

Where separating walls and compartment walls meet a roof, further guidance can be found in the 'Roofs' section.

Penetrations in walls that are required to have fire resistance must be designed to meet the requirements of the Building Regulations. Fire stopping in apartments and flats with a floor over 4.5m will have additional requirements. Please see 'Internal Walls - Cavity Barriers and Fire Stopping' for further guidance.

Fire stopping should be provided in accordance with the relevant regional building regulations.

- Party/separating walls should be finished 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.

Fire resistance

Typically, in dwellings, a half-hour or one-hour fire-resistance is required to satisfy the relevant regional Building Regulations with regard to fire separation between dwellings and/or compartments within dwellings.

Compartment walls that are common to two or more buildings should run the full height of the building in a continuous vertical plane and should be continued through the roof space.

Where a compartment wall meets another external wall or floor junction fire resistance should be maintained.

All internal, separating and compartment walls should have the fire resistance required by the relevant regional Building Regulations.

Penetrations in walls that are required to have fire resistance must be designed to meet the requirements of the Building Regulations.

7.

Internal Walls

7.4

General Requirements - Cavity Barriers and Fire Stopping

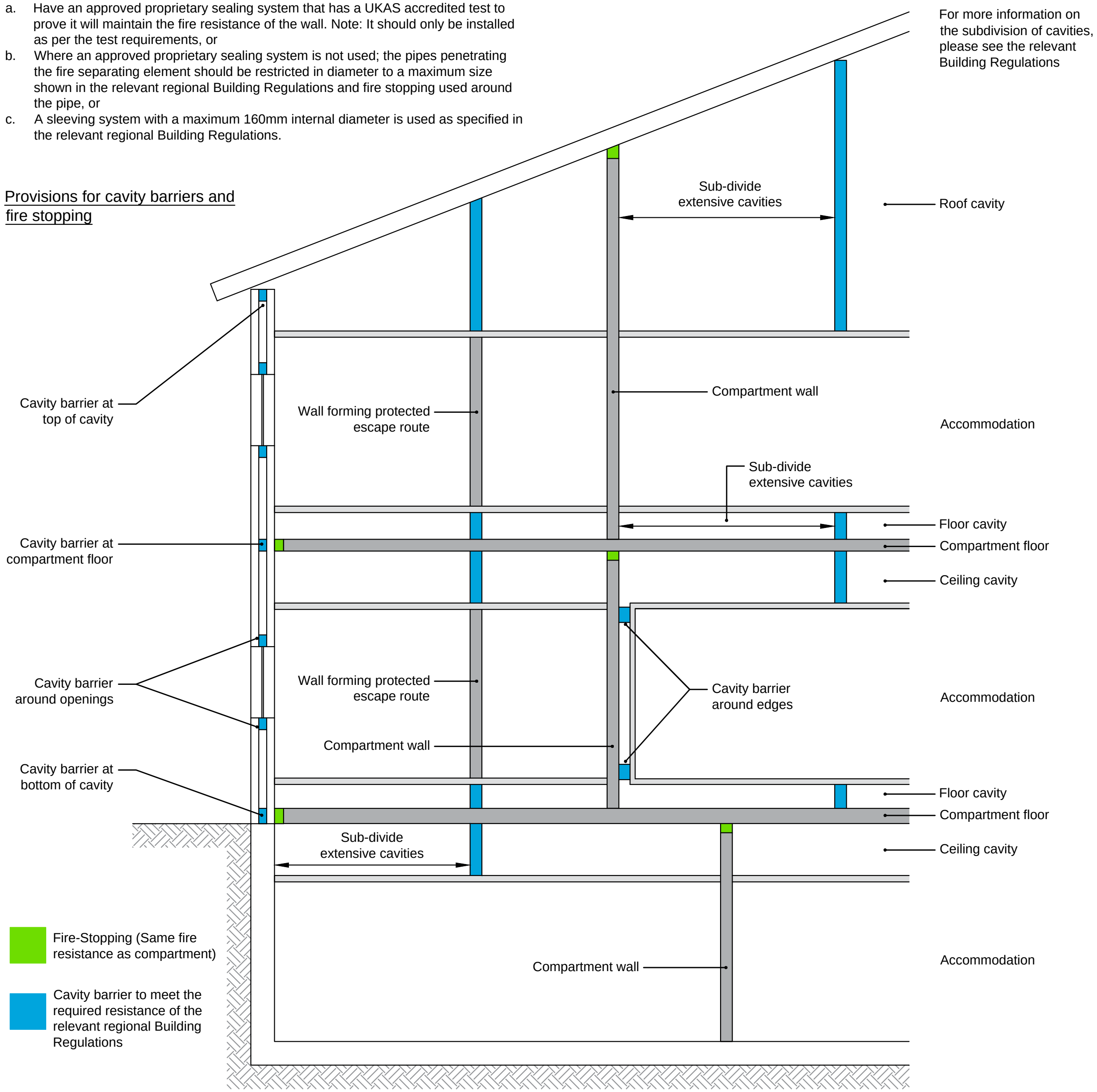
GENERAL REQUIREMENTS - CAVITY BARRIERS AND FIRE STOPPING

Openings for pipes in separating elements

Pipes which pass through fire separating elements (unless in a protected shaft) shall:

a. Have an approved proprietary sealing system that has a UKAS accredited test to prove it will maintain the fire resistance of the wall. Note: It should only be installed as per the test requirements, or
b. Where an approved proprietary sealing system is not used; the pipes penetrating the fire separating element should be restricted in diameter to a maximum size shown in the relevant regional Building Regulations and fire stopping used around the pipe, or
c. A sleeving system with a maximum 160mm internal diameter is used as specified in the relevant regional Building Regulations.

Provisions for cavity barriers and fire stopping



Fire resistance general

All walls should have the fire resistance required by the relevant Building Regulations.

Fire stopping

Penetrations in walls between buildings shall be fire stopped, there are to be no holes or gaps for smoke to pass through once the fire stopping has been fitted.

Further additional requirements for internal fire stopping and fire protection for compartment floors, walls, and roof junctions to flats and apartments with a floor 4.5m or more above the ground

The following additional guidance applies to internal fire stopping and fire protection only to buildings with a floor 4.5m or more above the ground that contain flats or apartments.

Although building legislation is robust in applying provisions for fire protection and fire stopping, it can often be difficult to implement high standards of fire stopping in complex buildings. This can lead to significant safety risks if the building does not have the correct levels of fire protection and if holes in compartment walls are not sealed correctly. This guidance assists Developers in providing good standards of fire stopping and fire protection.

It is not the intention to enhance the requirements of the Building Regulations, but more to ensure that the statutory requirements are applied correctly to the construction. It is therefore deemed that the requirements of Part B of the Building Regulations in England and Wales, or Section 2 of the Scottish Building Standards (whichever is appropriate depending on region), that apply to fire stopping, separating walls, service penetrations, minimum periods of fire resistance and concealed spaces will also meet the requirements of this guidance.

1. Fire stopping

Design information

Drawings showing the lines of compartmentation and the lines of fire-resisting construction should be provided to the Surveyor and the Builder. The drawings should also give the required level of fire resistance for each element. Drawings to show the position of cavity barriers should be provided, and the specification of cavity barriers included.

Materials for fire stopping and cavity barriers

All materials used to form a fire barrier must have relevant third-party certification or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products. A competent person is deemed to be a third-party approved contractor specialising in fire stopping and passive fire protection.

2. Fire protection in buildings

Design information

The design details must show the correct level of fire resistance for the building, in accordance with Part B of the Building Regulations or Section 2 of the Scottish Building Standards, depending on region.

Materials for fire protection

All materials used to form a fire barrier must have relevant third-party certification, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products.

Where intumescent paints are used to provide the required level of fire protection, certification confirming that the paint applied will achieve the correct level of fire protection is required.

8.

Windows and Doors

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. Certification is required for any curtain wall and rain screen construction completed by an approved installer.

Materials

No additional requirements.

Design

1. Windows, external doors and frames, and roof lights shall be designed and constructed so that they:
   a. Meet the requirements of BS 6375-1 are durable and resistant to weather;
   b. Provide adequate resistance to transmission of sound where necessary;
   c. Have adequate thermal performance and air tightness;
   d. Have sufficient strength to withstand operational and wind loads;
   e. Offer reasonable resistance to unauthorized entry;
   f. Are suitable, where necessary, for means of escape in case of fire;
   g. Can be operated readily and safely by the user.
2. Windows and roof lights shall be designed and constructed so that they offer, where necessary,adequate natural ventilation.
3. External doors and frames shall be designed and constructed so that they:
   a. Resist to the spread of fire when situated between a dwelling and an attached or integral garage;
   b. Permit convenient access for disabled people.
4. Glazing in windows, doors and roof lights shall be designed and constructed so that it:
   a. Has sufficient strength;
   b. Can be readily cleaned.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

8.

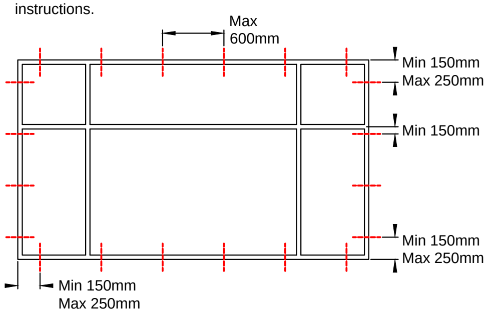
Windows and Doors

8.1

uPVC

Fixing distances for uPVC windows and doorsets

Windows and doors should be installed in accordance with manufacturers instructions.



Frames should be fixed in accordance with the manufacturer's recommendations or, if no instructions are given, with the following guidance:

Wherever practicable, the sides of the frame should be secured as follows:

- Corner fixings should be between 150mm and 250mm from the external corner.
- No fixings should be less than 150mm from the centre line of a mullion or transom.
- There should be a minimum of two fixings on each jamb and sill, with intermediate fixings at centres no greater than 600mm.
- If the head is fixed with polyurethane foam, then the fixings at the head may be as follows:
  a) frame width up to 1200mm - no fixings;
  b) frame width 1201mm to 2400mm - one central fixing;
  c) frame width 2401mm to 3600mm - two equally spaced fixings.
- Frames should be fixed either by galvanised steel cramps or by non-corrodible screw fixings to the surrounding wall.

Note: These fixings do not apply to french doors, patio doors, or bi-fold doors. Manufacturers recommended fixing details should be followed.

Windows and doors installation

Windows and door frames should be installed so that:

- They do not carry loads unless designed to do so.
- External doors and opening lights to windows should be reasonably air tight by ensuring that effective draught seals are fitted.
- The masonry on the external side of vertical DPC should not be in contact with internal finishes.
- The window head is set back behind the edge of the cavity tray.
- The frame to wall junction is weather tight and reasonably air tight.
- In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap it. In other areas of exposure, the frame should be set back at least 38mm and overlap the DPC.
- Distortions of doors should be minimized by not locating radiators or other heaters close to doors.
- The reveal should be protected throughout its width by a continuous DPC. The width of the DPC should be sufficient to overlap/be fixed to the frame and fully protect the reveal. Alternatively, an insulated finned cavity closer with third-party certification may be used.

Workmanship

Window and door frames should be installed either by building in tightly as work proceeds or by fitting into pre-formed openings, suitably dimensioned to provide an accurate fit for the frame plus the perimeter weather tight joint.

UPVC frame windows and doors should be installed with a gap of between 5mm and 10mm to allow for thermal expansion. For large framed units such as patio doors the gap can be up to 15mm.

Window and door frames should be installed in accordance with the manufacturers instructions.

Windows and doors

uPVC windows and doors should be subject to independent third-party certification.

Workmanship should follow the recommendations of BS 8213-4.

The design and construction of factory assembled windows must meet BS 7412.

Non factory assembled units and 'bespoke' units are also expected to meet the same standard.

Factory made and bespoke doors and windows should be selected to withstand the design weather conditions and be classified and tested in accordance with the following weather performance standards:

- BS 6375-1 Weather tightness.
- Air permeability - BS EN 12207 - Classification & BS EN 1026 - Test method.
- Water resistance - BS EN 12208 - Classification & BS EN 1027 - Test method.
- Wind resistance - BS EN 12210 - Classification & BS EN 12211 - Test method.

Bay, oriel and dormer windows require particular care in detailing and fitting so that they are stable, weather tight and reasonably air tight.

Roof lights should be proprietary components, fixed within prepared openings in accordance with the manufacturer's instructions and have effective weather sealing.

Non-timber components should comply with the following British Standards (as appropriate), and be installed and fixed in accordance with the manufacturer's recommendations:

- BS EN 514:2018 Plastics. Poly(vinyl chloride) (PVC) based profiles. Determination of the strength of welded corners and T-joints.
- BS 7412:2007 Specification for windows and doorsets made from unplasticized polyvinyl chloride (PVC-U) extruded hollow profiles.

External UPVC windows and doorsets should be designed and constructed in accordance with the requirements of the following British Standards:

- BS 6262 Code of Practice for glazing for building.
- BS 6375: 1 Performance of windows.
- BS 7412 Specification for windows and doorsets made from unplasticized polyvinyl chloride (PVC-U) extruded hollow profiles.
- BS 8213 Windows, doors and roof lights.

Windows and doors should comply with the current Building Regulations taking into consideration:

- Means of escape in the event of a fire.
- Thermal insulation.
- Ventilation.
- Safety.
- Security.

Draught Seals

External doors and opening lights to windows should be reasonably air tight by ensuring that effective draught seals are fitted.

Fire doors

Any door between a dwelling and an attached or integral garage should be a half-hour fire-resisting door and frame.

Sealant around windows and doors

For gaps less than 5mm, the sealant must cover both the frame and masonry by 6mm.

For gaps greater than 5mm, a backing strip should be provided behind the sealant and the sealant should have a minimum depth of 6mm.

Glazing

- Any glazing on-site must have a drained and ventilated bottom bead with a minimum gap of 5mm between the edge seal of the insulated glass unit and the bottom channel frames glazing rebate.
- The workmanship should be in accordance with BS 8000: 7.
- The window beads should suitably lap the windows and doors to prevent premature degradation of the glazing unit.

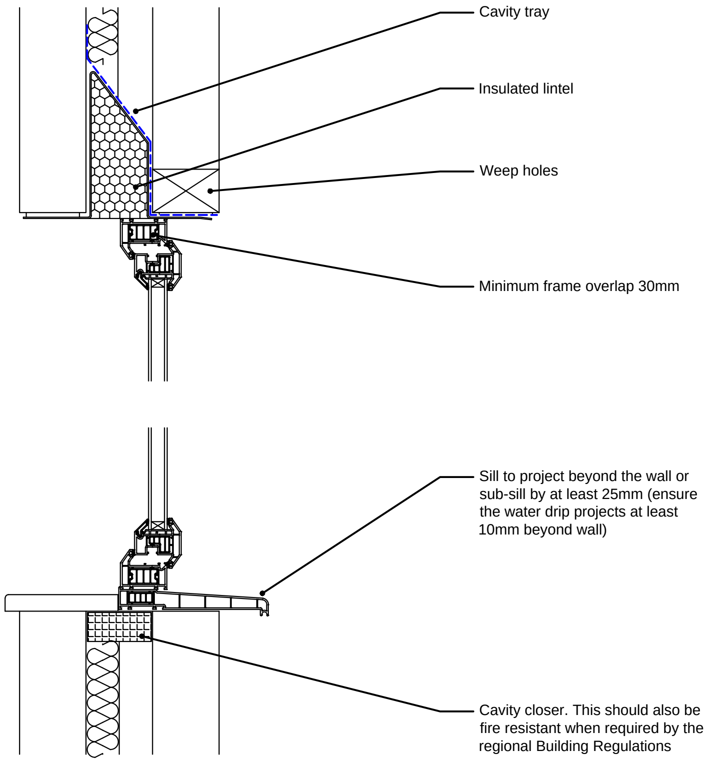
Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

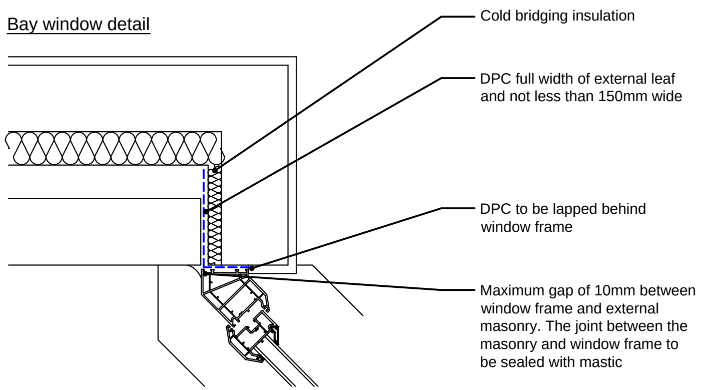
For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.

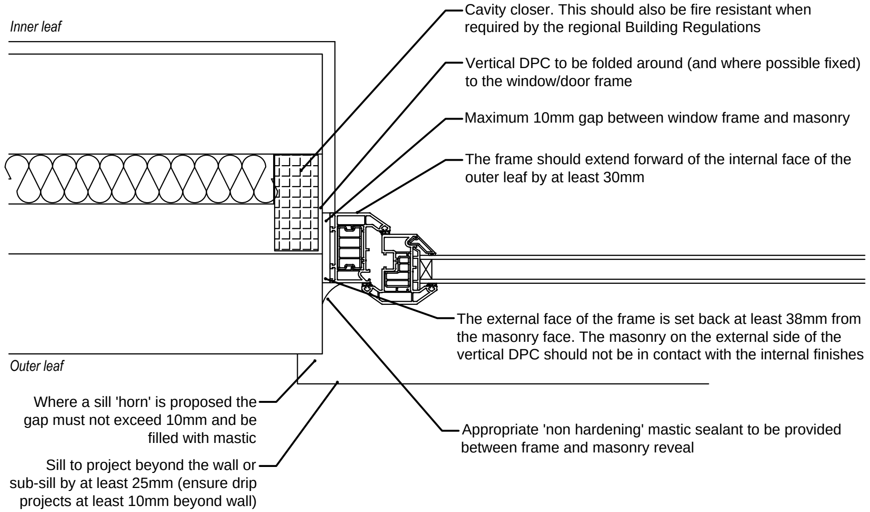
Typical vertical section through window



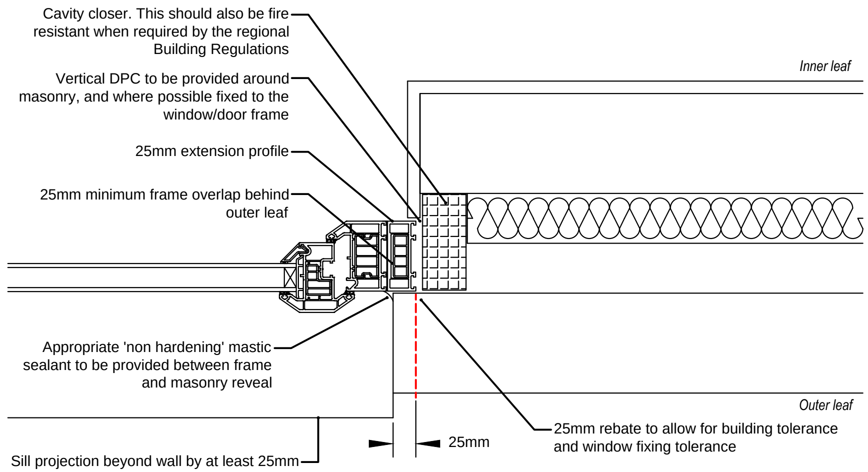
Bay window detail



Typical window reveal detail (normal exposure)



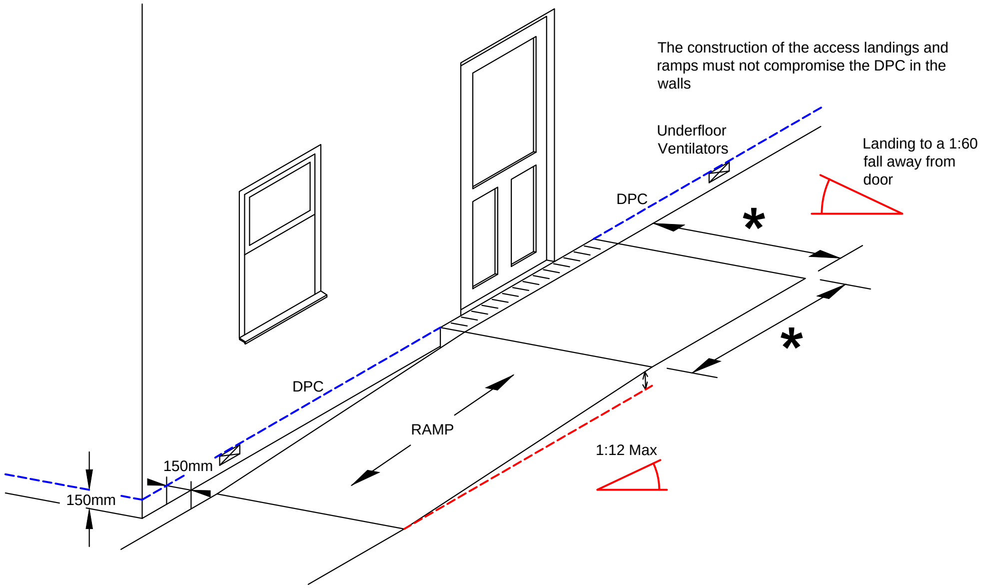
Checked rebate window frame detail for areas of severe exposure



When installing window/door frames in a checked rebate, allow for the frame to be deeper:

- To accommodate the 25mm rebate, and
- To allow for opening lights to open clear of the masonry/render.

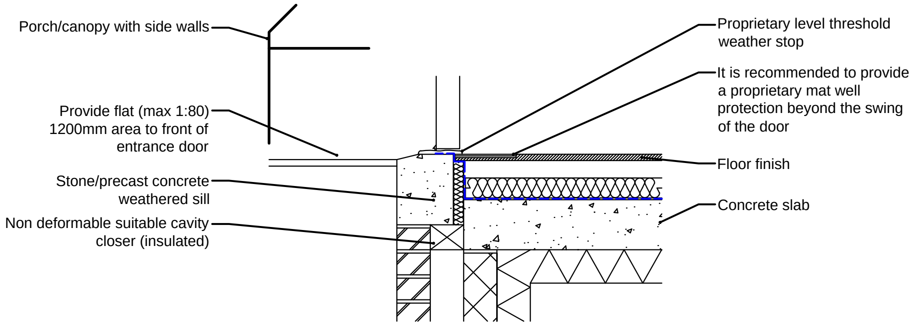
Ramped/level threshold to principle entrance door



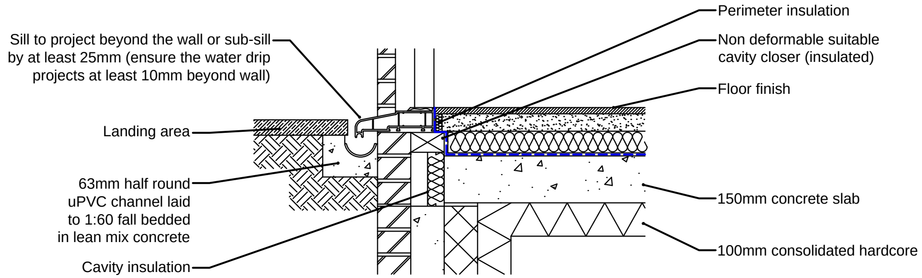
* See Building Regulations for disabled ramp design and landing dimensions.

Ramps should not exceed 1:12 gradient. Where the outside ground levels slope towards the property, an effective gully system should be provided to prevent flooding, e.g. in front of garage doors.

Typical level threshold where a porch/canopy is provided



Typical level threshold suspended concrete slab - without canopy protection



Level threshold

Thresholds and sills should be at least 150mm above finished ground level. However, where a level (threshold) access is required, the general guidance in this section should be followed - ensuring a high level of supervision and workmanship together with the correct specification of materials and consideration to design, location, and exposure.

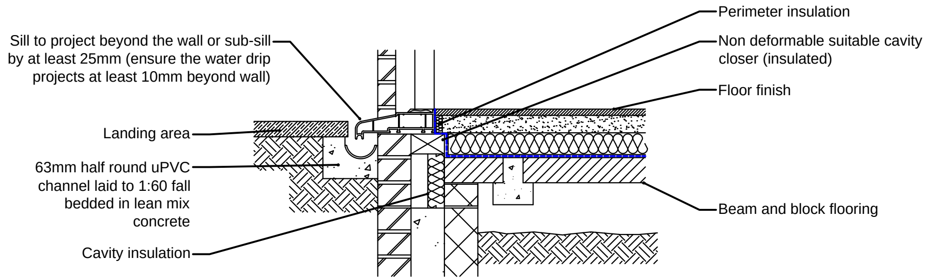
Wherever possible, locate the entrance door away from the prevailing weather and provide a storm porch. Where a drainage channel is provided, this must be connected to the storm drainage system to prevent flooding occurring and water ingress into the building.

It is recommended that a mat well be constructed within the entrance hall to accommodate the swing of the door without fouling the carpet and/or the proprietary door seal.

Level thresholds timber frame structure

At the level threshold open perpends should be provided in close proximity to the timbers on each side of the door opening one brick course below the lowest timber. The open perpends must provide adequate ventilation of the external wall cavity, and drainage to disperse water that may penetrate the cladding.

Typical level threshold suspended beam and block floor



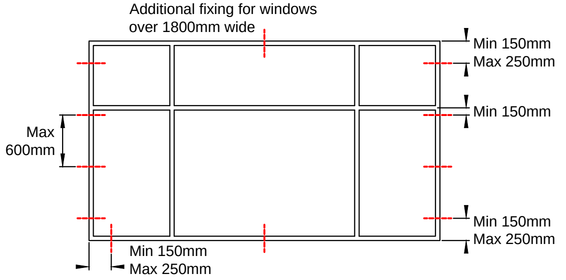
8.

Windows and Doors

8.2
Timber

Fixing distances for timber windows and doorsets

Windows and doors should be installed in accordance with manufacturers instructions.



Wherever practicable, the sides of the frame should be secured as follows:

- Corner jamb fixings should be between 150mm and 250mm from the external corner.
- Intermediate fixings should be at centres no greater than 600mm.
- There should be a minimum of two fixings on each jamb.
- On windows and doorsets over 1800mm wide, central head and sub-sill fixings should be provided.
- Frames should be fixed either by galvanized steel cramps or by non-corrodible screw fixings into the surrounding wall.

Windows and doors installation

Windows and door frames should be installed so that:

- They do not carry loads unless designed to do so.
- The masonry on the external side of vertical DPC should not be in contact with internal finishes.
- The window head is set back behind the edge of the cavity tray.
- The frame to wall junction is weather tight and reasonably air tight.
- In areas of very severe exposure, checked rebates should be provided. The frame should be set back behind the outer leaf and should overlap it. In other areas of exposure, the frame should be set back at least 38mm and overlap the DPC.
- Distortions of doors should be minimized by not locating radiators or other heaters close to doors.
- The reveal should be protected throughout its width by a continuous DPC. The width of the DPC should be sufficient to overlap/be fixed to the frame and fully protect the reveal. Alternatively, an insulated finned cavity closer with third-party certification may be used.

Workmanship

- Timber frame windows and doors should be installed so that any gap provided between the masonry and the frame should not exceed 10mm.
- For gaps less than 5mm, the sealant must cover both the frame and masonry by 6mm.
- For gaps greater than 5mm, a backing strip should be provided behind the sealant and the sealant should have a minimum depth of 6mm.

Windows and doors

Workmanship should follow the recommendations of BS 1186: 2. The design and construction of factory assembled windows must meet BS 644:2009. Non factory assembled units and 'bespoke' units are also expected to meet the same standards.

Non factory assembled units and 'bespoke' units are also expected to meet the same standard.

Factory made and bespoke doors and windows should be selected to withstand the design weather conditions and be classified and tested in accordance with the following weather performance standards:

- BS 6375-1 Weather tightness.
- Air permeability - BS EN 12207 - Classification & BS EN 1026 - Test method.
- Water resistance - BS EN 12208 - Classification & BS EN 1027 - Test method.
- Wind resistance - BS EN 12210 - Classification & BS EN 12211 - Test method.

Bespoke/handmade window and door units must be designed and constructed to meet the same level of weather tightness as factory made tested units. Where these are proposed, there must be a detailed specification of the design, construction, and durability of the proposed units submitted to the Warranty provider before installation on site.

For bespoke/handmade windows; site testing for water penetration of the joints to windows and doors in accordance with the CWCT test methods is recommended to check the site workmanship of the building envelope as constructed. See CWCT Technical Note No. 41 for guidance on site hose testing.

Roof lights should be proprietary components, fixed within prepared openings in accordance with the manufacturer's instructions and have effective weather sealing.

Timber used for external joinery should be a species classified as suitable in BS EN 942 and preservative treated; if not, use a moderately durable species or better (sapwood excluded). Guidance on selection is provided in TRADA Wood Information Sheets 3.10 and 4.16.

Windows and doors should comply with the current Building Regulations taking into consideration:

- Means of escape in the event of a fire.
- Thermal insulation.
- Ventilation.
- Safety.
- Security.

External joinery should be designed and constructed in accordance with the requirements of the following British Standards:

- BS 4787: 1 Internal and external wood door sets, door leaves and frames.
- BS 6262 Code of Practice for glazing for buildings.
- BS 6375: 1 Performance of windows.
- BS 644: 1 Wood windows.
- BS 8213: 1 Windows, doors and roof lights.

Non-timber components should comply with the following British Standards (as appropriate), and be installed and fixed in accordance with the manufacturer's recommendations:

- BS 4873 Aluminium alloy windows and door sets.
- BS 6510 Steel windows and doors.

Draught Seals

External doors and opening lights to windows should be reasonably air tight by ensuring that effective draught seals are fitted.

Decoration

Preservative-treated joinery cut or adjusted on-site should be brushed liberally with an appropriate and coloured preservative.

The primer coat should be applied to all final exposed parts, including rebates prior to glazing installed or bottoms of doors.

Preservative-treated joinery cut or adjusted on-site should be brushed liberally with an appropriate and coloured preservative. Where the colour of the preservative will adversely affect the final appearance of the joinery, an appropriate clear preservative should be used. Where a painted finish is proposed to the window/door frame and opening units; the primer coat should be applied to all final exposed parts, including rebates prior to glazing installed or bottoms of doors, or windows.

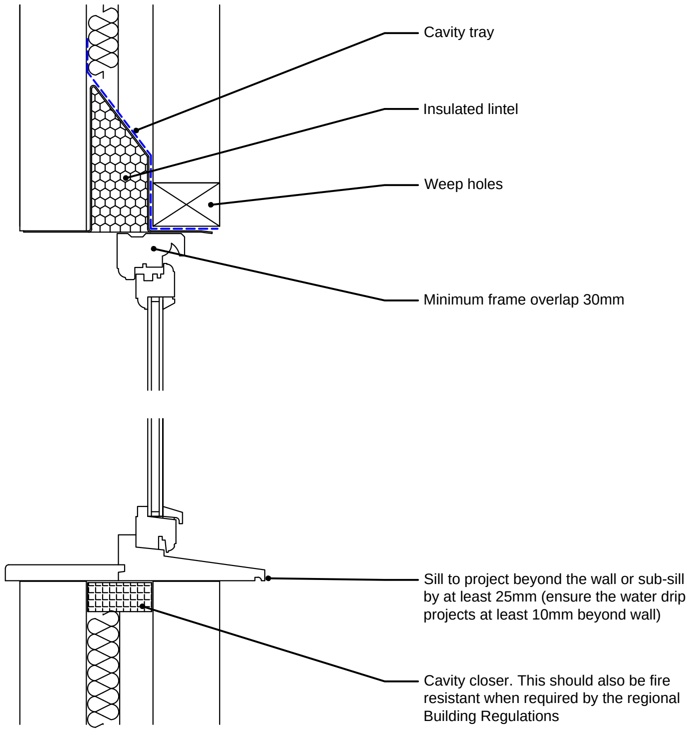
Additional requirements in a coastal location

Where developments are within a coastal location additional Warranty requirements should be met.

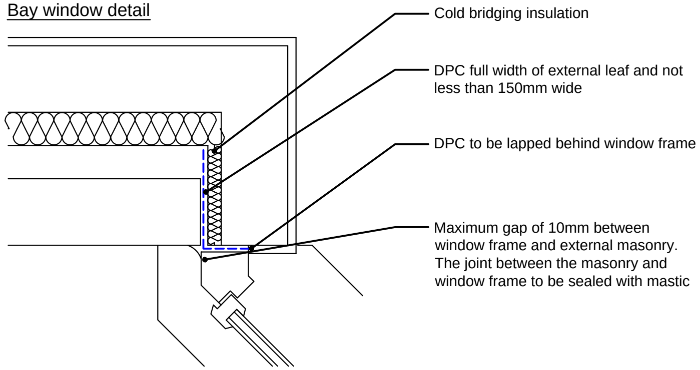
For the purpose of this Technical Manual we are considering sites within 5Km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.

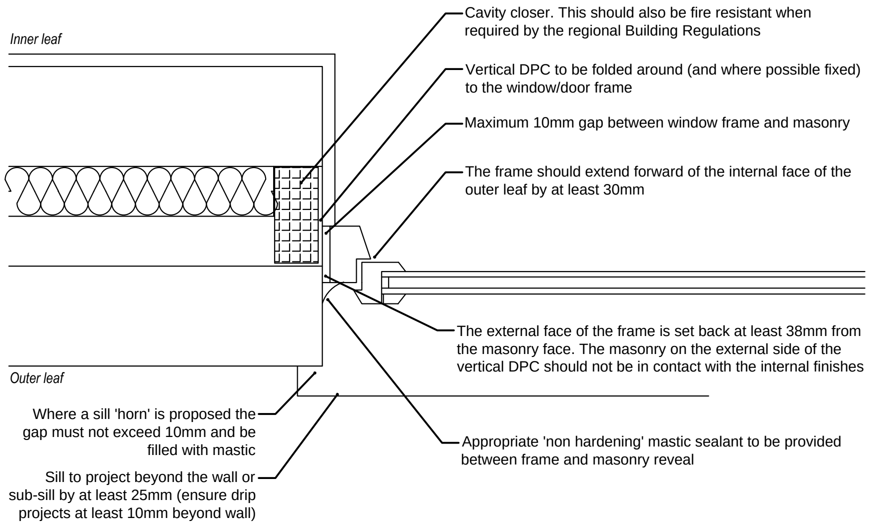
Typical vertical section through window



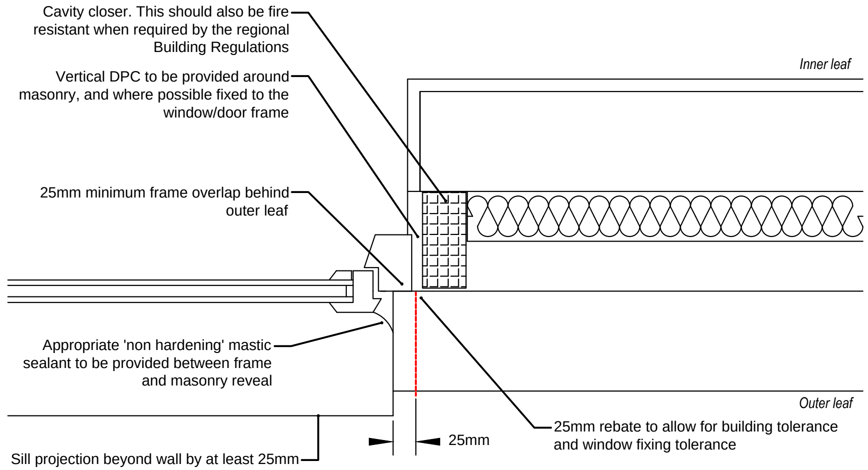
Bay window detail



Typical window reveal detail (normal exposure)



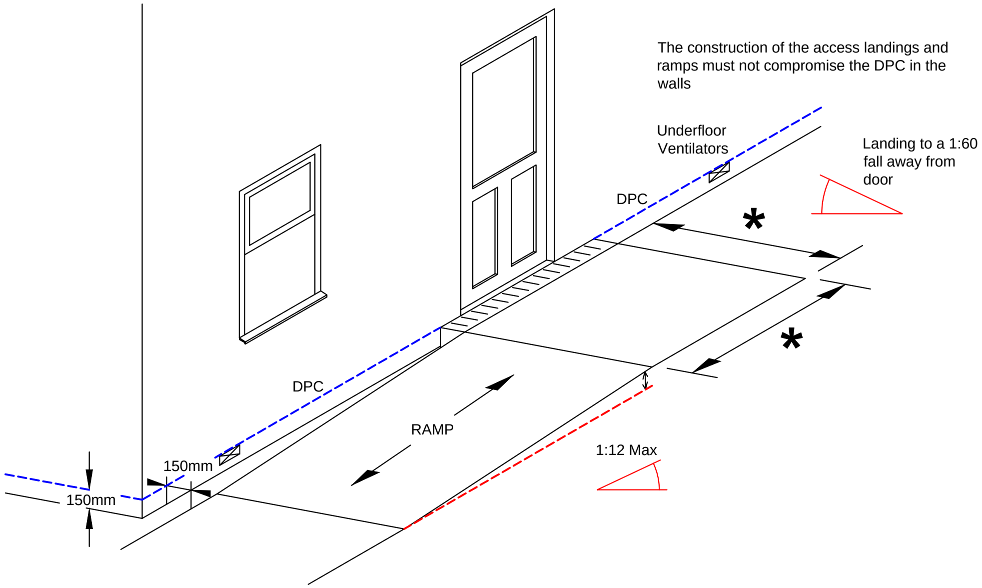
Checked rebate window frame detail for areas of severe exposure



When installing window/door frames in a checked rebate, allow for the frame to be deeper:

- To accommodate the 25mm rebate, and
- To allow for opening lights to open clear of the masonry/render.

Ramped/level threshold to principle entrance door



* See Building Regulations for disabled ramp design and landing dimensions.

Ramps should not exceed 1:12 gradient. Where the outside ground levels slope towards the property, an effective gully system should be provided to prevent flooding, e.g. in front of garage doors.

Level threshold

Thresholds and sills should be at least 150mm above finished ground level. However, where a level (threshold) access is required, the general guidance in this section should be followed - ensuring a high level of supervision and workmanship together with the correct specification of materials and consideration to design, location, and exposure.

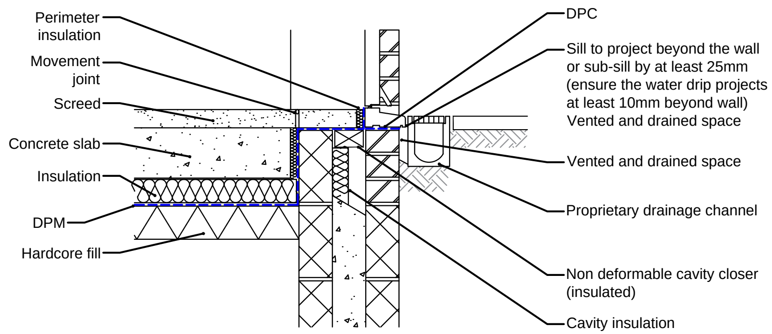
Wherever possible, locate the entrance door away from the prevailing weather and provide a storm porch. Where a drainage channel is provided, this must be connected to the storm drainage system to prevent flooding occurring and water ingress into the building.

It is recommended that a mat well be constructed within the entrance hall to accommodate the swing of the door without fouling the carpet and/or the proprietary door seal.

Level thresholds timber frame structure

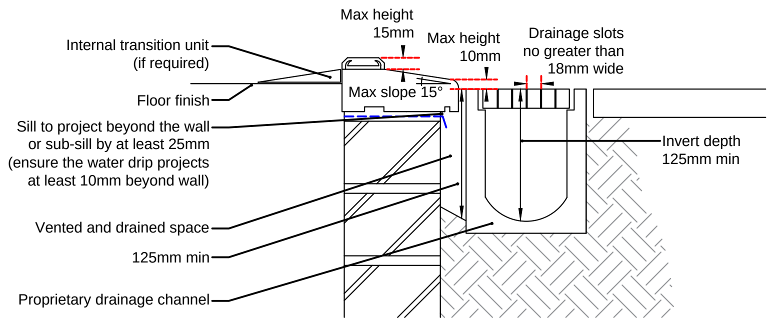
At the level threshold open perpends should be provided in close proximity to the timbers on each side of the door opening one brick course below the lowest timber. The open perpends must provide adequate ventilation of the external wall cavity, and drainage to disperse water that may penetrate the cladding.

Ground bearing slab construction, timber door sill



Timber sill

Where timber sills are installed, to prevent deterioration of the timber due to the risk of moisture ingress, a drained and vented void must be provided immediately in front of the sill (at least 125mm invert).



8.

Windows and Doors

8.3

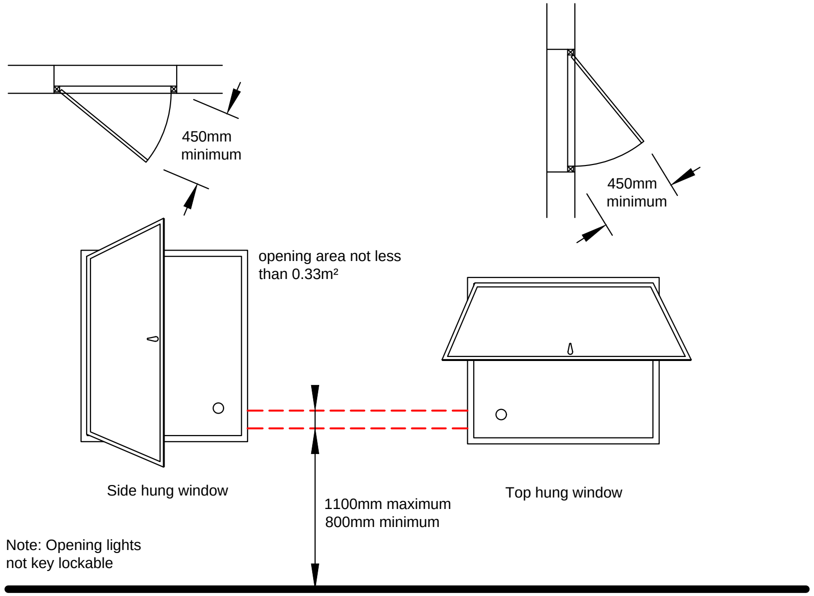
General Requirements

Means of escape

In terms of emergency egress windows in two storey dwellings, with the exception of kitchens, all habitable rooms in the upper storey served by one stairway shall be provided with a window:

- With an unobstructed opening area of at least 0.33m2.
- At least 450mm high x 450mm wide.
- With the bottom of the opening area not more than 1100mm above the floor.

Emergency egress window provision



Cavity barriers

The installation of cavity barriers should be provided at all structural openings formed in external walls as per the relevant regional Building Regulations please see the 'External Walls' section for further information.

Fire doors

Any door between a dwelling and an attached or integral garage should be a half-hour fire-resisting door and frame.

Security

The design and specification of doors and windows which provide access into a dwelling or into a building containing a dwelling should take into account the requirements of current regional Building Regulations to ensure the system is classified and tested to the appropriate burglar resistance class.

In addition:

- The frames of secure doorsets and windows should be mechanically fixed to the building structure in accordance with the manufacturer's tested specifications.
- Where a doorset is installed in a lightweight framed wall, a resilient layer should be incorporated to reduce the risk of anyone breaking through the wall to access the locking systems. The resilient layer should be for the full height of the door and 600mm either side of the doorset, 9mm timber sheathing or expanded metal may be used.
- Any glazing which if broken in an attempt to gain access to the locking device on a door must be a minimum class of P1A in accordance with BS EN 356:2000.
- A means of caller identification should be provided at the main door to the dwelling to allow means of seeing callers. The same doorsets should also have a securely fixed door chain or door limiter fitted.
- The doors and windows should be manufactured to a design that has been shown by tests to meet the security requirements of PAS 24.

Protection from falling

For houses and flats the guidance in Approved Document K2 (Building Regulations England and Wales) specifies a minimum guard height of 800mm to window openings in the external wall. This would normally be achieved by forming window openings of at least 800mm above the finished floor level. The wall beneath the opening is therefore considered to be the barrier to falling.

Where window openings are formed less than 800mm from the finished floor level, permanent guarding should be provided to the opening in accordance with the design requirements specified in the relevant Building Regulations.

If window openings are formed less than 800mm from the finished floor level, and there is no permanent guarding provided, and the glass is required to act as the barrier and provide containment to persons falling against it; the glass needs to be designed in accordance with the requirements of BS 6180. The designer shall determine the potential impact energy by establishing the perpendicular unhindered distance that could be travelled prior to impact.

In the absence of an assessment by a suitably qualified person, any glass which is required to provide containment must meet with BS EN 12600 Class 1(C)1.

Control of condensation

Minimise the effects of condensation on glazing and frames by:

- Using details that prevent condensation running onto walls or floors
- Housing window boards into frames to prevent condensation entering the joint
- Providing thermal insulation to walls at lintels, sills and jambs. Guidance on this subject is provided in BRE's report Thermal insulation: Avoiding risks.

Critical locations

Glazing in doors and windows in areas known as 'critical locations' needs to be given special consideration in order to prevent potential injury to people within or around the building.

These 'critical locations', as shown below, are:

- In a door or in a side panel adjacent to a door where the glazing is within 300mm of the door and the glazing is situated between floor level and a height of 1500mm.
- In an internal or external wall or partition between floor level and a height of 800mm.

It is important that any glazing within these 'critical locations' should be either:

- Provided with permanent protection.
- Small panes.
- Robust.
- Break safely.

If permanent protection is provided, there is no requirement for the glazing itself to be of a special type. Permanent protection may take the form of railing or barriers and should:

- Be designed to be robust.
- Have a maximum opening or gap in any railing of 75mm or less.
- Be a minimum of 800mm high.
- Be non-climbable (especially where floor is acting as a balcony).

Small panes, either an isolated pane within glazing bars or copper or lead lights should be restricted in size so that any breakage would be strictly limited.

Small panes should be:

- No more than 0.5m2 in area.
- No wider than 250mm.

Where annealed glass is used a minimum of 6mm thickness is recommended (4mm for copper or lead lights). Some materials are inherently strong such as glass blocks or polycarbonates, whereas annealed glass will need to be of an increased thickness as the area of the panel increases to be considered 'safe'. As an alternative to any of the above solutions it is possible for the material to break 'safely' when tested to BS EN 12600 which would mean that:

- Only a small opening was created with a limited size of detached particles.
- The balance would create only small pieces that are not sharp or pointed.
- The pane disintegrates with only small detached particles.

A glazing material would be suitable for a critical location if it meets the requirements of BS 6262 - 4 Table 1 when tested in accordance with BS EN 12600. Glass installed in a door or in a side panel to a door that exceeds 900mm wide must meet the relevant requirements of BS EN 12600 and BS 6262 - 4.

Appearance of glazing

Glass must meet the visual assessment criteria of the Glass and Glazing Federation and CWCT Technical Note 35 (TN 35). The total number of faults permitted in a glass unit shall be the sum total of those permitted by the relevant BS EN Standard for each pane of glass incorporated into the unit concerned.

Acceptable Faults include:

- Inclusions, bubbles, spots and stains.
- Residues within the insulated glass unit cavity.
- Fine scratches not more than 25mm long.
- Minute particles.

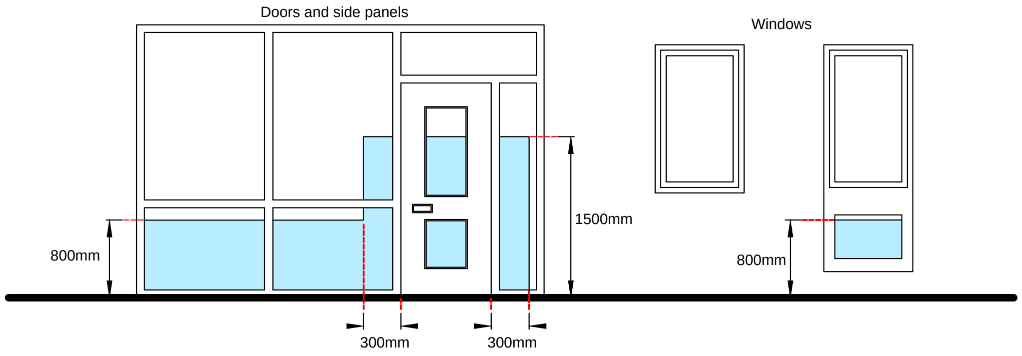
When assessing the appearance of glass:

- The viewing distance used shall be the furthest stated in any of the BS EN Standards for the glass types incorporated in the glazed unit. In the event of doubt the viewing distance shall be three metres.
- The viewing shall commence at the viewing distance and shall not be preceded by viewing at a closer distance.
- The viewing shall be undertaken in normal daylight conditions without use of magnification.

The above does not apply within 50mm of the edge of the pane, where minor scratching is acceptable. Scratches on doors, windows and frames and factory finished door and window components should not have conspicuous abrasions, or scratches when viewed from a distance of 0.5m.

- Surface abrasions caused during the building-in process should be removed in accordance with the manufacturer's instructions, which may include polishing out, re-spraying or painting.
- In rooms where there is no daylight, scratches should be viewed in artificial diffused light from fixed wall or ceiling outlets and not from portable equipment.

Glazing to critical locations



Glazing should be in accordance with BS 6262. Insulated glass units (IGU) should meet requirements of BS EN 1279 - Glass in building - insulating glass units, be CE marked and carry third-party accreditation. This includes windows in possession of a BBA certificate and timber windows.

- They should have continuous dual seals; single seal units are not acceptable.
- Desiccant should be provided to spacer bars.
- Any glazing on-site must have a drained and ventilated bottom bead with a minimum gap of 5mm between the edge seal of the insulated glass unit and the bottom channel of the frames glazing rebate.
- Any glazing with an area greater than $1m^2$ must have a drained and ventilated bottom bead with a minimum gap of 5mm between the edge seal of the insulated glass unit and the bottom channel of the frames glazing rebate.
- Glazing with an area less than $1m^2$ may be solid bedded.
- UPVC frames and spacer bars should be stamped with BS 7412, 7413 and 7414.

Linseed oil glazing putty should not be used when the joinery is finished with vapour permeable paint or stain. Glazing putty should also not be used with organic solvent-based stains, the putty should be neatly finished to receive a protective paint coat.

Putty is not suitable for laminated glass and double-glazed units, the workmanship should be in accordance with BS 8000: 7. To ensure the compatibility of the whole glazing system is to a high level of workmanship and control, it is recommended that factory pre-glazed systems be installed in all external openings.

The window beads should suitably lap the windows and doors to prevent premature degradation of the glazing unit.

External glazing beads should be pinned at a maximum of 150mm centres (a maximum of 50mm from corners) or screwed at 200mm centres (maximum 50mm from corners).

The preferred method of installation for double-glazed units is either:

- Drained and ventilated frames, as recommended by the Glass and Glazing Federation (GGF), where possible this method should be adopted for external glazing.
- Solid bedding of units in 16mm-18mm deep frame rebates; 18mm rebates are recommended by the GGF to allow for tolerances. In all cases, sealants should not be sensitive to ultraviolet light. External glazing beads should be fixed at a maximum of 150mm centres, and the glazing bedded in non-setting putty. Louvre windows should not be used and double-glazing should be fixed and bedded as recommended by the GGF.

Nickel sulphide inclusions in glazing

In buildings which exceed three storeys in height, 100% of toughened glazing should be formed and then heat soak tested in accordance with BS EN 14179-1. The glass must be permanently marked in accordance with BS EN 14179-1 and substantiated evidence of heat soak testing must be disclosed for all effected panes.

Alternatively where toughened glazing does not exceed 50kg in weight and where there is safe and easy access to remove and replace the glazing without the need for access scaffolding or fall arrest equipment, a methodology statement of how this will be undertaken should be provided.

9.

Stairs

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

1. Stairs and landings must have appropriate guarding to meet the relevant regional Building Regulations.
2. Staircases, ramps and guards shall be designed and constructed so that they:
    a. Offer safe passage between levels in the building;
    b. Provide a safe means of escape in case of fire;
    c. Where necessary, provide a safe means of access for ambulant disabled people;
    d. Are structurally sound;
    e. Adequately protect the user from the risk of falling;
    f. Are adequately lit.
3. Access staircases in flats which form part of the separation between flats and between other parts of the same building shall:
    a. Have adequate resistance to the spread of fire;
    b. Have adequate resistance to the passage of sound.

Limitations of Functional Requirements

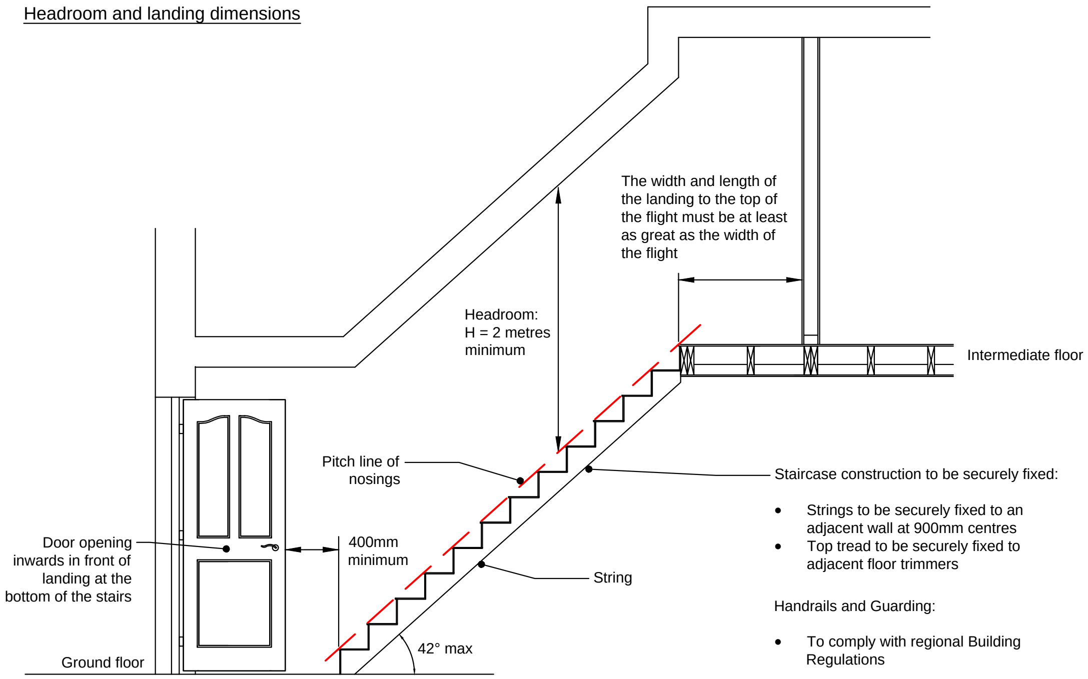
1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

9.

Stairs

9.1
Timber

Headroom and landing dimensions



Stairways

Staircases, newels, balustrades and handrails are to be adequately fixed to avoid excessive deflection.

Strings are required on staircases to provide a secure fix to an adjacent wall, that should be constructed of masonry or timber. The top tread should not be solely relied upon for fixing. It is recommended that stair strings should have fixings at 900mm centres. The fixings should be at least 6mm diameter screws that penetrate into the masonry wall or timber stud by at least 60mm.

Unless it is for a means of entrance/exit within a communal type building, there is no longer guidance given for a minimum width of a staircase. In these circumstances, the width and pitch, etc. will be determined by the use of the building.

Where a staircase serves an individual property, the need is for it to provide a safe means of access between different levels.

All staircases are to have:

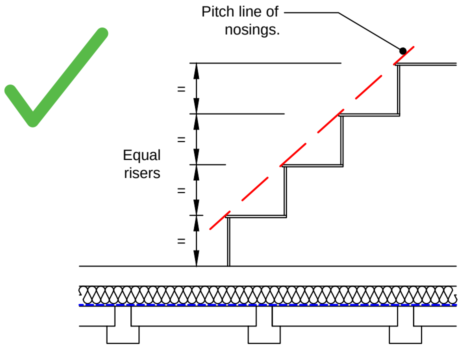
- A maximum rise of 220mm, with a minimum going of 220mm, although the stair pitch, which is a line connecting all nosing's, should not exceed 42°.
- The dimensions for maximum rise and minimum going should be as detailed in the table below.
- At its narrowest point, the minimum width of a winder tread should be no less than 50mm.
- The minimum headroom over the flight and landing should be 2m.

Rise and going requirements for stairs

Type of stairs	**Maximum rise (mm)**	**Minimum going (mm)**
Private stairs	220	220 (225 Scotland)
Common stairs	190 (170 Scotland)	250
Access stairs	170	250

For buildings other than dwellings, make the step 'nosings' apparent with a permanent secure strip that contrasts visually, a minimum of 55mm wide on both the tread and the riser.

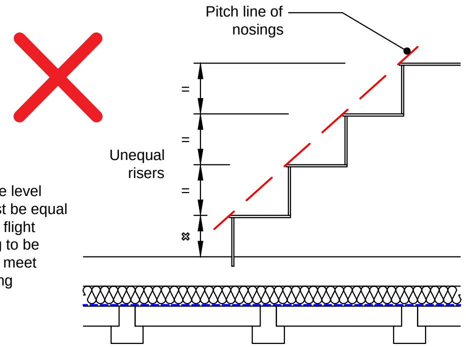
Flight constructed of equal risers



Note:

- Treads must be level
- The risers must be equal throughout the flight
- Rise and going to be consistent and meet regional Building Regulations

Flight must not consist of unequal risers



Handrails and guarding

Handrails and guarding over the flight and landing should be established at a height of between 900mm and 1000mm. It should be non-climbable, and any gap within a riser or guarding should not exceed 99mm.

Handrail design should ensure:

- A firm handhold.
- Trapping or injuring the hand is prevented.
- A minimum 25mm clearance at the back of the handrail.
- Secure fixing.

Where the staircase is greater than or equal to 1000mm in width, a handrail should be provided to both sides of the staircase.

Landings

Landings must be provided at the top and bottom of every flight and should be:

- The width and length at least as great as the smallest width of the flight (also, in buildings other than dwellings; have an unobstructed length of at least 1200mm).
- Be kept clear of permanent obstructions including opening doors, except in a building where a door may swing across the landing at the bottom of a flight providing there is a clear unobstructed landing of at least 400mm deep maintained between the flight and the opening swing of the door.
- Inside the building, landings must be level.
- Landings are to be properly framed to provide full support to, and secure fixings, for flights, nosing's, newels, apron linings etc.

Headroom

The overall floor opening is to be checked for the size required to accept the stairs and allow for sufficient headroom.

- The minimum headroom above the stairs is to be measured vertically from the pitch line.
- The clear headroom should be 2m over the entire length and width of a stairway, including landings.

Overall vertical rise

Staircases are traditionally manufactured off-site, so the floor-to-floor dimensions should be extremely accurate, although an allowance should be made for floor finishes to structural floors or staircase treads.

Pitch

Staircases should be accurately located and fixed with the string at the correct angle, so that all treads are horizontal. The pitch should be suitable or the intended use in accordance with the relevant regional Building Regulations.

The maximum angle of pitch of a stairway should not exceed 42° for private stairs.

Floor finishes

Allowance should be made for stair and floor finishes, ensuring that all risers are equal.

Lighting

Artificial light sources should be provided to all staircases and landings. Within a building, lighting to stairs should be controlled by two-way switching.

Automatic light-sensitive controls may be used in common areas, provided lights can also be two-way switched manually.

Where staircases are lit by glazing, any glass immediately adjacent to the stair should be:

- Protected by a balustrade or railing, or
- Toughened or laminated glass, and non openable, or
- Constructed of glass blocks.

Decoration

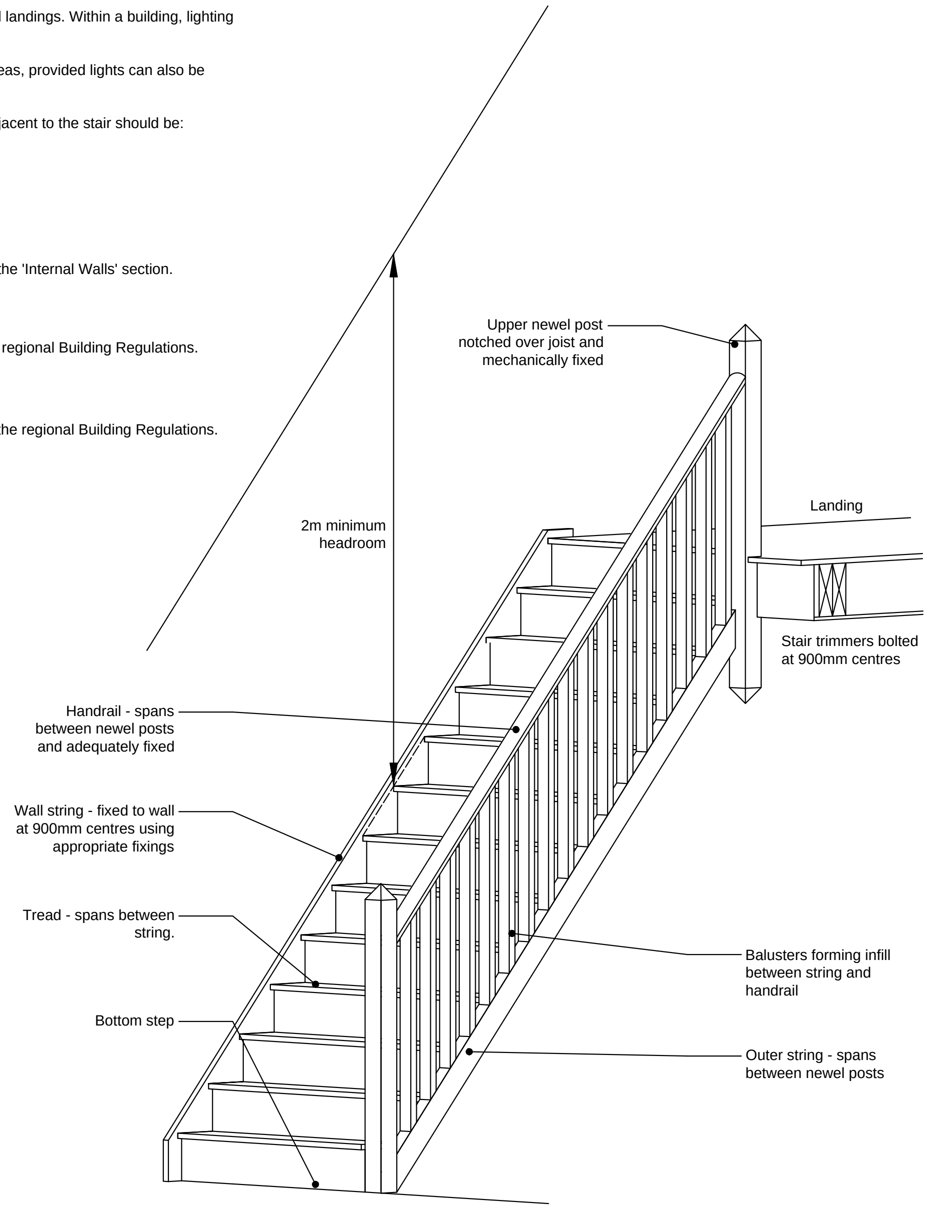
Further guidance on painting and decorating can be found in the 'Internal Walls' section.

Fire resistance

Stairs should have the appropriate fire resistance to meet the regional Building Regulations.

Sound resistance

Stairs should have the appropriate sound resistance to meet the regional Building Regulations.



Staircase: Straight flight

10.

Upper Floors

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. Fire stopping and cavity barriers are to be completed by a third-party approved contractor for all flats and apartments with a floor 4.5m above ground level.

Materials

1. Fire stopping and cavity barrier materials are to have relevant third-party certification confirming suitability in its application.

Design

1. Party floors between buildings must achieve satisfactory levels of sound insulation to meet the relevant requirements of the Building Regulations.
2. Layouts indicating the positions of compartment walls/floors and other lines of fire resistance must be provided for all flats and apartments with a floor 4.5m above ground level and must demonstrate compliance with regional Building Regulations.
3. Upper floors - (including separating floors) shall be designed and constructed so that they:
   a. Provide suitable surfaces for normal use activities;
   b. Are structurally sound;
   c. Are durable and resistant to moisture;
   d. Have adequate resistance to the effects of fire and surface spread of flame;
4. Separating floors - floors which separate a building from other parts of the same building (such as in flats) shall be designed and constructed so that they:
   a. Have adequate resistance to the spread of fire between buildings, and between buildings and other buildings;
   b. Have adequate resistance to the passage of sound between buildings, and between buildings and other buildings.
5. Separating floor between the dwelling area and garage or outside - within a Housing Unit shall be designed and constructed so that they:
   a. Have adequate resistance to the spread of fire between garage, and dwelling area;
   b. Prevent undue heat losses from the dwelling area to unheated garage or outside.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

10.

Upper Floors

10.1

Suspended Timber

10.1.1 SUSPENDED TIMBER: Layout of joists and bearing requirements on to masonry walls

Floor Joists

For advice on sizing of certain timber members of floors, the Designer should refer to the following sources:

- Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. Published by BM TRADA. Note: Reference should be made to the version of the BM TRADA document current at the time of construction of the floor/ceiling or roof.
- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

It is essential that joists are not overloaded during construction. Joints in joists should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

Joists should have a minimum end bearing of 90mm, unless joist hangers are used, where a 35mm bearing is acceptable (subject to the manufacturer's details).

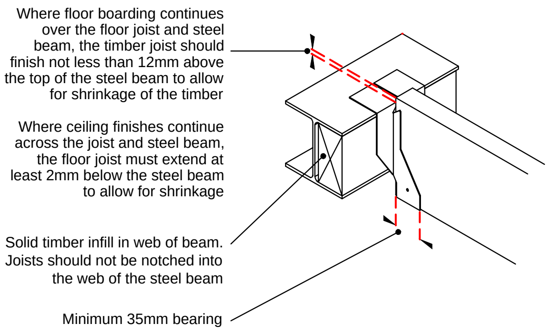
Steel beams

Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft) please follow the requirements for additional corrosion protection in 'Appendix B - Coastal Locations' and ' Appendix C - Materials, Products, and Building Systems'.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

Steel beam bearing

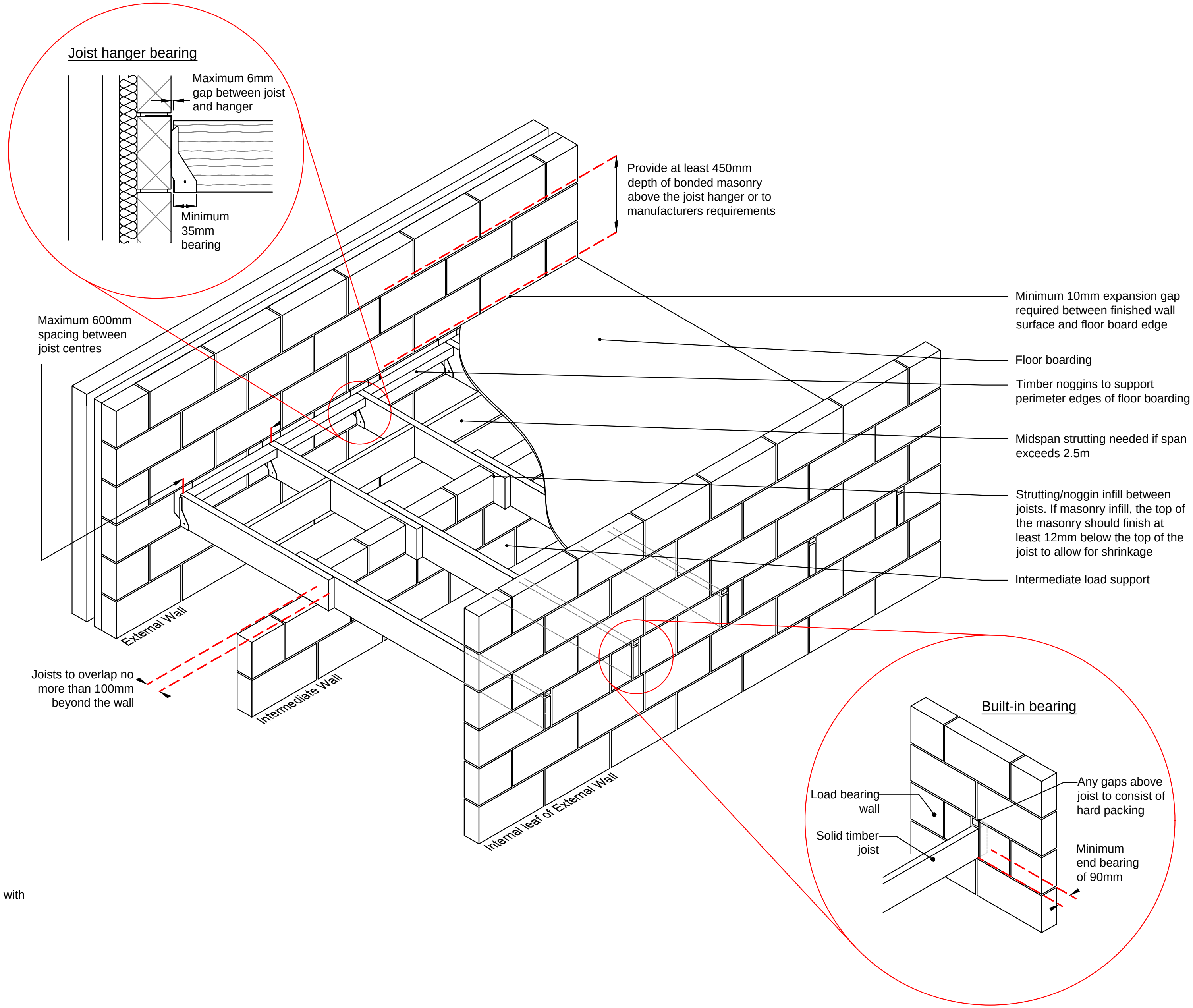


Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:
- Lateral restraint straps.
- Restraint type joist hangers.
- Other forms of restraint proven by a Chartered Engineer.

Further guidance can be found in the 'External Walls' section.



Floor Joists

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- BS EN 1995, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

It is essential that joists are not overloaded during construction. Joints in joists should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

Joists should have a minimum end bearing of 90mm, unless joist hangers are used, where a 35mm bearing is acceptable (subject to the manufacturer's details).

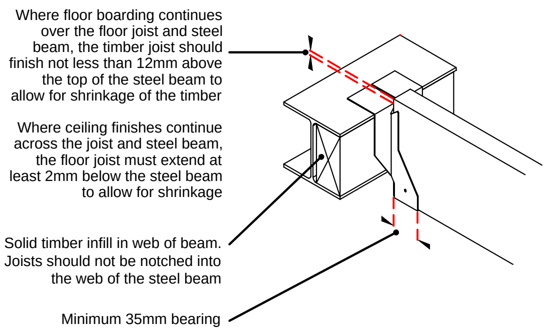
Steel beams

Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft) please follow the requirements for additional corrosion protection in in 'Appendix B - Coastal Locations' and ' Appendix C - Materials, Products, and Building Systems'.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

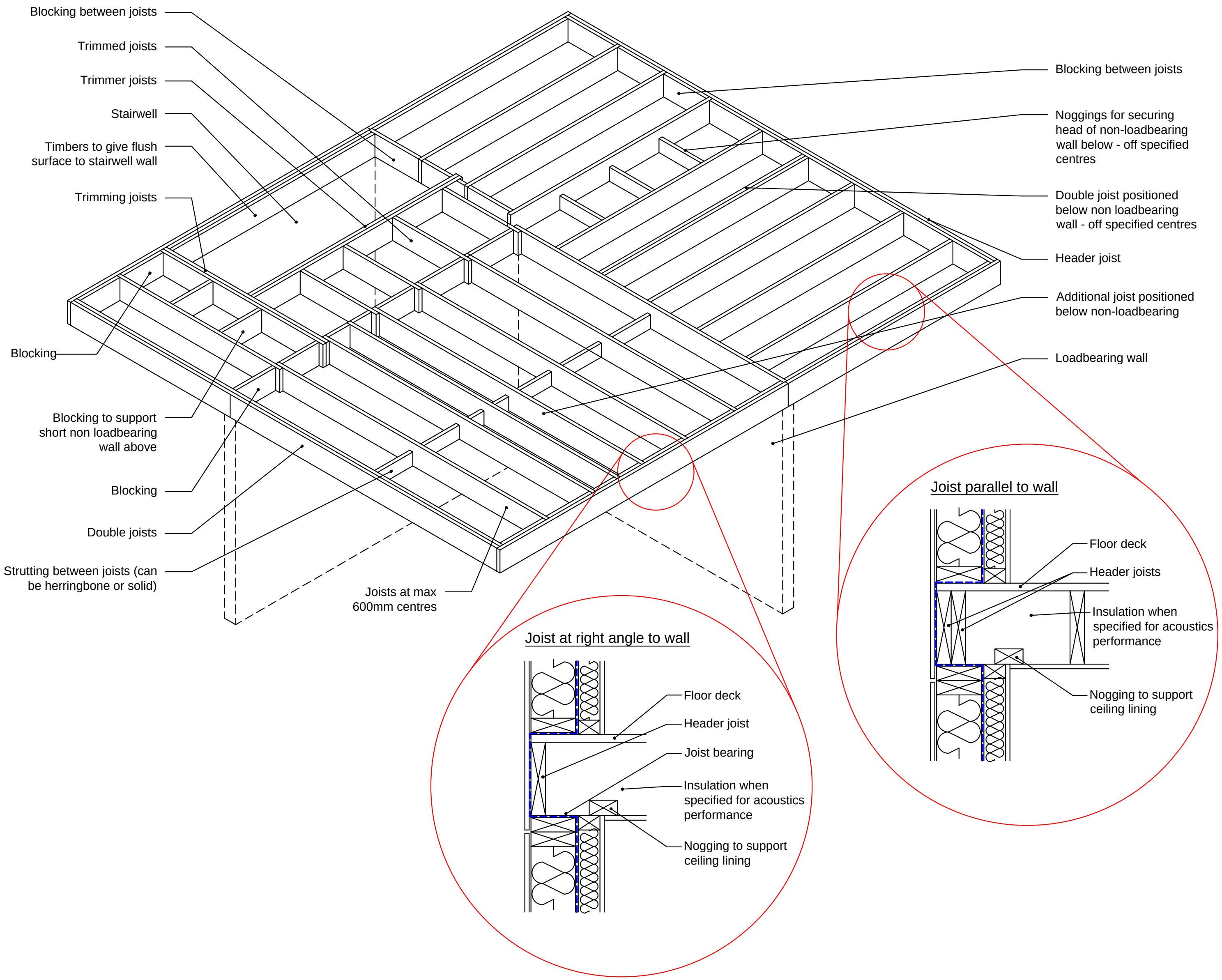
Steel beam bearing



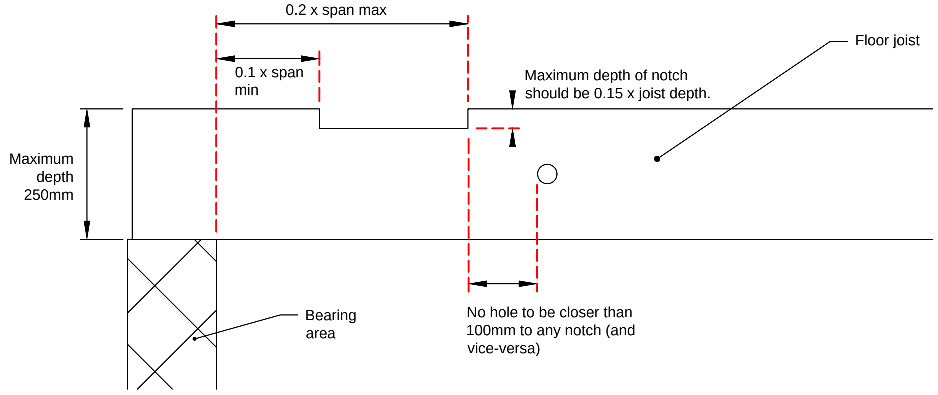
Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

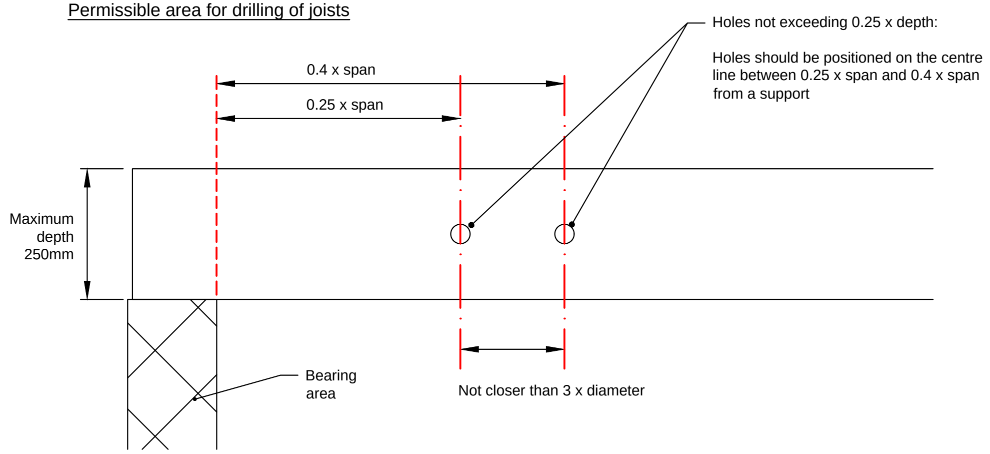
Further guidance can be found in the 'External Walls' section.



Permissible area for notching of joists



Permissible area for drilling of joists



Notching and drilling in solid timber joists basic guide

Requirements for notching and drilling of solid timber joists (further guidance can be found in BS 8103, TRADA span tables, BS EN 1996 and PD 6693 - 1), this guidance is for joists up to 250mm deep, notching and drilling for joists exceeding this depth should be designed by a Structural Engineer.

Notches: Notches should be made in between 0.1 and 0.2 x span. Notches should be no deeper than 0.15 x depth of the joists in this area. e.g. For a 250mm deep joist, the maximum notch depth should not exceed 35mm.

Holes: Holes should be drilled on the centre line of the joist. Holes should be between 0.25 and 0.4 x the span. Holes should be a maximum diameter of 0.25 x the joists depth and kept apart by at least 3x the diameter. The maximum hole diameter should not exceed 65mm.

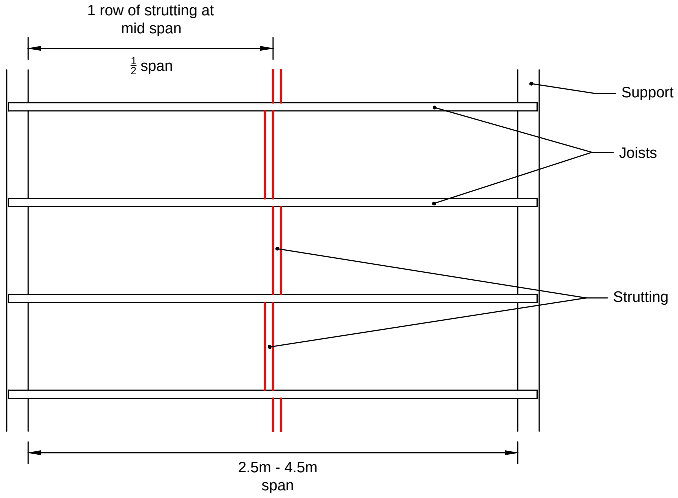
Note: Notches and holes should be a minimum of 100mm apart.

The table below gives an indication of the areas in a joist which are suitable for notching and drilling.

Typical permissible zones for notching and drilling of solid timber joists

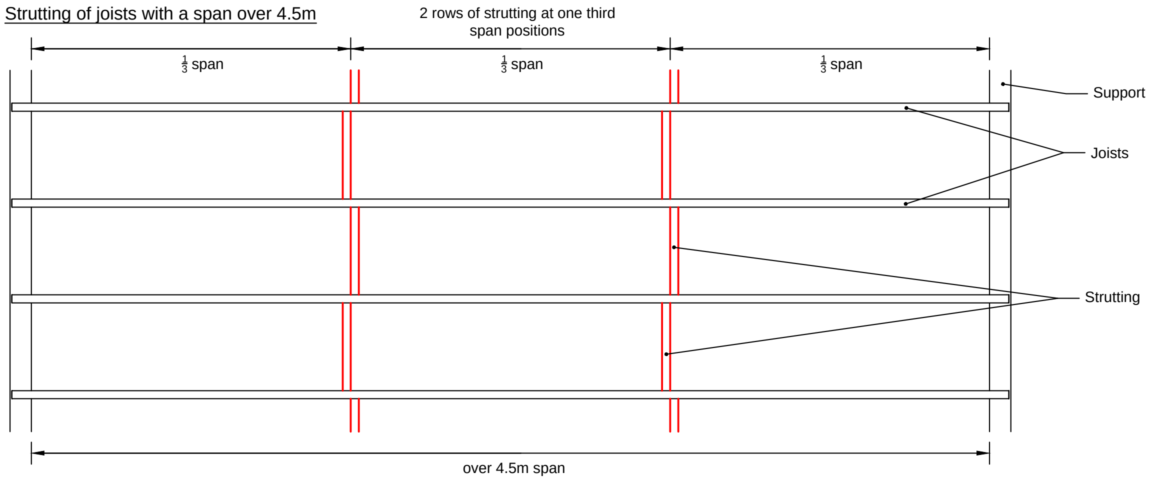
Span (m)	**Notches to be taken out only within these zones (m)**		**Holes only to be drilled within these zones (m)**	
1.5	0.15	0.30	0.375	0.6
2	0.2	0.4	0.5	0.8
2.5	0.25	0.5	0.625	1
3.0	0.3	0.6	0.75	1.2
3.5	0.35	0.7	0.875	1.4
4	0.4	0.8	1	1.6
4.5	0.45	0.9	1.125	1.8
5	0.5	1	1.25	2

Strutting of joists with a span between 2.5m and 4.5m



Where the span of a floor joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with Figure 3 of BS 8103-3: 2009 or by a proprietary system

Strutting of joists with a span over 4.5m



Where the span of a floor joist or flat roof joist is more than 4.5m, two rows of strutting at 1/3rd the span position will be necessary

Strutting or bridging of solid timber floor joists

Where the span of a floor joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with Figure 3 of BS 8103-3: 2009 or by a proprietary system.

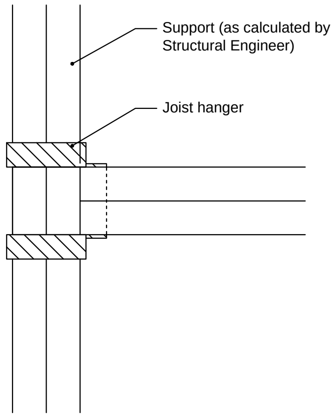
Timber strutting can be in the form of solid bridging of at least 38mm basic thickness and with a depth equal to at least three-quarters of the depth of the joists; or it can consist of herringbone strutting with members of at least 38mm by 38mm basic size. Herringbone strutting should not be used where the distance between the joists is more than approximately three times the depth of the joists.

Deflection of floors

For upper floors (intermediate floors), designers and engineers must observe our tolerance requirements for levelness of floors. Please refer to the 'Tolerances' section for further guidance.

There may be an instance where a joist might be designed to meet permissible deflections with a relevant British Standard; however, our tolerance requirements will take precedence.

Typical trimming detail (plan)



Double joists should be bolted together at 600mm centres using minimum 10mm diameter bolts with large washers that will prevent the bolt head and nut from penetrating the joist. It is recommended that the bolting of double joists is along the centre line of joists. Suitably sized trimmer joists shall be provided around floor openings

Trimmed openings may be needed around staircase openings and chimneys. Solid trimmed joists may be supported using either joist hangers or a structurally designed connection; timber trimmers around openings should consist of at least two members and be designed by a Structural Engineer

10.

Upper Floors

10.2

I-joists

I-joists

Engineered timber I-joists include a timber flange (usually solid timber or laminated veneer lumber (LVL)) and a panel product web (usually OSB). They are manufactured in an assortment of depths and flange widths under controlled factory conditions to low and uniform moisture contents.

I-joists should be designed in accordance with BS EN 1995, Eurocode 5 design of Timber Structures. General: Common rules and rules for buildings. I-joists should be appropriately CE marked and comply with ETAG 011 or hold independent third party certification.

It is essential that joists are not overloaded during construction. Joints in joists should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

Joists should have a minimum end bearing of 90mm, unless joist hangers are used, where the minimum bearing should be to the manufacturers specifications.

Joist hangers should be detailed in the design, including confirmation that the joist hangers have the equivalent to restraint straps at 2m centres where required to provide restraint.

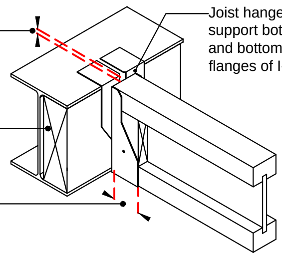
Steel beams

Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft) please follow the requirements for additional corrosion protection in 'Appendix B - Coastal Locations' and ' Appendix C - Materials, Products, and Building Systems'.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

Steel Bearing



Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

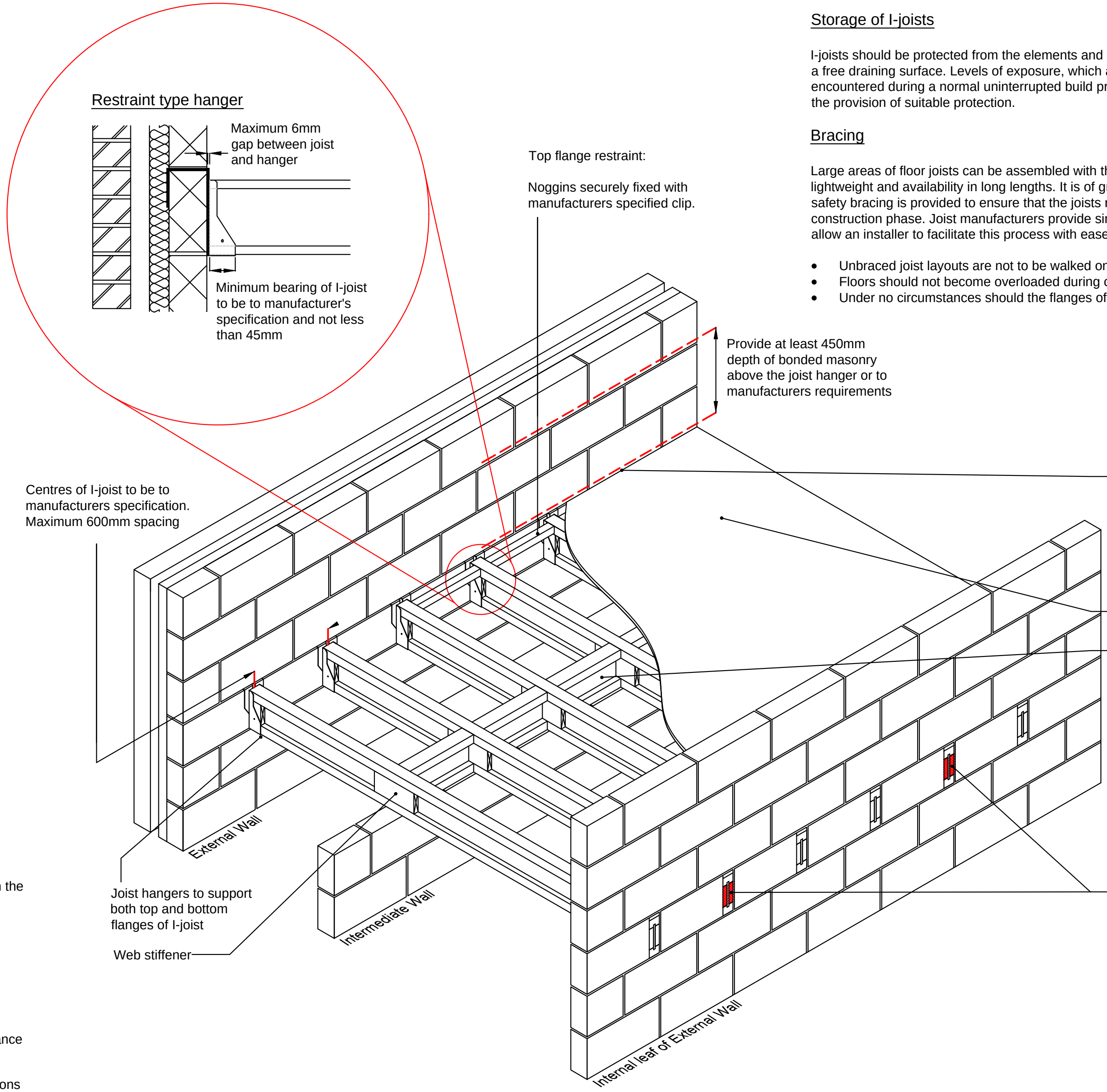
Restraint can be provided by:

- Restraint type joist hangers
- Lateral restraint straps
- Other forms of restraint proven by a Chartered Engineer

Deflection

For upper floors (intermediate floors), designers and engineers must observe our tolerance requirements for levelness of floors. Please refer to the 'Tolerances' section.

There may be an instance where a joist might be designed to meet permissible deflections within a relevant British Standard; however, our tolerance requirements will take precedence.



The top and bottom flanges must not be notched. Where ceiling and floor boards are nailed to the flanges, care must be taken to avoid splitting of the flange member.

Storage of I-joists

I-joists should be protected from the elements and supported on suitable bearers over a free draining surface. Levels of exposure, which are more severe than those encountered during a normal uninterrupted build programme should be addressed by the provision of suitable protection.

Bracing

Large areas of floor joists can be assembled with these products due to their lightweight and availability in long lengths. It is of great importance that adequate safety bracing is provided to ensure that the joists remain stable through the construction phase. Joist manufacturers provide simple guide recommendations that allow an installer to facilitate this process with ease and speed.

- Unbraced joist layouts are not to be walked on by workers.
- Floors should not become overloaded during construction.
- Under no circumstances should the flanges of the I-joist be cut, notched or drilled.

I-JOISTS: Layout of joists and bearing requirements on to a timber frame

I-joists

Engineered timber I-joists include a timber flange (usually solid timber or laminated veneer lumber (LVL)) and a panel product web (usually OSB). They are manufactured in an assortment of depths and flange widths under controlled factory conditions to low and uniform moisture contents.

I-joists should be designed in accordance with BS EN 1995, Eurocode 5 design of Timber Structures. General: Common rules and rules for buildings. I-joists should be appropriately CE marked comply with ETAG 011 or hold independent third party certification.

It is essential that joists are not overloaded during construction. Joints in joists, rafters and purlins should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

Joists should have a minimum end bearing of 90mm, unless joist hangers are used, where the minimum bearing should be to the manufacturers specifications.

Joist hangers should be detailed in the design, including confirmation that the joist hangers have the equivalent to restraint straps at 2m centres where required to provide restraint.

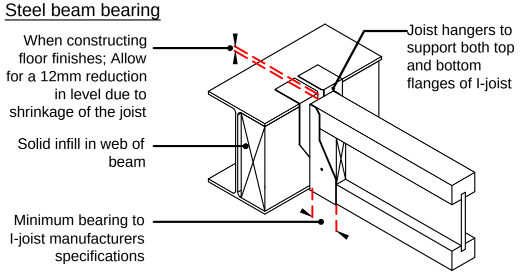
Steel Beams

Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft) please follow the requirements for additional corrosion protection in 'Appendix B - Coastal Locations' and ' Appendix C - Materials, Products, and Building Systems'.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

Steel beam bearing



Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

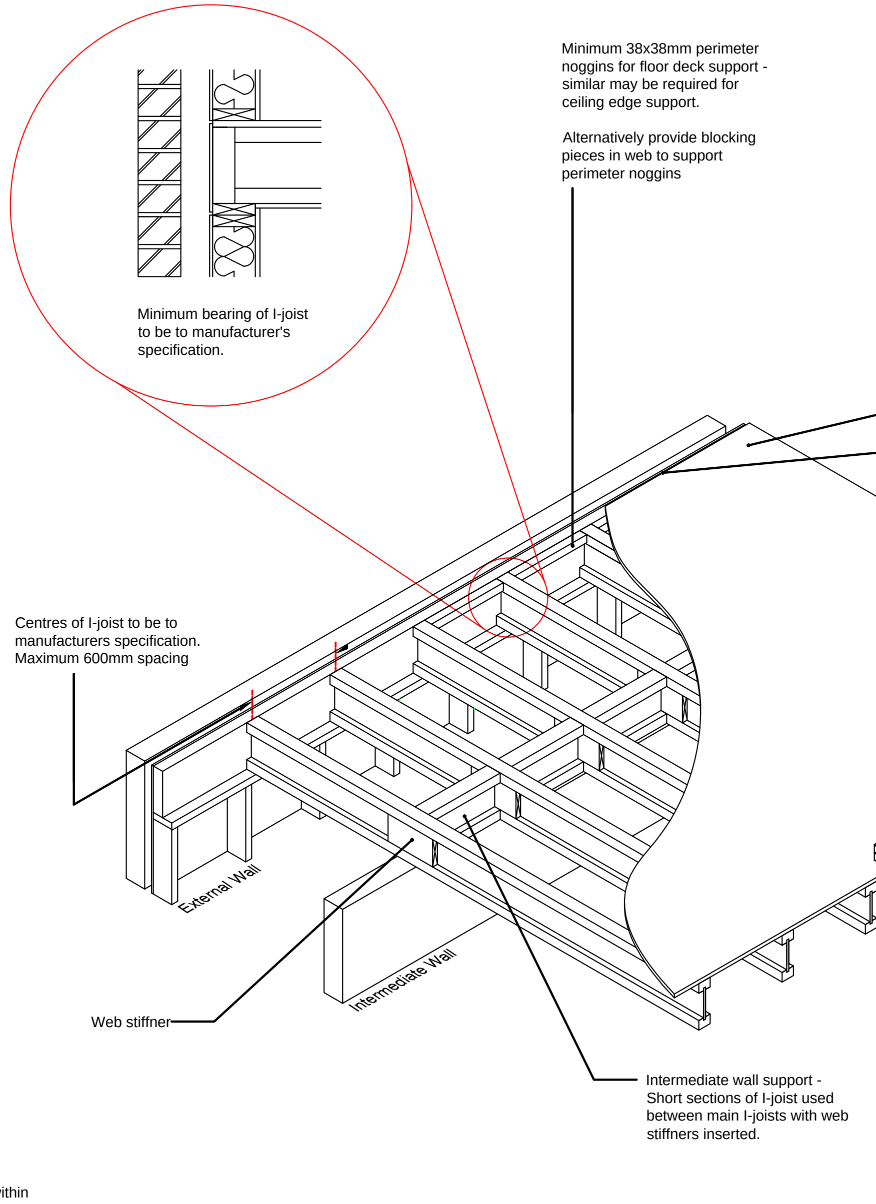
Restraint can be provided by:

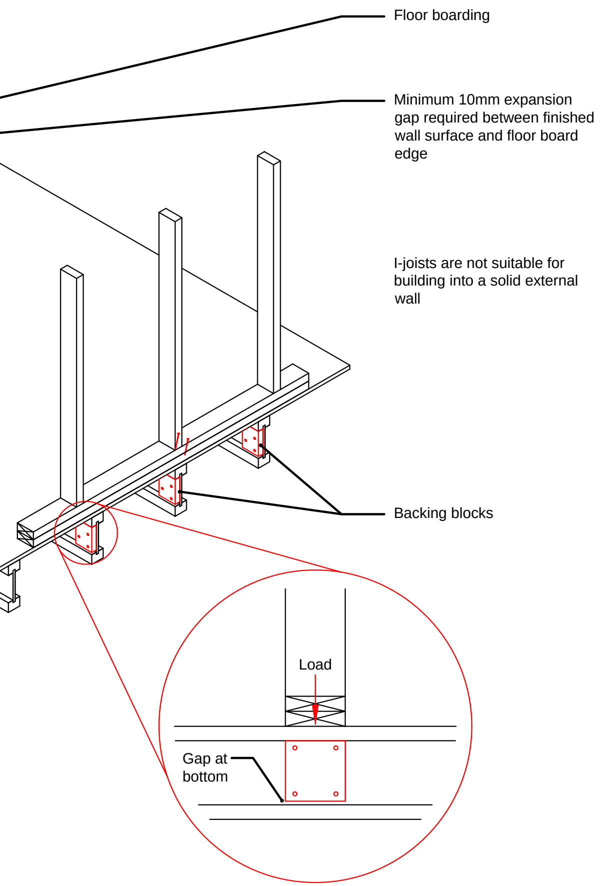
- Restraint type joist hangers
- Lateral restraint straps
- Other forms of restraint proven by a Chartered Engineer

Deflection

For timber floors (intermediate floors), designers and engineers must observe our tolerance requirements for levelness of floors. Please refer to the 'Tolerances' section.

There may be an instance where a joist might be designed to meet permissible deflections within a relevant British Standard; however, our tolerance requirements will take precedence.





The top and bottom flanges must not be notched. Where ceiling and floor boards are nailed to the flanges, care must be taken to avoid splitting of the flange member.

Storage of I-joists

I-joists should be protected from the elements and supported on suitable bearers over a free draining surface. Levels of exposure, which are more severe than those encountered during a normal uninterrupted build programme should be addressed by the provision of suitable protection.

Bracing

Large areas of floor joists can be assembled with these products due to their lightweight and availability in long lengths. It is of great importance that adequate safety bracing is provided to ensure that the joists remain stable through the construction phase. Joist manufacturers provide simple guide recommendations that allow an installer to facilitate this process with ease and speed.

- Unbraced joist layouts are not to be walked on by workers.
- Floors should not become overloaded during construction.
- Under no circumstances should the flanges of the I-joist be cut, notched or drilled.

I-JOISTS: Lateral restraint, support of non load bearing partitions, and fixing of multiple i-joists

I-joist installation

The installation of I-joists must follow the manufacturer's guidance and specification for the project.

Lateral restraint straps

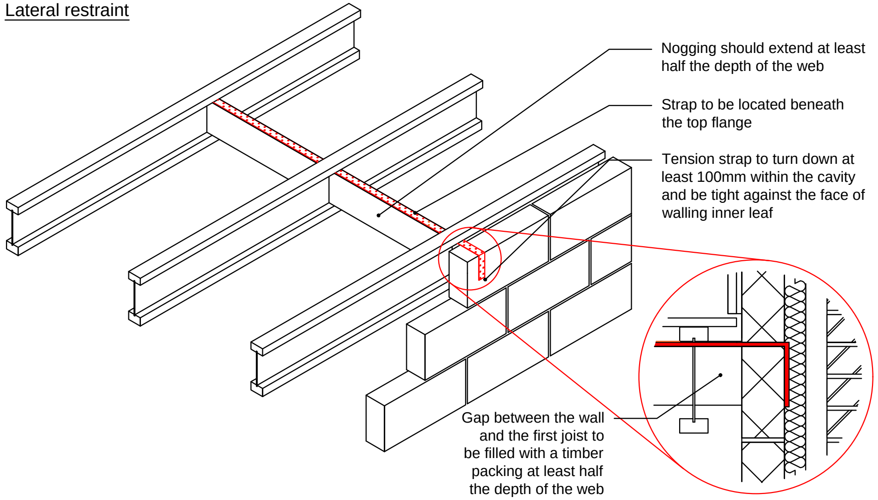
Floors should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanized or stainless steel restraint straps at 2m centres.

Straps need not be provided to floors at, or about, the same level on each side of a supported wall and at the following locations:

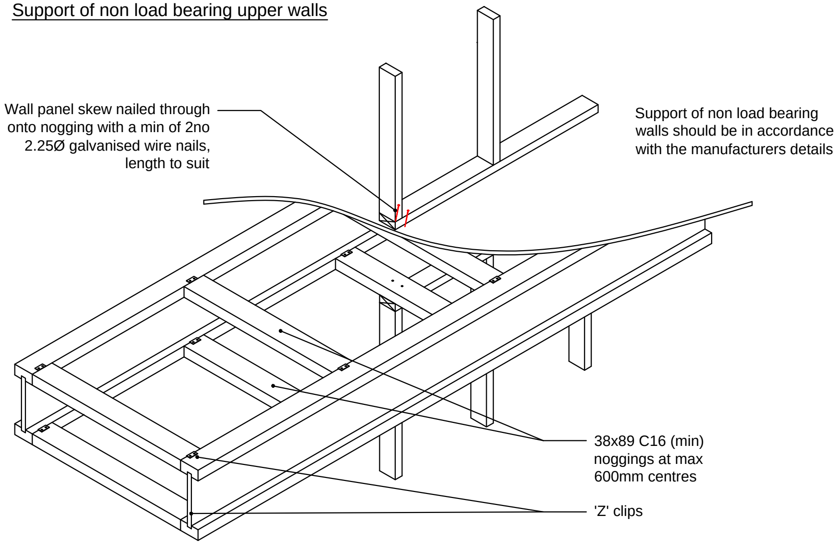
Timber floors in two storey dwellings where:

- Joists are at maximum 1.2m centres and have at least 90mm bearing on supported walls or 75mm bearing on to a timber wall plate.
- Carried by the supported wall by restraint type joist hangers as described in BS 5268: 7.1.

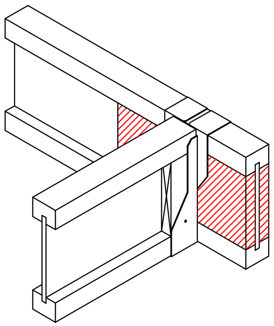
Lateral restraint



Support of non load bearing upper walls

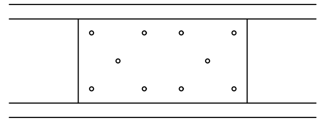


Backer blocks



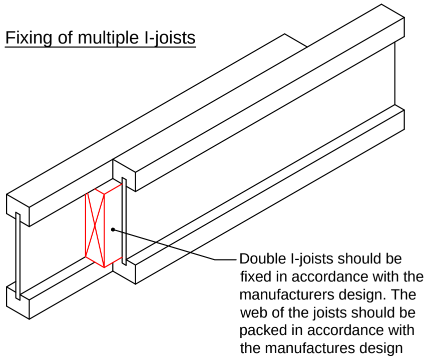
Trimmed openings may be needed around staircase openings and chimneys. Solid trimmed joists may be supported using joist hangers. Timber trimmers around openings should consist of at least two members and be designed and installed in accordance with the manufacturers instructions. Where an I-joist is faced fixed to another I-joists backer blocks should be provided on both sides of the web of the trimmer.

Fixing of I-joists should be in accordance with the engineers design and specification. A timber filler block should be installed between I-joists.

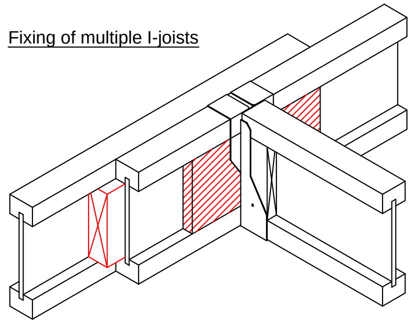


Backer blocks should be fixed in accordance with the manufacturer's design.

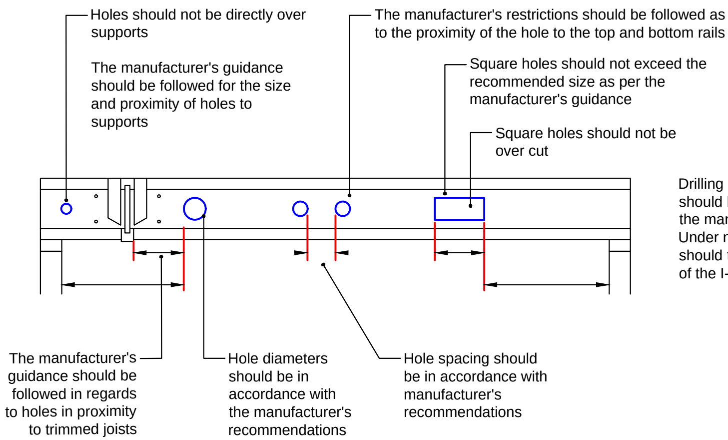
Fixing of multiple I-joists



Fixing of multiple I-joists



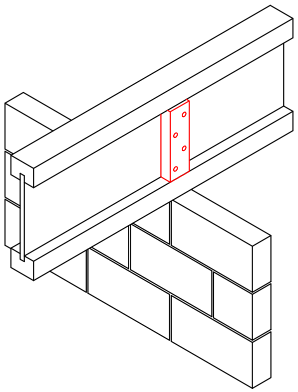
Notching and drilling of I-joists



Drilling and square holes should be in accordance with the manufacturers design. Under no circumstances should the top and bottom rails of the I-joists be notched

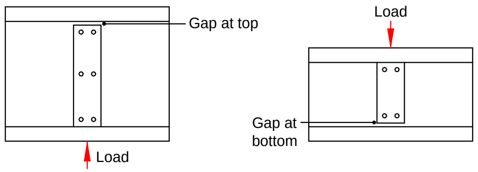
Building in of I-joists over internal walls

To reduce shrinkage, all mortar should be adequately dry and solidly packed in, but it should not be packed up tight to the underside of the top flange. Before the floor decking is fixed, all continuous joists must be packed down to the intermediate bearing wall.



Additional blocking should be installed in accordance with the manufacturers instructions.

Generally a gap is required at the top or bottom of the packing, dependent on the direction of the load. Generally if the load comes from the bottom e.g. bearing on an internal wall the gap should be at the top. If the load is from the top the gap should be provided at the bottom.

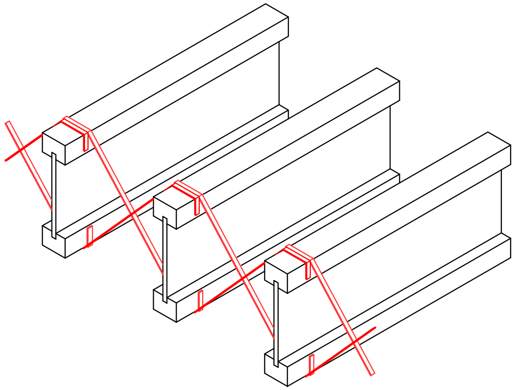


The backing blocks should be fixed in accordance with the manufacturers design. Generally, backing blocks on deeper joists require a higher number of fixings.

Proprietary strutting devices

Solid strutting is difficult to install between I-joists and propriety strutting maybe used as an alternative.

The most widely used types of proprietary strutting device are steel herringbone systems. These are generally pressed lengths of galvanized mild steel, usually 1mm thickness and are produced in a variety of lengths to suit differing joist depths and spacing's.

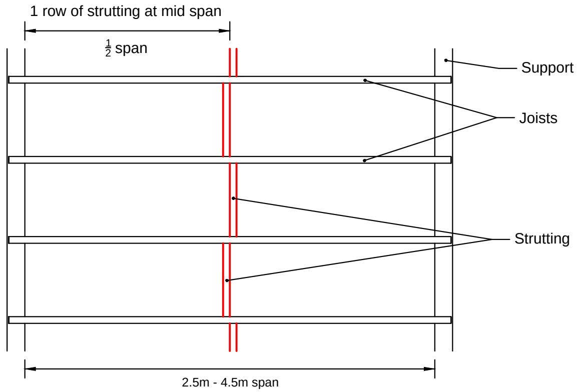


Strutting or bridging

Strutting or bridging of I-joists should be installed in accordance with the manufacturers requirements at centres no greater than those recommended in the Eurocode 5 span tables.

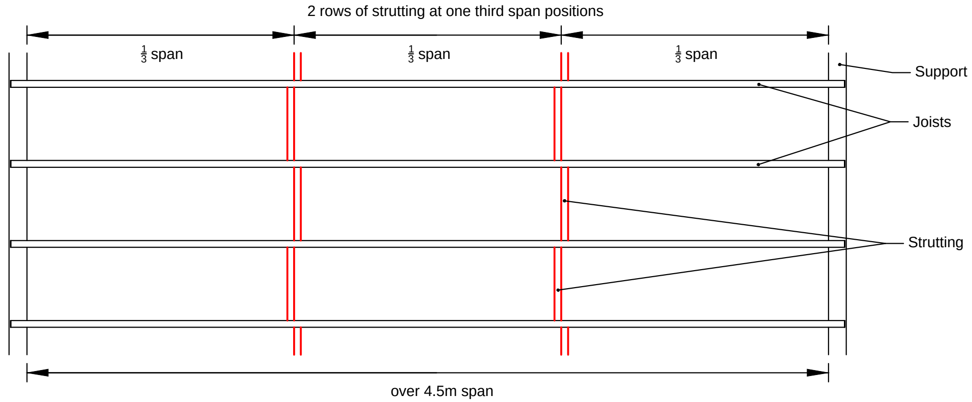
Joist span (m)	Rows of strutting
up to 2.5	None
2.5 - 4.5	1 at mid-span
over 4.5	2 at 1/3 points

Strutting of joists with a span between 2.5m and 4.5m



Where the span of a floor joist or flat roof joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with the manufacturers design.

Strutting of joists with a span over 4.5m



Where the span of a floor joist or flat roof joist is more than 4.5m, two rows of strutting at 1/3rd the span position will be necessary.

10.

Upper Floors

10.3
Metal Web

Metal web joists

Consists of parallel stress graded timber flanges joined together with V-shaped galvanised steel webs. The webs are fixed to the flanges via nail plates. The open web design gives great flexibility in running through services.

Metal web joists should be designed in accordance with BS EN 1995, Eurocode 5 design of Timber Structures. General: Common rules and rules for buildings.

Metal web joists should be appropriately CE marked comply with ETAG 011 or hold independent third party certification.

It is essential that joists are not overloaded during construction. Joints in joists should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

The minimum end bearing of the joists should be in accordance with the manufacturers instruction and the site specific design. Generally the minimum end bearing should be no less than 90mm, unless joist hangers are used, where the minimum bearing should be to the manufacturers specifications.

Steel beams

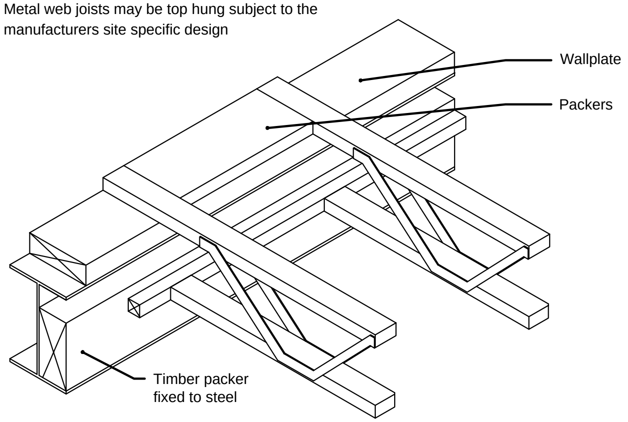
Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft) please follow the requirements for additional corrosion protection in 'Appendix B - Coastal Locations' and ' Appendix C - Materials, Products, and Building Systems'.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

Steel beam bearing

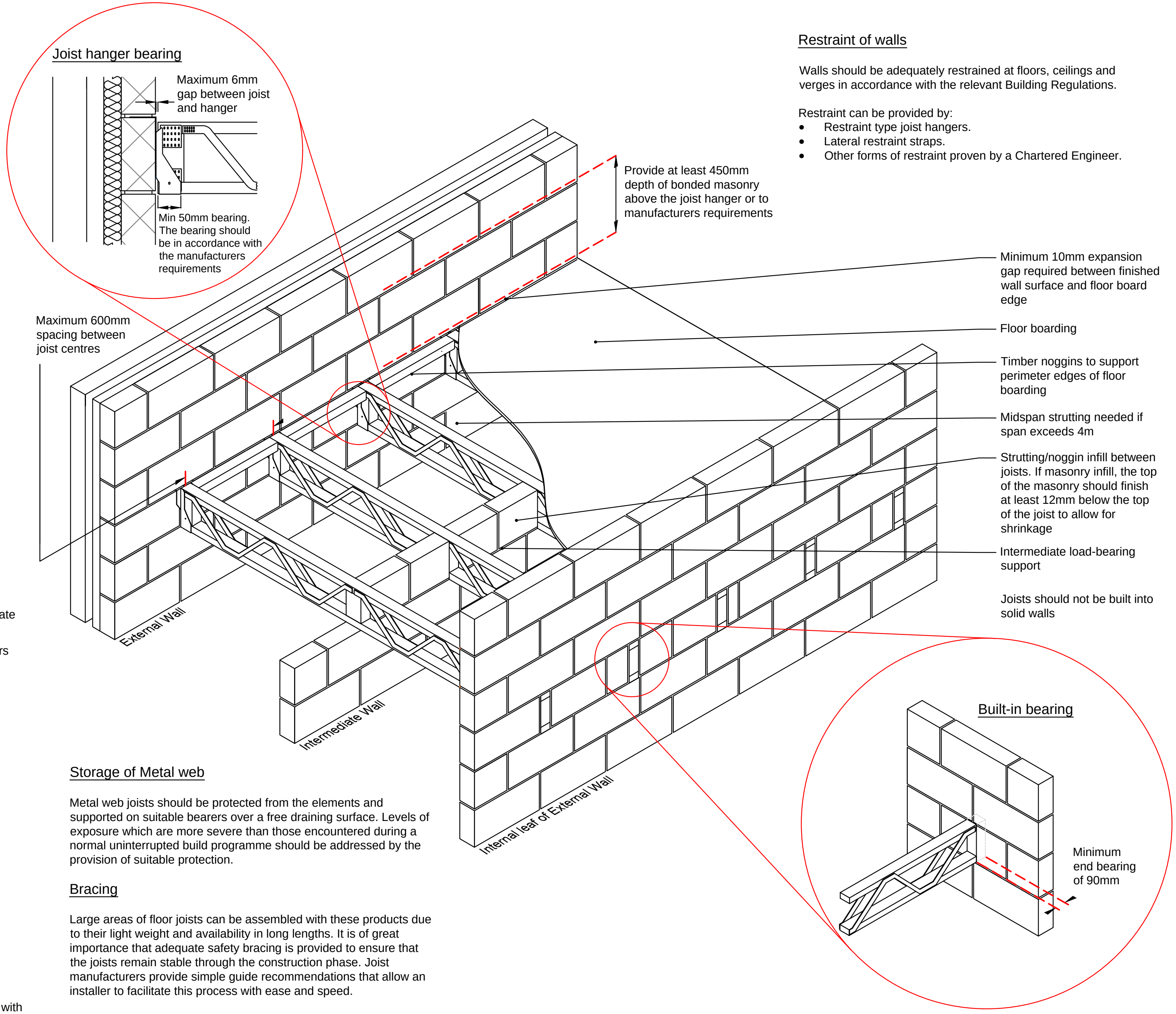
Metal web joists may be top hung subject to the manufacturers site specific design



Deflection

For upper floors (intermediate floors), designers and engineers must observe our tolerance requirements for levelness of floors. Please refer to the 'Tolerances' section.

There may be an instance where a joist might be designed to meet permissible deflections with a relevant British Standard; however, our tolerance requirements will take precedence.



Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:

- Restraint type joist hangers.
- Lateral restraint straps.
- Other forms of restraint proven by a Chartered Engineer.

Storage of Metal web

Metal web joists should be protected from the elements and supported on suitable bearers over a free draining surface. Levels of exposure which are more severe than those encountered during a normal uninterrupted build programme should be addressed by the provision of suitable protection.

Bracing

Large areas of floor joists can be assembled with these products due to their light weight and availability in long lengths. It is of great importance that adequate safety bracing is provided to ensure that the joists remain stable through the construction phase. Joist manufacturers provide simple guide recommendations that allow an installer to facilitate this process with ease and speed.

Unbraced joist layouts are not to be walked on by workers.

Floors should not become overloaded during construction.

Metal web joists

Consists of parallel stress graded timber flanges joined together with V-shaped galvanised steel webs. The webs are fixed to the flanges via nail plates. The open web design gives great flexibility in running through services.

Metal web joists should be designed in accordance with BS EN 1995, Eurocode 5 design of Timber Structures. General: Common rules and rules for buildings.

Metal web joists should be appropriately CE marked comply with ETAG 011 or hold independent third party certification.

It is essential that joists are not overloaded during construction. Joints in joists should only be in place over a load-bearing support, or the joint be designed by a qualified Structural Engineer.

Joists should be restrained at supports using tightly fitted strutting.

The minimum end bearing of the joists should be in accordance with the manufacturers instruction and the site specific design. Generally the minimum end bearing should be no less than 90mm, unless joist hangers are used, where the minimum bearing should be to the manufacturers specifications.

Steel beams

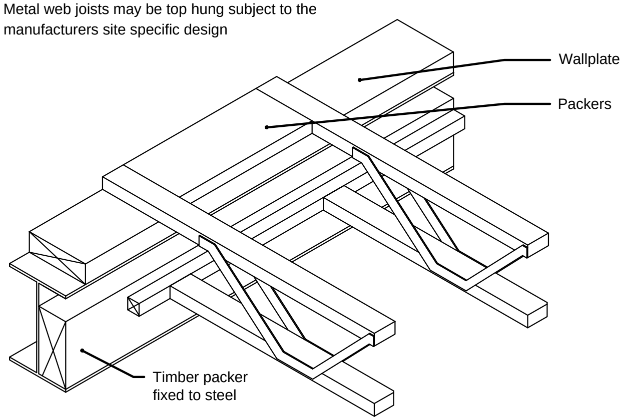
Steel beams should be designed by a suitably qualified Structural Engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft) please follow the requirements for additional corrosion protection in 'Appendix B - Coastal Locations' and ' Appendix C - Materials, Products, and Building Systems'.

To prevent the distortion of finishes, joists should be stopped from twisting over supports and provision provided to accommodate up to 12mm of drying shrinkage in floor joists supported by steel beams.

Steel beam bearing

Metal web joists may be top hung subject to the manufacturers site specific design

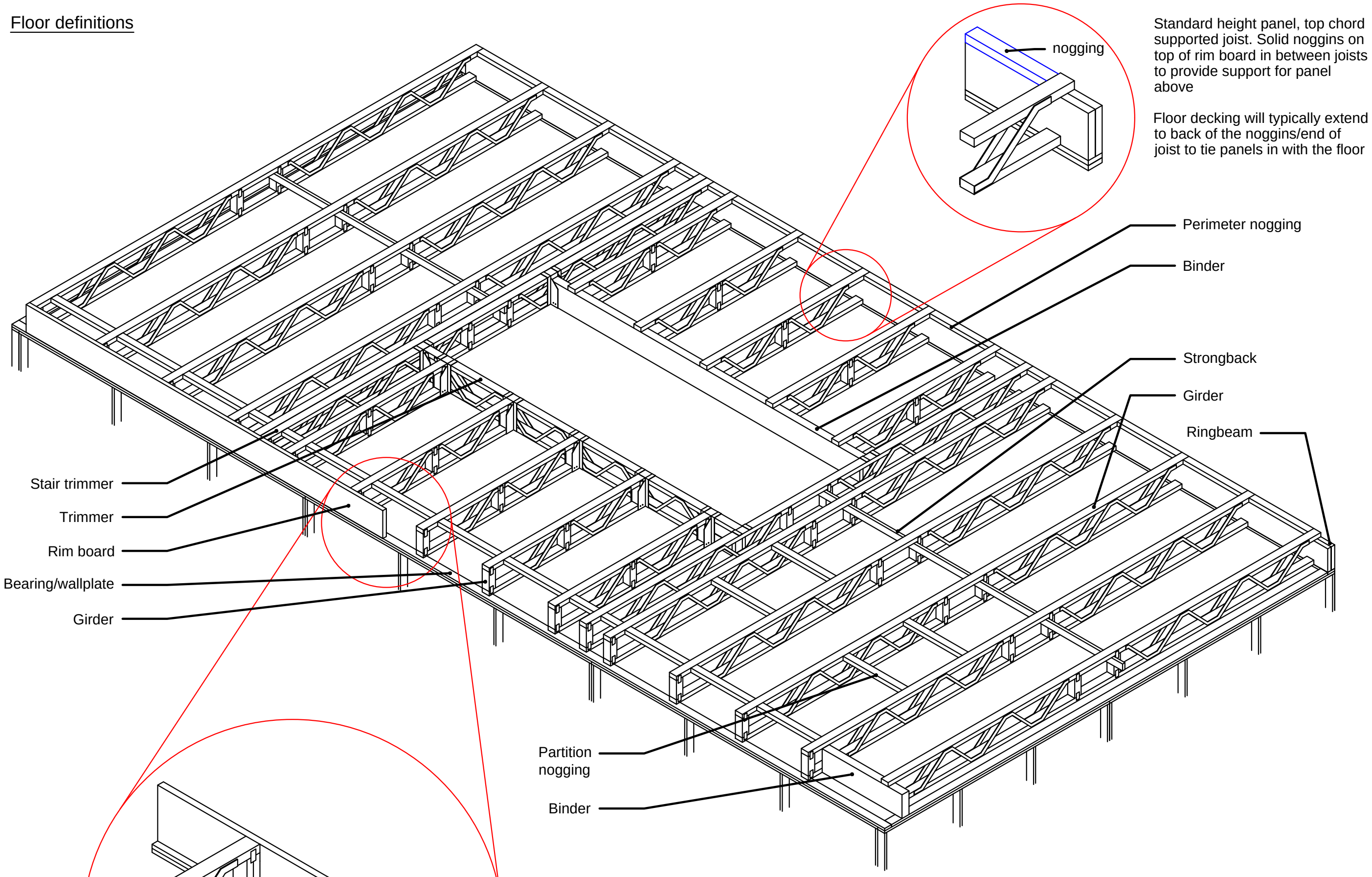


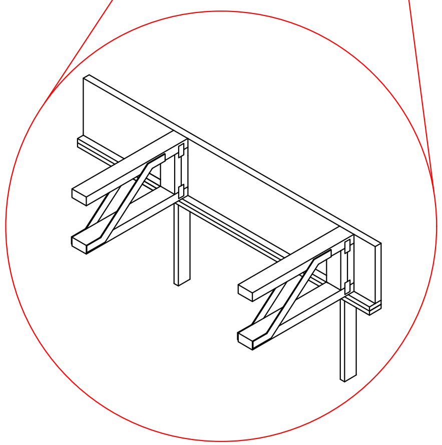
Deflection

For upper floors (intermediate floors), designers and engineers must observe our tolerance requirements for levelness of floors. Please refer to the 'Tolerances' section.

There may be an instance where a joist might be designed to meet permissible deflections with a relevant British Standard; however, our tolerance requirements will take precedence.

Floor definitions





Traditional arrangement - bottom chord supported joists on normal height panels. Rim board around outside closes off floor zone. Solid blocking in between joists provides support for panel above

Storage of Metal web

Metal web joists should be protected from the elements and supported on suitable bearers over a free draining surface. Levels of exposure which are more severe than those encountered during a normal uninterrupted build programme should be addressed by the provision of suitable protection.

Bracing

Large areas of floor joists can be assembled with these products due to their light weight and availability in long lengths. It is of great importance that adequate safety bracing is provided to ensure that the joists remain stable through the construction phase. Joist manufacturers provide simple guide recommendations that allow an installer to facilitate this process with ease and speed.

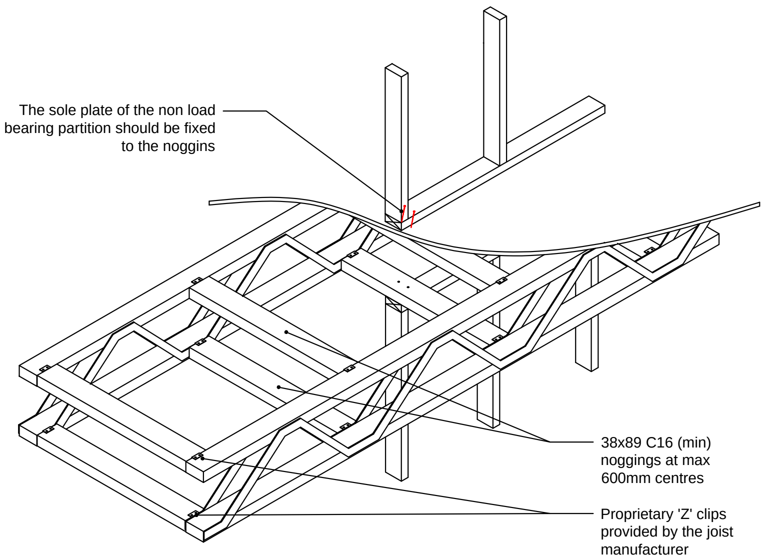
Unbraced joist layouts are not to be walked on by workers.

Floors should not become overloaded during construction.

Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Support of light-weight non load bearing partitions



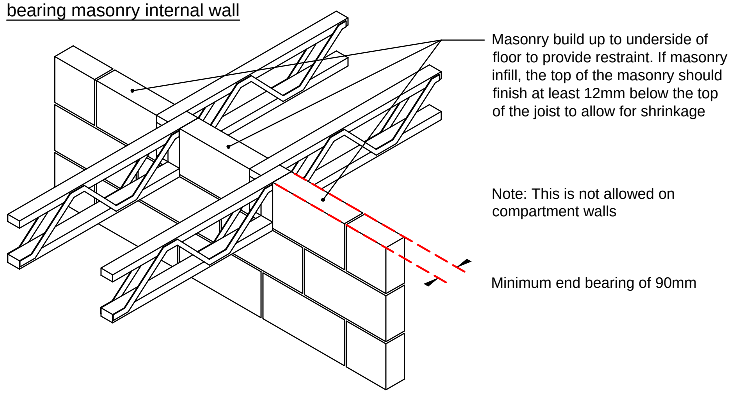
Where light weight non load bearing partition are parallel to the joists, they should be suitably supported in accordance with the manufacturers design.

Where metal web joists are used they should be:

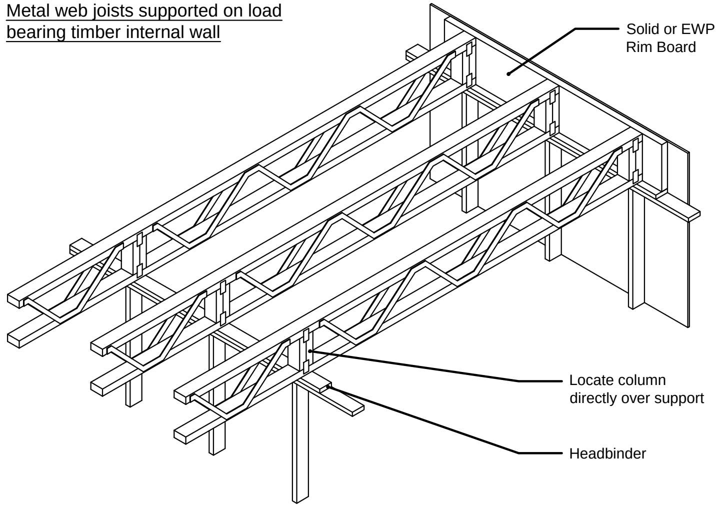
- Positioned centrally below a non load bearing partition. Double or triple joists should be provided in accordance with the manufacturers details and fixed with propitiatory fixings in accordance with the manufactures design.
- Or the weight of the partition should be supported by noggins or bearers fixed to joists with the floor systems propitiatory fixings on either side. The noggins should be at a maximum of 600mm centres and should be 38mm x 90mm unless designed otherwise.

Sole plates should be fixed to the noggins or joists.

Metal web joists supported on load bearing masonry internal wall

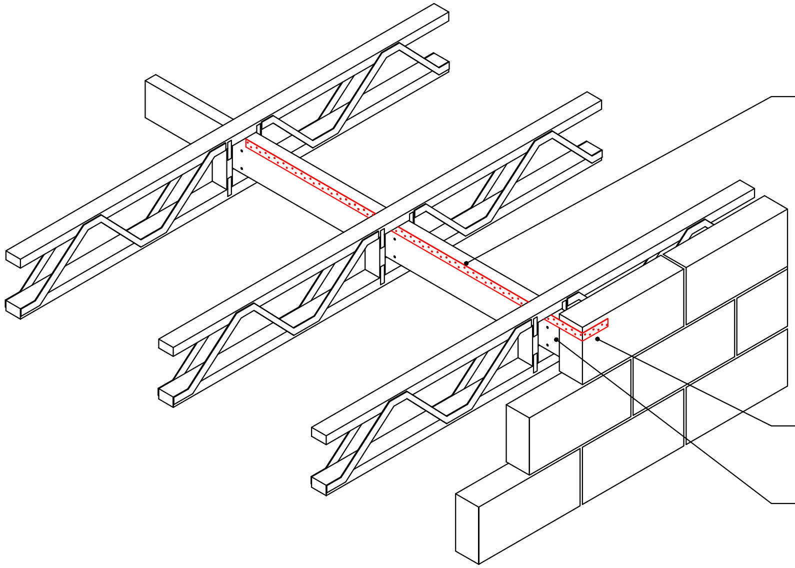


Metal web joists supported on load bearing timber internal wall

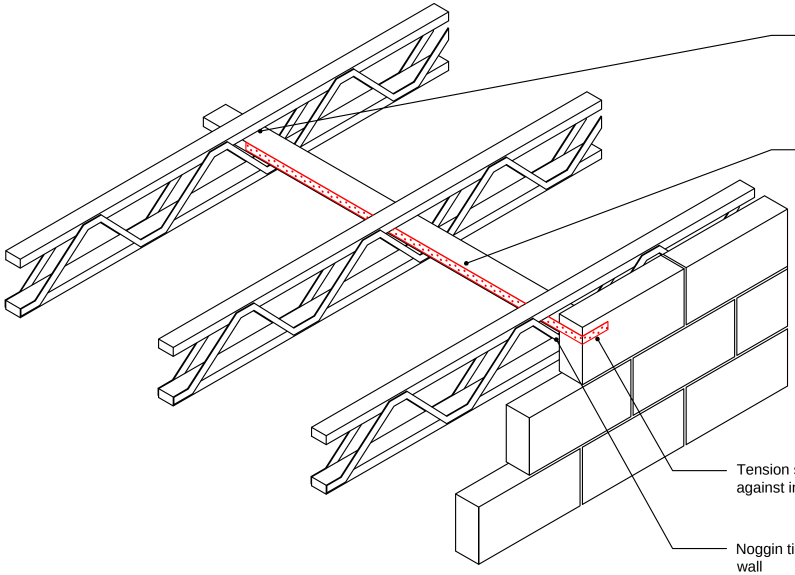


Example of metal web joists bearing on intermediate load bearing wall. Column within the metal web joist should be located directly over the support. In accordance with the manufacturers design

Horizontal restraint strap fixed to strongback



Horizontal restraint strap fixed to continuous noggin



Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:

- Restraint type joist hangers.
- Other forms of restraint proven by a Chartered Engineer.
- Lateral restraint floor straps, provided at no more than 2m centres.

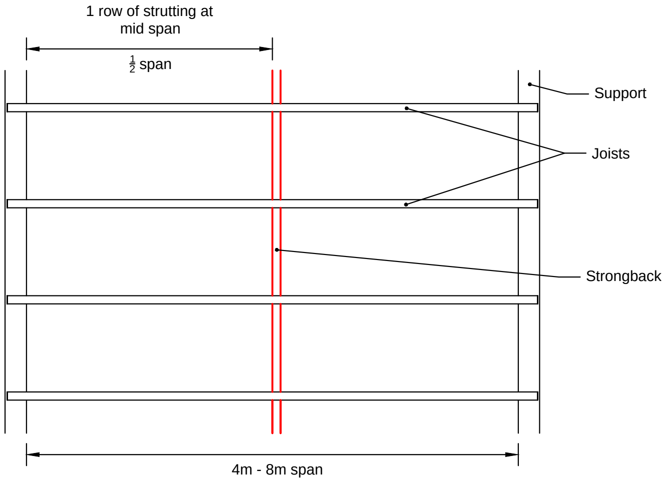
Lateral restraint straps

Floors should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanised or stainless steel restraint straps at 2m centres. Straps need not be provided to floors at, or about, the same level on each side of a supported wall and at the following locations:

Timber floors in two storey dwellings where:

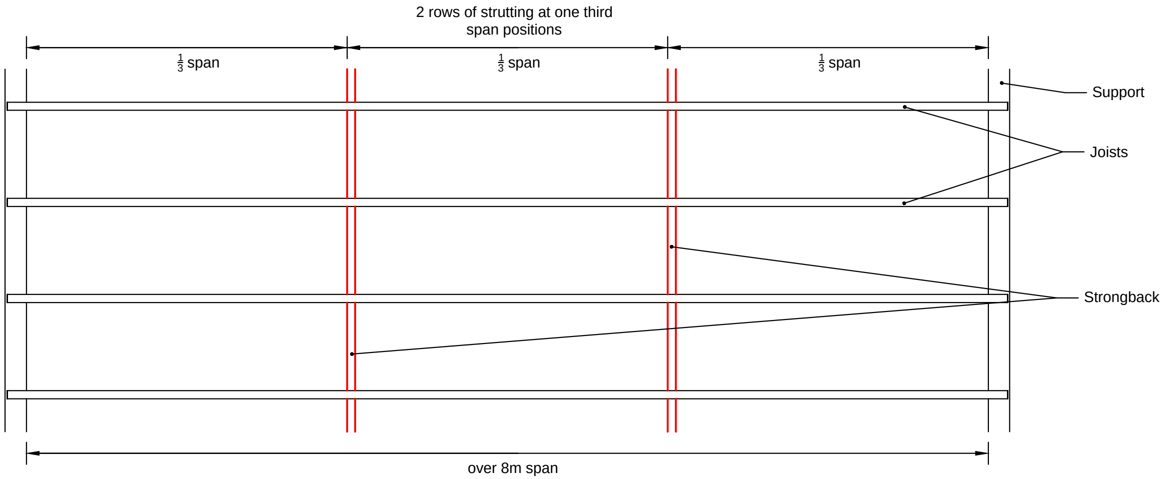
- Joists are at maximum 1.2m centres and have at least 90mm bearing on supported walls or 75mm bearing on to a timber wall plate.
- Carried by the supported wall by restraint type joist hangers as described in BS 5268: 7.1.

Strutting of joists with a span between 4m and 8m



Where the span of a floor joist or flat roof joist is more than 4m, strutting is necessary. This should be provided by timber strong backs in accordance with the manufacturers design

Strutting of joists with a span over 8m



A minimum of two rows of strutting are required for spans over 8m. This should be provided by strongbacks in accordance with the manufacturers design

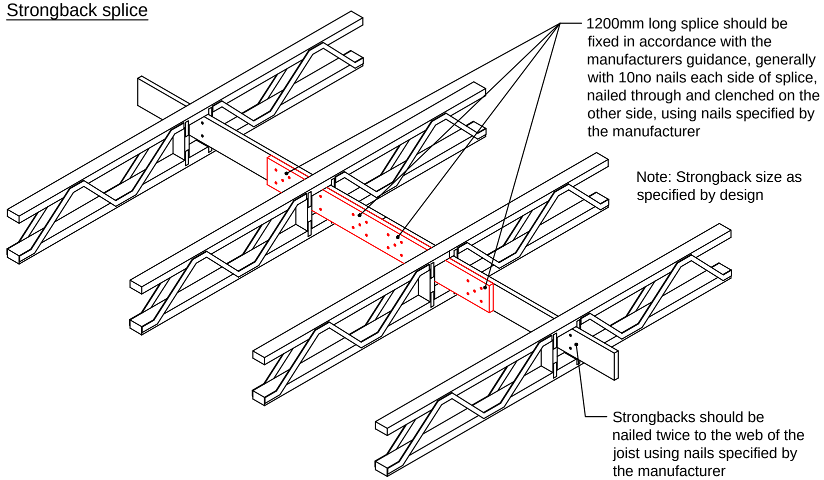
Metal web joists

Strutting to metal web joists should be provided in accordance with the manufacturers guidance and the table below.

Strutting of joists

Joist span (m)	Rows of strutting
4-8	1 (at centre of span)
over 8	2 (at equal spacing)

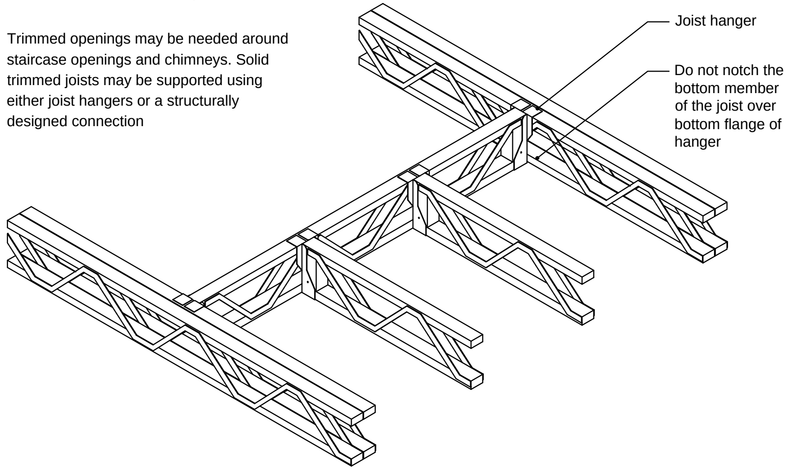
Strongback splice



Typical trimming detail

Double joists should be fixed as per the manufactures design, this can be with a propriety clip or fixed at specified centres with fixings provided by the manufacturer. It is important to ensure that the work on site is in accordance with the manufacturers design.

Trimmed openings may be needed around staircase openings and chimneys. Solid trimmed joists may be supported using either joist hangers or a structurally designed connection

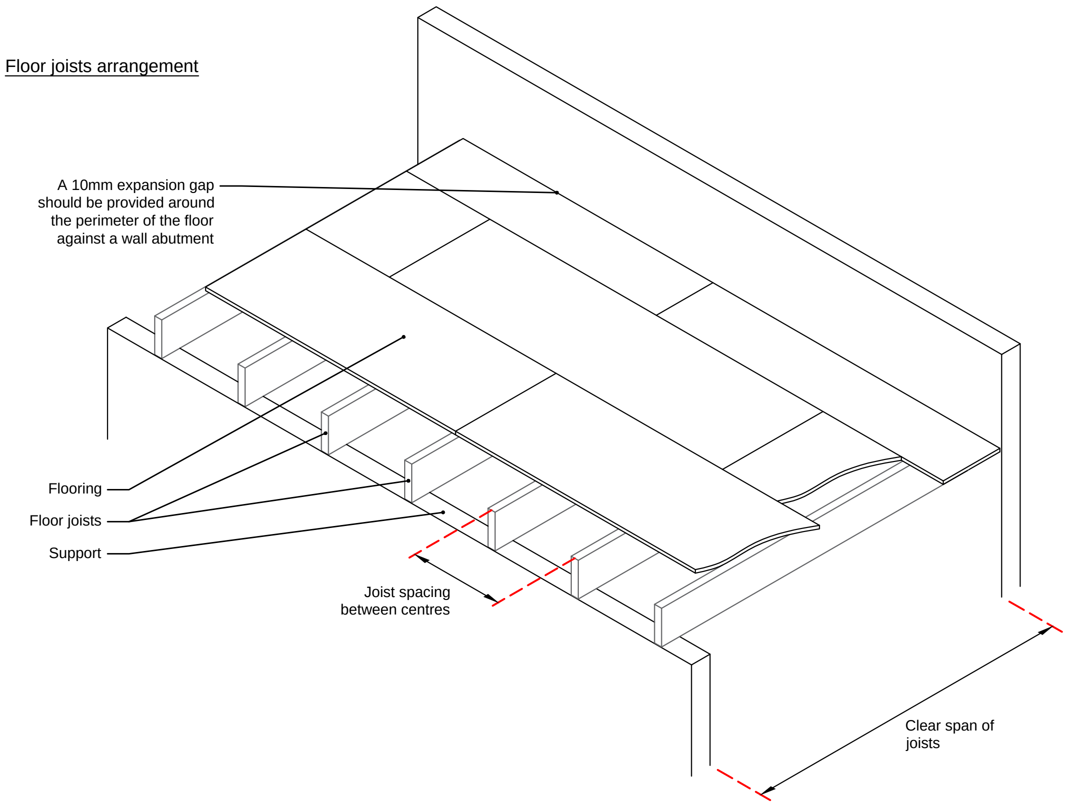


10.

Upper Floors

10.4
Floor Boarding for Timber Upper Floors

Floor joists arrangement



Floor boarding

Suitable floor boards include tongue and grooved softwood flooring with a minimum moisture content at the time of fixing of between 16%-20% and in accordance with BS 1297. All boards must be double nailed or secret nailed to each joist using nails that are at least three times the depth of the board. Floor coverings should be fixed in accordance with BS 8103-3. Boards must have a minimum thickness, as indicated in the table below.

Softwood floor boarding: Minimum thickness and centres of support

Finished board thickness (mm)	Maximum centres of joist (mm)	Typical nail fixings (mm)
15	Max 450	45mm lost head nail
18	Max 600	60mm lost head nail

Particle boarding

Acceptable particle boards consist of Oriented Strand Board (OSB) or chipboard. Chipboard should be tongue and grooved and all joints glued. The boards should be laid so that the shortest length is laid parallel to the span. OSB boards should be type 3 or 4 to BS EN 300, and should be laid with the major axis at right angles to the joists (the major axis is indicated on the OSB board by a series of arrows). Boards must have a minimum thickness, as indicated in the table below.

Particle boards should be either screwed or nailed to the joists at 250mm centres. Nails should be annular ring shanks that are at least three times the depth of the board.

A 10mm expansion gap should be provided around the perimeter of the floor against a wall abutment.

Particle floor boarding: Minimum thickness and centres of support

Thickness (mm) (chipboard)	Thickness (mm) (OSB)	Maximum span (mm)	Typical nail fixing (mm)
18 and 19	15	450	60mm annular ring shank
22	18 and 19	600	65mm annular ring shank

Sound resistance

Internal floors shall, where necessary, be designed and constructed to have adequate resistance to the transmission of sound to meet the requirements of the regional Building Regulations.

The resilient insulation layers where required should be fitted as per manufacturers instructions.

The resilient layer and subsequent floor makeup should be suitable to support the design loads. Any point loads or additional loading may have special requirements.

Floor boarding laid above a resilient layer must be isolated from the walls and skirtings by the insertion of a resilient layer.

Floor finishes

If ceramic tiled floor finishes are proposed, the guidance in 'Appendix A- Finishes' is applicable. Heavier tiles are not suitable for timber floors.

If flexible sheet or wood based floor coverings are proposed, they must be installed in accordance with the manufacturer's instructions and:

- The supporting surface must be level, free of high spots and clear of debris.
- Where battens are required, they must be preservative treated, spaced correctly and fixed to prevent excessive movement.
- The correct type of underlay where required must be installed.
- Movement joints at door openings provided.
- Allowance for thermal expansion provided at perimeters.
- The manufacturers recommendations should be followed where continued under heavy/point loads.

10.

Upper Floors

10.5

Plaster Boarding for Timber Upper Floors

Plastered finishes

Workmanship of plastered finishes to ceilings should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

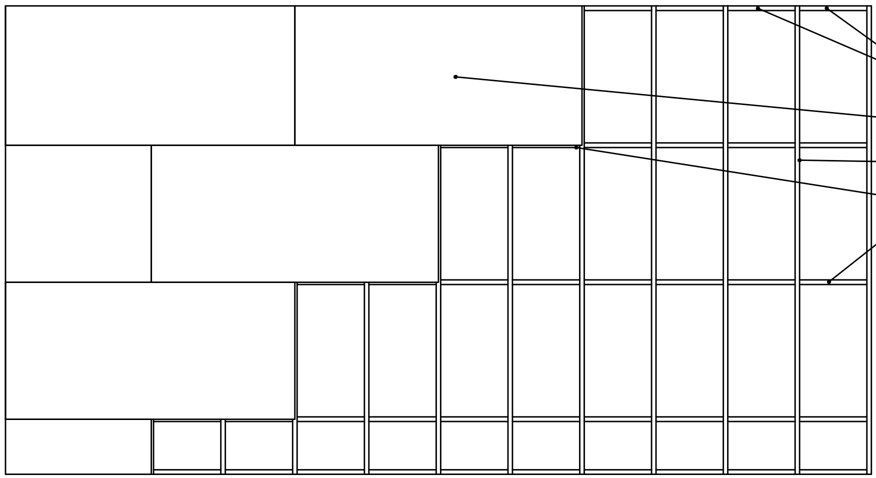
Substrate and background

Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 8481.

Plaster mixes

Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

Ceiling plan - plasterboard fixed to timber joists



Minimum plaster thicknesses

The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified in this Technical Manual, and be of a suitable quality so that a decorative finish can be applied. Minimum thickness should be in accordance with the table below.

Element	Minimum number of coats	Typical thickness
Ceiling - plasterboard	1	Skim to provide suitable and durable finish

Support of plasterboard

Supports for plasterboard should be designed so that the following span limits are not exceeded:

Board thickness (mm)	Timber support centres (mm)	Intermediate noggings required	Perimeter noggings required
9.5	400	No	Yes
	450	Yes	Yes
12.5	400	No	Yes
	450	No	Yes
	600	Yes	Yes
15	600	No	No

When fixing plaster boarding:

- Fix boards with decorative side out to receive joint treatment or a skim plaster finish.
- Lightly butt boards together and never force boards into position.
- Install fixings no closer than 13mm from cut edges and 10mm from bound edges.
- Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper.
- Stagger horizontal and vertical board joints between layers by a minimum of 600mm.
- Locate boards to the centre line of framing where this supports board edges or ends.
- Fix to timber joists using dry-wall screws.

Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve building air tightness.

10.

Upper Floors

10.6

Suspended Beam and Block

Pre cast concrete floor units

Precast beams are proprietary products, which the design and construction are specific to the manufacturer of the product. Projects incorporating precast beams must be provided with full manufacturers design, structural calculations and specifications including fixings specific for the project.

Precast concrete units and infill blocks are to be carefully stored and handled on-site, preventing damage occurring before, during and after incorporation into the structure. Units should be lifted as near as possible to their ends.

The installation of pre cast concrete floor beams and blocks must follow the manufacturer's guidance and specification for the project.

The bearing surface of walls, beams and other supports to receive precast units are to be smooth and level.

Infill blocks and slabs should fully bear onto supporting beams and walls.

Precast suspended beam and block floors

Ensure that precast concrete beam and block floors are fully supported by load-bearing walls.

Similar beams of the same size may have differing strength properties because of their varying reinforcement size, so it is important to check beam reference numbers and their layout. It is also essential sometimes to provide two or more beams adjacent to each other where spans are excessive or in heavily loaded areas. Suitable infill bricks or blocks are to be properly bedded on mortar and provided between pre cast (PC) beams where bearing onto supporting walls.

Beams and blocks are to be grouted together with a 1:6 cement to sand mix in accordance with the manufacturer's instructions.

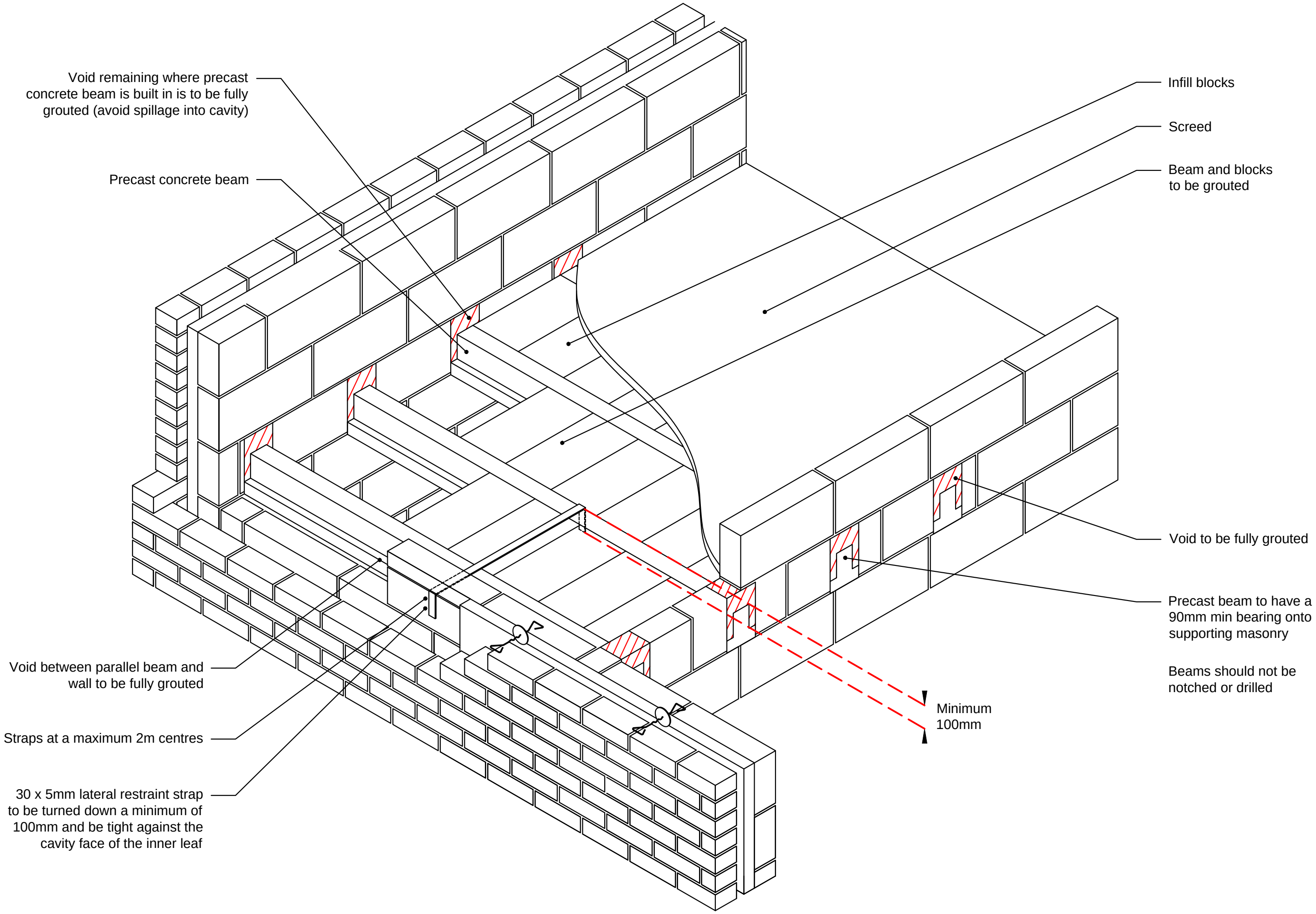
Load-bearing walls are to continue through the beam and block floor.

Holes for service pipes are properly filled by laying non-timber formwork between PC joists and filling with good quality concrete (ST2 mix) prior to screeding.

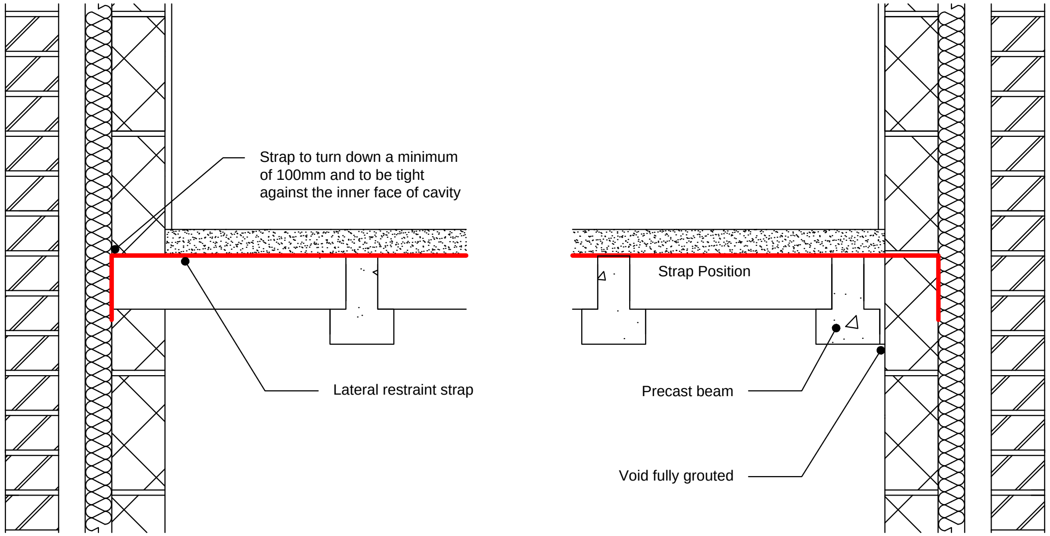
Beams should bear onto masonry with a minimum 90mm bearing, and steelwork with a minimum 70mm bearing.

Provide restraint straps to walls where the beams run parallel.

Ensure that the blockwork carrying the beam and block flooring has sufficient compressive strength.



Lateral restraint of walls



Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:

- Lateral restraint straps.
- Other forms of restraint proven by a Chartered Engineer.

Lateral restraint straps

Beam and block floors should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanised or stainless steel restraint straps at 2m maximum centres.

Straps need not be provided to floors at, or about, the same level on each side of a supported wall and in two storey dwellings where concrete floors have a minimum 90mm bearing on supported wall.

Deflection of floors

For upper floors (intermediate floors), designers and engineers must observe our Tolerance requirements, for levelness of floors. Please refer to the Tolerances.

There may be an instance where a joist might be designed to meet permissible deflections with a relevant British Standard; however, our tolerance requirements will take precedence.

Sound resistance

Internal floors shall, where necessary, have adequate resistance to the transmission of sound to meet the requirements of the regional Building Regulations.

Resilient layers where required should be fitted as per manufactures instructions.

The resilient layer and subsequent floor makeup should be suitable to support the design loads, any point loads or additional loading may have special requirements.

Plastered finishes

Workmanship of plastered finishes to ceilings should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

Substrate and background

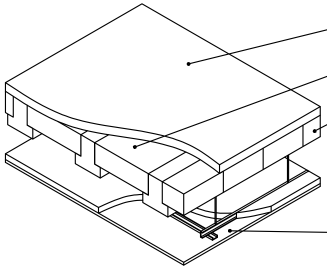
Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 8481.

Plaster mixes

Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

Suspended ceilings

Suspended ceilings should be designed and constructed in accordance with BS EN 13964.



Fixing requirements

Fixings should be appropriate for the site conditions and the loads to be supported. They must also be installed in accordance with the manufacturer's specifications. Fixings to suspended beam and blocks should be at the correct designated centres using the correct wires/brackets that are compatible with the suspended ceiling (and the intended environmental conditions - see below). Pull tests should be carried out on ceilings with an area exceeding $100m^2$ and a factor of safety of 2 is applicable.

Ceiling grid layouts and fixing schedule and method of fixing to soffit, should be provided.

Confirmation that the weight of the ceiling construction and any additional fire/sound insulation loads has been taken account of in the supporting structure design calculations.

Where there is any doubt regarding the adequacy or installation or variation from the initial design a manufacturer's inspection and certification will be required.

High humidity or external environment or specialised conditions

Where the ceiling is above a high humidity area or is an external suspended ceiling; third party certification should be provided to demonstrate the product is suitable for the specified environment.

Where suspended ceilings are designed to give a minimum period of fire resistance, fire test certification will be required to confirm the periods of fire resistance given. This should also take into account any recessed light fittings which may bypass the fire resistant layer.

The additional weight of materials used to achieve fire resistant specifications or where sound insulation requirements occur; must also be taken account of in the structural design of the supporting structure and the fixings of the ceiling construction.

Fire resistance

Where suspended ceilings are designed to give a minimum period of fire resistance, fire test certification will be required to confirm the periods of fire resistance given. This should also take into account any recessed light fittings which may bypass the fire resistant layer. Consideration should also be given to the quality of workmanship in these installations, and a manufacturer approved installer be used.

The additional weight of materials used to achieve fire resistant specifications or where sound insulation requirements occur must also be taken account of in the structural design of the supporting structure and the fixings of the ceiling construction.

Minimum plaster thicknesses

The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified in this Technical Manual, and be of a suitable quality so that a decorative finish can be applied. Minimum thickness should be in accordance with the table below.

Element	Minimum number of coats	Typical thickness
Ceiling - plasterboard	1	Skim to provide suitable and durable finish

Support of plasterboard

Supports for plasterboard should be designed so that the following span limits are not exceeded:

Board thickness (mm)	Timber support centres (mm)	Intermediate noggings required	Perimeter noggings required
9.5	400	No	Yes
	450	Yes	Yes
12.5	400	No	Yes
	450	No	Yes
	600	Yes	Yes
15	600	No	No

When fixing plaster boarding:

- Fix boards with decorative side out to receive joint treatment or a skim plaster finish.
- Lightly butt boards together and never force boards into position.
- Install fixings no closer than 13mm from cut edges and 10mm from bound edges.
- Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper.
- Stagger horizontal and vertical board joints between layers by a minimum of 600mm.
- Locate boards to the centre line of framing where this supports board edges or ends.
- Plasterbpard should be fixed using dry-wall screws.

Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve building air tightness.

10.

Upper Floors

10.7

Concrete Plank

Precast concrete floor units

Precast concrete floor units are proprietary products, which the design and construction are specific to the manufacturer of the product. Projects incorporating precast concrete planks must be provided with full manufacturers design, structural calculations and specifications including fixings specific for the project.

Precast concrete units are to be carefully stored and handled on-site, preventing damage occurring before, during and after incorporation into the structure. Units should be lifted as near as possible to their ends.

The installation of precast concrete floor units must follow the manufacturer's guidance and specification for the project.

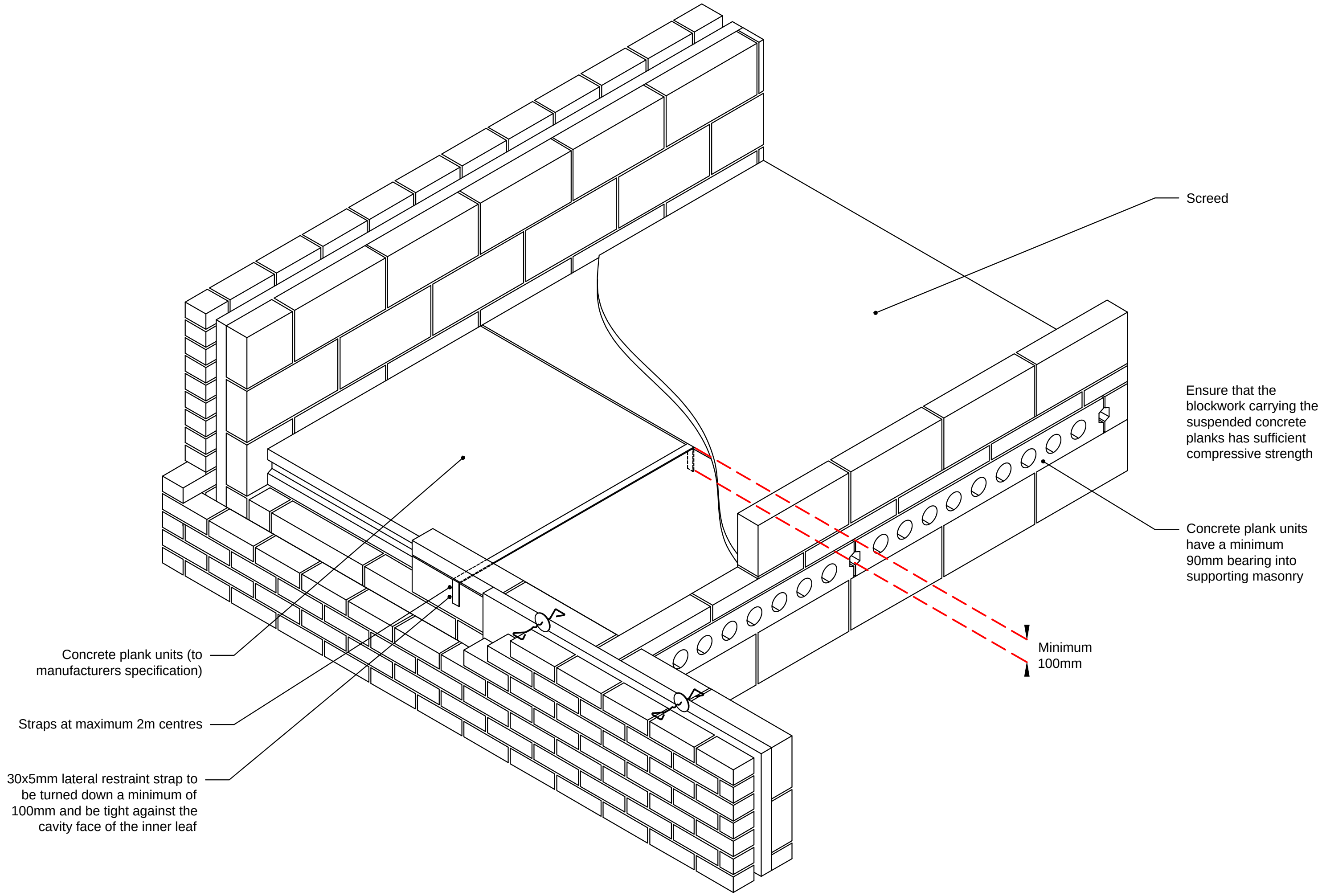
The bearing surface of walls, beams and other supports to receive precast units should be smooth and level.

Infill blocks and slabs should fully bear onto supporting beams and walls.

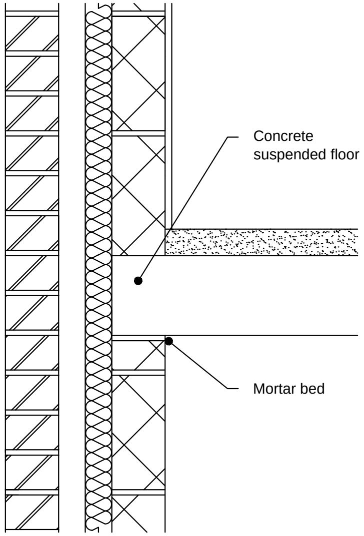
Ensure that precast suspended concrete plank floors are fully supported by load-bearing walls.

It is important to check the plank reference numbers and their layout. Similar units of the same size may have differing strength properties because of their varying reinforcement size, so it is important to check unit reference numbers and their layout. Suspended concrete planks should be grouted in accordance with the manufacturer's instructions ensuring the correct strength and aggregate size is used.

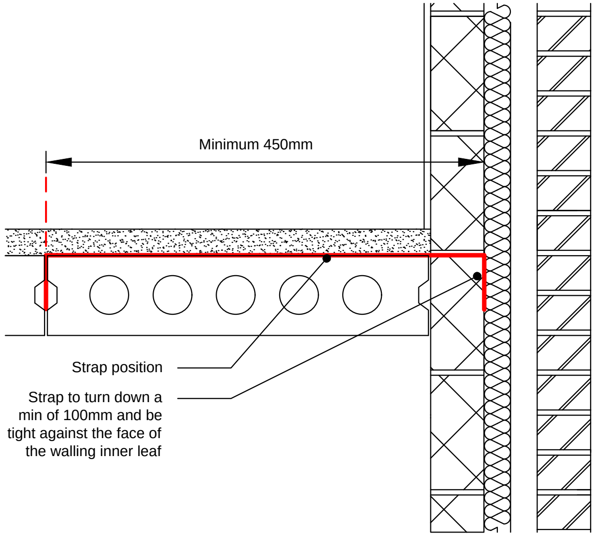
Holes for service pipes are to be properly filled by laying non-timber formwork between PC joists and filling with good quality concrete (ST2 mix) prior to screeding.



Lateral restraint of walls



The floor units should bear onto masonry with a minimum 90mm bearing, and steelwork at a minimum 70mm



Provide restraint straps to walls where the suspended concrete planks run parallel

Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:

- Lateral restraint straps.
- Other forms of restraint proven by a Chartered Engineer.

Lateral restraint straps

Concrete plank floors should provide lateral restraint to all walls running parallel to them by means of 30mm x 5mm galvanised or stainless steel restraint straps at maximum 2m centres.

Straps need not be provided to floors at, or about, the same level on each side of a supported wall and in two storey dwellings where concrete floors have a minimum 90mm bearing on supported wall.

Deflection of floors

For upper floors (intermediate floors), designers and engineers must observe our tolerance requirements, for levelness of floors.

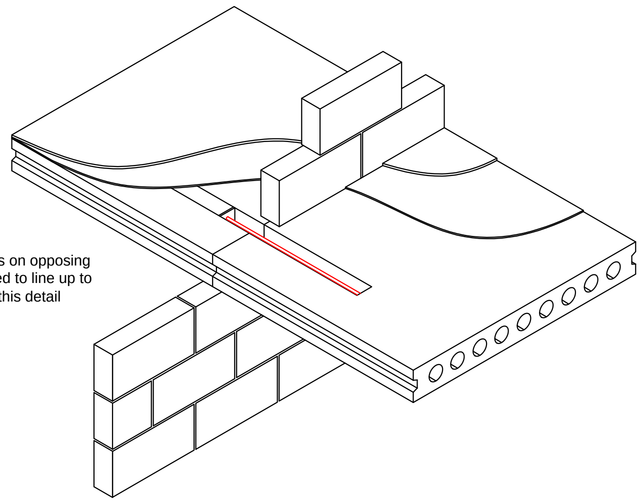
There may be an instance where a floor might be designed to meet permissible deflections with a relevant British Standard; however, our tolerance requirements will take precedence.

Sound resistance

Internal floors shall, where necessary, have adequate resistance to the transmission of sound to meet the requirements of the regional Building Regulations.

Resilient layers where required should be fitted as per manufactures instructions.

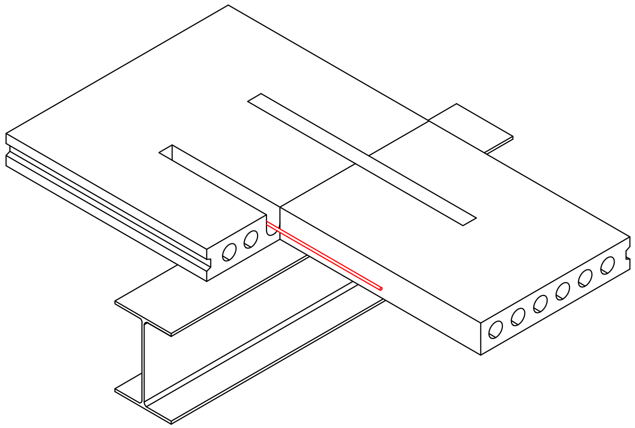
The resilient layer and subsequent floor makeup should be suitable to support the design loads, any point loads or additional loading may have special requirements.



Narrow wall bearing

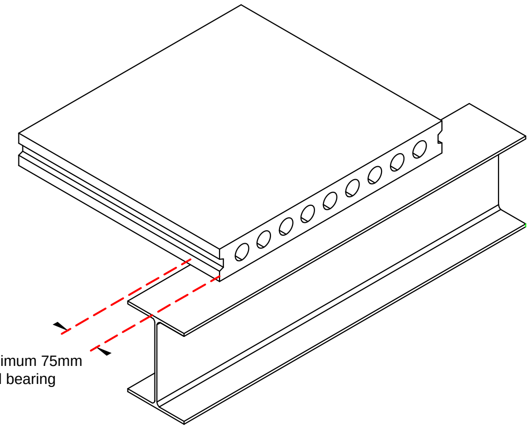
Generally for walls narrower than 190mm the slabs should be tied together in accordance with the manufactures instructions.

Typically this is achieved by two cores per 1200mm wide slab are formed open so that a reinforcement bar can be inserted across to form the tie detail, however this should be constructed in accordance with the manufacturers site specific design.



Continuity over steelwork

When continuing over steel work the slabs may also require tying together in accordance with the manufacturers recommendations.

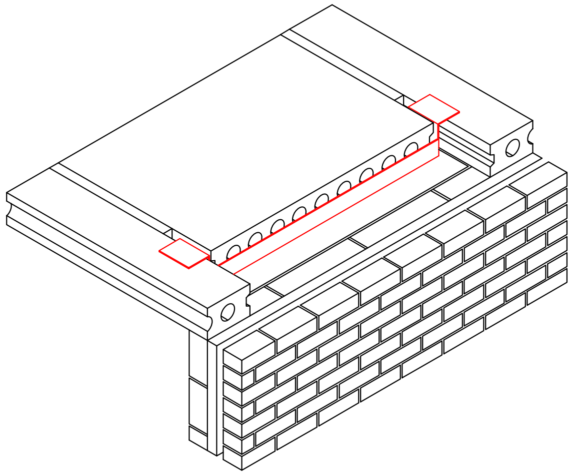


Bearing on top of steelwork

A minimum of 75mm bearing should be provided on steel beams. Planks may require mechanical restraint to the steel beam in accordance with the manufactures specification.

Steel beams should be designed by a suitably qualified structural engineer and should have appropriate fire resistance to meet the requirements of the regional Building Regulations.

Where steel beams and columns are used to support the upper floor construction on a project in a coastal location, and maybe exposed to an aggressive external environment (e.g. under croft), please follow the requirements for additional corrosion protection in 'Appendix B - Coastal Locations' and 'Appendix C - Materials, Products, and Building Systems'.



Holes and notches

Openings to accommodate service voids and column notches should be preformed. Large openings may require steel trimming supports. Holes of less than 100mm can be formed on site in accordance with the manufactures design.

All holes/openings should be in accordance with the manufacturers design.

Plastered finishes

Workmanship of plastered finishes to ceilings should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

Substrate and background

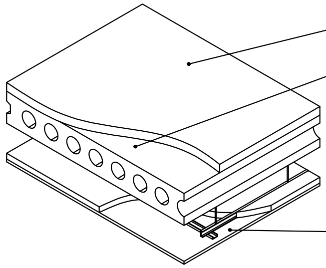
Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 8481.

Plaster mixes

Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

Suspended ceilings

Suspended ceilings should be designed and constructed in accordance with BS EN 13964.



Fixing requirements

Fixings should be appropriate for the site conditions and the loads to be supported. They must also be installed in accordance with the manufacturer's specifications. Fixings to the concrete plank should be at the correct designated centres using the correct wires/brackets that are compatible with the suspended ceiling (and the intended environmental conditions - see below). Pull tests should be carried out on ceilings with an area exceeding $100m^2$ and a factor of safety of 2 is applicable.

Ceiling grid layouts and fixing schedule and method of fixing to soffit, should be provided.

Confirmation that the weight of the ceiling construction and any additional fire/sound insulation loads has been taken account of in the supporting structure design calculations.

Where there is any doubt regarding the adequacy or installation or variation from the initial design a manufacturer's inspection and certification will be required.

High humidity or external environment or specialised conditions

Where the ceiling is above a high humidity area or is an external suspended ceiling; third party certification should be provided to demonstrate the product is suitable for the specified environment.

Where suspended ceilings are designed to give a minimum period of fire resistance, fire test certification will be required to confirm the periods of fire resistance given. This should also take into account any recessed light fittings which may bypass the fire resistant layer.

The additional weight of materials used to achieve fire resistant specifications or where sound insulation requirements occur; must also be taken account of in the structural design of the supporting structure and the fixings of the ceiling construction.

Fire resistance

Where suspended ceilings are designed to give a minimum period of fire resistance, fire test certification will be required to confirm the periods of fire resistance given. This should also take into account any recessed light fittings which may bypass the fire resistant layer. Consideration should also be given to the quality of workmanship in these installations and a manufacturer approved installer be used.

The additional weight of materials used to achieve fire resistant specifications or where sound insulation requirements occur must also be taken account of in the structural design of the supporting structure and the fixings of the ceiling construction.

Minimum plaster thicknesses

The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified in this Technical Manual, and be of a suitable quality so that a decorative finish can be applied. Minimum thickness should be in accordance with the table below.

Element	Minimum number of coats	Typical thickness
Ceiling - plasterboard	1	Skim to provide suitable and durable finish

Support of plasterboard

Supports for plasterboard should be designed so that the following span limits are not exceeded:

Board thickness (mm)	Timber support centres (mm)	Intermediate noggings required	Perimeter noggings required
9.5	400	No	Yes
	450	Yes	Yes
12.5	400	No	Yes
	450	No	Yes
	600	Yes	Yes
15	600	No	No

When fixing plaster boarding:

- Fix boards with decorative side out to receive joint treatment or a skim plaster finish.
- Lightly butt boards together and never force boards into position.
- Install fixings no closer than 13mm from cut edges and 10mm from bound edges.
- Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper.
- Stagger horizontal and vertical board joints between layers by a minimum of 600mm.
- Locate boards to the centre line of framing where this supports board edges or ends.
- Fix using dry-wall screws.

Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve building air tightness.

10.

Upper Floors

10.8

General Requirements for Concrete Upper Floors

Floor finishes

Screeding

Traditional floor screeds consist of sand and cement. If the ratios and properties of these screeds are not correctly controlled; cracking, peeling or collapse of the screed will occur (due to being too strong/weak).

Proprietary screeds typically are pre-blended to achieve greater consistency and strength and more suitable over larger areas. As such where the floor area exceeds 50m^2 only a proprietary screed installed by the screed manufacturers trained installers will be accepted.

Screeds should be fit for purpose, have a suitable finish and be of an appropriate thickness.

Curing

Screeds should be cured naturally and should not be covered for at least three weeks.

Background surfaces

Background surfaces where screeds are being supported should meet the following requirements:

- **Bond**
  Background surfaces for bonded screeds should provide an adequate mechanical key. If necessary, cement grouting or a bonding agent should be specified to provide adequate adhesion. Where bonded screeds are used, mechanical means of preparing the concrete should be used to create an adequate bond between the substrate and the screed.
- **Moisture protection**
  The floor design should ensure that moisture from the ground does not enter the dwelling.
- **Adequate support**
  Substrate structures must be adequately constructed to provide adequate support to the screed. (Note: Timber floor constructions are not suitable to support screeded finishes.)
- **Screed mix**
  Cement and sand screeds should have a mix ratio of between 1:3 and 1:4½.

Proprietary additives should have been assessed and have third-party certification.

The minimum thicknesses of screeds are as follows:

Screed thickness requirements

Surface	Minimum thickness at any point (mm)
Laid monolithically with base	12
Laid and bonded to a set and hardened base	20
Laid on a separating membrane (e.g. 1000g polyethylene)	50
Laid on resilient slabs or quilts (screed reinforced with galvanised wire mesh)	65

Where service pipes are bedded in the screed, the screed should be deep enough to provide at least 25mm of screed cover over service pipes, insulation and reinforcing.

Maximum areas of screed

Screeds should be laid room by room. Unreinforced screeds should have a maximum area of 40m^2. Expansion joints should be provided and consistent with joints in the floor slab below.

Finishing of screeds

Screed should provide an even surface as appropriate, as defined in the Tolerance section. Concrete floor slabs may be suitably finished to serve directly as a wearing surface without the need for an additional topping, in accordance with the recommendations of BS 8204. If required, surface sealers or hardeners should only be used in accordance with the manufacturer's instructions.

Tiling on anhydrite screeds

If an anhydrite screed is used, it must be sealed before the application of any cement based tile adhesive is proposed. Anhydrite screeds can be difficult to identify once laid, if the screed type cannot be identified the screed should be fully sealed as a precaution to prevent the possibility of the tiling adhesive debonding from the screed.

The floor screed should be fully dry before the sealant is applied. The screed drying time will depend on the thickness and type of screed.

A decoupling membrane is also recommended as this can reduce the stress on the tiling layer.

Insulation

Insulation below screeds should have enough compressive strength to support the screed. DPM's should be installed in the correct positions, as indicated by the insulation manufacturer's instructions. Sound insulation should be installed in accordance with the manufacturer's instructions.

Constructing screeds over all substrates:

- Substrates must be level with no pockets or high spots to ensure the thickness of the screed remains even.
- Where screeds are laid over insulation; the insulation must be tightly butted together and level.
- Screeds must be correctly mixed.
- Screeds must not be walked on during the drying period.
- Screeds must not be constructed during cold periods (below 5 degrees).
- Movement joints will be required across door thresholds.
- Movement joints are required if bay sizes exceed 40m^2 with a maximum of 8m on any one side.
- Movement joints are also required where joints exist or a change of span occurs e.g. beam and block floors.
- The screed must be ready to accept any floor tiling (see guidance below for over insulated substrates).

Drying times

- With cementitious levelling screeds, one day should be allowed for each millimetre of thickness for the first 50 mm, followed by an increasing time for each millimetre above this thickness (BS 8204).
- Polymer modified screeds: strictly follow the manufacturer's specifications and recommendations.
- The developer should keep an accurate record of the screed drying times elapsed before floor tiling is laid and the Warranty surveyor may ask for this information.

Note: The moisture contents of levelling screeds onto which particular floorings are to be laid and methods for measuring moisture content are given in BS 5325, BS 8201, BS 8203 and BS 8425.

Building services

Where building services pass through the screed e.g. underfloor heating, allowance should be made for thermal movement between the screed and the service (so that service pipes can resist chemical attack from the screed).

Additional steps where constructing screeds over concrete substrates

Where a concrete slab is insulated from below and a finishing screed is required to the top surface:

- The concrete substrate slab must be of the correct thickness and not less than 100mm thick.
- Concrete substrate must be adequately dried out and not wet. See drying time guidance.
- Surfaces of hardened in situ concrete bases for bonded screeds should be roughened (Scrabbled) and cleaned to remove laitance and to expose cleanly, but not loosen, the coarse aggregate particles.
- Brushing to remove laitance from a fresh concrete base is inadequate preparation before laying a bonded screed and is not recommended.
- Remove all loose debris, dirt and dust by appropriate means, preferably with vacuum equipment.
- Carry out the preparation of the surface with as little delay as is practicable before the screed is laid so as to reduce the risk of contamination.
- The surface of the prepared slab must be reasonably level to avoid deviations in thickness's of the screed.

Constructing screeds over insulated substrates with under floor heating (UFH) system and tiled floor finishes

1. Provision and construction of movement joints

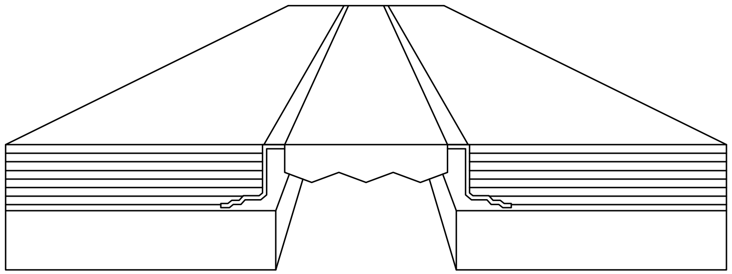
Movement joints should be provided in the floor screed/tiling where floor heating is provided in the following places:

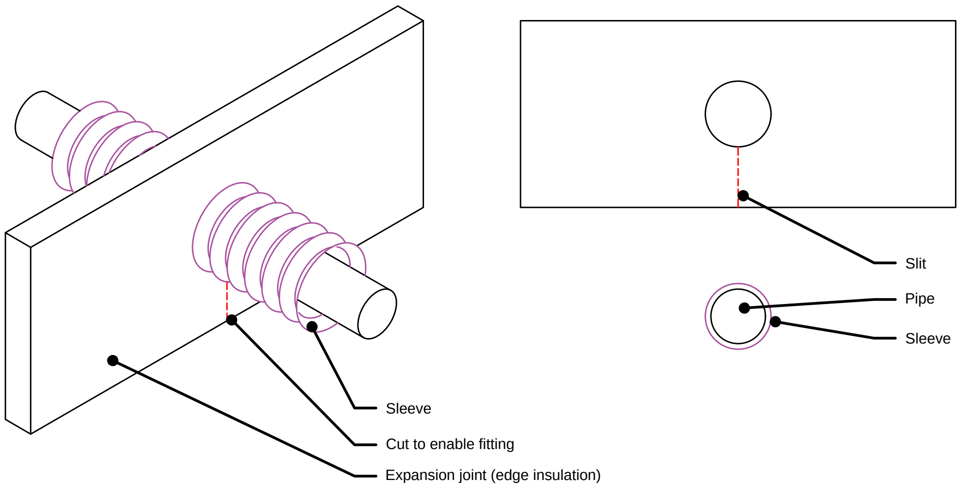
- Between independently controlled heating zones.
- Between heated and unheated areas of screed.
- Additional joints should be considered in areas of high thermal gain e.g. large conservatories or glass atria.

Bay joints should be formed using rigid joint formers where possible, which can be placed during the preparation phase and will remain in place during operation. The joint former should be 5mm lower than the finished screed depth to allow a smooth transition in height between bays.

- All joints in the screed should extend through to any subsequent bonded floor covering.
- Joint positions should be specified prior to the installation of the screed and full consultation between all parties including the main contractor, underfloor heating installer, finished flooring installer and the screed installer should take place to determine appropriate locations.
- Movement joints should be carried through the subfloor to the floor finish and all applied layers terminated either side of the joint.
- The joint should be filled with a suitable flexible filler and a proprietary cover strip applied to cover the joint. Grout must not be used.
- Movement joints should not be bridged by any resilient, textile or other adhered floor finish.
- Movement joint covers may be flush, surface mounted or bedded in mortar and metal, metal with a rubber insert or PVC (see typical detail below).

Typical movement joint covers





2. Provision of edge strip perimeter expansion joint - tile level (floor finish)

When incorporating under floor heating (UFH):

- Screeds should be isolated at all edges, abutments and columns to allow for movement due to thermal loadings.
- The floor screed and tiling (floor finish) manufacturers guidance to be followed particularly when incorporating under-floor heating to determine the minimum thickness of edge strip required to allow for expansion. Typically, between 6-15mm may be required.
- The joint can be concealed by the skirting.
- These joints must be left empty, or else filled with a compressible material.
- Movement joints must not be filled with grout.

3. Screed drying time

- The drying time allowed must be calculated for the proposed depth of screed, taking account of the environmental conditions present e.g. temperature and humidity. Where polymer modified type screeds are being used the manufacturer's requirements must be strictly followed for the actual depth of screed. Surface finishes placed on a screed too early will fail.
- Drying times for polymer modified screeds could potentially be different to cementitious screeds.
- All subcontractors involved with the screed and floor finishes (including installation of underfloor heating systems) must follow the installation requirements and not deviate or change materials.
- The screed should not be walked on until fully cured.

4. UFH testing and commissioning

- Ensure there are no joints in the heating system loops.
- UFH systems should be commissioned before tiling is applied. This will add to the total time before any tiling finish can be applied.
  Note: If floor finishes are installed prior to the UFH being turned on and commissioned, any residual moisture in the floor is driven to the surface of the screed and can potentially cause delamination of the floor finish.
- Pressure testing of the system does not constitute commissioning of the system. The heat source has to be in place and operating in order to deliver the correct temperatures.
- The UFH system must be commissioned in accordance with the manufacturer's recommendations by their approved installers. A commissioning certificate will be required.

5. Moisture testing of the screed where floor tiling is proposed

- Moisture testing should be carried out after the commissioning of the UFH system but before any tiles are laid.
- Where UFH is not installed, moisture testing of the screed should still be carried out before tiling.
- Moisture testing is carried out using a suitable approved method such as a flooring hygrometer or carbide bomb test. Due to the potential inaccuracies of using hygrometers at high humidity levels, a direct measurement should be used such as Carbide Bomb or oven dried sample.
- The base is deemed to be sufficiently dry when the relative humidity, as measured by a surface mounted flooring hygrometer/probe is 75% RH or less. For the use of a flooring hygrometer, reference should be made to Dampness testing in BS 5325, BS 8203, BS 8425 and BS 8201.
- If underfloor heating is present in the base, the heating must be switched off 96 hours prior to any hygrometer test being carried out.
- The hygrometer must be allowed to remain in position until full equilibrium has been established. This is generally considered to be 72 hours but could be longer over thick sections and considerably longer on power floated concrete.

6. Screed preparation for finishes

- The top surface of screeds may require to be scored, sanded or keyed in preparation to accept the primer and floor tiling adhesive.
- Sanding, keying etc. of the screed surface allows the penetration of primers. It also provides a “key” for the adhesive to grip onto.
- The surface must then be cleared of dirt and debris prior to primers being applied.
- Any primers and adhesives must not be applied until the screed has fully hardened and dried out. Drying times vary depending on the type of screed.
- Surfaces to be tiled should be rigid, dimensionally stable, flat with no dips and rises, sound, clean and free from laitance, paints, salts, grease, dust and any contamination which may prevent adhesion.

7. Application of the flexible tiling adhesive using double gluing technique

Tile fixing should be carried out in accordance with BS 5385 and BS 8000 Codes of Practice for the installation of wall and floor tiles.

- The tiling manufacturer's specifications for fixing should be followed, e.g. travertine tiles may require double gluing. Large sized tiles may also require this fixing method.
- Double gluing (applying adhesive to the underside of the tile and also the substrate) may be necessary.
- The adhesive must be used to the manufacturer's recommendations.
- The adhesive will require to be compressed by the tile to ensure full adhesion.
- Large voids must be avoided when fixing tiles.
- Floors should not be opened to traffic until the adhesive has hardened.

8. Full contact of the tile and adhesive

- The adhesive will require to be compressed by the tile to ensure full adhesion and solid bedding without creating voids.
- Thin-bed method with adhesive and notched trowel: Verify that there is full contact between the adhesive and the piece base.

9. Adhering to the manufacturers' process during the installation of the flooring

All the relevant manufacturers recommendations should be followed which will identify timelines to adhere i.e:

- Removing the laitance by sanding to provide a key for the primer and/or adhesive.
- Commissioning the underfloor heating before tiling commenced.
- Allowing the UFH system to cool down for at least 48 hours before tiling commences.
- Moisture testing to confirm the dryness of the screed before tiling commenced.
- Ensuring the time from screed completion to tiling commencement is calculated and adhered to.
- Ensure the tiling adhesive is allowed to set before the tiling is walked on (typically 12 -24 hours dependent on environment conditions).
- Ensure the UFH system is not turned on for at least 48 hours after the tiling is completed.
- If an anhydrite screed is used, it must be sealed before the application of a cement based tile adhesive if proposed in conjunction with a tiled floor surface covering.

10. Exceeding the Maximum 27°C floor temperature

The underfloor heating system must be correctly commissioned to ensure temperature fluctuations are avoided and potential damage to the floor finishes.

BS 8203 Code of Practice for the Installation of Resilient Floorcoverings states: When used with many flooring materials underfloor heating can cause problems if the temperature at the interface between the subfloor and flooring exceeds 27°C, or is subject to rapid fluctuations in temperature.

Where a resilient floor covering is proposed: 'the temperature should never exceed the agreed maximum of 27°C at the underside of the floorcovering (the adhesive line).

Note: UFH designers may refer to this as the 'interface' temperature.

Please Note: BS EN 1264 - 2 refers to a max 29°C however for Warranty purposes a maximum 27°C is to be followed.

11. End user information

End users must be aware of how to use an UFH system, as these need to be operated differently than other heating systems both for in use and to avoid damage to screeds and finishes.

10.

Upper Floors

10.9

General Requirements - Cavity Barriers and Fire Stopping

Openings for pipes in separating elements

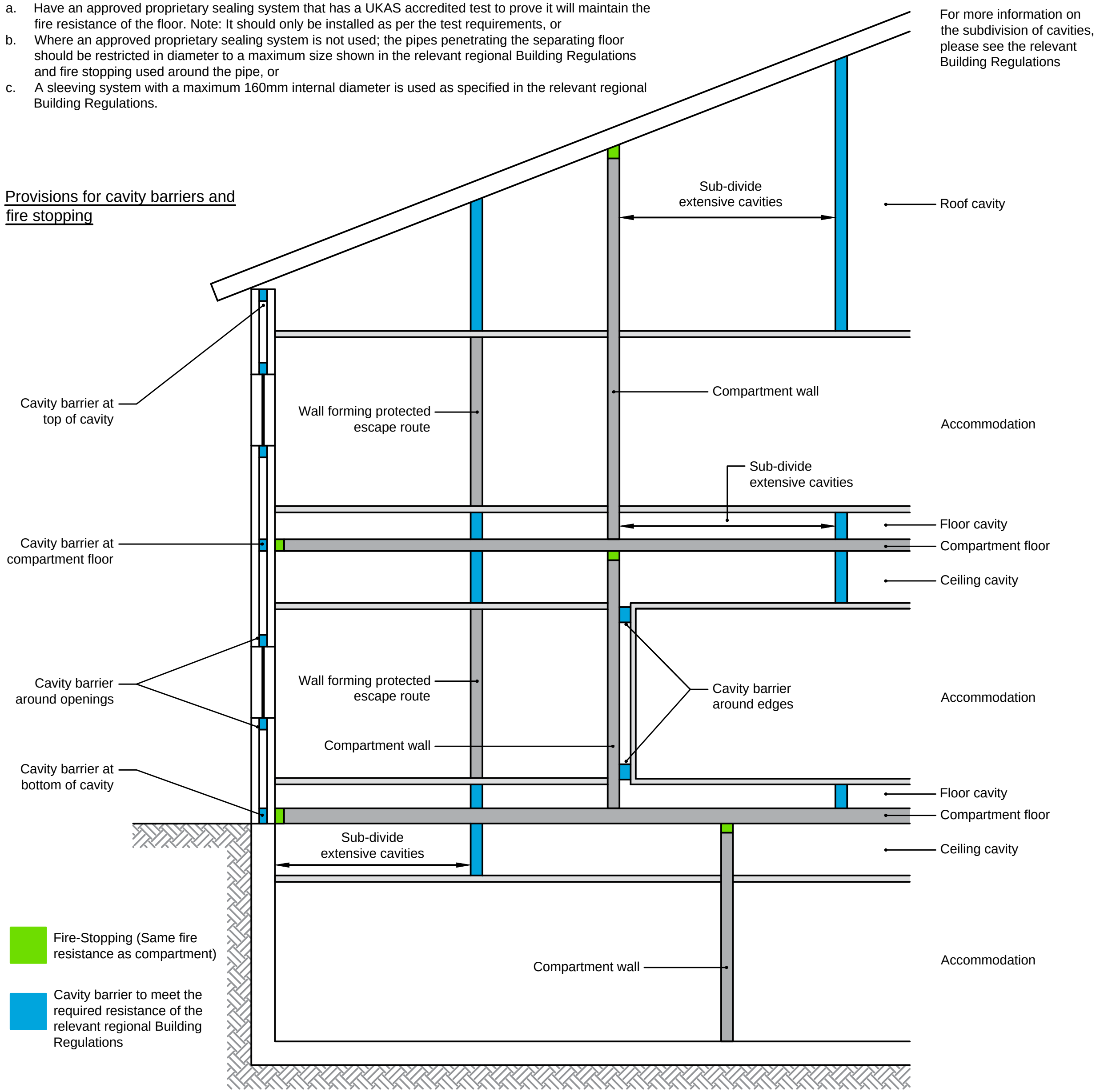
Pipes which pass through fire separating elements (unless in a protected shaft) shall:

a. Have an approved proprietary sealing system that has a UKAS accredited test to prove it will maintain the fire resistance of the floor. Note: It should only be installed as per the test requirements, or

b. Where an approved proprietary sealing system is not used; the pipes penetrating the separating floor should be restricted in diameter to a maximum size shown in the relevant regional Building Regulations and fire stopping used around the pipe, or

c. A sleeving system with a maximum 160mm internal diameter is used as specified in the relevant regional Building Regulations.

Provisions for cavity barriers and fire stopping



Note: Diagrams courtesy of the approved documents for England

Fire resistance general

All floors should have the fire resistance required by the relevant Building Regulations. To achieve the same fire resistance, I-joists and metal web joists may require a different specification for the ceiling than that for solid timber joists. Holes should not be made in the ceilings, e.g. for down lighters, unless it can be proven that the floor construction achieves the required fire resistance.

Fire stopping

Penetrations in floors between buildings shall be fire stopped, there are to be no holes or gaps for smoke to pass through once the fire stopping has been fitted. Where down lighters are incorporated in a ceiling they should be fitted in accordance with the manufacturer's instructions.

Further additional requirements for internal fire stopping and fire protection for compartment floors, walls, and roof junctions to flats and apartments with a floor 4.5m or more above the ground

The following additional guidance applies to internal fire stopping and fire protection only to buildings with a floor 4.5m or more above the ground that contain flats or apartments.

Although building legislation is robust in applying provisions for fire protection and fire stopping, it can often be difficult to implement high standards of fire stopping in complex buildings. This can lead to significant safety risks if the building does not have the correct levels of fire protection and if holes in compartment walls are not sealed correctly. This guidance assists Developers in providing good standards of fire stopping and fire protection.

It is not the intention to enhance the requirements of the Building Regulations, but more to ensure that the statutory requirements are applied correctly to the construction. It is therefore deemed that the requirements of Part B of the Building Regulations in England and Wales, or Section 2 of the Scottish Building Standards (whichever is appropriate depending on region), that apply to fire stopping, separating walls, service penetrations, minimum periods of fire resistance and concealed spaces will also meet the requirements of this guidance.

1. Fire stopping

Design information

Drawings showing the lines of compartmentation and the lines of fire-resisting construction should be provided to the Surveyor and the Builder. The drawings should also give the required level of fire resistance for each element. Drawings to show the position of cavity barriers should be provided, and the specification of cavity barriers included.

Materials for fire stopping and cavity barriers

All materials used to form a fire barrier must have relevant third-party certification or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products. A competent person is deemed to be a third-party approved contractor specialising in fire stopping and passive fire protection.

2. Fire protection in buildings

Design information

The design details must show the correct level of fire resistance for the building, in accordance with Part B of the Building Regulations or Section 2 of the Scottish Building Standards, depending on region.

Materials for fire protection

All materials used to form a fire barrier must have relevant third-party certification, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products.

Where intumescent paints are used to provide the required level of fire protection, certification confirming that the paint applied will achieve the correct level of fire protection is required.

11.

Roofs

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings, where:
   a. On large developments over 3 stories in height (including ground storey) where the total combined roof area exceeds $50m^2$;
   b. Low rise developments less than 3 stories in height where the roof area exceeds $50m^2$;
   c. Where the roof includes features beyond a typical wall abutment e.g. (but not limited to) variations of upstand constructions / penetrations / fixings / external permanent machinery / balustrade fittings;
   d. Where the waterproof membrane is to be covered over by pedestrian finishes or solar panels;
   e. Where EDPM roof coverings are proposed.
2. Flat roof membranes will be required to be weather and waterproof. In certain circumstances the flat roof covering will also require to be tested at completion (please refer to the guidance within this Technical Manual for further information).

Materials

No additional requirements.

Design

1. Roof coverings must prevent any external moisture from passing into the internal environment of the building.
2. Roof structures and coverings shall be designed and constructed so that they:
   a. Are structurally sound;
   b. Satisfactorily resist the passage of moisture due to rain and snow to the inside of the building, and to materials which might be adversely affected by such moisture;
   c. Encourage the rapid discharge of moisture due to rain and snow from their external surfaces to a suitable discharge system;
   d. Have an adequate thermal performance;
   e. Are durable and resistant to moisture due to the weather, condensation or some other cause;
   f. Have adequate resistance to fire penetration and the spread of flame across their external surfaces;
   g. Do not allow fire spread across the tops of separating walls;
   h. Resist flanking sound transmission where adjacent to separating walls.
   i. Adequately discharge rainwater from the roof area to a suitable drainage system.
3. In addition to point 2: Flat roof design shall, unless specifically agreed otherwise with the Warranty provider, comply with the requirements of BS 6229 and be designed to have a minimum finished fall of 1 in 80.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

11.

Roofs

11.1

Pitched - Pre-formed Truss

Statutory requirements

Roof structure and loading

Roof framing and rafter design must be in accordance with current regional Building Regulations.

The roof of the building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground safely, and without causing such deflection or deformation of any part of the building, or such movement of the ground, as to impair the stability of any part of another building.

The roof structure should be of such construction that it has adequate interconnection with the walls, allowing it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

The need for diagonal rafter bracing equivalent to that recommended in BS EN 1995- 1: 2004+A1, or Annex H of BS 8103-3 for trussed rafter roofs, should be provided, especially for single-hipped and non-hipped roofs of more than 40° for detached houses.

For advice on 'sizing of certain timber members in floors and roofs for dwellings', the Designer should refer to the following sources:

- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995-1, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

Design Criteria

The design criteria set out is intended to be adequate for imposed roof loads of 1.00kN/m^2 for spans not exceeding 12m, and 1.50kN/m^2 for spans not exceeding 6m.

All structural timber should be stress graded. All such timber must be stamped as either 'DRY' or 'KD' (Kiln Dry). The use of ungraded, or 'green', timber is not acceptable.

Allowances for wind loading

The need for a roof to withstand wind pressure and suction will be met if the proposed roof is braced effectively, as discussed elsewhere in this section, and secured to the structure, as detailed below, with walls adequately restrained.

The securing of roofs to the supporting structure normally involves a timber wall plate or similar, which should be levelled using a spirit level so that loadings from the roof are directed perpendicularly down the supporting wall.

The wall plate should be fixed to ensure correct positioning when roof timbers or trusses are being installed by means of galvanised mild steel holding down straps (30mm x 5mm x 1000mm long at maximum 2m centres) nailed to the wall plate and securely fixed to the inner surface of the wall with compatible fixings.

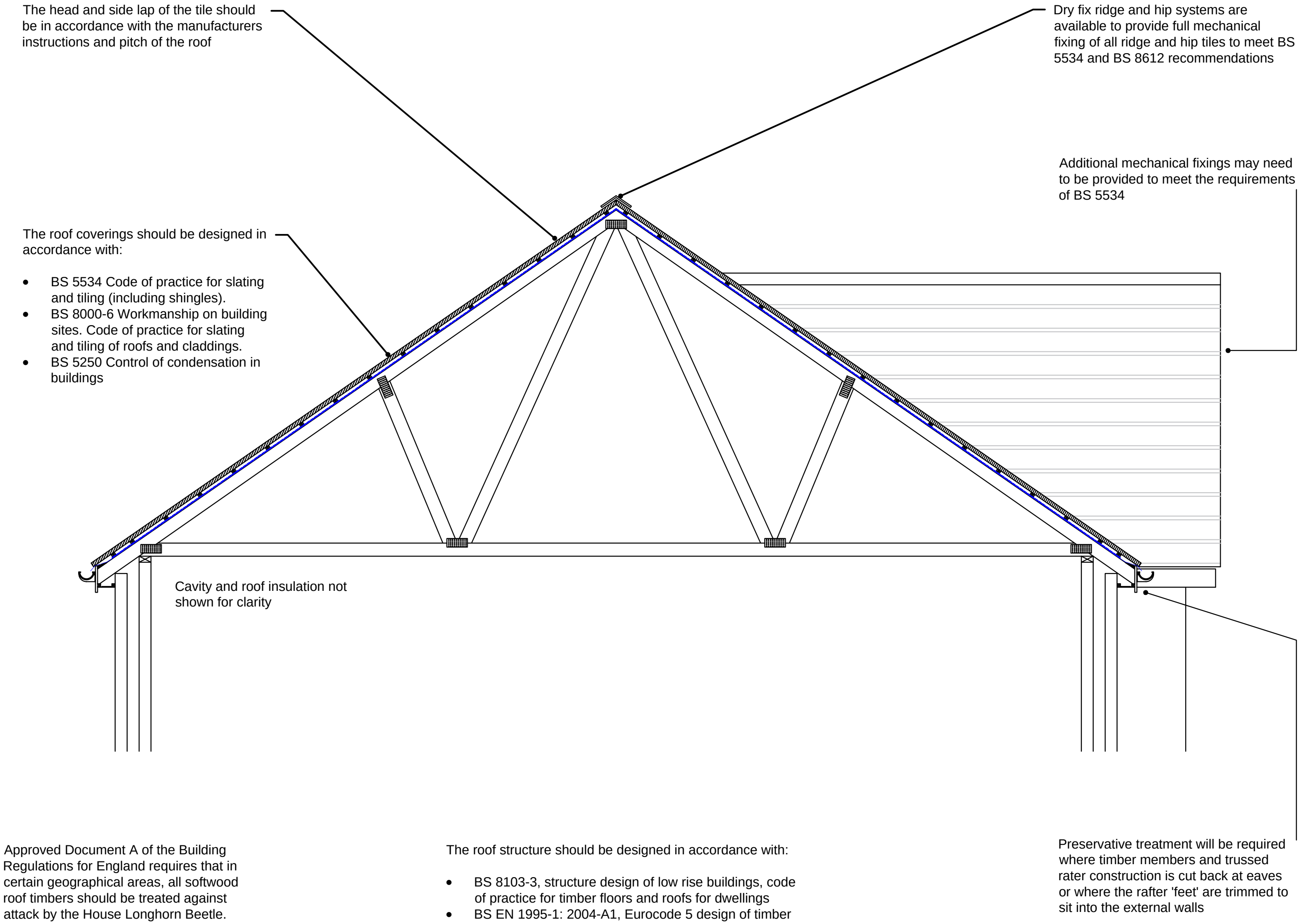
There is a need to ensure that holding down straps are provided in areas of severe wind exposure where required by the roof design.

Additional requirements in a coastal locations

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.



Approved Document A of the Building Regulations for England requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle. See 'Appendix C - Materials, Products, and Building Systems' for further information

The roof structure should be designed in accordance with:

- BS 8103-3, structure design of low rise buildings, code of practice for timber floors and roofs for dwellings
- BS EN 1995-1: 2004-A1, Eurocode 5 design of timber structures. General. Common rules for buildings

Roof Structure

Trussed rafter design

Design responsibility

The Building Designer is responsible for the 'framing' of any given roof as a whole. This means that he or she must take responsibility for the bracing together (framing) of the trussed rafter configuration, which then supports the roof covering and the tying together of the supporting walls.

Whilst it is the supplier of the rafters who generally has the knowledge and expertise required to achieve the best engineering solutions, the designer must be certain that the loading calculations and resultant configuration is fit for purpose.

The following checklists, derived from BS EN 1995-1: 2004+A1 and PD 6693-1, set out:

- Information required by the manufacturer from the Designer.
- Information that should be supplied by the manufacturer to the Designer.

Designer to truss manufacturer

- The height and location of the building, with reference to any unusual wind conditions.
- The profile of the trussed rafter, including camber if required.
- The span of the trussed rafter.
- The pitch or pitches of the roof.
- The method of support and position of supports.
- The type or weights of roof tiles or covering, including sarking, insulation and ceiling materials.
- The size and approximate position of any water tanks or other equipment to be supported on the trussed rafters.
- The overhang of the rafters at eaves, and other eaves details.
- The positions and dimensions of hatches, chimneys and other openings.
- The service use of the building, with reference to any unusual environmental conditions and the type of preservative treatment where required.
- The spacing of trussed rafters and special timber sizes where these are required to match existing construction.

Truss manufacturer to Designer

- Finished sizes, species, stress grades or strength classes of timber members.
- The type, sizes and positions of all jointing devices with tolerances, or the number of effective teeth or nails required in each member at each joint.
- The positions and sizes of all bearings.
- Loadings and other conditions for which the trussed rafters are designed.
- The spacing of trussed rafters.
- The positions, fixings and sizes of any lateral supports necessary to prevent buckling of compression members, such as rafters and struts. Details of the permanent bracing necessary to ensure the overall stability of the complete roof structure and supporting walls should be provided by the Building Designer.
- The method of support for tanks and ancillary equipment, together with the capacity or magnitude of additional load assumed.
- The range of reactions to be accommodated at the support positions, including those required to resist wind uplift forces.
- The basis of the design.
- Details of any changes in spacing to accommodate chimneys or openings.
- Any special precautions for handling and erection, in addition to those covered by BS EN 1995-1.

Spans

Maximum permissible spans for the most common building types and rafter configurations are given in BS EN 1995-1: Section 9.
For designs that fall outside BS EN 1995-1 conditions, the trussed rafter must demonstrate adequate jointing and structural integrity by calculation.

Loads

Trussed rafters and the framed roof must have dead and imposed loads calculated in accordance with BS EN 1991-1-1, BS EN 1991-1-3 and BS EN 1991-1-4 and be in accordance with PD 6693-1.

Loads acting on rafters are dead loads (tiles/slates, battens, underlay and rafter self-weight), imposed loads (snow load and maintenance) and the wind uplift load. Other dead loads that act on the ceiling ties (ceiling, insulation, water tanks and the tie self-weight) and imposed loads (loft access and weight of storage) will also have to be taken into account by the Designer.

The following limits for imposed loads on the rafters uniformly distributed over the whole roof, measured on plan:

- Roofs pitched 10° to 30°: 0.75kN/m2.
- Roofs pitched 31° to 75°: 0.75kN/m2 - 0 kN/m2 (reduced linearly), or
- A concentrated load of 0.9kN, whichever produces the greater stress or deflection.

Experience shows that for most common tiled and slated roofs, the uniformly distributed load is more severe.

Bracing, support and typical roof openings (BS EN 1995-1-1 and PD 6693-1)

As stated above, the Designer is responsible for framing the roof. The correct bracing configuration locks all timber supporting roof elements into a single structural, load-bearing unit. Standard bracing details are given in BS 5268-3.

Where recovering of existing roofs occurs: Approved Document A Section 4, deals with the requirements for checking the structural integrity of the roof and supporting structure when considering the re-roofing of buildings.

For information and design criteria necessary for ordering: BS 5268-3 provides a comprehensive list of criteria that should be supplied by the Building Designer or Site Supervisor to the Trussed Rafter Designer/Fabricator to enable a design to be prepared.

This includes:

- Span of the trussed rafter, wall plate to wall plate plus the width of wall plate at each end.
- Pitch of the roof.
- Method of support.
- Position of support.
- Anticipated loading of the roof structure i.e. the weight of the roof tiles and the exposure of the site should it attract excessive wind loads.
- Position and size of water tanks.
- Position and size of openings i.e. Loft hatches, roof windows, chimneys.
- Due to the site locality, any particular preservative treatment necessary for the timber, e.g. to protect against House Longhorn Beetle.
- Eaves details i.e. overhang required, etc.

In return, the Trussed Rafter Designer should supply the following details for site use:

- Position, bearing and spacing of trussed rafters.
- Position, fixings and sizes of lateral supports to prevent buckling of compression members such as rafters and struts.
- Deviations from standard spacing's, etc. to accommodate openings.
- Support details for water tanks.
- Any special handling equipment.

Modifications to trussed rafters

Trussed rafters should never be cut, altered or repaired for use without the full agreement of the Trussed Rafter Designer. Remedies for defects to erected trusses can be found in BS 5268: 3, but the Roof Designer's advice should be sought prior to repairs being carried out.

Combined trussed rafter and traditionally framed roofs

Extra care is necessary where the two principal timber pitched roof types are used in conjunction. The trussed rafters should be specifically designed to accept any additional loadings imposed by an adjacent traditional roof. Similarly, account should be taken of any loadings imposed by trusses on traditional roofs where only nominal loadings have been allowed for. If in doubt, consult the Roof Designer.

Statutory requirements

Treatment of timber

Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice, and in the following circumstances:

- Roof timbers should be preservative treated where the insulation and ceiling line follow the roof pitch.
- Trussed rafter construction which is cut back at eaves or where the rafter 'feet' is trimmed to sit into the external walls. Preservative treatment will be required to the cut ends.
- The Approved Document of Regulation 7 of the Building Regulations for England requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle.

The treatment should be impregnated with a preservative suitable for use in 'Use Class 1' in pitched roofs and 'Use Class 2 flat roofs', in accordance with BS 8417, for a 60 year anticipated service life. Cut ends must be liberally brushed or dipped with an end-grain preservative.

It is strongly recommended that, where punched, metal fasteners are proposed to roof trusses. Only micro-emulsion or organic solvent preservatives should be used for timber treatment, to limit the possibility of corrosion of the fasteners and so as not to adversely affect glued joints.

Further information can be found in 'Appendix C- Materials, Products, and Building Systems'.

Gable spandrel panels

The gable spandrel panel should be suitably designed to transmit loads to the roof structure and down through the supporting walls.

It is important that gable spandrel panels should be designed to transmit these loads to the roof structure via lateral restraints and vertically down to the supporting walls. Full design with structural calculations should be provided.

The truss designer the project Structural Engineer should provide details of the lateral resistant to the gable spandrel panel, including details of the restraint used and the fixings to be provided.

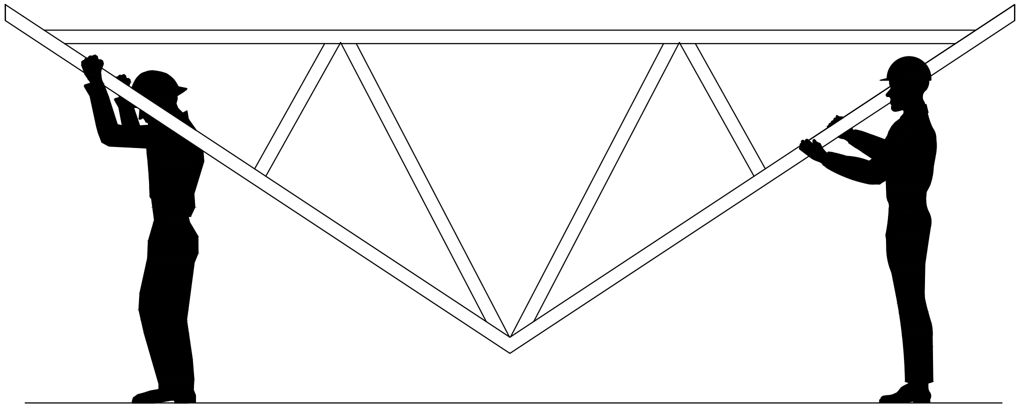
Handling and transportation

When transporting and handling trussed rafters, sagging and flexing should be avoided at all times. Whether handling is manual or by using mechanical equipment, trusses should be moved in a vertical positions unless support can be provided to every joint.

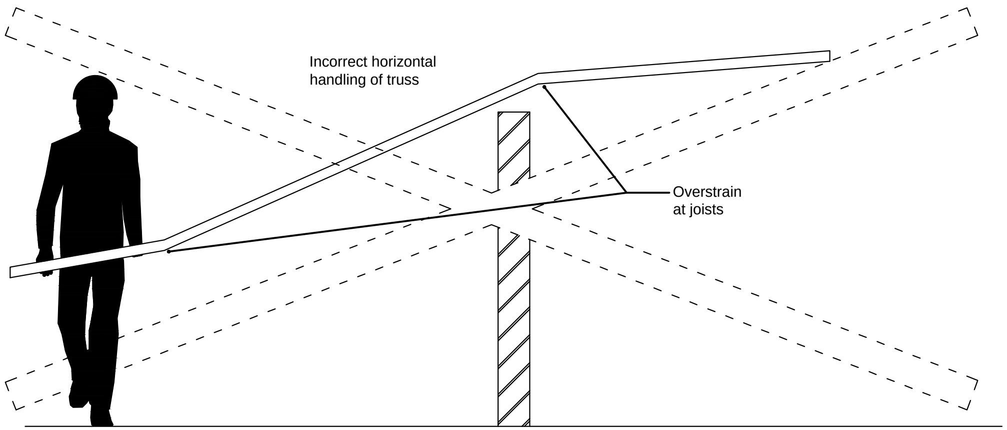
Manual lifting

On long-span trusses, it may be necessary to employ additional labour at intermediate positions. If required, the truss may be inverted so that the apex hangs down. See-sawing the truss across walls and scaffolding must be avoided. Individual designs and site conditions may dictate different requirements in order to install trusses in their final position.

Suggested method of manual lifting



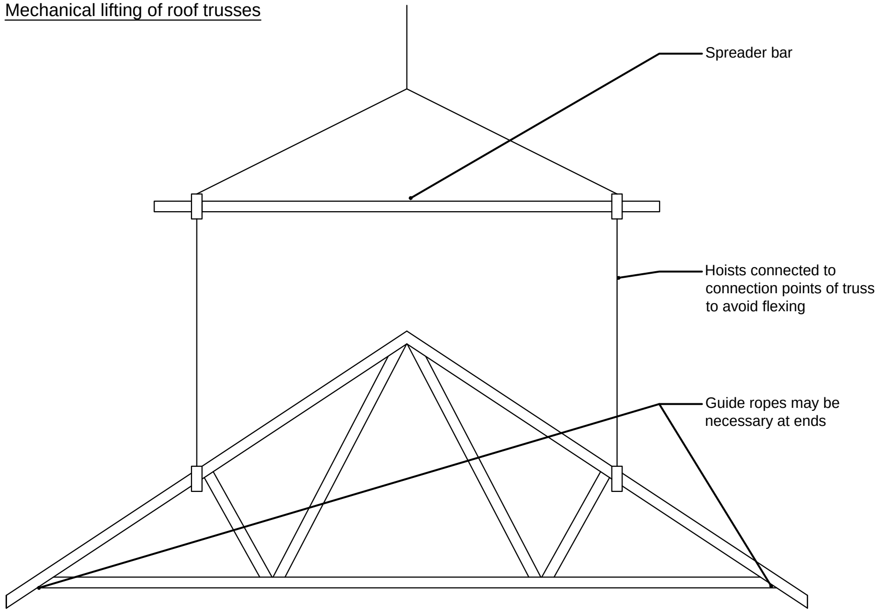
Avoid bending or see-sawing of trusses



Mechanical lifting

Ideally, when using mechanical lifting, the trusses should be lifted in banded sets and lowered onto suitable supports. Lifting points should be rafter or ceiling intersections or node points. Lifting trusses singularly should be avoided a suitable spreader bar should be used to withstand the sling force.

Mechanical lifting of roof trusses



Erection

It is essential when erecting a trussed rafter roof to ensure that the first trussed rafter is erected and braced rigidly in the correct vertical position so that it provides a base model against which all the other trusses can be set out.

Any temporary bracing should not be removed until permanent bracing has been installed. Immediately prior to the fixing of permanent bracing, the trussed rafters should be checked again for alignment and verticality.

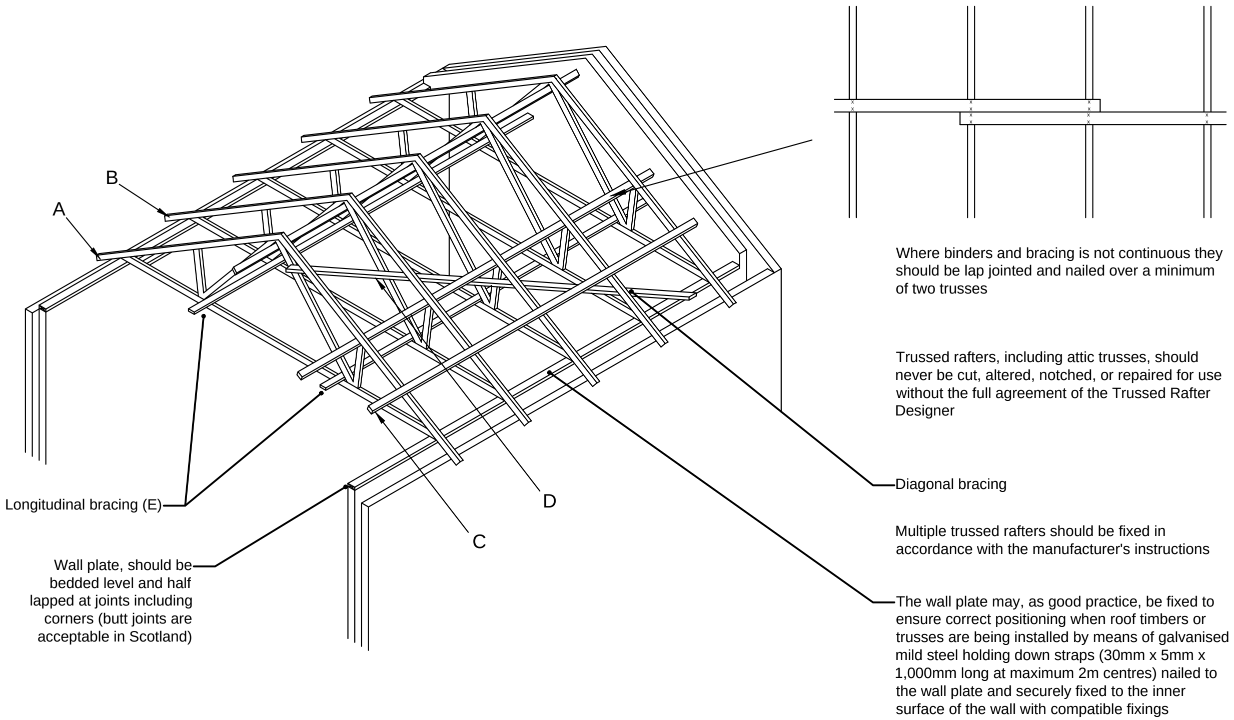
Trussed roof installation

The roof structure should be fully braced by 100mm x 25mm timber, twice nailed to roof timbers using 65mm long x 3.35mm diameter galvanised wire nails. Where nail guns are used, 75mm long x 3.1mm diameter annular ring-shank nails are allowed.

Procedure for erection

- Before placing first truss, mark required position of trussed rafters on opposing wall plates.
- Erect and brace first trussed rafter (A) (only one shown but fix others as necessary).
- Erect next adjacent trussed rafter (B) and brace back to (A) using brace (C).
- Erect other trussed rafters as with (B).
- When the final accurate positioning of the trussed rafters has been confirmed, the rafter feet can be fixed into position.
- Fix permanent diagonal bracing (D) (only one brace shown for clarity).
- Fix longitudinal bracing (E) (only three shown for clarity).
- Fix all remaining bracing.
- Remove all temporary bracing.

The International Truss Plate Association Technical Handbook, available from trussed rafter suppliers, provides additional advice on trussed rafter erection.



Bracing to duo-pitched roofs

Fixing

To achieve a stable and wind-resistant roof and gable wall structure, the roof must be secured to the gable wall, if applicable, and fully braced by 100mm x 25mm timber, twice nailed to roof timbers using 65mm long x 3.35mm diameter galvanised wire nails. Where nail guns are used, 75mm long x 3.1mm diameter annular ring-shank nails are allowed. They do not need to be galvanised.

Types of bracing

There are three main types of wind bracing, which should be fixed:

- Diagonal rafter bracing.
- Longitudinal bracing.
- Chevron bracing (only necessary on trussed rafter spans over 8m).

Diagonal and longitudinal bracing are required in all trussed rafter roofs. Bracing for wind loads can also be enhanced by adequately fixed tiling battens and/or sarking boards. The ceiling plasterboard (12.5mm thickness) or a similar rigid material will also contribute to the bracing process. Sarking boards, such as moisture-resistant plywood (minimum thickness 9mm) and moisture-resistant chipboard (minimum thickness 12mm), may provide adequate bracing without the need for additional wind bracing to the roof. Sarking boards should be laid with staggered joints and nailed at 200mm centres on every truss with 50mm long x 3mm diameter galvanised round wire nails.

Longitudinal bracing

Longitudinal bracing should be positioned tightly to abut separating and gable walls. In timber frame construction, you should ensure that longitudinal braces are fixed to timber frame gables/separating walls to provide additional lateral restraint.

Chevron bracing

Chevron bracing is only required for roof spans exceeding 8m, and it can be identified as diagonal bracing to the web members of the roof truss.

For spans of between 8m and 11m, such bracing may only be required to a single web member on either side of the roof. For spans exceeding 11m, more extensive chevron bracing may be necessary. 100mm x 25mm chevron bracing should be installed continuously along the lines of webs so that there are no more than two consecutive trusses between braces. Each brace must be at 45 degrees and fixed to at least 3 trusses.

Mono-pitched roof bracing

In mono-pitched trussed rafter roofs, the diagonal bracing pattern for narrow-fronted houses should be adopted. The requirement for longitudinal bracing is the same as for duo-pitched trussed rafter roofs.

Chevron bracing is required to the webs in roofs exceeding a 5m span and also to upright members where inadequate lateral restraint is provided at the apex of the roof.

Coastal Locations and sites of severe or very severe exposure ratings (BS 8104)

Roof bracing for sites in these locations should be designed by a Structural Engineer.

Diminishing trusses

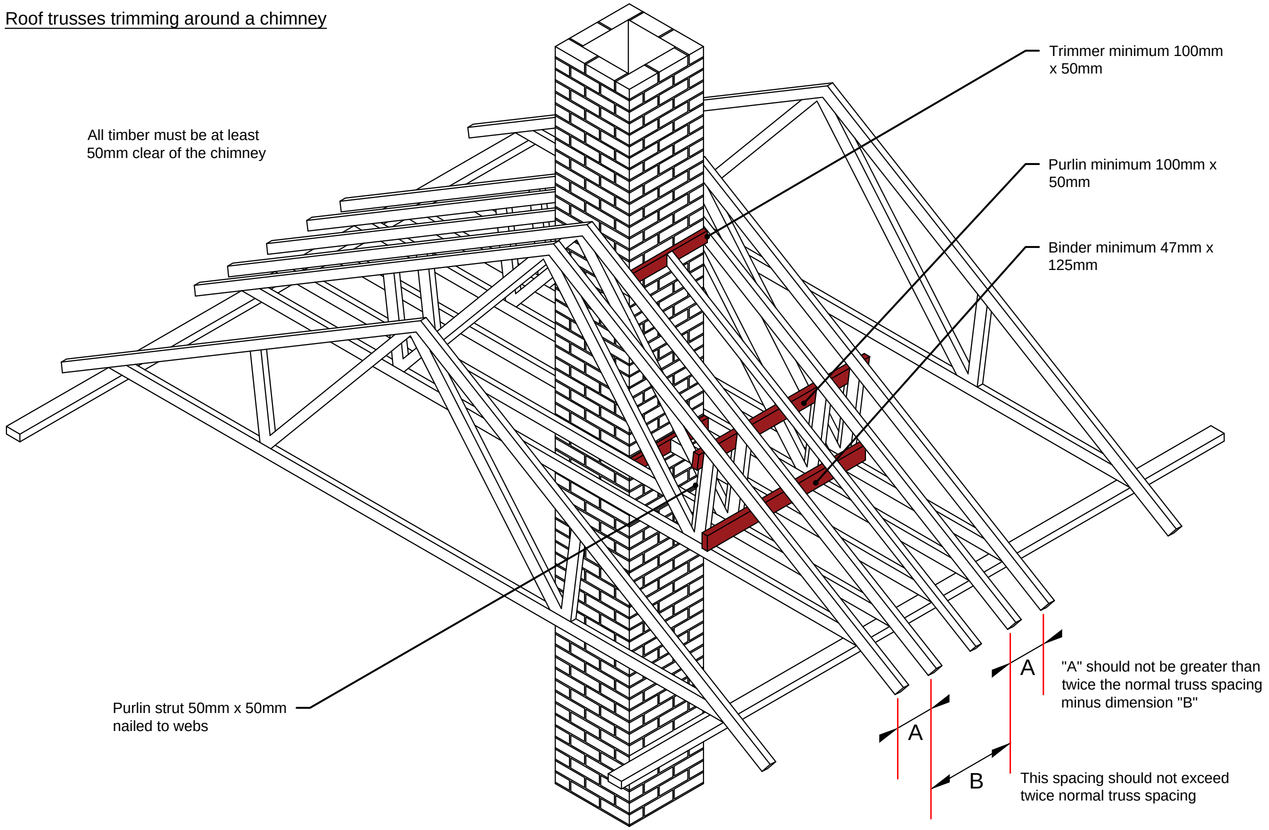
The Truss Roof Designer should provide details of fixings for the diminishing truss to the main roof truss:

- Where the diminishing truss has a splayed bottom chord that matches the pitch of the main truss (usually where the roof pitch is less than 30º), the truss can be skew-nailed to the main truss with two no 3.35mm diameter x 75mm galvanised wire nails.
- Where the diminishing truss has a square bottom chord, the truss can be skew-nailed to the main truss and supported on a continuous binder also fixed to the main truss. The top of the binder should be splayed to suit the bottom chord and; 2 no. 3.35mm diameter x 75mm galvanised wire nails should be used for the fixing.

Mono-pitch and girder trusses on trussed rafter hipped-end roofs

Mono-pitch trussed rafters can be used in conjunction with girder trusses on trussed rafter hipped roofs. Mono-pitched trusses are fixed to girder trusses using metal shoes. The bearing of mono-pitched trusses onto the mild steel proprietary girder shoe should be confirmed with the Roof Designer before site installation is attempted. Girder trusses are strengthened trusses designed to support loads in another plane (such as mono-pitched trusses).

Roof trusses trimming around a chimney



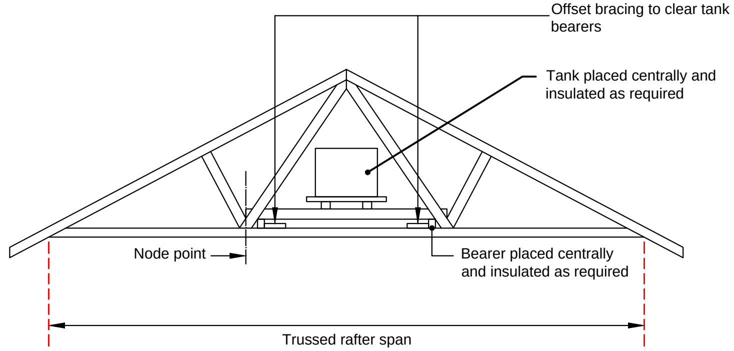
Provision for openings, i.e. loft hatches, chimneys, etc.

Wherever possible, a trussed rafter roof should be designed to accommodate necessary openings within the trussed rafter spacing, e.g. a loft hatch. Trusses must never be cut or trimmed except according to details supplied by the truss manufacturer. The Roof Designer should provide all necessary details. This is applicable particularly for where roof lights and dormers are formed. Detailed specifications of the trimming joists at the side, head and base of the opening must be provided to ensure the roof is safely supported.

Multiple-trussed rafters

Multiple-trussed rafters may be specified for a particular purpose, and may be delivered to site already fastened together. Alternatively, fixing together on-site of multiple trusses may be necessary, in which case it will be necessary to get full details of the fixing specification from the Roof Designer.

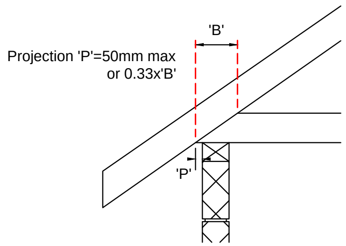
Tank stand configuration



Tank stands

Confirmation should be obtained from the Roof Designer that a trussed rafter roof design is capable of supporting water storage tanks. Tanks should be supported by bearer beams, on the ceiling ties portion of the truss. Bearers should be skew-nailed to supports as appropriate. Alternatively, proprietary joist hangers can be used. Tank bearers should be situated as close as possible to the node or intersection points of the trussed rafter. The dimensions of the bearers depend upon the size of the supported tank and the span of the trussed rafters. Tanks with a capacity up to 230 litres should be supported by a minimum of 3 rafters. Tanks up to 330 litres should be supported by a minimum of 4 rafters. The tank platform should not be constructed from chipboard as it may become wetted by condensation, plumbing leaks, or rainwater ingress and lose its strength.

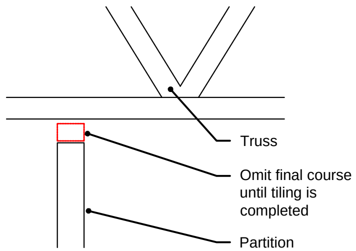
Correct positioning of roof trusses



Trussed roofs should be supported on timber wall plates. Wall plates should be bedded to line and level, joined using a half lapped joints at all joints including corners

The truss roof structure and the wall plate should be bedded and fixed to transmit and distribute loads and prevent uplift

Internal non-loadbearing walls

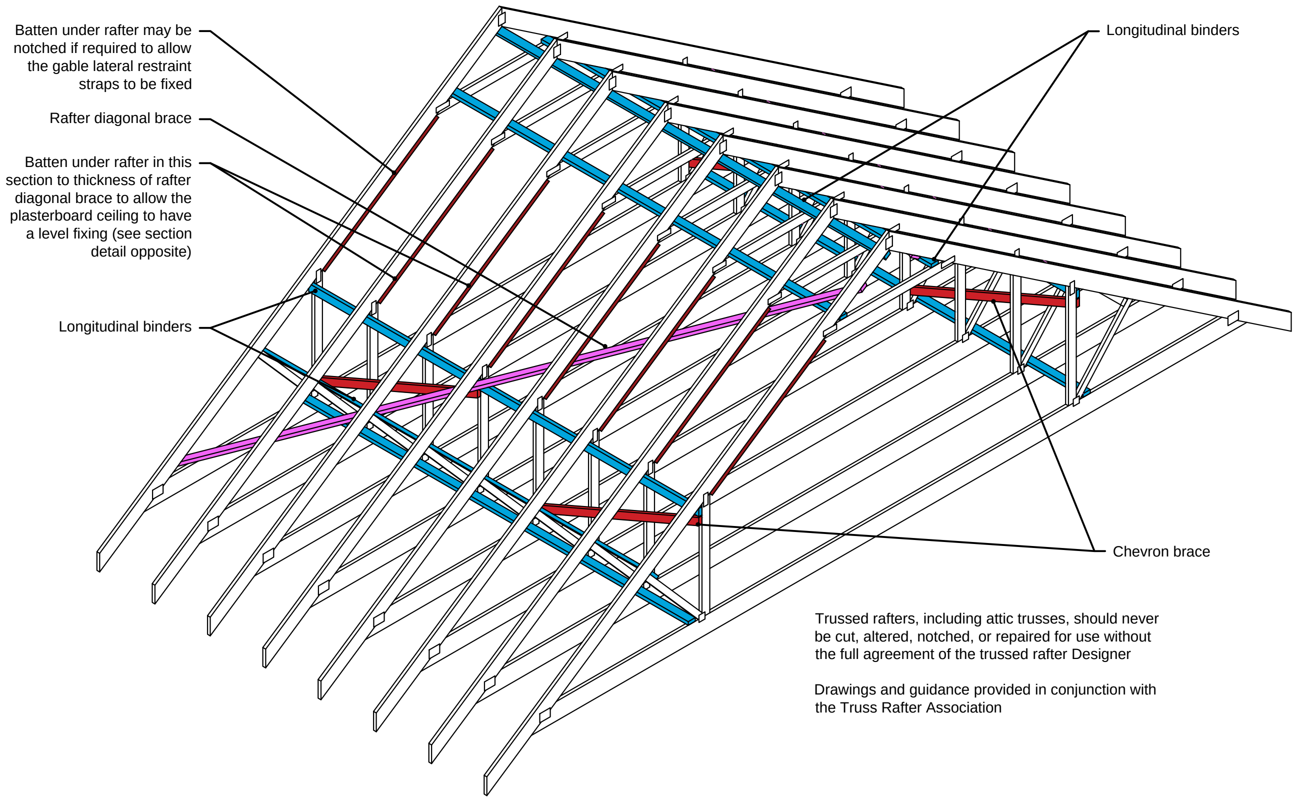


It is advisable to erect non-load bearing walls after the tiling has been completed thus allowing deflection to take place under dead load, thereby reducing the risk of cracking appearing in the ceiling finishes. If partitions are of brick or block, then alternatively the final course can be omitted until tiling has been completed

Attic truss

Where attic trusses are used, bracing should also be provided in accordance with the design, the diagonal bracing for attic trusses can be placed internally and the inside of the rafters battened out to take the plasterboard. Alternatively, plywood diaphragms can be placed between the rafters within the sloping ceiling area.

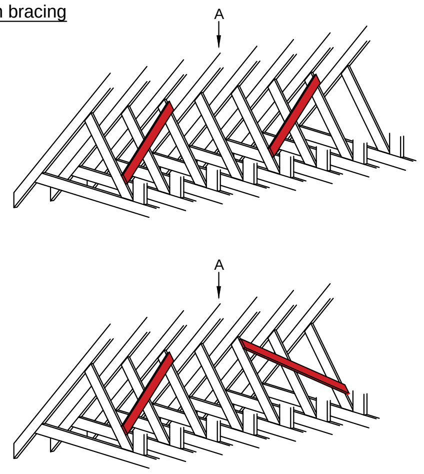
Attic truss bracing



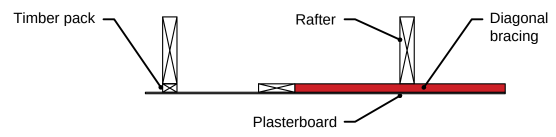
Trussed rafters, including attic trusses, should never be cut, altered, notched, or repaired for use without the full agreement of the trussed rafter Designer

Drawings and guidance provided in conjunction with the Truss Rafter Association

Chevron bracing



Section detail of Internal diagonal bracing battened out for plasterboard



Condensation and ventilation

Statutory requirements

The roof should be designed and constructed in accordance with clause 8.4 of BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250 Code of Practice for control of condensation in buildings Annex H.

Prevention of condensation in roof voids is best achieved through the provision of natural air ventilation. BS 5250 states that the Designer should take account of the following moisture sources in buildings:

- Water incorporated during the construction process (including precipitation).
- Precipitation after construction.
- Water vapour arising from the occupants and their activities.
- Atmospheric moisture drawn into the roof during warm humid weather conditions.

Well sealed ceilings/air tightness of ceilings

BS 5250 emphasises the importance of well sealed ceilings as a means of curbing the transfer of moisture into a roof space by means of moisture-laden air. This means:

- The avoidance of gaps and holes in a ceiling.
- The siting of access doors or hatches into the roof space away from moisture-producing areas, such as bathrooms or kitchens.
- That hatch covers must be effectively sealed.
- High levels of workmanship.

Air leakage through gaps in a ceiling transfer more heat and moisture into the roof by convection than passes through the ceiling materials by diffusion. Sealing the ceiling is therefore an essential requirement when considering the design of the roof envelope.

Key design issues to consider are as follows:

- Avoid construction gaps.
- Avoid roof access doors or hatches in rooms that produce excessive moisture.
- Use a proprietary sealed loft hatch and frame, and seal correctly in accordance with the manufacturer's recommendations.

There is advice found in BS EN 13141-1 Ventilation for buildings. Performance testing of components/products for residential ventilation.

- Seal all services and roof lights.
- Use recessed light fittings rated IP60 to IP65 to BS EN 60529.
- Seal the head of cavity walls to prevent the transfer of warm moist air into the loft.

Air and vapour control layer (AVCL)

If an AVCL is installed it should be placed on the warm side of the insulation. Installation of an AVCL at ceiling level will increase the need for sufficient ventilation below it during the drying out of wet trade construction phases. The performance of an AVCL depends not only on the material selected, but also on the workmanship and the ability of the construction to be assembled on-site (see BS 5250). It is essential that an AVCL is adequately lapped and all joints sealed, and that its integrity is maintained. Particular attention should be paid to detail design and installation around penetrations through the AVCL e.g. services, compartment walls and to the sealing of punctures caused by fixings.

Cold roof

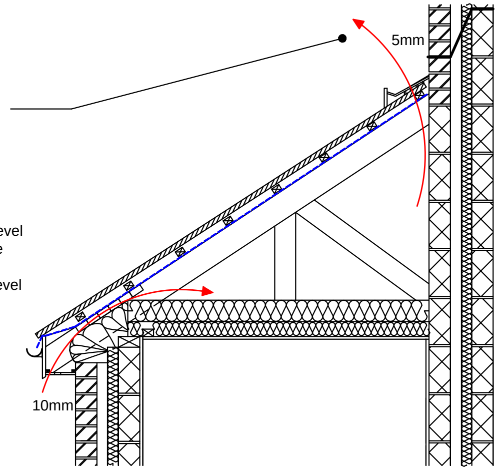
The following suggest the correct positioning of vents and the precise amount of free airspace required for 'cold roof' construction, in accordance with current Building Regulations and BS 5250.

These recommendations apply if a high water vapour resistance (type HR) underlay is used.

Mono pitched/lean to roof

A free airspace of 5,000mm^2/m should also be provided at high level (equivalent to a continuous 5mm opening)

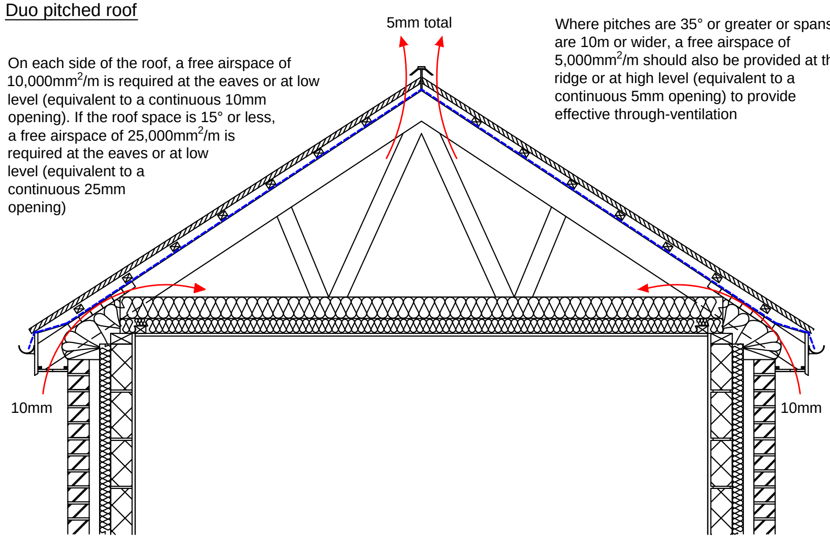
If the roof space is 15° or less, a free airspace of 25,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 25mm opening). If the roof pitch is more than 15°, a free airspace of 10,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 10mm opening)



Duo pitched roof

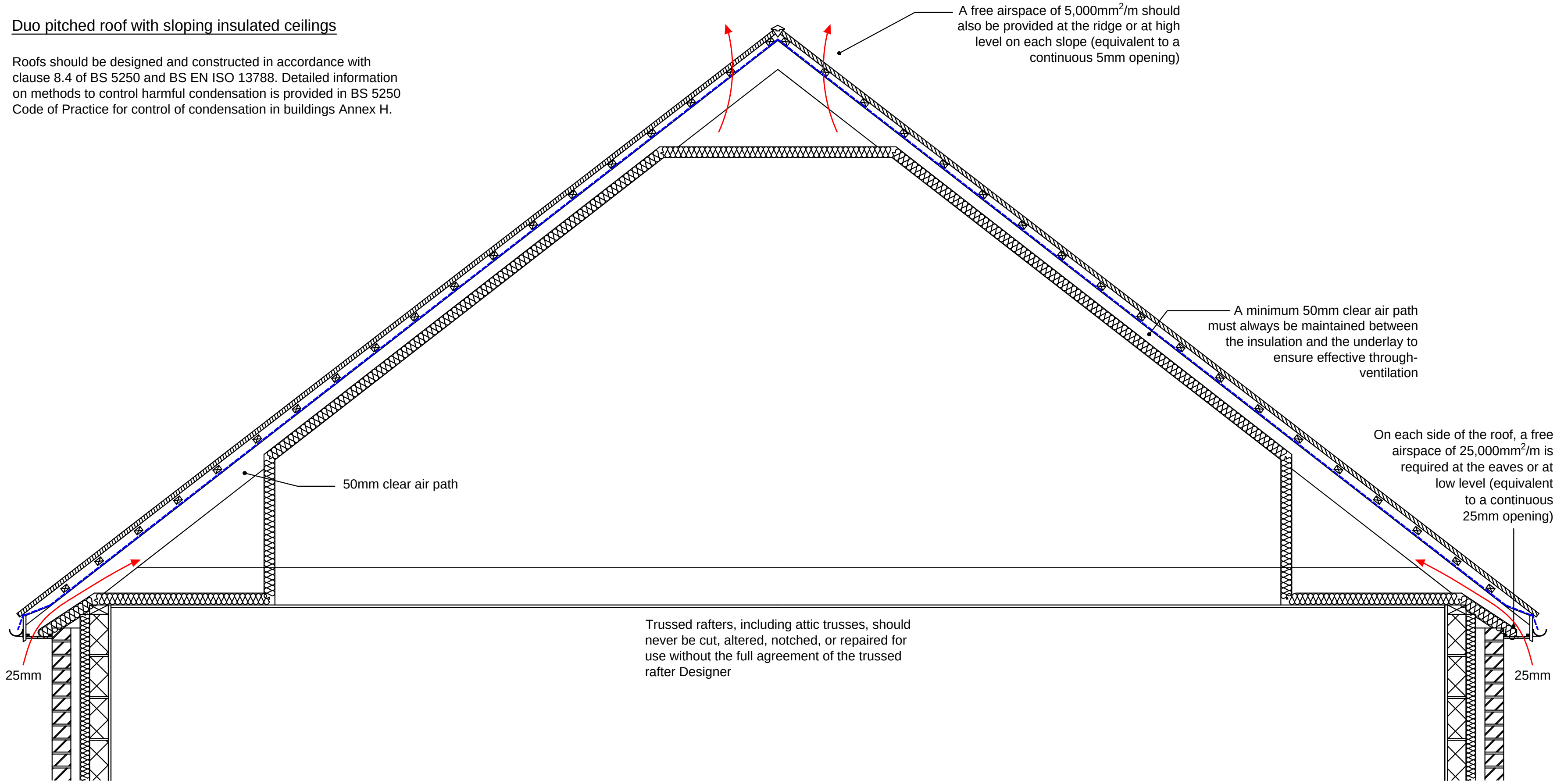
On each side of the roof, a free airspace of 10,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 10mm opening). If the roof space is 15° or less, a free airspace of 25,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 25mm opening)

Where pitches are 35° or greater or spans are 10m or wider, a free airspace of 5,000mm^2/m should also be provided at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation



Duo pitched roof with sloping insulated ceilings

Roofs should be designed and constructed in accordance with clause 8.4 of BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250 Code of Practice for control of condensation in buildings Annex H.



Duo-pitch roof with fire break walls

Where a roof is divided by fire break walls and therefore cross ventilation cannot be achieved, each roof void is treated separately. Each void should be provided with 5,000mm^2/m of free air space at the highest level possible and 10,000mm^2/m of free air space provided at the lowest level. The ventilation should not impair the fire performance of the wall.

Vapour permeable (type LR) underlays

If an LR underlay is used, interstitial condensation is unlikely to occur, provided the ceiling is well sealed and the eaves have a minimum continuous ventilation opening of 3mm. If the ceiling is not well sealed, openings equivalent to 7mm should be used; 10mm eaves vent systems will satisfy both requirements.

BS 5250 does not consider the situation where it is proposed to provide no ventilation to the roof void, or ventilation more limited than described above. Should Designers wish to adopt this principle, they should refer to the conditions attached to Technical Approvals given by UKAS (or European equivalent) accredited technical approval bodies.

Close Fitting Roof Coverings

When specifying a close fitting roof covering which is relatively airtight, such as fibre cement slates, there is a risk of interstitial condensation forming on the underside of the underlay and external covering. To avoid this risk, the batten space should be ventilated in accordance with BS 5250 using counter battens for both warm and cold roof constructions. This is due to problems that may arise where an underlay which offers low resistance to the passage of water vapour will tend to lower the risk of condensation in the loft, but might increase the risk of condensation in the batten space.

Where underlays are used which allow the transfer of moisture vapour into the batten space by diffusion or convection, potentially damaging condensation can occur if the batten space is not adequately ventilated either by purpose introduced ventilation or by natural ventilation through a suitably permeable roof covering.

Cold pitched roof with an LR underlay with a close fitting roof covering

If an LR underlay is used, the designer may provide less ventilation to the loft than is recommended for a roof with a HR underlay in BS 5250 providing that it is installed in accordance with the manufacturers 3rd party accreditation.

Note: BS 5250 does not cover situations where limited or no ventilation is proposed to the loft space.

With some LR (breathable) underlays, moisture can move by both diffusion and convection from the loft into the batten space.

To reduce the risk of potentially damaging condensation, the batten space should be ventilated. This should be achieved by means of counter battens and vents at both low and high level:

- Low-level vents should be equivalent in free area to a slot 25mm deep running the whole length of the eaves.
- High-level vents should be equivalent in area to a slot 5mm deep running the whole length of the ridge in accordance with BS 5250.

Note: Alternative methods of ventilating the batten void should provide an equivalent level of ventilation.

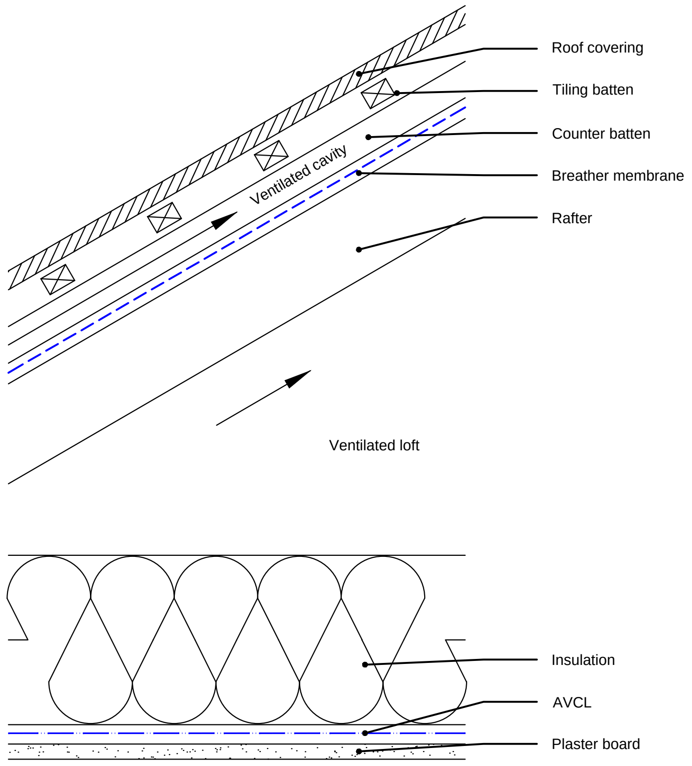
If ventilation is not provided to the batten space there needs to be an increased level of ventilation to the roof space and that should be in accordance with BS 5250. The underlay manufacturer's 3rd party accreditation also needs to be followed.

It is very difficult to determine a HR or LR underlay by sight alone and the manufacturers third party accreditation should be referred too if ventilation requirements are in doubt.

Cold pitched roof with HR underlay with a close fitting roof covering

An HR underlay provides high vapour resistance on the cold side of the thermal insulation, preventing the diffusion of water vapour from the loft in to the batten space; it is therefore essential that the loft space be ventilated in accordance with BS 5250 and this Technical manual.

Cold pitched roof - LR underlay - Impermeable external covering



Warm roof construction

Insulation may be provided above the rafter and between rafters to form a warm roof construction. The position of insulation and vapour control layers (AVCL) must strictly adhere to the insulation manufacturer's recommendations. All warm roof construction products must have appropriate third party certification.

Ventilation to counter batten void will be required where vapour permeable (type LR) underlays are not used.

Warm pitched roof with an LR underlay and tight fitting roof covering

In warm pitched roofs with an LR underlay, an AVCL (air and vapour control layer) should be provided at ceiling line. Where an external covering (such as fibre cement slates) is relatively airtight there is also a risk of interstitial condensation forming on the underside of the underlay and the external covering; to avoid that risk the batten space should be ventilated as described.

Warm roof construction (vented battens)

In roofs with an HR underlay, whatever form of external covering or ceiling is provided, there is a risk of interstitial condensation forming on the underside of the HR underlay; to avoid that risk, an AVCL should be provided on the warm side of the insulation, and ventilated voids should be formed between the underside of the underlay and the insulation.

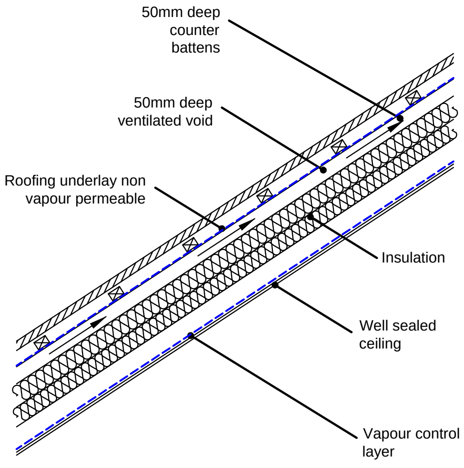
Thermal insulation provisions for the compliance with the Building Regulations

Thermal insulation must be installed to meet current Building Regulations, to an acceptable level of workmanship, to avoid cold bridges and to meet the following provisions:

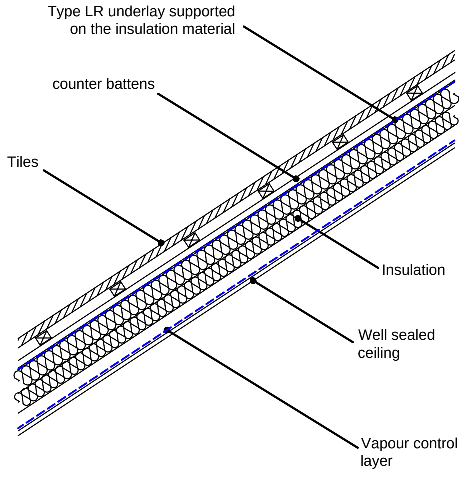
- The use of over joist and under rafter insulation is considered best practice, as it eliminates the cold bridge caused by the joist/rafter.
- If required by BS 5250, use a vapour control plasterboard or a separate VCL behind the plasterboard.
- Use a proprietary eaves ventilator to ensure ventilation is in accordance with BS 5250.
- The installation of the eaves ventilator must not prevent free water drainage below the tiling battens.

The requirements of the regulations are designed to reduce carbon emissions from new buildings and improve the performance of existing buildings where new work is carried out.

Warm roof construction (vented battens)



Warm roof construction (vapour breathable underlay)



Insulation may be provided above the rafter and between rafters to form a warm roof construction. The position of insulation and Vapour control layers (AVCL) must strictly adhere to the insulation manufacturer's recommendations. All warm roof construction products must have appropriate third-party certification.

Ventilation to counter batten void will be required where vapour permeable (type LR) underlays are not used.

Roof coverings

Legislation and planning

Tiled and pitched roof coverings should be in accordance with the relevant Building Regulations.

The principal British Standards relevant to this section are:

- BS 5534 Code of Practice for slating and tiling (including shingles). This gives recommendations for the design, materials, application, installation and performance of slates and tiles (BS 5534 should be read in conjunction with BS 8000-6).
- BS 8000-6 Workmanship on building sites. Code of Practice for slating and tiling of roofs and claddings. This applies to the laying and fixing of clay and concrete tiles, natural and fibre cement slates and their associated fixings and accessories.
- BS 5250 Control of condensation in buildings. This describes the causes and effects of surface and interstitial condensation in buildings, and gives recommendations for control of condensation in roofs.

To ensure safe working practices during construction, the Designer should consider relevant safety regulations. These include the Construction (Design and Management) Regulations and the Health and Safety Executive's Approved Code of Practice for Management of Health and Safety at Work.

Certain advisory bodies, such as the Loss Prevention Council, Building Research Establishment Ltd (BRE) and Timber Research and Development Association (TRADA), also produce recommendations and guidance on roof construction.

Weather exposure

Rain and snow

The roof of the building shall adequately protect the building and people who use the building from harmful effects caused by precipitation and wind-driven spray. Roofs are required to resist the penetration of precipitation (rainfall) to the inside of the building, thereby preventing damage to any part of the building where it might be carried.

Most pitched roofs keep the rain and snow out of the building and give a satisfactory performance. However, it is acknowledged that similar roofs built to the same design and using identical roof materials, but in different locations, may not necessarily provide the same level of assurance since they will be subject to different weather conditions and exposure.

Exposure to driving rain

The UK has a high risk of severe driving rain, and even in some sheltered locations may be subject to high levels of deluge rainfall. BS 5534 defines four categories of exposure, based on the driving rain data given in BS 8104 and BR 262, and should be used for buildings up to 12m in height. For buildings over 12m in height, the influence of increased wind speeds should be taken into account using BS EN 1991-1-4.

Control of internal pressure

The total wind force on a roof is dependent on the pressure differential between the inner and outer faces of the roof covering. Such pressures are significantly reduced by the use of underlay or boarding beneath tiling or slating. Its contribution towards shielding the underside of the tiles or slates from the full transmission of internal pressures means the underlay is required to have an adequate tensile strength for the specific application. The tensile strength of the underlay, its air permeability factor and the withdrawal resistance of batten nail fixings are therefore important when determining the overall resistance to wind uplift of the roof system.

Aircraft vortices

Roofs near airports can experience high local wind load forces due to air vortices created by certain aircraft when taking off and landing, which may be greater than the wind loads calculated to BS 5534. Designers should seek advice from the Airport Authority Planning Department when designing roof fixings in these locations, and refer to the guidance contained in BRE Digest 467 Slate and tile roofs: avoiding damage from aircraft wake vortices.

Calculating the fixing specification

The procedures for calculating the wind loads and determining the fixing specification for tiles and slates in accordance with BS EN 1991-1-4 and BS 5534 are complex to undertake. Designers are advised to obtain a full roofing fixing specification from the slate or tile manufacturer.

Alternative proprietary mortar mixes may be accepted if they are shown to have similar durability and workability.

Workmanship

Tile fixing

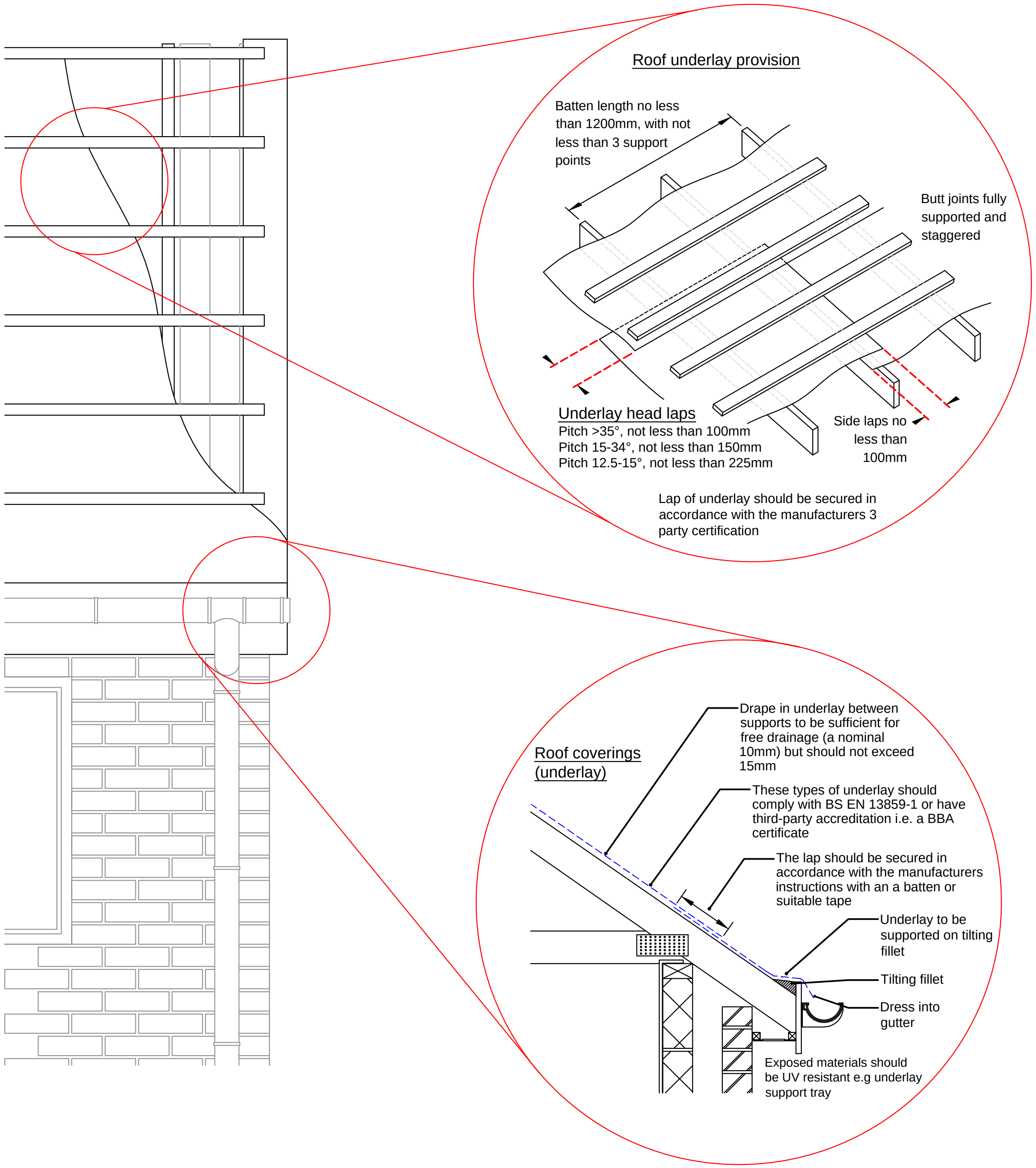
Tile fixing should be in accordance with BS 8000-6 and the manufacturer's recommendations.

Relevant British Standards

- BS EN 490
- BS 5250
- BS EN 1990
- BS 5534
- BS EN 1991-1-4
- BS 8000-6
- EN 13859-1
- BS 6399

Further guidance

Practical guidance on the application of single-lap and double-lap tiling can also be obtained from CITB/CS Trainer Resource Package for Operatives in the Construction Industry Manuals, Construction Industry Training Board.



Underlays

Lay the specified roofing underlay parallel to eaves or ridge with horizontal overlaps, as specified in the table below. Vertical side laps should be a minimum of 100mm. Minimise the gap at laps resulting from different tautness between underlay courses. Drape in underlay between supports is to be sufficient for free drainage (a nominal 10mm) but should not exceed 15mm in accordance with BS 5534. Fix underlay with the fixings specified, keeping the number of perforations to a minimum. Handle and fix underlay with care to ensure there are no tears or punctures, and repair any tears or punctures prior to tiling. Ensure that the underlay does not obstruct the flow of air through ventilators located at eaves, ridge or in the main roof, and appropriately weather all holes formed in underlays for soil vent pipes, etc. Avoid contact between the underlay and the underside of tiles. To prevent wind uplift, fix additional battens or timber strips where laps occur between tiling battens (refer to BS 5534 6.2 Underlays).

Rafter pitch	Not fully supported (mm)	Fully supported (mm)
12.5° to 15°	225	150
15° to 35°	150	100
35° and above	100	75

Minimum horizontal laps for underlays

Specification for underlays

Fully supported and non supported underlays:

- BS 8747 Class 1F reinforced bitumen or Class 5U polyester reinforced bitumen.
- 2HR* underlay to BS EN 13859-1 Class W1 water penetration classification with third party certification for the use intended.
- 3LR† underlay to BS EN 13859-1 Class W1 water penetration classification with third party certification for the use intended.

* HR (high water vapour resistance) underlay - >0.25MNs/g.
† LR (low water vapour resistance) underlay - <0.25MNs/g.
(LR underlays are sometimes referred to as 'vapour permeable' or 'vapour open').

Materials

Underlay nails

Nails for use with roofing underlays should be clout head nails of no less than 3mm shank diameter and 20mm length made of copper, aluminium alloy or steel coated by any of the zinc or zinc alloy coating methods specified in BS EN 10230-1.

Underlay

These types of underlay should comply with BS EN 13859-1 or have third-party accreditation i.e. a BBA certificate.

There are two categories of underlay: HR, non-vapour permeable and LR, vapour permeable. These types of underlay should comply with BS EN 13859-1 or have third-party accreditation, i.e. a BBA certificate. They should also have sufficient tensile and nail-tear strength, and low extensibility, to produce the required resistance to wind uplift.

Underlays for use beneath tiles and slates are either fully supported over boarding, sheathing or sarking, or unsupported and draped over rafters/counter battens, and should meet the conditions detailed.

Classification of underlays

Underlays should be classified in accordance with their geographic location and wind zone. Underlays should only be used in those wind zones for which the design wind pressure is not greater than the declared wind uplift resistance. Refer to BS 5534 A8. Figure A.4 for design wind pressures for geographical wind zones location map. It is important to ensure the underlay is suitable for the geographical wind zone and that laps in the underlay are secured in accordance with the manufacturers 3 party accreditation for the geographical wind zone and batten spacing. This lap can be secured either with a batten or a manufacturers 3rd party approved product.

Timber battens

Timber species
Tiling battens and counter battens should be selected from the timber species set out in BS 5534, and their characteristics and defects should not exceed the permissible limits given in Annex D to G of BS 5534.

Grading
Battens should be suitable graded to meet the requirements in BS 5534. Only battens that have been graded and bear the BS 5534 marking will be acceptable for use.

Sizing
Timber batten sizes should be not less than the minimum values recommended in BS 5534 for the common applications listed therein.

Battens for large spans or special loading conditions should be designed by structural calculation for strength and stiffness, in accordance with Annex F of BS 5534.

Preservatives
BS 8417: 2011 provides recommendations for preservatives for timber. Indicative preservative treatment schedules are given in Annex E of BS 5534. Battens treated with preservatives can contain toxic substances that could introduce an environmental hazard, and should be disposed of safely.

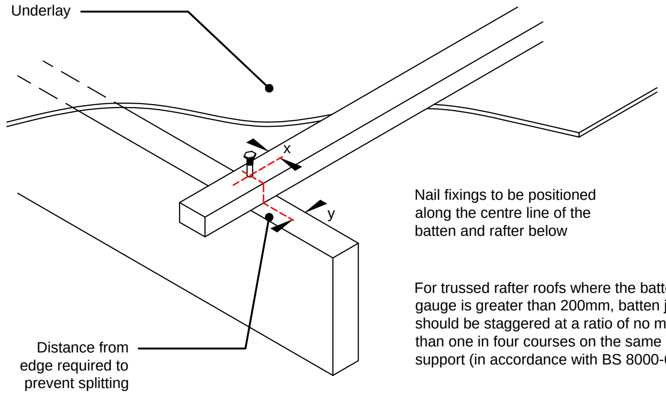
Fixing timber battens
Battens should be at least 1200mm in length and supported at each end and intermediately by at least three rafters or walls. Stagger butt joints over intermediate supports, splay nail each batten end and nail battens to each rafter.

For trussed rafter roofs where the batten gauge is greater than 200mm, do not have more than one joint in any four consecutive battens on the same support.

For trussed rafter roofs where the batten gauge is less than 200mm do not have more than three joints together in any 12 consecutive battens on the same support.

The batten sizes given in the table should be taken as minimum dimensional requirements. Take care that nails used to secure tiles do not penetrate the underside of battens or the underlay.

Fixing battens to rafters



Recommended batten sizes for pitched roofs and vertical work (BS 5534 in accordance with clause 4.11.4.1 Table 3)

Tile type	**Basic minimum sizes***			
Rafter/supports	**450mm span**		**600mm span**	
	width	depth	width	depth
Plain pitched/vertical	38	25	38	25
Single lap interlocking tiles/slate	38	25	50	25
Fibre cement slates	38	25	50	25
Natural slates	50	25	50	25
*All dimensions subject to re-sawing allowance: width +3mm, depth 0 or +3mm based on measurement reference moisture content of 20%				

Fixing roof battens

Fix the specified battens up the roof slope on top of the rafters, ensuring a minimum 40mm nail penetration into rafters (smooth shank). Nail counter battens at maximum 300mm centres vertically up the roof slope. Where boarding is used the fixing should coincide with the line of rafters.

11.
Roofs

11.2
Pitched - Traditional Cut

Statutory requirements

Roof structure and loading

Roof framing and rafter design must be in accordance with current regional Building Regulations and British Standards.

The roof of the building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground safely, and without causing such deflection or deformation of any part of the building, or such movement of the ground, as to impair the stability of any part of another building.

The roof structure should be of such construction that it has adequate interconnection with the walls, allowing it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building. The potential for roof spread should be considered by the Structural Engineer and incorporated within the design calculations for the roof.

In this respect, it is acknowledged that a traditional cut roof i.e. using rafters, purlins and ceiling joists, generally has sufficient built-in resistance to instability and wind forces, e.g. from either hipped ends, tiling battens, rigid sarking or the like. However, the need for diagonal rafter bracing equivalent to that recommended in BS EN 1995-1: 2004+A1, or Annex H of BS 8103-3 for trussed rafter roofs, should be considered, for all cut roofs especially for single-hipped and non-hipped roofs of more than 40° for detached houses.

For advice on 'sizing of certain timber members in floors and roofs for dwellings', the Designer should refer to the following sources:

- Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. Published by TRADA. Note: Reference should be made to the version of the TRADA document current at the time of construction of the roof.
- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995-1: 2004+A1, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

Design Criteria

The design of pitched roofs should:

- Have a dead and imposed loads calculated in accordance with BS EN 1991-1-1, BS EN 1991-1-3 and BS EN 1991-1-4.
- Be in accordance with PD 6693-1.

All structural timber used in a conventional cut roof, i.e. rafters, purlins, ceiling joists, binders and other timber elements, should be stress graded. All such timber must be stamped as either 'DRY' or 'KD' (Kiln Dry). The use of ungraded, or 'green', timber is not acceptable.

Allowances for wind loading

The need for a roof to withstand wind pressure and suction will be met if the proposed roof is braced effectively, as discussed elsewhere in this section, and secured to the structure, as detailed below with walls adequately restrained.
The securing of roofs to the supporting structure normally involves a timber wall plate or similar, which should be levelled using a spirit level so that loadings from the roof are directed perpendicularly down the supporting wall.

The wall plate should be fixed to ensure correct positioning when roof timbers are being installed by means of galvanised mild steel holding down straps (30mm x 5mm x 1000mm long at maximum 2m centres) nailed to the wall plate and securely fixed to the inner surface of the wall with compatible fixings.
There is a need to ensure that holding down straps are provided in areas of severe wind exposure where required by the roof design.

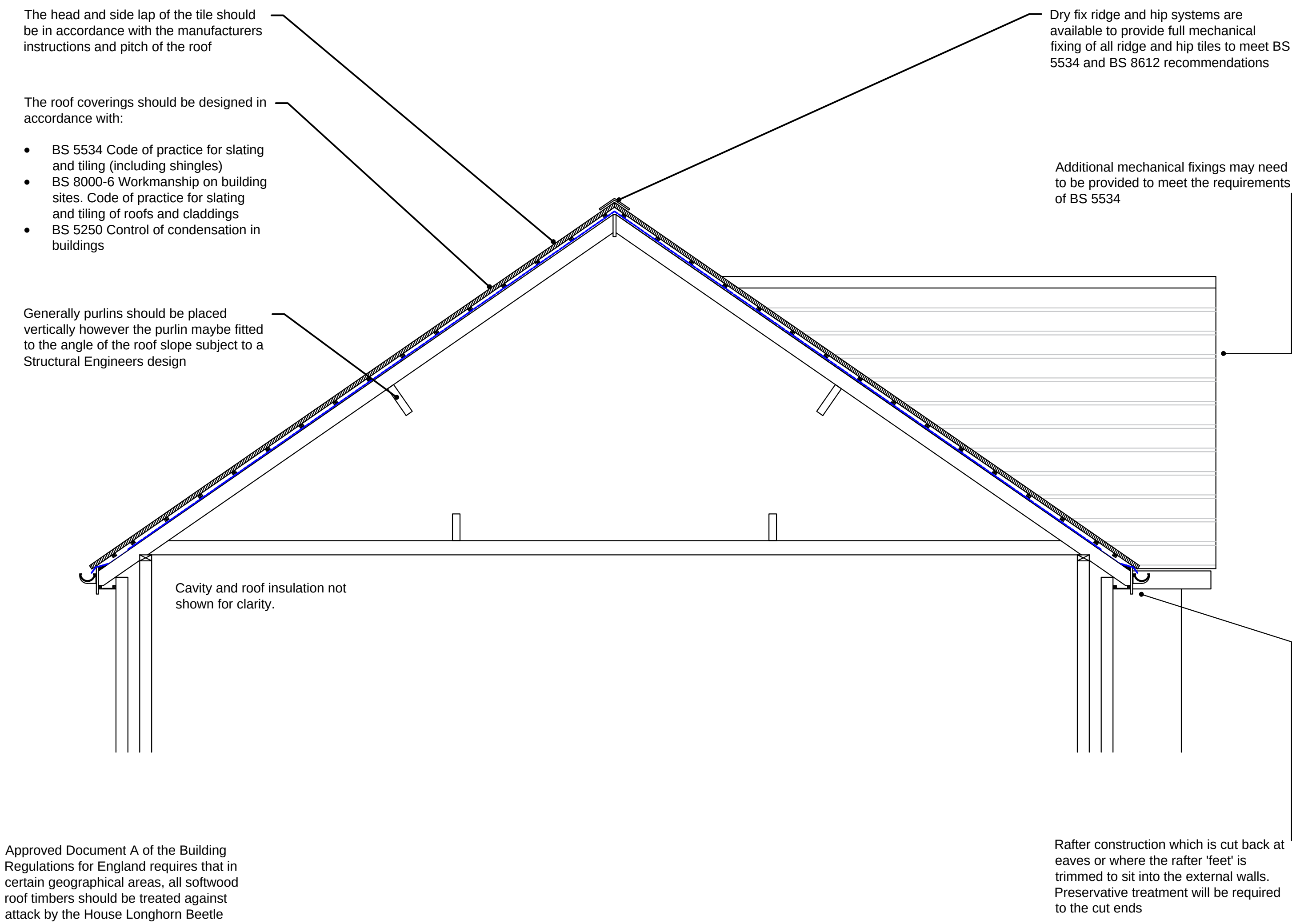
Additional holding down fixings may be required dependent on the roof structure and wind loading, this should be considered by the Structural Engineer and be incorporated within the structural calculations.

Additional requirements in a coastal locations

Where developments are within a coastal location additional Warranty requirements should be met.

For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estrine areas where they are within 5km of the general shoreline.

Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.



Cut roof design

Design responsibility

The Building Designer is responsible for the 'framing' of any given roof as a whole. This means that he or she must take responsibility for the bracing together (framing) of the roof configuration, which then supports the roof covering and the tying together of the supporting walls.

The Designer must be certain that the loading calculations and resultant configuration is fit for purpose.

All cut roofs that are beyond the limitations of the 'Eurocode 5 Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings' published by TRADA should be designed by a suitably qualified and experienced Structural Engineer and calculations and structural drawings should be submitted for assessment when requested.

The design of the cut roof should demonstrate:

- Finished sizes, species, stress grades or strength classes of timber members.
- The type, sizes and positions of all jointing devices with tolerances, or the number of effective teeth or nails required in each member at each joint.
- The positions and sizes of all bearings.
- Loadings and other conditions for which the cut roof is designed.
- The spacing of rafters, joists, binders and purlins.
- The positions, fixings and sizes of any lateral supports necessary to prevent buckling of compression members, such as rafters and struts. Details of the permanent bracing necessary to ensure the overall stability of the complete roof structure and supporting walls should be provided by the Building Designer.
- The method of support for water tanks and ancillary equipment, together with the capacity or magnitude of additional load assumed.
- The range of reactions to be accommodated at the support positions, including those required to resist wind uplift forces.
- The basis of the design.
- Details of any changes in spacing to accommodate chimneys or openings.
- Any special precautions for handling and erection, in addition to those covered by BS EN 1995-1: 2004+A1.
- The span of the rafters, joists, binders, purlins etc.
- The pitch or pitches of the roof.
- The method of support and position of supports.
- The type or weights of roof tiles or covering, including sarking, insulation and ceiling materials.
- The size and approximate position of any water tanks or other equipment to be supported on the trussed rafters.
- The overhang of the rafters at eaves, and other eaves details.
- The positions and dimensions of hatches, chimneys and other openings.
- The size of any structural members and supporting calculations.
- Due to the site locality, any particular preservative treatment necessary for the timber, e.g. to protect against House Longhorn Beetle.

Loads

Traditional cut roofs must have dead and imposed loads calculated in accordance with BS EN 1991-1-1, BS EN 1991-1-3 and BS EN 1991-1-4 and be in accordance with PD 6693-1.

Loads acting on rafters include dead loads (*for example* tiles/slates, battens, underlay and rafter self-weight), imposed loads (snow load and maintenance) and the wind load. Other dead loads that act on the ceiling ties (ceiling, insulation, water tanks and the tie self-weight) and imposed loads (loft access and weight of storage) will also have to be taken into account by the Designer.

Experience shows that for most common tiled and slated roofs, the uniformly distributed load is more severe.

Combined trussed rafter and traditionally framed roofs

Extra care is necessary where the two principal timber pitched roof types are used in conjunction. The trussed rafters should be specifically designed to accept any additional loadings imposed by an adjacent traditional roof. Similarly, account should be taken of any loadings imposed by trusses on traditional roofs where only nominal loadings have been allowed for. If in doubt, consult the Roof Designer.

Treatment of timber

Statutory requirements

Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice, and in the following circumstances:

- Roof timbers should be preservative treated where the insulation and ceiling line follow the roof pitch.
- Rafter construction which is cut back at eaves or where the rafter 'feet' is trimmed to sit into the external walls. Preservative treatment will be required to the cut ends.
- The Approved Document of Regulation 7 of the Building Regulations for England requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle.

The treatment should be impregnated with a preservative suitable for use in 'Use Class 1' in pitched roofs. Cut ends must be liberally brushed or dipped with an end-grain preservative.

It is strongly recommended that, where punched, metal fasteners are proposed to roof trusses. Only micro-emulsion or organic solvent preservatives should be used for timber treatment, to limit the possibility of corrosion of the fasteners and so as not to adversely affect glued joints.

Further information can be found in 'Appendix C- Materials, Products, and Building Systems'.

Gable spandrel panels

The gable spandrel panel should be suitably designed to transmit loads to the roof structure and down through the supporting walls.

It is important that gable spandrel panels should be designed to transmit these loads to the roof structure via lateral restraints and vertically down to the supporting walls. Full design with structural calculations should be provided.

The truss designer the project Structural Engineer should provide details of the lateral resistant to the gable spandrel panel, including details of the restraint used and the fixings to be provided.

Traditional pitched roofs

Traditionally framed roof

The moisture content of structural timber should not exceed 20% at the time of stress grading and at the time of erection. All structural timber for use within the building fabric should be stress graded and marked 'KD' (Kiln Dry) or 'DRY'.

All openings formed in the roof structure for dormers, rooflights etc. must be carefully designed to ensure the roof remains safely supported and weather tight.

The purlins/binders should be adequately supported to contribute fully to the roof structure. For example, they could be built into the inner leaf of a gable end wall and supported by struts onto the load-bearing structure at centres specified in the design.

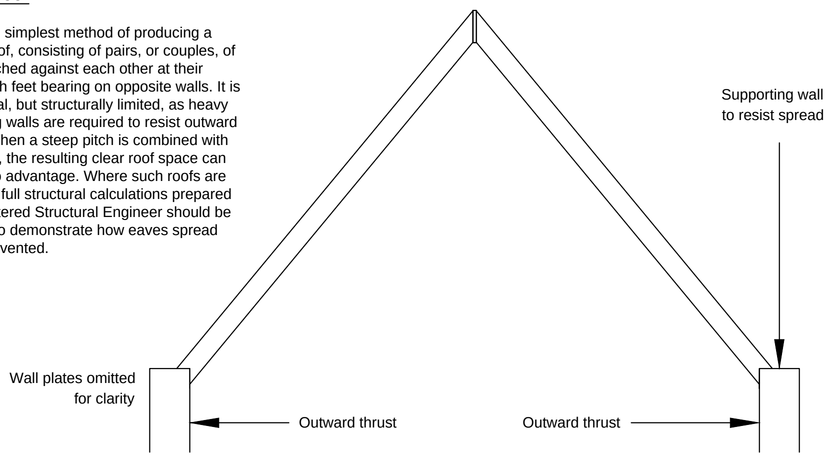
Always ensure that the correct strength class of timber is both ordered and used. Structural timbers are allocated a strength class by BS 5268-2. The most common strength classes used are C16 and C24.

The timber supplier will require the following information before supplying timber:

- Type and strength class of timber required.
- Required sizes of timber.
- Any treatment required.

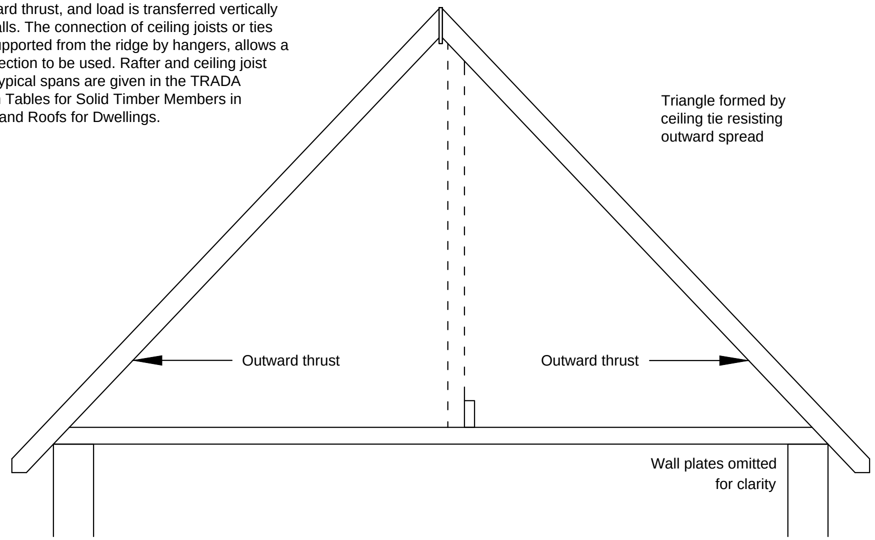
Couple roof

This is the simplest method of producing a pitched roof, consisting of pairs, or couples, of rafters pitched against each other at their heads, with feet bearing on opposite walls. It is economical, but structurally limited, as heavy supporting walls are required to resist outward spread. When a steep pitch is combined with low eaves, the resulting clear roof space can be used to advantage. Where such roofs are designed, full structural calculations prepared by a Chartered Structural Engineer should be provided to demonstrate how eaves spread will be prevented.



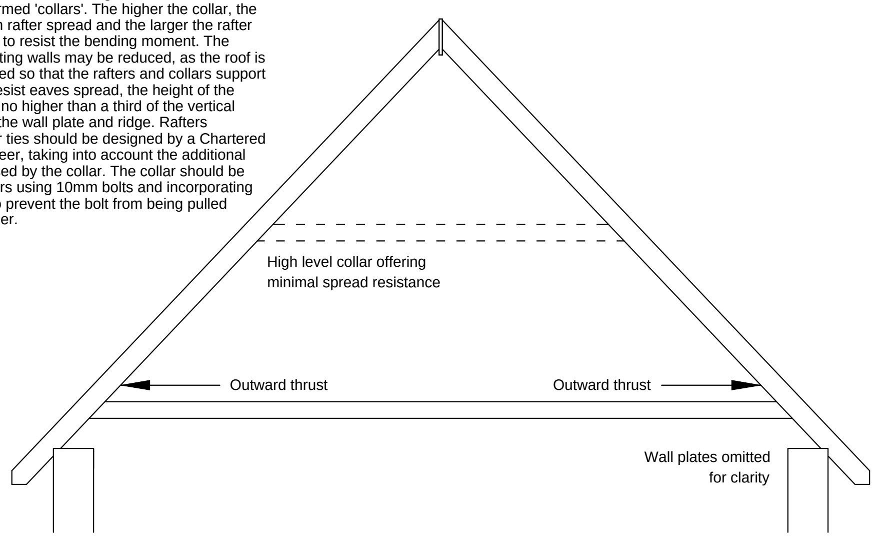
Close couple

Pairs of rafter feet are joined together with ties, often doubling up as ceiling joists, to form triangulation. The tie resists the outward thrust, and load is transferred vertically to supporting walls. The connection of ceiling joists or ties with a binder, supported from the ridge by hangers, allows a smaller timber section to be used. Rafter and ceiling joist dimensions for typical spans are given in the TRADA document, Span Tables for Solid Timber Members in Floors, Ceilings and Roofs for Dwellings.

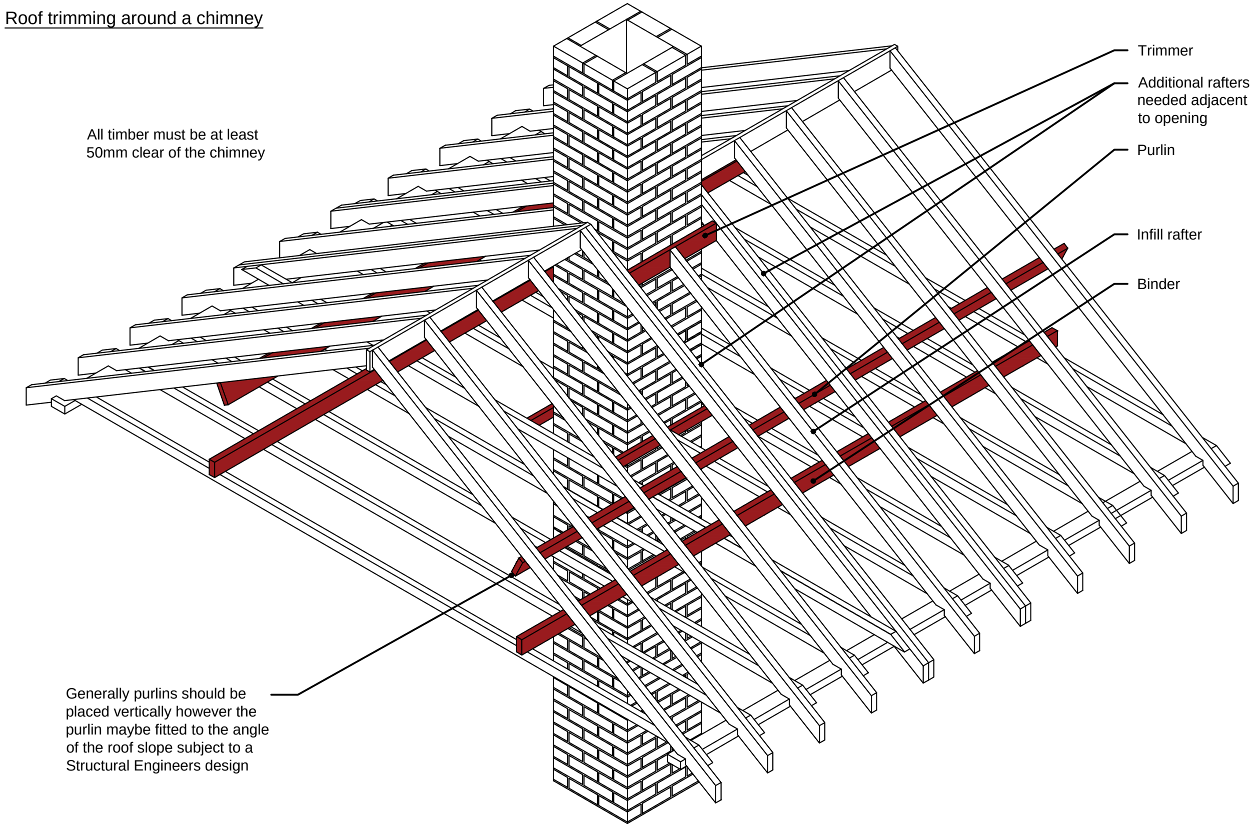


Raised collar roof

When ties are introduced at a higher level than the rafter feet, they are termed 'collars'. The higher the collar, the less influence on rafter spread and the larger the rafter section required to resist the bending moment. The height of supporting walls may be reduced, as the roof is effectively lowered so that the rafters and collars support the ceiling. To resist eaves spread, the height of the collar should be no higher than a third of the vertical height between the wall plate and ridge. Rafters supporting collar ties should be designed by a Chartered Structural Engineer, taking into account the additional point load imposed by the collar. The collar should be fixed to the rafters using 10mm bolts and incorporating large washers to prevent the bolt from being pulled through the timber.



Roof trimming around a chimney



Provision for openings

All openings formed in the roof structure for dormers, rooflights etc. must be carefully designed to ensure the roof remains safely supported and weather tight.

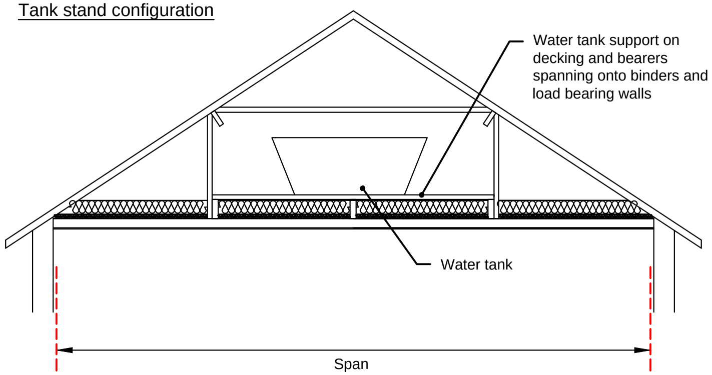
Roof lights formed in traditional cut roofs

The roof should have doubled up rafters either side of the opening to support the trimming joists at the head and base of the unit. The head and base trimming joists should be fixed to the doubled rafters according to the structural design requirements.

Tank stands

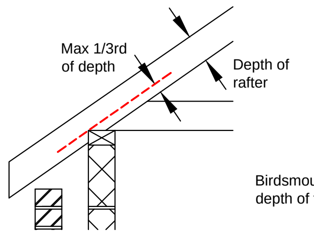
The design of tank stands should be provided as part of the Structural Engineers roof design.

Tank stand configuration



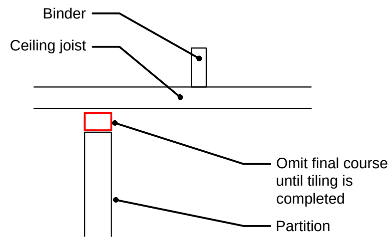
The tank platform should not be constructed from chipboard as it may become wetted by condensation, plumbing leaks, or rainwater ingress and lose its strength

Maximum depth of birds mouth



Birdsmouth depth maximum 1/3rd of the depth of the rafter

Internal non-loadbearing walls



It is advisable to erect non-load bearing walls after the tiling has been completed thus allowing deflection to take place under dead load, thereby reducing the risk of cracking appearing in the ceiling finishes. If partitions are of brick or block, then alternatively the final course can be omitted until tiling has been completed

Condensation and ventilation

Statutory requirements

The roof should be designed and constructed in accordance with clause 8.4 of BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250 Code of Practice for control of condensation in buildings Annex H.

Prevention of condensation in roof voids is best achieved through the provision of natural air ventilation. BS 5250 states that the Designer should take account of the following moisture sources in buildings:

- Water incorporated during the construction process (including precipitation).
- Precipitation after construction.
- Water vapour arising from the occupants and their activities.
- Atmospheric moisture drawn into the roof during warm humid weather conditions.

Well sealed ceilings/air tightness of ceilings

BS 5250 emphasises the importance of well sealed ceilings as a means of curbing the transfer of moisture into a roof space by means of moisture-laden air. This means:

- The avoidance of gaps and holes in a ceiling.
- The siting of access doors or hatches into the roof space away from moisture-producing areas, such as bathrooms or kitchens.
- That hatch covers must be effectively sealed.
- High levels of workmanship.

Air leakage through gaps in a ceiling transfer more heat and moisture into the roof by convection than passes through the ceiling materials by diffusion. Sealing the ceiling is therefore an essential requirement when considering the design of the roof envelope.

Key design issues to consider are as follows:

- Avoid construction gaps.
- Avoid roof access doors or hatches in rooms that produce excessive moisture.
- Use a proprietary sealed loft hatch and frame, and seal correctly in accordance with the manufacturer's recommendations.

There is advice found in BS EN 13141-1 Ventilation for buildings. Performance testing of components/products for residential ventilation.

- Seal all services and roof lights.
- Use recessed light fittings rated IP60 to IP65 to BS EN 60529.
- Seal the head of cavity walls to prevent the transfer of warm moist air into the loft.

Air and vapour control layer (AVCL)

If an AVCL is installed it should be placed on the warm side of the insulation. Installation of an AVCL at ceiling level will increase the need for sufficient ventilation below it during the drying out of wet trade construction phases. The performance of an AVCL depends not only on the material selected, but also on the workmanship and the quality of the construction to be assembled on-site (see BS 5250). It is essential that an AVCL be adequately lapped and all joints sealed, and that its integrity is maintained. Particular attention should be paid to detail design and installation around penetrations through the AVCL e.g. services, compartment walls and to the sealing of punctures caused by fixings.

Cold roof

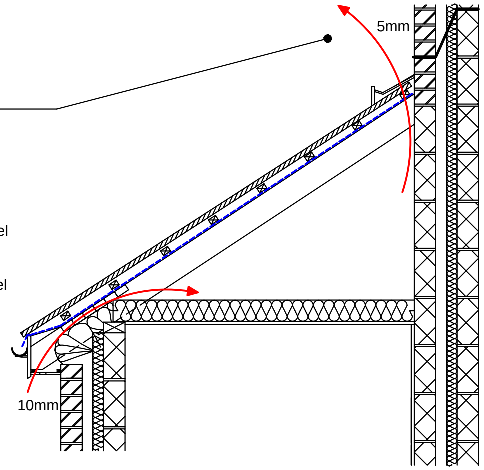
The following suggest the correct positioning of vents and the precise amount of free airspace required for 'cold roof' construction, in accordance with current Building Regulations and BS 5250.

These recommendations apply if a high water vapour resistance (type HR) underlay is used.

Mono pitched/lean to roof

A free airspace of 5,000mm^2/m should also be provided at high level (equivalent to a continuous 5mm opening)

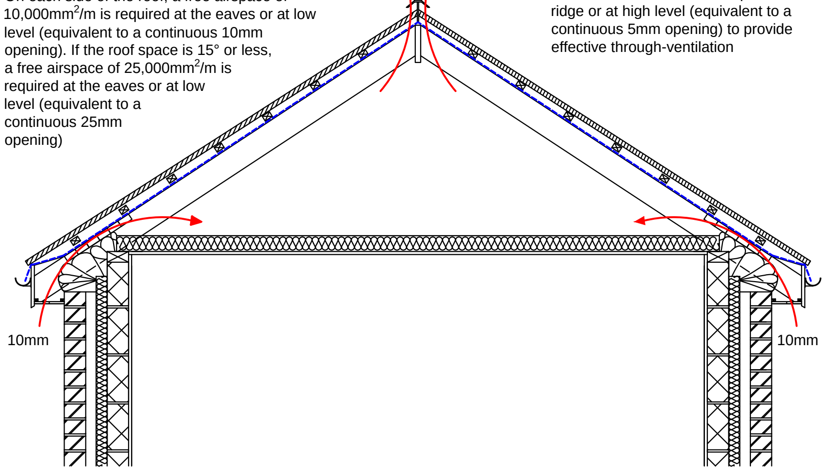
If the roof space is 15° or less, a free airspace of 25,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 25mm opening). If the roof pitch is more than 15°, a free airspace of 10,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 10mm opening)



Duo pitched roof

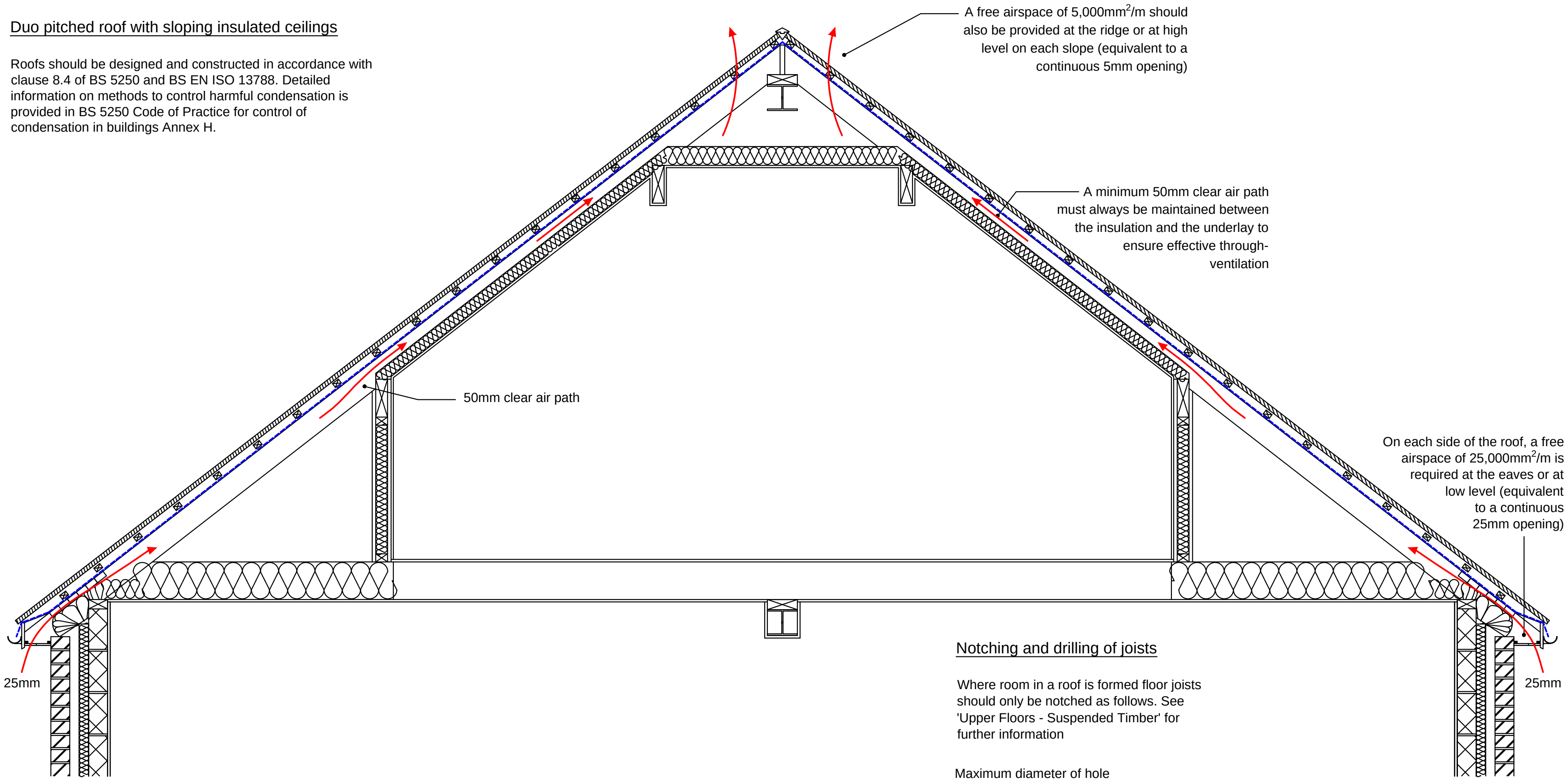
On each side of the roof, a free airspace of 10,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 10mm opening). If the roof space is 15° or less, a free airspace of 25,000mm^2/m is required at the eaves or at low level (equivalent to a continuous 25mm opening)

Where pitches are 35° or greater or spans are 10m or wider, a free airspace of 5,000mm^2/m should also be provided at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation



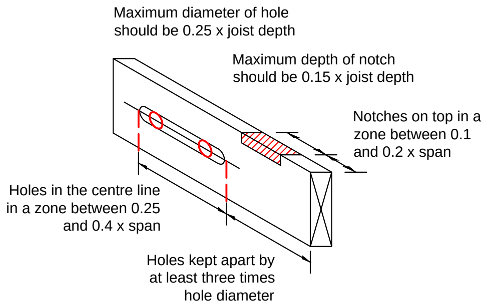
Duo pitched roof with sloping insulated ceilings

Roofs should be designed and constructed in accordance with clause 8.4 of BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250 Code of Practice for control of condensation in buildings Annex H.



Notching and drilling of joists

Where room in a roof is formed floor joists should only be notched as follows. See 'Upper Floors - Suspended Timber' for further information



Duo-pitch roof with fire break walls

Note: Where a roof is divided by fire breaks e.g in flats where the protected corridor walls continue up to the underside of the roof and fire stopped; each roof void is treated separately. Each void should be provided with 5,000mm^2/m of free air space at the highest level possible and 10,000mm^2/m of free air space provided at the lowest level. The ventilation should not impair the fire performance of the wall.

Vapour permeable (type LR) underlays

If an LR underlay is used, interstitial condensation is unlikely to occur, provided the ceiling is well sealed and the eaves have a minimum continuous ventilation opening of 3mm. If the ceiling is not well sealed, openings equivalent to 7mm should be used; 10mm eaves vent systems will satisfy both requirements.

BS 5250 does not consider the situation where it is proposed to provide no ventilation to the roof void, or ventilation more limited than described above. Should Designers wish to adopt this principle, they should refer to the conditions attached to Technical Approvals given by UKAS (or European equivalent) accredited technical approval bodies.

Close Fitting Roof Coverings

When specifying a close fitting roof covering which is relatively airtight, such as fibre cement slates, there is a risk of interstitial condensation forming on the underside of the underlay and external covering. To avoid this risk, the batten space should be ventilated in accordance with BS 5250 using counter battens for both warm and cold roof constructions. This is due to problems that may arise where an underlay which offers low resistance to the passage of water vapour will tend to lower the risk of condensation in the loft, but might increase the risk of condensation in the batten space.

Where underlays are used which allow the transfer of moisture vapour into the batten space by diffusion or convection, potentially damaging condensation can occur if the batten space is not adequately ventilated either by purpose introduced ventilation or by natural ventilation through a suitably permeable roof covering.

Cold pitched roof with an LR underlay with a close fitting roof covering

If an LR underlay is used, the designer may provide less ventilation to the loft than is recommended for a roof with a HR underlay in BS 5250 providing that it is installed in accordance with the manufacturers 3rd party accreditation.

Note: BS 5250 does not cover situations where limited or no ventilation is proposed to the loft space.

With some LR (breathable) underlays, moisture can move by both diffusion and convection from the loft into the batten space.

To reduce the risk of potentially damaging condensation, the batten space should be ventilated. This should be achieved by means of counter battens and vents at both low and high level:

- Low-level vents should be equivalent in free area to a slot 25 mm deep running the whole length of the eaves.
- High-level vents should be equivalent in area to a slot 5 mm deep running the whole length of the ridge in accordance with BS 5250.

Note: Alternative methods of ventilating the batten void should provide an equivalent level of ventilation.

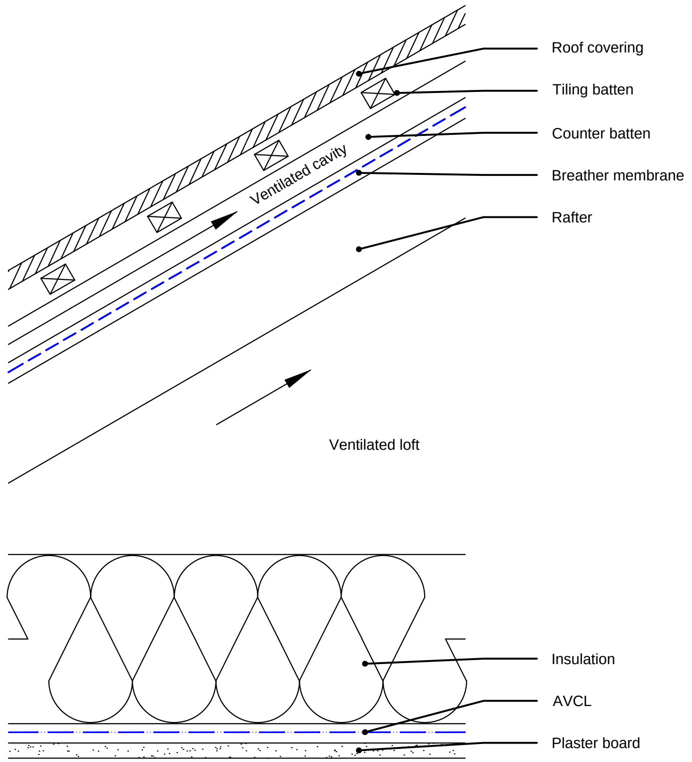
If ventilation is not provided to the batten space there needs to be an increased level of ventilation to the roof space and that should be in accordance with BS 5250. The underlay manufacturer's 3rd party accreditation also needs to be followed.

It is very difficult to determine a HR or LR underlay by sight alone and the manufacturers third party accreditation should be referred too if ventilation requirements are in doubt.

Cold pitched roof with HR underlay with a close fitting roof covering

An HR underlay provides high vapour resistance on the cold side of the thermal insulation, preventing the diffusion of water vapour from the loft in to the batten space; it is therefore essential that the loft space be ventilated in accordance with BS 5250 and this Technical manual.

Cold pitched roof - LR underlay - Impermeable external covering



Warm roof construction

Insulation may be provided above the rafter and between rafters to form a warm roof construction. The position of insulation and vapour control layers (AVCL) must strictly adhere to the insulation manufacturer's recommendations. All warm roof construction products must have appropriate third party certification.

Ventilation to counter batten void will be required where vapour permeable (type LR) underlays are not used.

Warm pitched roof with an LR underlay and tight fitting roof covering

In warm pitched roofs with an LR underlay, an AVCL (air and vapour control layer) should be provided at ceiling line. Where an external covering (such as fibre cement slates) is relatively airtight there is also a risk of interstitial condensation forming on the underside of the underlay and the external covering; to avoid that risk the batten space should be ventilated as described.

Warm roof construction (vented battens)

In roofs with an HR underlay, whatever form of external covering or ceiling is provided, there is a risk of interstitial condensation forming on the underside of the HR underlay; to avoid that risk, an AVCL should be provided on the warm side of the insulation, and ventilated voids should be formed between the underside of the underlay and the insulation.

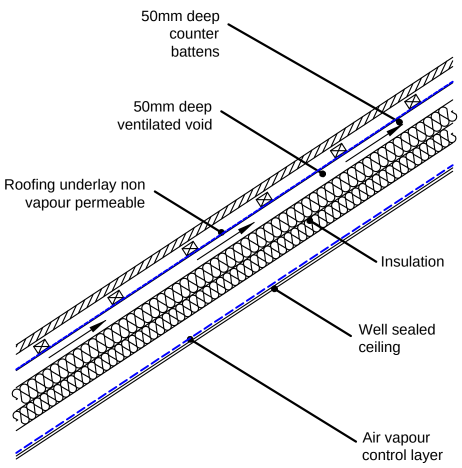
Thermal insulation provisions for the compliance with the Building Regulations

Thermal insulation must be installed to meet current Building Regulations, to an acceptable level of workmanship, to avoid cold bridges and to meet the following provisions:

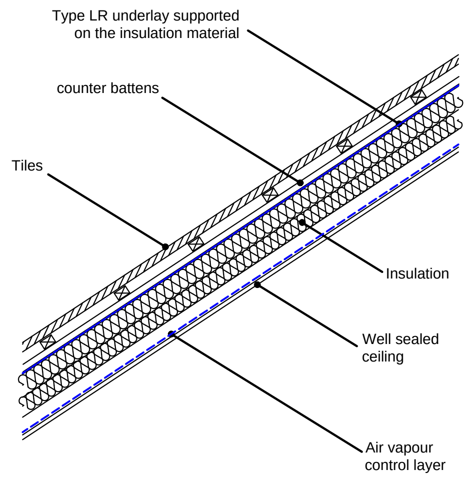
- The use of over joist and under rafter insulation is considered best practice, as it eliminates the cold bridge caused by the joist/rafter.
- If required by BS 5250, use a vapour control plasterboard or a separate VCL behind the plasterboard.
- Use a proprietary eaves ventilator to ensure ventilation is in accordance with BS 5250.
- The installation of the eaves ventilator must not prevent free water drainage below the tiling battens.

The requirements of the regulations are designed to reduce carbon emissions from new buildings and improve the performance of existing buildings where new work is carried out.

Warm roof construction (vented battens)



Warm roof construction (vapour breathable underlay)



Insulation may be provided above the rafter and between rafters to form a warm roof construction. The position of insulation and air vapour control layers (AVCL) must strictly adhere to the insulation manufacturer's recommendations. All warm roof construction products must have appropriate third-party certification.

Ventilation to counter batten void will be required where vapour permeable (type LR) underlays are not used.

Roof coverings

Legislation and planning

Tiled and pitched roof coverings should be in accordance with the relevant Building Regulations.

The principal British Standards relevant to this section are:

- BS 5534 Code of Practice for slating and tiling (including shingles). This gives recommendations for the design, materials, application, installation and performance of slates and tiles (BS 5534 should be read in conjunction with BS 8000-6).
- BS 8000-6 Workmanship on building sites. Code of Practice for slating and tiling of roofs and claddings. This applies to the laying and fixing of clay and concrete tiles, natural and fibre cement slates and their associated fixings and accessories.
- BS 5250 Control of condensation in buildings. This describes the causes and effects of surface and interstitial condensation in buildings, and gives recommendations for control of condensation in roofs.

To ensure safe working practices during construction, the Designer should consider relevant safety regulations. These include the Construction (Design and Management) Regulations and the Health and Safety Executive's Approved Code of Practice for Management of Health and Safety at Work.

Certain advisory bodies, such as the Loss Prevention Council, Building Research Establishment Ltd (BRE) and Timber Research and Development Association (TRADA), also produce recommendations and guidance on roof construction.

Weather exposure

Rain and snow

The roof of the building shall adequately protect the building and people who use the building from harmful effects caused by precipitation and wind-driven spray. Roofs are required to resist the penetration of precipitation (rainfall) to the inside of the building, thereby preventing damage to any part of the building where it might be carried.

Most pitched roofs keep the rain and snow out of the building and give a satisfactory performance. However, it is acknowledged that similar roofs built to the same design and using identical roof materials, but in different locations, may not necessarily provide the same level of assurance since they will be subject to different weather conditions and exposure.

Exposure to driving rain

The UK has a high risk of severe driving rain, and even in some sheltered locations may be subject to high levels of deluge rainfall. BS 5534 defines four categories of exposure, based on the driving rain data given in BS 8104 and BR 262, and should be used for buildings up to 12m in height. For buildings over 12m in height, the influence of increased wind speeds should be taken into account using BS EN 1991-1-4.

Control of internal pressure

The total wind force on a roof is dependent on the pressure differential between the inner and outer faces of the roof covering. Such pressures are significantly reduced by the use of underlay or boarding beneath tiling or slating. Its contribution towards shielding the underside of the tiles or slates from the full transmission of internal pressures means the underlay is required to have an adequate tensile strength for the specific application. The tensile strength of the underlay, its air permeability factor and the withdrawal resistance of batten nail fixings are therefore important when determining the overall resistance to wind uplift of the roof system.

Aircraft vortices

Roofs near airports can experience high local wind load forces due to air vortices created by certain aircraft when taking off and landing, which may be greater than the wind loads calculated to BS 5534. Designers should seek advice from the Airport Authority Planning Department when designing roof fixings in these locations, and refer to the guidance contained in BRE Digest 467 Slate and tile roofs: avoiding damage from aircraft wake vortices.

Calculating the fixing specification

The procedures for calculating the wind loads and determining the fixing specification for tiles and slates in accordance with BS EN 1991-1-4 and BS 5534 are complex to undertake. Designers are advised to obtain a full roofing fixing specification from the slate or tile manufacturer.

Alternative proprietary mortar mixes may be accepted if they are shown to have similar durability and workability.

Workmanship

Tile fixing

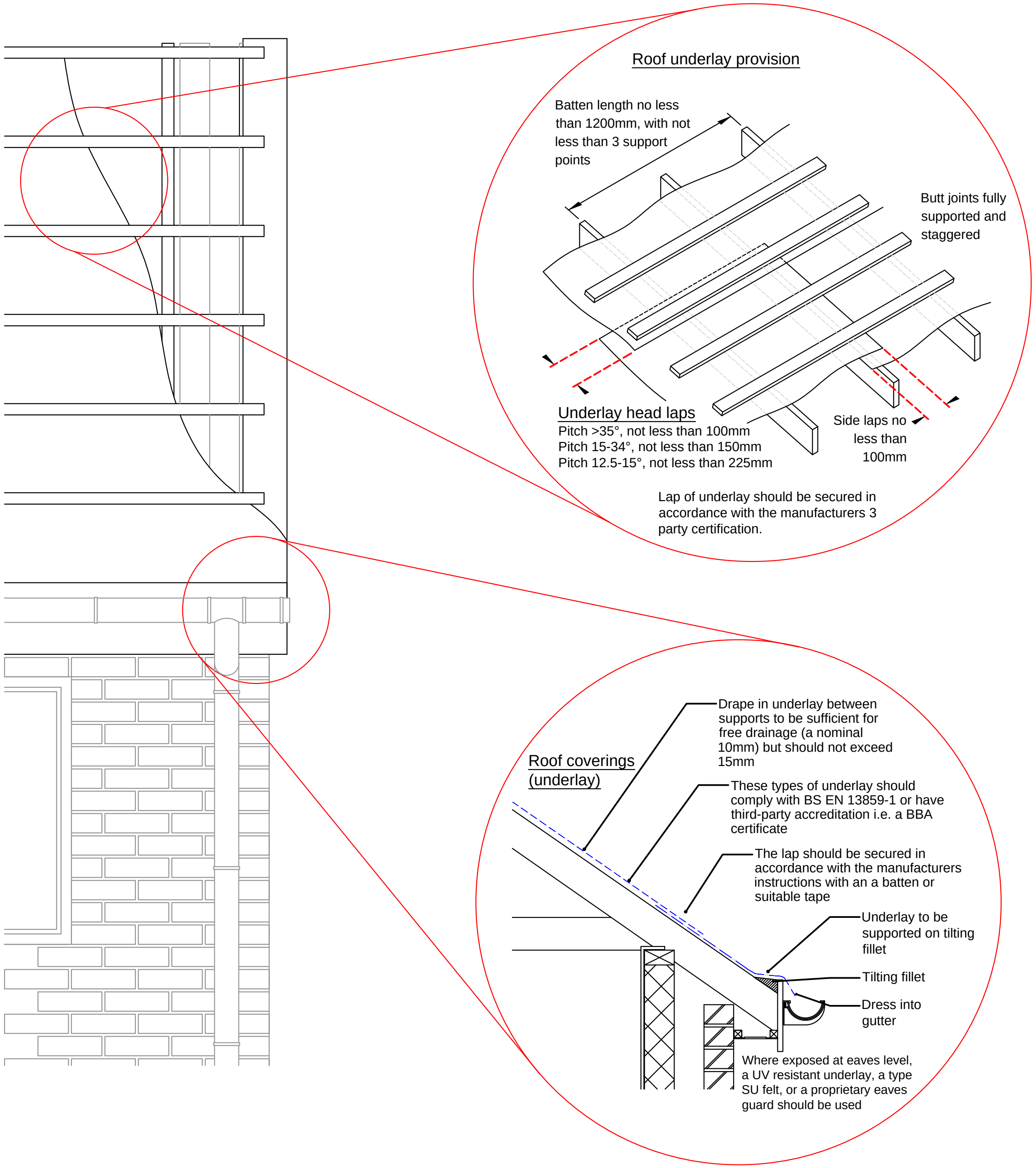
Tile fixing should be in accordance with BS 8000-6 and the manufacturer's recommendations.

Relevant British Standards

- BS EN 490
- BS 5250
- BS EN 1990
- BS 5534
- BS EN 1991-1-4
- BS 8000-6
- EN 13859-1
- BS 6399

Further guidance

Practical guidance on the application of single-lap and double-lap tiling can also be obtained from CITB/CS Trainer Resource Package for Operatives in the Construction Industry Manuals, Construction Industry Training Board.



Underlays

Lay the specified roofing underlay parallel to eaves or ridge with horizontal overlaps, as specified in the table below. Vertical side laps should be a minimum of 100mm. Minimise the gap at laps resulting from different tautness between underlay courses. Drape in underlay between supports is to be sufficient for free drainage (a nominal 10mm) but should not exceed 15mm in accordance with BS 5534. Fix underlay with the fixings specified, keeping the number of perforations to a minimum. Handle and fix underlay with care to ensure there are no tears or punctures, and repair any tears or punctures prior to tiling. Ensure that the underlay does not obstruct the flow of air through ventilators located at eaves, ridge or in the main roof, and appropriately weather all holes formed in underlays for soil vent pipes, etc. Avoid contact between the underlay and the underside of tiles. To prevent wind uplift, fix additional battens or timber strips where laps occur between tiling battens (refer to BS 5534 6.2 Underlays).

Rafter pitch	Not fully supported (mm)	Fully supported (mm)
12.5° to 15°	225	150
15° to 35°	150	100
35° and above	100	75

Minimum horizontal laps for underlays

Specification for underlays

Fully supported and non supported underlays:

- BS 8747 Class 1F reinforced bitumen or Class 5U polyester reinforced bitumen.
- 2HR* underlay to BS EN 13859-1 Class W1 water penetration classification with third party certification for the use intended.
- 3LR† underlay to BS EN 13859-1 Class W1 water penetration classification with third party certification for the use intended.

* HR (high water vapour resistance) underlay - >0.25MNs/g.
† LR (low water vapour resistance) underlay - <0.25MNs/g.
(LR underlays are sometimes referred to as 'vapour permeable' or 'vapour open').

Materials

Underlay nails

Nails for use with roofing underlays should be clout head nails of no less than 3mm shank diameter and 20mm length made of copper, aluminium alloy or steel coated by any of the zinc or zinc alloy coating methods specified in BS EN 10230-1.

Underlay

These types of underlay should comply with BS EN 13859-1 or have third-party accreditation i.e. a BBA certificate.

There are two categories of underlay: HR, non-vapour permeable and LR, vapour permeable. These types of underlay should comply with BS EN 13859-1 or have third-party accreditation, i.e. a BBA certificate. They should also have sufficient tensile and nail-tear strength, and low extensibility, to produce the required resistance to wind uplift.

Underlays for use beneath tiles and slates are either fully supported over boarding, sheathing or sarking, or unsupported and draped over rafters/counter battens, and should meet the conditions detailed.

Classification of underlays

Underlays should be classified in accordance with their geographic location and wind zone. Underlays should only be used in those wind zones for which the design wind pressure is not greater than the declared wind uplift resistance. Refer to BS 5534 A8. Figure A.4 for design wind pressures for geographical wind zones location map. It is important to ensure the underlay is suitable for the geographical wind zone and that laps in the underlay are secured in accordance with the manufacturers 3 party accreditation for the geographical wind zone and batten spacing. This lap can be secured either with a batten or a manufacturers 3rd party approved product.

Timber battens

Timber species

Tiling battens and counter battens should be selected from the timber species set out in BS 5534, and their characteristics and defects should not exceed the permissible limits given in Annex D to G of BS 5534.

Grading

Battens should be suitable graded to meet the requirements in BS 5534. Only battens that have been graded and bear the BS 5534 marking will be acceptable for use.

Sizing

Timber batten sizes should be not less than the minimum values recommended in BS 5534 for the common applications listed therein.

Battens for large spans or special loading conditions should be designed by structural calculation for strength and stiffness, in accordance with Annex F of BS 5534.

Preservatives

BS 8417: 2011 provides recommendations for preservatives for timber. Indicative preservative treatment schedules are given in Annex E of BS 5534. Battens treated with preservatives can contain toxic substances that could introduce an environmental hazard, and should be disposed of safely.

Fixing timber battens

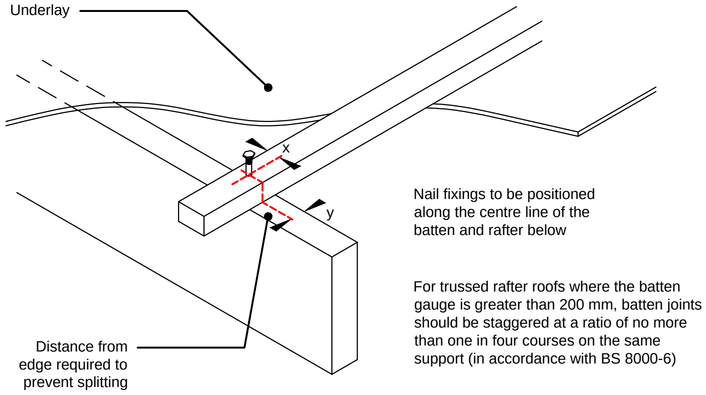
Battens should be at least 1200mm in length and supported at each end and intermediately by at least three rafters or walls. Stagger butt joints over intermediate supports, splay nail each batten end and nail battens to each rafter.

For trussed rafter roofs where the batten gauge is greater than 200 mm, do not have more than one joint in any four consecutive battens on the same support.

For trussed rafter roofs where the batten gauge is less than 200 mm do not have more than three joints together in any 12 consecutive battens on the same support.

The batten sizes given in the table should be taken as minimum dimensional requirements. Take care that nails used to secure tiles do not penetrate the underside of battens or the underlay.

Fixing battens to rafters



Recommended batten sizes for pitched roofs and vertical work (BS 5534 in accordance with clause 4.11.4.1 Table 3)

Tile type	**Basic minimum sizes***			
Rafter/supports	**450mm span**		**600mm span**	
	width	depth	width	depth
Plain pitched/vertical	38	25	38	25
Single lap interlocking tiles/slate	38	25	50	25
Fibre cement slates	38	25	50	25
Natural slates	50	25	50	25
*All dimensions subject to re-sawing allowance: width +3mm, depth 0 or +3mm based on measurement reference moisture content of 20%				

Fixing roof battens

Fix the specified battens up the roof slope on top of the rafters, ensuring a minimum 40mm nail penetration into rafters (smooth shank). Nail counter battens at maximum 300mm centres vertically up the roof slope. Where boarding is used the fixing should coincide with the line of rafters.

11.

Roofs

11.3

Concrete Interlocking Tiles

Performance of tiles

Rain penetration of the roof covering is dependent on a combination of the rainfall rate, wind speed and the ability of the roof tile to resist the ingress of snow and rain water. The Designer should therefore be aware of the various means by which rain and snow can, under certain conditions, penetrate the roof covering.

These include:

- Capillary action and rain water creep.
- Raindrop bounce and negative pressure rain suction.
- Driving rain, deluge rain and flooding.
- Surcharging of rain water over laps on long-rafter roofs.
- Wind-driven snow.

Roof pitch

When determining the pitch, head-lap and/or side-lap of a tile, the roof pitch is taken to be equal to the rafter pitch. Hence, all references to pitch refer to the rafter pitch, with the laid angle of the roof tile or slate always being less than roof pitch.

The actual pitch of a tile should be determined in accordance with the following guidelines:

- Tile to rafter pitch angles.
- Interlocking single-lap tiles: 5° less than rafter pitch.

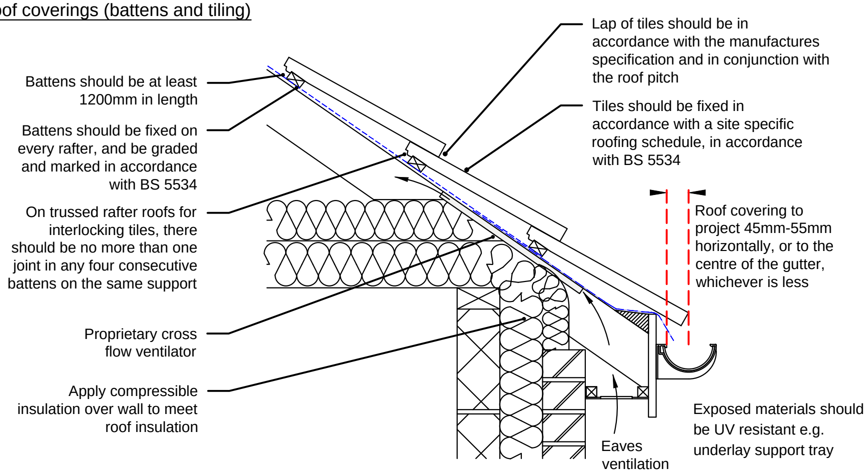
If the design rafter pitch is less than the minimum recommended rafter pitch for the particular tile, then they can be considered as having an aesthetic function only. In such cases, the true weatherproofing of the roof system must rely on a fully supported waterproof membrane with an uninterrupted drainage path between counter battens to the eaves gutter.

Wind

Design for wind loading

When considering the wind loading on the roof covering, designers should consult BS 5534. This provides calculation methods to assess the wind load on each tile as a uniformly distributed load, and also takes into account the porosity of the tiles and the effectiveness of the substrate (boarding or sarking), and/or underlay shielding, when calculating wind uplift loads. The standard method in BS EN 1991-1-4 Eurocode 1. Actions on structures. General actions. Wind actions should be used to determine the basic wind speed of the site, which is then used to calculate the effective wind speed and dynamic wind pressure on the roof by applying a series of factors to account for terrain, topography, building height and length etc.

Roof coverings (battens and tiling)



Tile fixings

BS 5534 recommends the use of aluminium or stainless steel nails under normal conditions of exposure. Plain or galvanised nails may be used for fixing battens to rafters, but care must be exercised when there is high humidity as certain timber preservative treatments may corrode steel, zinc or aluminium. For all roof areas and rafter pitches, every tile should be mechanically fixed.

Workmanship

Tile fixing should be in accordance with BS 8000-6 and the manufacturer's recommendations.

Calculating the fixing specification

The procedures for calculating the wind loads and determining the fixing specification for tiles in accordance with BS EN 1991-1-4 and BS 5534 are complex to undertake. Designers are advised to obtain a full site specific fixing specification from the tile manufacturer.

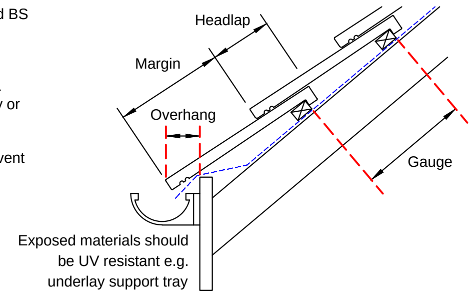
Tile details - key check points

Eaves and bottom edge (in accordance with BS 5534 and BS 8000-6).

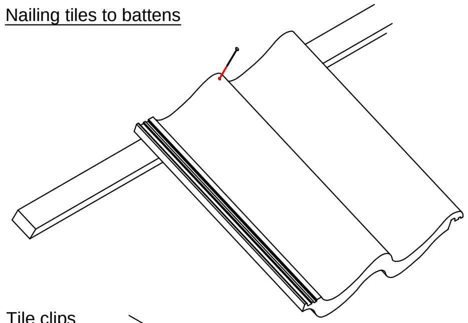
At the eaves (bottom edge), the batten should be set to provide the required overhang of the tiles into the gutters. The recommended overhang is 45mm-55mm horizontally or to the centre of the gutter, whichever is less.

- Ensure fascia board is to correct height so as to prevent tiles kicking up or drooping.
- Fit duct trays to retain insulation.
- Fix underlay protector trays, fascia vents and comb fillers (profiled tiles).
- Clip eaves course where required.
- Ensure vent path to roof space is achieved.
- Ensure exposed materials are UV resistant.

Eaves and bottom edge detail



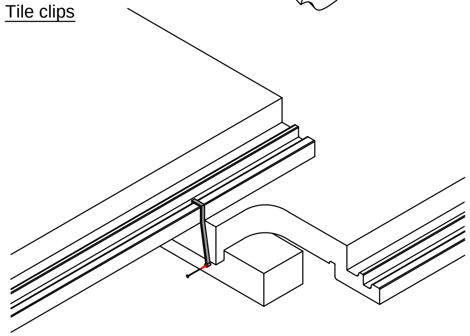
Nailing tiles to battens



Tile nails

Nails for use with tiles should be of copper, aluminium, stainless steel, phosphor or silicon bronze. Aluminium nails intended for use with tiles should conform to BS 1202-3 and should be clout head nails of 3.35mm or 2.65mm diameter. The length of nail will be determined by the required wind uplift and the design of the tile. Stainless steel nails for use with tiles should conform to BS EN 10088-3:2005 and BS 5534 grade 304, 316, 321 or 347, and should be specified for coastal areas, areas of high exposure or where there is a risk from chemical reaction.

Tile clips



Tile clips

Tile clips should be located over the side interlock of the tile immediately behind the overlapped tile, and nailed to the tiling batten. Tile clips provide resistance to the applied overturning moment more successfully than a nail fixing. The latter is closer to the pivot line, where the nib touches the batten and cannot resist the uplift force at the tail. The phenomenon is also related to roof pitch and the step height of the roof covering, and BS 5534 acknowledges that, at roof pitches of 45°-55°, all tiles should be at least nailed to battens to prevent displacement. At pitches exceeding 55° all tiles must be both head nailed and tile clipped to reduce 'chatter' in high winds.

Ridges, hips, verges and valleys

The use of mortar for the bedding of ridge tiles, hip tiles, or lay tiles does not provide sufficient tensile bond strength to resist wind uplift, as it can be affected by a number of factors, such as wind loadings, mix of mortar, design and movement of the roof structure. The tensile strength of mortar should not be taken into account as the mechanical fixings should provide the resistance. Tiles only bedded on mortar are not acceptable.

Note: Dry fix ridge and hip systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

Verge (in accordance with BS 5534, BS 8612 and BS 8000-6)

Battens should overlap onto the outer skin of the brickwork or the undercloak material; for interlocking tiles can project 30mm-60mm. Where the distance of the nearest batten fixing to the rafter is greater than 300mm, an additional mechanical fixing is recommended.

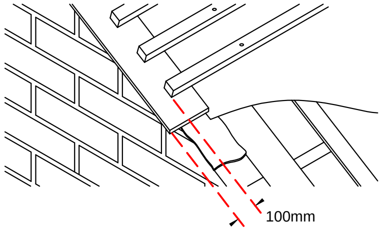
Note: Where proprietary verge tiles or systems are specified, the detailing should be in accordance with manufacturers' recommendations that are relevant to UK conditions of use.

- Use recommended undercloak for mortar.
- Level off irregularities in brickwork.
- Carry underlay over gable wall or bargeboard, and fit undercloak.
- Use the correct mortar mix.
- Bed and point tiles in one operation.
- Keep mortar clear from the ends of tiling battens.
- Fix all perimeter tiles (clip and/or nail).

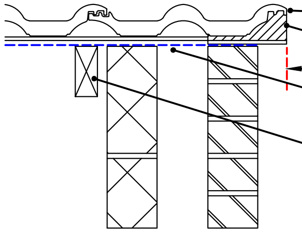
Undercloak

Where an undercloak is used it should comprise plain tiles, slates or fibre cement sheet strip. It is usually fixed at verges beneath the battens and on top of the underlay to support the mortar onto which the verge tiles are bedded. If batten ends are cut, treat with a suitable preservative. A 100mm wide bed of mortar should be neatly laid on the undercloak, this should be bedded solidly and finished neatly.

Verge detail



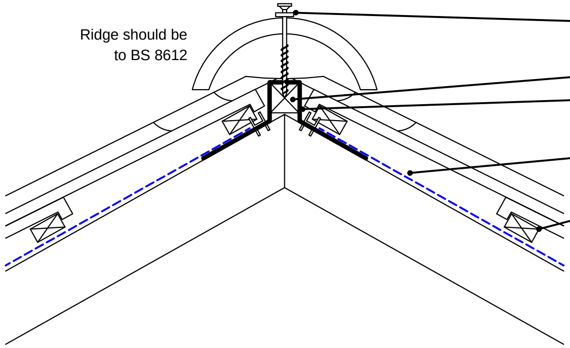
Verge detail (section)



Where proprietary verge tiles or systems are specified the detailing should be in accordance with the manufacturers recommendations that are relevant to UK conditions of use.

Mortar must not be the sole means of fixing and should only be used for decorative purposes. Suitable mechanical fixings are required. Mortar should be to the recommendations in BS 5534 and typically consist of a cement and sand mix based on sharp sand, with soft sand added to achieve workability. The proportion of sharp sand should not be less than a third of the total sand content to ensure the durability of the feature.

Typical dry ridge detail



Ridge (in accordance with BS 5534, BS 8612: Dry-fixed ridge, hip and verge systems for slating and tiling and BS 8000-6)

Dry fix systems

Proprietary dry roofing products and systems should be used as an alternative to just mortar bedding at verges, ridges, hips and valleys to provide weathering and mechanical resistance properties. Dry roofing products as fitted should not adversely affect the performance of the roof as laid.

Dry ridge systems should be manufactured and tested to meet BS 8612. The dry ridge system should be specified in accordance with BS8612 and be suitable for the location and the wind loading (see 'Note 1' below).

Specifiers should seek evidence that this will not be the case, and should use dry roofing products only if such evidence is available.

Note 1: Users should pay particular attention to the resistance to wind load and durability performance of dry roofing products.

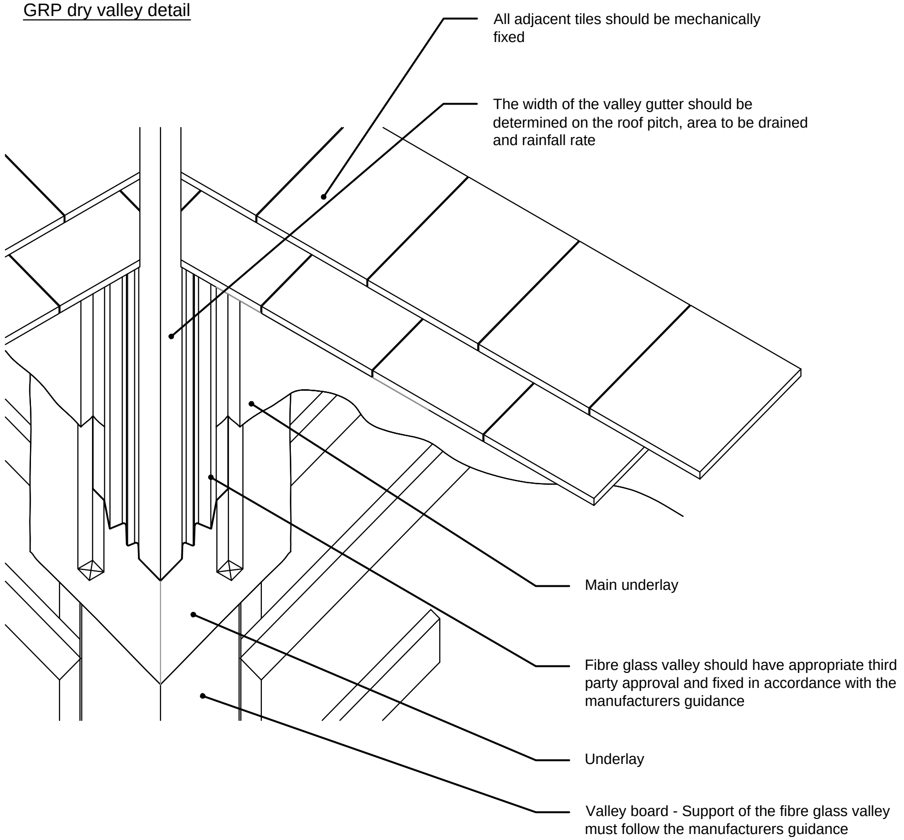
The ridge or top course batten should be set to allow the ridge tiles, ridge units or metal ridge to overlap the top course of tiles by the overlap necessary for the main tiles. For interlocking tiles, this should be not less than 75mm. For double-lap products, the top batten should be set to allow the ridge to overlap the penultimate course by the required head-lap.

For ridge tiles:

- Check ridge tile is suitable for pitch of roof.
- Edge bed components onto tiles.
- Ensure top course tiles or slates are mechanically fixed.
- Mitre tiles neatly at hip ridge junctions, and use a lead saddle underneath for protection.
- Use the correct mortar mix.
- Use dentil slips in deep profiled tiles in all joints more than 25mm thick to reduce mortar and risk of shrinkage.
- **All** mortar bedded ridge tiles **must** also be mechanically fixed by proprietary fixings in accordance with the roof covering manufacturer's recommendations.

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

GRP dry valley detail



Valley (in accordance with BS 5534 and BS 8000-6)

The design of pitched valley gutters is just one roof detail where the latest guidance is much improved over previous Codes of Practice. The valley is the most vulnerable area of a pitched roof in respect to potential water ingress, as it drains all of the water from adjacent roof slopes.

Consequently, the design data is related to the pitch of the roof, the rainfall rate, the length of the valley and the catchment area or area of the roof to be drained. Designers are able to determine the width of the valley trough so that it is appropriate for discharging the rain water from the adjacent roof covering to the eaves gutter.

For valley gutters:

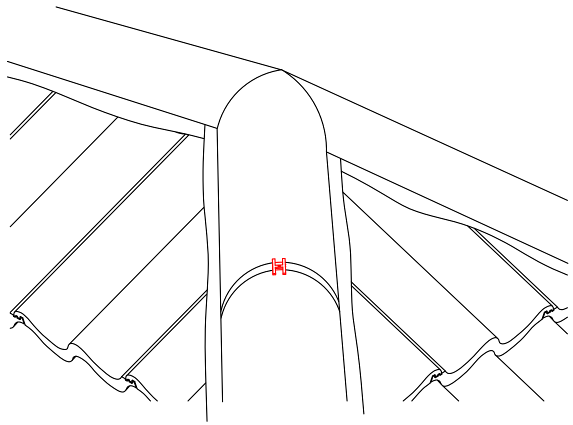
- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure roof structure provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay beneath a lead sheet valley.
- Keep open gutter width 100mm-250mm (correct width to be determined by reference to Table 11 and 12 in BS 5534).
- Keep roof design as simple as possible.
- Avoid discharge of valleys onto roofing wherever possible, but where inevitable use a lead saddle.
- Avoid direct contact with lead when using mortar; provide a fibre cement undercloak or tile slips.
- Do not block tile laps with mortar to avoid water damming.
- Where fibre glass valleys are used only products supported by a third party product approval will be acceptable and the installation and support of the fibre glass valley unit must follow the manufacturers guidance.
- Mechanically fix all tiles adjacent to valleys.

Hip (in accordance with BS 5534, BS 8512 and BS 8000-6)

For hip roof construction:

- Check hip tile is suitable for pitch of roof.
- Mitre tiles neatly at hip ridge junctions and use a lead saddle underneath for protection.
- Use the correct hip iron at base of hip.
- Use the correct mortar mix.
- Use dentil slips in deep profiled tiles in all joints more than 25mm thick to reduce mortar and risk of shrinkage.
- All mortar bedded hip tiles must also be mechanically fixed (screws, nails, clips, etc.).

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 and BS 8512 recommendations.



Fire stopping

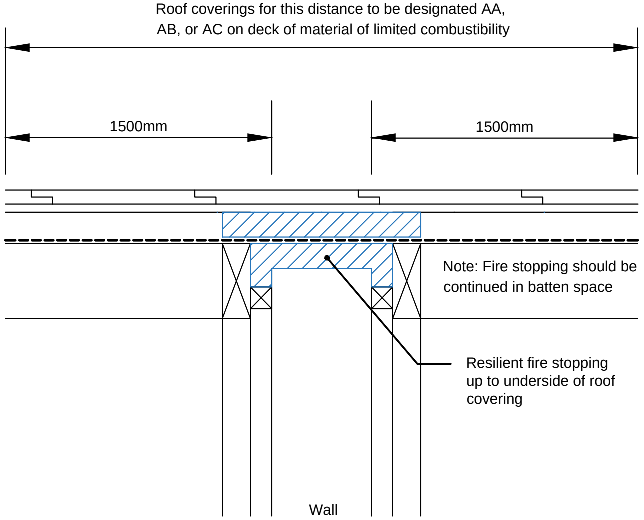
Compartmentation

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed space, it is particularly vital that fire-resistant cavity barriers are provided at the following points:

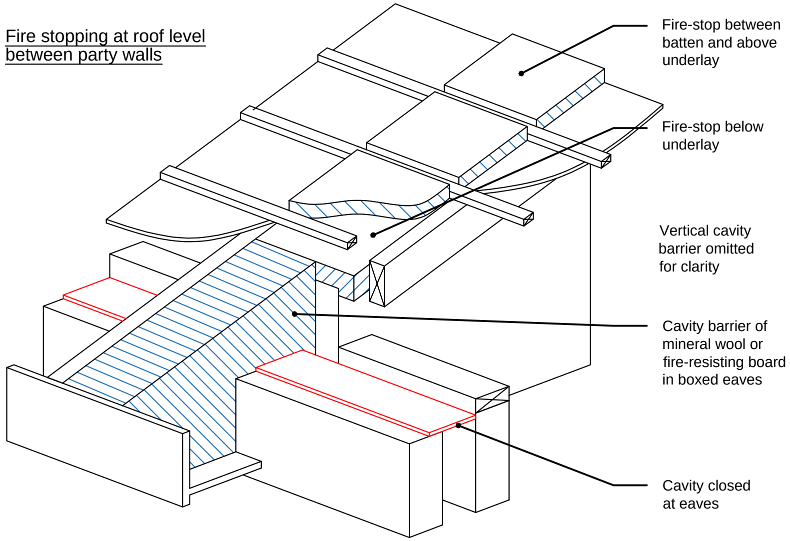
- At junctions of separating wall and external cavity wall.
- At junctions of compartment wall and compartment floor (not illustrated).
- At junctions of separating wall with roof, under roof tiles.
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire stopping, where necessary, at the wall/roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment. To reduce this risk, a roof zone 1500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.

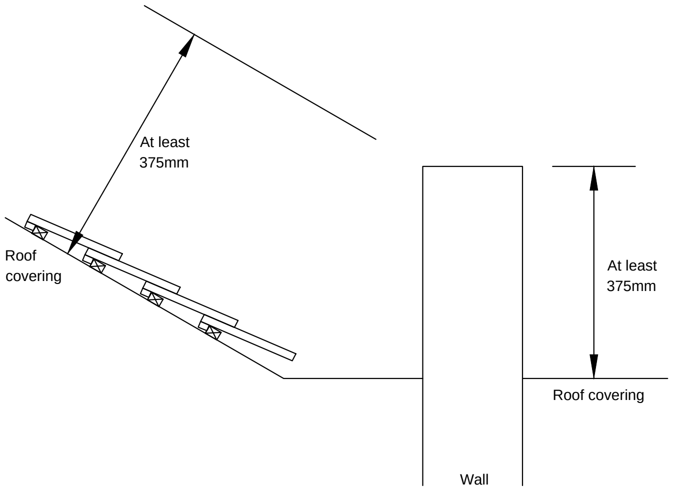


Fire stopping at roof level between party walls



Fire stopping should be provided in accordance with the relevant regional Building Regulations

- Party/separating walls 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.



Further additional requirements for internal fire stopping and fire protection for compartment floors, walls, and roof junctions to flats and apartments with a floor 4.5m or more above the ground

The following additional guidance applies to internal fire stopping and fire protection only to buildings with a floor 4.5m or more above the ground that contain flats or apartments.

Although building legislation is robust in applying provisions for fire protection and fire stopping, it can often be difficult to implement high standards of fire stopping in complex buildings. This can lead to significant safety risks if the building does not have the correct levels of fire protection and if holes in compartment walls are not sealed correctly. This guidance assists Developers in providing good standards of fire stopping and fire protection.

It is not the intention to enhance the requirements of the Building Regulations in this section, but more to ensure that the statutory requirements are applied correctly to the construction. It is therefore deemed that the requirements of Part B of the Building Regulations in England and Wales, or Section 2 of the Scottish Building Standards (whichever is appropriate depending on region), that apply to fire stopping, separating walls, service penetrations, minimum periods of fire resistance and concealed spaces will also meet the requirements of this guidance.

Fire stopping

Design information

Drawings showing the lines of compartmentation and the lines of fire-resisting construction should be provided to the Surveyor and the Builder. The drawings should also give the required level of fire resistance for each element. Drawings to show the position of cavity barriers should be provided, and the specification of cavity barriers included.

Materials for fire stopping and cavity barriers

All materials used to form a fire barrier must have relevant third-party certification or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products. A competent person is deemed to be a third-party approved contractor specialising in fire stopping and passive fire protection.

Fire protection in buildings

Design information

The design details must show the correct level of fire resistance for the building, in accordance with the Part B of the Building Regulations or Section 2 of the Scottish Building Standards, depending on region.

Materials for fire protection

All materials used to form a fire barrier must have relevant third-party certification, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products.

Where intumescent paints are used to provide the required level of fire protection, certification confirming that the paint applied will achieve the correct level of fire protection is required.

Materials for flashings and weatherings

Lead is generally ideal for roofing purposes; it is easily dressed over complicated shapes using simple hand tools, and can be joined by soldering or lead burning. For most roofing purposes, Codes 3, 4 and 5 will be adequate, but for extreme conditions of exposure, thicker codes may be necessary.

Lead sheet used for roofs, flashings and weathering's should, in terms of suitability to meet the Warranty requirements, be in accordance with BS EN 12588 or hold a valid UKAS (or European equivalent) third-party accreditation (e.g. British Board of Agrément, BRE, etc.) that demonstrates adequacy and durability for use.

Flashings and weathering's

The following is a brief summary of metal flashing details.

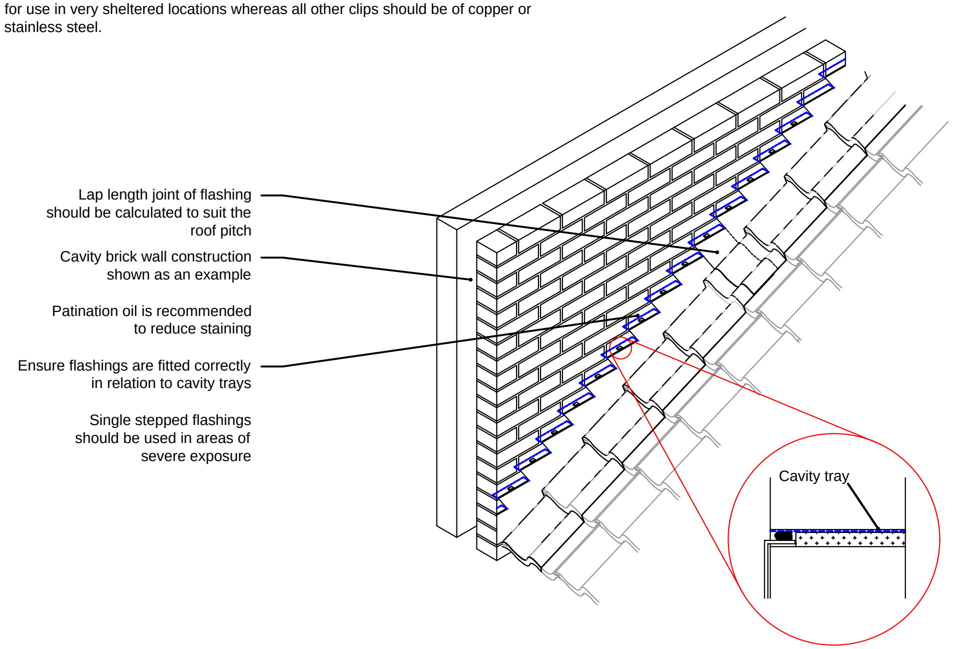
A coat of patination oil should be applied to lead flashings after fixing. Lead can be used in contact with other metals, such as copper and stainless steel, without risk of bimetallic corrosion, but should not be used with aluminium in a marine or coastal environment.

Side abutments

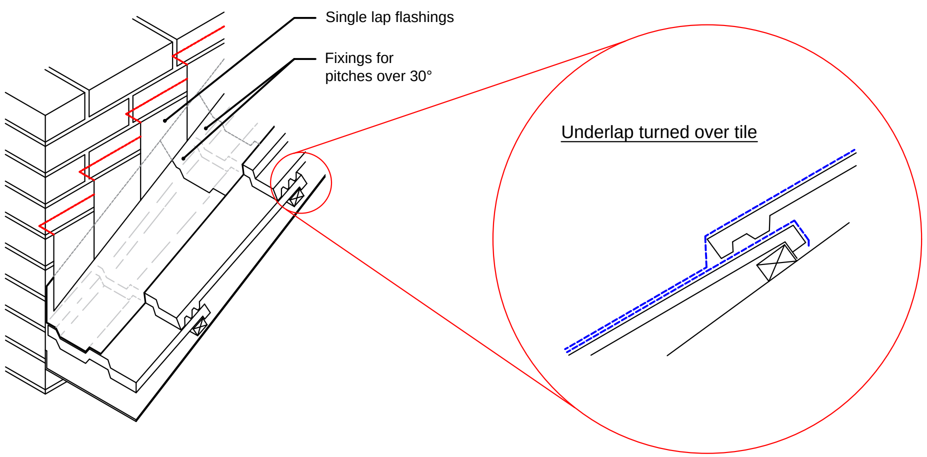
There are three common ways of weathering a side abutment with interlocking tiles; stepped cover flashings, secret gutters and a combination of stepped cover flashing above secret gutter.

Side abutment (stepped cover flashing)

- Turn roofing underlay a minimum of 50mm up at the abutment.
- Finish the tiling battens as close to the abutment as possible.
- Lay the tiles to butt as close as possible to the wall.
- Cut a piece of Code 4 lead to form a combined step and cover flashing.
- Flashing should not exceed 1.5m in length, and should be 150mm-200mm in width or wide enough to cover the first roll, whichever gives the greater cover.
- Chase out brickwork mortar joints and push folds of flashing into chases; wedge in with small pieces of lead.
- Dress cover flashing as tightly as possible to tile profile.
- Repoint brickwork.
- In areas of high exposure, or when dressing lead over flat tiles, use clips to hold cover flashing in place; when using this type of flashing with flat tiles below 25°, increase cover of flashing over tile to 200mm.
- All free edges of flashings should be clipped to suit the exposure. Lead clips are only for use in very sheltered locations whereas all other clips should be of copper or stainless steel.

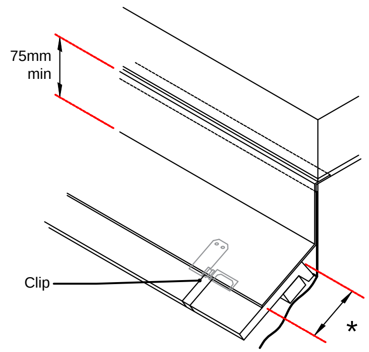


Single step and cover flashing for areas of severe and very severe exposure



Top edge abutment

- Turn roofing underlay a minimum of 50mm up at the abutment.
- Fix the top tiling batten as close as possible to the abutment.
- Complete tiling in the usual way.
- Chase abutment and insert lengths of code 4 lead, no more than 1.5m long; wedge in with small pieces of lead or stainless steel lead flashing clips, no less than 450mm apart.
- Lead should be wide enough to give at least 150mm cover to top course of tiles, below 30°. Increase cover to. 290mm at 15 degrees rafter pitch.
- Vertical upstand should be 75mm-100mm.
- Lap each length of lead by no less than 100mm.
- Dress lead to the profile of the tiles.
- Secure lead flashings with copper or stainless steel clips, with frequency dependent on exposure.



* The lap should be measured from the lowest fixing of underlying material and be no less than 150mm or the table below, whichever is the greater

Minimum lap of the flashing with the roof covering

Pitch of roof	Cover of lead flashing on roof (mm)
30°	150mm
20°	220mm
15°	290mm

Note:
1. For pitches over 30°, a minimum lap of 150mm should be provided
2. In areas of severe/very severe exposure the vertical upstand should increase to 100mm

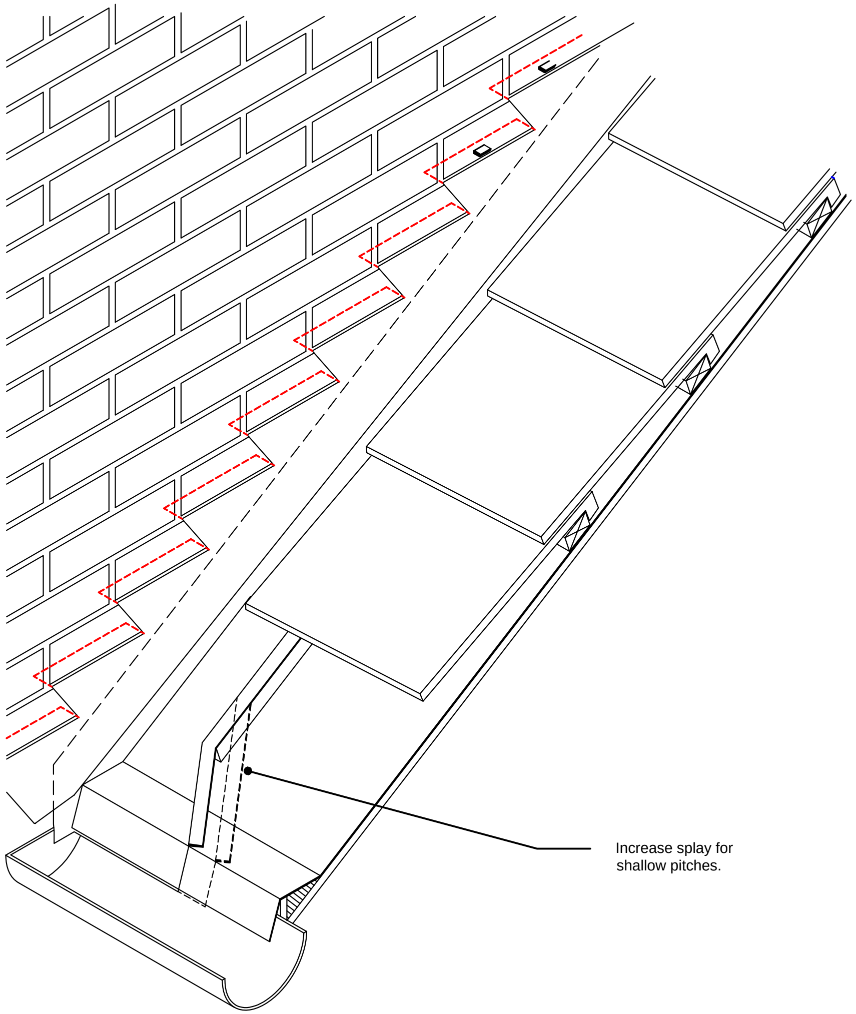
Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited)

Side abutment secret gutter arrangement

A secret gutter may be formed as an alternative to a step and cover flashing when using single-lap flat interlocking tiles, profiled tiles are not suitable for use in conjunction with a secret gutter.

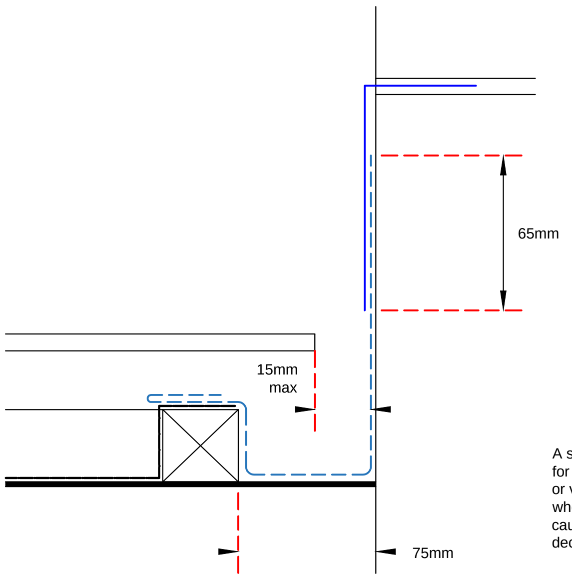
- Form secret gutters before starting tiling.
- Fix a support between the last rafter and the abutment; this should be a minimum of 75mm wide and run the full length of the abutment.
- Fix a splayed timber fillet at the discharge point to raise lead lining to the right height; avoid backward falls.
- Fix a counter batten along the outer edge of rafter.
- Line gutter with Code 4 or 5 lead, in lengths of no more than 1.5m.
- Lap each strip offered over the lower one by a minimum of 150mm, and fix with copper nails at head.
- Turn up lead welts to provide a weather check and exclude birds and vermin from entering tile batten space.
- Gutter should be a minimum of 25mm deep and have a vertical upstand of no less than 65mm above the top surface of the tiles.
- Fit a stepped flashing, chased into brickwork and dressed over vertical upstand.
- Turn roofing the underlay up the side of the counter battens and butt the tiling battens up to the counter batten.
- Lay tiles to leave a gap of 15mm by the side of the abutment.
- All free edges of flashings should be clipped to suit the exposure. Lead clips are only for use in very sheltered locations whereas all other clips should be of copper or stainless steel.

Secret gutter construction



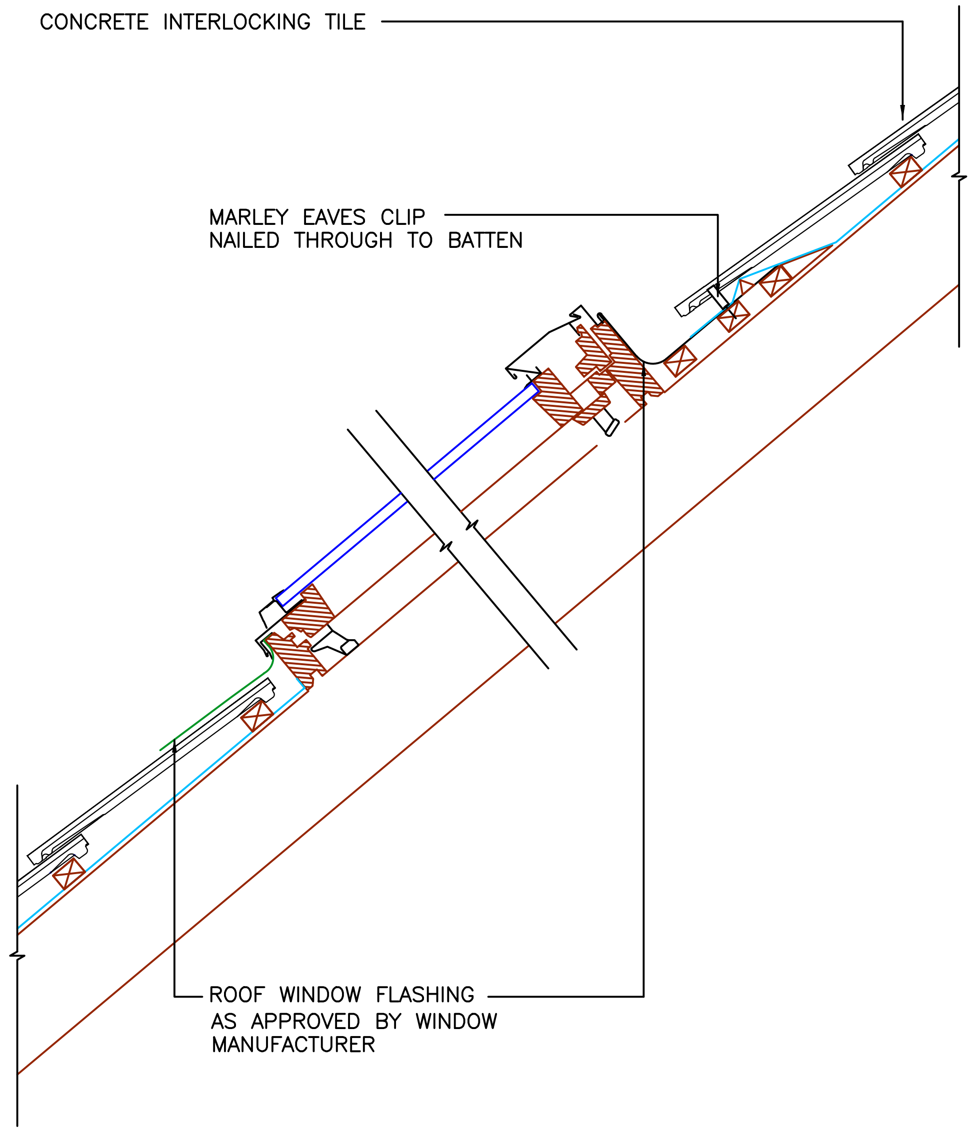
Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited)

Typical detail for normal exposure (section)



A secret gutter is not recommended for shallow pitches, areas of severe or very severe exposure, or areas where surrounding vegetation may cause risk of blockage e.g. deciduous trees.

Section through roof light (shown with Marley/Eternit roof light)



Roof lights

Most roof lights are of the 'factory manufactured' variety which should have appropriate third party approval. Most of these come with 'flashing kits' which should be installed in accordance with the manufacturers instructions. If a flashing kit is not provided, the flashing should be installed following the Lead Sheet Association good practice guide.

Box/Back gutters

Back gutters may be lead welded off-site and positioned when tiling is undertaken. A gutter should be formed where the bottom edge of tiling meets an abutment. Form the gutter before tiling, but after felting and battening is complete.

- Fix a lay board to support lead lining, with a tilting fillet, close to the abutment to flatten the pitch of the lead.
- Dress a sheet of Code 5 lead (width of abutment plus 450mm) into position with a vertical upstand of at least 100mm up the abutment.
- Dress the extra width of lead around the corner of the abutment after any side abutment weathering has been fitted.
- Dress the upper edge of lead over the tilting fillet and turn it back to form a welt.
- Chase abutment, insert a cover flashing of Code 4 lead and dress it over the vertical upstand of the gutter.

Roof protrusions

The flashings against chimney stacks, skylights and other similar projections through the roof surface should be similar to that described for abutments where appropriate.

- Make perforations for pipes, chimney stays, supports for ladders etc. weather tight by dressing over and under tiling with a lead or copper slate to which a sleeve is burned or soldered.
- Boss sleeve around pipe or stay, and seal at top with a collar.

Saddles

The following details can apply to any type of valley or hip /ridge intersection:

- Use Code 4 lead no less than 450mm square and large enough to give a lap of at least 150mm over the gutter lining on each side.
- Saddles should be capable of being readily dressed down when in position.

Clips

Clips for flashings are important in all roofing applications and where used should be fixed at 300mm-500mm centres, depending on the exposure of the building.

Clips may be formed from the following materials:

- Lead: Only suitable for sheltered locations with a thickness the same as that of the flashing it is fixing.
- Copper: Should be a minimum of 0.6mm thick, and may be thicker for very exposed locations.
- Stainless steel: Should be 22swg or 28swg thick, and is used for very exposed locations or where the fixing point is more than 75mm from the free edge of the flashing.
- Nails and screws: Copper wire nails (with jagged shanks) should be a minimum 25mm long x 10 gauge. Stainless steel annular ring shank wire nails should be a minimum 25mm long x 12 gauge. Screws should be brass or stainless steel, minimum 25mm long x 10 gauge.

11.

Roofs

11.4

Plain Tiles

Performance of tiles

Rain penetration of the roof covering is dependent on a combination of the rainfall rate, wind speed and the ability of the roof tile to resist the ingress of snow and rain water. The Designer should therefore be aware of the various means by which rain and snow can, under certain conditions, penetrate the roof covering.

These include:

- Capillary action and rain water creep.
- Raindrop bounce and negative pressure rain suction.
- Driving rain, deluge rain and flooding.
- Surcharging of rain water over laps on long-rafter roofs.
- Wind-driven snow.

Roof pitch

When determining the pitch, head-lap and/or side-lap of a tile or slate, the roof pitch is taken to be equal to the rafter pitch. Hence, all references to pitch refer to the rafter pitch, with the laid angle of the roof tile or slate always being less than roof pitch.

The actual pitch of a tile should be determined in accordance with the following guidelines:

- Tile/slate to rafter pitch angles.
- Plain tiles: 7° less than rafter pitch.

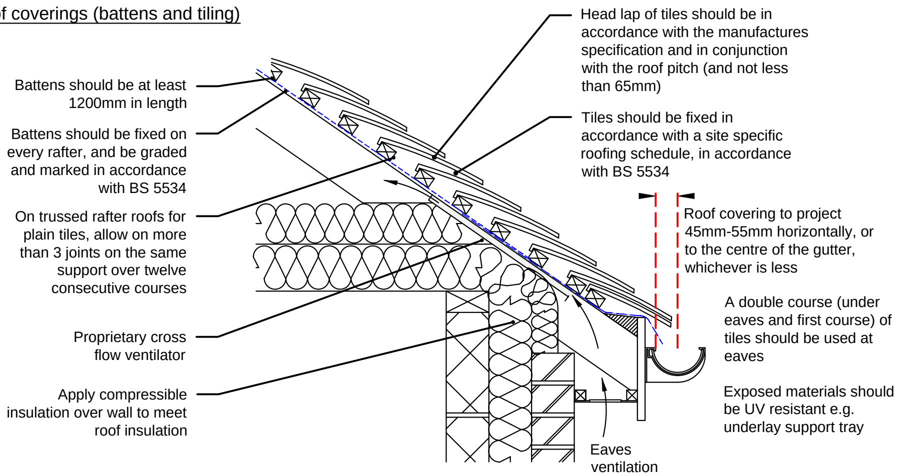
If the design rafter pitch is less than the minimum recommended rafter pitch for the particular tile, then they can be considered as having an aesthetic function only. In such cases, the true weatherproofing of the roof system must rely on a fully supported waterproof membrane with an uninterrupted drainage path between counter battens to the eaves gutter.

Wind

Design for wind loading

When considering the wind loading on the roof covering, designers should consult BS 5534. This provides calculation methods to assess the wind load on each tile as a uniformly distributed load, and also takes into account the porosity of the tiles and the effectiveness of the substrate (boarding or sarking), and/or underlay shielding, when calculating wind uplift loads. The standard method in BS EN 1991-1-4 Eurocode 1. Actions on structures. General actions. Wind actions should be used to determine the basic wind speed of the site, which is then used to calculate the effective wind speed and dynamic wind pressure on the roof by applying a series of factors to account for terrain, topography, building height and length etc.

Roof coverings (battens and tiling)



Tile fixings

BS 5534 recommends the use of aluminium or stainless steel nails under normal conditions of exposure. Plain or galvanised nails may be used for fixing battens to rafters, but care must be exercised when there is high humidity as certain timber preservative treatments may corrode steel, zinc or aluminium. For all roof areas and rafter pitches, every tile should be mechanically fixed.

Workmanship

Tile fixing should be in accordance with BS 8000-6 and the manufacturer's recommendations.

Calculating the fixing specification

The procedures for calculating the wind loads and determining the fixing specification for tiles in accordance with BS EN 1991-1-4 and BS 5534 are complex to undertake. Designers are advised to obtain a full site specific fixing specification from the tile manufacturer.

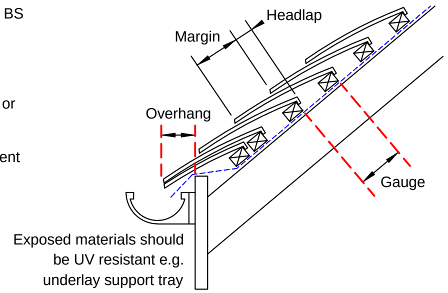
Tile details - key check points

Eaves and bottom edge (in accordance with BS 5534 and BS 8000-6).

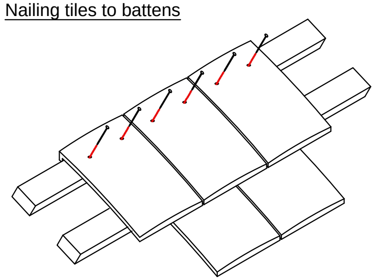
At the eaves (bottom edge), the batten should be set to provide the required overhang of the tiles into the gutters. The recommended overhang is 45mm-55mm horizontally or to the centre of the gutter, whichever is less.

- Ensure fascia board is to correct height so as to prevent tiles/slates kicking up or drooping.
- Fit duct trays to retain insulation.
- Fix underlay protector trays, fascia vents and comb fillers (profiled tiles).
- Clip eaves course where required.
- Ensure vent path to roof space is achieved.
- Ensure exposed materials are UV resistant.

Eaves and bottom edge detail



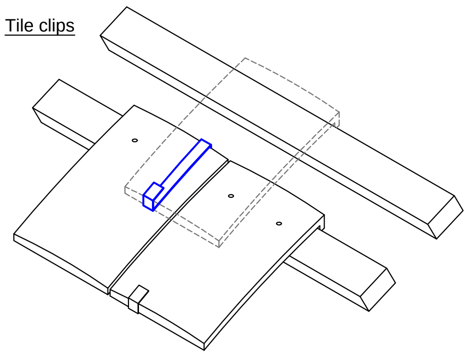
Nailing tiles to battens



Tile nails

Nails for use with tiles should be of copper, aluminium, stainless steel, phosphor or silicon bronze. Aluminium nails intended for use with tiles should conform to BS 1202-3 and should be clout head nails of 3.35mm or 2.65mm diameter and of lengths that provide not less than 15mm penetrations into battens. The length of nail will be determined by the required wind uplift and the design of the tile. Stainless steel nails for use with tiles should conform to BS EN 10088-3:2005 and BS 5534 grade 304, 316, 321 or 347, and should be specified for coastal areas, areas of high exposure or where there is a risk from chemical reaction.

Tile clips



Tile clips

Tile clips may need to be utilized to achieve a subtitle number of fixings to comply with BS 5534 especially on hips or valleys. Tile clips provide resistance to the applied overturning moment more successfully than a nail fixing. The latter is closer to the pivot line, where the nib touches the batten and cannot resist the uplift force at the tail.

BS 5534 acknowledges that for nibbed tiles, where the rafter pitch is below 60°, two nails should be used in each tile in at least every fifth course. For rafter pitches of 60° and above, including vertical, two nails should be used in every tile.

Ridges, hips, verges and valleys

The use of mortar for the bedding of ridge tiles, hip tiles, or lay tiles does not provide sufficient tensile bond strength to resist wind uplift, as it can be affected by a number of factors, such as wind loadings, mix of mortar, design and movement of the roof structure. The tensile strength of mortar should not be taken into account as the mechanical fixings should provide the resistance. Tiles only bedded on mortar are not acceptable.

Note: Dry fix ridge and hip systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

Verge (in accordance with BS 5534, BS 8612 and BS 8000-6)

Battens should overlap onto the outer skin of the brickwork or the undercloak material; for plain tiles, the verge should project 38mm-50mm. Where the distance of the nearest batten fixing to the rafter is greater than 300mm, an additional mechanical fixing is recommended.

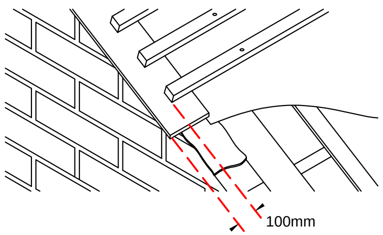
Note: Where proprietary verge tiles or systems are specified, the detailing should be in accordance with manufacturers' recommendations that are relevant to UK conditions of use.

- Use recommended undercloak for mortar.
- Level off irregularities in brickwork.
- Carry underlay over gable wall or bargeboard, and fit undercloak.
- Use the correct mortar mix.
- Bed and point tiles in one operation.
- Keep mortar clear from the ends of tiling battens.
- Fix all perimeter tiles (clip and/or nail).

Undercloak

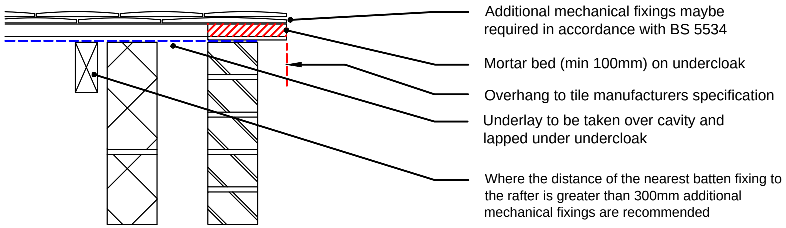
Where an undercloak is used it should comprise plain tiles, slates or fibre cement sheet strip. It is usually fixed at verges beneath the battens and on top of the underlay to support the mortar onto which the verge tiles or slates are bedded, If batten ends are cut, treat with a suitable preservative. A 100mm wide bed of mortar should be neatly laid on the undercloak, this should be bedded solidly and finished neatly.

Verge detail



For plain tiles:
- the verge overhang, when unsupported, should be not less than 38mm and not greater than 50mm
- the verge should be detailed with a tile-and-a-half and a full tile in alternate course

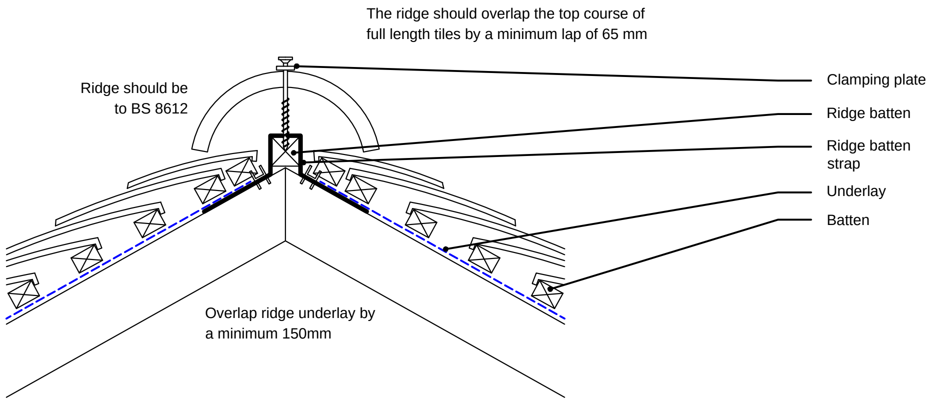
Verge detail (section)



Where proprietary verge tiles or systems are specified the detailing should be in accordance with the manufacturers recommendations that are relevant to UK conditions of use.

Mortar must not be the sole means of fixing and should only be used for decorative purposes. Suitable mechanical fixings are required. Mortar should be to the recommendations in BS5 534 and typically consist of a cement and sand mix based on sharp sand, with soft sand added to achieve workability. The proportion of sharp sand should not be less than a third of the total sand content to ensure the durability of the feature.

Typical dry ridge detail



Ridge (in accordance with BS 5534, BS 8612: Dry-fixed ridge, hip and verge systems for slating and tiling and BS 8000-6)

Dry fix systems

Proprietary dry roofing products and systems should be used as an alternative to just mortar bedding at verges, ridges, hips and valleys to provide weathering and mechanical resistance properties. Dry roofing products as fitted should not adversely affect the performance of the roof as laid.

Dry ridge systems should be manufactured and tested to meet BS 8612. The dry ridge system should be specified in accordance with BS 8612 and be suitable for the location and the wind loading (see 'Note 1' below).

Specifiers should seek evidence that this will not be the case, and should use dry roofing products only if such evidence is available.

Note 1: Users should pay particular attention to the resistance to wind load and durability performance of dry roofing products.

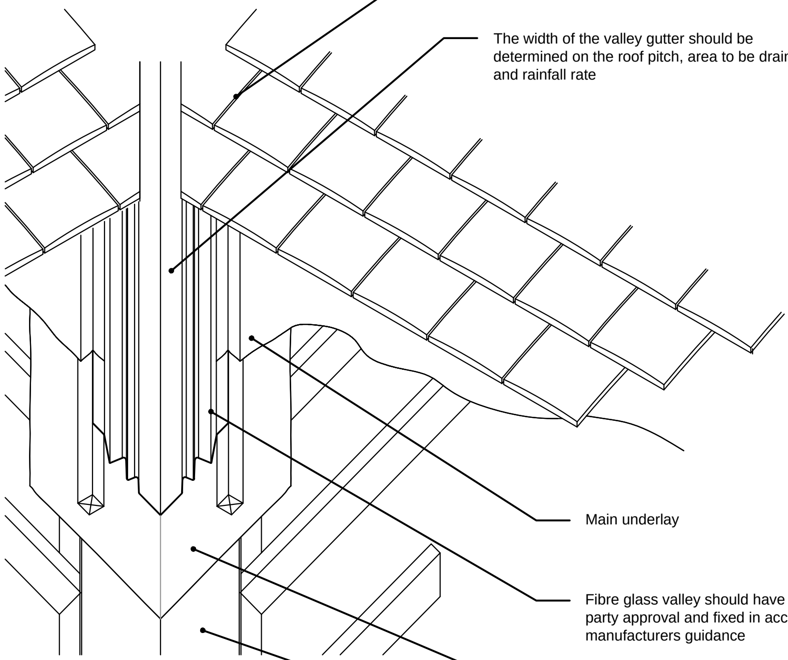
The ridge or top course batten should be set to allow the ridge tiles, ridge units or metal ridge to overlap the top course of tiles by the overlap necessary for the main tiles. For plain tiles, this should be not less than 65mm. For double-lap products, the top batten should be set to allow the ridge to overlap the penultimate course by the required head-lap.

For ridge tiles:

- Check ridge tile is suitable for pitch of roof.
- Edge bed components onto tiles.
- Ensure top course tiles or slates are mechanically fixed.
- Mitre tiles neatly at hip ridge junctions, and use a lead saddle underneath for protection.
- Use the correct mortar mix.
- **All** mortar bedded ridge tiles **must** also be mechanically fixed by proprietary fixings in accordance with the roof covering manufacturer's recommendations.

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

GRP dry valley detail



Valley (in accordance with BS 5534 and BS 8000-6)

The design of pitched valley gutters is just one roof detail where the latest guidance is much improved over previous Codes of Practice. The valley is the most vulnerable area of a pitched roof in respect to potential water ingress, as it drains all of the water from adjacent roof slopes.

Consequently, the design data is related to the pitch of the roof, the rainfall rate, the length of the valley and the catchment area or area of the roof to be drained. Designers are able to determine the width of the valley trough so that it is appropriate for discharging the rain water from the adjacent roof covering to the eaves gutter.

For valley gutters:

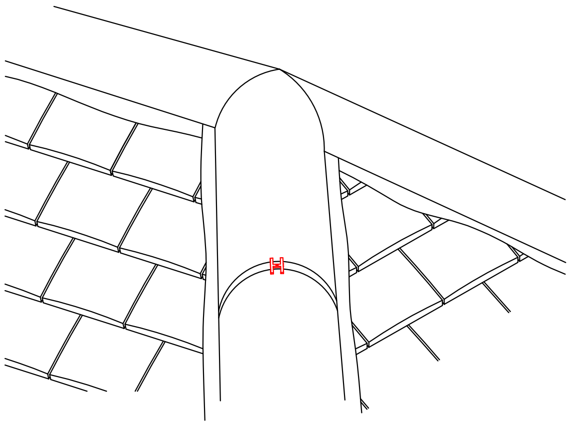
- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure roof structure provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay beneath a lead sheet valley.
- Keep open gutter width 100mm-250mm (correct width to be determined by reference to Table 11 and 12 in BS 5534).
- Keep roof design as simple as possible.
- Avoid discharge of valleys onto roofing wherever possible, but where inevitable use a lead saddle.
- Avoid direct contact with lead when using mortar; provide a fibre cement undercloak or tile slips.
- Do not block tile laps with mortar to avoid water damming.
- Where fibre glass valleys are used only products supported by a third party product approval will be acceptable and the installation and support of the fibre glass valley unit must follow the manufacturers guidance.
- Mechanically fix all tiles adjacent to valleys.

Hip (in accordance with BS 5534, BS 8512 and BS 8000-6)

For hip roof construction:

- Check hip tile is suitable for pitch of roof.
- Mitre tiles neatly at hip ridge junctions and use a lead saddle underneath for protection.
- Use the correct hip iron at base of hip.
- Use the correct mortar mix.
- All mortar bedded hip tiles must also be mechanically fixed (screws, nails, clips, etc.).

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 and BS 8512 recommendations.



Fire stopping

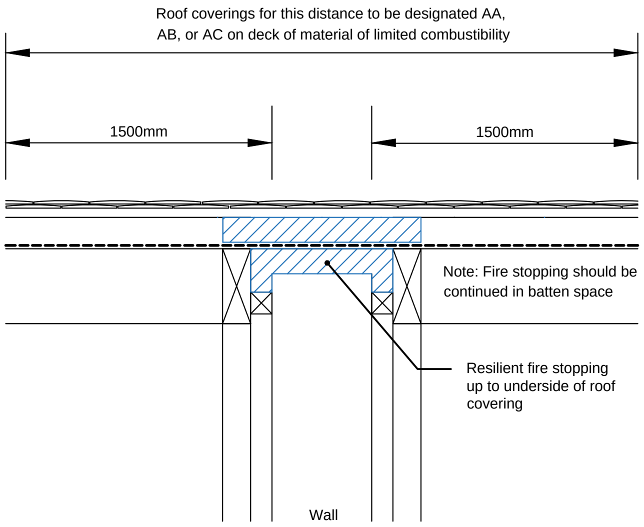
Compartmentation

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed space, it is particularly vital that fire-resistant cavity barriers are provided at the following points:

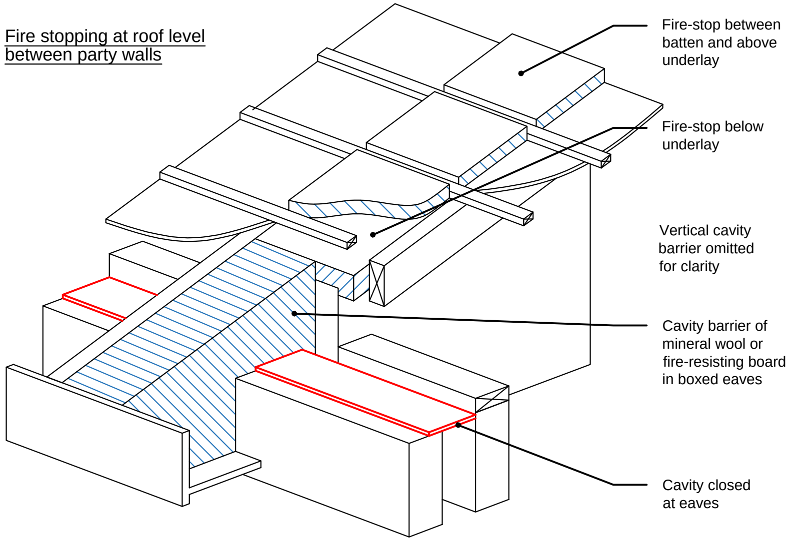
- At junctions of separating wall and external cavity wall.
- At junctions of compartment wall and compartment floor (not illustrated).
- At junctions of separating wall with roof, under roof tiles.
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire stopping, where necessary, at the wall/roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment. To reduce this risk, a roof zone 500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.

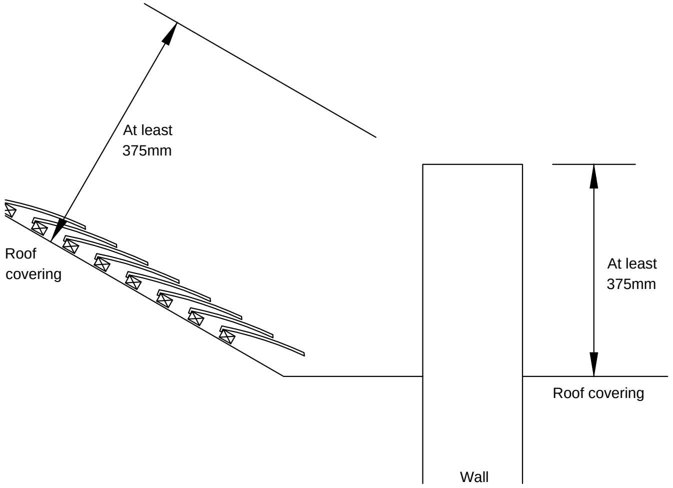


Fire stopping at roof level between party walls



Fire stopping should be provided in accordance with the relevant regional Building Regulations

- Party/separating walls 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.



Further additional requirements for internal fire stopping and fire protection for compartment floors, walls, and roof junctions to flats and apartments with a floor 4.5m or more above the ground

The following additional guidance applies to internal fire stopping and fire protection only to buildings with a floor 4.5m or more above the ground that contain flats or apartments.

Although building legislation is robust in applying provisions for fire protection and fire stopping, it can often be difficult to implement high standards of fire stopping in complex buildings. This can lead to significant safety risks if the building does not have the correct levels of fire protection and if holes in compartment walls are not sealed correctly. This guidance assists Developers in providing good standards of fire stopping and fire protection.

It is not the intention to enhance the requirements of the Building Regulations in this section, but more to ensure that the statutory requirements are applied correctly to the construction. It is therefore deemed that the requirements of Part B of the Building Regulations in England and Wales, or Section 2 of the Scottish Building Standards (whichever is appropriate depending on region), that apply to fire stopping, separating walls, service penetrations, minimum periods of fire resistance and concealed spaces will also meet the requirements of this guidance.

Fire stopping

Design information

Drawings showing the lines of compartmentation and the lines of fire-resisting construction should be provided to the Surveyor and the Builder. The drawings should also give the required level of fire resistance for each element. Drawings to show the position of cavity barriers should be provided, and the specification of cavity barriers included.

Materials for fire stopping and cavity barriers

All materials used to form a fire barrier must have relevant third-party certification or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products. A competent person is deemed to be a third-party approved contractor specialising in fire stopping and passive fire protection.

Fire protection in buildings

Design information

The design details must show the correct level of fire resistance for the building, in accordance with the Part B of the Building Regulations or Section 2 of the Scottish Building Standards, depending on region.

Materials for fire protection

All materials used to form a fire barrier must have relevant third-party certification, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products.

Where intumescent paints are used to provide the required level of fire protection, certification confirming that the paint applied will achieve the correct level of fire protection is required.

Materials for flashings and weatherings

Lead is generally ideal for roofing purposes; it is easily dressed over complicated shapes using simple hand tools, and can be joined by soldering or lead burning. For most roofing purposes, Codes 3, 4 and 5 will be adequate, but for extreme conditions of exposure, thicker codes may be necessary.

Lead sheet used for roofs, flashings and weathering's should, in terms of suitability to meet the Warranty requirements, be in accordance with BS EN 12588 or hold a valid UKAS (or European equivalent) third-party accreditation (e.g. British Board of Agrément, BRE, etc.) that demonstrates adequacy and durability for use.

Flashings and weathering's

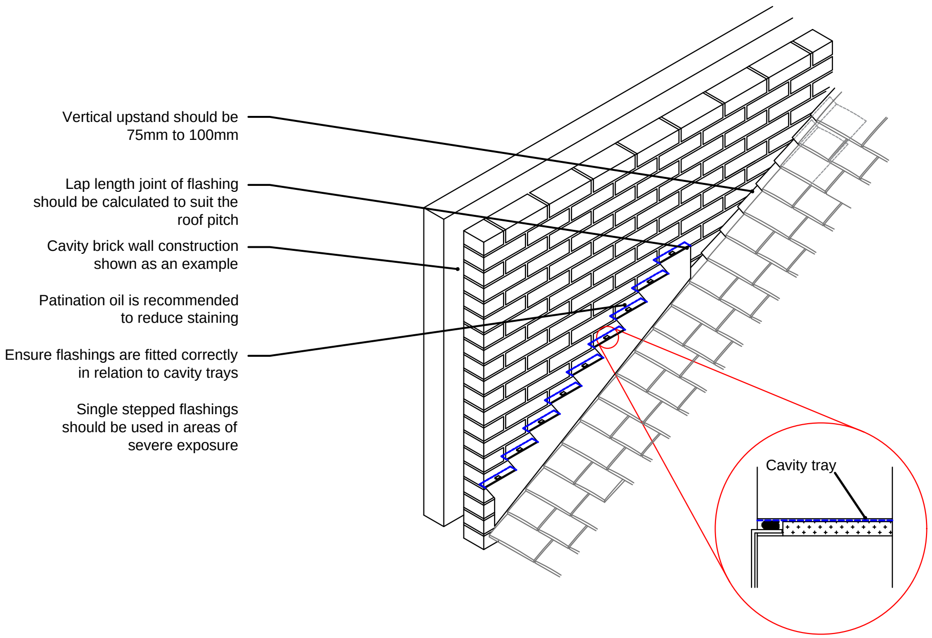
The following is a brief summary of metal flashing details.

A coat of patination oil should be applied to lead flashings after fixing. Lead can be used in contact with other metals, such as copper and stainless steel, without risk of bimetallic corrosion, but should not be used with aluminium in a marine or coastal environment.

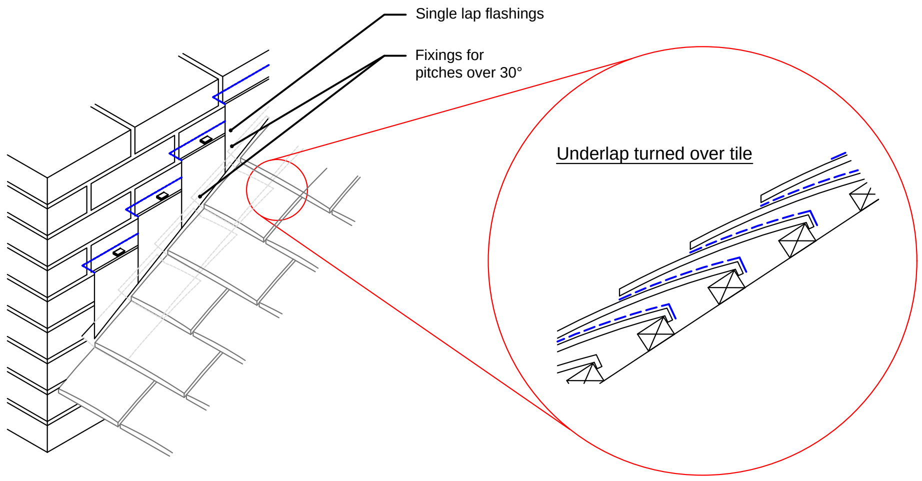
Side abutment (soakers and step flashings)

Soakers are used where double-lap plain tiles abut a wall.

- Turn underlay 50mm up the abutment and cut tiling battens 10mm-25mm short of the wall and fix securely.
- Lay tiles close to the abutment with a soaker fitted between each tile.
- Form Code 3 lead soakers with an upstand of 75mm to place against the abutment. They should be 175mm wide and 190mm long, allowing a 25mm downturn over the back of the tile. After all tiles and soakers have been fixed, insert a stepped flashing into the abutment wall and dress down over the upturned edges of the soakers.

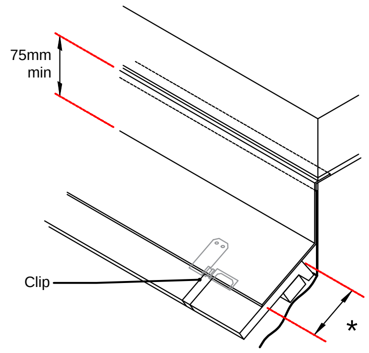


Single step and cover flashing for areas of severe and very severe exposure



Top edge abutment

- Turn roofing underlay a minimum of 50mm up at the abutment.
- Fix the top tiling batten as close as possible to the abutment.
- Complete tiling in the usual way.
- Chase abutment and insert lengths of code 4 lead, no more than 1.5m long; wedge in with small pieces of lead or stainless steel lead flashing clips, no less than 450mm apart.
- Lead should be wide enough to give at least 150mm cover to top course of tiles, below 30°. Increase cover to. 290mm at 15 degrees rafter pitch.
- Vertical upstand should be 75mm-100mm.
- Lap each length of lead by no less than 100mm.
- Dress lead to the profile of the tiles.
- Secure lead flashings with copper or stainless steel clips, with frequency dependent on exposure.



* The lap should be measured from the lowest fixing of underlying material and be no less than 150mm or the table below, whichever is the greater

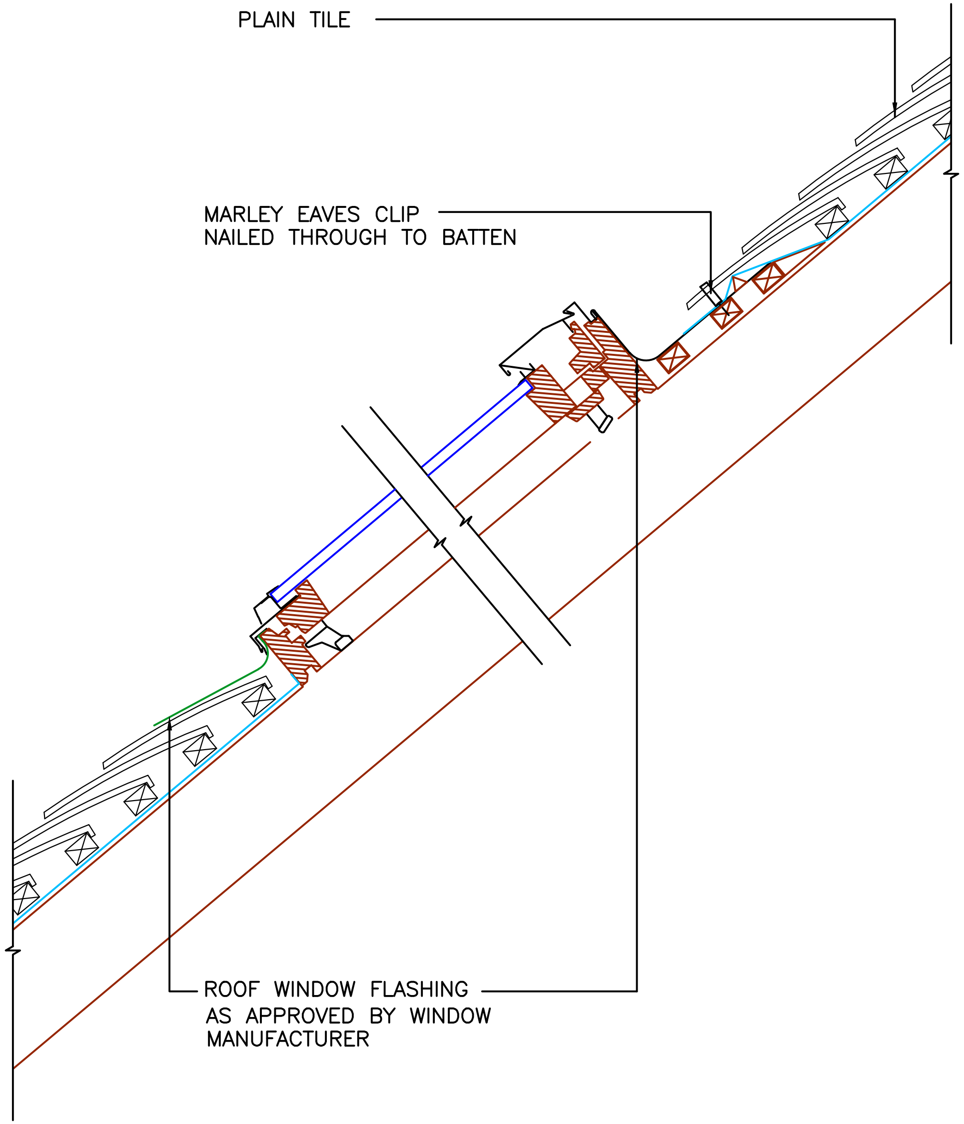
Minimum lap of the flashing with the roof covering

Pitch of roof	Cover of lead flashing on roof (mm)
30°	150mm
20°	220mm
15°	290mm

Note:
1. For pitches over 30°, a minimum lap of 150mm should be provided
2. In areas of severe/very severe exposure the vertical upstand should increase to 100mm

Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited)

Section through roof light (shown with Marley/Eternit roof light)



Roof lights

Most roof lights are of the 'factory manufactured' variety which should have appropriate third party approval. Most of these come with 'flashing kits' which should be installed in accordance with the manufacturers instructions. If a flashing kit is not provided, the flashing should be installed following the Lead Sheet Association good practice guide.

Box/Back gutters

Back gutters may be lead welded off-site and positioned when tiling is undertaken. A gutter should be formed where the bottom edge of tiling meets an abutment. Form the gutter before tiling, but after felting and battening is complete.

- Fix a lay board to support lead lining, with a tilting fillet, close to the abutment to flatten the pitch of the lead.
- Dress a sheet of Code 5 lead (width of abutment plus 450mm) into position with a vertical upstand of at least 100mm up the abutment.
- Dress the extra width of lead around the corner of the abutment after any side abutment weathering has been fitted.
- Dress the upper edge of lead over the tilting fillet and turn it back to form a welt.
- Chase abutment, insert a cover flashing of Code 4 lead and dress it over the vertical upstand of the gutter.

Roof protrusions

The flashings against chimney stacks, skylights and other similar projections through the roof surface should be similar to that described for abutments where appropriate.

- Make perforations for pipes, chimney stays, supports for ladders etc. weather tight by dressing over and under tiling with a lead or copper slate to which a sleeve is burned or soldered.
- Boss sleeve around pipe or stay, and seal at top with a collar.

Saddles

The following details can apply to any type of valley or hip /ridge intersection:

- Use Code 4 lead no less than 450mm square and large enough to give a lap of at least 150mm over the gutter lining on each side.
- Saddles should be capable of being readily dressed down when in position.

Clips

Clips for flashings are important in all roofing applications and where used should be fixed at 300mm-500mm centres, depending on the exposure of the building.

Clips may be formed from the following materials:

- Lead: Only suitable for sheltered locations with a thickness the same as that of the flashing it is fixing.
- Copper: Should be a minimum of 0.6mm thick, and may be thicker for very exposed locations.
- Stainless steel: Should be 22swg or 28swg thick, and is used for very exposed locations or where the fixing point is more than 75mm from the free edge of the flashing.
- Nails and screws: Copper wire nails (with jagged shanks) should be a minimum 25mm long x 10 gauge. Stainless steel annular ring shank wire nails should be a minimum 25mm long x 12 gauge. Screws should be brass or stainless steel, minimum 25mm long x 10 gauge.

11.

Roofs

11.5

Slate

Performance of slates

Rain penetration of the roof covering is dependent on a combination of the rainfall rate, wind speed and the ability of the roof slates to resist the ingress of snow and rain water. The Designer should therefore be aware of the various means by which rain and snow can, under certain conditions, penetrate the roof covering.

These include:

- Capillary action and rain water creep.
- Raindrop bounce and negative pressure rain suction.
- Driving rain, deluge rain and flooding.
- Surcharging of rain water over laps on long-rafter roofs.
- Wind-driven snow.

Natural slates

Natural slates must meet the following level of performance and durability as detailed in BS EN 12326:

- Achieve a T1 code rating for 'Thermal cycle' test.
- Achieve a S1 code rating for 'Carbonate content' test.
- A copy of the consignment documentation or "accompanying commercial document" (ACD) from the supplier/producer should be provided to confirm these test performances.

It is important that slates are graded on site to ensure an even finish.

Roof pitch

When determining the pitch, head-lap and/or side-lap of slate, the roof pitch is taken to be equal to the rafter pitch. Hence, all references to pitch refer to the rafter pitch, with the laid angle of the roof tile or slate always being less than roof pitch.

The actual pitch of a slate or tile should be determined in accordance with the following guidelines:

- Slate to rafter pitch angles.
- Double-lap fibre cement slates: 1.25° less than rafter pitch.

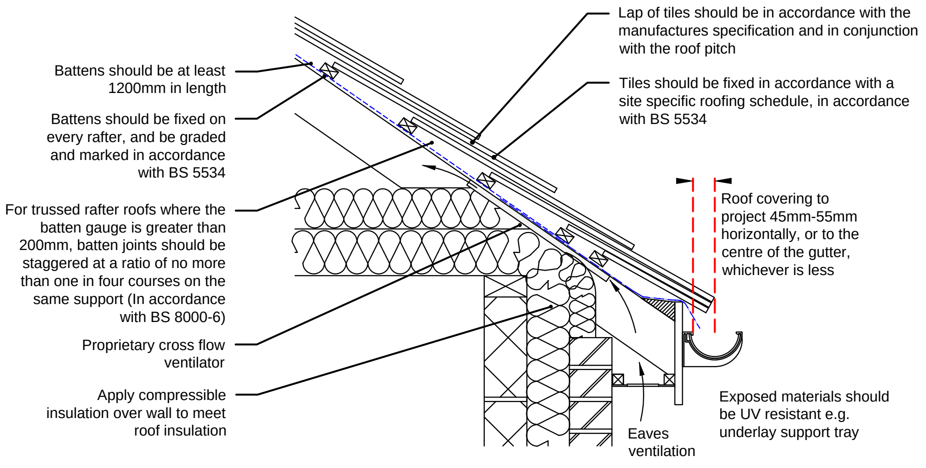
If the design rafter pitch is less than the minimum recommended rafter pitch for the particular slate, then they can be considered as having an aesthetic function only. In such cases, the true weatherproofing of the roof system must rely on a fully supported waterproof membrane with an uninterrupted drainage path between counter battens to the eaves gutter.

Wind

Design for wind loading

When considering the wind loading on the roof covering, designers should consult BS 5534. This provides calculation methods to assess the wind load on each slate as a uniformly distributed load, and also takes into account the porosity of the slates and the effectiveness of the substrate (boarding or sarking), and/or underlay shielding, when calculating wind uplift loads. The standard method in BS EN 1991-1-4 Eurocode 1. Actions on structures. General actions. Wind actions should be used to determine the basic wind speed of the site, which is then used to calculate the effective wind speed and dynamic wind pressure on the roof by applying a series of factors to account for terrain, topography, building height and length etc.

Roof coverings (battens and tiling)



Fibre-cement slates and fittings

When tested in accordance with BS EN 492, fibre-cement slates and fittings should conform to the requirements for frost resistance specified in that standard.

Workmanship

Tile fixing should be in accordance with BS 8000-6 and the manufacturer's recommendations.

Slate fixings

BS 5534 recommends the use of aluminium or stainless steel nails under normal conditions of exposure. Plain or galvanised nails may be used for fixing battens to rafters, but care must be exercised when there is high humidity as certain timber preservative treatments may corrode steel, zinc or aluminium. For all roof areas and rafter pitches, every tile should be mechanically fixed.

Calculating the fixing specification

The procedures for calculating the wind loads and determining the fixing specification for slates in accordance with BS EN 1991-1-4 and BS 5534 are complex to undertake. Designers are advised to obtain a full site specific fixing specification from the slate manufacturer.

Key check points

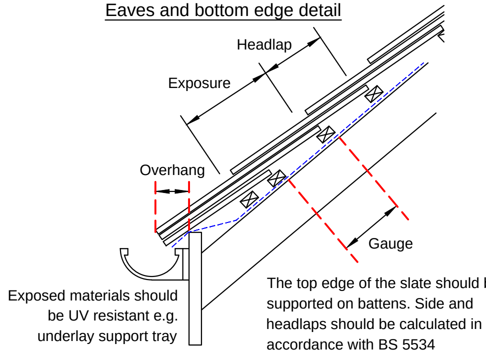
Eaves and bottom edge (in accordance with BS 5534 and BS 8000-6).

At the eaves (bottom edge), the batten should be set to provide the required overhang of the slates into the gutters.

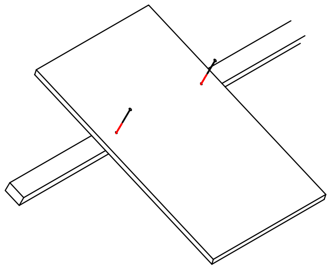
The recommended overhang is 45mm-55mm horizontally or to the centre of the gutter, whichever is less.

- Ensure fascia board is to correct height so as to prevent tiles/slates kicking up or drooping.
- Fit duct trays to retain insulation.
- Fix underlay protector trays, fascia vents and comb fillers (profiled tiles).
- Clip eaves course where required.
- Ensure vent path to roof space is achieved.
- Ensure exposed materials are UV resistant.

Eaves and bottom edge detail



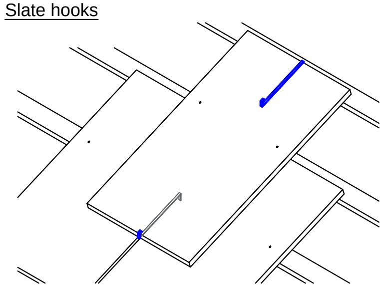
Nailing slates to battens



Slate nails and rivets

Nails intended for use with fibre cement slates should be of copper, conforming to the requirements for clout nails specified in BS 1202-2. The shank diameter and length should be determined by the exposure of the site and the nail's withdrawal resistance. Normally, 30mm x 2.65mm copper nails are adequate for most applications. For exposed sites, or where aggressive environments are encountered, contact the slate manufacturer. Copper disc 'tail' rivets are used to further secure the tail of fibre cement slates against wind chatter.

Slate hooks



Slate hooks

Hooks are formed from stainless steel wire conforming to BS 1554 grade 316 S11 or 316 S19. For further advice on the use of slate hooks, refer to BS 5534 section 4.12.3 and 5.3.6.4 Hooks and rivets for slates. Slates should not be nailed to accommodate hooks.

Hooks with crimped shanks reduce the capillary rise of water at the perpendicular joints between slates and are suitable for all roof pitches between 25° and 90°. Straight shank hooks should not be used at roof pitches below 30°. Hooks should not be used at roof pitches below 25°.

Ridges, hips, verges and valleys

The use of mortar for the bedding of ridge tiles, hip tiles, or lay tiles does not provide sufficient tensile bond strength to resist wind uplift, as it can be affected by a number of factors, such as wind loadings, mix of mortar, design and movement of the roof structure. The tensile strength of mortar should not be taken into account as the mechanical fixings should provide the resistance. Ridge tiles only bedded on mortar are not acceptable.

Note: Dry fix ridge and hip systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

Verge (in accordance with BS 5534, BS 8612 and BS 8000-6)

Battens should overlap onto the outer skin of the brickwork or the undercloak material; the verge should project to manufacturer's specification. Where the distance of the nearest batten fixing to the rafter is greater than 300mm, an additional mechanical fixing is recommended.

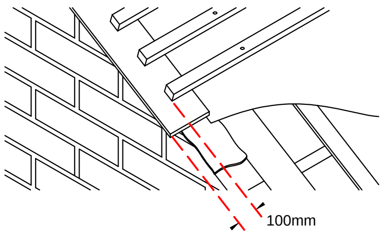
Note: Where proprietary verge tiles or systems are specified, the detailing should be in accordance with manufacturers' recommendations that are relevant to UK conditions of use.

- Use recommended undercloak for mortar.
- Level off irregularities in brickwork.
- Carry underlay over gable wall or bargeboard, and fit undercloak.
- Use the correct mortar mix.
- Bed and point tiles in one operation.
- Keep mortar clear from the ends of tiling battens.
- Fix all perimeter slates (clip and/or nail).
- Natural slate verges should be formed with full slates and either slate-and-a-half or half slates that are a minimum of 150mm wide.

Undercloak

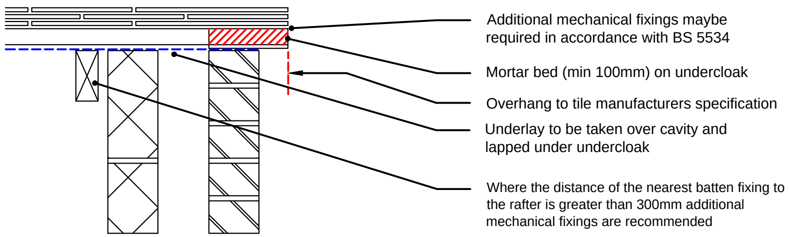
Where an undercloak is used it should comprise plain tiles, slates or fibre cement sheet strip. It is usually fixed at verges beneath the battens and on top of the underlay to support the mortar onto which the slates are bedded, If batten ends are cut, treat with a suitable preservative. A 100mm wide bed of fully compressed width should be neatly laid on the undercloak, this should be bedded solidly and finished neatly.

Verge detail



Note: the verge overhang, when unsupported, should be not less than 38mm and not greater than 50mm

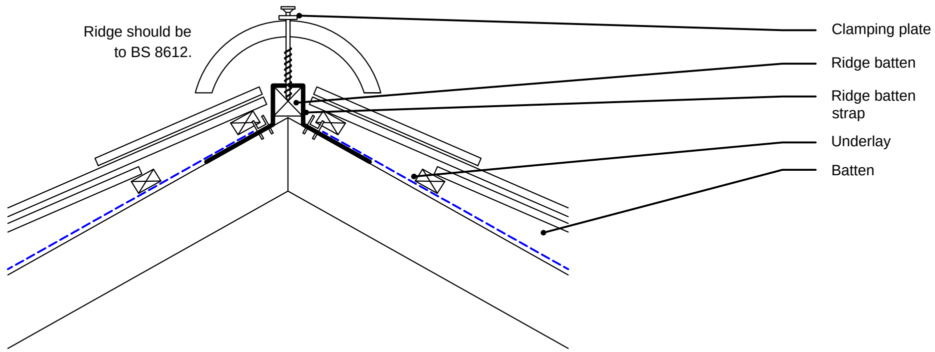
Verge detail (section)



Where proprietary verge tiles or systems are specified the detailing should be in accordance with the manufacturers recommendations that are relevant to UK conditions of use.

Mortar must not be the sole means of fixing and should only be used for decorative purposes. Suitable mechanical fixings are required. Mortar should be to the recommendations in BS 5534 and typically consist of a cement and sand mix based on sharp sand, with soft sand added to achieve workability. The proportion of sharp sand should not be less than a third of the total sand content to ensure the durability of the feature.

Typical dry ridge detail



Ridge (in accordance with BS 5534, BS 8612: Dry-fixed ridge, hip and verge systems for slating and tiling and BS 8000-6)

Dry fix systems

Proprietary dry roofing products and systems should be used as an alternative to just mortar bedding at verges, ridges, hips and valleys to provide weathering and mechanical resistance properties. Dry roofing products as fitted should not adversely affect the performance of the roof as laid.

Dry ridge systems should be manufactured and tested to meet BS 8612. The dry ridge system should be specified in accordance with BS 8612 and be suitable for the location and the wind loading (see 'Note 1' below).

Specifiers should seek evidence that this will not be the case, and should use dry roofing products only if such evidence is available.

Note 1: Users should pay particular attention to the resistance to wind load and durability performance of dry roofing products.

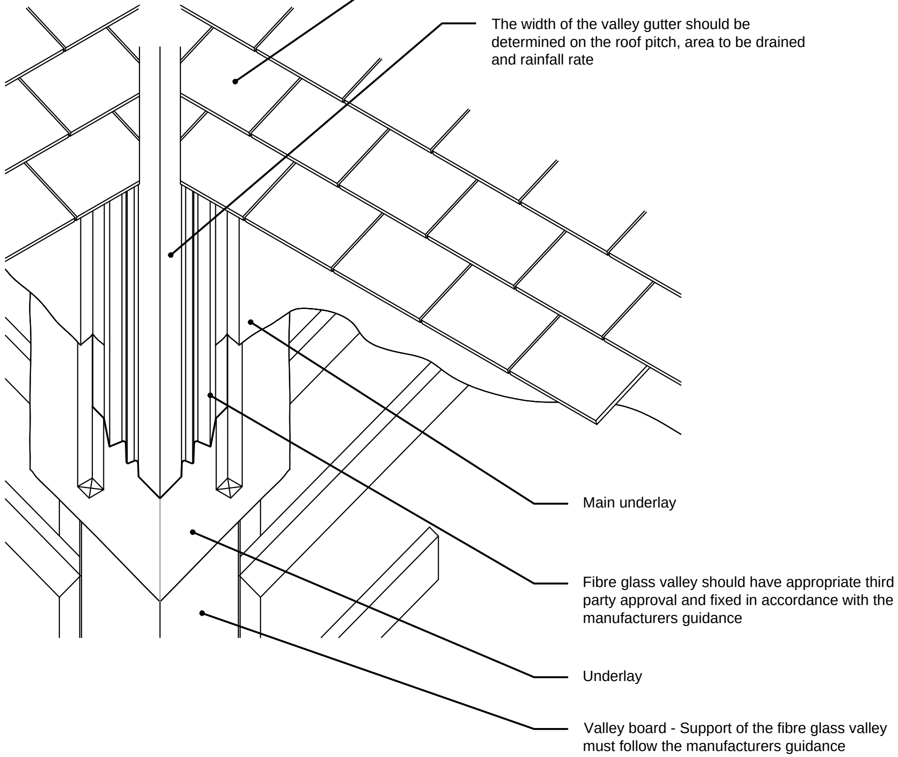
The ridge or top course batten should be set to allow the ridge tiles, ridge units or metal ridge to overlap the top course of slates by the overlap necessary for the main slates. For double-lap products, the top batten should be set to allow the ridge to overlap the penultimate course by the required head-lap.

For ridge tiles:

- Check ridge tile is suitable for pitch of roof.
- Edge bed components onto slates.
- Ensure top course tiles or slates are mechanically fixed.
- Mitre tiles neatly at hip ridge junctions, and use a lead saddle underneath for protection.
- Use the correct mortar mix.
- Use dentil slips in deep profiled tiles in all joints more than 25mm thick to reduce mortar and risk of shrinkage.
- **All** mortar bedded ridge tiles **must** also be mechanically fixed by proprietary fixings in accordance with the roof covering manufacturer's recommendations.

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

GRP dry valley detail



Valley (in accordance with BS 5534 and BS 8000-6)

The design of pitched valley gutters is just one roof detail where the latest guidance is much improved over previous Codes of Practice. The valley is the most vulnerable area of a pitched roof in respect to potential water ingress, as it drains all of the water from adjacent roof slopes.

Consequently, the design data is related to the pitch of the roof, the rainfall rate, the length of the valley and the catchment area or area of the roof to be drained. Designers are able to determine the width of the valley trough so that it is appropriate for discharging the rain water from the adjacent roof covering to the eaves gutter.

For valley gutters:

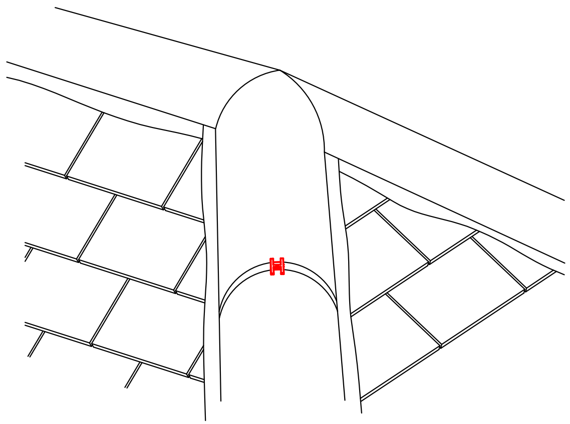
- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure roof structure provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay beneath a lead sheet valley.
- Keep open gutter width 100mm-250mm (correct width to be determined by reference to Table 11 and 12 in BS 5534).
- Keep roof design as simple as possible.
- Avoid discharge of valleys onto roofing wherever possible, but where inevitable use a lead saddle.
- Avoid direct contact with lead when using mortar; provide a fibre cement undercloak or tile slips.
- Do not block tile laps with mortar to avoid water damming.
- Where fibre glass valleys are used only products supported by a third party product approval will be acceptable and the installation and support of the fibre glass valley unit must follow the manufacturers guidance.
- Mechanically fix all slates adjacent to valleys.

Hip (in accordance with BS 5534, BS 8512 and BS 8000-6)

For hip roof construction:

- Check hip tile is suitable for pitch of roof.
- Mitre tiles neatly at hip ridge junctions and use a lead saddle underneath for protection.
- Use the correct hip iron at base of hip.
- Use the correct mortar mix.
- Use dentil slips in deep profiled tiles in all joints more than 25mm thick to reduce mortar and risk of shrinkage.
- All mortar bedded hip tiles must also be mechanically fixed (screws, nails, clips, etc.).

Note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 and BS 8512 recommendations.



Fire stopping

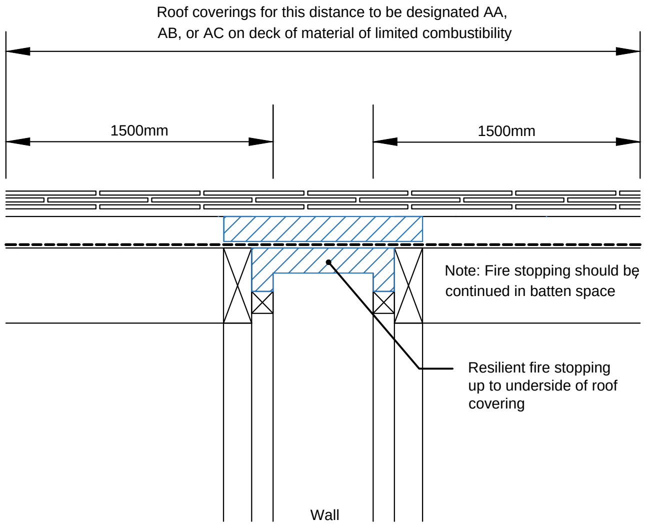
Compartmentation

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed space, it is particularly vital that fire-resistant cavity barriers are provided at the following points:

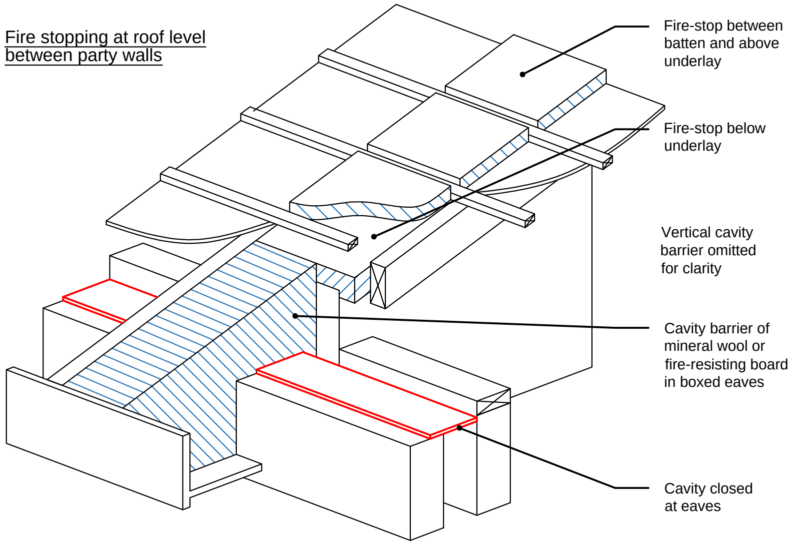
- At junctions of separating wall and external cavity wall.
- At junctions of compartment wall and compartment floor (not illustrated).
- At junctions of separating wall with roof, under roof tiles.
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire stopping, where necessary, at the wall/roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment. To reduce this risk, a roof zone 500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.

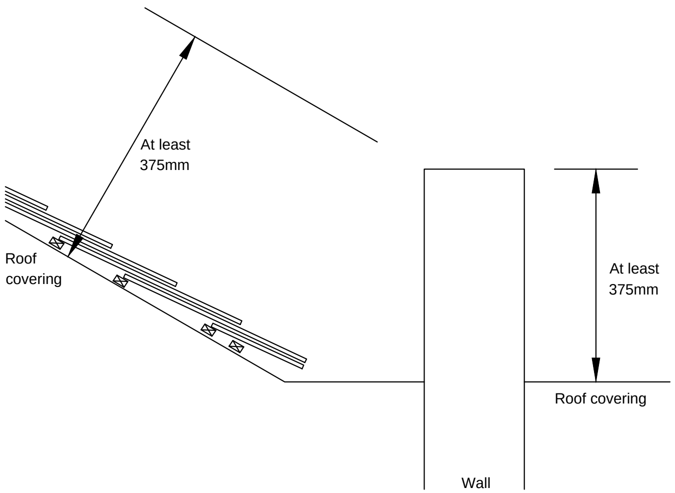


Fire stopping at roof level between party walls



Fire stopping should be provided in accordance with the relevant regional Building Regulations.

- Party/separating walls 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.



Further additional requirements for internal fire stopping and fire protection for compartment floors, walls, and roof junctions to flats and apartments with a floor 4.5m or more above the ground

The following additional guidance applies to internal fire stopping and fire protection only to buildings with a floor 4.5m or more above the ground that contain flats or apartments.

Although building legislation is robust in applying provisions for fire protection and fire stopping, it can often be difficult to implement high standards of fire stopping in complex buildings. This can lead to significant safety risks if the building does not have the correct levels of fire protection and if holes in compartment walls are not sealed correctly. This guidance assists Developers in providing good standards of fire stopping and fire protection.

It is not the intention to enhance the requirements of the Building Regulations in this section, but more to ensure that the statutory requirements are applied correctly to the construction. It is therefore deemed that the requirements of Part B of the Building Regulations in England and Wales, or Section 2 of the Scottish Building Standards (whichever is appropriate depending on region), that apply to fire stopping, separating walls, service penetrations, minimum periods of fire resistance and concealed spaces will also meet the requirements of this guidance.

Fire stopping

Design information

Drawings showing the lines of compartmentation and the lines of fire-resisting construction should be provided to the Surveyor and the Builder. The drawings should also give the required level of fire resistance for each element. Drawings to show the position of cavity barriers should be provided, and the specification of cavity barriers included.

Materials for fire stopping and cavity barriers

All materials used to form a fire barrier must have relevant third-party certification or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products. A competent person is deemed to be a third-party approved contractor specialising in fire stopping and passive fire protection.

Fire protection in buildings

Design information

The design details must show the correct level of fire resistance for the building, in accordance with the Part B of the Building Regulations or Section 2 of the Scottish Building Standards, depending on region.

Materials for fire protection

All materials used to form a fire barrier must have relevant third-party certification, or be CE marked in accordance with the Construction Products Regulations. The materials must be installed in accordance with the manufacturer's instructions and recommendations.

Installation

The fire stopping material or cavity barriers should be installed by a person who is deemed competent to install such products.

Where intumescent paints are used to provide the required level of fire protection, certification confirming that the paint applied will achieve the correct level of fire protection is required.

Materials for flashings and weatherings

Lead is generally ideal for roofing purposes; it is easily dressed over complicated shapes using simple hand tools, and can be joined by soldering or lead burning. For most roofing purposes, Codes 3, 4 and 5 will be adequate, but for extreme conditions of exposure, thicker codes may be necessary.

Lead sheet used for roofs, flashings and weathering's should, in terms of suitability to meet the Warranty requirements, be in accordance with BS EN 12588 or hold a valid UKAS (or European equivalent) third-party accreditation (e.g. British Board of Agrément, BRE, etc.) that demonstrates adequacy and durability for use.

Flashings and weathering's

The following is a brief summary of metal flashing details.

A coat of patination oil should be applied to lead flashings after fixing. Lead can be used in contact with other metals, such as copper and stainless steel, without risk of bimetallic corrosion, but should not be used with aluminium in a marine or coastal environment.

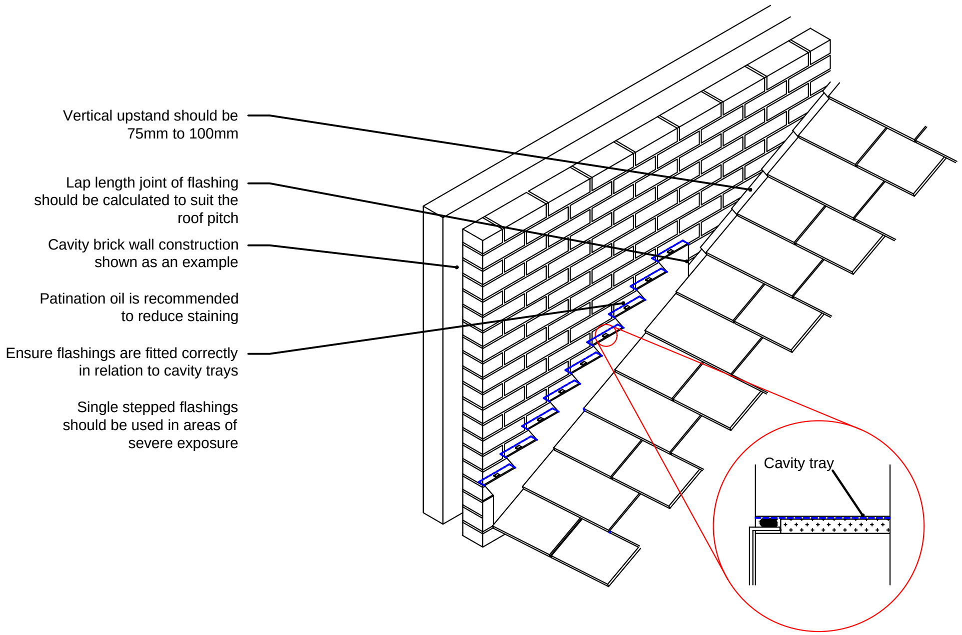
Side abutments

There are three common ways of weathering a side abutment with slate; stepped cover flashings, secret gutters and a combination of stepped cover flashing above secret gutter.

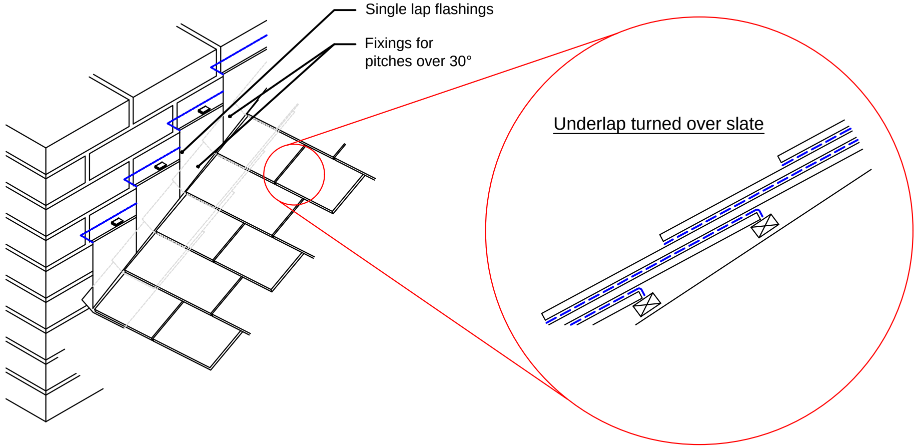
Fibre cement and natural slates

Side abutment (step and cover flashing with soakers)

- Continue the underlay across the roof and turn up the wall by a minimum of 50mm. Cut the battens 10mm-25mm short of the wall, and fix securely.
- Finish the slating with alternate courses of slates and slate-and-a-half slates, cut as necessary to maintain the bond.
- Code 3 lead soakers, with a minimum width of 175mm and length equal to gauge + lap +20mm, are to be interleaved with the slates and turned 75mm up the wall.
- The Code 4 stepped lead flashing should be secured in the brickwork bed joints with lead wedges and dressed neatly over the soakers.

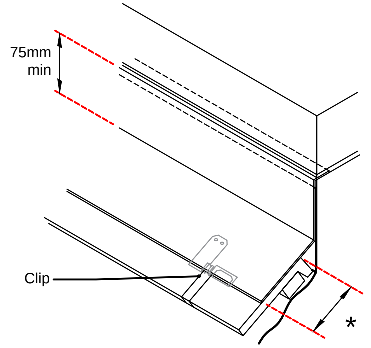


Single step and cover flashing for areas of severe and very severe exposure



Top edge abutment

- Turn roofing underlay a minimum of 50mm up at the abutment.
- Fix the top tiling batten as close as possible to the abutment.
- Complete tiling in the usual way.
- Chase abutment and insert lengths of code 4 lead, no more than 1.5m long; wedge in with small pieces of lead or stainless steel lead flashing clips, no less than 450mm apart.
- Lead should be wide enough to give at least 150mm cover to top course of tiles, below 30°. Increase cover to. 290mm at 15 degrees rafter pitch.
- Vertical upstand should be 75mm to 100mm.
- Lap each length of lead by no less than 100mm.
- Dress lead to the profile of the tiles.
- Secure lead flashings with copper or stainless steel clips, with frequency dependent on exposure.



* The lap should be measured from the lowest fixing of underlying material and be no less than 150mm or the table below, whichever is the greater

Minimum lap of the flashing with the roof covering

Pitch of roof	Cover of lead flashing on roof (mm)
30°	150mm
20°	220mm
15°	290mm

Note:
1. For pitches over 30°, a minimum lap of 150mm should be provided
2. In areas of severe/very severe exposure the vertical upstand should increase to 100mm

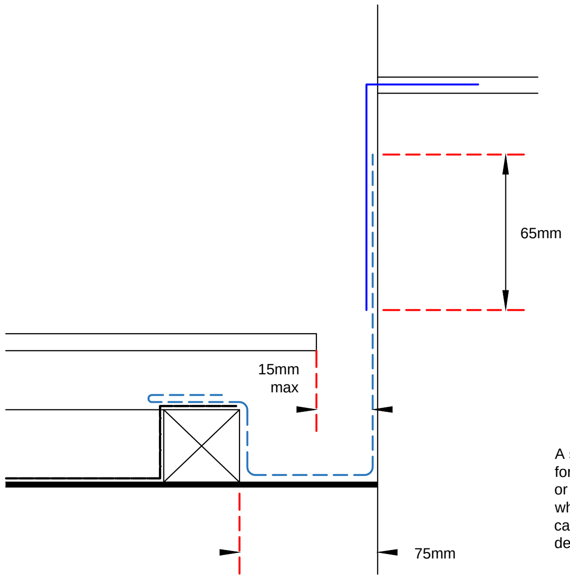
Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited)

Side abutment secret gutter arrangement

A secret gutter may be formed as an alternative to a step and cover flashing when using slates, profiled tiles are not suitable for use in conjunction with a secret gutter.

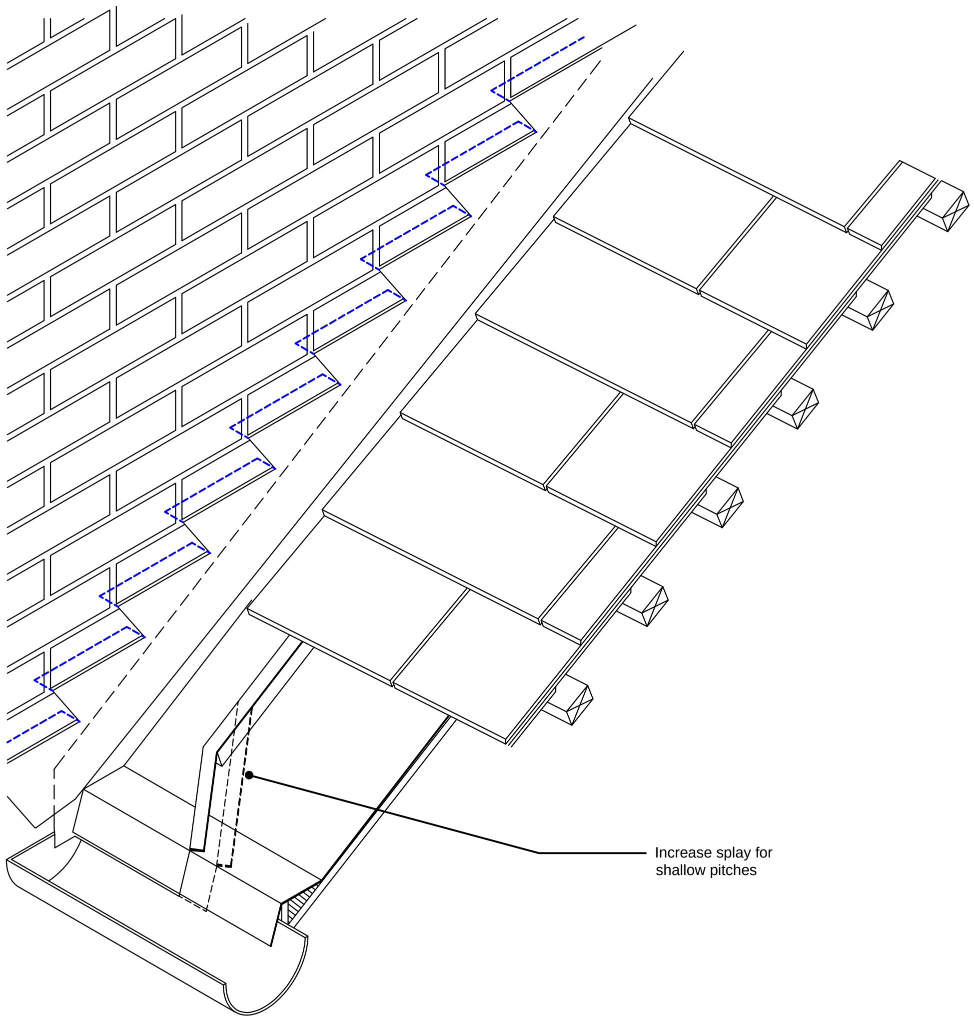
- Form secret gutters before starting tiling.
- Fix a support between the last rafter and the abutment; this should be a minimum of 75mm wide and run the full length of the abutment.
- Fix a splayed timber fillet at the discharge point to raise lead lining to the right height; avoid backward falls.
- Fix a counter batten along the outer edge of rafter.
- Line gutter with Code 4 or 5 lead, in lengths of no more than 1.5m.
- Lap each strip offered over the lower one by a minimum of 150mm, and fix with copper nails at head.
- Turn up lead welts to provide a weather check and exclude birds and vermin from entering tile batten space.
- Gutter should be a minimum of 25mm deep and have a vertical upstand of no less than 65mm above the top surface of the slates.
- Fit a stepped flashing, chased into brickwork as before and dressed over vertical upstand.
- Turn roofing the underlay up the side of the counter battens and butt the tiling battens up to the counter batten.
- Lay tiles to leave a gap of 15mm by the side of the abutment.
- All free edges of flashings should be clipped to suit the exposure. Lead clips are only for use in very sheltered locations whereas all other clips should be of copper or stainless steel.

Typical detail for normal exposure (section)



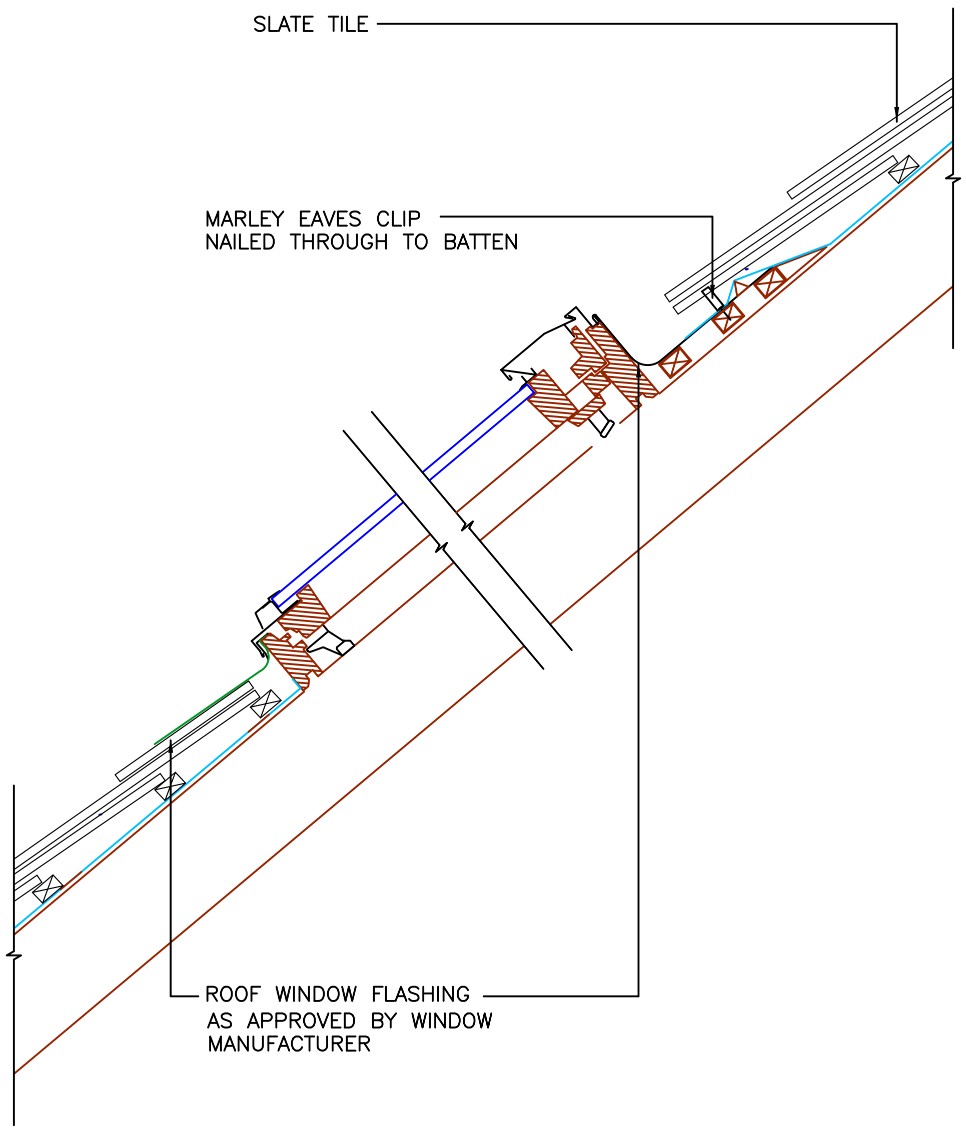
A secret gutter is not recommended for shallow pitches, areas of severe or very severe exposure, or areas where surrounding vegetation may cause risk of blockage e.g. deciduous trees

Secret gutter construction



Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited)

Section through roof light (shown with Marley/Eternit roof light)



Roof lights

Most roof lights are of the 'factory manufactured' variety which should have appropriate third party approval. Most of these come with 'flashing kits' which should be installed in accordance with the manufacturers instructions. If a flashing kit is not provided, the flashing should be installed following the Lead Sheet Association good practice guide.

Box/Back gutters

Back gutters may be lead welded off-site and positioned when tiling is undertaken. A gutter should be formed where the bottom edge of tiling meets an abutment. Form the gutter before tiling, but after felting and battening is complete.

- Fix a lay board to support lead lining, with a tilting fillet, close to the abutment to flatten the pitch of the lead.
- Dress a sheet of Code 5 lead (width of abutment plus 450mm) into position with a vertical upstand of at least 100mm up the abutment.
- Dress the extra width of lead around the corner of the abutment after any side abutment weathering has been fitted.
- Dress the upper edge of lead over the tilting fillet and turn it back to form a welt.
- Chase abutment, insert a cover flashing of Code 4 lead and dress it over the vertical upstand of the gutter.

Roof protrusions

The flashings against chimney stacks, skylights and other similar projections through the roof surface should be similar to that described for abutments where appropriate.

- Make perforations for pipes, chimney stays, supports for ladders etc. weather tight by dressing over and under tiling with a lead or copper slate to which a sleeve is burned or soldered.
- Boss sleeve around pipe or stay, and seal at top with a collar.

Saddles

The following details can apply to any type of valley or hip /ridge intersection:

- Use Code 4 lead no less than 450mm square and large enough to give a lap of at least 150mm over the gutter lining on each side.
- Saddles should be capable of being readily dressed down when in position.

Clips

Clips for flashings are important in all roofing applications and where used should be fixed at 300mm-500mm centres, depending on the exposure of the building.

Clips may be formed from the following materials:

- Lead: Only suitable for sheltered locations with a thickness the same as that of the flashing it is fixing.
- Copper: Should be a minimum of 0.6mm thick, and may be thicker for very exposed locations.
- Stainless steel: Should be 22swg or 28swg thick, and is used for very exposed locations or where the fixing point is more than 75mm from the free edge of the flashing.
- Nails and screws: Copper wire nails (with jagged shanks) should be a minimum 25mm long x 10 gauge. Stainless steel annular ring shank wire nails should be a minimum 25mm long x 12 gauge. Screws should be brass or stainless steel, minimum 25mm long x 10 gauge.

11.

Roofs

11.6

Flat Roofs

Definitions

For the purposes of this Technical Guidance, the following definitions shall apply:

Condensation: process whereby water is deposited from air containing water vapour when its temperature drops to or below dew point.

Filter layer: construction material (usually a geotextile) that substantially reduces the transfer of mineral and organic material to the insulation in an inverted warm deck roof.

Flat roof: a roof having a pitch no greater than 10º to the horizontal.

Insulation cricket: wedge of shallow-fall insulation material, designed to divert the flow of rainwater on a roof.

Interstitial condensation: condensation occurring within or between the layers of the building envelope.

Protection layer: construction material (usually a geotextile all rigid board) that isolates another construction material from mechanical damage.

Separation layer: construction material (usually a geotextile) that separates two construction materials that are not chemically compatible.

Structural deck: continuous layer of the construction (comprising concrete, profiled metal or timber panel) supported by the building structure and which supports the roof system.

Thermal bridge: part of a roof of lower thermal resistance than its surrounding elements, which may result in localised cold surfaces on which condensation, mould growth or staining may occur.

Air vapour control layer (AVCL): construction material (usually a membrane) that substantially reduces the movement of water vapour through the roof system.

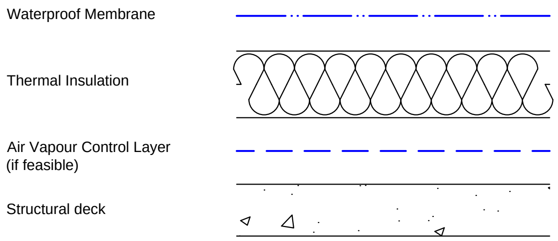
Water control membrane (WCM): construction material (usually a sheet membrane) that substantially reduces the transfer of rain water to the insulation in an inverted warm deck roof.

Warm deck roof

The principal thermal insulation is placed immediately below the roof covering, resulting in the structural deck and support being at a temperature close to that of the interior of the building.

The design should ensure that:

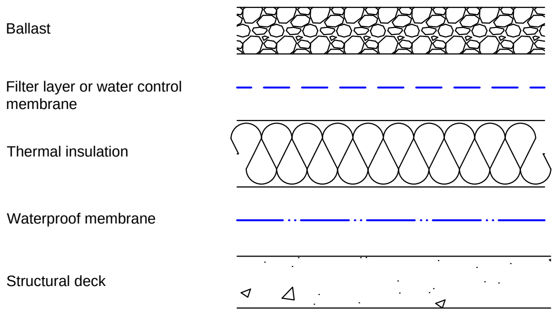
- The waterproof membrane has sufficient resistance to temperature to suit the conditions created by a substrate of insulation.
- The insulation has sufficient mechanical characteristics to resist loading.
- The AVCL is provided by the deck or by a membrane placed above the deck.
- The structural deck is maintained at a temperature above that which could cause condensation to occur at this level during service.



Inverted warm deck roof

A variant of the warm deck roof in which the principal thermal insulation is placed above the waterproof membrane, resulting in the waterproof membrane, structural deck and structural support being at a temperature close to that of the interior of the building. Generally, the principal insulation is secured by separate ballast (paving or stone).

A filter membrane or WCM should be provided to control mineral and organic material passing into and below the insulation joints. A WCM is recommended because it will provide improved rain water run off, which may allow for a reduced thickness of insulation and reduced loading of ballast. If a WCM is included, it is essential that the drainage design facilitates the rapid transfer of rain water across the product and to rain water outlets.



Hybrid roof

Many roofs combine the features of two or more of the roof types previously described. Examples include structural decks of high thermal resistance combined with additional insulation, and existing roofs to which thermal insulation is added. Once assessed in terms of their thermal and water vapour transmission characteristics, such roofs will generally fall into one of the categories described.

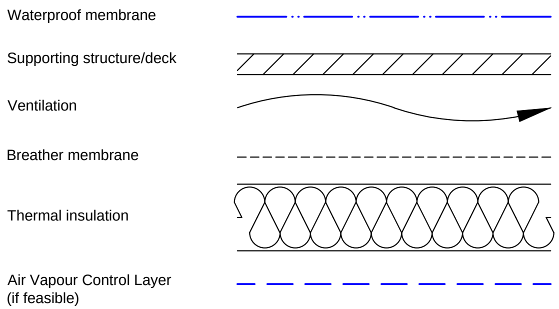
In some constructions the waterproof membrane is placed between two layers of insulation, combining the properties of warm roof and inverted warm roof construction. This form of construction is generally known as a 'duo roof '.

There is an increased risk of interstitial condensation with a hybrid roofs and therefore where these types of roof systems are used a full condensation risk analysis should be carried out.

Cold deck roof

Cold deck roofs are not recommended and an alternative form of flat roof should be adopted.

The principal thermal insulation is placed at or immediately above the ceiling i.e. below the structural deck, resulting in the waterproof membrane and structural deck being substantially colder in winter than the interior of the building. The structural support will typically form a thermal bridge between the high and low temperature zones of the construction. It is very difficult to insulate a cold roof system to current mandatory levels without introducing thermal bridges and/or increasing the risk of interstitial condensation in the system. In addition, the mandatory requirement for uninterrupted external air circulation limits the application of the system where abutting elevations or changes in building geometry occur. Mushroom intermittent vents have proved not to be effective. Therefore, it is not recommended.



Cold roof section 'under ventilation' (to/from external air. Minimum height of void 50mm)

Refurbishments involving cold deck constructions

If an existing cold deck roof is refurbished, it is important to ensure that the ventilation requirement is achieved, whether or not the level of insulation is to be increased. It is also not feasible to introduce vapour control and insulation below an existing structural deck of concrete, e.g. if during refurbishment, a cold deck roof is converted to a warm deck roof by placing insulation above the deck and closing off the ventilation. It is necessary to provide at least as much thermal resistance above the deck as was previously provided below the deck. A condensation risk calculation should always be carried out in such circumstances to ensure that the deck is above dew point during service.

Limitations of this guidance

The guidance on timber structures is limited to buildings of not more than three storeys above ground.

Loading

Roof structure and loading

The design of the roof structure must be in accordance with current regional Building Regulations.

The roof of the building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground safely, and without causing such deflection or deformation of any part of the building, or such movement of the ground, as to impair the stability of any part of another building.

The roof structure should be of such construction that it has adequate interconnection with the walls, allowing it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

If joists are spanning intermediate beams it is important that the joists are fixed to these beams and it is important that this is carried out in accordance with the Structural Engineers specification.

Fixings for balustrades must be carefully designed to ensure appropriate fixings are robust and any penetration through waterproof roof coverings are sealed correctly in accordance with the waterproof covering manufacturer's recommendations. Such fixings should not be made through to a wood substrate but to the masonry structure e.g. timber plates or packing pieces must not be used under the waterproof membrane to secure the balustrade too.

For advice on 'sizing of certain timber members in floors and roofs for dwellings', the Designer should refer to the following sources:

- Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings. Published by BM TRADA. Note: Reference should be made to the version of the BM TRADA document current at the time of construction of the roof.
- BS 8103-3, Structure design of low rise buildings, Code of Practice for timber floors and roofs for dwellings.
- BS EN 1995-1: Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

It is important that the deck have adequate provision to resist wind uplift, and that the deck is adequately anchored to the main structure.

Resistance to wind load

In all situations, including ballasted, green and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.

Allowances for wind loading

The need for a roof to withstand wind pressure and suction will be met if the proposed roof is braced effectively and secured to the structure, as detailed below, with walls adequately restrained.

The securing of roofs to the supporting structure normally involves a timber wall plate or similar, which should be levelled using a spirit level so that loadings from the roof are directed perpendicularly down the supporting wall.

The roof structure should be fixed in accordance with the design to resist the site specific wind loads.

As a minimum, when roof timbers are being installed, the wall plate should be fixed to ensure correct positioning by means of galvanised mild steel holding down straps (30mm x 5mm x 1000mm long at maximum 2m centres) nailed to the wall plate and securely fixed to the inner surface of the wall with compatible fixings.

Resistance to imposed loads

At the earliest possible stage, the employer should define the range of potential functions of the roof with regards loading with equipment, e.g. air handling, renewable energy capture and the intensity and frequency of foot traffic. This should inform the selection of the deck, insulation, safety guarding and protection.

Structural timber

All structural timber used should be stress graded. All such timber must be stamped as either 'DRY' or 'KD' (Kiln Dry). The use of ungraded or 'green' timber is not acceptable.

Treatment of timber

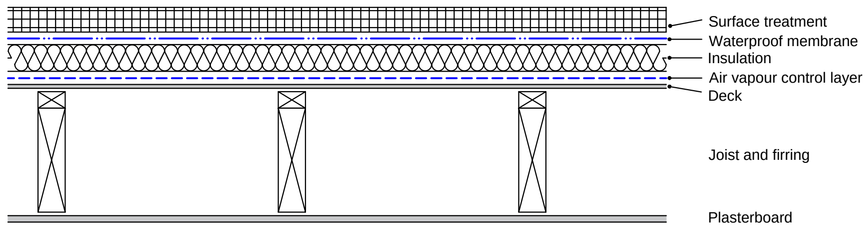
Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice further information can be found in 'Appendix C - Materials, Products, and Building Systems'.

Insulation of warm decks

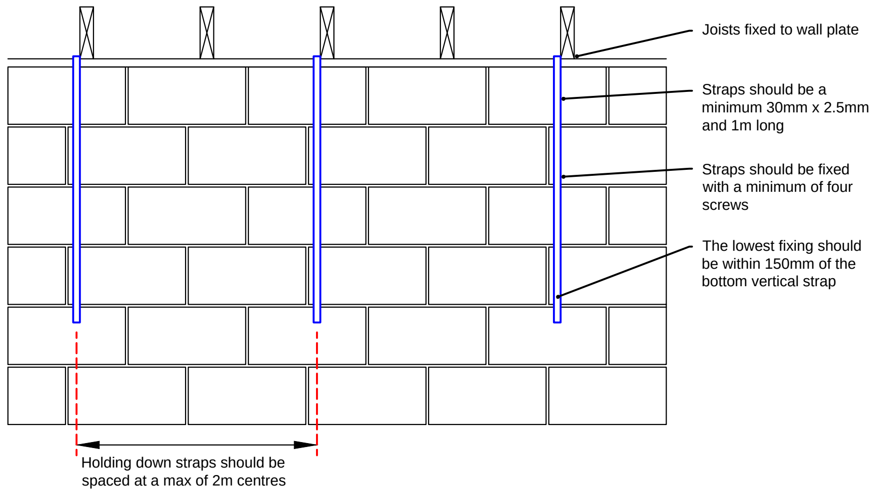
The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Compressible materials cannot support imposed loads and their use in flat roofs is limited to cold flat roofs - which are not recommended for Warranty projects. Warm roofs require the use of rigid insulation, and should be suitably specified to support the any anticipated loads from trafficking across the roof. Insulation in an inverted roof should also have high resistance to water absorption, freeze/thaw cycling and be shielded from UV light.

Typical warm deck construction

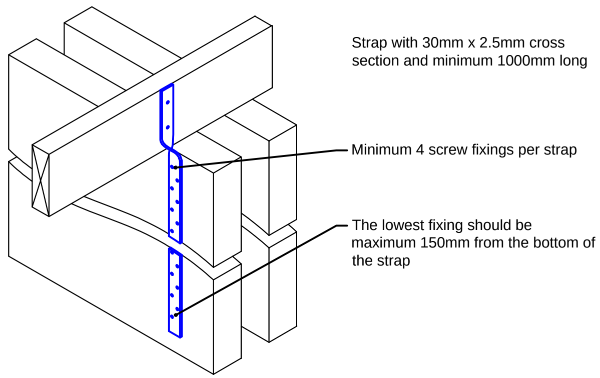
Falls can be created by firrings or tapered insulation.



Holding down straps



Alternative strap detail



Structural deck

General

At the earliest practical stage, the likely deflection of the deck should be confirmed, to ensure a minimum 1:80 as built fall is maintained. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

The firrings should be fixed prevent wind uplift. Firrings should be fixed in accordance with the following:

- Where the firrings run at 90 degrees to the flat roof joists, the firrings (min. 50mm deep) are deeper in section as they must span between the joists, therefore due to their size they may be too deep to ensure a nail has adequate purchase. Therefore all firring pieces should be held in place by proprietary frame anchors, secured to the joists/firring pieces, positioned at each intersection of a firring with a joist with each frame anchor being fully nailed up.
- Where firrings sit directly on top of the joists, these should be secured at 300mm centres, by 3.1mm x 90mm ring shank nails, with a minimum purchase of 40mm. Where firrings become too deep and the minimum purchase cannot be achieved, skew nailing should be adopted using two 3.1mm x 90mm ring shank nails at 300mm centres.

Timber deck

Roofing grade OSB should be manufactured to BS EN 300 grade OSB/3 and be certificated by the British Board of Agrément. The minimum recommended thickness is 18mm.

Plywood should be minimum 18mm thickness and certificated to conform to BS EN 1995-1-1 Eurocode 5. Design of timber structures, and to BS EN 636 Plywood, specifications minimum service class 2 - humid conditions, or, where required, service class 3 - exterior conditions.

Pretreated timber planking, tongue and groove (close boarded timber) should have a minimum thickness of 19mm. Suitable floor boards and decking include:

- Pretreated tongue and grooved softwood boarding should have a minimum moisture content at the time of fixing of between 16%-20% and in accordance with BS 8103.
- For boards of no more than 175 mm basic width, two nails should be used at each intersection.
- For wider boards, a minimum of three nails should be used at each intersection.

Fixing of timber decks

Fixing nails should be at centres not exceeding 150 mm along any end or edge, and not exceeding 300 mm along any intermediate support.

Plywood

Fixing Plywood should be laid with the face grain perpendicular to the supports.

All end joints should occur over joists of at least 38 mm basic thickness or be supported by noggings. Fixing nails should be either:

- Plain wire nails at least 3.35 mm in diameter and at least 65 mm long, which penetrate at least 40 mm into the support; or
- Annular-ringed shank nails at least 3.35 mm in diameter and at least 50 mm long, which penetrate at least 32 mm into the support.

OSB

All boards should be fastened firmly to the supporting timber. Flat headed annular-ringed shank nails and screws have superior holding power and should be used in preference to plain shank nails.

All fixings should be a minimum of 50 mm or 2 times the thickness of the board, whichever is greater; and the diameter of the fixing should be a minimum of 0.16 times the thickness of the board.

Fastenings should be at least 8 mm from the edge of the board. Nail heads should be punched 2 mm to 3 mm below the surface of the board and screws should be pre-drilled and countersunk. In service class 2 fixings should be corrosion resistant. Corrosion resistant materials include galvanized or sheradized steel, austenitic stainless steel, phosphor bronze and silicon bronze.

Composite panels (deck/vapour control/insulation)

The suitability of composite panels in providing a combined deck, AVCL and thermal insulation in a single component should be assessed with reference to the loading and hygrothermal conditions in the application. There is no relevant hEN or British Standard. Products suitable for roofing should have current certification by one of the following:

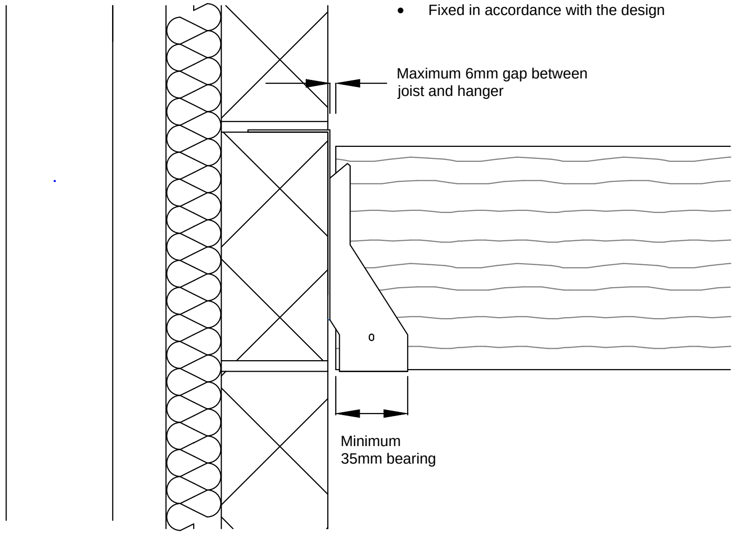
- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

Note: MgO boards and cement particle boards are not suitable as a supporting deck. It may be used to clad an abutment or parapet but is not suitable for use with mechanically fastened single ply membranes.

Joist hanger bearing

Joist hangers should be:

- In accordance with BS EN 845
- The correct size for the timber joist or trimmer
- Fixed in accordance with the design



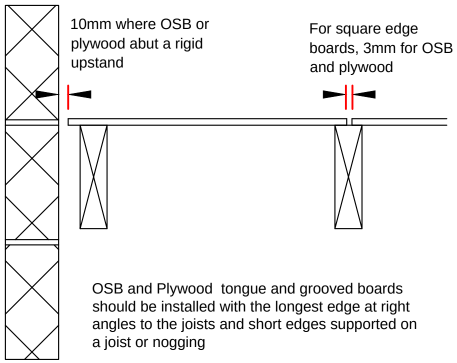
Allowance for expansion at ridged abutments

OSB should be installed at the direction indicated on the boards with the strongest direction perpendicular to the joists

A maximum movement gap of 3mm should be provided for square edge boards

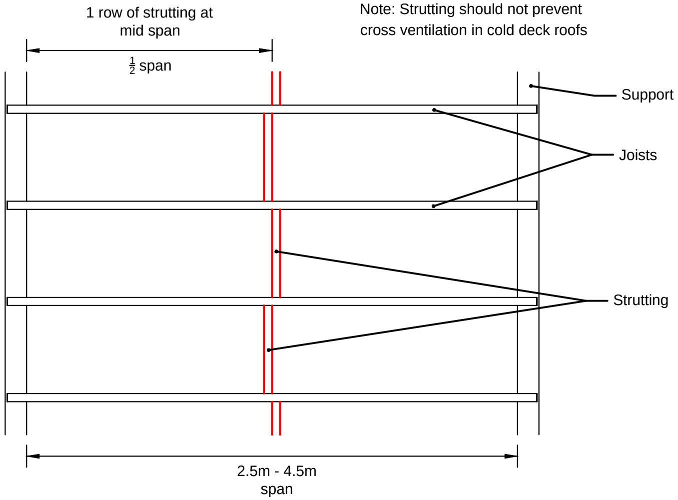
A minimum of 10mm movement gap should be provided at the perimeter where the walls abut a ridged upstand

Boards should be supported by noggins at the perimeter where they run at right angles to roof joists



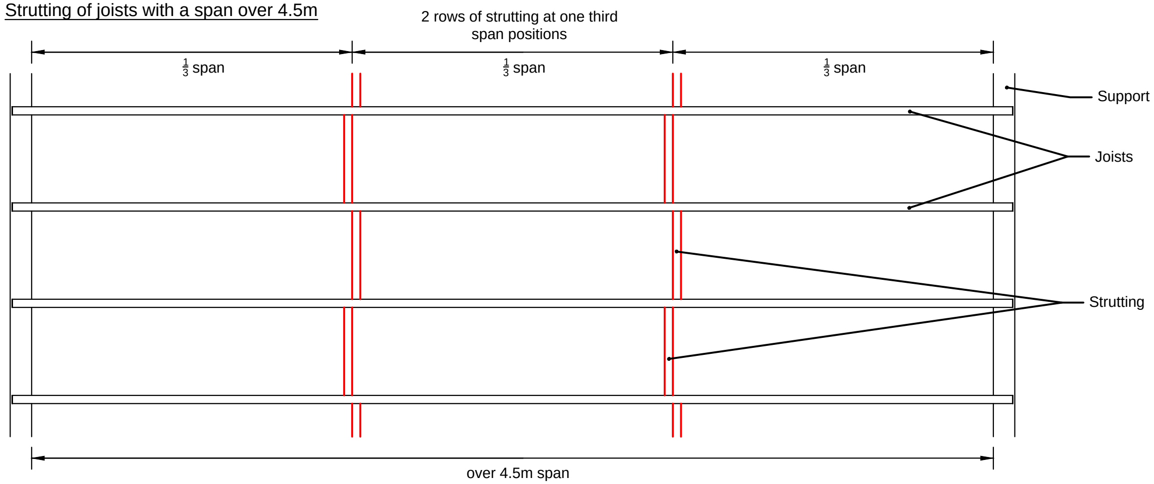
OSB and Plywood tongue and grooved boards should be installed with the longest edge at right angles to the joists and short edges supported on a joist or nogging

Strutting of joists with a span between 2.5m and 4.5m



Where the span of a roof joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with Figure 3 of BS 8103-3: 2009 or by a proprietary system

Strutting of joists with a span over 4.5m



Where the span of a flat roof joist is more than 4.5m, two rows of strutting at 1/3rd the span position will be necessary.

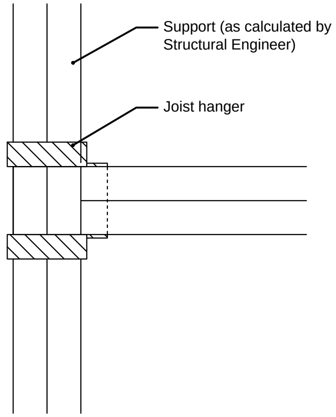
Strutting or bridging of solid timber roofs

Where the span of a flat roof joist is more than 2.5m, strutting is necessary. This should be provided either by timber bridging or strutting in accordance with Figure 3 of BS 8103-3: 2009 or by a proprietary system.

Timber strutting can be in the form of solid bridging of at least 38mm basic thickness and with a depth equal to at least three-quarters of the depth of the joists; or it can consist of herringbone strutting with members of at least 38mm by 38mm basic size. Herringbone strutting should not be used where the distance between the joists is more than approximately three times the depth of the joists.

Strutting should not prevent cross ventilation in cold deck roofs.

Typical trimming detail (plan)

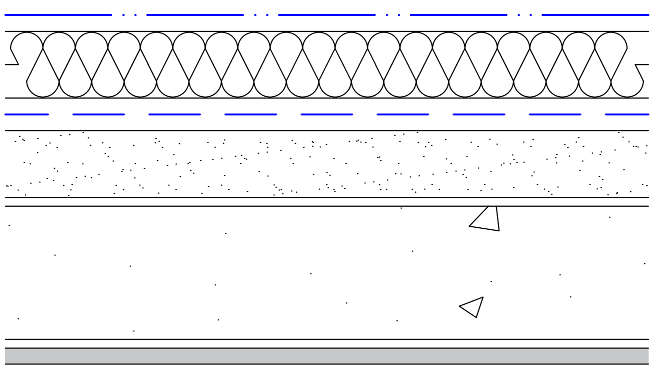


Double joists should be bolted together at 600mm centres using minimum 10mm diameter bolts with large washers that will prevent the bolt head and nut from penetrating the joist. It is recommended that the bolting of double joists is along the centre line of joists. Suitably sized trimmer joists shall be provided around floor openings

Trimmed openings may be needed around staircase openings and chimneys. Solid trimmed joists may be supported using either joist hangers or a structurally designed connection; timber trimmers around openings should consist of at least two members and be designed by a Structural Engineer

Typical deck construction (warm roof)

Note: Permanent waterproofing should not be installed until the deck has fully dried.



For in situ concrete decks it is important that:

- The form work is adequately and accurately constructed.
- The mix should be one that has relatively low shrinkage characteristics.
- The slab should be adequately protected until cured.

Pre cast concrete decks should:

- Have a minimum of 90mm bearing unless justified by the design.
- Be grouted in accordance with the design, and
- Allowance for movement should be provided at abutments.

Loading

Statutory requirement

The design for loading should comply with the current Building Regulations.

Resistance to wind load

In all situations, including ballasted and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.

It is important that the deck have adequate provisions to resist wind uplift by either being of sufficient self weight or adequately anchored to the main structure.

Resistance to imposed loads

At the earliest possible stage, the designer should define the range of potential functions of the roof with regards loading with equipment e.g. air handling, renewable energy capture and the intensity and frequency of foot traffic. This should inform the selection of the deck, insulation, safety guarding and protection.

Structural deck

General

At the earliest practical stage, the likely deflection in the deck, and the tolerance in the level of its finish, should be confirmed, because this informs the design for drainage. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

Concrete

Precast concrete construction should be designed in accordance with BS 8110. Information on span capability and the installation requirements of precast panels can be obtained from manufacturers. Information on the location of required movement joints should be obtained early in the design process as they have implications for drainage layout and detailing. Precast panels installed to a fall can provide a simple layout but without cross falls.

In-situ concrete construction should be designed in accordance with BS 8110.Concrete decks should be laid to falls wherever possible, concrete maybe more difficult to lay to a fall, and it is common to create falls in the insulation (warm roofs only) or by using an additional screed. Information on compressive strength, resistance to point load and drying periods of wet screeds can be obtained from suppliers and relevant trade associations.

Where structural movement joints are required in large concrete decks, a clearly defined movement joint detail should be constructed to a design and with the materials that afford durability equivalent to that of the roof system.

In precast panel decks the locations of any anticipated differential movement (e.g. at perimeter or abutment interfaces or between adjacent panels that are subject to differential loading) must be identified in order that stress is not transferred to the waterproof membrane.

Screeds

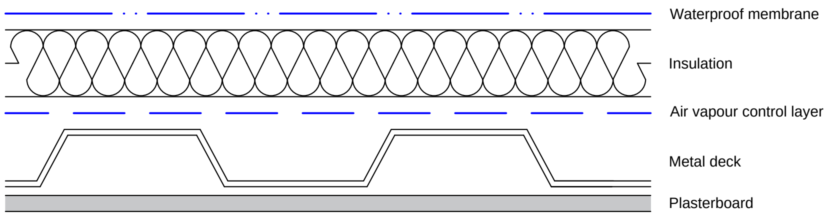
Screeds should be suitably specified for the anticipated loadings, further information can be found in 'Appendix C - Materials, Products, and Building Systems'. Moisture from the construction can become trapped in a roof if the waterproof layer is applied before a concrete slab or screed has had sufficient time to dry out. In situ concrete slabs and cementitious screeds contain large volumes of water which, if not allowed to dry out, can prevent adhesion of the waterproof layer. If bonding to the slab, it is advised that an adhesion test be carried out.

Insulation of warm decks

The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Warm roofs require the use of rigid insulation, and should be suitably specified to support the any anticipated loads from trafficking across the roof. Insulation in an inverted roof should also have high resistance to water absorption, freeze/thaw cycling and be shielded from UV light.

Typical deck construction (warm roof)

Falls can be created by firrings or tapered insulation



Loading

Statutory requirement
The design for loading should comply with the current Building Regulations.

Resistance to wind load
In all situations, including ballasted and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.

Resistance to imposed loads
At the earliest possible stage, the designer should define the range of potential functions of the roof with regards loading with equipment e.g. air handling, renewable energy capture and the intensity and frequency of foot traffic. This should inform the selection of the deck, insulation, safety guarding and protection.

Insulation of warm decks

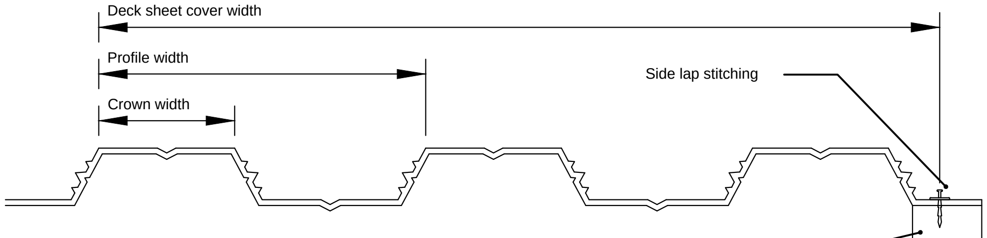
The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Warm roofs require the use of rigid insulation, and should be suitably specified to support the any anticipated loads from trafficking across the roof. Insulation in an inverted roof should also have high resistance to water absorption, freeze/thaw cycling and be shielded from UV light.

Structural deck

General
At the earliest practical stage, the likely deflection in the deck, and the tolerance in the level of its finish, should be confirmed, because this informs the design for drainage. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

Profiled metal (steel or aluminium)
Profiled metal decks should have a crown width at least 50% of the profile width. To provide a sound base for the insulation and waterproofing system, and to avoid reduced drainage performance, the mid-span deflection of the metal deck should not exceed 1/200 of the span under uniformly distributed design loads. When considering the deck profile and the necessity for side lap stitching and metal deck closures, reference should be made to the manufacturers of the deck, insulation and waterproof membrane.

Profiled metal decks: critical dimensions



The metal roof structure should be side stitched to ensure it performs as a continuous plane layer (unless the manufacturer state otherwise).

Profiled metal decks should conform to the following standards:

- Galvanised steel: minimum recommended thickness 0.7mm to BS EN 10346 Fe E280G Z275. Typical gauge range 0.7mm-1.2mm.
- Plain aluminium: minimum recommended thickness 0.9mm to BS EN 485-2 AA3004 H34. Reference should also be made to BS EN 1396 as appropriate.

It is important that the deck have adequate provisions to resist wind uplift by being adequately anchored to the main structure.

Thermal performance

Design for thermal performance must comply with current regional Building Regulations, as appropriate.

Thermal insulation

The thermal insulation should be selected with regard to the following minimum criteria:

- Thermal resistance (and therefore thickness) to suit minimum clearances at details.
- Resistance to compression.
- Compatibility with the AVCL and waterproof membrane.
- Compatibility with adhesives (if insulation is adhered).
- Contribution to the external fire performance of the system.
- Acoustic properties: resistance to external sound is not currently regulated. However, there may be a need to consider attenuation from balconies (See the 'Balconies and Terraces' section for further information).

Note: The alternative of a separate acoustic attenuation layer should be considered where appropriate.

Thermal transmittance

Design for thermal transmittance should take account of the effect of thermal bridging within the roof field and at interfaces between the roof system and adjoining elements, such as parapet walls or abutments.

In particular, allowance should be made for the effect of:

- Thermal bridging by metal fasteners used to secure insulation and/or membrane. Thermal break telescopic tube fasteners are recommended to avoid this.
- Thermal bridging due to drainage of rain water or snow-melt through insulation in inverted roofs. The use of WCMs beneath ballast to reduce thermal bridging is recommended.
- The locations of above average thermal transmittance at sumps, gutters or areas of minimum thickness of tapered insulation.

Manufacturers of thermal insulation and WCMs provide certification and calculations of the effects of thermal bridging by fasteners and drainage respectively. Further advice is available in Building Research Establishment BR 262 Thermal insulation: avoiding risks.

Air permeability

Relevant contract drawings should define the position of the component - the air barrier - that determines resistance to air permeability. This may be achieved by an additional, purpose designed membrane or by an additional function of another component, such as the deck or waterproof membrane.

Control of condensation

Any provision required to control interstitial condensation within the roof should be determined to the calculation method defined by BS 5250, but with ambient conditions set in BS 6229. The calculated maximum accumulation of moisture within thermal insulation should not exceed 350g/m2 and there shall be no net accumulation in any annual cycle.

Minimum recommended resistance to compression of thermal insulation

Roof system type	Insulation type(1, 2)	Insulation code	Minimum compression resistance(3) (KPa)
Warm deck roof	Polyisocyanurate foam	PIR	150
	Expanded polystyrene	EPS	150
	Extruded polystyrene	XPS	200
	Mineral wool	MW	75
	Cellular glass	CG	N/A
Inverted warm deck roof	As per certification	XPS	200

Notes:
(1) As defined in the appropriate European Product Specification
(2) Results for composite products should meet or exceed the minimum for each component when tested separately
(3) Results should be expressed at CS (10), i.e. at 10% compression when tested to BS EN 826

Installation of thermal insulation

The attachment of the thermal insulation should be designed to resist calculated wind load by a declared margin of safety. This includes consideration of dead loads required in all roof zones in ballasted warm roofs and inverted warm roofs.

Except in tapered insulation schemes, thermal insulation should always be laid in a broken bond pattern. Where two or more layers are laid, the joints in each layer should be offset. On substrates of profiled metal, the short dimension should be parallel to the deck crowns and supported across half the crown width.

Insulation should be lightly butted so as to avoid thermal bridging caused by gaps. If large gaps are created by damaged or undersized boards, any infill sections should be attached in accordance with the manufacturer's instructions.

Air vapour control layer (AVCL)

The AVCL should be selected with regard to the following minimum criteria:

- Ease with which it can be sealed at laps and at abutments to other elements.
- The method of attachment.
- Condensation risk, expressed as calculated vapour pressure based on notional conditions pertaining to the project building.
- Compatibility with the waterproof membrane and thermal insulation.

The following is a minimum recommended specification. The actual specification will depend on the level of vapour resistance required, based on calculation, and the type of deck.

The attachment of the AVCL should be designed to resist calculated wind load by a declared margin of safety. All laps should be sealed and the AVCL should be sealed to the adjoining element, which forms the continuation of the resistance to air permeability. The AVCL should be extended behind all thermal insulation, including insulation placed on vertical surfaces such as parapet walls. Where the roof system is penetrated by a detail such as a pipe or duct, a suitable method for providing continuous vapour control should be provided, and this method should be followed in practice.

Where a reinforced bitumen membrane AVCL is used, its installation should be in accordance with BS 8217.

Minimum recommended specification for AVCL for warm deck roofs

Roof system type	Deck type	AVCL	Attachment
Reinforced bitumen(1) membrane	Profiled metal	S2P3(2)	Partial bond by 3G or approved proprietary alternative
	Concrete	S2P3	Fully bonded
	Timber panel	S2P3	Partial bond by 3G or approved proprietary alternative
High density polyethylene	All	200μ	Loose laid beneath mechanically fixed insulation
High density polyethylene and metal foil laminate	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions
Coated metal foil laminate - self-adhesive	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions

Notes:
(1) Reinforced bitumen membranes: minimum recommended specification based on classification in BS 8747.
(2) S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic); the higher the rating, the higher the performance.

Falls and drainage

Statutory requirement
Design for drainage of the flat roof covering should comply with the current Regional Building Regulations.

British and industry standards
BS 6229 states that a minimum finished fall at any point of 1:80 (1.25%) should be achieved. Since adjoining roof planes at 1:80 will meet at a mitre of less than 1:80, the intended finished fall at such intersections should be considered at an early stage.

Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculations, this may necessitate design falls of twice the minimum finished falls (1:40 or 2.5%).

Cut-to-falls systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall. However the use of these systems does not remove the need to check that deck deflection and tolerance is overcome and that a resulting fall in the waterproof membrane of a minimum of 1:80 is achieved. Allowance for deflection is particularly important in designing inverted roofs where calculation of dead loading should be based upon the ballast type and depth to be used.

The manufacturers of certain waterproofing products have certification for their use in 'completely flat' or 'zero falls' applications. However, for the purposes of this standard, the design conditions of BS 6229 shall be assumed to prevail in all warm, inverted, and cold deck roof systems, and a designed fall will be required including allowance for deflection of the deck from all anticipated loads.

Consideration should also be given to:

- The available upstand height at the high end of the falls. This may be a limiting factor on the length/size of the roof area to be drained. If necessary additional rainwater outlets should be provided.
- Avoidance of ponding behind wide obstructions to the drained slope such as plant plinths or roof lights. Additional rainwater outlets and/or insulation crickets should be provided.
- Avoidance of gutters by designing with intersecting roof planes.
- Falls between rain water outlets along a perimeter.

Since the primary function of the roof is to exclude water, it is important to consider how best to direct this into the drainage system.

Ponding on membrane roofs must be avoided because:

- It encourages the deposit of dirt and leaves, which can be unsightly, may obstruct outlets and/or become a slip hazard.
- In the event of damage, the interior will suffer increased water ingress.
- The load may cause progressive deflection of the deck.
- Ice or algae may create a slip or wind hazard, particularly on walkways.

Independent research has shown that roofs with extensive ponding require increased maintenance input.

Waterproof coverings of all types are tested for water absorption and water tightness as part of third-party certification. However, the construction process, including the installation of components and the forming of seams, is clearly facilitated in dry, well-drained conditions.

Note: Rainwater outlets and downpipes can constitute thermal bridges which may increase the risk of localized condensation; an assessment might be required to determine whether insulated outlets are to be used.

Creation of falls

Roof falls may either be created during the construction of the deck or alternatively by using tapered insulation systems.

The creation of falls in the deck should always be attempted because it has the following advantages:

- There will be a consistent thermal environment across the roof.
- The AVCL will also be to a fall.
- If mechanical fasteners are to be used for the waterproof membrane, their length will be constant, which facilitates planning and installation.

Cementitious screeds provide a stable substrate to mitred falls with minimal tolerances, and are recommended. Screeds should be in accordance with BS 8204. Lightweight screeds should be overlaid with a 1:6 (cement to sand) screed topping of a minimum 10mm thickness.

Tapered insulation schemes, suitable for warm deck roofs only, have the following advantages:

- It is possible to create effective drainage layouts to complex plan areas.
- Mitred falls can be created easily to direct rain water to single points where outlets are to be located.

Where falls are created by tapered insulation, the design should ensure that the average U-value and maximum U-value at any point, required by SBEM or SAP calculation, is achieved.

Where the roof finish is to include paving on access routes, consideration should be given to the height difference created by the falls and spacing of rain water outlets in order that the maximum height of paving supports is not exceeded or trip hazards created.

Drainage

Drainage design should be based upon calculations in accordance with BS EN 12056 Part 3 given a design head of water (typically 30mm). Rainwater outlet capacity should be taken from properly certificated information provided by manufacturers, and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes, such as walkways.

- For flat roofs with parapets where internal drainage is provided, at least two outlets (or one outlet plus an emergency overflow) shall be provided for each roof area.
- Overflows or emergency outlets should be provided on flat roofs with parapets and in non-eaves gutters in order to reduce the risk of over spilling of rainwater into a building or structural overloading.
- Outlets should be positioned so that the direction of flow is not changed sharply (e.g. through 90° just before reaching it).

Rainwater outlets

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Capacity in litres per second at a range of typical water heads.
- Compatibility with the waterproof membrane.
- Integral insulation to avoid condensation.
- Method of attachment.
- Rainwater outlets for inverted roofs should be of the dual height type, designed to maximise removal of rainwater at WCM level.

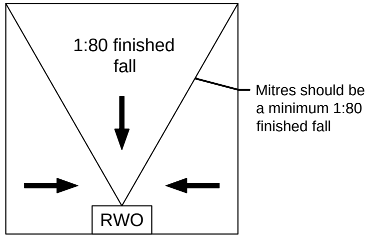
Overflows

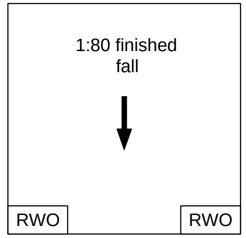
Roofs which drain to a single internal outlet or combined outlets connected into a single downpipe, should be provided with an overflow to drain and warn of outlet/downpipe blockage and so avoid the risk of flooding. The capacity of the overflow should be not less than that of the outlet or combined outlets and its discharge should be visible but directed away from the building. Over flows should be positioned as close to the outlets as possible to avoid rainwater build up on roofs.

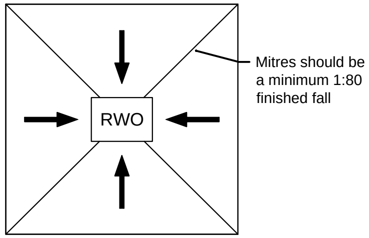
Box gutters

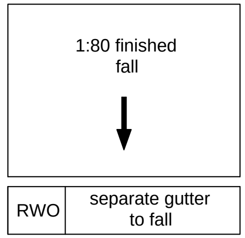
It is not generally necessary to provide separate box gutters where two planes of roofing intersect, or where a single plane falls to an abutment. In the latter case, there will be no fall between outlets, so consideration should be given to creating these in the structure or insulation. Box gutters are slow, difficult to construct and introduce unnecessary complexity. The need to maintain a fall in gutters and comply with the energy requirements of the Building Regulations may be difficult to achieve.

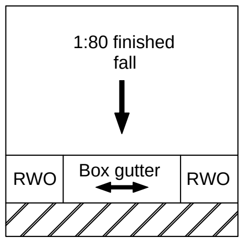
Drainage layout options











Gutters must be a minimum of 1:80 as-built fall towards the drainage outlet

Siphonic drainage

All waterproof membranes are compatible with siphonic roof drainage systems, which for larger roofs offer many advantages:

- Very high capacity, enabling fewer outlets and therefore less detailing work on-site.
- Smaller bore horizontal collector pipe work, enabling reduced roof void depth.
- Self-cleaning in many situations.

Note: Siphonic drainage is generally not appropriate for inverted roofs.

For further information see www.siphonic-roof-drainage.co.uk

These roof proposal are to be considered on a case by case basis and full design and calculations should be submitted for Warranty approval before construction begins on site.

Materials - Requirement

Compatibility of components

The selection of components within the roofing system should be discussed in detail with the membrane manufacturer or appropriate trade association to ensure chemical and mechanical compatibility between components, since the incorrect specification may lead to reduced performance or premature failure of the roofing system. The correct choice of insulation is also important when it is to be adhered to the substrate. In case of doubt, the insulation manufacturer or relevant trade association should be consulted.

General

Materials for use in flat roofing systems are suitable only if the manufacturer has declared compliance with the relevant harmonised European Assessment Document (ETA, previously a European Assessment Guideline, ETAG) and has affixed the CE Mark to the product. All waterproof membrane products shall also have a certificate of fitness for purpose issued by a member of the European Union of Agrément (UEAtc). This may comprise a British Board of Agrément certificate or an equivalent certificate of another UEAtc member.

Requirement

The waterproof membrane should be selected with regard to the following minimum criteria:

- Anticipated service life based on independent certification.
- Minimum maintenance.
- Ease of adaptation and repair.

External fire performance

All roof coverings within close proximity of buildings must achieve the fire designation required by the relevant Building Regulations.

Statutory requirement

Design for external fire performance must comply with current Building Regulations.

Certification of system

The manufacturer of the waterproof membrane must demonstrate by reference to independent test certification that the system of waterproofing and insulation (type and thickness) for a particular project meets or exceeds the minimum level of fire performance defined by the Building Regulations.

Polymeric single ply membranes

The manufacturer should declare compliance with the harmonised European Product Specification for single ply membranes, BS EN 13956, which defines requirements for testing and declaration of characteristic values.

There is no relevant British Standard. Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

Such certification should be accompanied by full instructions for installation.

There is no British Standard for the installation of single ply membranes. Installation should be in accordance with the Single Ply Roofing Association's Design Guide to Single Ply Roofing and with the specific instructions of the membrane manufacturer.

The attachment of the single ply membrane should be designed to resist calculated wind load by a declared safety factor of two times (200%). This design will normally be provided by the membrane manufacturer.

Whatever the means of attachment, specific restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action.

Perimeter restraint is achieved by several methods, depending upon the manufacturer:

- Individual fasteners, protected by a flashing.
- A linear bar, protected by a flashing.
- Welding the field sheet to a membrane-coated metal trim secured to the deck (with thermal break fasteners where appropriate).

If restraint relies upon adhesive alone, the membrane manufacturer shall provide evidence of satisfactory testing for resistance to wind load using a method defined by the Single Ply Roofing Association.

If the remainder of the roof system is to be bonded, it is essential that the design resistance to wind load is also achieved for the attachment of these components.

Irrespective of the wind uplift considerations or distribution requirements for securing the membrane, the fixing of the insulation boards should always be considered separately, unless specifically sanctioned by the membrane manufacturer. The number and distribution of mechanical fasteners required to fix the insulation boards may vary with the insulation type, geographical location of the building, topographical data and the height of the roof concerned.

The upper termination of the single ply membrane at linear details such as plinths, parapets, abutments and door openings should be secured by one of the following mechanical means:

- Clamping beneath a metal rail, e.g. a parapet capping or roof light frame.
- Welding to a membrane-metal laminate trim (itself mechanically fixed).
- Mechanical fixing using individual fasteners or a mechanically fixed termination bar.

The welding of single ply membranes is a critical process. The following should be considered:

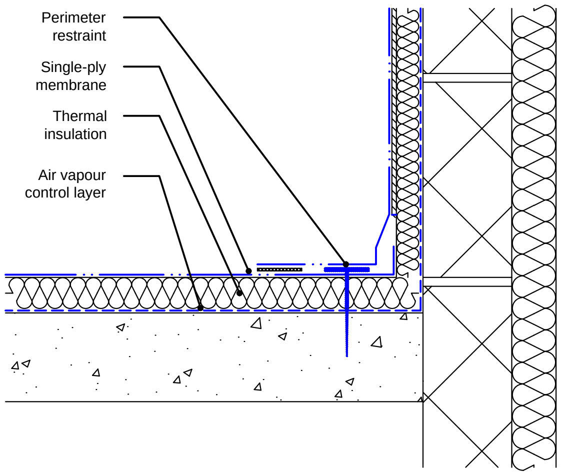
- Supply of certification for each installer indicating successful completion of the manufacturer's product specific training.
- Provision of consistent electrical power supply.
- Production and retention of test weld samples at the start of each day.
- Declared procedures for repair of weak welds or damage.

Warm roof systems with polymeric single ply membranes

Where the insulation is mechanically fixed, the number and arrangement of fasteners required to resist wind load will be prescribed by the manufacturer, applying a safety factor of two to the design load on each fastener. This arrangement may vary across the roof according to wind load, but should be followed in all areas. Thermal break fasteners shall be used wherever feasible.

Where the insulation is adhered, the adhesive should be approved by the insulation manufacturer and should be laid at the coverage rate and pattern designed to achieve calculated wind load with a safety of factor of two times (200%). The contractor should allow for temporary loading as required to achieve a suitable adhesion and to achieve the best possible level in the upper surface of the insulation.

Methods of restraint of a single-ply membrane at perimeters



Liquid applied membranes

There is no harmonised European Product Specification for liquid applied membranes for roofing. The European Technical Approval Guideline ETAG 005 Part 1 - General gives overall guidance on assessment of fitness for use, including methods of verification and attestation of conformity. The remaining seven parts, known as the Complementary Parts or the ETA Parts, deal with specific requirements for particular families of products, and are therefore generic types covered primarily by this Guidance Note, shown as follows:

- Part 2: Polymer modified bitumen emulsions and solutions.
- Part 3: Glass reinforced resilient unsaturated polyester resins.
- Part 4: Flexible unsaturated polyesters.
- Part 5: Hot applied polymer modified bitumen.
- Part 6: Polyurethanes.
- Part 7: Bitumen emulsions and solutions.
- Part 8: Water dispersible polymers.

The manufacturer of a product for use in flat roofing should declare compliance with the relevant parts of ETAG 005. In the absence of this declaration, the product should have a current certificate of fitness for purpose issued by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

Such certification should be accompanied by full instructions for installation.

Installation of Liquid Applied Membranes

There is no British Standard for the installation of liquid-applied membranes. Installation should be in accordance with the Liquid Roofing and Waterproofing Association guidance, as follows:

- Guidance Note No. 2 - Substrates for liquid applied waterproofing.
- Guidance Note No. 4 - Roof, Balcony and Walkway Refurbishment Using Liquid applied Waterproofing Systems.
- Guidance Note No. 5 - Health and Safety Provision for LAWS on Roofs, Balconies and Walkways.
- Guidance Note No. 6 - Safe Use of Liquid applied Waterproofing Systems.
- A consistent film thickness is essential for reliable and durable liquid-applied membranes.

The following should be considered:

- Supply of a card for each installer indicating successful completion of the manufacturer's product-specific training.
- The coverage rate in kg/m^2 must be declared before work starts.
- During installation assessment of wet film thickness by one of the following methods as appropriate:
  - gauge pin.
  - 'comb' type measurer.
  - visual inspection.

Mastic asphalt

There is no harmonised European Product Specification for mastic asphalt for roofing. Products used for flat roofing should comply with BS 6925: 1988 Specification for mastic asphalt for buildings and civil engineering (limestone aggregate).

Proprietary grades of polymer modified mastic asphalt are produced for roofing and paving applications. There is no British Standard or European Standard for these products.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

The separating membrane should be one of the following, and should be laid directly under the mastic asphalt:

- Sheathing felt, comprising a base of flax or jute, or other suitable fibres, impregnated with bitumen.
- Glass fibre tissue.

Bitumen-coated plain expanded metal lathing should be in accordance with BS EN 13658-2.

Stone chippings (bedded) for use as a protective topping should be washed, crushed rock, normally 10mm-14mm nominal size aggregate, bedded in a proprietary gritting solution over the mastic asphalt membrane.

Warm roof systems with mastic asphalt waterproofing

Generally, mastic asphalt on sheathing felt provides sufficient dead load to resist wind load, but this should be demonstrated by calculations in all situations.

Installation of mastic asphalt

The number of coats should be appropriate to the waterproofing requirements and traffic conditions of the roof. When laid to falls of 1:80 or more, mastic asphalt roofing is laid in two coats to a thickness of 20mm, on a separating membrane of sheathing felt, all in accordance with BS 8218.

On sloping and vertical surfaces over 10° pitch, the mastic asphalt should be laid in three coats to a thickness of 20mm without a separating membrane.

On sloping and vertical surfaces of timber or lightweight concrete, the mastic asphalt should be laid in three coats to a thickness of 20mm on expanded metal lathing over a separating membrane of sheathing felt.

Reinforced bitumen membranes

The manufacturer should declare compliance with the harmonised European Product Specification for reinforced bitumen membranes, BS EN 13707, which defines requirements for testing and declaration of characteristic values. There is no relevant British Standard.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

In addition, specifications for systems of multi-layer reinforced bitumen membranes for flat roofing should comply with BS 8747.

Minimum recommended specification for reinforced bitumen membranes

Roof system type	Deck type	Insulation type(1)	Venting layer(2)	Underlayer (3)	Cap sheet(4)
Warm deck	Profiled metal	Thermoplastic foam	3G	S2P3(5)	S4P4(5)
		Mineral fibre	-	S2P3	S4P5
	Concrete	Thermoplastic foam	-	S2P3	S4P4
		Mineral fibre	-	S2P3	S4P4
	Timber panel	Thermoplastic foam	3G	S2P3	S4P5
		Mineral fibre	-	S2P3	S4P4
Inverted warm deck	Profiled metal	Extruded Polystyrene (XPS)	3G	S2P3	S4P5
	Concrete		-	S2P3	S4P5
	Timber panel	Deck type not suitable for inverted roofs			

Notes:
(1) Insulation type: Thermoplastic foam: PIR, EPS, PF. Mineral fibre: MW
(2) Venting layer: BS 8747 3G or proprietary equivalent with suitable certification
(3) Under layer: as defined in BS 8747. SBS-modified products are recommended
(4) Cap sheet: as defined in BS 8747. SBS-modified products are recommended
(5) S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic); the higher the rating, the higher the performance

Bitumen membranes should be protected from solar radiation. This should be by integral protection provided in the product in the form of:

- Mineral granules.
- Metal foil.

The use of solar reflective paint is not permitted. The use of stone chippings is not recommended unless required to achieve enhanced external fire performance. If used, chippings should be washed, crushed rock, normally 10mm-14mm nominal size aggregate, bedded in a proprietary gritting solution.

Warm roof systems with reinforced bitumen membrane waterproofing

The limiting wind load for the different methods of attachment of insulation is prescribed by BS 8217 as follows:

- Partial bitumen bond: up to 2.4kN/m^2.
- Full bitumen bond: up to 3.6kN/m^2.

Where the method of attachment is outside the scope of BS 8217, the manufacturer should demonstrate that the method provides sufficient resistance to wind load.

Reinforced bitumen membranes installation

Installation should be in accordance with BS 8217. In case of doubt, or where the waterproof membrane is beyond the scope of the Standard, the advice of the Flat Roofing Alliance (National Federation of Roofing Contractors) should prevail.

The safe use of gas torches, and the positioning, monitoring and transferring hot bitumen to the work face, should be adopted, all in accordance with the Health and Safety Executive/Flat Roofing Alliance Code of Practice for Safe Handling of Bitumen.

The practice of applying reinforced bitumen membranes by torching onto thermoplastic foam insulation is not permitted, unless the boards are manufactured with a covering of reinforced bitumen membrane.

Site-applied hot-melt coverings

There is no harmonised European Product Specification for site-applied hot-melt waterproofing systems.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

As these systems comprise a multi-layer application (usually a base coat, reinforcement and top coat), a detailed specification for the system should be available prior to commencement of the works to enable its suitability for the project to be confirmed.

Site-applied hot melt coverings

There is no British Standard for the application of proprietary hot melt waterproof membrane systems. Reference should be made to independent certification and the manufacturer's detailed instructions.

Fixing of guarding/balustrades

Fixings for balustrades must be carefully designed to ensure appropriate fixings are robust and any penetration through waterproof roof coverings is sealed correctly in accordance with the waterproof covering manufacturer's recommendations.

Detailing

General principles

At an early stage in the design process, an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weather proof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in design of all details:

- Upstands to extend 150mm above the finished roof level.
- Downstands (of separate metal or other flashings) should lap the upstand by a minimum 75mm.
- Construction should achieve independence between different elements and trades.
- Thermal and fire performance should be maintained across the detail.
- A continuous barrier to air leakage should be maintained.
- Reliance on sealant as the sole means of protection should be avoided.

The total roof zone depth should be assessed at critical points, such as the top of drainage slopes, to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level.

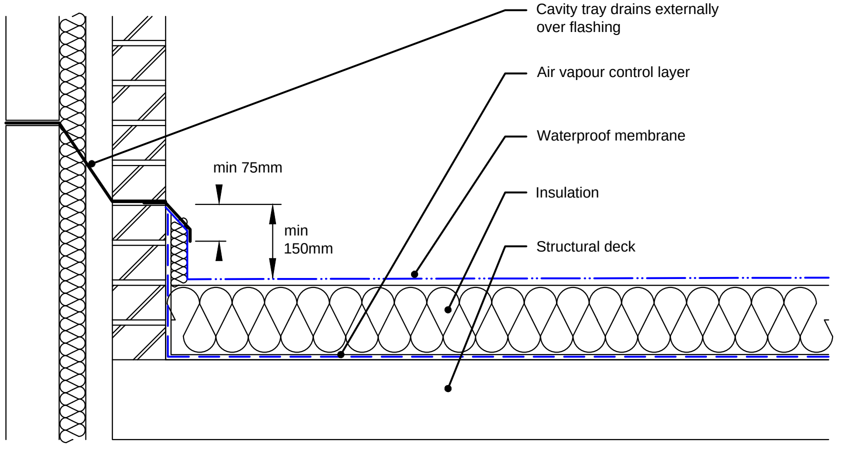
It is important that this minimum 150mm upstand is maintained at all points around the waterproofed area, except at continuous water checks and verges.

Designers should carefully consider the risks of any departure from this criterion. In the event of this being unavoidable, a written justification should be provided.

Special design features are essential, depending upon the generic type of waterproof membrane, including:

- Minimum clearances to enable the waterproof membrane to be installed.
- Termination of the waterproof membrane at interfaces to other elements.
- Penetrations.
- Supports.

Example of warm deck roof at an abutment

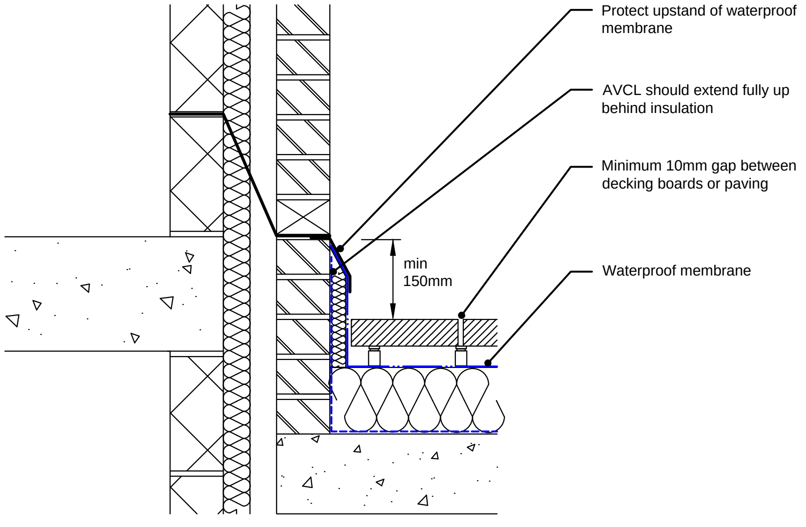


Insulation fully wrapped around by air vapour control layer waterproof membrane

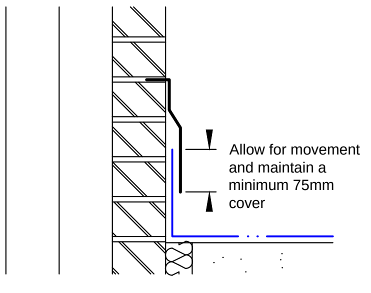
Notes:

- A fillet is required at the base of the upstand for certain types of waterproof membrane.
- Vertical insulation may not be required.
- AVCL, waterproof membrane, or both may form the air seal to the abutting wall.
- The principles for a parapet wall are similar but the cavity tray may be detailed differently.
- Discharging the cavity tray in the course above the corner flashing (a) avoids it being damaged during the roofing works and (b) allows for increase in insulation depth at refurbishment.

Upstand to decking and paving finishes - e.g where access is required



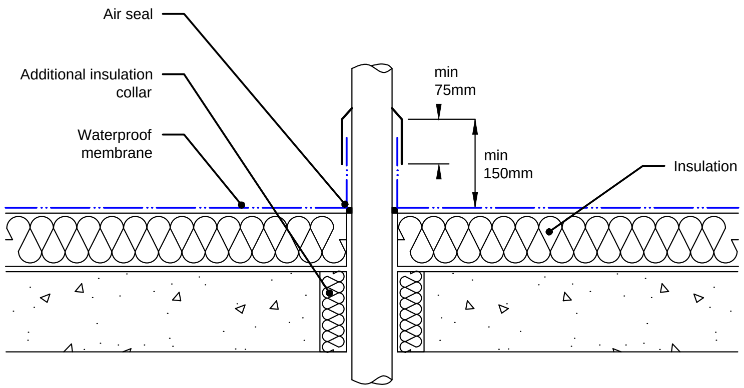
Timber frame construction where a lower level construction meets a brick outer leaf wall to roof abutment timber frame



Where a timber frame structure abuts a masonry structure allowance should be made to accommodate movement in the timber frame and ensure the appropriate cover is maintained.

For detailing with parapet wall construction, see the 'External Wall' section.

Penetration through roof system



Notes:

- A fillet is required at the base of the upstand for certain types of waterproof membrane.
- An effective seal is required between the air vapour control layer and pipe. Clearly it is difficult to dress a sheet material around a pipe. The method for doing so should be stated in the contract drawings and/or specification.

Special design features

Special design features are essential, depending upon the generic type of waterproof membrane, including:

- Minimum clearances to enable the waterproof membrane to be installed.
- Termination of the waterproof membrane at interfaces to other elements.
- Penetrations.
- Supports.

Mechanical and electrical services

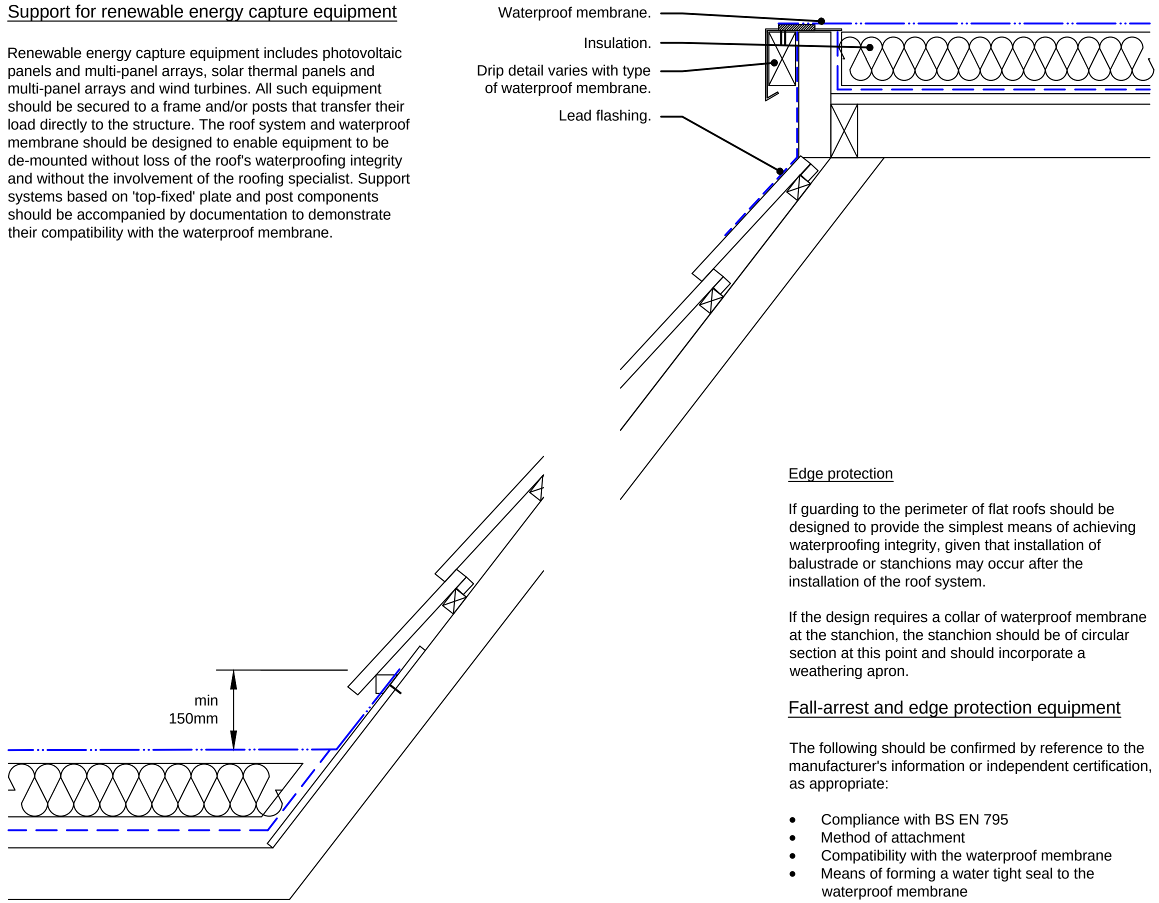
Detailed design should take account of the installation of such equipment by other (usually following) trades, as follows:

- Service entry/exit points should be suitably weathered to enable connection without loss of integrity of the waterproof membrane and without the involvement of the roofing specialist.
- The upstand of the waterproof membrane at risers should be arranged to enable a separate downstand or weathering flashing to be formed in ductwork.
- Cladding to insulation placed around ductwork should not be sealed to the waterproof membrane.
- Sufficient clearance should be provided to horizontal ductwork to ensure it does not rest upon the waterproof membrane or roof finish.

Support for renewable energy capture equipment

Renewable energy capture equipment includes photovoltaic panels and multi-panel arrays, solar thermal panels and multi-panel arrays and wind turbines. All such equipment should be secured to a frame and/or posts that transfer their load directly to the structure. The roof system and waterproof membrane should be designed to enable equipment to be de-mounted without loss of the roof's waterproofing integrity and without the involvement of the roofing specialist. Support systems based on 'top-fixed' plate and post components should be accompanied by documentation to demonstrate their compatibility with the waterproof membrane.

Principles: Flat roof interface to pitched roof



Edge protection

If guarding to the perimeter of flat roofs should be designed to provide the simplest means of achieving waterproofing integrity, given that installation of balustrade or stanchions may occur after the installation of the roof system.

If the design requires a collar of waterproof membrane at the stanchion, the stanchion should be of circular section at this point and should incorporate a weathering apron.

Fall-arrest and edge protection equipment

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Compliance with BS EN 795
- Method of attachment
- Compatibility with the waterproof membrane
- Means of forming a water tight seal to the waterproof membrane

Testing

Final inspection

At practical completion of the flat roof, all areas should be clear of stored material, other site operations and all protection. A thorough, recorded, visual inspection of all areas, including details, should be carried out with representation from the General Contractor and Roofing Contractor in attendance.

Parameters for testing

Upon completion testing of the flat roof covering will be required to be carried out as per the following criteria.

Testing of flat roofs and balconies (All types of materials)

Testing is required in the following situations:

1. On large developments: Apartments etc. over 3 stories in height (including the ground storey), where the total combined roof/balcony areas exceeds 50m^2. In this case, a minimum of 20% of the roof areas must be tested.
2. On Low rise housing: Detached/semi-detached/terraced housing 3 stories or less in height (including the ground storey) when:
   - The roof roof/balcony areas exceed 50m^2.
   - Where the project consists of 10 or more properties: one test per ten houses (with a minimum of two tests per site) are required.

In addition to above, in all cases: Testing may be required in the following situations where the complexity of a roof and its ancillary components presents a higher risk. It will be necessary to identify this at the initial site assessment carried out between the Developer and the Warranty Surveyor.

Design:

1. If the roof includes features beyond a typical wall abutment e.g. (but not limited to); variations of upstand constructions/penetrations/fixings/external permanent machinery/balustrading fittings etc.
2. If the waterproof membrane is to be covered over (by pedestrian finishes or solar panels). Note: Inverted roofs of straightforward design and with continuous hot-applied waterproof membrane could be exempted.

Construction:

3. If there are to be/have been, follow on trades on the roof after completion of the roof covering.
4. If secondary items such as fall protection devices, PV supports, balustrades etc. are to be attached.

Where EPDM roof coverings are proposed, no testing is required if:

1. The EPDM product must has a valid third party product approval certificate.
2. The EPDM covering is installed by one of the manufacturer's approved contractors.
3. And the maximum size of roof is limited to 100m^2.
4. Where the roof area exceeds 100m^2, the proposal must be referred to SPRA for consultation.

Procurement of testing services

If testing to demonstrate waterproofing integrity is required it should be undertaken by a suitably qualified and experienced third-party who is independent of the roofing contractor.

The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films, such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is not recommended as a method of demonstrating the integrity of flat roofs. It may be used to test balconies.

Approved Installers

Where a roof falls into the criteria below, an approved contractor who is recognised by the manufacture as competent to install the manufacturer's roof membrane system will need to be used. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.

A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings in the following situation:

- On large developments over 3 stories in height (including ground storey) where the total combined roof/balcony area exceeds 50m^2.
- Low-rise housing less than 3 stories in height where the roof/balcony area exceeds 50m^2.
- Where the roof includes features beyond a typical wall abutment e.g. (but not limited to) variations of upstand constructions/penetrations/fixings /external permanent machinery/balustrade fittings etc.
- Where the waterproof membrane is to be covered over by pedestrian finishes, balustrades/fall protection devices or solar panels.
- Where EDPM roof coverings are proposed.

Provision of information

Operation and maintenance manual

The following information is required.

Specification, as-built:

- Waterproof membrane: generic type, product(s) and (as appropriate) thickness.
- Thermal insulation: generic type, product(s) and thickness.
- Acoustic insulation: generic type, product and (as appropriate) thickness.
- Vapour control layer: generic type, product (as appropriate) and thickness (as appropriate).
- Rain water outlets: type, product and capacity.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproof membrane.

Where provision for access is required to flat roofs

Statutory requirement
Design for access should comply with current Building Regulations.

Edge protection
In the absence of suitable parapet walls, permanent edge protection should be provided along roof level pedestrian routes to equipment that requires regular access for servicing.

Protection of roof system
At the earliest possible stage, the anticipated loading of the roof by plant and access during service use should be assessed in terms of:

- Load e.g. foot traffic, equipment.
- Frequency.
- Risk of impact.

The design should include protection to suit the anticipated conditions as appropriate:

- Slip-resistant walkway material.
- Polymeric single ply membranes; compatible sheets or tiles welded to the membrane.
- Load-spreading materials.
- All waterproof membrane types; paving on paving supports or protection layer.
- Polymeric single ply and reinforced bitumen membranes: galvanised steel sheet with additional covering with slip-resistant finish.

Installation

Protection of the roof
Temporary protection (during construction)
Responsibility for temporary protection and a method statement for its use should be agreed prior to commencement of works. Suitable materials should be selected in consultation with membrane manufacturers as appropriate, for example:

- Linked recycled thermoplastic sheets.
- Rolled recycled thermoplastic or elastomeric sheets.

Particular consideration should be given to locations of concentrated access, such as step-out areas onto the roof or where wheeled equipment may be used.

A clear plan of type, location, sequencing and removal of temporary protection should be available before the roof system installation starts.

Permanent protection (during service)
Permanent protection should not be laid on routes where access is most likely, and should not be laid on routes where temporary ponding is likely e.g. near parapet walls in the absence of cross falls between rain water outlets.

It is recommended that concrete paving is laid on support pads, as this allows adjustment, thus reducing the risk of a trip hazard:

- The height of support pads should not exceed the maximum recommended by the manufacturer.
- Paving should not be cut. If cutting (part-slabs) is unavoidable to match plan geometry then an alternative means of support may be required.
- Paving should be firmly butted up against support pad separating pegs.

Further guidance on the suitably of finishes for temporary access can be found in the 'Balconies and Terraces' section.

Ancillary components

Non-access areas: stone ballast
Stone ballast for inverted warm deck roofs and ballasted warm deck roofs should be clean, rounded aggregate graded 20mm-40mm and as free from fines as practicable. Ballast should be applied over a protection layer on warm ballasted systems and over a filter layer or WCM on inverted warm roofs.

Access areas: concrete paving slabs
Concrete paving slabs for use as walkways or as paving on terrace decks should conform to BS EN 1340, and be laid in accordance with the manufacturer's instructions.

Access areas: flexible walkway tiles
Evidence of the compatibility of the tile with the waterproof membrane is required.

Lightning protection
The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Design in compliance with BS EN 62305.
- Method of attachment to the waterproof membrane, including arrangements for self-ballasting of conductors and finials (centres, compressive loads).
- Recommended detailing at penetration of roof system.

11.

Roofs

11.7
Green Roofs

Scope

This guidance should be read in conjunction with the 'Roofs - Flat Roofs' section of this Technical Manual.

This guidance provides specific advice and requirements in respect of membrane roof systems over which a finish of living vegetation or materials that will support vegetation is to be applied.

The membrane roof systems may comprise one of the following;

Warm deck comprising of:

- Waterproof membrane.
- Principal thermal insulation.
- Vapour control layer.
- Continuously supporting deck (structural deck).

Inverted warm deck roof systems:

- Ballast.
- Water control membrane.
- Principal thermal insulation.
- Waterproof membrane.
- Continuously supporting deck.

Cold deck roof systems (not acceptable for Warranty):

- Waterproof membrane.
- Continuously supporting deck.
- Ventilation externally.
- Principal thermal insulation.
- Air vapour control layer.

Definitions

For the purposes of this Technical Guidance, the following definitions shall apply:

Condensation: process whereby water is deposited from air containing water vapour when its temperature drops to or below dew point.

Filter layer: construction material (usually a geotextile) that substantially reduces the transfer of mineral and organic material to the insulation in an inverted warm deck roof.

Flat roof: a roof having a pitch no greater than 10º to the horizontal.

Insulation cricket: wedge of shallow-fall insulation material, designed to divert the flow of rainwater on a roof.

Interstitial condensation: condensation occurring within or between the layers of the building envelope.

Protection layer: construction material (usually a geotextile all rigid board) that isolates another construction material from mechanical damage.

Separation layer: construction material (usually a geotextile) that separates two construction materials that are not chemically compatible

Structural deck: continuous layer of the construction (comprising concrete, profiled metal or timber panel) supported by the building structure and which supports the roof system.

Thermal bridge: part of a roof of lower thermal resistance than its surrounding elements, which may result in localised cold surfaces on which condensation, mould growth or staining may occur.

Water control membrane (WCM): construction material (usually a sheet membrane) that substantially reduces the transfer of rain water to the insulation in an inverted warm deck roof.

Biodiverse roof: a roof that is designed to create a desired habitat that will attract a particular flora and fauna, whether replicating the original footprint of the building or enhancing the previous habitat.

Brown roof: a biodiverse roof where the growing medium is purposely selected to allow local plant species to inhabit the roof over time.

Drainage layer/reservoir board: available in a variety of materials, including hard plastic, polystyrene, foam, coarse gravel and crushed recycled brick, depending on the design Functional Requirements. This allows excess water to drain away, thereby preventing the waterlogging of the substrate. Some drainage layers also incorporate water storage cells to retain additional water that can be diffused to the plant support layer during prolonged dry periods.

Extensive green roof: a lightweight, low maintenance roof system, typically with succulents or other hardy plant species (often sedum) planted into a shallow substrate (typically less than 100 mm) that is low in nutrients. Irrigation is not normally required.

Filter fleece/fines layer: geotextile of low resistance to water penetration, which prevents fines and sediments from being washed out of the green roof into the drainage system.

FFL: Forschungsgesellschaft Landschaftsentwicklung Landschaftbau (German Landscape Research, Development and Construction Society).

Green roof: a roof or deck onto which vegetation is intentionally grown or habitats for wildlife are established, including extensive, intensive and semi-intensive roofs, roof gardens, biodiverse roofs, brown roofs and public and private amenity spaces.

Green roof system: the component layers of a green roof build-up.

Growing medium/substrate: an engineered soil replacement that contains a specified ratio of organic and inorganic material, specifically designed to provide green roof plants with the air, water and nutrient levels they need to survive, whilst facilitating the release of excess water.

GRO: Green Roof Organisation, the industry forum for green roof development and promotion in the UK.

Hydro seeding: spraying a specially designed blend of seeds and growing medium.

Inspection chamber: a chamber situated over an internal rain water outlet designed to constrain the surrounding landscaping but allowing easy access for maintenance. Allows water entry but helps prevent unwanted silt, debris or vegetation from entering and obstructing free drainage.

Intensive green roof: a version of a green roof often referred to as a roof garden that provides benefits akin to a small urban park or domestic garden. Designed primarily for recreational use, intensive roofs are typically configured with 200mm+ of substrate, and often require regular maintenance and irrigation.

Moisture/protection layer: geotextile blanket, available in varying thicknesses (typically between 2mm-12mm), which performs a dual function. Firstly, protecting the waterproof membrane during the installation of the green roof system, and secondly, increasing the water holding capacity of the green roof system.

Root barrier: a waterproof membrane designed to prevent roots from penetrating the waterproofing layer and building fabric. This function may be incorporated in a single membrane waterproofing product.

Sedum: genus of about 400 species of low-growing, leafy succulents that are wind, frost and drought tolerant and found throughout the northern hemisphere. Not all species are suitable for roofs.

Semi-intensive green roof: intermediate green roof type with characteristics of both extensive and intensive green roofs. Typically with a 100mm-200mm substrate depth, sometimes irrigated, occasionally managed and usually planted with a range of species.

SuDS: Sustainable (Urban) Drainage Systems.

Air Vapour control layer (AVCL): construction material (usually a membrane) that substantially reduces the transfer of water vapour through the roof.

Wildlife roof: a version of a biodiverse roof designed to provide a specific habitat to attract a wildlife species.

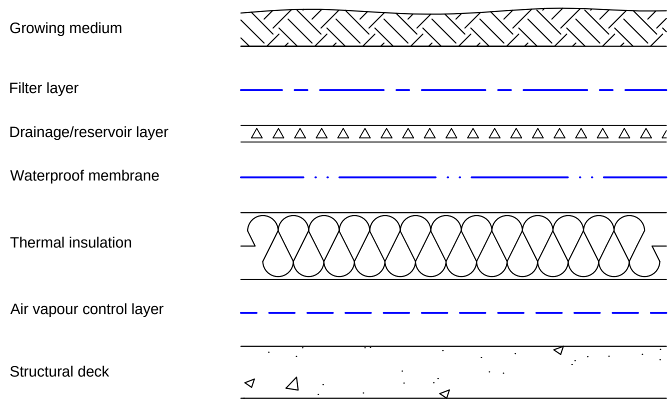
Design and system types

A green roof essentially comprises an organic vegetation layer and those components necessary to support its growth, which is placed over a membrane roof system. For convenience, green roofs are divided into the following types:

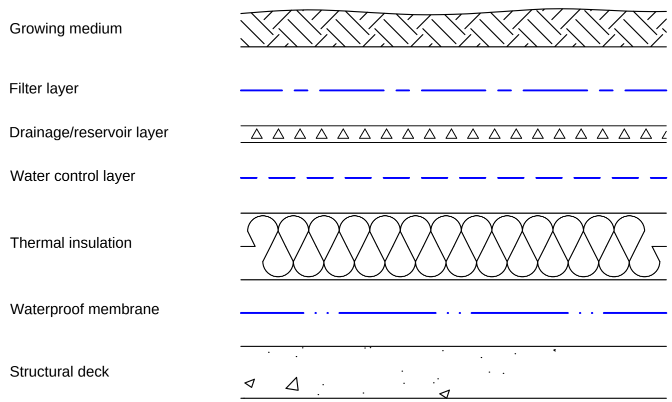
- Biodiverse roof.
- Brown roof.
- Extensive green roof.
- Semi-intensive green roof.
- Intensive green roof.

The roof system may be of warm deck, inverted warm configuration. Cold deck roofs are not suitable for Warranty. Generally, the warm deck configuration is recommended unless there are specific design circumstances for which inverted roofs are better suited. A technical justification for any departure from warm deck will be required.

Extensive green roof - warm roof system (section)



Intensive green roof - inverted warm roof system (section)



Loading

Statutory requirement
Design for loading should comply with current Building Regulations. Further information can be found in the 'Roofs - Flat Roof' section of this Technical Manual.

Resistance to wind load
In all situations, including ballasted and inverted roofs, a calculation of wind load to BS EN 1991-1-4 should be undertaken by a suitably competent person. Wind load acting on a green roof will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

In biodiverse, brown and extensive green roof systems, the dead load contribution from the growing medium should be calculated on an assumption of dry substrate conditions. Such loadings may be insufficient to restrain the green roof and certain types of waterproof membrane and insulation, necessitating the provision of supplementary ballast or netting restraint. Information on loading is available from horticultural suppliers.

Resistance to imposed loads
At the earliest possible stage, the employer should define the range of potential imposed loads for which the green roof is to be designed, such as seats, stand-alone planters, storage and public access. In the absence of such a performance requirement, the loading limits of the roof should be defined.

Design for sustainability

Please refer to the 'Roofs - Flat Roofs' section of this Technical Manual.

Materials

Please refer to the 'Roofs - Flat Roofs' section of this Technical Manual.

Note: If the waterproof membrane is also intended to provide root resistance, suitable certification of testing in accordance with BS EN 13948 should be available.

Air vapour control layer (AVCL)

Please refer to the 'Roofs - Flat Roofs' section of this Technical Manual.

Thermal insulation

Please refer to the 'Roofs - Flat Roofs' section of this Technical Manual.

Protection of the roof

Temporary protection (during construction and in service)
Responsibility for temporary protection and a method statement for its use should be agreed prior to commencement of works. Suitable materials should be selected in consultation with membrane manufacturers as appropriate, for example:

- Linked recycled thermoplastic sheets.
- Rolled recycled thermoplastic or elastomeric sheets.

Particular consideration should be given to locations of concentrated access, such as step-out areas onto the roof or where wheeled equipment may be used.

Thermal performance

Statutory requirement
Design for thermal performance must comply with current Building Regulations, as appropriate.

Provision for access

Statutory requirement
Design should comply with the current regional Building Regulations.

Temporary provision during construction

At the earliest possible stage, the anticipated loading of the roof system (prior to application of the green roof components) should be assessed in terms of:

- Load e.g. foot traffic, equipment.
- Frequency.
- Risk of impact.

If such usage is intense or long-lasting during the construction phase, consideration should be given to temporary works only, with completion occurring after all non-roofing usage has ceased as follows:

- Warm deck roof system: following the installation of vapour control layer, temporary protection is required to be overlaid to the remainder of the system is installed.
- Inverted warm deck roof system: overlay completed waterproof membrane with a geotextile and continuous temporary decking, such as plywood, Oriented Strand Board or compatible recycled thermoplastic board.

Permanent pedestrian access finishes

Pedestrian finishes should be designed to suit the purpose and frequency of access in the context of the intended planned maintenance regime. For example, paving on paving supports may be desirable to allow drainage and to level up the finish, but may be unsuitable if plants could spread beneath the paving. Generally, for amenity access, a finish of porous or hard concrete paving laid directly on a suitable protection fleece may be most suitable.

For service and maintenance access only, a flexible walkway tile may be sufficient (depending on the waterproof membrane and roof system type).

For further information regarding permanent protection during service, see the 'Roofs - Flat Roofs' section of this Technical Manual.

External fire performance

Statutory requirement
Design for external fire performance must comply with current Building Regulations.

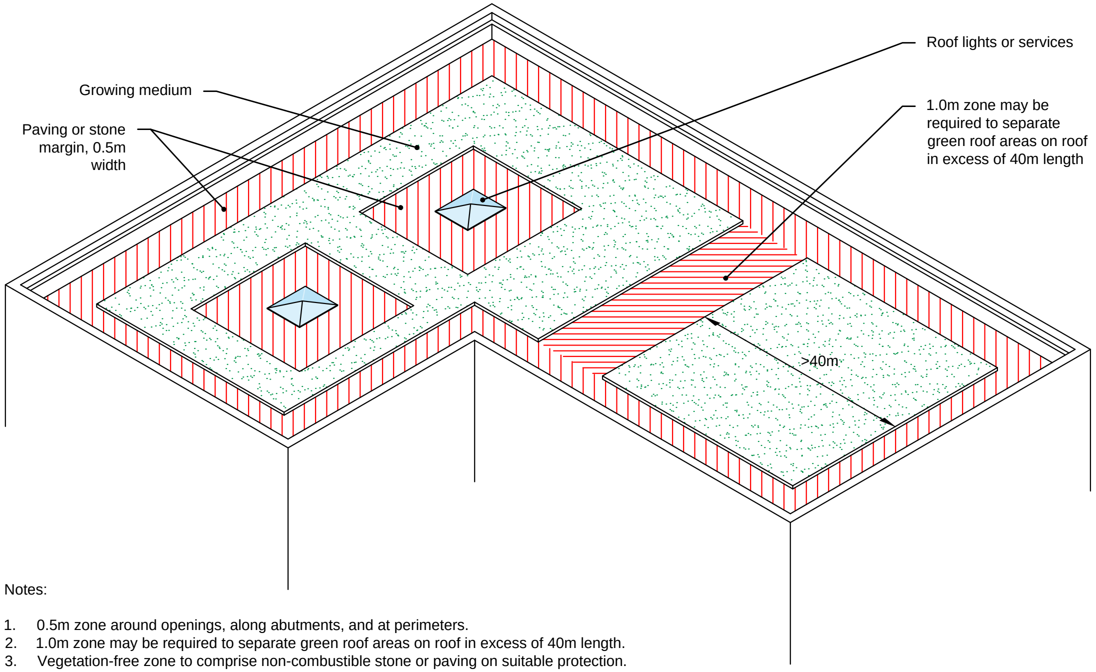
Design for resistance to external fire
The design of green roof systems can influence the fire performance of the overall roof system. The rate of growth and moisture content of natural vegetation is unpredictable and determined by irregular weather conditions. The substitution of planted species with others is also unpredictable. Design to minimise fire risk cannot be based on an assumption of regular maintenance or of irrigation during drought. The latter is not relevant with sedum species, which die back, but is important for intensive roof gardens or extensive systems planted with grasses.

The design should not allow the vegetation to grow or propagate towards adjoining elements, such as abutments, eaves or pitched roofs. It should also be kept away from openings, such as roof lights and smoke vents.

This is achieved in two ways:

- A vegetation-free zone of minimum 0.5m width at all perimeters, abutments and openings. This zone should be extended to 1m to separate large roof zones in excess of 40m in length.
- Design of flexible walkways, hard paving and ballasted areas so as to minimise root and plant spread.

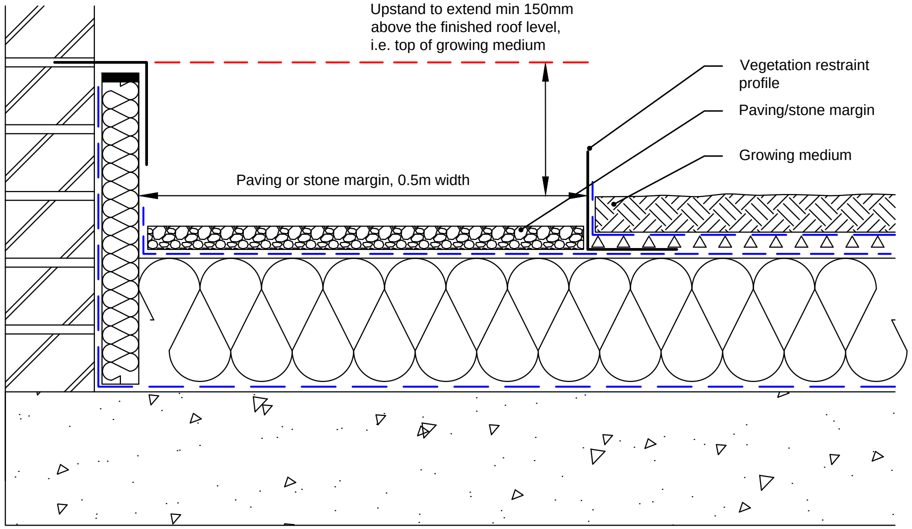
Green roofs: Vegetation-free zones (plan, zone width: not to scale of building)



Notes:

1. 0.5m zone around openings, along abutments, and at perimeters.
2. 1.0m zone may be required to separate green roof areas on roof in excess of 40m length.
3. Vegetation-free zone to comprise non-combustible stone or paving on suitable protection.

Green roofs: Vegetation-free zones: Warm roof (section)



Notes:

1. Vegetation restraint profile should be secured with ballast as necessary. Additional restraint will be required on sloping roofs to stop creep of the vegetation zone.
2. Protection of waterproof membrane should be extended under ballast zone.
3. Paving or stone should not simply be added to the growing medium at the perimeter as this (a) may reduce the available height of upstands, and (b) will not stop plants growing in the zone.

Detailing

General principles
At an early stage in the design process, an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weatherproof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in design of all details:

- Upstands to extend 150mm above the finished roof level i.e. top of growing medium.
- Downstands (of separate metal or other flashings) should lap the upstand by a minimum of 75mm.
- Reliance on sealant as the sole means of protection should be avoided.
- Consideration of the effect of vegetation growth on the integrity of the weatherproofing.

The total roof zone depth should be measured from the surface of the growing medium and assessed at critical points, such as the top of drainage slopes, to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the area of the green roof, except at continuous water checks and at verges.

Waterproof membranes

For further information on waterproof membranes please refer to the 'Roofs - Flat Roof' section of this Technical Manual.

Please note: Warm roof systems - restraint against wind load. It is unusual for the installation of ballast and green roof components to follow immediately after installation of the roof system. This may be because the roof system and green roof overlay are to be installed by different contractors, or because of site factors, such as limited storage. Unless it is sequenced to do so, the roof system should be installed with restraint against wind load based on an assumption of an exposed waterproof membrane.

If the waterproof membrane is also intended to provide root resistance, suitable certification of testing in accordance with BS EN13948 should be available.

Falls and drainage

Statutory requirement
Design for drainage of the flat roof covering should comply with the current Regional Building Regulations.

British and industry standards
BS 6229 states that a minimum finished fall at any point of 1:80 (1.25%) should be achieved. Since adjoining roof planes at 1:80 will meet at a mitre of less than 1:80, the intended finished fall at such intersections should be considered at an early stage.

The relevant requirements of BS 6229 should prevail in respect of green roofs, irrespective of the type of vegetative covering.

Falls are required for green roofs because:

- Standing water will inevitably result from design without falls, due to tolerances and deflection. Standing water, which may become stagnant, is not conducive to plant growth and should not be confused with the temporary retention of water in drainage/reservoir layers.
- Absence of falls will result in ponding, a potential slip hazard and the retention of mineral fines in vegetation-free zones, which in turn may encourage the growth of weeds.

Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculations, this may necessitate design falls of twice the minimum finished falls (1:40 or 2.5%).

Cut-to-falls systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall. However the use of these systems does not remove the need to check that deck deflection and tolerance is overcome and that a resulting fall in the waterproof membrane of a minimum of 1:80 is achieved. Allowance for deflection is particularly important in designing inverted roofs where calculation of dead loading should be based upon the ballast type and depth to be used.

The manufacturers of certain waterproofing products have certification for their use in 'completely flat' or 'zero falls' applications. However, for the purposes of this standard, the design conditions of BS 6229 shall be assumed to prevail in all warm, inverted, and cold deck roof systems, and a designed fall will be required including allowance for deflection of the deck from all anticipated loads.

Consideration should also be given to:

- The available upstand height at the high end of the falls. This may be a limiting factor on the length/size of the roof area to be drained. If necessary additional rainwater outlets should be provided.
- Avoidance of ponding behind wide obstructions to the drained slope such as plant plinths or roof lights. Additional rainwater outlets and/or insulation crickets should be provided.
- Avoidance of gutters by designing with intersecting roof planes.
- Falls between rain water outlets along a perimeter.

Since the primary function of the roof is to exclude water, it is important to consider how best to direct this into the drainage system.

Ponding on membrane roofs must be avoided because:

- It encourages the deposition of dirt and leaves, which can be unsightly, may obstruct outlets and/or become a slip hazard.
- In the event of damage, the interior will suffer increased water ingress.
- The load may cause progressive deflection of the deck.
- Ice or algae may create a slip or wind hazard, particularly on walkways.

Independent research has shown that roofs with extensive ponding require increased maintenance input.

Waterproof coverings of all types are tested for water absorption and water tightness as part of third-party certification. However, the construction process, including the installation of components and the forming of seams, is clearly facilitated in dry, well-drained conditions.

Please note: Rainwater outlets and downpipes can constitute thermal bridges which may increase the risk of localized condensation; an assessment might be required to determine whether insulated outlets are to be used.

Creation of falls

Roof falls may either be created during the construction of the deck or alternatively by using tapered insulation systems.

Where the roof finish is to include paving with or without paving supports, consideration should be given to the height difference created by the falls and spacing of rain water outlets in order that the maximum height of paving supports is not exceeded, the minimum height of upstands is not affected or trip hazards created.

The creation of falls in the deck should always be attempted because it has the following advantages:

- There will be a consistent thermal environment across the roof.
- The AVCL will also be to a fall.
- If mechanical fasteners are to be used for the waterproof membrane, their length will be constant, which facilitates planning and installation.

Cementitious screeds provide a stable substrate to mitred falls with minimal tolerances, and are recommended. Screeds should be in accordance with BS 8204. Lightweight screeds should be overlaid with a 1:6 (cement to sand) screed topping of a minimum 10mm thickness.

Tapered insulation schemes, suitable for warm deck roofs only, have the following advantages:

- It is possible to create effective drainage layouts to complex plan areas
- Mitred falls can be created easily to direct rain water to single points where outlets are to be located

Where falls are created by tapered insulation, the design should ensure that the average U-value and maximum U-value at any point, required by SBEM or SAP calculation, is achieved.

Where the roof finish is to include paving on access routes, consideration should be given to the height difference created by the falls and spacing of rain water outlets in order that the maximum height of paving supports is not exceeded or trip hazards created.

Drainage

Drainage design should be based upon calculations in accordance with BS EN 12056 Part 3 given a design head of water. Rain water outlet capacity should be taken from properly certificated information provided by manufacturers, and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes, such as walkways.

Green roofs are proven to reduce the volume and rate of transfer of rain water-to-rain water goods. This effect is clearly dependent upon many factors, including depth and type of growing medium, type of drainage/reservoir layer, weather conditions prevailing prior to the rainfall event and fall in the waterproof membrane. Due to these variables, it is recommended that the design for rain water drainage in accordance with BS EN 12056 is as follows:

- Brown, biodiverse and extensive green roof systems: no allowance for rain water attenuation.
- Intensive green roof systems: attenuation as advised by the horticultural supplier. If no data is supplied, no allowance should be made.

The UK's National Annex to BS EN 12056 does permit the use of a coefficient to factor down the drainage infrastructure to account for factors such as the additional retention performance of green roofs. However the coefficient that is used to reflect this reduction should be based on average annual retention and not on responses to dynamic storm events.

Any drainage infrastructure designed to accommodate this reduced flow rate may not accurately account for seasonal differences or individual storm events. Any reductions in drainage capacity should be countered by alternative measures, e.g. appropriate detailing to ensure that any attenuation of water at the roof level will not be detrimental to the building structure or fabric.

Rain water outlets should be readily accessible without disruption to the green roof or pedestrian finish. On finishes raised above the waterproof membrane (warm deck roofs) or Water Control Membrane (inverted roofs), this may be achieved by a suitably marked paving slab or demountable section of decking. Within the area of the green roof, a specific vegetation-free inspection chamber and cover should be provided in order to avoid plant growth obstructing the outlet. Purpose made products are available from suppliers of green roof components and waterproof membranes, and it is recommended that they be used wherever possible.

Rain water goods from higher roof areas or adjacent roof areas should not be designed to discharge onto the green roof. The downpipe should be connected directly to the downpipe serving the green roof.

Rainwater outlets

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

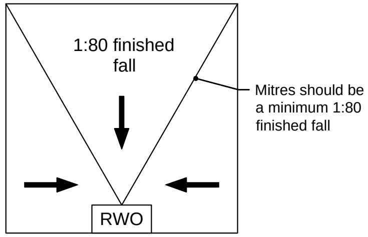
- Capacity in litres per second at a range of typical water heads.
- Compatibility with the waterproof membrane.
- Integral insulation to avoid condensation.
- Method of attachment.
- Rainwater outlets for inverted roofs should be of the dual height type, designed to maximise removal of rainwater at WCM level.

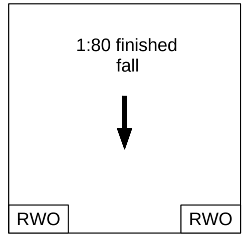
Design for irrigation

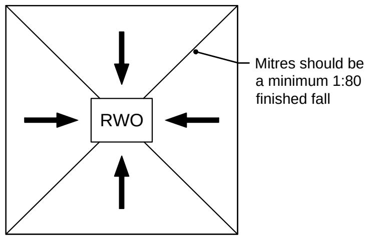
Rainfall is the typical source of water. However, complementary irrigation options may be required for semi-intensive and intensive systems or those where, for example, the appearance of a grass finish may be important.

Provision may include hoses, sprinklers, overhead irrigation and automated systems that pump from some reservoir storage. The establishment of a need for an irrigation system, and the design of an irrigation scheme, should be in accordance with the principles of BS 7562-3. Where irrigation is required, a frost-protected water supply, rain water or grey water storage facility should be provided at roof level.

Drainage layout options







Gutters must be a minimum of 1:80 as-built fall towards the drainage outlet

Siphonic drainage

Green roofs are compatible with siphonic roof drainage systems. In the right circumstances, these can offer the advantages of:

- Very high capacity, enabling fewer outlets and therefore less detailing work on site.
- Smaller bore horizontal collector pipework, enabling reduced roof void depth.
- Self-cleaning in many situations.

However, siphonic drainage should be designed specifically for the green roof system because it must operate siphonically with sufficient regularity to avoid silting-up small-bore pipework.

For further information, see www.siphonic-roof-drainage.co.uk

These roof proposal are to be considered on a case by case basis and full design and calculations should be submitted for Warranty approval before construction begins on site.

Testing

Testing of the green roof system

No reliable method is available for testing the integrity of a green roof following application of the green roof components. Therefore the roof covering should be tested before application of the green roof components, and care should be taken to ensure that damage to the waterproof membrane does not occur during installation. With extensive greening on certain warm roof systems, it may be feasible to use low voltage earth leakage, but any defects recorded will in any case involve removal of the green roof components. Therefore, it is strongly recommended to ensure the very highest possible standards of protection of the water proof membrane during the application of the green roof components.

Procurement of testing services

The water proof membrane should be tested for integrity before the application of any other components above it. Testing should be undertaken by a third-party that is independent of the roofing contract.

The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

Final inspection

At practical completion of the flat roof, all areas should be clear of stored material, other site operations and all protection. A thorough, recorded, visual inspection of all areas, including details, should be carried out with representation from the General Contractor and Roofing Contractor in attendance.

Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films, such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is a suitable method of demonstrating the integrity of small areas of roof to which a green roof system is to be applied. However, consideration should be given to the effect of ingress on programme and the risk of entrapped water in insulation (warm deck roofs) and decks (all types). The area under any one test should not exceed $50m^2$.

Approved Installers

An approved contractor who is recognised by the manufacture as competent to install the manufacturer's roof membrane system will need to be used. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.

Provision of information

Operation and maintenance manual

The following information is required:

Specification, as-built:

- Waterproof membrane: generic type, product(s) and (as appropriate) thickness.
- Thermal insulation: generic type, product(s) and thickness.
- Acoustic insulation: generic type, product and (as appropriate) thickness.
- Vapour control layer: generic type, product (as appropriate) and thickness (as appropriate).
- Rain water outlets: type, product and capacity.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Instructions for irrigation (method/frequency), weed control and application of fertiliser (type/season/frequency).

11.

Roofs

11.8

Metal Deck Roofing

Introduction

Metal roofing is usually built to a decent standard, but occasionally there are problems, especially where site workmanship has not been up to standard. Any roof cladding details proposed outside of the following guidance will require a specialist consultants design using third party accredited solutions where appropriate.

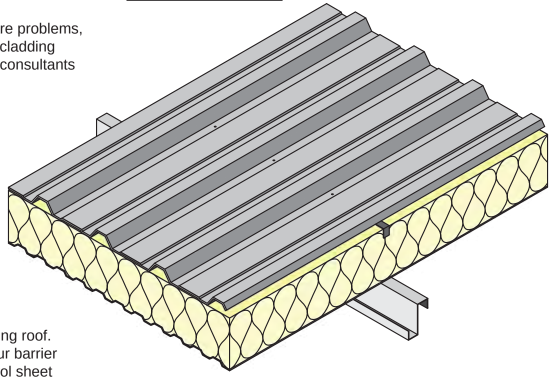
Double skin insulated roof

A double skin insulated roof is made-up on-site from separate components generally comprising: liner sheet, vapour control layer (VCL), spacer system, insulation, breather membrane and finished externally with top weathering sheets.

Top weathering sheets are generally secret fixed onto clips or standing seam sheets onto halters, these being machine seamed once fixed. Pierce fixed sheets are still widely used, which are fixed directly to the spacer system with external visible fixings.

Liner sheets can be solid or perforated to give an acoustic, sound-deadening roof. They are fixed directly to purlins, and can act as a VCL if a separate vapour barrier is not specified. If the liner is not used as a VCL, a reinforced vapour control sheet should be incorporated within the roof.

Double skin system



Insulation must be installed between the VCL and the top weathering sheet; some systems may require ventilation above the insulation and others may not; it varies from manufacturer to manufacturer. Where there is no requirement to ventilate, the insulation should be compressed slightly to ensure that there are no air voids where condensation may occur.

Workmanship

Top weathering sheets

Ensure that the top weathering sheets are installed in accordance with the manufacturer's instructions.

These must be long enough to discharge into the gutter correctly and allow for an eaves angle if required by the system.
Check that end and side lap tape sizes conform to the manufacturer's requirements.

For pierce fixed trapezoidal sheets, check for tell tales to end laps and side laps for the correct number of rows of tape.

Liner sheets

Where the liner sheet is solid and used as a vapour check, note the following:

- Frequency of main fixings to purlins and frequency of side lap stitchers.
- End laps to be sealed with mastic tape; check the size and that this is continuous. Side laps have a wider 50mm Polyband tape placed from the inside so this is visible from above.
- Check for cuts or splits in this metal liner.
- Ensure that to eaves and ridge the correct filler blocks have been used, bedded in mastic; if necessary, a closure flashing must be used from the crown of the sheet to the wall junction to maintain a vapour check. Check the use of sealant tapes and fire-retardant foam.

Separate vapour control layer (VCL)

This should be a reinforced sheet, and is used to ensure a more positive air seal around the perimeter of the building. The vapour check should be sealed in the field area with the correct tape, with the number of rows dependent on the application. Check the integrity of these tapes and that they are continuous and correctly joined. Where the vapour check abuts the walls to the verge or eaves, it must be properly sealed in accordance with the Architect's detail. Around penetrations, the vapour check must be cut and sealed to any pipes or upstands.

The spacer system is fixed through the vapour check and liner into the purlins. The spacer system will have a soft sealing pad to ensure the vapour check is maintained around the fixing. Check for punctures of the vapour check by foot traffic or damage, and patch as required.

Insulation

Check the packaging to ensure that the correct thickness is being used if one layer is used, or a combination of thicknesses to give the correct specified thickness. For two thicknesses or more, check that all joints are staggered and check the Lambda value against the specification.

Ensure that no packaging or debris is left in the roof void prior to or during the installation of the insulation. The insulation should fill the void or be compressed into the void; there should be no slumping or gaps and it should be packed into voids at the junctions of the ridge and verge.

With standing seam roofs, a rigid mineral slab insulation should be placed at eaves, ridge and around all penetrations and walkways to support the vulnerable areas of the roof, which will give a solid support to the roof sheet pans. This is easy to see during construction and easily felt on completion. The supported pan of the sheet feels solid to walk on.

Support system

Check the frequency of brackets against the specification and the number of fixings per bracket, and that they are the correct type of fixing. With standing seam roofs, the halter may be fixed with a stainless steel fixing; check the type and frequency of fixing. Check the orientation of the halter in relation to the lay of the sheet, i.e. will they pick up the seam, as there is a right and wrong way round for halters.

Manufacturers provide halter templates to set out halters, and there must be one on-site to obtain the correct gauging of the halters.

Roof penetrations

These must be sealed to maintain the VCL. Where the liner is used as a VCL, the metal-to-metal junction must be sealed with fire-retardant foam. With a separate VCL, this must be sealed to the upstand or pipes with the appropriate tape. Externally with aluminium roof sheets, the junctions with penetrations should be site welded or weathered using glass reinforced plastic (GRP) in-situ weathering.

Roof lights

Standing seam roof sheets are usually on separate insulated upstands. With pierce fixed trapezoidal roof sheets, roof lights are in line, either factory or site assembled. Ensure that the correct size of tape is used, check the number of rows of tape that are required and that side lap tapes are not twisted by fasteners.

General

Check surface finishes for abrasions, dents and cuts, and that the roof has not been used as a cutting surface for flashings or other metal. Hot swarf from angle grinders burns into the plastisol coating of steel sheets, marks aluminium and rapidly turns to rust. Flashings should have sufficient overlap or butt straps, 150mm wide, and be sealed and supported. Check the frequency of fixings and that they are of the correct type.

Composite panel metal roofing

A simple sheet roof system with ensured insulation thickness that is delivered with the top weathering sheet, insulation and white liner all in one sheet. With the increase in insulation, thickness panels are being made shorter in length so they can be handled into position. This means that there are more end laps to be checked.

The standard manufacturer's details are to be adhered to, but the following need to be checked.

Workmanship and installation

Fixings

There may be a requirement for stainless steel fixings to be used. Check by inspecting boxes and use a magnet; drill points will be magnetic only.
Check fixings are suitable for the purlin type - steel, light gauge cold rolled, heavy gauge or timber - as all fixings are different.

Check the bearing area of the purlin; if the building is not square, the sheets will run out and the end lap detail will not be supported. This can be overcome by using a galvanised support that is fixed to the purlin and which supports the end lap.

Check that the right number of fixings has been used for the panel and the frequency of side lap stitchers; ensure that they are side lap stitchers and not main fixings.

Sealant tapes

Check the number of rows required by the manufacturer of the panel for end laps. Tell tales should be visible at side laps of each sheet. Tell tales are the ends of the mastic tape run that can be seen or must be felt for at the side of each sheet. The same applies to side laps; there should be a tell-tale at the end of the sheet. Use the end of a hacksaw blade to locate the rows of mastic tape.

On roof lights, mastic tape is visible; check its location, that its size complies with the manufacturer's requirements and that there are the correct number of rows. Tape should not be twisted by the fixings.

Air tightness

There must be a supply of gun foam, fire rated, at roof level for filling in voids before flashings are fixed. If there is not one on site, air tightness and maintaining the insulation cannot be fully achieved.

The use of foam needs to be inspected during the course of construction, and internal tapes to eaves and ridge purlins need to be inspected for size and position. At the ridge, the gap between panels needs to be filled with foam to maintain the insulation and prevent condensation forming. There also needs to be a suitably sealed inner ridge.

Verge details are difficult and it may be necessary for an internal verge to be cut and sealed around purlins. Check sealant tapes and the use of gun foam to maintain insulation. The manufacturer's details may not be achievable, but an alternative must be devised to maintain air tightness. A degree of confidence in this requirement should be shown on-site as an indication of the importance of air tightness and how this can be achieved.

Gutter junctions

If parapet or valley gutters are being used, check the air seal at the junction of the two. Gutter joints are not always level, and any gaps have to be filled. This will not only prevent wind-driven rain from entering the building, but will also maintain an air seal.

Check that roof sheets are oversailing into the gutter correctly.

Roof penetrations

Penetrations such as flues, vents, upstand-type roof lights and sun tubes need to be sealed internally, the insulation being maintained with site-applied foam. Externally, upstands must be weathered correctly and, with steel composite sheets, this is best achieved using GRP in-situ weathering.

General

Check surface finish for cuts and abrasions.

Check that the roof has not been used as a cutting surface for flashings or other metal. Hot swarf from angle grinders burns into the plastisol coating and rapidly turns to rust.

Flashings should have a sufficient overlap and be sealed and supported. Check the frequency of fixings and that they are of the right type.
Check for closure from gutters and sheet oversails. There should be suitable shrouds to prevent birds or vermin from getting into the building, which can be often overlooked.

Checklist for double skin insulated roof systems in steel or aluminium

Component/Inspection	Rectification needed		Comments
	Yes	No	
Check bearing width of purlin			
Check minimum overlap of linear decking sheets: 1. Light gauge steel 2. Hot rolled steel 3. Timber - check for minimum penetration			
Check that side laps are stitched at the correct centres			
Vapour control checks using the liner: 1. Check tape to side laps, minimum width 50mm air and moisture barrier tape 2. Check tape to end laps 3. Check inner fillers to ridge, eaves and verge 4. Check for sealing around the perimeter with fire-resisting foam			
Vapour control checks using a separate VCL: 1. Check the minimum overlap is correct 2. Check for the correct sealant tape 3. Check for the correct number of rows of sealant tape 4. Check junctions between VCL and building elements, e.g. upstands, eaves, verge, etc. 5. Check for puncture and repair where necessary			
Spacer systems: 1. Check for correct height of bracket or halter 2. Correct number of fixings per bracket or halter 3. Check for stainless steel if specified 4. Check for gauging of halters for standing seam and secret fix roof sheets			Use a magnet
Insulation: 1. Check that the correct thickness is being used 2. Check that insulation is the correct type and has the same properties as specified 3. Check for compression 4. Check that insulation joints are staggered 5. Ensure that insulation designed to support load has been correctly installed to eaves, ridge, penetrations and walkways 6. Ensure all packaging and debris is removed prior to fitting of the roof sheets			
Breather membranes: 1. Ensure the membrane is laid in the correct direction and in accordance with the manufacturer's instructions			
Roof sheets - standing seam and secret fixed: 1. Check that sheets are long enough so that water effectively drains into the gutter 2. Check the direction of lay of sheets in relation to the direction of the prevailing wind 3. Check eaves detail, including eaves drips and fixing, in accordance with the manufacturer's details 4. Check ridge detail, including turn up fillers and ridge dams, in accordance with the manufacturers details 5. Check verge detail and adequacy of support for cut sheets 6. Check flashing supports, sheet/verge flashing seals and frequency of fixings			
Roof sheets - pierced fixed: 1. Check overlap dimension 2. Check end lap tape and correct number of rows of tape 3. Check for side lap tape 4. Check quantity of fixings per sheet per purlin 5. Check washer size of main fixings and side lap stitchers 6. Check frequency of side lap stitchers 7. Inspect for correct tightening of main fixings and side lap stitchers			
Penetrations for vents, sun pipes etc. **A - Aluminium sheets:** 1. Check sheets are site welded and area post coated where colour sheets are used 2. Check that the VCL and breather membrane are maintained around the welded area 3. Check upstands are at least 150mm **B - Steel sheets:** Ideally use GRP in-situ weathering flashings; however, if folded flashings are used, check: 1. Overlap 2. Sealing and fixing of overlaps 3. If a flat sheet back to the ridge is used, check for insulation under the sheet 4. Check frequency of fixings 5. Check sealing of overlapping sheets			

Component/Inspection	Rectification needed		Comments
	Yes	No	
Flashings: 1. Check end overlap 2. Check frequency of fixings 3. Check correct type of fixing is used			
General: 1. Check roof surface for cuts and abrasions 2. Check for hot swarf damage			
Panel laps to be tight when viewed from inside the building			
Constant straight line on side laps to be achieved			
Fasteners correct for the purlin: 1. Light gauge steel 2. Heavy gauge steel 3. Timber			
Fastener material: 1. Coated carbon steel 2. Stainless steel			Check with a magnet
Fastener frequency main roof: 1. Main fixings 2. Side lap stitchers			
Fastener frequency roof lights: 1. Main fixings 2. Side lap stitchers			
Bearing area of purlin at end lap; is a supporting bearing plate required?			Is the building square?
End laps: 1. Correct number of rows of joining tape 2. Correct size of end lap tape 3. Correct position of end lap tape in relation to fixing			
Roof light tape positions: 1. Correct number of rows of joining tape 2. Correct size of end lap tape 3. Correct position of end lap tape in relation to fixing			
Is the roof adequately air tight (visual inspection and air tightness test where necessary)?			
Provision of fire-retardant gun foam: 1. Eaves level 2. Verges 3. Gutters 4. Internal verge positions 5. Foam insulation at ridge			
Gutter junctions: 1. Adequacy of seals at gutter junctions 2. Correct provision of weir overflows to gutter runs 3. Correct junction detail between gutters and verge flashings 4. Gaps sealed to prevent vermin infestation 5. Correct discharge of water from roof sheets into gutter			
Roof penetrations: 1. Check seals around cut foam insulation internally 2. Check internal flashing closures 3. Check weather penetrations externally			
Flashings: 1. Check end overlaps 2. Check frequency of fixings			
General: 1. Check roof covering for cuts and abrasions 2. Check for hot swarf damage			

12.

Balconies and Terraces

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. A roof membrane manufacturer's approved installer must be used for all balcony/terrace coverings, where:
    a. The balcony/terrace forms a roof over a building and,
    b. On large developments over 3 stories in height (including ground storey) where the total combined balcony area exceeds $50m^2$.
    c. Low rise developments less than 3 stories in height where the balcony area exceeds $50m^2$.
    d. Where the roof/balcony/terrace includes features beyond a typical wall abutment e.g. (but not limited to) variations of upstand constructions / penetrations / fixings / external permanent machinery / balustrade fittings etc.
    e. Where the waterproof membrane is to be covered over by pedestrian finishes or solar panels.
    f. Where EDPM roof coverings are proposed.
2. Balcony/terrace roof membranes will be required to be weather and waterproof and, in certain circumstances the flat roof covering will also require to be tested at completion (please refer to the guidance within this Technical Manual for further information).

Materials

No additional requirements.

Design

1. Roof coverings must prevent any external moisture passing into the internal environment of the building.
2. Balcony/terrace roof structures and coverings, shall be designed and constructed so that they:
    a. Are structurally sound;
    b. Satisfactorily resist the passage of moisture due to rain and snow to the inside of the building, and to materials which might be adversely affected by such moisture;
    c. Encourage the rapid discharge of moisture due to rain and snow from their external surfaces to a suitable discharge system;
    d. Have an adequate thermal performance;
    e. Are durable and resistant to moisture due to the weather, condensation or some other cause;
    f. Have adequate resistance to fire penetration and the spread of flame across their external surfaces;
    g. Do not allow fire spread across the tops of separating walls;
    h. Resist flanking sound transmission where adjacent to separating walls.
    i. Adequately discharge rainwater from the roof area to a suitable drainage system.
3. In addition to point 2: shall, unless specifically agreed otherwise with the Warranty provider, comply with the requirements of BS 6229 and be designed to have a minimum finished fall of 1 in 80.
4. Balconies and Terraces must have appropriate guarding meeting the relevant Building Regulations.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

12.

Balconies and Terraces

12.1
Forming a Roof

Introduction

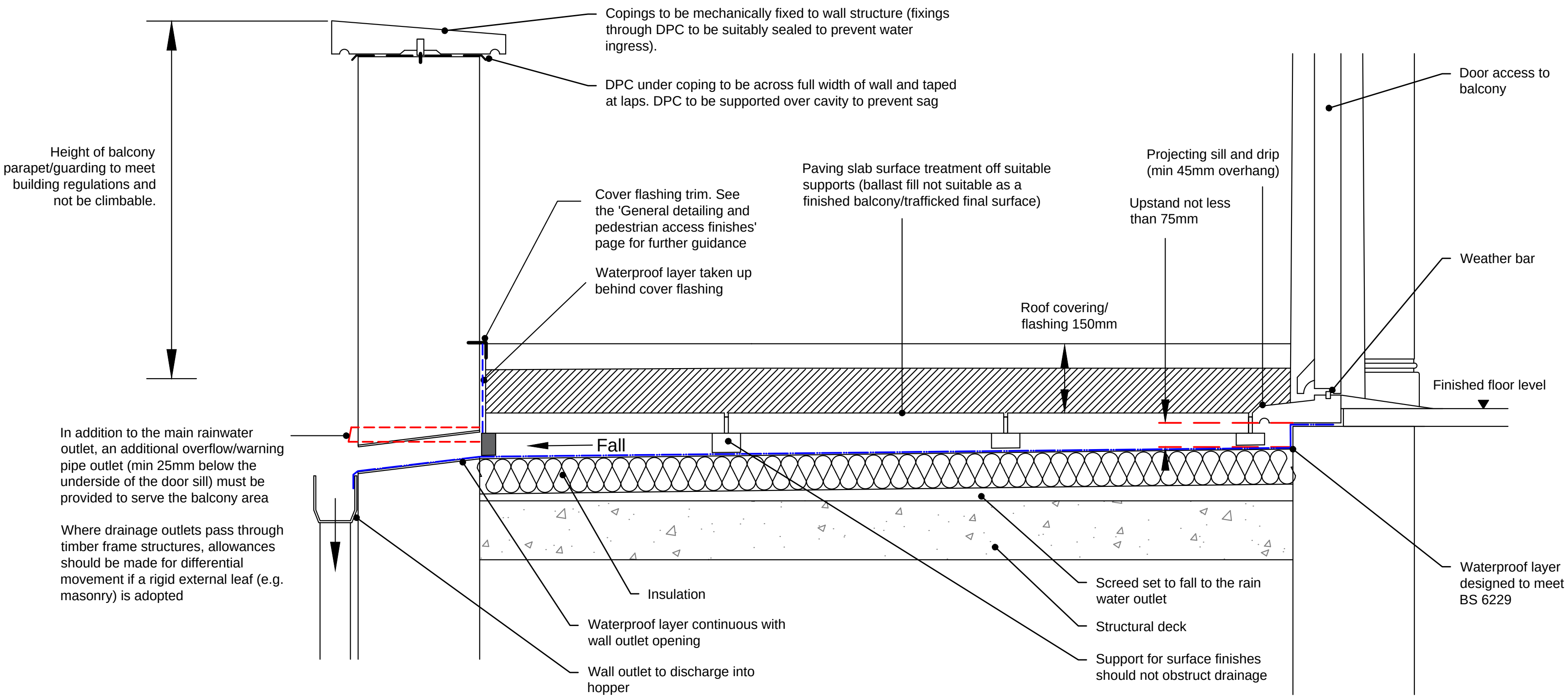
This section provides specific advice and requirements in respect of balconies and terraces, where the balcony or terrace forms part of the roof or forms the entire roof to other occupied parts of a building and is warm deck construction.

Design

Selection of system type

The cold deck roof system is not permitted on balconies or terraces that form part of the roof to other occupied parts of the building. In these circumstances the selection of system type (warm deck or inverted warm deck) should be based upon the following criteria;

- Roof zone depth (height from ceiling to termination of waterproofing).
- Likely point loading.
- Construction process (a complete inverted warm deck roof, with suitable protection and which may be suitable for storage or access by other trades, a warm deck roof may not be suitable for storing heavy loads).



Notes:

- Insulation above structural deck and waterproof layer to be XPS insulation suitable for weight of surface treatment.
- Waterproof membrane must be laid to a fall - to a suitable outlet. All joints formed must be sealed in accordance with the manufacturers requirements and not result in water being trapped/ponding.
- Membrane not to be laid in air temperatures less than 5°C.
- Where structural deck is constructed over accommodation below the design, construction should meet sound insulation requirements.
- Structural deck to be an engineered design for the loading/intended use.

Introduction

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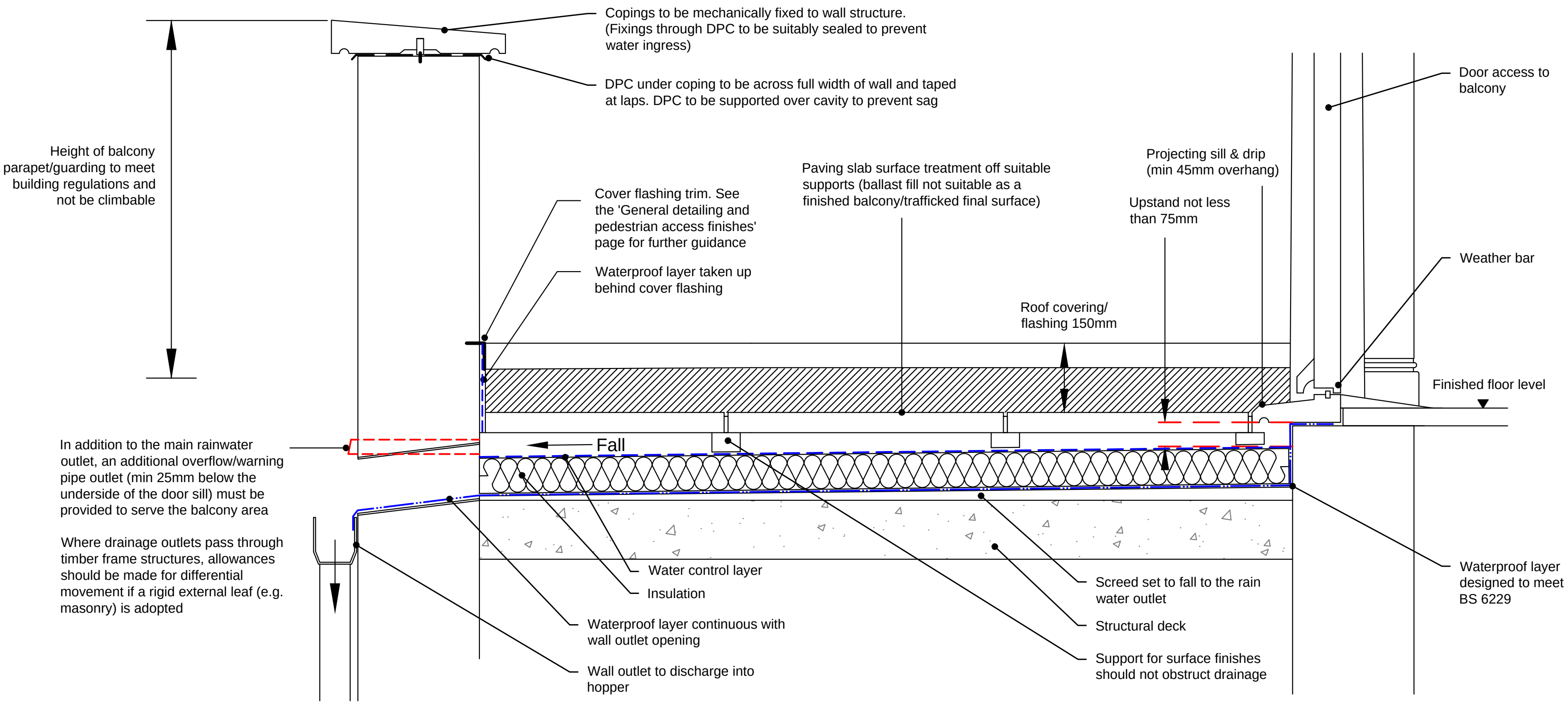

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- Membrane not to be laid in air temperatures less than 5°C.
- Where structural deck is constructed over accommodation below the design, construction should meet sound insulation requirements.
- Structural deck to be an engineered design for the loading/intended use.

Definitions

For the purposes of this Technical Guidance, the following definitions shall apply:

Condensation: process whereby water is deposited from air containing water vapour when its temperature drops to or below dew point.

Filter layer: construction material (usually a geotextile) that substantially reduces the transfer of mineral and organic material to the insulation in an inverted warm deck roof.

Flat roof: a roof having a pitch no greater than 10º to the horizontal.

Insulation cricket: wedge of shallow-fall insulation material, designed to divert the flow of rainwater on a roof.

Interstitial condensation: condensation occurring within or between the layers of the building envelope.

Protection layer: construction material (usually a geotextile all rigid board) that isolates another construction material from mechanical damage.

Separation layer: construction material (usually a geotextile) that separates two construction materials that are not chemically compatible.

Structural deck: continuous layer of the construction (comprising concrete, profiled metal or timber panel) supported by the building structure and which supports the roof system.

Thermal bridge: part of a roof of lower thermal resistance than its surrounding elements, which may result in localised cold surfaces on which condensation, mould growth or staining may occur.

Air vapour control layer (AVCL): construction material (usually a membrane) that substantially reduces the movement of water vapour through the roof system.

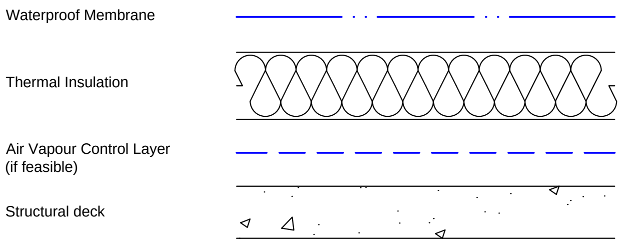
Water control membrane (WCM): construction material (usually a sheet membrane) that substantially reduces the transfer of rain water to the insulation in an inverted warm deck roof.

Warm deck roof

The principal thermal insulation is placed immediately below the roof covering, resulting in the structural deck and support being at a temperature close to that of the interior of the building.

The design should ensure that:

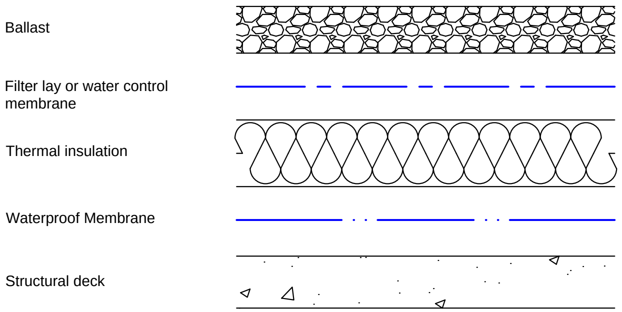
- The waterproof membrane has sufficient resistance to temperature to suit the conditions created by a substrate of insulation.
- The insulation has sufficient mechanical characteristics to resist loading.
- The AVCL is provided by the deck or by a membrane placed above the deck.
- The structural deck is maintained at a temperature above that which could cause condensation to occur at this level during service.



Inverted warm deck roof

A variant of the warm deck roof in which the principal thermal insulation is placed above the waterproof membrane, resulting in the waterproof membrane, structural deck and structural support being at a temperature close to that of the interior of the building. Generally, the principal insulation is secured by separate ballast (paving or stone).

A filter membrane or WCM should be provided to control mineral and organic material passing into and below the insulation joints. A WCM is recommended because it will provide improved rain water run off, which may allow for a reduced thickness of insulation and reduced loading of ballast. If a WCM is included, it is essential that the drainage design facilitates the rapid transfer of rain water across the product and to rain water outlets.



Hybrid roof

Many roofs combine the features of two or more of the roof types previously described. Examples include structural decks of high thermal resistance combined with additional insulation, and existing roofs to which thermal insulation is added. Once assessed in terms of their thermal and water vapour transmission characteristics, such roofs will generally fall into one of the categories described.

In some constructions, the waterproof membrane is placed between two layers of insulation, combining the properties of warm roof and inverted warm roof construction. This form of construction is generally known as a 'duo roof '.

There is an increased risk of interstitial condensation with a hybrid roof and therefore where these types of roof systems are used a full condensation risk analysis should be carried out.

Cold deck roof

The cold deck roof system is not permitted on balconies or terraces that form part of the roof to other occupied parts of the building.

In these circumstances an alternative roof system should be adopted.

Structure General

The design and construction of flat roofs should be in accordance with BS 6229 - Flat roofs with continuously supported flexible waterproof coverings - Code of practice states and the relevant euro codes. The following is adapted from BS 6229 - Flat roofs with continuously supported flexible waterproof coverings - Code of practice states:

Structure

The roof structure should be designed for strength and stiffness in accordance with the Code of Practice for the relevant structural material.

Dead and imposed loads upon a roof should be assessed in accordance with BS EN 1991-1-1 + UK National Annex, taking due consideration of any added surfacing; paving slabs, gravel etc. Snow loads should be assessed in accordance with BS EN 1991-1-3 + UK National Annex. Wind loads should be assessed in accordance with BS EN 1991-1-4:2005 + A1:2010 + UK National Annex.

Relevant structural material on roof structure strength and stiffness should be assessed in accordance with BS EN 1992-1-1, BS EN 1993-1-1, BS EN 1994-1-1, BS EN 1995-1-1, BS EN 1999-1-1 and their UK National Annexes.

The resistance to wind uplift of the waterproof covering and finishes on a flat roof should be assessed having regard to the dead weight of those materials and to the nature, type and disposition of their attachment to the slab or deck, in accordance with BS 8217 and BS EN 16002.

Whilst a roof slab should be regarded as airtight and where the critical layer is the exposed roof surface, be it the waterproofing, or inverted insulation system, a roof deck might be regarded as air permeable and likely to allow internal air pressures to impinge on the roof system from below.

Wind uplift pressure, in an air-permeable deck, is exerted on the underside of any layer of the construction which is substantially air-impermeable, such as the vapour control layer or the waterproof layer; this pressure, less the appropriate dead weight, should be resisted by adequate mechanical or bonded connections between the air impermeable layer and the deck.

The roof design should take account of possible differential movements within the slab/deck and at junctions with supporting structure, parapets, kerbs and upstands.

Note: Such movements might be caused by movement of the structural frame or by changes of temperature and moisture content.

Limitations of this guidance

The guidance on timber structures is limited of not more than three storey's above ground.

Loading

Balcony/Terrace structure and loading

The design of the roof structure must be in accordance with current regional Building Regulations.

The balcony/terrace of the building shall be constructed so that the combined dead, imposed and wind loads are sustained and transmitted by it to the ground safely, and without causing such deflection or deformation of any part of the building, or such movement of the ground, as to impair the stability of any part of another building.

The roof structure should be of such construction that it has adequate interconnection with the walls, allowing it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

If joists are spanning intermediate beams it is important that the joists are fixed to these beams it is important that this is carried out in accordance with the Structural Engineers specification.

The Designer must establish the intended loadings expected on the balcony/terrace including loads from finishing surfaces such as paving slabs and/ or ballast as well as any potential planting.

Fixings for balustrades must be carefully designed to ensure appropriate fixings are robust and any penetration through waterproof roof coverings are sealed correctly in accordance with the waterproof covering manufacturer's recommendations. Such fixings should not be made through to a wood substrate but to the masonry structure e.g. wooden plates or packing pieces must not be used under the waterproof membrane to secure the balustrade too.

The design of the terrace/balcony should be designed by a suitably quantified Structural Engineer in accordance with BS EN 1995-1: Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

It is important that the deck have adequate prevision to resist wind uplift by being adequately anchored to the main structure.

Allowances for wind loading

In all situations, including ballasted and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.Wind load acting on a balcony will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output. it is important to ensure that the balcony/terrace is securely fixed to the main structure in-accordance with the Structural Engineers design.

Resistance to imposed loads

At the earliest possible stage the employer should define the range of potential imposed loads for which the balcony is to be designed such as planters, storage and public access. In the absence of such a performance requirement the loading limits of the balcony should be defined.

Structural timber

All structural timber used should be stress graded. All such timber must be stamped as either 'DRY' or 'KD' (Kiln Dry). The use of ungraded, or 'green', timber is not acceptable.

Treatment of timber

Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice. Further information can be found in 'Appendix C - Materials, Products, and Building Systems'.

Structural deck

General

At the earliest practical stage, the likely deflection of the deck should be confirmed, to ensure a minimum 1:80 as built fall is maintained. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

Structural decks should be suitable of supporting the intended loads.

The structural deck should be designed by a suitable qualified Structural Engineer. It is important to ensure that the structural deck is installed and fixed in accordance with the Structural Engineer's design.

Insulation of warm decks

The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Compressible materials cannot support imposed loads and are not suitable in warm deck roofs. Warm roofs require the use of rigid insulation, and should be suitably specified to support the any anticipated loads from trafficking across the roof. Insulation in an inverted roof should also have high resistance to water absorption, freeze/thaw cycling and be shielded from UV light.

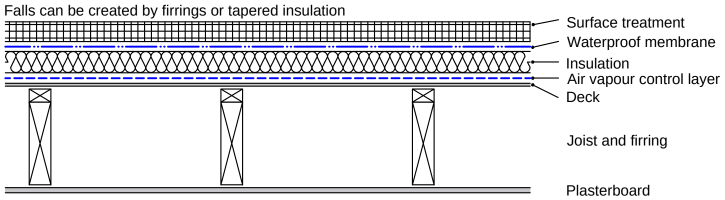
Composite panels (deck/vapour control/insulation)

The suitability of composite panels in providing a combined deck, AVCL and thermal insulation in a single component should be assessed with reference to the loading and hygrothermal conditions in the application. There is no relevant hEN or British Standard. Products suitable for roofing should have current certification by one of the following:

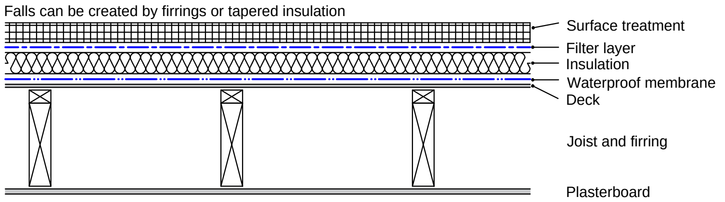
- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

Note: MgO boards and cement particle board is not suitable as a supporting deck. It may be used to clad an abutment or parapet but is not suitable for use with mechanically fastened single ply membrane.

Typical warm deck construction

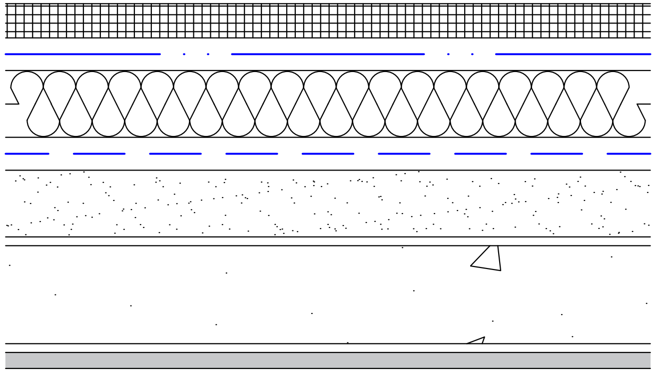


Typical inverted warm deck construction



Typical warm deck construction

Note: Permanent waterproofing should not be installed until the deck has fully dried



Typical inverted warm deck construction

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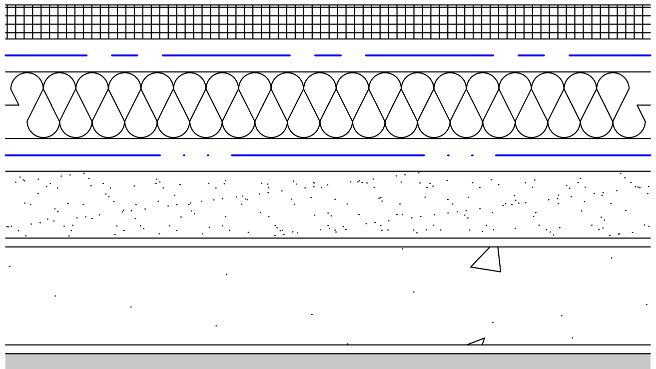


For in situ concrete decks it is important that:

- The form work is adequately and accurately constructed.
- The mix should be one that has relatively low shrinkage characteristics.
- The slab should be adequately protected until cured.

Pre cast concrete decks should:

- Have a minimum of 90mm bearing unless justified by the design.
- Be grouted in accordance with the design, and
- Allowance for movement should be provided at abutments.

Balcony/terrace loading

Statutory requirement

The design for loading should comply with the current Building Regulations.

Resistance to wind load

In all situations, including ballasted and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.

Wind load acting on a balcony will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

It is important that the deck have adequate provisions to resist wind uplift by either being of sufficient self weight or adequately anchored to the main structure.

Resistance to imposed loads

At the earliest possible stage the designer should define the range of potential imposed loads for which the balcony is to be designed such as planters, storage and public access. In the absence of such a performance requirement the loading limits of the balcony should be defined.

Structural deck

General

At the earliest practical stage, the likely deflection in the deck, and the tolerance in the level of its finish, should be confirmed, because this informs the design for drainage. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

Concrete

Precast concrete construction should be designed in accordance with BS 8110. Information on span capability and the installation requirements of precast panels can be obtained from manufacturers. Information on the location of required movement joints should be obtained early in the design process as they have implications for drainage layout and detailing. Precast panels installed to a fall can provide a simple layout but without cross falls.

In-situ concrete construction should be designed in accordance with BS 8110. Concrete decks should be laid to falls wherever possible, concrete maybe more difficult to lay to a fall, and it is common to create falls in the insulation (warm roofs only) or by using an additional screed. Information on compressive strength, resistance to point load and drying periods of wet screeds can be obtained from suppliers and relevant trade associations.

Where structural movement joints are required in large concrete decks, a clearly defined movement joint detail should be constructed to a design and with the materials that afford durability equivalent to that of the roof system.

In precast panel decks the locations of any anticipated differential movement e.g. at perimeter or abutment interfaces or between adjacent panels that are subject to differential loading, must be identified in order that stress is not transferred to the waterproof membrane.

Screeds

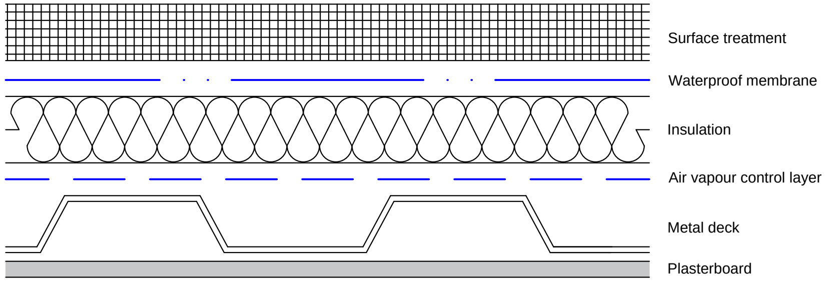
Screeds should be suitably specified for the anticipated loadings, further information can be found in 'Appendix C - Materials, Products, and Building Systems'. Moisture from the construction can become trapped in a roof if the waterproof layer is applied before a concrete slab or screed has had sufficient time to dry out. In situ concrete slabs and cementitious screeds contain large volumes of water which, if not allowed to dry out, can prevent adhesion of the waterproof layer. If bonding to the slab, it is advised that an adhesion test be carried out.

Insulation of warm decks

The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Compressible materials cannot support imposed loads and are not suitable in warm decks. Warm roofs require the use of rigid insulation, and should be suitably specified to support the any anticipated loads from trafficking across the roof. Insulation in an inverted roof should also have high resistance to water absorption, freeze/thaw cycling and be shielded from UV light.

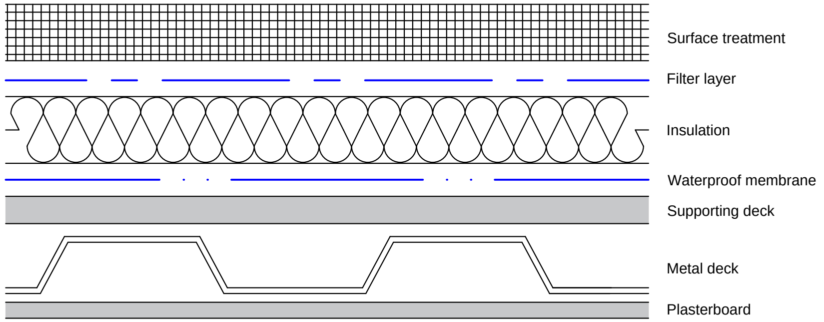
Typical deck construction (warm roof)

Falls can be created by firrings or tapered insulation



Typical inverted warm deck construction

Falls can be created by firrings or tapered insulation



Loading

Statutory requirement
The design for loading should comply with the current Building Regulations.

Resistance to wind load
In all situations, including ballasted and inverted roofs, a calculation of wind load at each zone of the roof to BS EN 1991-1-4 should be undertaken by a suitably competent person.

Wind load acting on a balcony will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

Resistance to imposed loads
At the earliest possible stage the employer should define the range of potential imposed loads for which the balcony is to be designed such as planters, storage and public access. In the absence of such a performance requirement the loading limits of the balcony should be defined.

Insulation of warm decks

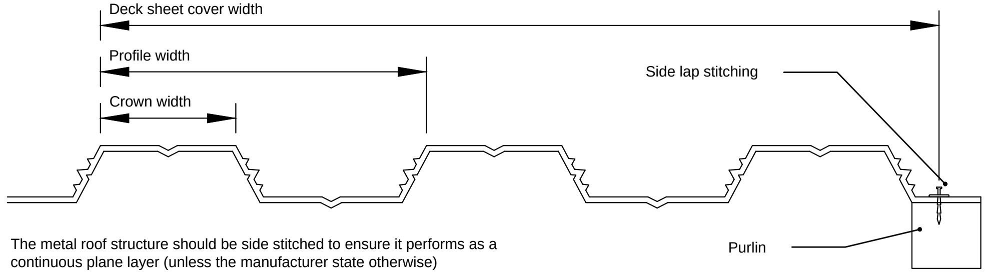
The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Compressible materials cannot support imposed loads and are not suitable in warm decks. Warm roofs require the use of rigid insulation, and should be suitably specified to support the any anticipated loads from trafficking across the roof. Insulation in an inverted roof should also have high resistance to water absorption, freeze/thaw cycling and be shielded from UV light.

Structural deck

General
At the earliest practical stage, the likely deflection in the deck, and the tolerance in the level of its finish, should be confirmed, because this informs the design for drainage. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

Profiled metal (steel or aluminium)
Profiled metal decks should have a crown width at least 50% of the profile width. To provide a sound base for the insulation and waterproofing system, and to avoid reduced drainage performance, the mid-span deflection of the metal deck should not exceed 1/200 of the span under uniformly distributed design loads. When considering the deck profile and the necessity for side lap stitching and metal deck closures, reference should be made to the manufacturers of the deck, insulation and waterproof membrane.

Profiled metal decks: critical dimensions



The metal roof structure should be side stitched to ensure it performs as a continuous plane layer (unless the manufacturer state otherwise)

Profiled metal decks should conform to the following standards:

- Galvanised steel: minimum recommended thickness 0.7mm to BS EN 10346 Fe E280G Z275. Typical gauge range 0.7mm-1.2mm.
- Plain aluminium: minimum recommended thickness 0.9mm to BS EN 485-2 AA3004 H34. Reference should also be made to BS EN 1396 as appropriate.

It is important that the deck have adequate provisions to resist wind uplift by being adequately anchored to the main structure.

Thermal performance

Design for thermal performance must comply with current regional Building Regulations, as appropriate.

Thermal insulation

The thermal insulation should be selected with regard to the following minimum criteria:

- Thermal resistance (and therefore thickness) to suit minimum clearances at details.
- Resistance to compression.
- Compatibility with the AVCL and waterproof membrane.
- Compatibility with adhesives (if insulation is adhered).
- Contribution to the external fire performance of the system.
- Acoustic properties: resistance to external sound is not currently regulated. However, there may be a need to consider attenuation from balconies.

Note: The alternative of a separate acoustic attenuation layer should be considered where appropriate.

Thermal transmittance

Design for thermal transmittance should take account of the effect of thermal bridging within the roof field and at interfaces between the roof system and adjoining elements, such as parapet walls or abutments.

In particular, allowance should be made for the effect of:

- Thermal bridging by metal fasteners used to secure insulation and/or membrane. Thermal break telescopic tube fasteners are recommended to avoid this.
- Thermal bridging due to drainage of rain water or snow-melt through insulation in inverted roofs. The use of a WCM beneath ballast to reduce thermal bridging is recommended.
- The locations of above average thermal transmittance at sumps, gutters or areas of minimum thickness of tapered insulation.

Manufacturers of thermal insulation and WCMs provide certification and calculations of the effects of thermal bridging by fasteners and drainage respectively. Further advice is available in Building Research Establishment BR 262 Thermal insulation: avoiding risks.

Installation of thermal insulation

The attachment of the thermal insulation should be designed to resist calculated wind load by a declared margin of safety. This includes consideration of dead loads required in all roof zones in ballasted warm roofs and inverted warm roofs.

Air permeability

Relevant contract drawings should define the position of the component - the air barrier - that determines resistance to air permeability. This may be achieved by an additional, purpose designed membrane or by an additional function of another component, such as the deck or waterproof membrane.

Control of condensation

Any provision required to control interstitial condensation within the roof should be determined to the calculation method defined by BS 5250, but with ambient conditions set in BS 6229. The calculated maximum accumulation of moisture within thermal insulation should not exceed 350g/m2 and there shall be no net accumulation in any annual cycle.

Air vapour control layer (AVCL)

The AVCL should be selected with regard to the following minimum criteria:

- Ease with which it can be sealed at laps and at abutments to other elements.
- The method of attachment.
- Condensation risk, expressed as calculated vapour pressure based on notional conditions pertaining to the project building.
- Compatibility with the waterproof membrane and thermal insulation.

The following is a minimum recommended specification. The actual specification will depend on the level of vapour resistance required, based on calculation, and the type of deck.

The attachment of the AVCL should be designed to resist calculated wind load by a declared margin of safety. All laps should be sealed and the AVCL should be sealed to the adjoining element, which forms the continuation of the resistance to air permeability. The AVCL should be extended behind all thermal insulation, including insulation placed on vertical surfaces such as parapet walls. Where the roof system is penetrated by a detail such as a pipe or duct, a suitable method for providing continuous vapour control should be provided, and this method should be followed in practice.

Where a reinforced bitumen membrane AVCL is used, its installation should be in accordance with BS 8217.

Minimum recommended specification for AVCL for warm deck roofs

Roof system type	Deck type	AVCL	Attachment
Reinforced bitumen[1] membrane	Profiled metal	S2P3[2]	Partial bond by 3G or approved proprietary alternative
	Concrete	S2P3	Fully bonded
	Timber panel	S2P3	Partial bond by 3G or approved proprietary alternative
High density polyethylene	All	200µ	Loose laid beneath mechanically fixed insulation
High density polyethylene and metal foil laminate	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions
Coated metal foil laminate - self-adhesive	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions

Notes:
(1) Reinforced bitumen membranes: minimum recommended specification based on classification in BS 8747.
(2) S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic); the higher the rating, the higher the performance.

Falls and drainage

Statutory requirement

Design for drainage of the flat roof covering should comply with the current Regional Building Regulations.

British and industry standards

The requirements of BS 6229 should prevail in respect of balconies and terraces, whether or not they form part or the entire roof to occupied parts of a building, and irrespective of the type of waterproof membrane.

Wherever practical, balconies and terraces should be designed to fall away from the building elevation. If this is not practical for reasons of continuity of rainwater services, the falls should be arranged across the balcony, parallel to the elevation.

BS 6229 states that a minimum finished fall at any point of 1:80 (1.25%) should be achieved.

Since adjoining roof planes at 1:80 will meet at a mitre of less than 1:80, the intended finished fall at such intersections should be considered at an early stage.

Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculations, this may necessitate design falls of twice the minimum finished falls (1:40 or 2.5%).

Cut-to-falls systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall. However the use of these systems does not remove the need to check that deck deflection and tolerance is overcome and that a resulting fall in the waterproof membrane of a minimum of 1:80 is achieved. Allowance for deflection is particularly important in designing inverted roofs where calculation of dead loading should be based upon the ballast type and depth to be used.

The manufacturers of certain waterproofing products have certification for their use in 'completely flat' or 'zero falls' applications. For the purposes of this standard the design conditions of BS 6229 shall be assumed to prevail in all balcony/terrace situations.

Consideration should also be given to;

- The available upstand height at the high end of the falls. This may be a limiting factor on the length/size of the balcony/terrace area to be drained. If necessary additional rainwater outlets should be provided.
- Avoidance of ponding behind wide obstructions to the drained slope such as plant plinths or roof lights. Additional rainwater outlets and/or insulation crickets should be provided.
- Avoidance of gutters by designing with intersecting roof planes.
- Falls between rain water outlets along a perimeter.

Since the primary function of the roof is to exclude water, it is important to consider how best to direct this into the drainage system.

Ponding on membrane roofs should be avoided because;

- It encourages the deposit of dirt and leaves, which can be unsightly, may obstruct outlets and/or become a slip hazard.
- In the event of damage, the interior will suffer increased water ingress.
- The load may cause progressive deflection of the deck.
- Ice or algae may create a slip or wind hazard, particularly on walkways.

Independent research has shown that roofs with extensive ponding require increased maintenance input.

Waterproof coverings of all types are tested for water absorption and water tightness as part of third-party certification. However, the construction process, including the installation of components and the forming of seams, is clearly facilitated in dry, well-drained conditions.

Note: Rainwater outlets and downpipes can constitute thermal bridges which may increase the risk of localized condensation; an assessment might be required to determine whether insulated outlets are to be used.

Creation of falls

Roof falls may either be created during the construction of the deck or alternatively by using tapered insulation systems (warm deck systems only).

The creation of falls in the deck should always be attempted because it has the following advantages:

- There will be a consistent thermal environment across the roof.
- The AVCL will also be to a fall.
- If mechanical fasteners are to be used for the waterproof membrane, their length will be constant, which facilitates planning and installation.

Cementitious screeds provide a stable substrate to mitred falls with minimal tolerances, and are recommended. Screeds should be in accordance with BS 8204. Lightweight screeds should be overlaid with a 1:6 (cement to sand) screed topping of a minimum 10mm thickness.

Tapered insulation schemes, suitable for warm deck roofs only, have the following advantages;

- It is possible to create effective drainage layouts to complex plan areas.
- Mitred falls can be created easily to direct rain water to single points where outlets are to be located.

Where falls are created by tapered insulation, the design should ensure that the average U-value and maximum U-value at any point, required by SBEM or SAP calculation, is achieved.

Where the roof finish is to include paving on supports, consideration should be given to the height difference created by the falls and spacing of rainwater outlets so that the maximum height of paving supports is not exceeded, the minimum height of upstands is not affected or trip hazards created. On large balconies and terraces it may be necessary to increase the number of outlets in order to reduce maximum roof zone depth.

Drainage

Drainage design should be based upon calculations in accordance with BS EN 12056 Part 3 given a design head of water (typically 30mm). Rain water outlet capacity should be taken from properly certificated information provided by manufacturers, and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes, such as walkways. The drainage above the waterproof covering and below any raised decking finishes must not be restricted or blocked by the decking supports. The decking supports must allow free drainage of all areas of the roof to the designated outlets.

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- Rainwater outlets should be readily accessible without disruption to the pedestrian finish. On finishes raised above the waterproof membrane (warm deck roofs) or Water Control Membrane (inverted roofs), this may be achieved by a suitably marked paving slab or demountable section of decking.
- Where rainwater downpipes from other higher roof areas or balconies discharge via a lower balcony or terrace, an open downpipe shoe is not permitted. The downpipe should be connected directly to the downpipe serving the lower balcony or terrace.

Rainwater outlets

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Capacity in litres per second at a range of typical water heads.
- Compatibility with the waterproof membrane.
- Integral insulation to avoid condensation.
- Method of attachment.
- Rainwater outlets for inverted roofs should be of the dual height type, designed to maximise removal of rainwater at WCM level.

Roofs which drain to a single internal outlet or combined outlets connected into a single downpipe should be provided with an overflow to drain and warn of outlet/downpipe blockage and so avoid the risk of flooding. The capacity of the overflow should be not less than that of the outlet or combined outlets and its discharge should be visible but directed away from the building. Over flows should be positioned as close to the outlets as possible to avoid rainwater build up on roofs.

Overflows

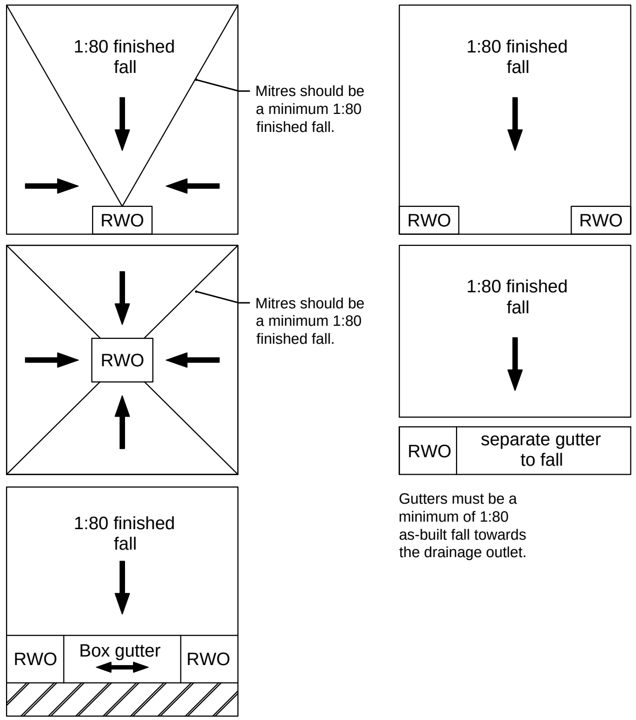
Roofs which drain to a single internal outlet or combined outlets connected into a single downpipe, should be provided with an overflow to drain and warn of outlet/downpipe blockage and so avoid the risk of flooding. The capacity of the overflow should be not less than that of the outlet or combined outlets and its discharge should be visible but directed away from the building. Over flows should be positioned as close to the outlets as possible to avoid rainwater build up on roofs.

If a balcony is served by a single rainwater outlet, an overflow facility of equivalent capacity and clearly visible externally should be provided at or near the same location, no more than 50mm above the level of the waterproof membrane and a minimum of 25mm below any thresholds.

Box gutters

It is not generally necessary to provide separate box gutters where two planes of roofing intersect, or where a single plane falls to an abutment. In the latter case, there will be no fall between outlets, so consideration should be given to creating these in the structure or insulation. Box gutters are slow, difficult to construct and introduce unnecessary complexity. The need to maintain a fall in gutters and comply with the energy requirements of the Building Regulations may be difficult to achieve.

Drainage layout options



Gutters must be a minimum of 1:80 as-built fall towards the drainage outlet.

Siphonic drainage

All waterproof membranes are compatible with siphonic roof drainage systems, which for larger roofs offer many advantages:

- Very high capacity, enabling fewer outlets and therefore less detailing work on-site.
- Smaller bore horizontal collector pipework, enabling reduced roof void depth.
- Self-cleaning in many situations.

Note: Siphonic drainage is generally not appropriate for inverted roofs.

For further information see www.siphonic-roof-drainage.co.uk

These roof proposal are to be considered on a case by case basis and full design and calculations should be submitted for Warranty approval before construction begins on site.

Materials - Requirement

Compatibility of components

The selection of components within the roofing system should be discussed in detail with the membrane manufacturer or appropriate trade association to ensure chemical and mechanical compatibility between components, since the incorrect specification may lead to reduced performance or premature failure of the roofing system. The correct choice of insulation is also important when it is to be adhered to the substrate. In case of doubt, the insulation manufacturer or relevant trade association should be consulted.

General

Materials for use in flat roofing systems are suitable only if the manufacturer has declared compliance with the relevant harmonised European Assessment Document (ETA, previously a European Assessment Guideline, ETAG) and has affixed the CE Mark to the product. All waterproof membrane products shall also have a certificate of fitness for purpose issued by a member of the European Union of Agrément (UEAtc). This may comprise a British Board of Agrément certificate or an equivalent certificate of another UEAtc member.

Requirement

The waterproof membrane should be selected with regard to the following minimum criteria:

- Anticipated service life based on independent certification.
- Minimum maintenance.
- Ease of adaptation and repair.

External fire performance

All roof coverings within close proximity of buildings must achieve the fire designation required by the relevant Building Regulations.

Statutory requirement

Design for external fire performance must comply with current Building Regulations.

Certification of system

The manufacturer of the waterproof membrane must demonstrate by reference to independent test certification that the system of waterproofing and insulation (type and thickness) for a particular project meets or exceeds the minimum level of fire performance defined by the Building Regulations.

Polymeric single ply membranes

The manufacturer should declare compliance with the harmonised European Product Specification for single ply membranes, BS EN 13956, which defines requirements for testing and declaration of characteristic values.

There is no relevant British Standard. Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

Such certification should be accompanied by full instructions for installation.

There is no British Standard for the installation of single ply membranes. Installation should be in accordance with the Single Ply Roofing Association's Design Guide to Single Ply Roofing and with the specific instructions of the membrane manufacturer.

The attachment of the single ply membrane should be designed to resist calculated wind load by a declared safety factor of two times (200%). This design will normally be provided by the membrane manufacturer.

Whatever the means of attachment, specific restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action.

Perimeter restraint is achieved by several methods, depending upon the manufacturer:

- Individual fasteners, protected by a flashing.
- A linear bar, protected by a flashing.
- Welding the field sheet to a membrane-coated metal trim secured to the deck (with thermal break fasteners where appropriate).

If restraint relies upon adhesive alone, the membrane manufacturer shall provide evidence of satisfactory testing for resistance to wind load using a method defined by the Single Ply Roofing Association.

If the remainder of the roof system is to be bonded, it is essential that the design resistance to wind load is also achieved for the attachment of these components.

Irrespective of the wind uplift considerations or distribution requirements for securing the membrane, the fixing of the insulation boards should always be considered separately, unless specifically sanctioned by the membrane manufacturer. The number and distribution of mechanical fasteners required to fix the insulation boards may vary with the insulation type, geographical location of the building, topographical data and the height of the roof concerned.

The upper termination of the single ply membrane at linear details such as plinths, parapets, abutments and door openings should be secured by one of the following mechanical means:

- Clamping beneath a metal rail, e.g. a parapet capping or roof light frame.
- Welding to a membrane-metal laminate trim (itself mechanically fixed).
- Mechanical fixing using individual fasteners or a mechanically fixed termination bar.

The welding of single ply membranes is a critical process. The following should be considered:

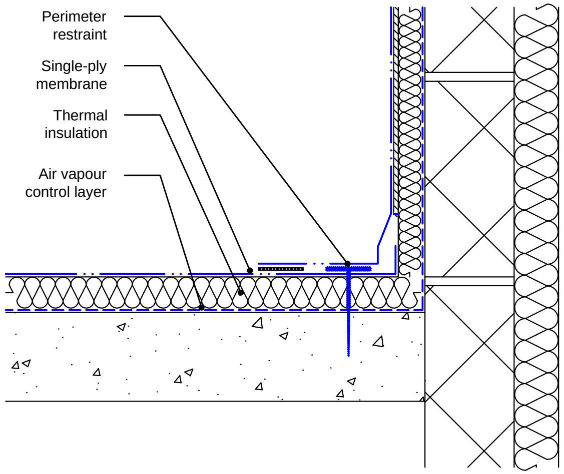
- Supply of certification for each installer indicating successful completion of the manufacturer's product specific training.
- Provision of consistent electrical power supply.
- Production and retention of test weld samples at the start of each day.
- Declared procedures for repair of weak welds or damage.

Warm roof systems with polymeric single ply membranes

Where the insulation is mechanically fixed, the number and arrangement of fasteners required to resist wind load will be prescribed by the manufacturer, applying a safety factor of two to the design load on each fastener. This arrangement may vary across the roof according to wind load, but should be followed in all areas. Thermal break fasteners shall be used wherever feasible.

Where the insulation is adhered, the adhesive should be approved by the insulation manufacturer and should be laid at the coverage rate and pattern designed to achieve calculated wind load with a safety of factor of two times (200%). The contractor should allow for temporary loading as required to achieve a suitable adhesion and to achieve the best possible level in the upper surface of the insulation.

Methods of restraint of a single-ply membrane at perimeters



Liquid applied membranes

There is no harmonised European Product Specification for liquid applied membranes for roofing. The European Technical Approval Guideline ETAG 005 Part 1 - General gives overall guidance on assessment of fitness for use, including methods of verification and attestation of conformity. The remaining seven parts, known as the Complementary Parts or the ETA Parts, deal with specific requirements for particular families of products, and are therefore generic types covered primarily by this Guidance Note, shown as follows:

- Part 2: Polymer modified bitumen emulsions and solutions.
- Part 3: Glass reinforced resilient unsaturated polyester resins.
- Part 4: Flexible unsaturated polyesters.
- Part 5: Hot applied polymer modified bitumen.
- Part 6: Polyurethanes.
- Part 7: Bitumen emulsions and solutions.
- Part 8: Water dispersible polymers.

The manufacturer of a product for use in flat roofing should declare compliance with the relevant parts of ETAG 005. In the absence of this declaration, the product should have a current certificate of fitness for purpose issued by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

Such certification should be accompanied by full instructions for installation.

Installation of Liquid Applied Membranes

There is no British Standard for the installation of liquid-applied membranes. Installation should be in accordance with the Liquid Roofing and Waterproofing Association guidance, as follows:

- Guidance Note No. 2 - Substrates for liquid applied waterproofing.
- Guidance Note No. 4 - Roof, Balcony and Walkway Refurbishment Using Liquid applied Waterproofing Systems.
- Guidance Note No. 5 - Health and Safety Provision for LAWS on Roofs, Balconies and Walkways.
- Guidance Note No. 6 - Safe Use of Liquid applied Waterproofing Systems.
- A consistent film thickness is essential for reliable and durable liquid-applied membranes.

The following should be considered:

- Supply of a card for each installer indicating successful completion of the manufacturer's product-specific training.
- The coverage rate in kg/m^2 must be declared before work starts.
- During installation assessment of wet film thickness by one of the following methods as appropriate:
    - Gauge pin.
    - 'Comb' type measurer.
    - Visual inspection.

Mastic asphalt

There is no harmonised European Product Specification for mastic asphalt for roofing. Products used for flat roofing should comply with BS 6925: 1988 Specification for mastic asphalt for buildings and civil engineering (limestone aggregate).

Proprietary grades of polymer modified mastic asphalt are produced for roofing and paving applications. There is no British Standard or European Standard for these products.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

The separating membrane should be one of the following, and should be laid directly under the mastic asphalt:

- Sheathing felt, comprising a base of flax or jute, or other suitable fibres, impregnated with bitumen.
- Glass fibre tissue.

Bitumen-coated plain expanded metal lathing should be in accordance with BS EN 13658-2.

Stone chippings (bedded) for use as a protective topping should be washed, crushed rock, normally 10mm-14mm nominal size aggregate, bedded in a proprietary gritting solution over the mastic asphalt membrane.

Warm roof systems with mastic asphalt waterproofing

Generally, mastic asphalt on sheathing felt provides sufficient dead load to resist wind load, but this should be demonstrated by calculations in all situations.

Installation of mastic asphalt

The number of coats should be appropriate to the waterproofing requirements and traffic conditions of the roof. When laid to falls of 1:80 or more, mastic asphalt roofing is laid in two coats to a thickness of 20mm, on a separating membrane of sheathing felt, all in accordance with BS 8218.

On sloping and vertical surfaces over 10° pitch, the mastic asphalt should be laid in three coats to a thickness of 20mm without a separating membrane.

On sloping and vertical surfaces of timber or lightweight concrete, the mastic asphalt should be laid in three coats to a thickness of 20mm on expanded metal lathing over a separating membrane of sheathing felt.

Reinforced bitumen membranes

The manufacturer should declare compliance with the harmonised European Product Specification for reinforced bitumen membranes, BS EN 13707, which defines requirements for testing and declaration of characteristic values. There is no relevant British Standard.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément.
- Another member of the UEAtc.
- Another notified body.

In addition, specifications for systems of multi-layer reinforced bitumen membranes for flat roofing should comply with BS 8747.

Minimum recommended specification for reinforced bitumen membranes

Roof system type	Deck type	Insulation type(1)	Venting layer(2)	Underlayer (3)	Cap sheet(4)
Warm deck	Profiled metal	Thermoplastic foam	3G	S2P3(5)	S4P4(5)
		Mineral fibre	-	S2P3	S4P5
	Concrete	Thermoplastic foam	-	S2P3	S4P4
		Mineral fibre	-	S2P3	S4P4
	Timber panel	Thermoplastic foam	3G	S2P3	S4P5
		Mineral fibre	-	S2P3	S4P4
Inverted warm deck	Profiled metal	Extruded Polystyrene (XPS)	3G	S2P3	S4P5
	Concrete		-	S2P3	S4P5
	Timber panel	Deck type not suitable for inverted roofs			

Notes:
(1) Insulation type: Thermoplastic foam: PIR, EPS, PF. Mineral fibre: MW
(2) Venting layer: BS 8747 3G or proprietary equivalent with suitable certification
(3) Under layer: as defined in BS 8747. SBS-modified products are recommended
(4) Cap sheet: as defined in BS 8747. SBS-modified products are recommended
(5) S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic); the higher the rating, the higher the performance

Bitumen membranes should be protected from solar radiation. This should be by integral protection provided in the product in the form of:

- Mineral granules.
- Metal foil.

The use of solar reflective paint is not permitted. The use of stone chippings is not recommended unless required to achieve enhanced external fire performance. If used, chipping's should be washed, crushed rock, normally 10mm-14mm nominal size aggregate, bedded in a proprietary gritting solution.

Warm roof systems with reinforced bitumen membrane waterproofing

The limiting wind load for the different methods of attachment of insulation is prescribed by BS 8217 as follows:

- Partial bitumen bond: up to 2.4kN/m^2.
- Full bitumen bond: up to 3.6kN/m^2.

Where the method of attachment is outside the scope of BS 8217, the manufacturer should demonstrate that the method provides sufficient resistance to wind load.

Reinforced bitumen membranes installation

Installation should be in accordance with BS 8217. In case of doubt, or where the waterproof membrane is beyond the scope of the Standard, the advice of the Flat Roofing Alliance (National Federation of Roofing Contractors) should prevail.

The safe use of gas torches, and the positioning, monitoring and transferring hot bitumen to the work face, should be adopted, all in accordance with the Health and Safety Executive/Flat Roofing Alliance Code of Practice for Safe Handling of Bitumen.

The practice of applying reinforced bitumen membranes by torching onto thermoplastic foam insulation is not permitted, unless the boards are manufactured with a covering of reinforced bitumen membrane.

Site-applied hot-melt coverings

There is no harmonised European Product Specification for site-applied hot-melt waterproofing systems.

Products suitable for roofing should have current certification by one of the following:

- British Board of Agrément
- Another member of the UEAtc
- Another notified body

As these systems comprise a multi-layer application (usually a base coat, reinforcement and top coat), a detailed specification for the system should be available prior to commencement of the works to enable its suitability for the project to be confirmed.

Site-applied hot melt coverings

There is no British Standard for the application of proprietary hot melt waterproof membrane systems. Reference should be made to independent certification and the manufacturer's detailed instructions.

Fixing of guarding/balustrades

Fixings for balustrades must be carefully designed to ensure appropriate fixings are robust and any penetration through waterproof roof coverings is sealed correctly in accordance with the waterproof covering manufacturer's recommendations.

Protection of waterproof system during construction

At the earliest possible stage, the anticipated loading of the balcony, terrace or podium area by plant and access during service should be assessed in terms of:

- Load, e.g. foot traffic, equipment.
- Frequency.
- Risk of impact.

If such usage is intense or long-lasting during the construction phase, consideration should be given to temporary works only, with completion occurring after all non-roofing usage has ceased as follows:

- Warm deck roof system: installation of temporary vapour control layer (VCL) to be overlaid when remainder of system is installed.
- Inverted warm deck roof system: overlay of completed waterproof membrane with geotextile and continuous temporary decking, such as plywood, oriented strand board or compatible recycled thermoplastic board.

Responsibility for temporary protection and a method statement for its use should be agreed prior to the commencement of works. Suitable materials should be selected in consultation with membrane manufacturers as appropriate, for example:

- Linked recycled thermoplastic sheets.
- Rolled recycled thermoplastic or elastomeric sheets.

Particular consideration should be given to locations of concentrated access, such as step-out areas onto the roof or where wheeled equipment may be used.

Provision for access

Statutory requirement

Balconies should have suitable access and drainage meeting the requirements of the current Building Regulations.

Ancillary components

Lightning protection

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Design in compliance with BS EN 62305.
- Method of attachment to the waterproof membrane, including arrangements for self-ballasting of conductors and finials (centres, compressive loads).
- Recommended detailing at penetration of roof system.

Detailing

General principles

At an early stage in the design process, an audit of balcony/terrace geometry should be carried out to establish what types of details will be required and whether they are to be weather proof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in the design of all details:

- Upstands to extend 150mm above finished roof level, except at door access to balconies and terraces.
- Downstands (of separate metal or other flashings) should lap the upstand by a minimum of 75mm.
- Where the balcony or terrace forms part of the entire roof of an occupied building, a continuous barrier to air leakage should be maintained.
- Reliance on sealant as the sole means of protection is not acceptable.

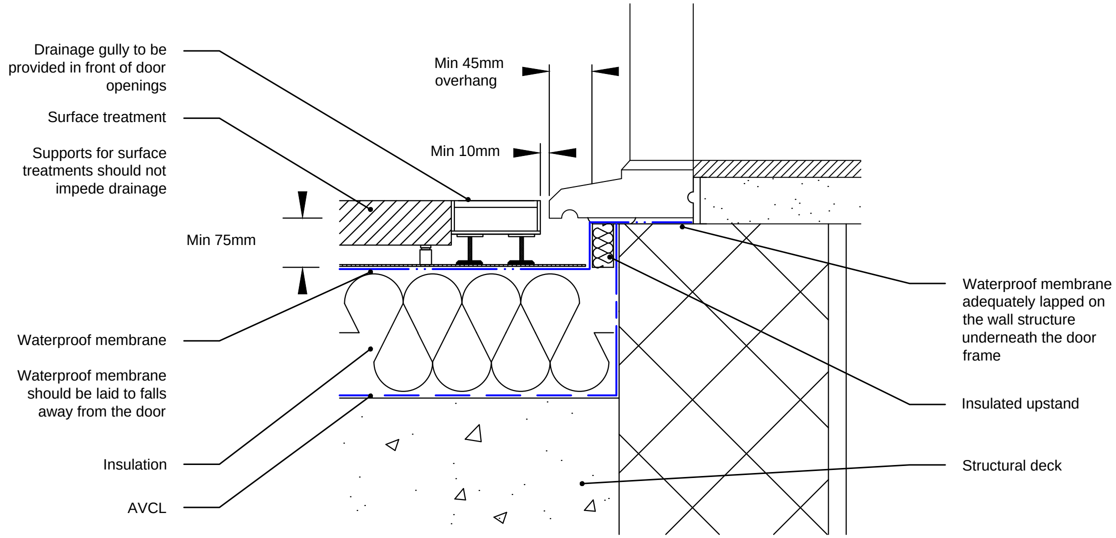
The total roof zone depth should be assessed at critical points, such as the top of drainage slopes, to ensure there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the waterproofed area, except at door access to balconies. Balconies are a frequent and acceptable exception due to the need for level or unobstructed access, provided the recommendations in this section are followed.

Designers should carefully consider the risks of any departure from this criterion. In the event that variation of this guidance is unavoidable a written justification for assessment by the Warranty Surveyor should be provided by the balcony designer.

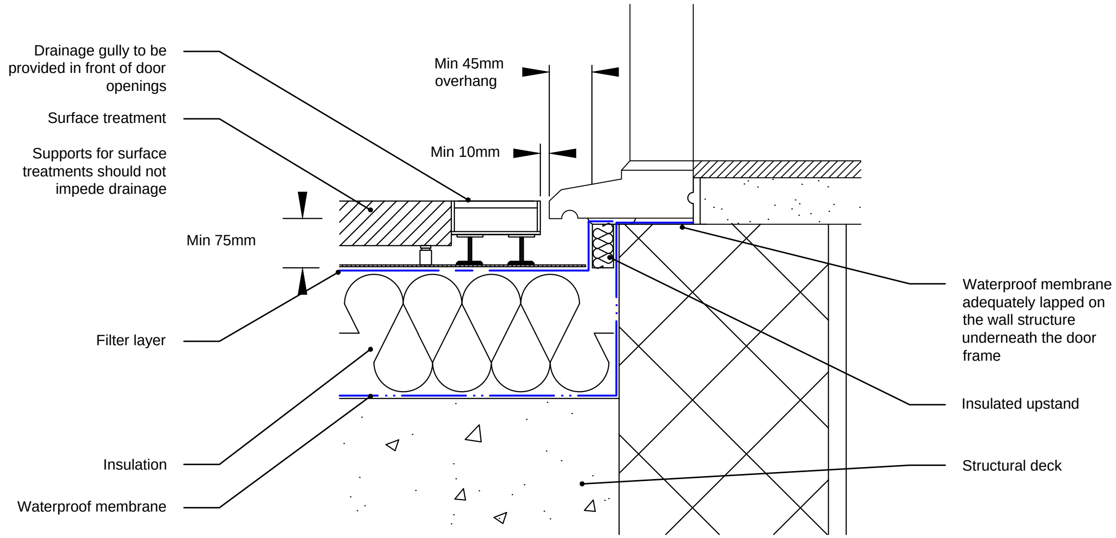
Special design features are essential, depending upon the generic type of waterproof membrane, including:

- Minimum clearances to enable the waterproof membrane to be installed.
- Termination of the waterproof membrane at interfaces to other elements.
- Penetrations.
- Supports.

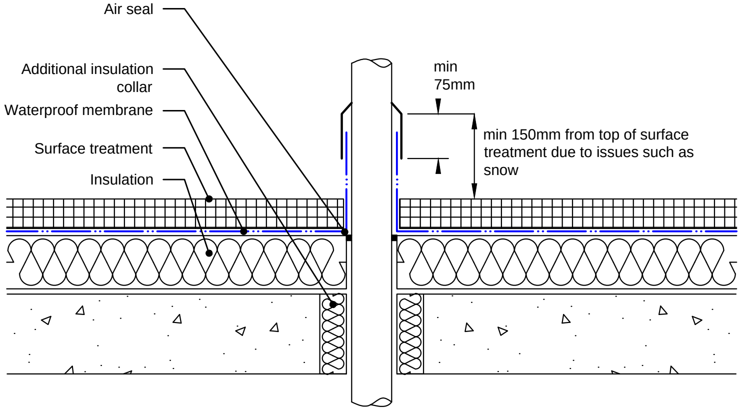
Upstand at door access - Warm deck roof - Level threshold



Upstand at door access - Inverted warm deck roof - Level threshold



Penetration through roof system



Notes:

- A fillet is required at the base of the upstand for certain types of waterproof membrane.
- An effective seal is required between the air vapour control layer and pipe. Clearly it is difficult to dress a sheet material around a pipe. The method for doing so should be stated in the contract drawings and/or specification.

Special design features

Special design features are essential, depending upon the generic type of waterproof membrane, including:

- Minimum clearances to enable the waterproof membrane to be installed.
- Termination of the waterproof membrane at interfaces to other elements.
- Penetrations.
- Supports.

Mechanical and electrical services

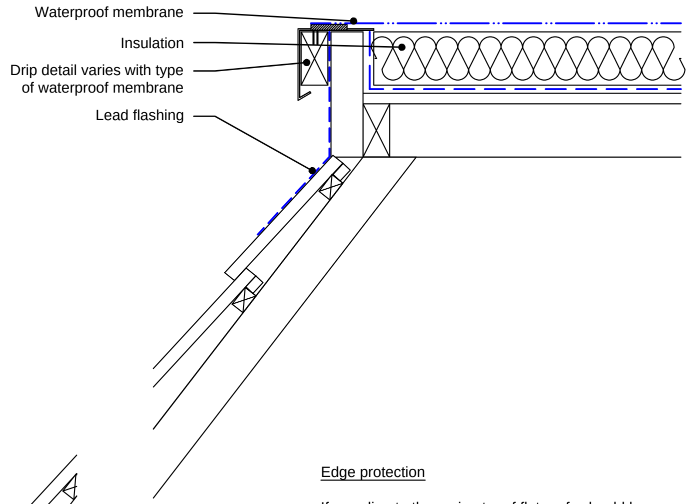
Detailed design should take account of the installation of such equipment by other (usually following) trades, as follows:

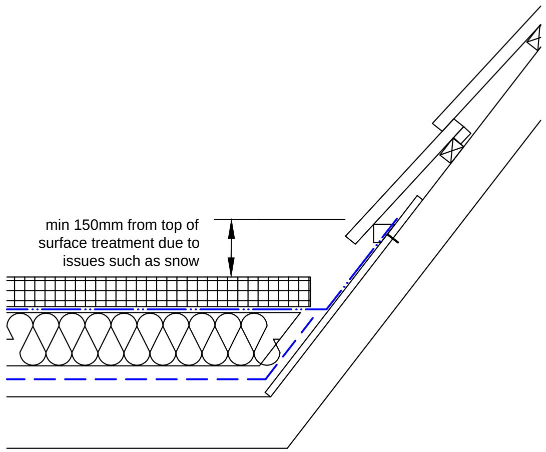
- Service entry/exit points should be suitably weathered to enable connection without loss of integrity of the waterproof membrane and without the involvement of the roofing specialist.
- The upstand of the waterproof membrane at risers should be arranged to enable a separate downstand or weathering flashing to be formed in ductwork.
- Cladding to insulation placed around ductwork should not be sealed to the waterproof membrane.
- Sufficient clearance should be provided to horizontal ductwork to ensure it does not rest upon the waterproof membrane or roof finish.

Renewable energy capture equipment

Renewable energy capture equipment includes photovoltaic panels and multi-panel arrays, solar thermal panels and multi-panel arrays and wind turbines. All such equipment should be secured to a frame and/or posts that transfer their load directly to the structure. The roof system and waterproof membrane should be designed to enable equipment to be de-mounted without loss of the roof's waterproofing integrity and without the involvement of the roofing specialist. Support systems based on 'top-fixed' plate and post components should be accompanied by documentation to demonstrate their compatibility with the waterproof membrane.

Principles: Flat roof interface to pitched roof





Edge protection

If guarding to the perimeter of flat roofs should be designed to provide the simplest means of achieving waterproofing integrity, given that installation of balustrade or stanchions may occur after the installation of the roof system.

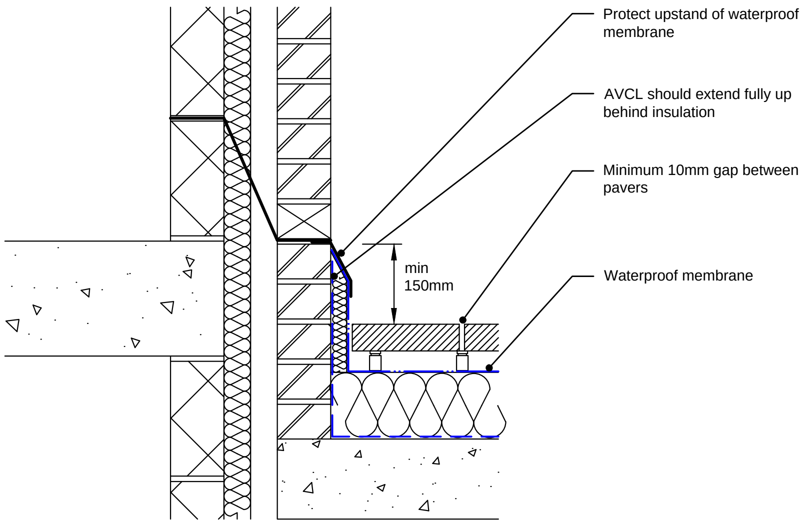
If the design requires a collar of waterproof membrane at the stanchion, the stanchion should be of circular section at this point and should incorporate a weathering apron.

Fall-arrest and edge protection equipment

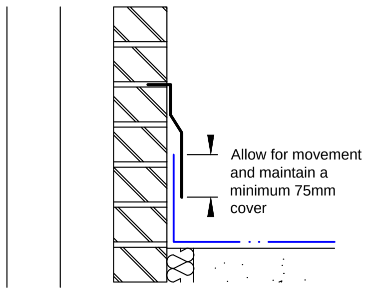
The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Compliance with BS EN 795.
- Method of attachment.
- Compatibility with the waterproof membrane.
- Means of forming a water tight seal to the waterproof membrane.

Upstand to decking and paving finishes e.g where access is required



Timber frame construction where a lower level construction meets a brick outer leaf wall to roof abutment timber frame



Where a timber frame structure abuts a masonry structure allowance should be made to accommodate movement in the timber frame and ensure the appropriate cover is maintained

For detailing with parapet wall construction, see the 'External Wall' section

Edge protection/guarding

The guarding to the perimeter of balconies/terraces should be designed to provide the simplest means of achieving waterproofing integrity, given that installation of balustrade or glazing stanchions may occur after the installation of the roof system.

Acceptable examples include the following, in order of preference:

Full-height parapet walls:

- Stanchions or rails secured to low parapet walls above the level of the waterproof membrane (incorporated in copings or secured to elevation).
- Stanchions secured, clamped and sealed to stainless steel bolts set in raised plinths, which were constructed prior to application of the waterproof membrane (suitable for warm deck and inverted warm deck roof systems).
- Stanchions secured, clamped and sealed to stainless steel bolts set at deck level, which were installed prior to application of the waterproof membrane (suitable for warm deck roof systems only).

If the design requires a collar of waterproof membrane at the stanchion, the stanchion should be of circular section at this point and should incorporate a weathering apron.

Pedestrian access finishes

- The design should include protection to suit the anticipated conditions as appropriate.
- Pedestrian access finish and there supports should not impeded the ability for the balcony to drain to all outlets.
- Supports or pedestals to pedestrian finishes should not be mechanically fixed through the waterproof membrane.
- All pedestrian access finished should comply with the relevant Regional Building regulations in regards to combustibility requirements in regards to a relevant boundary.

Pedestrian finishes for balconies/terraces

Finish	Roof system type		Waterproof membrane type			
	Warm	Inverted	Single Ply membrane	Bitumen membrane	Mastic asphalt	Liquid applied
Porous concrete tiles adhered to waterproof membrane (1)	Y	N	N	Y	Y(2)	Y
Fired tiles bedded in screed and grouted (1)	Y	N	Y	Y	Y(2)	Y
Precast concrete paving slabs on adjustable supports (3,4)	Y	Y	Y	Y	Y	Y

Notes:
(1) Product should be certified for use with waterproof membrane.
(2) Consideration should be given to the effects of solar gain on the stability of mastic asphalt under point loading in this situation.
(3) Paving support pad bearing area should be suitable for the compressive strength of the insulation under design loadings.
(4) Bearers should not impede drainage, and should be sized to suit the compressive strength of the insulation under design loadings.

Non-access areas: stone ballast

Stone ballast for inverted warm deck roofs and ballasted warm deck roofs should be clean, rounded aggregate graded 20mm-40mm and as free from fines as practicable. Ballast should be applied over a protection layer on warm ballasted systems and over a filter layer or WCM on inverted warm roofs.

Access areas: concrete paving slabs

Concrete paving slabs for use as walkways or as paving on terrace decks should conform to BS EN 1340, and be laid in accordance with the manufacturer's instructions.

It is recommended that concrete paving is laid on support pads as this allows adjustment, reducing risk of trip hazard. Recommendations are as follows:

- The height of support pads should not exceed the maximum recommended by the manufacturer.
- Paving should not be cut.
- Paving should be firmly butted up against support pad separating pegs.
- Support pad separating pegs should provide clear space for rapid disposal of rain water between paving slabs.
- Provision for movement at perimeters should comprise either a 75mm margin of washed stone or a compressible rubberised fill. In either case drainage should not be obstructed and a suitable restraint trim should be used to ensure stone does not fall beneath the paving adjacent.

Access areas: flexible walkway tiles

Evidence of the compatibility of the tile with the waterproof membrane is required.

Testing

Final inspection

At practical completion of the balcony/terrace, all areas should be clear of stored material, other site operations and all protection. A thorough, recorded, visual inspection of all areas, including details, should be carried out with representation from the General Contractor and Roofing Contractor in attendance.

Parameters for testing

Upon completion testing of the flat roof covering will be required to be carried out as per the following criteria.

Testing of flat roofs and balconies (All types of materials)

Testing is required in the following situations:

1. On large developments: Apartments etc. over 3 stories in height (including the ground storey), where the total combined roof/balcony areas exceeds 50m^2. In this case, a minimum of 20% of the roof areas must be tested.
2. On Low rise housing: Detached/semi-detached/terraced housing 3 stories or less in height (including the ground storey) when:
   - The roof roof/balcony areas exceed 50m^2.
   - Where the project consists of 10 or more properties: one test per ten houses (with a minimum of two tests per site) are required.

In addition to above, in all cases: Testing may be required in the following situations where the complexity of a roof and its ancillary components presents a higher risk. It will be necessary to identify this at the initial site assessment carried out between the Developer and the Warranty Surveyor:

Design:

1. If the roof includes features beyond a typical wall abutment e.g. (but not limited to); variations of upstand constructions/penetrations/fixings/external permanent machinery/balustrading fittings etc.
2. If the waterproof membrane is to be covered over (by pedestrian finishes or solar panels). Note: Inverted roofs of straightforward design and with continuous hot-applied waterproof membrane could be exempted.

Construction:

3. If there are to be/have been, follow on trades on the roof after completion of the roof covering.
4. If secondary items such as fall protection devices, PV supports, balustrades etc. are to be attached.

Where EPDM roof coverings are proposed, no testing is required if:

1. The EPDM product must has a valid third party product approval certificate.
2. The EPDM covering is installed by one of the manufacturer's approved contractors.
3. And the maximum size of roof is limited to 100m^2.
4. Where the roof area exceeds 100m^2, the proposal must be referred to SPRA for consultation.

Procurement of testing services

If testing to demonstrate waterproofing integrity is required it should be undertaken by a suitably qualified and experienced third-party who is independent of the roofing contractor.

The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films, such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is not recommended as a method of demonstrating the integrity of flat roofs. It may be used to test balconies.

Approved Installers

Where a roof falls into the criteria below, an approved contractor who is recognised by the manufacture as competent to install the manufacturer's roof membrane system will need to be used. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.

A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings in the following situation:

- On large developments over 3 stories in height (including ground storey) where the total combined roof/balcony area exceeds 50m^2.
- Low-rise housing less than 3 stories in height where the roof/balcony area exceeds 50m^2.
- Where the roof includes features beyond a typical wall abutment e.g. (but not limited to) variations of upstand constructions/penetrations/fixings /external permanent machinery/balustrade fittings etc.
- Where the waterproof membrane is to be covered over by pedestrian finishes, balustrades/fall protection devices or solar panels.
- Where EDPM roof coverings are proposed.

Provision of information

Operation and maintenance manual

The following information is required.

Specification, as-built:

- Waterproof membrane: generic type, product(s) and (as appropriate) thickness.
- Thermal insulation: generic type, product(s) and thickness.
- Acoustic insulation: generic type, product and (as appropriate) thickness.
- Vapour control layer: generic type, product (as appropriate) and thickness (as appropriate).
- Rain water outlets: type, product and capacity.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproof membrane.

13.

Chimneys and Flues

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. A commissioning certification is required for any work completed by an approved installer.

Materials

No additional requirements.

Design

1. Chimneys, flues, flue-pipes, fireplace recesses and hearths shall be designed and constructed so that they:
    a. Ensure efficient operation of the fuel-burning appliance for which they have been designed;
    b. Are provided with sufficient air for proper combustion of the fuel;
    c. Are structurally sound and do not adversely affect the structural stability of the building where they pass through floors, walls or roofs;
    d. Protect the structure and fabric of the building from the effects of fire;
    e. Do not adversely affect the ability of the building to resist the effects of weather and ground moisture;
    f. Discharge the products of combustion safely to the outside air.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

13.

Chimneys and Flues

13.1

Masonry

MASONRY: Chimney flashings and weathering details

Weathering requirements

If the chimney is in a severe exposure zone the cavity should extend around the outside of the stack and be continuous up to roof level, as per BS 5628, Part 3. Where the chimney breast is gathered in, the lower projecting masonry should be protected with a suitable capping and cavity trays. A 50mm cavity at the back of the chimney breast is maintained to prevent rainwater penetration. Further information can be found in the 'External Wall's section.

Corrosion of lead work

Where free lime from mortar comes into contact with lead trays or flashings (due mainly to the continual saturation of the brickwork) in areas such as chimneys, the lead should be protected from corrosion by the use of a thick coat of bitumen paint covering the faces likely to be in contact with the mortar. The protection against corrosion of lead work buried in mortar is suggested in guidance issued by the Lead Sheet Association. This treatment can also reduce the staining of lead and brickwork. It is unnecessary to treat flashings buried only 40mm-50mm into mortar joints (cover flashings), as this close to the drying surface the carbonation of free lime is rapid and there is no risk of corrosion in such circumstances.

Chimney tray - low level

A chimney tray is required at low level where a cavity-walled chimney with brick shoulders is built onto an external wall. The tray prevents water that may enter the shoulders from penetrating to the inner leaf of the wall.

The material used is 1mm aluminium alloy sheet to BS EN 485-2; Aluminium and aluminium alloys. Sheet strip and plate, mechanical properties. This has a higher melting point than lead, so is suitable for installation close to a heat source.

Chimney tray - high level

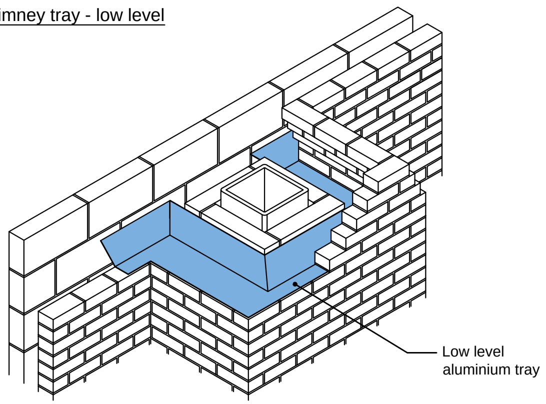
A high level tray may be required to prevent the entry of water at high level where a chimney rises through a pitched roof; suitable for new build or remedial work, this minimises disturbance to surrounding construction in remedial work.

The material used is lead sheet to BS EN 12588:2006 Lead and lead alloys. Rolled lead sheet for building purposes. Code 4 as standard. Standard sizes are 800mm x 800mm, 900mm x 900mm, 950mm x 950mm, to suit either a 195mm square or 195mm diameter circular flue.

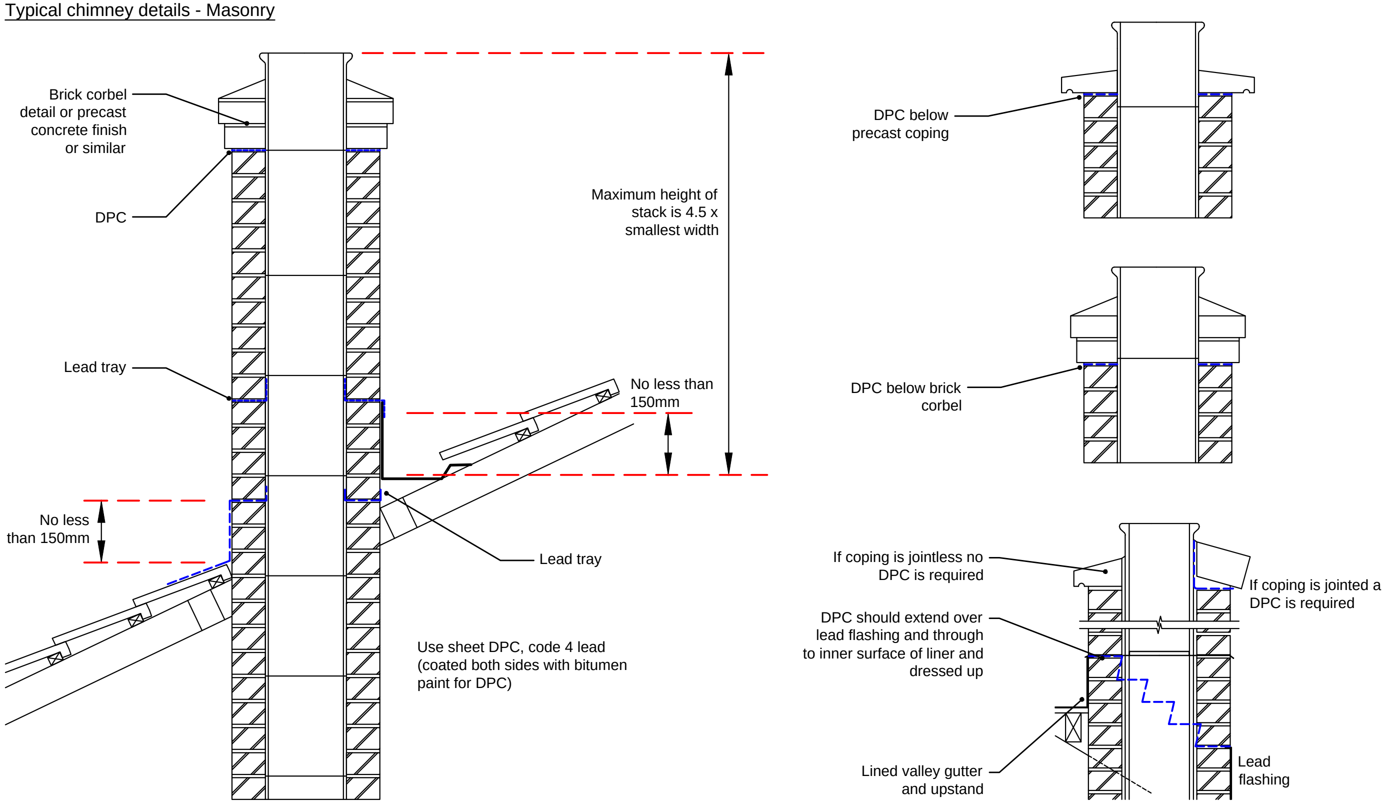
Lead work

Lead sheet used for roofs, flashings and weathering's should, in terms of suitability, be in accordance with BS EN 12588 or a UKAS (or European equivalent) valid third-party accreditation (e.g. British Board of Agrément, BRE, etc.) which demonstrates adequacy and durability for use (see 'Appendix C - Materials, Products, and Building Systems).

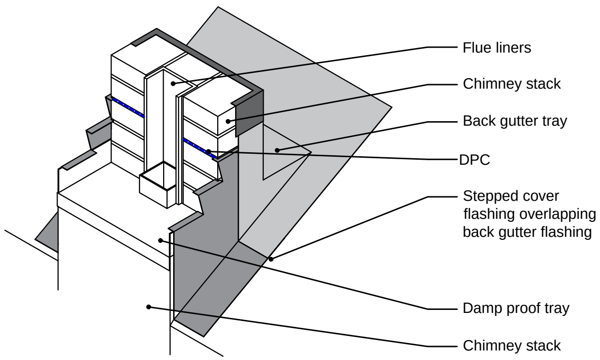
Chimney tray - low level



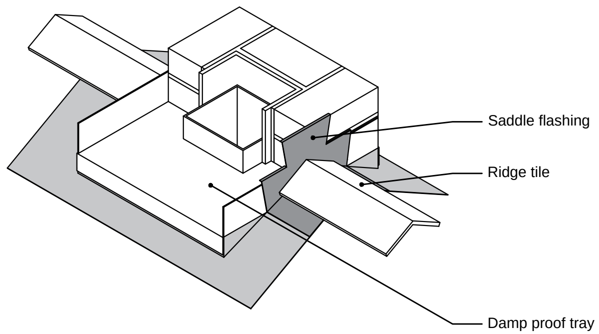
Typical chimney details - Masonry



Typical flashings to chimneys



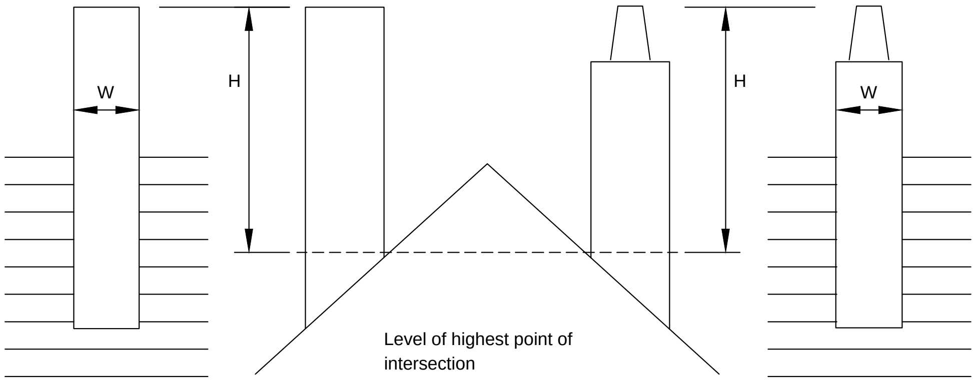
Flashings to chimneys at ridge



Support

If a chimney is not provided with adequate support using ties or not securely restrained, its height (measured to the top of the chimney) should not exceed 4.5 times its least horizontal dimension when measured from the highest point of intersection with the roof surface (density of masonry must be a minimum of 1500kg/m^3).

Proportions for masonry chimneys



Key:
W - is the least horizontal dimension of the chimney measured at the same point of intersection.
H - is measured to the top of any chimney pot or other flue terminal.

Chimneys and flues

Flue liners should be used as specified with sockets uppermost and jointed with fire-resisting mortar. Flue liners should be:

- Non-combustible.
- Reasonably smooth internally.
- Correctly jointed with mortar with the space between the liners and the brickwork filled with weak insulating concrete, unless the manufacturer recommends an alternative specification.
- Properly jointed at the junctions with the starter block or lintel and outlet terminal.

A notice plate containing safety information about any hearths and flues should be securely fixed in an unobtrusive but obvious position within the building.

Where a chimney forms part of a wall, the foundation should project at least 100mm wider than the chimney base and should be the same depth as the adjacent wall foundation. Factory made insulated chimneys should have a life of at least 30 years and be designed in accordance with BS 4543 and BS EN 1859, and installed in accordance with BS 7566. Where a chimney is not directly over an appliance or opening, a soot box accessible for emptying should be formed.

Render directly applied to masonry chimney

Rendering to chimneys should only be carried out where the masonry contains little or no sulphates. An appropriate specialist sealer/bonding key coat should be applied prior to applying the main coat of render.

A proprietary alkaline resistant mesh should be embedded throughout the render, the key coat should provide a sound substrate and be compatible with the subsequent render system.

A specialist render system and mortar should be employed for chimneys with a masonry background.

Traditional hand mix render using standard sand and cement is not accepted. Only a pre-blended bagged render system will be accepted as a suitable render system that has a third party accreditation such as BBA or ETA certification and backed up with a manufacturer's specification.

The chimney which is to be rendered should be examined for excessive moisture content prior to rendering. This is particularly important where the masonry background has no upper limit on its soluble salt content, e.g. 'N' designation clay bricks.

Ensure that all joints are finished flush with the surface to avoid shade variations.

To minimise the potential for differential thermal movement and effects that the different suction that each type of background material may create; the section of walling to receive the render should be constructed using the same type and density of material throughout.

To control suction always apply a specialist sealer key coat or suitable render preparatory coat. Allow a minimum of 48 hours for the key coat to fully dry before applying the next coat.

It is recommended that throats or drips to chimneys should project beyond the finished faces to throw water clear, a minimum of 40mm to the drip.

Angles, stop beads and jointing sections should be secured with drilled or shot-fired fixings, and not with gypsum plaster.

For further guidance, please see the 'External Walls - Traditional Masonry Cavity Wall - Rendered Masonry Clad' section.

Coastal Locations

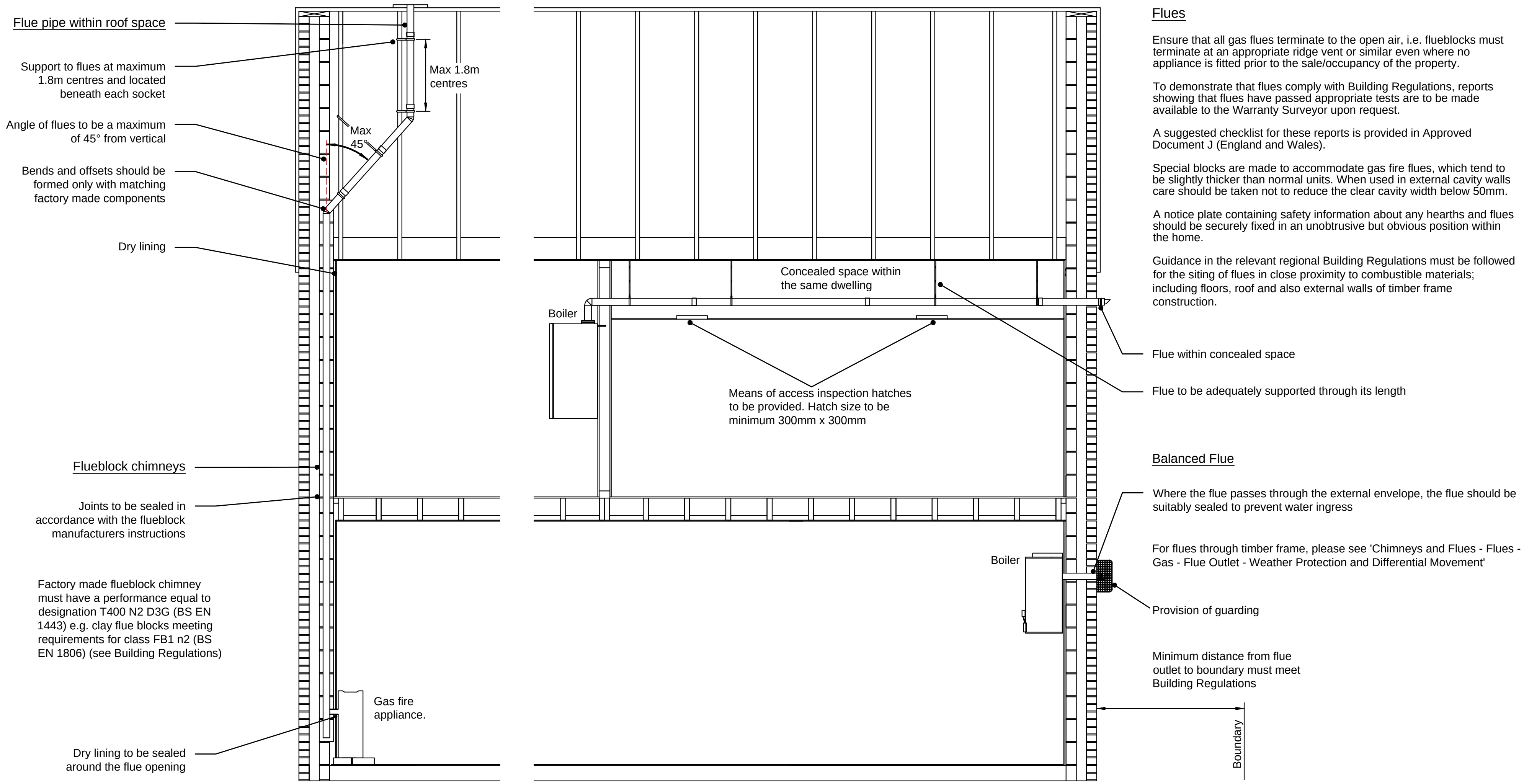
For the selection of construction materials and additional design requirements that may apply in coastal locations please refer to 'Appendix B - Coastal Locations' and 'Appendix C - Materials, Products, and Building Systems'.

13.

Chimneys and Flues

13.2

Flues - Gas



Flue block chimneys in masonry cavity walls

Flues for gas appliances

Flues

Ensure that all gas flues terminate to the open air, i.e. flueblocks must terminate at an appropriate ridge vent or similar even where no appliance is fitted prior to the sale/occupancy of the property.

To demonstrate that flues comply with Building Regulations, reports showing that flues have passed appropriate tests are to be made available to the Warranty Surveyor upon request.

A suggested checklist for these reports is provided in Approved Document J (England and Wales).

Special blocks are made to accommodate gas fire flues, which tend to be slightly thicker than normal units. When used in external cavity walls care should be taken not to reduce the clear cavity width below 50mm.

A notice plate containing safety information about any hearths and flues should be securely fixed in an unobtrusive but obvious position within the home.

Guidance in the relevant regional Building Regulations must be followed for the siting of flues in close proximity to combustible materials; including floors, roof and also external walls of timber frame construction.

Balanced Flue

Concealed flues

Where a flue is routed within a void, appropriate means of access should be provided to allow visual inspection of the flue.

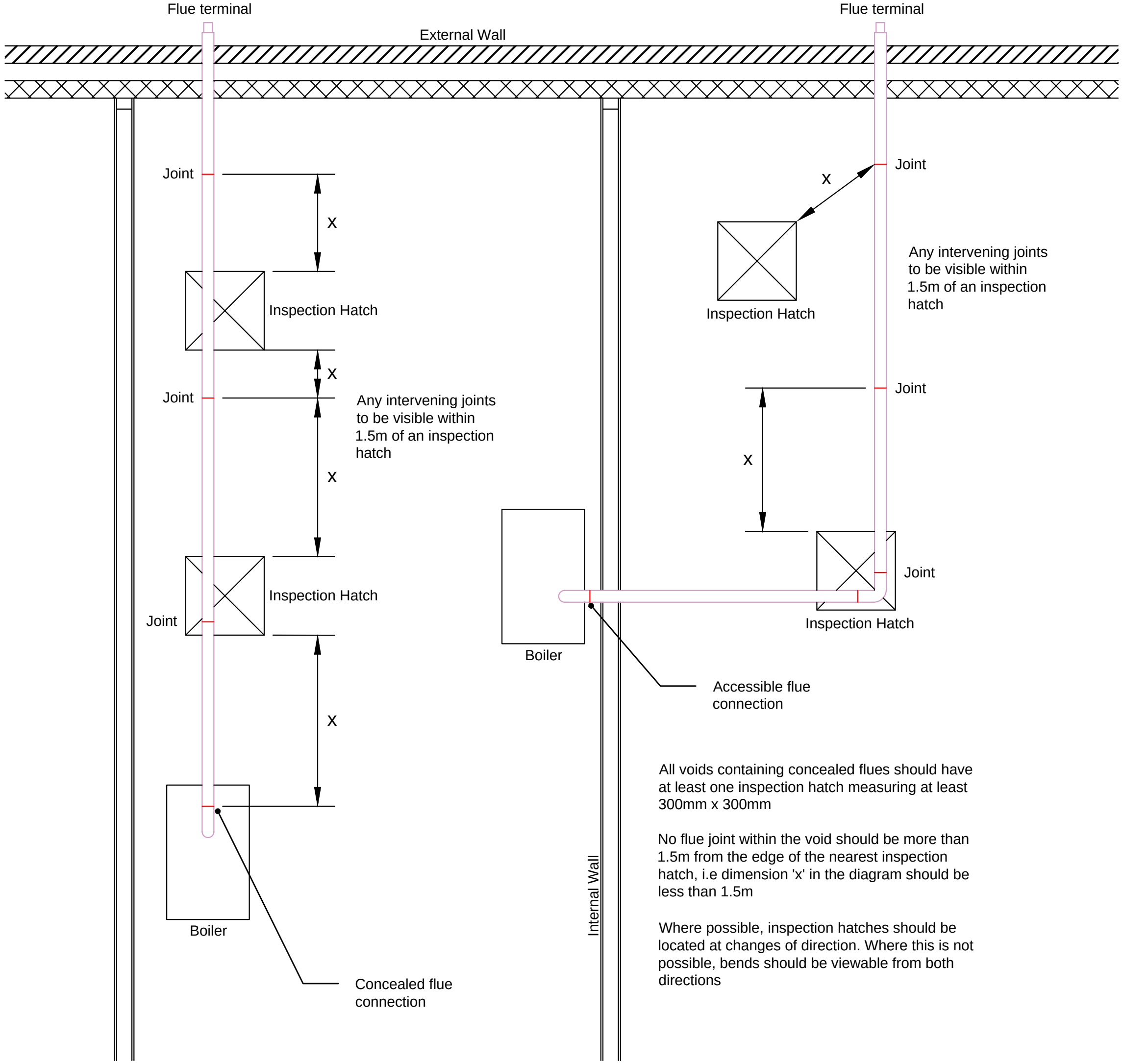
Means of access should be:

- Sufficiently sized and positioned to allow visual inspection to be under taken of the flue.
- The access hatch should be at least 300mm x 300mm or larger where necessary, to allow sufficient access to the void to look along the length of flue.

Means of access should not:

- Pass through another dwelling since access for inspection may not always be available to that dwelling and flue system running through it. (flues may pass through communal areas including purpose- designed ducts where inspection access is provided).
- Impair any fire, thermal or acoustic requirements of the relevant building regulations.

Example locations of access panels for concealed flues



All voids containing concealed flues should have at least one inspection hatch measuring at least 300mm x 300mm

No flue joint within the void should be more than 1.5m from the edge of the nearest inspection hatch, i.e dimension 'x' in the diagram should be less than 1.5m

Where possible, inspection hatches should be located at changes of direction. Where this is not possible, bends should be viewable from both directions

Minimum separation distances for terminals in mm (England and Wales)

Location		Balance flue			Open Flue	
		Natural draught		Fanned draught	Natural draught	Fanned draught
A	Below an opening (1)	Appliance rated head input (net)		300	(3)	300
		0-7kW >7-14kW >14-32kW >32kW	300 600 1500 2000			
B	Above an opening (1)	0-32kW >32kW	300 600	300	(3)	300
C	Horizontally to an opening (1)	0-7kW >7-14kW >14kW	300 400 600	300	(3)	300
D	Below gutters, soil pipes or drainpipes	300		75	(3)	75
E	Below eaves	300		200	(3)	200
F	Below balcony or car port roof	600		200	(3)	200
G	From a vertical drainpipe or soil pipe	300		150(4)	(3)	150
H	From an internal or external corner or to a boundary alongside the terminal (2)	600		300	(3)	200
I	Above ground, roof or balcony level	300		300	(3)	300
J	From a surface or a boundary facing the terminal (2)	600		600	(3)	600
K	From a terminal facing the terminal	600		1200	(3)	1200
L	From an opening in the car port into the building	1200		1200	(3)	1200
M	Vertically from a terminal on the same wall	1200		1500	(3)	1500
N	Horizontally from a terminal on the same wall	300		300	(3)	300
P	From a structure on the roof	N/A		N/A	1500mm if a ridge terminal. For any other terminal, as given in BS5440-1:2008	N/A
Q	Above the highest point of intersection with the roof	N/A		Site in accordance with manufacturers instructions	Site in accordance with BS 5440-1:2008	150

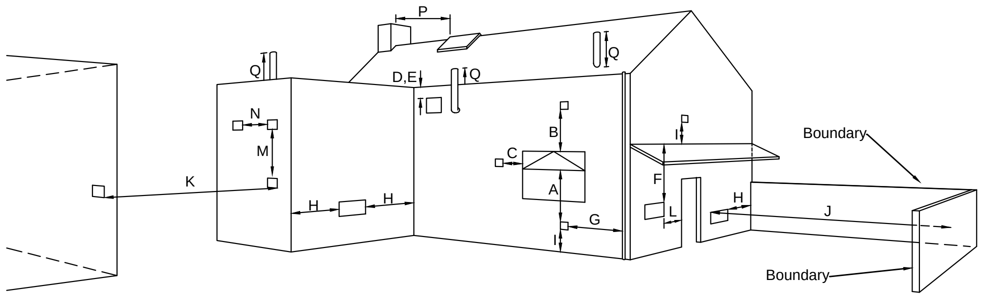
Notes:
1. An opening here means an openable element, such as an openable window, or a fixed opening such as an air vent. However, in addition, the outlet should not be nearer than 150mm (fanned draught) or 300mm (natural draught) to an opening into the building fabric formed for the purpose of accommodating a built- in element, such as a window frame.
2. Boundary as defined in paragraph 0.4 (4) of Approved document J. Smaller separations to the boundary may be acceptable for appliances that have been shown to operate safely with such separations from surfaces adjacent to or opposite the flue outlet.
3. Should not be used.
4. This dimension may be reduced to 75mm for appliances of up to 5kW input (net).
N/A means not applicable.

Location of outlets from flues serving gas appliances (reproduced from Approved Document J Building Regulations England and Wales).

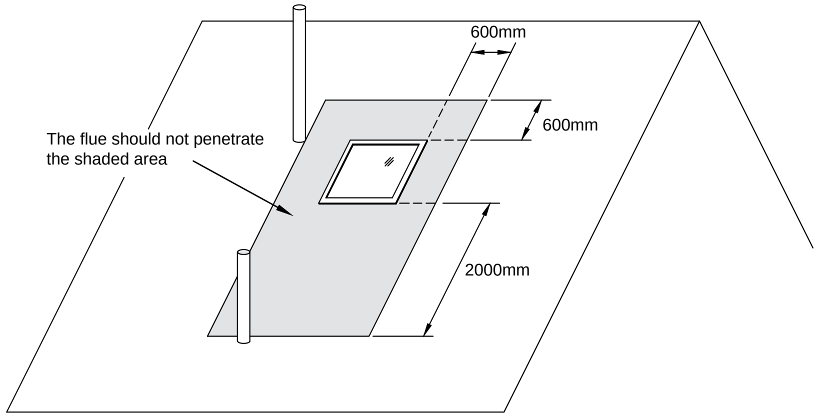
Requirements may differ in Scotland please refer to the Scottish Building Regulations for further information.

Location of flue outlets

Flues serving gas appliances should be located as shown in the images below, and the table to the left.



Location of outlets near roof windows or openings, on pitched or flat roofs, from flues serving gas appliances



Reproduced from Approved Document J Building Regulations England and Wales.

Guarding to flues

A flue outlet should be protected if persons could come into contact with it or if it could be damaged. If a flue outlet is in a vulnerable position, such as where the flue discharges within reach from the ground or a balcony, veranda or window, it should be designed to prevent the entry of any matter that could obstruct the flow of flue gases.

External weather tightness

- Where flues pass through the external wall construction (external weather proof envelope), they must be suitably sealed to protect against water ingress.
- A proprietary cavity tray may be required to be inserted over the flue if the flue opening in the external wall is formed after the external wall is completed.

Gas flues passing through chimneys

Where a gas flue passes through an external masonry chimney, please see the 'Chimneys and Flues - Masonry' section for further guidance.

Lead work

Lead sheet used for roofs, flashings and weathering's should, in terms of suitability, be in accordance with this Technical Manual, or be in accordance with BS EN 12588 or a UKAS (or European equivalent) valid third-party accreditation (e.g. British Board of Agrément, BRE, etc.) which demonstrates adequacy and durability for use (see 'Appendix C - Materials, Products, and Building Systems').

External masonry

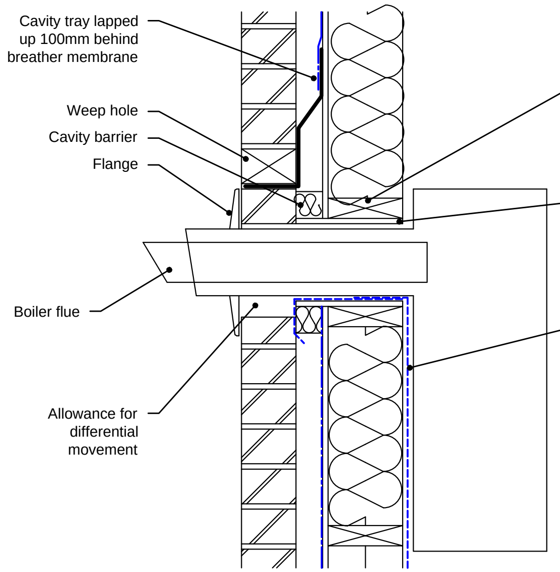
For further guidance on masonry construction see the 'External Walls' section.

Differential settlement

Allowance should be made within the structure for differential settlement around flues, as well as ensuring the water tightness of the external envelope is maintained.

- Where core drilling is used to create an opening in the external masonry cladding to timber frame or metal frame buildings; it should be ensured that suitable allowance is made for differential settlement within the external masonry.
- The core drill hole created in masonry cladding, will have to be elongated downwards to allow for the timber frame shrinking and the flue pipe moving with it.
- Care should be taken to ensure that the depth of the external flange is suitable to maintain weather tightness at the time of construction and once differential settlement has occurred.
- Cavity trays should be provided where appropriate.

Differential movement at services - Timber frame



Note: Internal linings and insulation has not been shown for clarity. A service void may be specified. Sufficient support and fixings for boiler may be provided with noggings or board material between studs or service void battens

The installation of extractor vents is similar

14.

Driveways and Paving

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

1. External timber used in decking and supports should be adequately treated or finished to resist insect attack. Timber treatment should be in accordance with the relevant British Standards and Codes of Practice.

Design

2. External vehicular and pedestrian access routes to the principal entrance shall be designed and constructed so that they:
   a. Permit safe and convenient access from the highway;
   b. Are of sufficient width;
   c. Are durable and weather resistant;
   d. Reasonably level and consistent with adjacent features;
   e. Suitably drained to prevent water logging of the ground near the building.

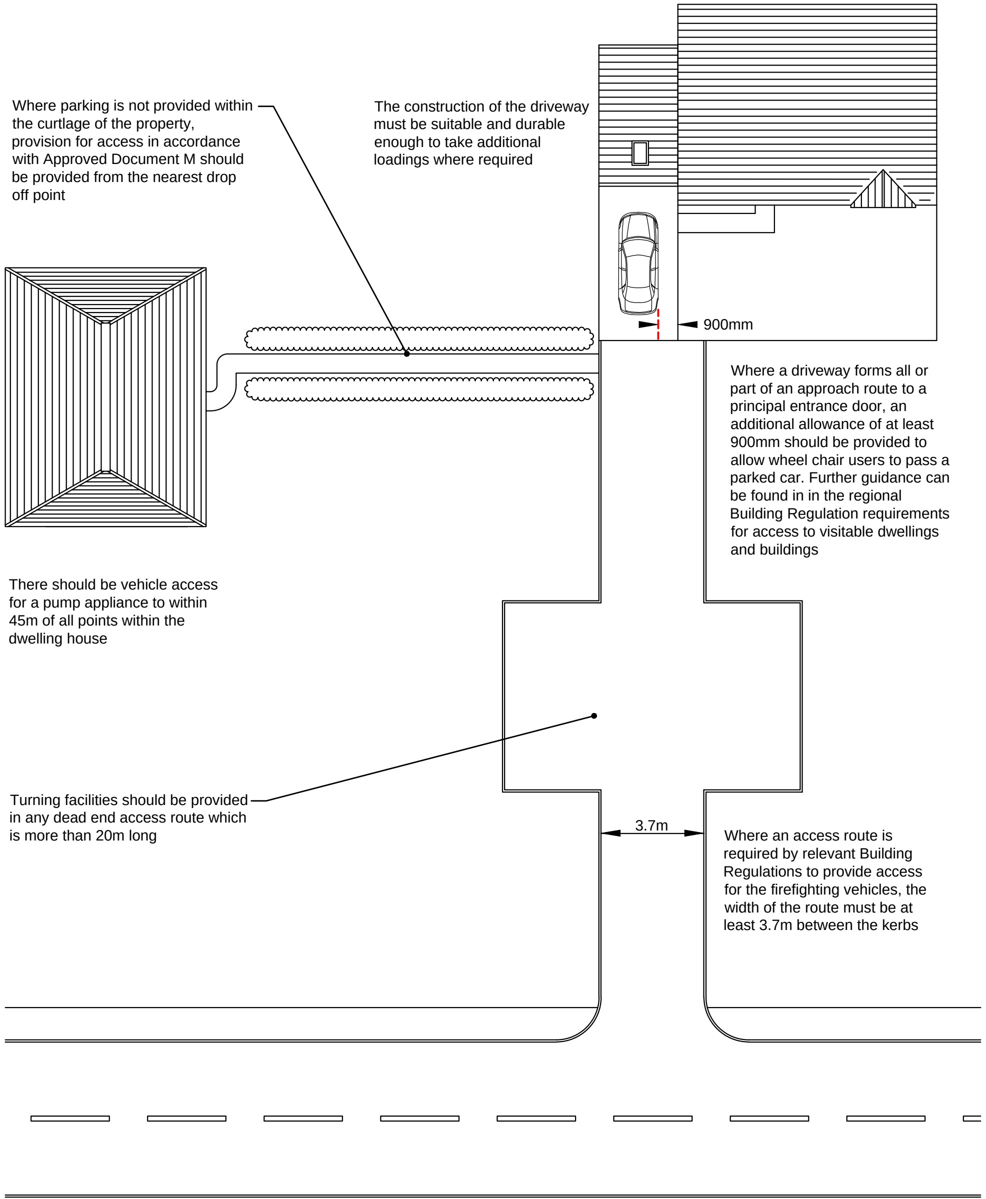
Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

14.

Driveways and Paving

14.1 Driveways and Paving



Vehicle access

Where a driveway is required by relevant Building Regulations, to provide access for fire fighting vehicles to allow a "pump" appliance to be able to get to within 45m of the entire dwelling house, the construction of the driveway must be suitable and durable to take the additional loadings (at least a minimum of 12.5 tonnes). The access width of the drive must be adequate (at least 3.7m) and if the driveway length is in excess of 20m a turning circle or hammer head should be provided (see image below 'Turning facilities').

A vehicle access route maybe a road of other route which, including any inspection covers should meet the requirements in the table below 'Typical fire and rescue service vehicle access route specification'.

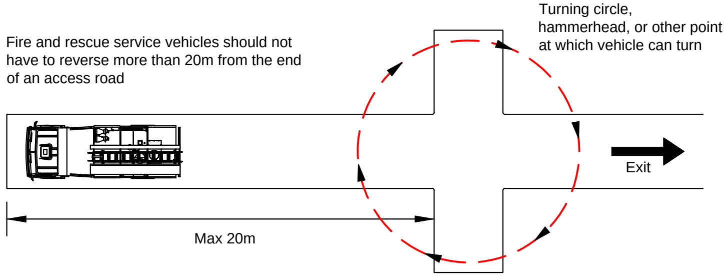
Typical fire and rescue service vehicle access route specification

Appliance type	Minimum width of road between kerbs (m)	Minimum width of gateways (m)	Minimum turning circle between kerbs (m)	Minimum turning circles between walls (m)	Minimum clearance height (m)	Minimum carrying capacity (tonnes)
Pump	3.7	3.1	16.8	19.2	3.7	12.5
High reach	3.7	3.1	26.0	29.0	4.0	17.0

Notes:
1) Fire appliances are not standardised. Some fire and rescue services have appliances of greater weight or different size. In consultation with the fire and rescue authority, the Building Control Body (BCB) may adopt other dimensions in such circumstances.

2) Because the weight of high reach appliances is distributed over a number of axles, it is considered that their infrequent use of a carriageway or route designed to 12.5 tonnes should not cause damage. It would therefore be reasonable to design the road base to 12.5 tonnes, although structures such as bridges should have the full 17 tonnes capacity.

Turning facilities



Limitations of the Technical Manual Functional Requirements

This guidance for drives and external pathways only applies to a drive and pathway that leads to the principal entrance to the visitable dwelling/building.

Driveway construction

Sub-base

A suitable sub-base that is capable of supporting the finished surface material should be provided. Suitable sub-base material is considered as:

- Weak mix concrete ST1 (site mixed acceptable).
- Well graded crushed stone or recycled concrete (minimum aggregate size 75mm).

The minimum thickness of sub-bases are indicated in the below table.

Minimum thickness of sub-bases

Use of surface	**Min sub-base thickness**	**Comments**
Pathway	75mm	
Driveway (light duty)	100mm	Light domestic traffic
Driveway (medium duty)	150mm	Suitable for carrying small lorries e.g. refuse, vehicles, or fuel delivery

Crushed stone or recycled aggregate sub-bases should be well compacted to adequately support the pathway or drive (see the table below). Where the ground below the sub-base is weak or soft (typically <10% CBR), the sub-base should be designed by a Structural Engineer.

Suitable compaction of sub-bases

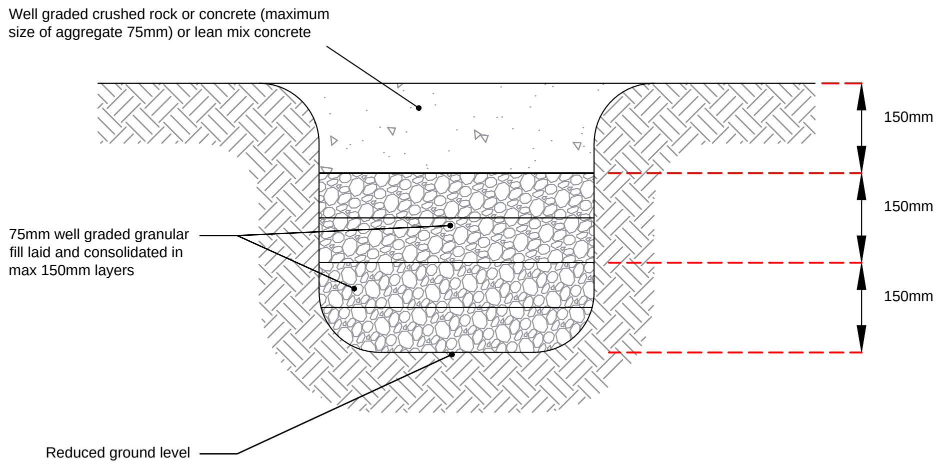
Compactor type	Compactor size	Minimum number of passes	
		100mm sub-base	150mm sub-base
Vibrating plate	1400-1800kg/m² 1800-2000kg/m² >2000kg/m²	8 5 3	Unsuitable 8 6
Vibrator roller	700-1300kg/m width 1300-1800kg/m width 1800-2300kg/m width	16 6 4	Unsuitable 16 6
Engine driven vibro-tamper	<65kg 65-75kg >75kg	5 3 2	8 6 4

Preparation of ground

The area to be surfaced should be prepared by stripping away all vegetation and organic material. Land drainage should be considered for ground that is saturated.

Excavation trenches e.g. service trenches, should be backfilled with granular type material to the required level. The backfill should be compacted in layers no greater than 150mm, and the fill material should at least have the same bearing capacity as the adjacent ground.

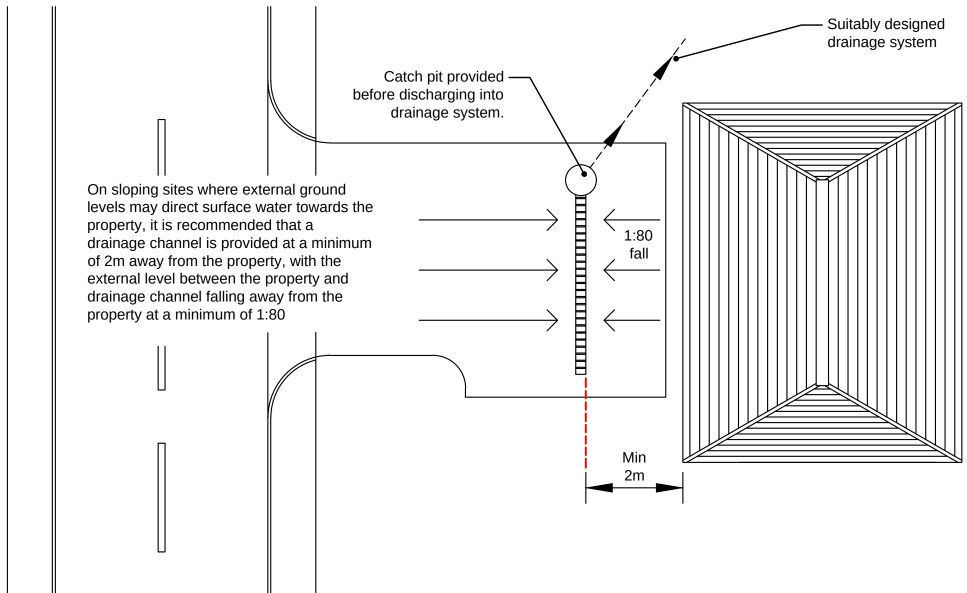
Backfilling of trenches



Retaining walls

Retaining walls are outside the scope of this guidance, however where a retaining wall provides support to the structure or the primary entrance to the property they should be designed by a suitably qualified Structural Engineer.

Sloping sites towards property



When a drainage channel is provided, it must be connected to the storm drainage system to prevent flooding occurring and water ingress into the building. An accessible silt trap should also be included to prevent excess debris entering the system.

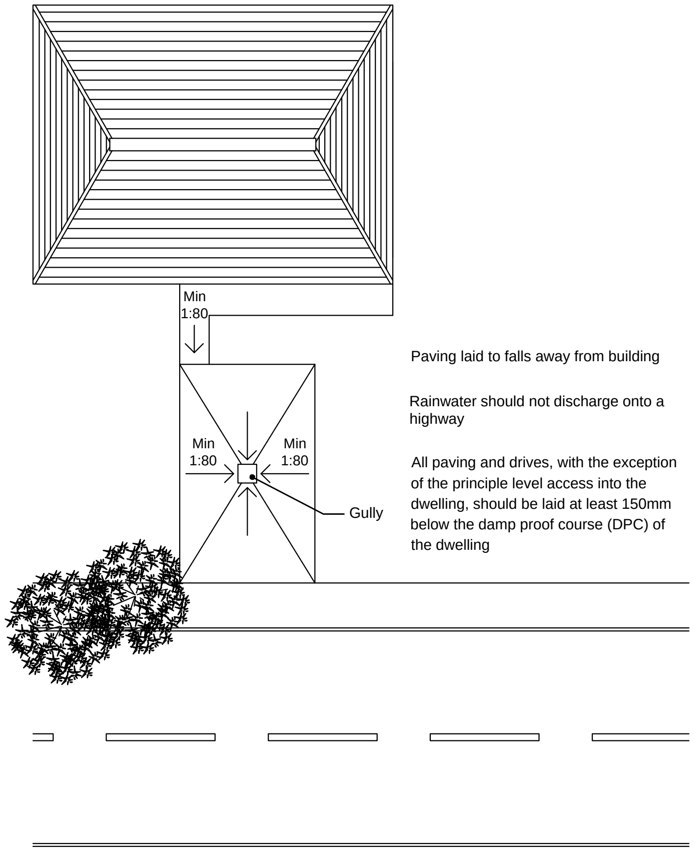
Where slotted surface water drainage channels are proposed to be used near the building (e.g. in front of garage door openings) and the ground levels would otherwise cause water to concentrate towards the building wall and potentially flood the building; a gradient should be created for at least 2m away from the wall of the building to divert the water towards the slotted drain channel.

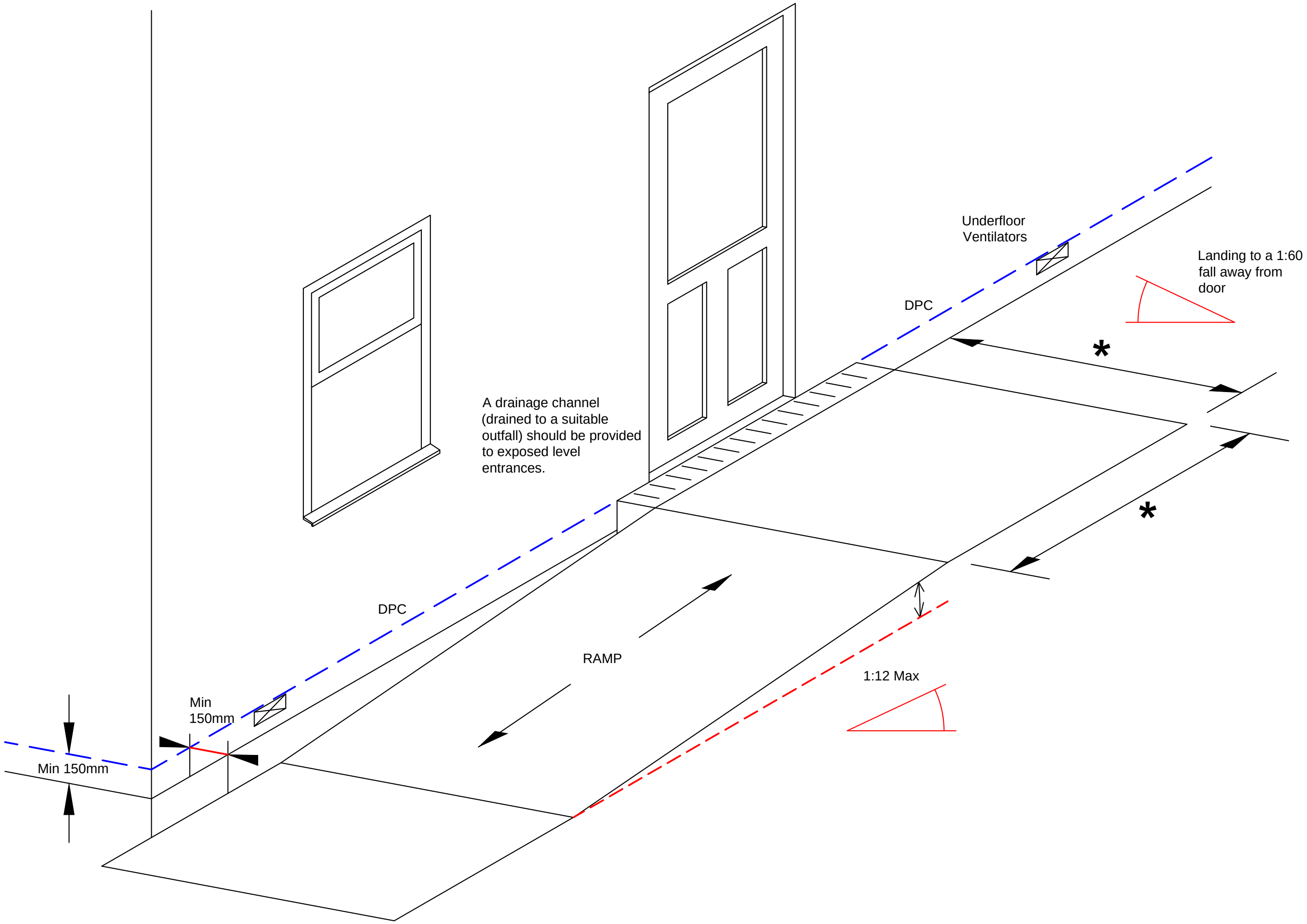
All paving and drives, with the exception of the principle level access into the dwelling, should be laid at least 150mm below the damp proof course (DPC) of the dwelling.

Laying of paths and drives

- Paths and driveways should be effectively drained to prevent ponding of water adjacent to the building.
- Paths and drives should be laid to fall away from the building at a minimum of 1:80 and a maximum of 1:12.
- Rainwater should either discharge into a trapped gully or drain to garden land that is well drained.
- Gullies should be trapped when discharging to a soakaway or combined drainage system (the approval of the statutory sewerage undertaker may be required).

Drainage and gradients of access drives and paths





Further guidance on level thresholds can be found in the 'Windows and Doors' section

The construction of the access landings and ramps must not compromise the DPC in the walls. A recommended 150mm gap between the ramp and the external wall (as shown) should be provided.

* See regional Building Regulations for disabled ramp design and landing dimensions. Ramps should not exceed 1:12 gradient. Where the outside ground levels slope towards the property, an effective gully system should be provided to prevent flooding e.g. in front of garage doors.

Where access requirements are required under regional Building Regulations to the principal entrance of the visitable dwelling the ground surface of the defined approach route must be firm, even, smooth enough to be wheeled over, not covered by loose laid materials such as gravel and shingle and have a minimum cross-fall of 1:40.

<u>Tolerances for surfacing of paths and drives</u>

Drives and paths: standing water

Differences in the surface should not exceed +/-10mm from a 2m straight edge with equal offsets. Some fracturing or weathering may also appear if using natural stone due to the make-up of the material. This tolerance applies to principle pathways and driveways to the dwelling that are required to meet regional Building Regulation standards for access to visitable dwellings and buildings.

Drainage system covers

Drainage system covers in hard standing areas should line up neatly with the adjacent ground.

Minimum thickness of surfaces for drives and paths

Surface type	Material specifications	Minimum thickness (1)		British Standard
		Path	Drive	
Macadam single course	40mm coated macadam	75	75	BS 4987
Rolled asphalt	Coarse asphalt 10mm nominal size	60	60	BS 594
Macadam two course	Nominal 20mm coated macadam	60	60	BS 4987
	Nominal 6mm wearing course	20	20	BS 4987
Block paving	Clay or calcium silicate	50	50	BS 6677
Block paving	Pre-cast concrete	60	60	BS 6717
Concrete	Designated mix	75	100(2)	
Pre-cast concrete paving	Dense concrete	50	n/a	BS 7263:1

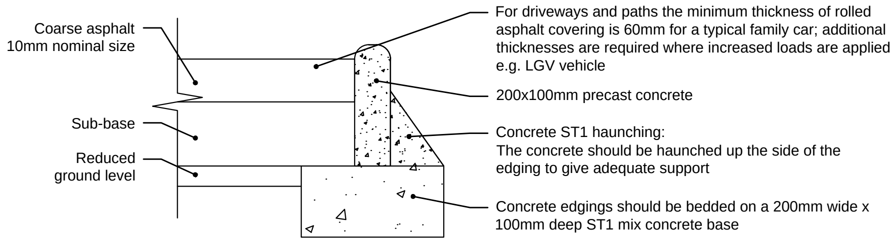
Notes:
(1) Drive minimum thickness assumes standard loadings for a typical family car. Additional thicknesses are required where increased loads are applied e.g. LGV vehicles.
(2) Drives increased to 150mm on poor ground or clay

Edgings

Edgings are to be provided to paths and driveways to prevent movement or displacement. Edgings should be laid to ensure that there are no excessive gaps and laid with smooth alignment along the top of the edging.

Asphalt

Ensure that sub-bases are dried and primed and that the surface is appropriately rolled with a vibratory roller to the required finish.

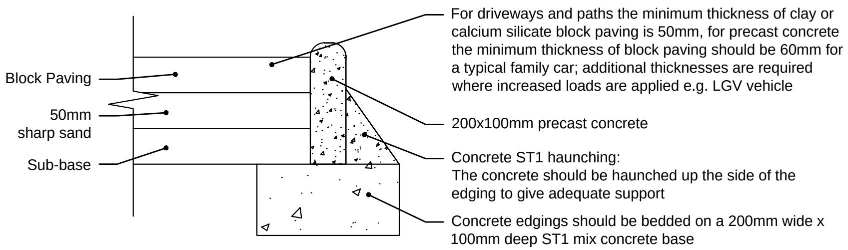


Block paving

Block paving should be laid on a minimum of 50mm sharp sand, and gaps between blocks should not exceed 5mm. All joints should be filled with kiln-dried sand or similar. Blocks should be cut using a block splitter and the finished path or driveway should be compacted with a plate vibrator. Care should be taken to ensure that the surface of the paving is not damaged or scuffed.

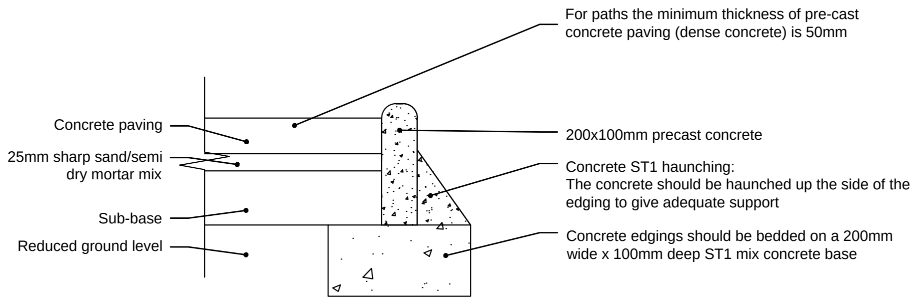
Porous block paving joints

Where paving is designed to allow ground water to drain through the joints, the gaps between blocks and the material within the joints should meet the initial design specification. The joint material should be sufficient to prevent blocking and prevent moss growth.



Concrete Paving

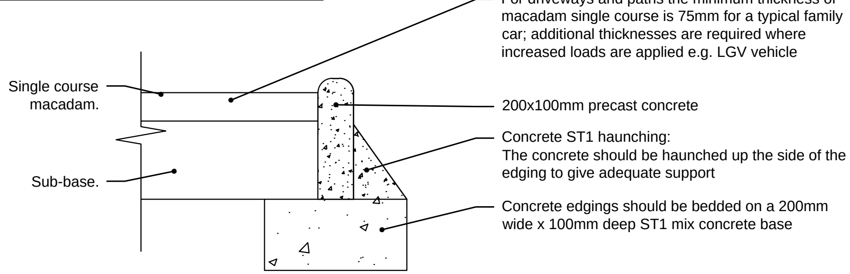
Paving slabs should be placed on a 25mm bed of sharp sand or semi-dry mortar mix (sand/cement mix ratio 3:1). Joints between slabs should be no greater than 4mm for straight edge paving slabs, and should be filled with kiln-dried sand. A neat consistent joint should be provided to rustic slabs. Slabs should be cut with a diamond blade cutter or similar to give a neat finish.



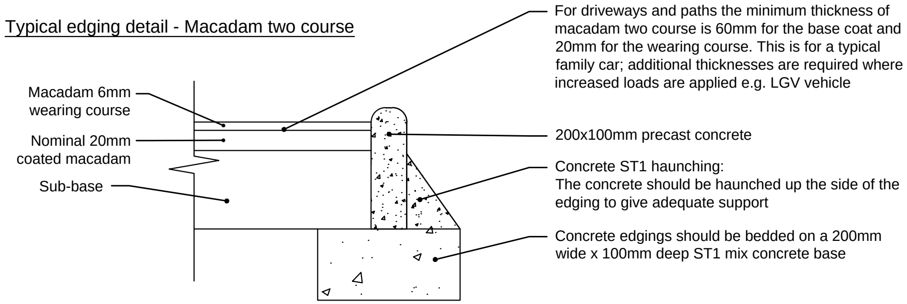
Macadam

Ensure that sub-bases are dried and primed and that the surface us appropriately rolled with a vibratory roller to the required finish.

Typical edging detail - Single course macadam



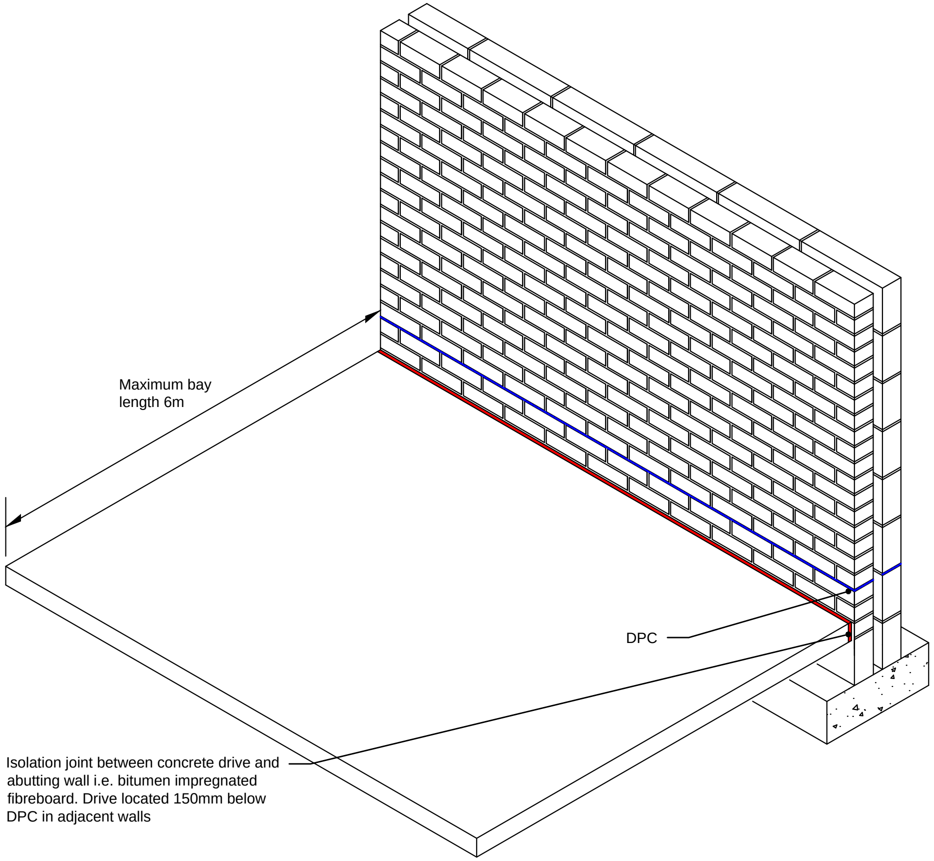
Typical edging detail - Macadam two course



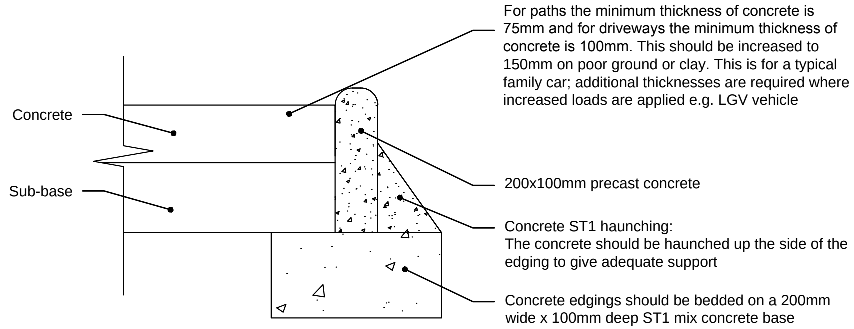
In-situ concrete

In-situ concrete should be laid in areas of 20m² maximum to allow for movement. Where abutting an adjacent structure, the concrete should be isolated using a flexible jointing material. Where the sub-base is well drained, it is recommended that the concrete is cast onto a damp proof membrane.

Typical cast in-situ drive or path abutting the dwelling



Typical edging detail - In-situ concrete



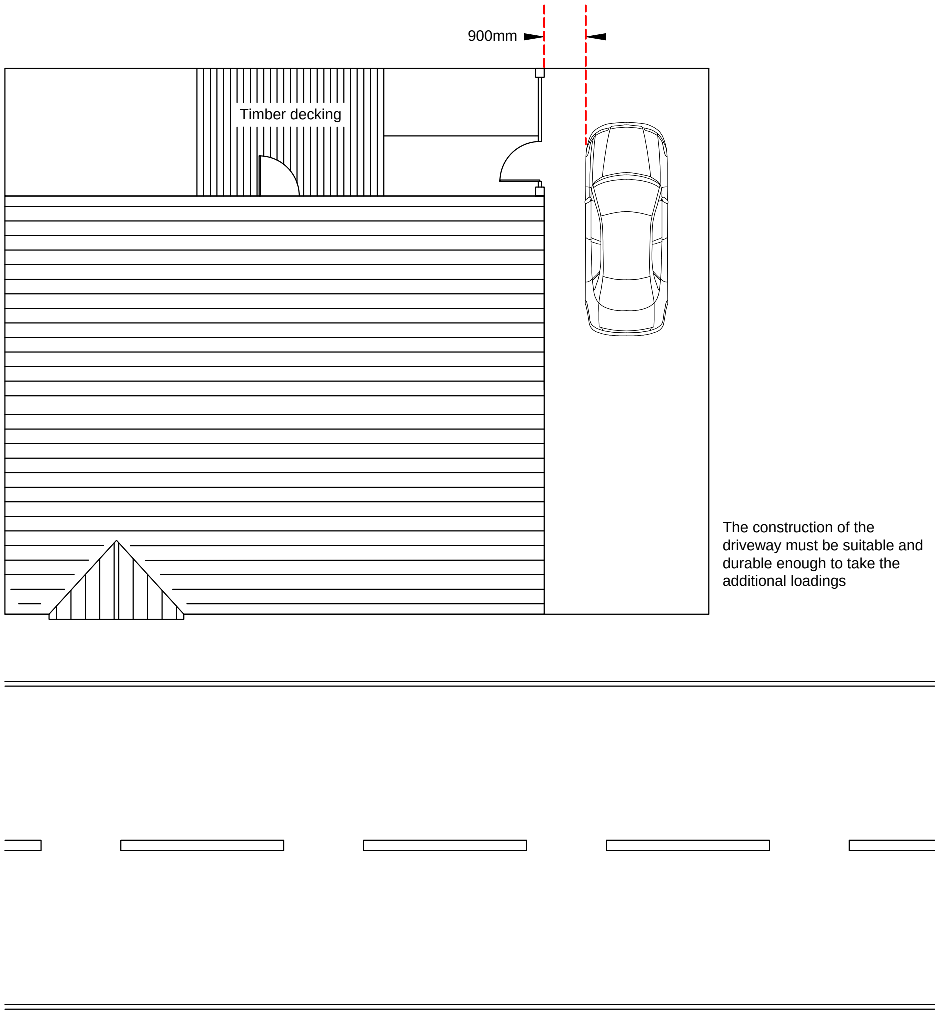
Limitations of guidance

The following guidance is applicable to timber decking that forms part of the principle entrance to the property.

This guidance is limited to decking that is no more than 600mm above the adjacent ground level.

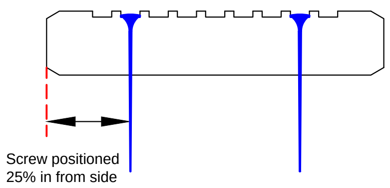
Timber decking on access route to principal entrance door

Where a driveway forms all or part of an approach route, an additional allowance of at least 900mm should be provided to allow wheel chair users to pass a parked car. Further guidance can be found in Approved Document M.



The construction of the driveway must be suitable and durable enough to take the additional loadings

Board fixing

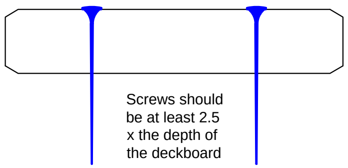


Fixing points at board ends shall be no closer than 25 mm to the board end and should always be predrilled to prevent splitting.

On grooved boards the fixing point should always be at the bottom of a groove, flush with the surface of the wood.

Screw heads should be countersunk level with the surface of the board.

Pre drilling pilot holes will prevent splitting. Always drill pilot holes 2mm oversized when fixing hardwood boards.



All metal fixings shall be made from corrosion-resistant materials, such as stainless steel, hot dipped, galvanised or other specialist coating. Before use, verify with the manufacturer that the fixings you have chosen are suitable for use with treated timber.

Aluminium fasteners should not be used with treated wood. Prevent galvanic corrosion by using the same type of metal for both fixings and connectors.

Screws should be at least two-and-a-half times the thickness of the board being fixed.

All joist bearing points shall be secured by two screws positioned at the quarter points of the board i.e. 25% in from the side.

Take care using high-pressure nail guns as they can damage timber.

Timber decking

Only timber naturally resistant to decay, or which can be treated by an industrial process to give long-term protection from decay, shall be used.

Hardwoods: Only use species rated as durable or moderately durable.
Softwoods: Only use species/components with natural durability or which have been treated in accordance with BS EN 335 to a 'Use Class' standard appropriate to their use i.e. 'Use Class 4' treatment for posts and other structural components in direct ground or freshwater contact, or 'Use Class 3' treatment for all components out of direct ground contact subject to frequent wetting.

Please note:

- Whitewood should not be used for posts embedded in the ground or for other elements (joists) in the ground or other non-permeable surface e.g. concrete slab.
- All crosscuts, notches or large boreholes shall be treated on site with a suitable preservative. For full guidance on wood preservation specification, contact the Wood Protection Association.

Timber grade (strength class): C16 minimum

The grade (strength class) of timber used for structural components such as posts, beams and joists shall be sufficient to cope with the loads placed upon it during its service life. Softwood with a strength class rating of C16 is considered the minimum standard for decks above 600mm in height, and is a requirement of Building Regulations for such raised-level structures. The higher strength classes, typically C18 and C24, should be specified where smaller component sections, longer spans or commercial deck performance design considerations are required.

For decks below 600mm in height, the use of C16 timber is also recommended.

Posts can be made from laminated sections, solid timber or round poles, and should have a load-bearing capability/size/spacing appropriate to the scale and end use of the structure. For extended life, the surface mounting of posts on precast piers or metal shoes is recommended.

Note:

- Do not exceed the recommended load and span for each strength class; for detailed recommendations, refer to span tables in TDA/TRADA Timber Decking: The Professionals' Manual.
- Use 'noggins'/blocking to strengthen frames where appropriate to prevent flexing.
- Timber moisture content at installation should be 20% maximum.

To minimise the effects of shrinkage, e.g. cupping, cracking, warping, etc. install timber as close as possible to the equilibrium moisture content of the site. For outdoor wood, moisture content varies from 19% in winter to 13% in summer in the UK. For best results, always install wood with moisture content lower than 20%. The stability of all wood used outdoors can be improved by the use of water-repellent treatments.

Board spacing

When laying timber decking boards:

- Allow for a 5mm minimum to 8mm maximum gap between board lengths.
- Where the board abuts a post, allow a 5mm gap.
- Where board ends meet, allow a 3mm gap.

Fall

To aid drainage, build a gentle fall of 1:100 into the deck, away from any adjacent property. Grooved deck boards are designed to assist the drainage of surface water, so lay them in the direction of the fall.

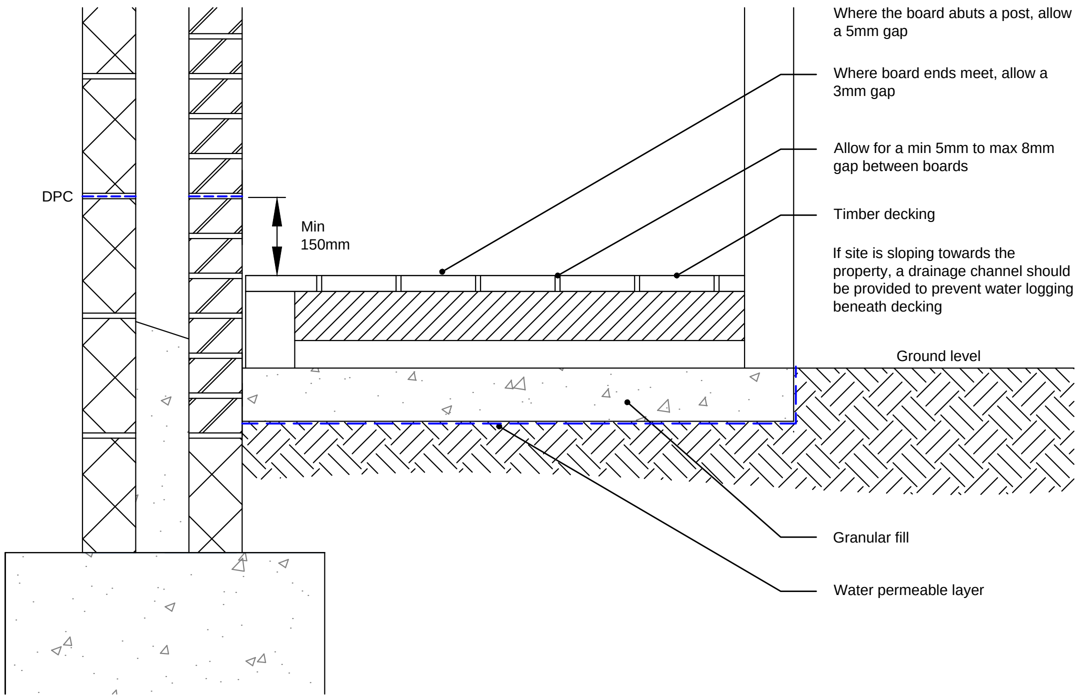
Level threshold

For further guidance on the formation of level thresholds please see the 'Windows and Doors' section.

Preparation of ground

The area to be surfaced should be prepared by stripping away all vegetation and organic material. Land drainage should be considered for ground that is saturated.

Timber decking



Further specification references

- TDA/TRADA Timber Decking: The Professionals' Manual - second edition November 2006
- TDA Technical Bulletin TB 02: Statutory requirements
- TDA Technical Bulletin TB 04: Parapet design and construction
- TDA Technical Bulletin TB 08: Metal fixings
- TDA Code of Practice TDA/RD 08/01: Raised timber decks on new homes - desired service life 60 years
- Wood Protection Association: Timber Preservation Manual

British Standards

The standards set out below all have a relevance to the creation of high-performance timber decks:

- BS EN 335-1 Use classes of wood and wood-based products against biological attack - Part 1: Classification of Use classes
- BS EN 335-2 Use classes of wood and wood-based products against biological attack - Part 2: Guide to the application of use classes to solid wood
- BS EN 335-3 Durability of wood and wood-based products - Definition of hazard classes of biological attack - Part 3: Application to wood-based panels
- BS EN 350-1 Durability of wood and wood-based products - Natural durability of solid wood - Part 1: Guide to the principles of testing and classification of the natural durability of wood
- BS EN 350-2 Durability of wood and wood-based products - Natural durability of solid wood - Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe
- BS EN 351-1 Durability of wood and wood-based products - Preservative-treated solid wood - Part 1: Classification of preservative penetration and retention
- BS EN 351-2 Durability of wood and wood-based products - Preservative-treated solid wood - Part 2: Guidance on sampling for the analysis of preservative-treated wood
- BS EN 460 Durability of wood and wood-based products - Natural durability of solid wood: Guide to the durability requirements for wood to be used in hazard classes
- BS EN 599-1 Durability of wood and wood-based products - Performance of wood preservatives as determined by biological tests - Part 1: Specification according to hazard class
- BS 8417 Preservation of timber - Recommendations. Guidance for specifiers on the treatment of timber drawing on relevant sections of BS EN standards
- BS 5756 Specification for visual strength grading of hardwood
- BS 6105 Specification for corrosion-resistant stainless steel fasteners
- BS 6399-1 Loading for buildings. Code of Practice for dead and imposed loads
- BS 7359 Nomenclature of commercial timbers, including sources of supply
- BS 5268-2 Structural use of timber. Code of Practice for permissible stress design, materials and workmanship
- BS 6180 Barriers in and about buildings - Code of Practice
- BS 6399-1 Loading for buildings. Code of Practice for dead and imposed loads

15.

Heating Services

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. A commissioning certificate is required for any work completed by an approved installer.

Materials

No additional requirements.

Design

1. Heating services - shall be designed, constructed and installed so that they:
   a. Conform to all relevant statutory requirements;
   b. Do not adversely affect the structural stability of the building;
   c. Prevent the entry of hazardous ground substances, external moisture or vermin;
   d. Are constructed using non-hazardous materials;
   e. Are durable and robust;
   f. Are safe and convenient in use.
2. An adequate and efficient hot water service shall be provided which is:
   a. Sufficient for normal domestic purposes;
   b. Insulated to prevent unintended heat losses.
3. Where provided, the central heating system shall be:
   a. Efficient and suitable for normal domestic purposes;
   b. Insulated to prevent unintended heat losses;
   c. Capable of being adequately controlled;
   d. Capable of maintaining suitable room temperatures.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

15.

Heating Services

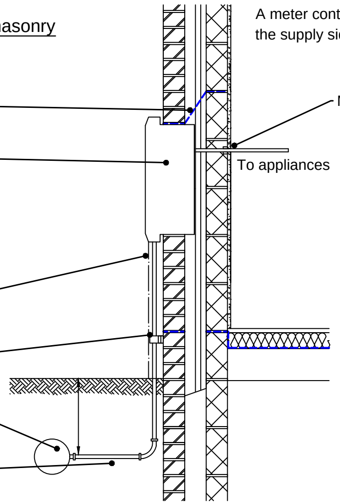
15.1

Standard Boiler - Gas

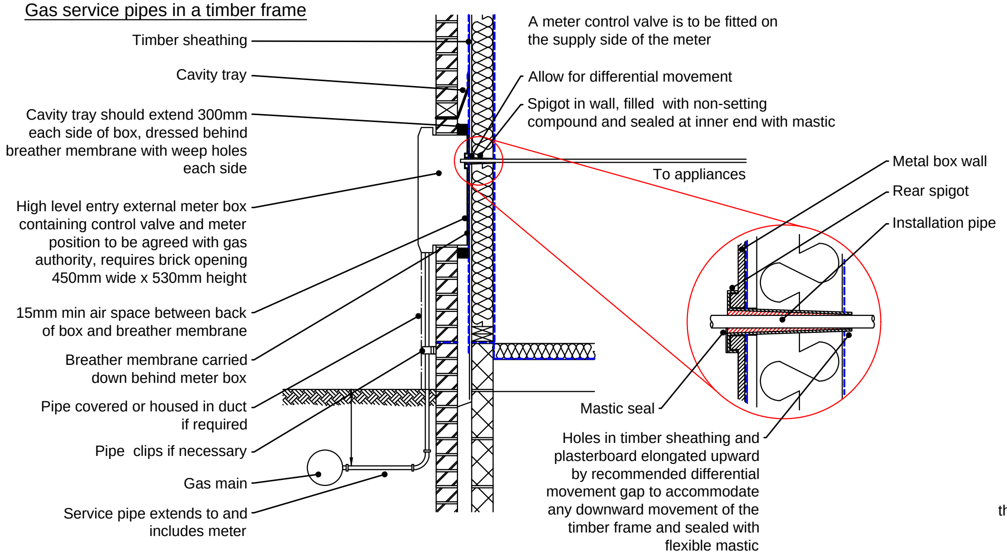
Gas service

Where provided, the gas service shall be of a suitable scale for normal domestic usage.

Gas service pipes in external masonry



Gas service pipes in a timber frame



External meter boxes should be of a type approved by the supply authority and located as close as practical to the main access point to the building.

Domestic meters may be of the following type:

- Built-in to the outer leaf of the wall.
- Surface-mounted on an external wall.
- Semi-concealed: sunk into the ground adjacent to the outer wall.
- Individual, purpose-made compartments, in accordance with British Standards.

Minimum efficiencies of heating systems

The boilers chosen for each building should be based on their efficiency within the PCDF list. The efficiency of the boiler should be no less than indicated in the table below.

Central heating system fuel	PCDF% (2009)
Mains natural gas	88

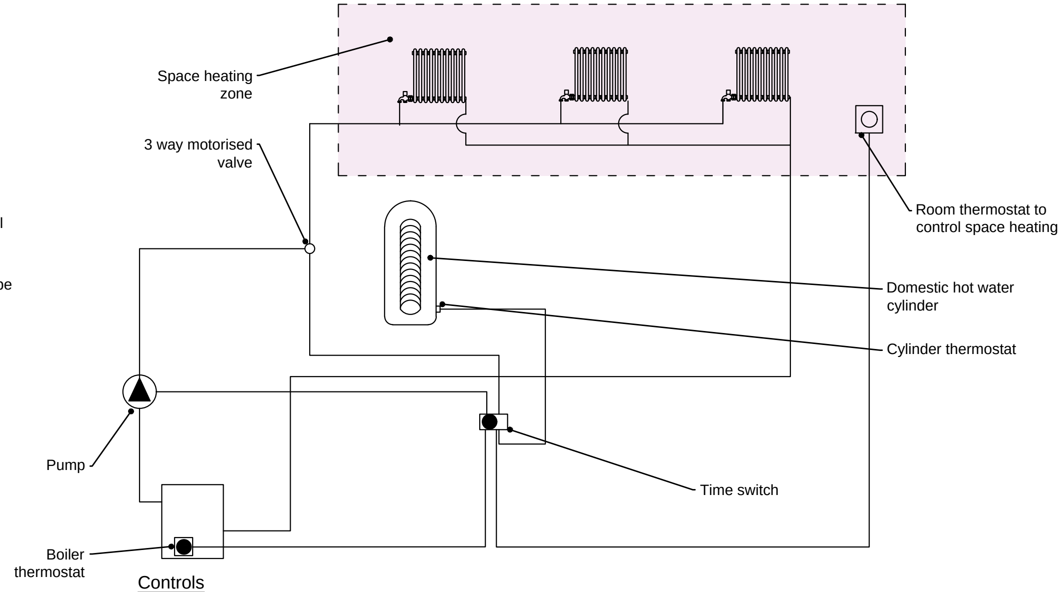
Space heating

Any whole-house heating system should be designed to meet internal temperatures to the levels set out as per below. External temperature is to be -3°C.

Whole house heating system - temperature

Location	Temperature	Air changes
Living room	21°C	1 per hour
Dining room	21°C	1 per hour
Kitchen	18°C	2 per hour
Bedrooms	18°C	1 per hour
Bed-sitting room	21°C	1 per hour
Bathrooms	22°C	2 per hour
Hall and landing	16°C	2 per hour
Separate WC	18°C	2 per hour

Controls for combined space heating and domestic hot water



Controls

Controls for wet heating systems are to be provided as follows:

- A room thermostat controlling the heater unit.
- A time switch allowing at least two heating periods a day. In the case of electrically heated storage systems (Electricaire), there will normally be a further time switch to control the electrical 'charging' periods to conform within the chosen tariff.
- A programmer to select:
  - Hot water.
  - Space heating.
  - Hot water and space heating.

A thermostat sensitive to the room air temperature should be provided for independent heaters.

Hot water services

Hot water systems may have provision for storage or may be of the instantaneous type e.g. combi boilers.

Vertical installation of cylinders is required with access, and cylinders are to be insulated as specified in the design.

Where an immersion heater is fitted, it should be:

- Appropriate for the type of water supplied to the building.
- Thermostatically controlled.
- Located so that it can be withdrawn for replacement.
- Fitted with an on/off switch.

Cisterns, vent pipes and all water services in unheated spaces should be insulated against freezing as specified in the design. Insulation is not to be placed below a cold waste tank where it can benefit from heat from beneath. Tanks that are raised need to be insulated on all sides in an unheated roof space.

Fully insulated bends and junctions are required, especially near openings to the outside air, such as the eaves. If possible, water pipes should not be located within a loft space where they could be affected by cold ventilation air.

Provision for expansion

An expansion pipe is to be provided on vented systems for hot water.

Unvented hot water systems

Third-party accreditation is required where an unvented hot water system with a storage capacity greater than 15 litres is required by the design. Installation is to be completed by a competent person.

Draining down facility

Hot water installations require the capability to be drained down.

Use of materials

Materials that are safe and minimise the risk of corrosion are to be used for pipes and fittings for water services. The recommendations of the water supplier with regard to materials and fittings should be followed.

It may be necessary to fit aluminium protector rods in areas where the corrosion of copper cylinders occurs. These are to be fitted during manufacture, in accordance with the relevant British Standards.

Notches and drillings

Floor joists should not be excessively notched or drilled. Further information can be found in the Upper Floors guidance.

Concealed services

If the services are hidden in walls or floors, they need to be positioned so that any significant cracking of the surface cannot occur.

Chasing of masonry cavity walls

If chases in walls are necessary, their depth should not exceed:

- One-sixth the thickness of the single leaf for horizontal chases.
- One-third the thickness for vertical chases.

Hollow blocks should not be chased unless specifically permitted by the manufacturer.

Pipework in walls

A metallic tape should be applied to the pipework where plastic pipework is hidden within or behind wall surfaces, which would otherwise not be located by a metal detector.

Jointing of pipes and fittings

Proprietary joints should be made strictly in accordance with the manufacturer's instructions.

Only fluxes recommended by the pipe manufacturer should be used, and all traces should be removed immediately after jointing. Fluxes containing lead are not acceptable.

Suitable clips or brackets are to be used to secure. Fixings should be installed adequately and spaced to stop sagging but not restrict thermal movement. Where needed, pipes should have adequate falls.

Sufficient room should be allowed for thermal expansion and contraction to avoid damage and noise from pipe movement.

Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations. Further information can be found in the 'Upper Floors' and 'Internal Walls' guidance.

Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required. Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.

Pipes in floor screeds

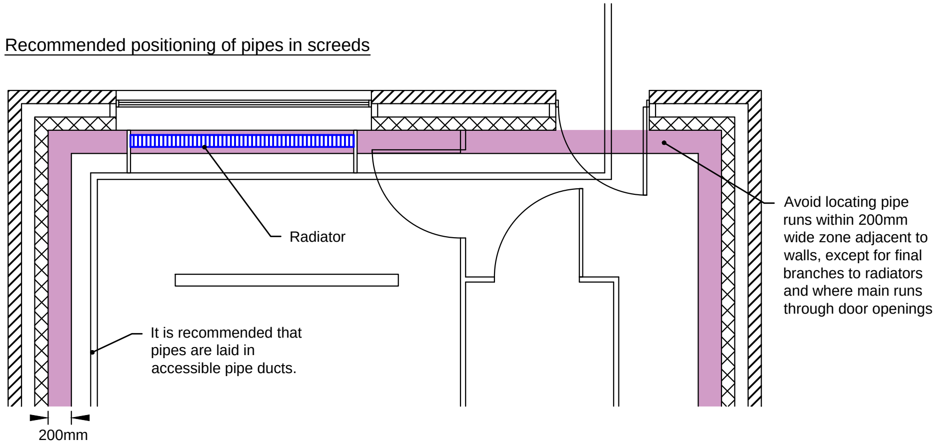
Where copper pipes are permitted in floor screeds, they should be:

- Sleeved or wrapped so that they can move freely along the length and at joints and bends.
- Jointed with capillary joints.

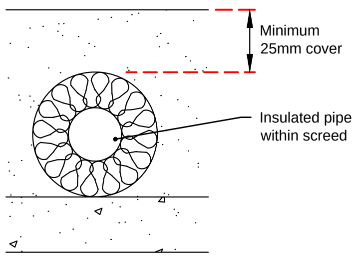
Services within or beneath floors

Protection through wrapping or ducting is necessary when pipes are situated under floor screeds. Thermal expansion allowances are to be made, especially at changes of direction.

Recommended positioning of pipes in screeds



Positioning of pipes in screeds



Screed cover should be a minimum 25mm over the pipe and insulating materials. The screed thickness should still be at least 25mm where pipes cross over.

16.

Ventilation

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. A commissioning certificate is required for any work completed by an approved installer.

Materials

No additional requirements.

Design

1. Ventilation services - shall be designed, constructed and installed so that they:
   a. Conform to all relevant statutory requirements;
   b. Do not adversely affect the structural stability of the building;
   c. Prevent the entry of hazardous ground substances, external moisture or vermin;
   d. Are constructed using non-hazardous materials;
   e. Are durable and robust;
   f. Are safe and convenient in use.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

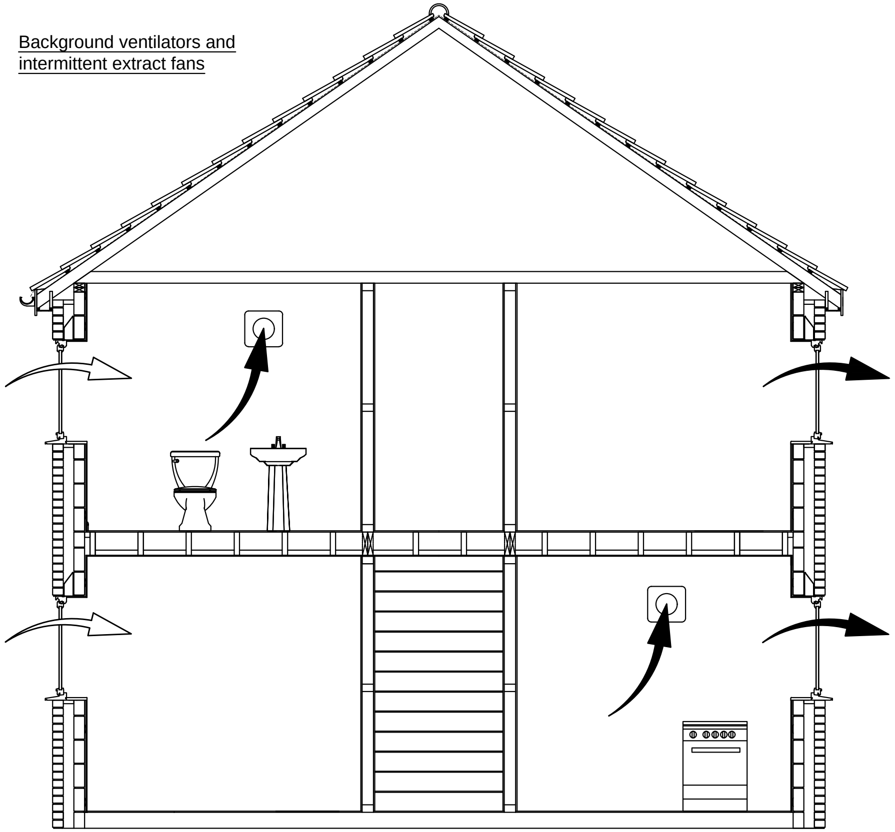
16.

Ventilation

16.1

System 1 - Background Ventilators and Intermittent Extract Fans

Background ventilators and intermittent extract fans



Intermittent extract fans and background ventilation

A System 1 is suitable for use in houses and many flats or apartments with multiple external elevations. In some circumstances, it can be difficult to comply with System 1, especially in dwellings with a single external elevation.

The System comprises of background ventilators, usually trickle ventilators fitted to windows, and extract fans fitted in moisture producing areas or "wet rooms" such as kitchens and bathrooms.

The background ventilators provide the whole building ventilation and also supply air to the intermittently operated extract fans which provide the extract ventilation removing odours and excessive humidity.

Extractor fans

Where ductwork from extractor fans goes through unheated spaces such as roof voids, action should be taken to minimise the chance of condensation forming in the ducting and any consequential damage caused to finishes and the fan unit.

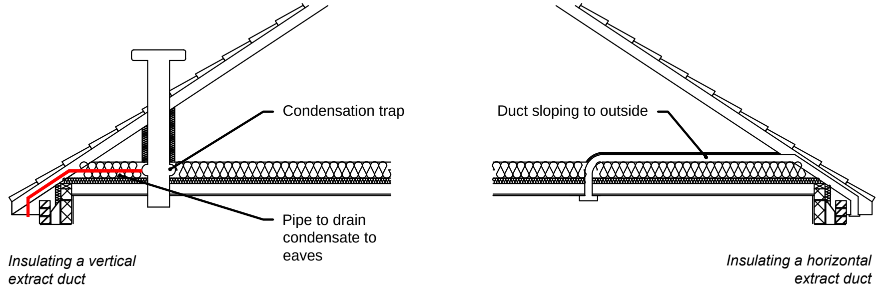
- Ensure ducting discharges to the outside air.
- Provide insulation to the outside of the ductwork, and lay to a fall away from the fan.

The system should provide extraction rates in accordance with Building Regulation requirements Approved Document F. All habitable and service rooms within dwellings should have some form of ventilation as a requirement. It may be permanent background ventilation, mechanical ventilation or an opening window.

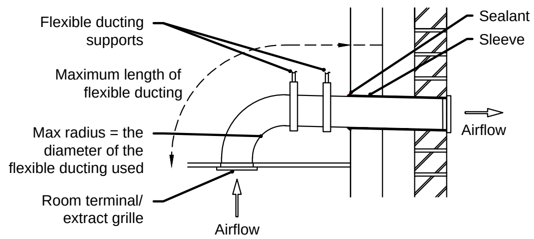
Mechanical extract ventilation rates

Room	Intermittent extract	Continuous extract
Kitchen	30 l/s adjacent to hob 60l/s elsewhere	13 l/s
Utility (access via dwelling)	30 l/s	8 l/s
Bath/shower room	15 l/s	8 l/s
Sanitary accommodation	6 l/s	6 l/s

Extract ducts



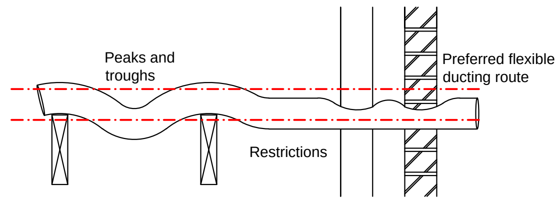
Correct duct installation



Adequate support is required for extract ducts, and they also need to have sealed joints where required. Insulation needs to be provided where ducts pass through unheated spaces, such as roof voids, to the outside air, or a condensation drain should be provided in accordance with the design.

Where ducts penetrate external walls these should be adequately protected against adverse weather and moisture ingress.

Incorrect duct installation



Background ventilation

Background ventilation should be provided in accordance with the relevant regional Building Regulations. Where background ventilators (trickle vents) are installed in windows and doors, they must be correctly specified for the location and should be installed so as not cause potential damage to render finishes or restrict the ability to open the window/door.

Purge ventilation

Purge ventilation should be provided in accordance with the relevant regional Building Regulations. Purge ventilation provision is required in each habitable room and should be capable of extracting a minimum of four air changes per hour (ach) per room directly to outside. Normally, openable windows or doors can provide this function, otherwise mechanical extract should be provided.

Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required. Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.
- Should not adversely effect the fire or sound performance of an compartment wall or floor.

Jointing of pipes and fittings

Proprietary joints should be made strictly in accordance with the manufacturer's instructions.

Suitable clips or brackets are to be used to secure. Fixings should be installed adequately, and spaced to stop sagging but not restrict thermal movement. Where needed, pipes should have adequate falls.

Sufficient room should be allowed for thermal expansion and contraction to avoid damage and noise from pipe movement.

Notches and drillings

Floor joists should not be excessively notched or drilled. Further information can be found in the Upper Floors guidance.

Concealed services

If the services are hidden in walls or floors, they need to be positioned so that any significant cracking of the surface cannot occur.

Services in timber frame

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Electrical services are to be rated for their location with consideration for insulation.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face of stud.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.

Further information can be found in both the 'Upper Floors', 'Internal Walls', and 'Electrical Services' guidance.

Chasing of masonry cavity walls

If chases in walls are necessary, their depth should not exceed:

- One-sixth the thickness of the single leaf for horizontal chases.
- One-third the thickness for vertical chases.

Hollow blocks should not be chased unless specifically permitted by the manufacturer.

Further information can be found in the 'Internal Walls' guidance.

Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

Issues that should be taken into account include:

- Suitable design detailing of components passing through elements of the building.
- The location and type of dampers and firestops to be used.
- The integrity of protected stairs and halls.
- The integrity of walls and floors.
- Additional requirements for flats and apartments with a floor above 4.5m.

Further information can be found in the 'Upper Floors' and 'Internal Walls' guidance.

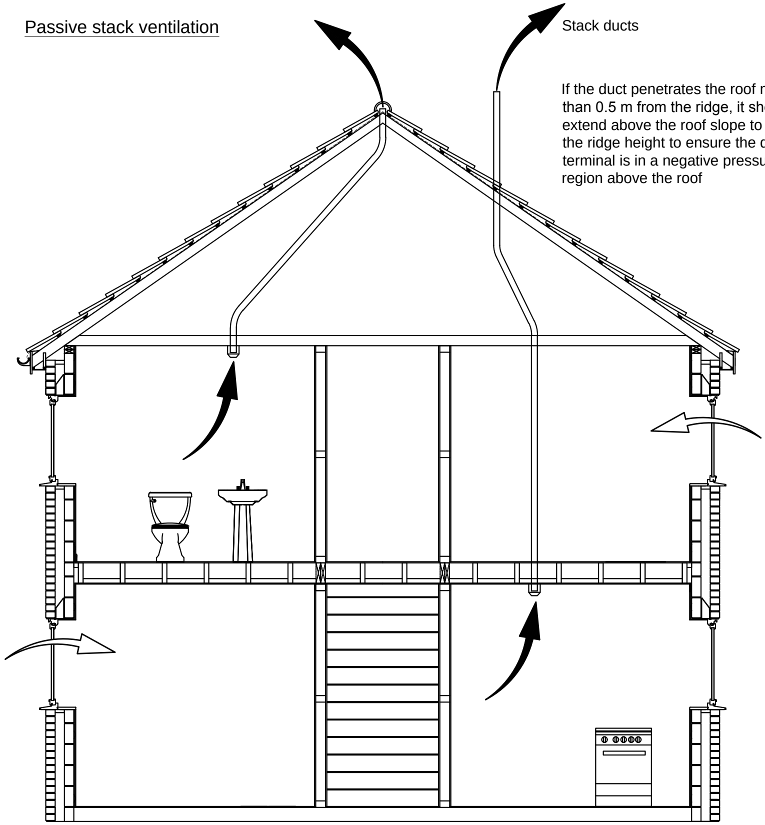
16.

Ventilation

16.2

System 2 - Passive Stack Ventilation

Passive stack ventilation



If the duct penetrates the roof more than 0.5 m from the ridge, it should extend above the roof slope to at least the ridge height to ensure the duct terminal is in a negative pressure region above the roof

Passive stack ventilation (PSV)

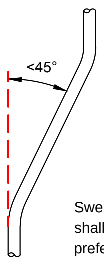
The system is to meet the relevant third-party accreditation.

The PSV layout should be designed to:

- Avoid cross flow between the kitchen and bathroom/WCs.
- Prevent, as far as possible, air flow in the ducts being adversely affected by the prevailing wind speed and direction, or by sudden changes in these.
- Minimise resistance to air flow by having ducts that are as near to vertical as possible.

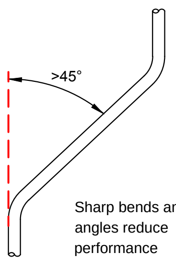
To ensure good transfer of air throughout the dwelling, there should be an undercut of minimum area 7600mm^2 in all internal doors above the floor finish (equivalent to an undercut of 10mm for a standard 760mm wide door).

Suitable bends for passive stack ducts



Swept bends and shallow angles are preferred

Unsuitable bends for passive stack ducts



Sharp bends and angles reduce performance

Ducts should use no more than one offset (i.e. no more than two bends) and these should be of the "swept" rather than "sharp" type to minimise flow resistance. Offset at an angle should be no more than 45° to the vertical.

Extract ducts

Where ductwork from extractor fans goes through unheated spaces such as roof voids, action should be taken to minimise the chance of condensation forming in the ducting and any consequential damage caused to finishes.

The system should provide extraction rates in accordance with regional Building Regulation requirements Approved Document F.

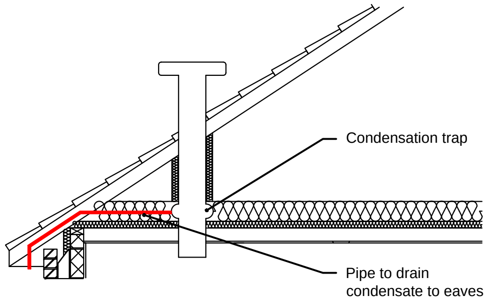
All habitable and service rooms within dwellings should have some form of ventilation as a requirement. It may be permanent background ventilation, mechanical ventilation or an opening window.

- Ducting should be insulated where it passes through unheated areas and voids (e.g. loft spaces) with the equivalent of at least 25mm of a material having a thermal conductivity of ≤0.04W(m.K) to reduce the possibility of condensation forming.
- Where a duct extends externally above roof level the section above the roof should be insulated or a condensate trap should be fitted just below roof level.

Adequate support is required for extract ducts, and they also need to have sealed joints where required. Insulation needs to be provided where ducts pass through unheated spaces, such as roof voids, to the outside air, or a condensation drain should be provided in accordance with the design.

The ducting should be installed in accordance with the manufacturer's instructions.

Extract ducts



Insulating a vertical extract duct

Whole-building ventilation

The whole-building ventilation rate for the supply of air to the habitable rooms in a dwelling should be no less than the rates stated in the table below.

Whole-building

Ventilation	Number of bedrooms in dwelling				
	1	2	3	4	5
Whole building ventilation rate [a, b] (l/s)	13	17	21	25	29

Notes:
a. In addition, the minimum ventilation rate should be not less than 0.3 l/s per m^2 of internal floor area (this includes all floors, e.g. for a two-storey building add the ground and first floor areas).

b. This is based on two occupants in the main bedroom and a single occupant in all other bedrooms. This should be used as the default value. If a greater level of occupancy is expected add 4 l/s per occupant.

Ductwork installation

- Separate ducts should be taken from the ceilings of the kitchen, bathroom, utility room or WC to separate terminals on the roof. Do not use common outlet terminals or branched ducts.
- Ducting should be properly supported along its length to ensure the duct can run straight without distortion or sagging and that there are no kinks at any bends or the connection to outlet terminals.
- In the roof space the duct should be secured to a wooden strut that is securely fixed at both ends
- A ridged duct should be used for system stability for the part of a PSV system which is outside, above the roof slope. It should protect down into the roof space far enough to allow firm support.

Background ventilation

Background ventilation should be provided in all rooms accept the rooms where PSV is located in accordance with the relevant regional Building Regulations. Where back ground ventilators (trickle vents) are installed in windows and doors, they must be correctly specified for the location and should be installed so as not cause potential damage to render finishes or restrict the ability to open the window/door.

Please note: open flued combustion appliances will still require an air supply in accordance with Approved Document J.

Purge ventilation

Purge ventilation should be provided in accordance with the relevant regional Building Regulations. Normally, openable windows or doors can provide this function, otherwise mechanical extract should be provided.

Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required. Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.
- Should not adversely effect the fire or sound performance of an compartment wall or floor.

Jointing of pipes and fittings

Proprietary joints should be made strictly in accordance with the manufacturer's instructions.

Suitable clips or brackets are to be used to secure. Fixings should be installed adequately, and spaced to stop sagging but not restrict thermal movement. Where needed, pipes should have adequate falls.

Sufficient room should be allowed for thermal expansion and contraction to avoid damage and noise from pipe movement.

Notches and drillings

Floor joists should not be excessively notched or drilled. Further information can be found in the Upper Floors guidance.

Services in framed structures

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.

Further information can be found in both the 'Upper Floors', 'Internal Walls', and 'Electrical Services' guidance.

Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

Issues that should be taken into account include:

- Suitable design detailing of components passing through elements of the building.
- The location and type of dampers and firestops to be used.
- The integrity of protected stairs and halls.
- The integrity of walls and floors.
- Additional requirements for flats and apartments with a floor above 4.5m.

Further information can be found in the 'Upper Floors' and 'Internal Walls' guidance.

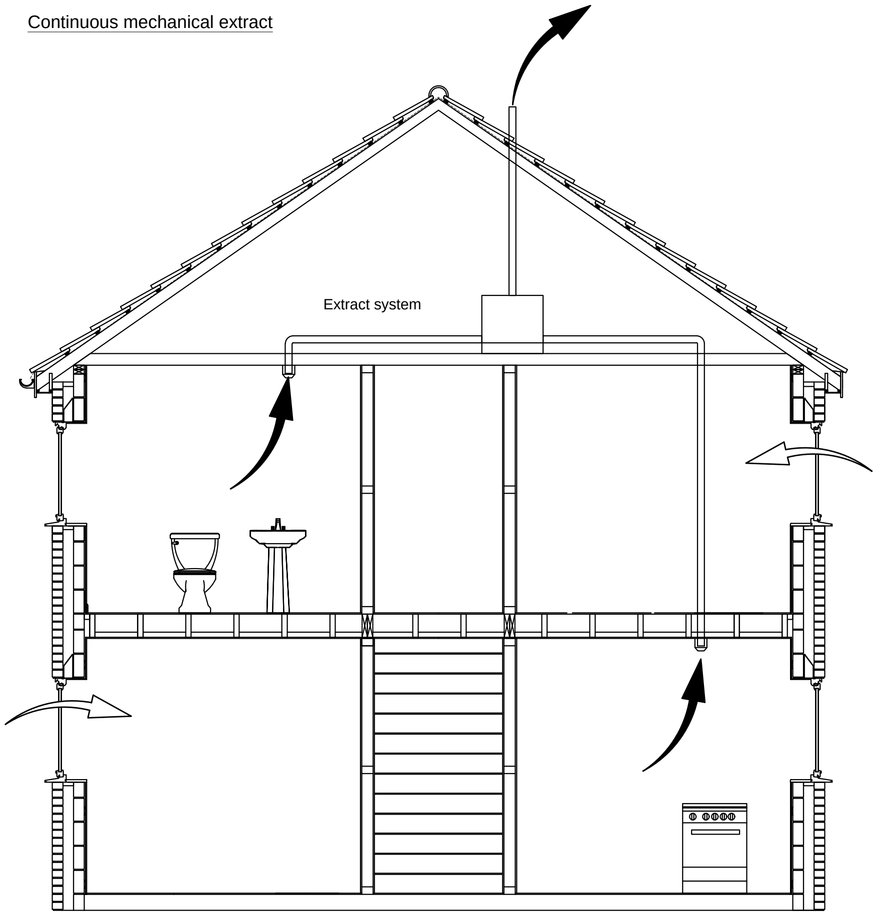
16.

Ventilation

16.3

System 3 - Continuous Mechanical Extract (MEV)

Continuous mechanical extract



Design

The MEV system should be designed as a complete package, the performance of all materials and components should be considered to ensure compatibility and performance of the system.

The MEV system should:

- Be designed to ensure that a satisfactory level of performance is achieve in accordance with the domestic ventilation compliance guides supporting the relevant regional Building Regulations.
- The design should ensure even distribution of airflow taking account airflow resistance, including the bends and fittings.
- Have adequate fan capacity accounting for airflow resistance of the system.
- The ductwork should be as direct as possible.
- Installed in accordance with the design and manufacturers recommendations.
- Airflow resistance should be calculated in accordance with BS EN 13141-2 and manufacturers data.

The design should outline

- The location of all ductwork runs, the position of the fan units and controls.
- The size, type and position of ductwork and terminals.
- Direction of falls for all horizontally laid ductwork.
- Type of fixings and specified fixing centres.
- The location and type of ancillary components e.g those used for fire safety.
- Demonstrate the airflow-balancing figures for the proposed system.

MEV fan unit

The MEV fan unit should be adequately fixed to a part of the building that can support the load and fixed in accordance with the design and manufactures recommendations.

Ductwork

The ductwork should provide suitable performance for the life of the system and should be ridged/semi ridged of a material that is suitable for use in MEV systems and installed in accordance with the manufacturers recommendations.

It is important to ensure that all ductwork is:

- Suitably supported in accordance with the ductwork manufactures recommendations, this is generally secured with evenly spaced clips at no more than 750mm centres.
- Horizontal ductwork should be laid to a fall in accordance with the design to prevent condensate collecting and should be installed to a true line to prevent localised dips.
- Laid to a slight outfall when passing through an external wall to reduce the risk of water ingress.
- Suitably jointed using purpose design products that are durable, securely fixed and air tight in accordance with the manufacturers recommendations.
- Suitably insulated where it passes through uninsulated parts of the property or carrying cold air through insulated parts of the dwelling e.g the roof space using pre insulated ductwork or propriety insulation system.
- Flexible ducting should be limited to use adjacent to fan units or air valves and should not be used to form bends.
- Ductwork should not be in direct contact with other surfaces e.g. ceilings.

Access and operation

MEV systems must be installed so that:

- The fan units and controls are easily accessible.
- Identify maintenance and servicing requirements.
- Ducts and air valves should have either fitted filters or be accessible for cleaning.

Commissioning

The MEV system should be commissioned to confirm performance to ensure compliance with the design. A copy of the commission certificate should be made available upon request.

Background ventilation

Background ventilation should be provided in accordance with Approved Document F.

To ensure good transfer of air throughout the dwelling, there should be an undercut of minimum area 7600mm² in all internal doors above the floor finish. This is equivalent to an undercut of 10mm for a standard 760mm width door.

Ensure that the air transfer provision is unrestricted after floor finishes have been laid (e.g. carpets should not encroach).

Purge ventilation

Purge ventilation should be provided in accordance with the relevant regional Building Regulations.

Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required. Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.
- Should not adversely effect the fire or sound performance of an compartment wall or floor.

Notches and drillings

Floor joists should not be excessively notched or drilled. Further guidance can be found in the 'Upper Floors' section.

Noise

All continuous running fans should be quiet as to not discourage there use by occupants.

Controls

- Any manual boost controls should be provided locally to the areas being served.
- In kitchens, any automatic controls must provide sufficient flow during cooking with fossil fuels (e.g. gas) to avoid build up of combustion products.
- Ensure the system always provides the minimum whole dwelling ventilation rate.

Services in framed structures

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face of stud.

Further information can be found in the 'Upper Floor', 'Internal Walls' and 'Electrical Services' sections.

Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

Issues that should be taken into account include:

- Suitable design detailing of components passing through elements of the building.
- The location and type of dampers and firestops to be used.
- The integrity of protected stairs and halls.
- The integrity of walls and floors.
- Additional requirements for flats and apartments with a floor above 4.5m.

Further information can be found in the 'Upper Floor' and 'Internal Walls' sections.

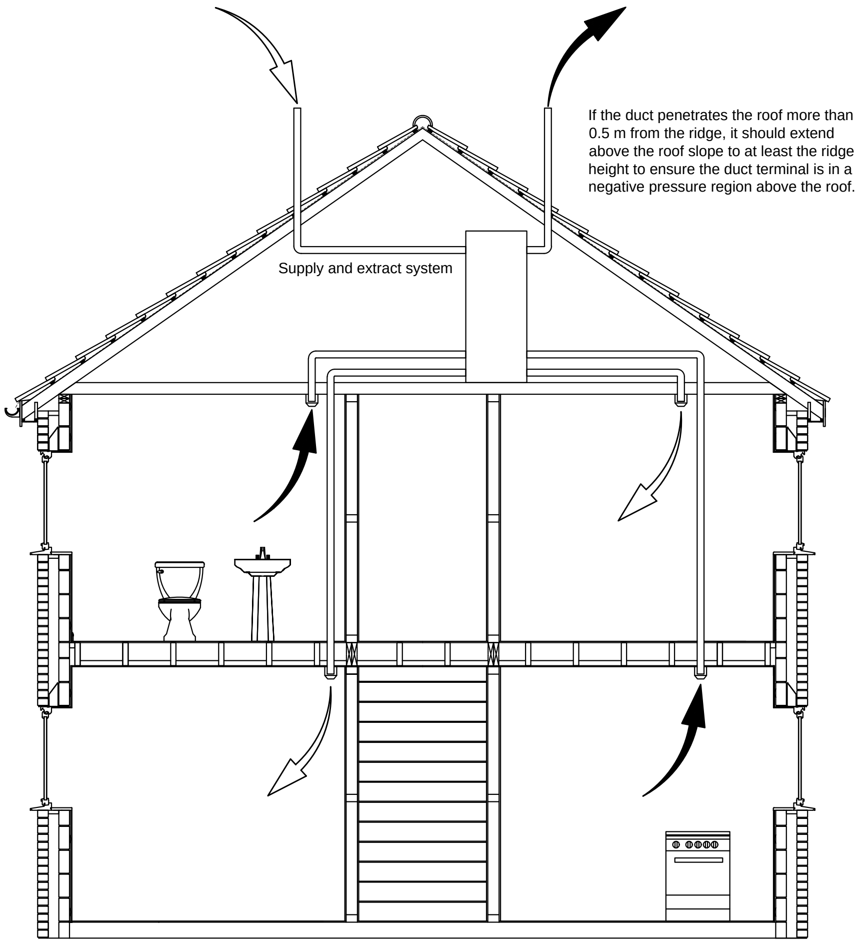
16.

Ventilation

16.4

System 4 - Continuous Mechanical Extract with Heat Recovery

Continuous mechanical supply and extract with heat recovery (MVHR)



Design

The MVHR system should be designed as a complete package, the performance of all materials and components should be considered to ensure compatibility and performance of the system.

The MHVR system should:

- Be designed to ensure that a satisfactory level of performance is achieve in accordance with the Domestic ventilation compliance guides supporting the relevant regional Building Regulations.
- The design should ensure even distribution of airflow taking account airflow resistance, including the bends and fittings.
- Have adequate fan capacity accounting for airflow resistance of the system.
- The ductwork should be as direct as possible.
- Installed in accordance with the design and manufacturers recommendations.
- Airflow resistance should be calculated in accordance with BS EN 13141-2 and manufacturers data.

The design should outline:

- The location of all ductwork runs, the position of the fan units and controls.
- The size, type and position of ductwork and terminals.
- Direction of falls for all horizontally laid ductwork.
- Type of fixings and specified fixing centres.
- The location and type of ancillary components e.g those used for fire safety.
- Demonstrate the airflow-balancing figures for the proposed system.

MVHR fan unit

The MVHR fan unit should be adequately fixed to a part of the building that can support the load and fixed in accordance with the design and manufactures recommendations.

Ductwork

The ductwork should provide suitable performance for the life of the system and should be ridged/ semi ridged of a material that is suitable for use in MVHR systems and installed in accordance with the manufacturers recommendations.

It is important to ensure that all ductwork is:

- Suitably supported in accordance with the ductwork manufactures recommendations, this is generally secured with evenly spaced clips at no more than 750mm centres.
- Horizontal ductwork should be laid to a fall in accordance with the design to prevent condensate collecting and should be installed to a true line to prevent localised dips.
- Laid to a slight outfall when passing through an external wall to reduce the risk of water ingress.
- Suitably jointed using purpose design products that are durable, securely fixed and air tight in accordance with the manufacturers recommendations.
- Suitably insulated where it passes through uninsulated parts of the property or carrying cold air through insulated parts of the dwelling e.g the roof space using pre insulated ductwork or propriety insulation system.
- Flexible ducting should be limited to use adjacent to fan units or air valves and should not be used to form bends.
- Ductwork should not be in direct contact with other surfaces e.g. ceilings.

Access and operation

MVHR systems must be installed so that:

- The fan units and controls are easily accessible.
- Suitable access for any maintenance and service requirements is provided.
- Ducts and air valves should have either fitted filters or be accessible for cleaning.

Commissioning

The MVHR system should be commissioned to confirm performance to ensure compliance with the design. A copy of the commission certificate should be made available upon request.

Purge ventilation

Purge ventilation should be provided in accordance with the relevant regional Building Regulations.

Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required. Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.
- Should not adversely effect the fire or sound performance of an compartment wall or floor.

Notches and drillings

Floor joists should not be excessively notched or drilled. Further guidance can be found in the 'Upper Floors' section.

Noise

All continuous running fans should be quiet as to not discourage there use by occupants.

Controls

- Any manual boost controls should be provided locally to the areas being served.
- In kitchens, any automatic controls must provide sufficient flow during cooking with fossil fuels e.g. gas, to avoid build up of combustion products.
- Ensure the system always provides the minimum whole dwelling ventilation rate.

Services in framed structures

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as flues/vents) should be enclosed with a cavity barrier and protected with a cavity tray.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face of stud.

Further information can be found in the 'Upper Floor', 'Internal Walls' and 'Electrical Services' sections.

Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

Issues that should be taken into account include:

- Suitable design detailing of components passing through elements of the building.
- The location and type of dampers and firestops to be used.
- The integrity of protected stairs and halls.
- The integrity of walls and floors.
- Additional requirements for flats and apartments with a floor over 4.5m.

Further information can be found in the 'Upper Floors' and 'Internal Walls' sections.

17.

Electrical Services

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

1. A commissioning certificate is required for any work completed by an approved installer.

Materials

No additional requirements.

Design

1. Electrical services - shall be designed, constructed and installed so that they:
    a. Conform to all relevant statutory requirements;
    b. Do not adversely affect the structural stability of the building;
    c. Prevent the entry of hazardous ground substances, external moisture or vermin;
    d. Are constructed using non-hazardous materials;
    e. Are durable and robust;
    f. Are safe and convenient in use.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

17. Electrical Services

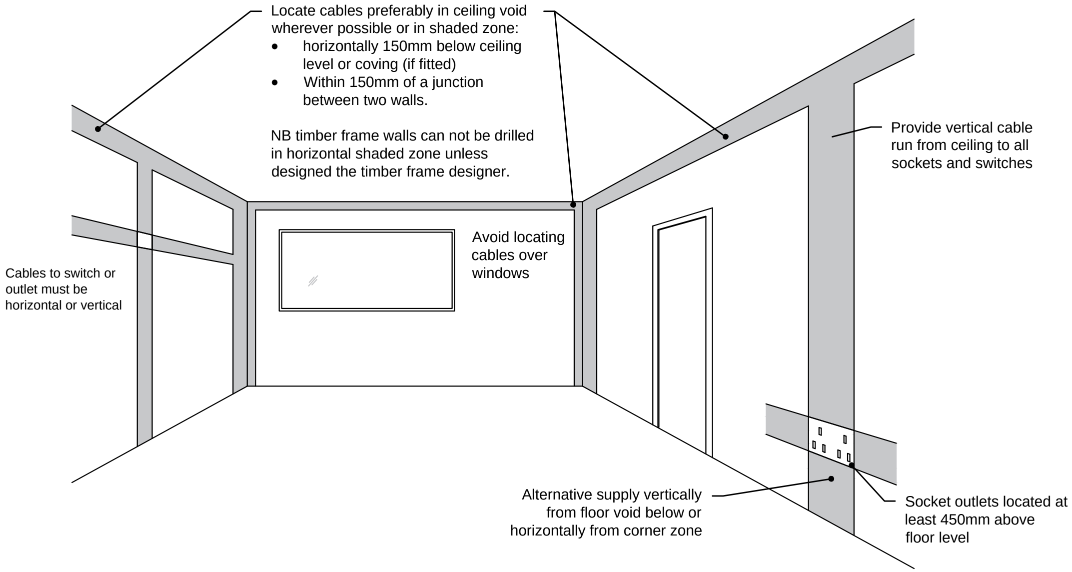
17.1 Mains

General

General provisions for installation:

- All electrical installations should be in accordance with the relevant regional Building Regulations and BS 7671.
- A suitable electrical service of the appropriate size for normal domestic use shall be provided.
- PVC-covered cables should not be in contact with polystyrene insulation.
- Electrical cables should not be diagonal, and their locations should be in accordance with the image below and current regional Building Regulations.
- Cables routed within the shaded zones must be in accordance with BS 7671 (see detail below).

Safety zones for electrical cables in walls



Supplementary earth bonding

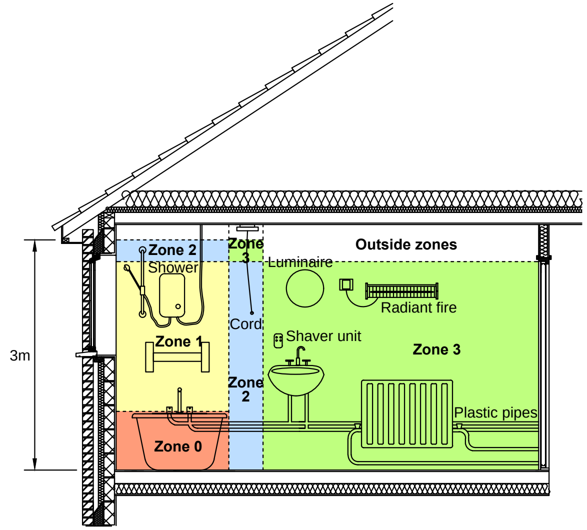
For domestic situations, supplementary bonding is required in areas of increased risk, which are rooms containing a bath or shower. It is not required within kitchens, utility rooms or washrooms.

Supplementary bonding is not required to the pipes or metal fittings attached where plastic pipes are used within a bathroom or shower room.

This also applies where short lengths of metal pipes connected to bathroom fittings are attached to plastic pipes.

Supplementary bonding is still required to electrical equipment such as electric showers or electric heaters. This type of bonding must also be connected to the protective conductor of all circuits supplying electrical equipment in the bathroom.

Supplementary bonding in a bathroom - plastic water supply pipe installation

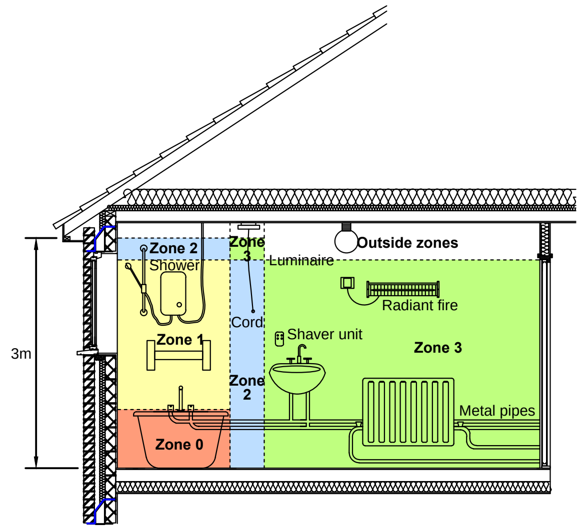


The protective conductors of all power and lighting points within the zones must be supplementary bonded. The bonding connection may be to an earth terminal of a switch or accessory supplying equipment.

Circuit protective conductors may be used as supplementary bonding conductors.

Supplementary bonding of short lengths of copper pipe installed where the pipes are visible is not necessary.

Supplementary bonding in a bathroom - metal water supply pipes



The protective conductors of all power and metal lighting points within the zones must be supplementary bonded to all conductive parts in the zones including metal waste, water and central heating pipes, metal baths, and shower basins.

Circuit protective conductors may be used as supplementary bonding conductors.

Metal baths not connected to a metal building structure do not require supplementary bonding if all metal pipes connected to them have been bonded.

Connection to pipes to be made with BS 951 clamps (complete with "Safety Electrical Connection" label).

Socket outlets

Socket outlets are to be conveniently positioned in close proximity to the TV aerial and telephone outlets, thus allowing for electrical equipment including TVs etc. Rooms should be provided with the following 13a outlets:

Room	Number of 13A Outlets	Comments
Kitchen/Utility	8	• Where separate kitchen and utilities are provided, each room should have at least 4 outlets. • Where appliances are provided, three outlets should be available for general use.
Dining room	4	
Living/family room	8	Two outlets should be near the TV ariel outlet.
Main bedroom	6	
Other bedrooms	4	
Landing	2	
Hall	2	

Note: the above refers to individual socket outlets e.g. a double socket would count as 2 outlets.

Cooking

Cooking appliances provided to the cooker space in a dwelling must be suitably switched and terminated with a minimum 30a electricity supply.

If a cooker panel is provided, it needs to be positioned to the side of the cooker space. A 13a socket outlet should be positioned at the cooker space where a gas supply is provided to the dwelling.

Co-axial cable

A concealed co-axial cable should be provided from the roof void to a terminal outlet within the main living room. Where the co-axial cable is not provided, a conduit and draw wire, or an alternative, should be provided. The provision of an aerial is not required.

Gas appliance

Where a gas appliance requires an electrical supply, a suitably fixed spur or socket outlet should be provided.

Light fittings

At least one fixed lighting outlet should be provided to all rooms. Areas greater than 25m^2 are to be provided with two fixed lighting outlets.

Halls, landings and staircases are to be provided with lighting outlets and two-way switches.

Down lighters and other flush-fitting attachments should not be installed through a ceiling if the ceiling is providing part of the required acoustic insulation or fire resistance to the property.

If down lighters are provided to ceilings below roof voids (excluding thatched roofs), precautions are to be taken to ensure that no fire risk is caused by the proximity of other materials.

Passive infrared (PIR) sensors are to be used in common and external areas.

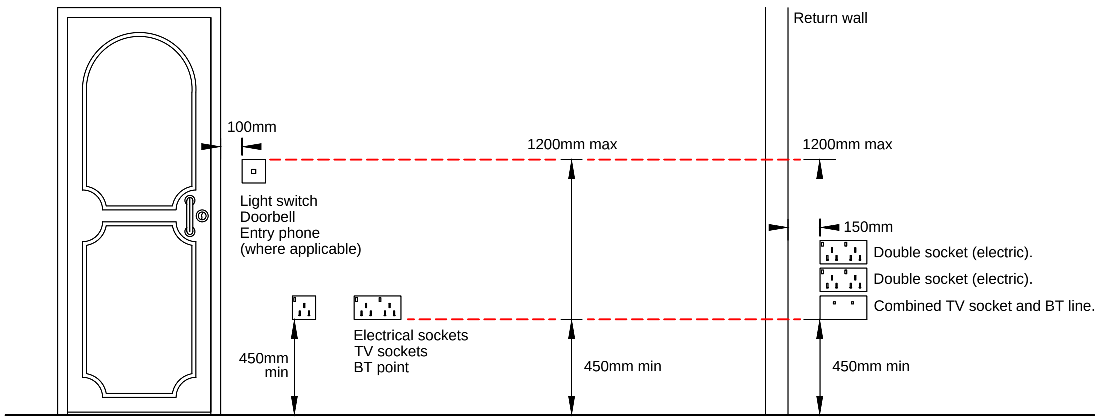
Positioning of sockets and switches

Sockets and switches should be positioned in accordance with the details on this sheet and the relevant regional Building Regulations.

Consumer units should be between 1350mm and 1450mm above floor level.

Heights of wiring accessories

Setting out sockets in proximity to internal walls



Notching and drilling

Floor joists should not be excessively notched or drilled. Further information can be found in the 'Upper Floors' guidance.

Concealed services

If the services are hidden in walls or floors, they need to be positioned so that any significant cracking of the surface cannot occur.

Services in framed walls

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure.
- Electrical services are to be rated for their location with consideration for insulation.
- Service penetrations through the VCL should be tight fitting to reduce air leakage and the passage of moisture vapour.
- Avoid running electrical services in the external wall cavity, except for meter tails.
- Services should be protected with metal plates if they pass within 25mm from face of stud.
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building.
- Services that pass through the external wall cavity and provide an opening (such as meter boxes) should be enclosed with a cavity barrier and protected with a cavity tray.

Further guidance can be found in the 'Internal Walls' and 'Upper Floors' guidance.

Chasing of masonry cavity walls

If chases in walls are necessary, their depth should not exceed:

- One-sixth the thickness of the single leaf for horizontal chases.
- One-third the thickness for vertical chases.

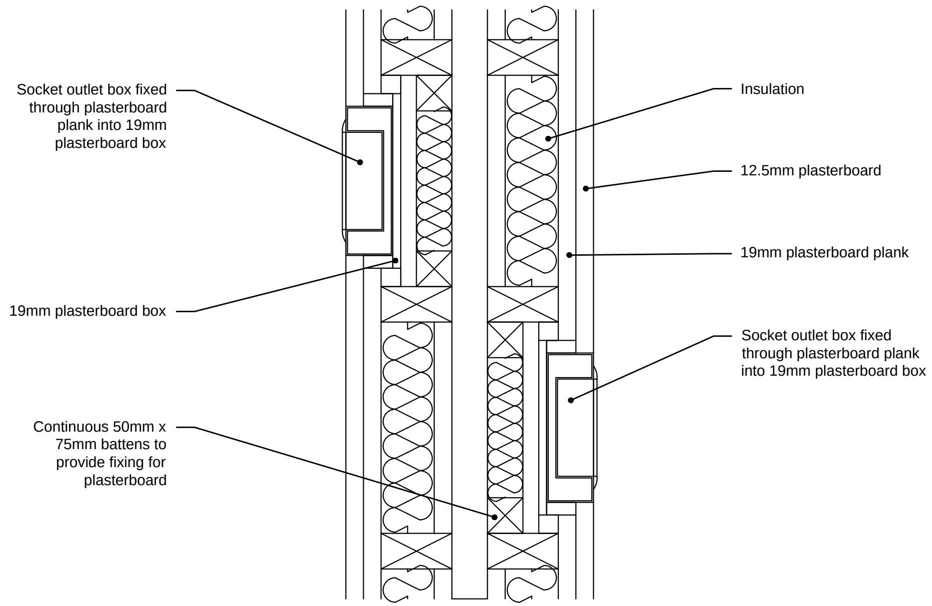
Hollow blocks should not be chased unless specifically permitted by the manufacturer.

Fire stopping

Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

Further guidance can be found in the 'Internal Walls' and 'Upper Floors' guidance.

Staggered services on party walls (section plan view)



Please note: The installation services within a party wall should not compromise the sound or fire resistance.

18.

Water Services

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

1. Water services - shall be designed, constructed and installed so that they:
    a. Conform to all relevant statutory requirements;
    b. Do not adversely affect the structural stability of the building;
    c. Prevent the entry of hazardous ground substances, external moisture or vermin;
    d. Are constructed using non-hazardous materials;
    e. Are durable and robust;
    f. Are safe and convenient in use.
2. Cold water service - an adequate cold water service shall be provided which is:
    a. Suitable for normal domestic purposes;
    b. Protected against frost.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

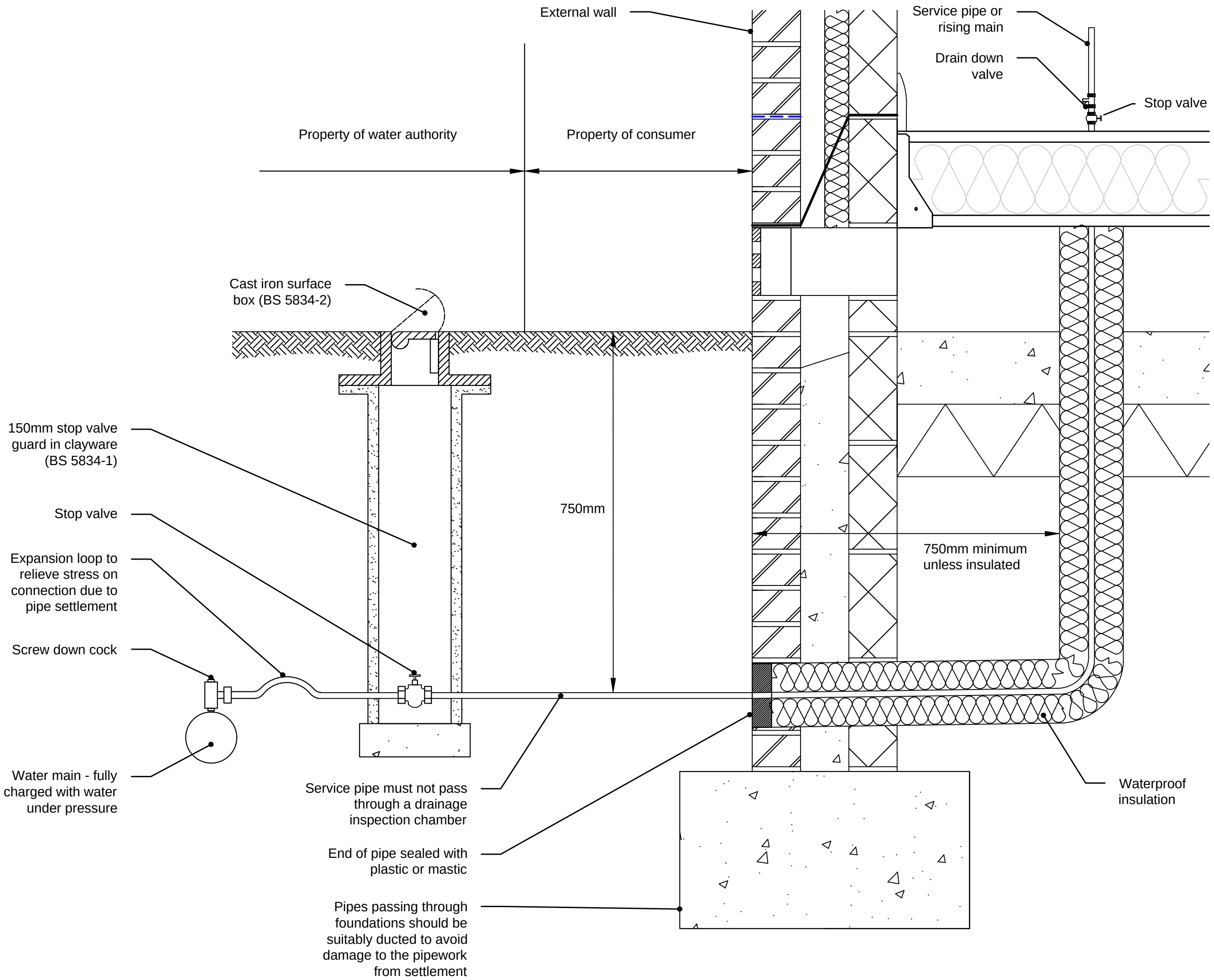
18.

Water Services

18.1

Cold Water Supply to Plumbing, Boilers, and Appliances

Installation of incoming water services



Cold water services

Each building should have an adequate supply of cold water. The water supply should be fed from below ground and insulated to prevent freezing.

Cold water systems may have provision for storage or be directly connected to the main supply. Drinking water needs to be supplied directly from the main supply.

Cold water pipes and storage cisterns located in roof spaces and other unheated areas should be appropriately insulated to the relevant standards.

Cold water storage cisterns will require the capacity specified in the design. Suitable support should be given for the cistern filled with water.

To stop the cistern bottom being deformed, permanent support is to be given where necessary. Adequate materials for support platforms are:

- Softwood boarding.
- Marine plywood.
- Chipboard type P5.
- Oriented Strand Board type OSB3 to British Standards.

All water tanks should be accessible. Gangway boarding is required to each cistern opening from the roof space access. An area of $1m^2$ of boarding is to be provided next to cisterns to permit routine maintenance.

Water storage cisterns should be protected from contamination by a rigid, close-fitting cover (which is not air tight) that excludes light and insects.

Holes should be formed with a cutter in the positions shown in the design.

Overflows in warning pipes should be no less than 19mm diameter and situated 25mm from the shut off water level in the cistern. The pipe may dip below the water level in accordance with water regulations. Alternatively, the pipe should terminate vertically downwards, or a tee should be fitted horizontally at the discharge end.

Draining down facility

Cold water installations require the capability to be drained down.

Use of materials

Materials that are safe and minimise the risk of corrosion are to be used for pipes and fittings for water services. The recommendations of the water supplier with regard to materials and fittings should be followed.

It may be necessary to fit aluminium protector rods in areas where the corrosion of copper cylinders occurs. These are to be fitted during manufacture, in accordance with the relevant British Standards.

Installation of building services

All items should be installed to ensure satisfactory operation.

Items to be taken into account include:

- Locations and fittings of pipes and cable service entries through the substructure.
- Services must be sleeved or ducted through structural elements (and not solidly embedded) to prevent damage. Fire stopping may also be required. Services should not to be located in the cavity of an external wall, except for electricity meter tails.
- Only to be buried in screeds where permitted by relevant Codes of Practice.

Where copper pipes are permitted in floor screeds, they should be:

- Sleeved or wrapped so that they can move freely along the length and at joints and bends.
- Jointed with capillary joints.

A metallic tape should be applied to the pipework where plastic pipework is hidden within or behind wall surfaces, which would otherwise not be located by a metal detector.

Jointing of pipes and fittings

Proprietary joints should be made strictly in accordance with the manufacturer's instructions.

Only fluxes recommended by the pipe manufacturer should be used, and all traces should be removed immediately after jointing. Fluxes containing lead are not acceptable.

Suitable clips or brackets are to be used to secure pipes. Fixings should be installed adequately and spaced to stop sagging but not restrict thermal movement. Where needed, pipes should have adequate falls.

Sufficient room should be allowed for thermal expansion and contraction to avoid damage and noise from pipe movement.

Notches and drillings

Floor joists should not be excessively notched or drilled. Further information can be found in 'Upper Floors' guidance.

Taps

Cold taps should be located to the right of the hot water tap.

Concealed services

If the services are hidden in walls or floors, they need to be positioned so that any significant cracking of the surface cannot occur.

Chasing of masonry cavity walls

If chases in masonry walls are necessary, their depth should not exceed:

- One-sixth the thickness of the single leaf for horizontal chases.
- One-third the thickness for vertical chases.

Hollow blocks should not be chased unless specifically permitted by the manufacturer.

Further information can be found in the 'Internal Walls' guidance.

Services within or beneath floors

Protection through wrapping or ducting is necessary when pipes are situated under floor screeds. Thermal expansion allowances are to be made, especially at changes of direction.

The insulating material around the pipework needs to be a minimum of 25mm in thickness. The screed thickness should still be at least 25mm where pipes cross over.

Fire stopping

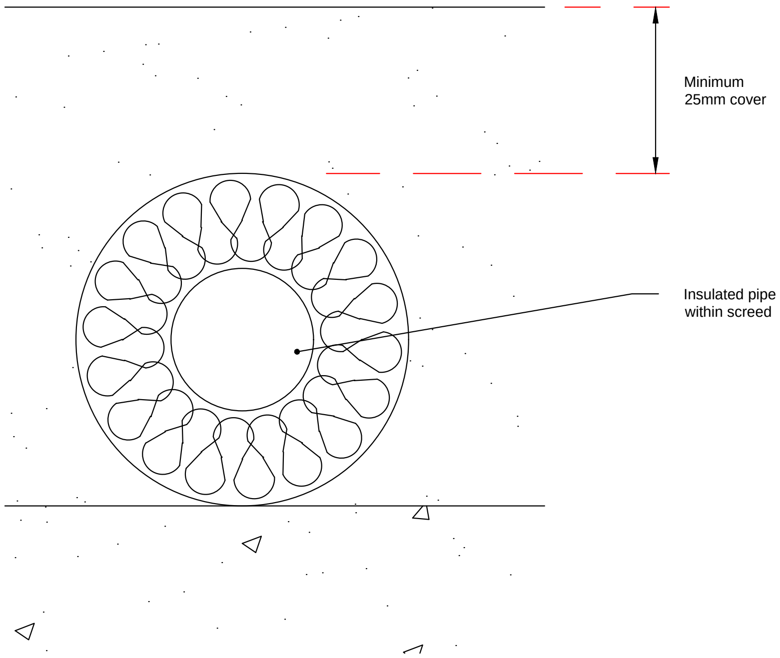
Fire stopping is required around services that penetrate fire-resisting floors, walls or partitions. If proprietary systems are used, they should be installed using the manufacturer's recommendations.

Further information can be found in the 'Internal Walls' and 'Upper Floors' guidance.

Supplementary bonding

Where required the pipework should be fitted with supplementary earth bonding.

Positioning of pipes in screeds



19.

Outbuildings

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

1. Outbuildings should be constructed to resist lateral and vertical loads adequately.
2. Foundations should be designed and constructed to suit local ground conditions and adequately support the weight of the structure and imposed loads.
3. Specialist works must be provided and supported by structural calculations completed by a suitably qualified engineer where necessary.
4. Outbuildings shall be designed and constructed so that they:
    a. Are structurally sound and do not impair the stability of adjacent structures;
    b. Are durable and resistant to weather and ground moisture;
    c. Have adequate provision for drainage of roof water;
    d. Have resistance to the spread of fire to the building or adjacent structures;
    e. Offer reasonable resistance to unauthorized entry.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

19.

Outbuildings

19.1

Garages

Limitations

This section does not apply to outbuildings where:

- The building is heated or protected against frost damage.
- The building is used as a habitable space, including home offices.
- It is essential that the walls will resist wind-driven rain.

Where a building is intended to be built to meet the above requirements (i.e. be heated and habitable and weather resistant), the building will need to meet all the requirements of this Technical Manual.

Introduction

In order to achieve a satisfactory standard of performance, garages, conservatories, small outbuildings and extensions should be designed and constructed so that:

- They are able to sustain and transmit all normal loads to the ground without affecting their own stability or that of the housing unit (or any adjacent buildings) by excessive deflection or deformation that would adversely affect the appearance, value and serviceability of the building or the housing unit.
- They provide an acceptable and durable external surface and are not adversely affected by harmful or toxic materials in the atmosphere or from the ground.
- They are resistant to moisture and do not allow the passage of moisture to parts of the building that would be adversely affected by it.
- They encourage the rapid discharge of moisture due to rain or snow from their surfaces to suitable gutters and down pipes, or to some other form of collection and discharge that prevents moisture from re-entering the building, where it might have adverse effects.
- In the event of fire, they resist fire spread to the housing unit and to adjacent buildings.
- They are provided with sufficient locks or other devices to resist unauthorised entry.
- Where additional services installations are provided (such as central heating boilers or electrical or plumbing installations), these comply with the relevant additional guidance contained in this manual.
- The risk of injury from accidental breakage of the glazing (where fitted) is reduced to a minimum.

A satisfactory performance for the design and construction of garages, conservatories, small outbuildings and extensions may be achieved by meeting the relevant parts of the guidance supporting the relevant regional Building Regulations.

Foundations

Foundations should be constructed so that loads are adequately transferred. Further information can be found in the 'Foundations' section.

Garage floors

Floors should have a minimum concrete thickness of 100mm and bear onto a suitable subbase. The concrete should be float finished and to at least a GEN3 grade, as the garage is not a habitable space some surface imperfections of the floor finish are acceptable. The effects of normal drying shrinkage of concrete floors could cause some small gaps around the perimeter at wall junctions.

Garage floors should be laid to falls to comply with the relevant regional Building Regulations.

Further information can be found in the 'Ground Floors' section.

Walls

Single leaf 100mm walls are considered acceptable, providing that the following provisions are met:

- The height of wall does not exceed 2400mm from ground level.
- Intermediate piers are provided, in accordance with adjacent detail. The piers should extend the full height of the wall.
- The piers should be built off a suitable foundation.
- The wall is adequately restrained at ceiling and verge level.
- The walls are capable of adequately transferring the roof loadings to the foundation.
- Walls are pointed both internally and externally.
- Walls should be provided with a suitable DPC located at least 150mm above ground level.
- Proprietary lintels should be provided over window/door openings.
- Where walls are constructed that exceed 2.4m in height e.g. Gable walls, the overall thickness must be increased to at least 190mm thick.

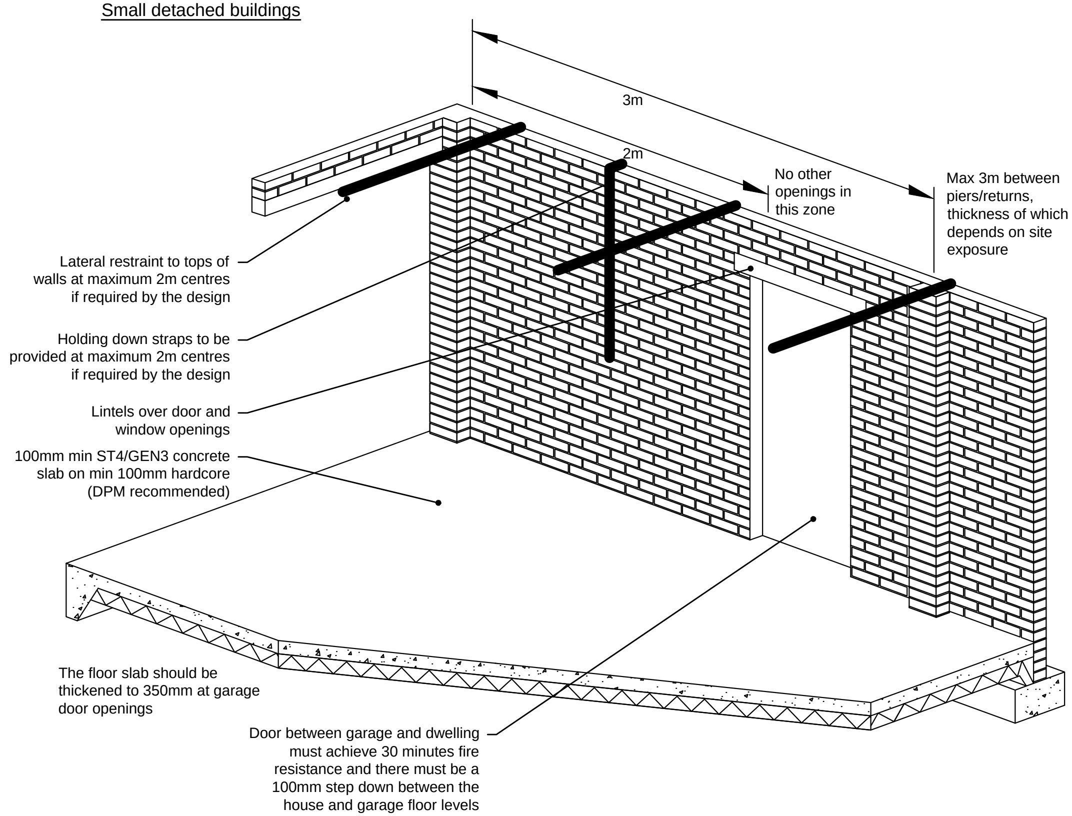
Roofs

Roofs should be weather tight. Flat roofs should have a minimum design fall of 1:40. Tiled roofs should be installed in accordance with the manufacturer's instructions, including pitch, fixing and lap.

Roof structures should be durable enough to support roof loadings adequately. Timber trusses should be adequately braced and traditional cut roofs should have timber elements that meet relevant Building Regulations and supporting documents.

Further information can be found in the 'Roofs' guidance.

Small detached buildings



Walls between outbuildings

Where walls separate outbuildings under two different ownerships or tenancies, the separating wall should be taken up to the underside of the roof and fire stopped.

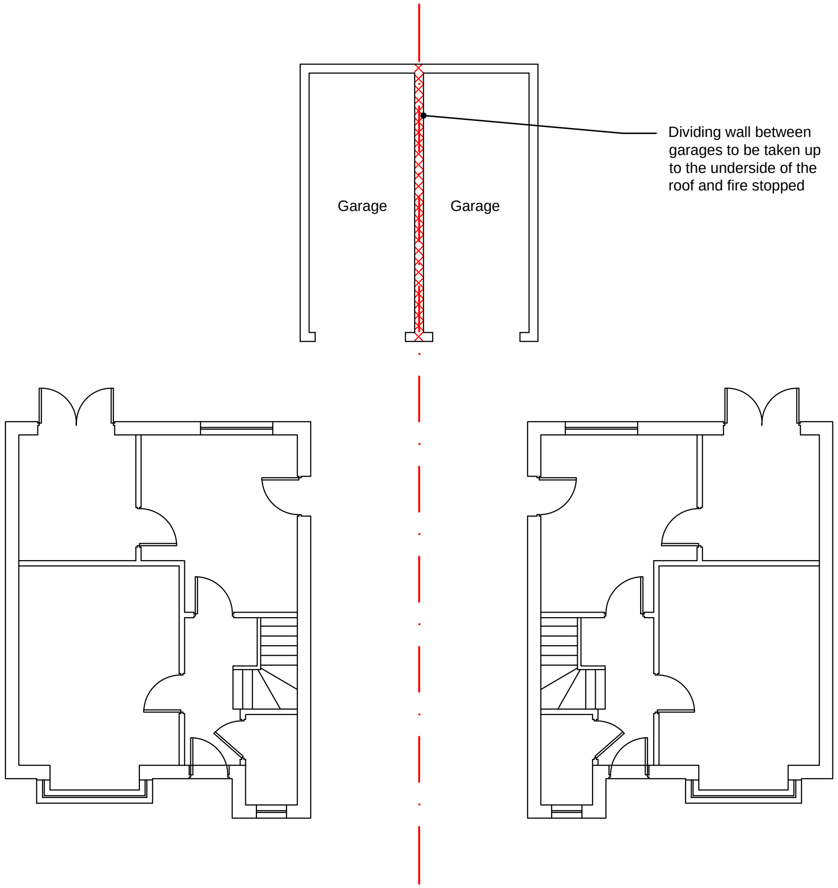
The following guidance is provided for typical examples of multiple ownership situations.

Note: The dividing walls should have the appropriate fire resistance in accordance with the relevant regional Building Regulations.

Example Plan 1: Linked detached garages

The dividing wall (also boundary) forms a compartment situation between two properties and must be taken up to the underside of the roof covering and fire stopped.

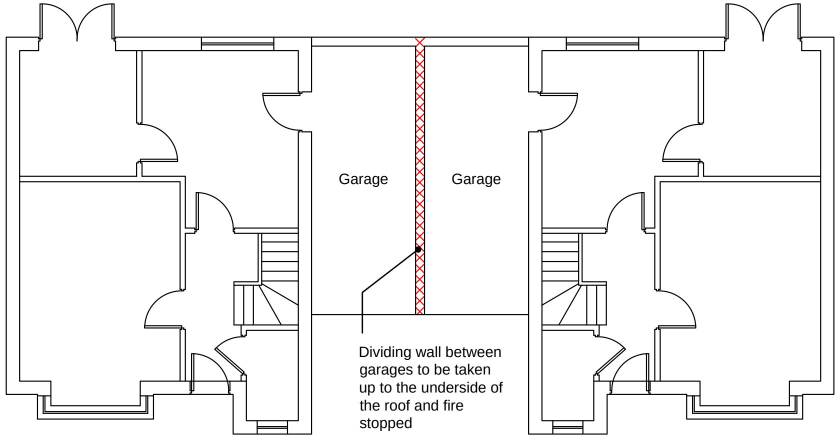
Detached garage away from dwelling



Example 2: Linked to dwelling and linked to another garage across boundary

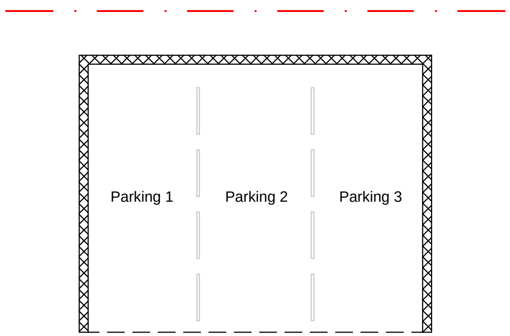
The dividing wall (on the boundary) forms a compartment situation between two properties and must be taken up to the underside of the roof covering and fire stopped.

Garages linking two properties



Linked carport/parking bay

Note: red dashed line can be a site boundary position.



Example 3: Linked carport (open fronted - no dividing walls) / parking place in under croft car parking area:

i.e. Where an allotted car park space is provided and no legal boundary situation exists between bays.

In this situation, where no ownership boundary will exist and just allotted parking bays, no requirements for compartment walls will exist, therefore can remain open.

The above information is for guidance purposes only in all situations compliance with the appropriate relevant regional Building Regulations should be achieved.

Fire stopping at roof level between party walls

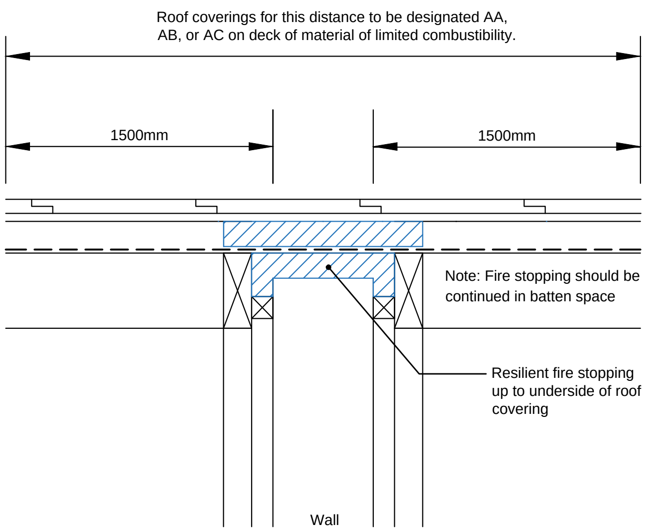
Compartmentation

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed space, it is particularly vital that fire-resistant cavity barriers are provided at the following points:

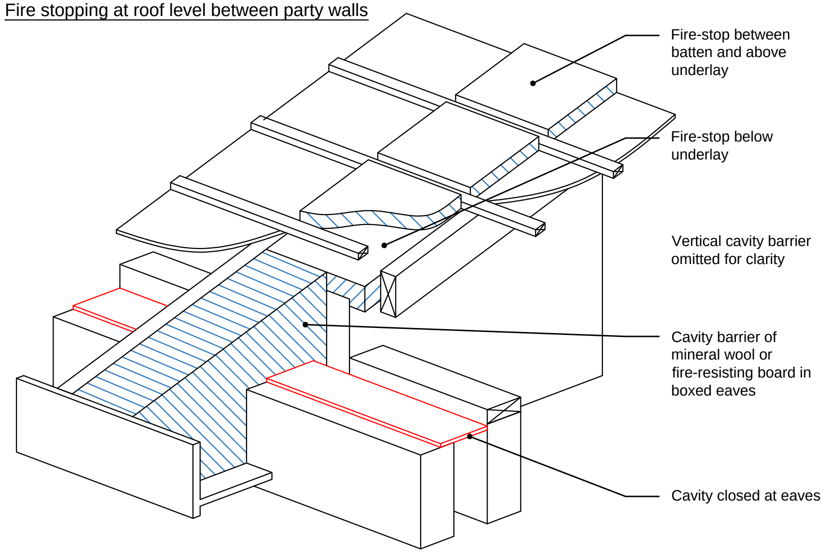
- At junctions of separating wall and external cavity wall.
- At junctions of compartment wall and compartment floor (not illustrated).
- At junctions of separating wall with roof, under roof tiles.
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire stopping, where necessary, at the wall/ roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment. To reduce this risk, a roof zone 1500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.

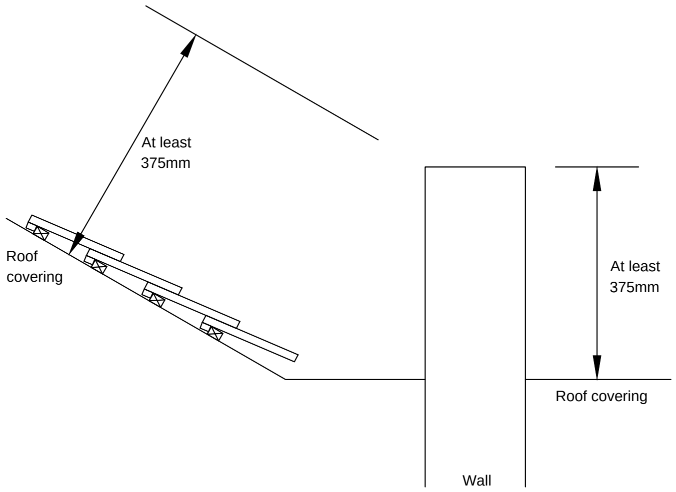


Fire stopping at roof level between party walls



Fire stopping should be provided in accordance with the relevant regional Building Regulations

- Party/separating walls 25mm below the top of the rafter line and a soft fire-resistant packing, such as mineral wool, should be used to allow for movement in roof timbers and prevent distortion of the roof tiles.
- The fire stopping should be continuous to eaves level and a cavity barrier of fire-resisting board or a wire reinforced mineral wool blanket nailed to the rafter and carefully cut to fully seal the boxed eaves should be installed.



20.

Ground Conditions

Contents

Additional Functional Requirements

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

1. All samples to be stored and kept in such a way that will not cause inaccuracy when soils are tested.

Design

1. The site investigation should be completed at an appropriate level for the risk in accordance with the relevant British Standard.
2. Site investigation and remedial measures must meet the relevant regional Building Regulations and additionally; those standards specifically referred to in the references section in the guidance that follows this Functional Requirement.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

20.

Ground Conditions

20.1

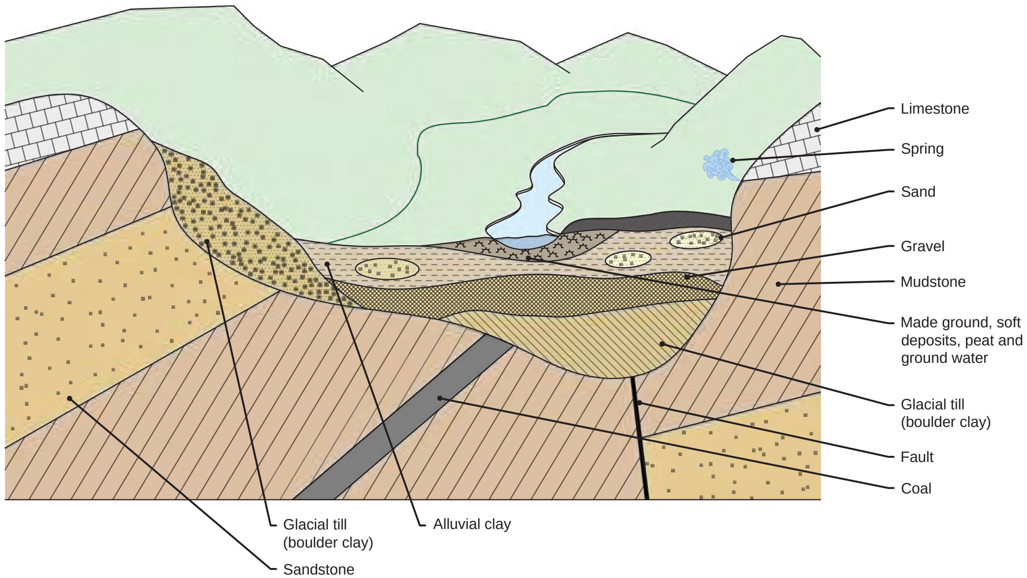
Site Investigation Requirements

This section sets out the requirements for an acceptable Site Investigation. It is intended to be flexible and user-friendly, and includes simple checklists aimed at ensuring compliance. The aim is to raise standards in the interests of both the Warranty provider and the Builder or Developer. This will lead to a safe and economic design that will minimise the risk to all those involved in the project.

Where projects run over time and over budget, this is usually as a direct result of problems within the ground. It is therefore vitally important to reduce the risk of unforeseen conditions that can directly affect the overall cost of the project. It is believed that Builders and Developers will view this work as an important safeguard, rather than unnecessary expenditure.

To ensure a consistently high standard, all stages of the work should be carried out by a Chartered Engineer or Chartered Geologist with at least five years' experience of this type of work. Specifying properly qualified personnel will considerably increase the overall industry standard.

The geological environment: Cross section of a river valley



Roles and Responsibilities

The roles and responsibilities of those parties involved in the development are the owner, developer, builder and self-builder.

Owner/developer/builder/self-builder

The provision of clear development proposals for the site, and the implementation of a competent Site Investigation using appropriately qualified personnel, is now a priority for regulators. These demonstrate that any geotechnical and contaminated land risks can be safely dealt with. Specific Health and Safety responsibilities, in particular the CDM Regulations also require compliance.

Environmental Health/Contaminated land officer

The provision of advice to the local Planning Department on technical matters and planning conditions requires a competent and comprehensive Site Investigation and associated risk assessment.

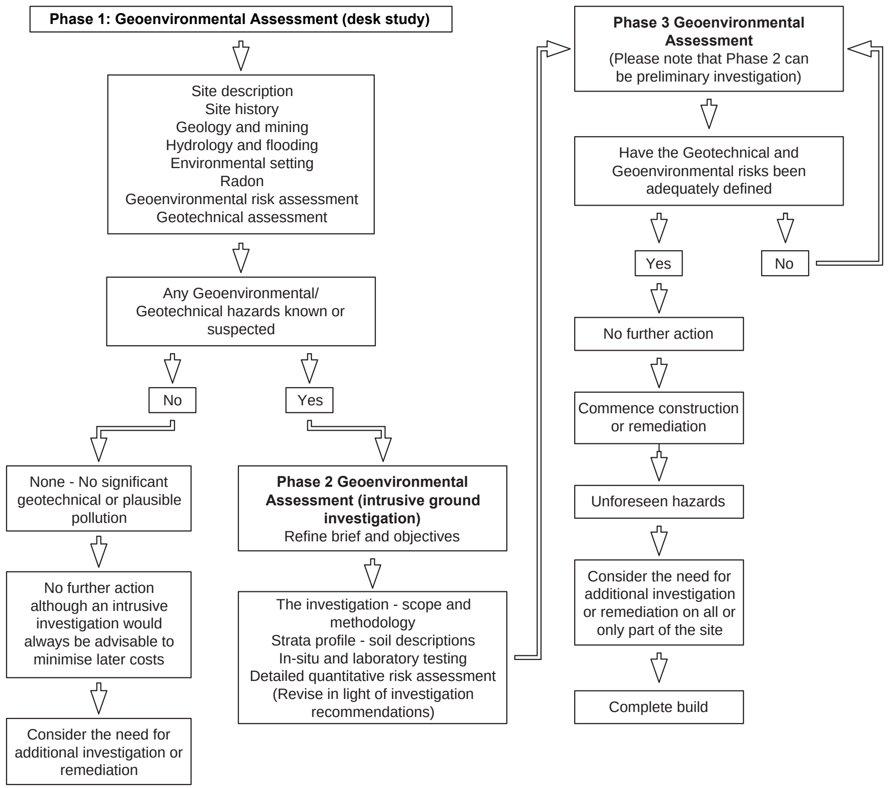
Local Authority Building Control

Building Control is responsible for enforcing the Building Regulations, which also requires a competent and comprehensive Site Investigation.

Health and Safety Executive

The HSE are responsible for Health and Safety at work, including the CDM Regulations.

Flow chart of Site Investigation procedures



Phase 1: Geoenvironmental Assessment (desk study)

Introduction

The aim of the Phase 1 Geoenvironmental Assessment is to identify and assess the potential geotechnical and geoenvironmental (contamination) hazards on the site. Since all sites are different, it is important to identify the scope and purpose of the desk study. This will include who commissioned the work, the development proposals, the relevant procedures followed and the objectives. Any issues specifically excluded should also be noted if these might normally be expected as part of the desk study.

Site description

The site description should define the exact extent of the site, and should include a site address, grid reference and elevation. The boundaries and topography of the site should be defined.

A site inspection should always be carried out not only of the site itself, but also the immediate surrounding area. This should include any information not apparent from the maps and describe what currently occupies the site, such as buildings, hard standing, watercourses, vegetation, trees and any particular features.

The type and distribution of vegetation can indicate soil and ground water conditions, and note should be made of any invasive plants, such as Japanese Knotweed and Giant Hogweed. Adjacent features and land use should be reported if there is likely to be an impact on the development. It is not uncommon for features such as tanks to be known about but unrecorded. The walkover should note any potential sources of contamination and geotechnical hazards, such as slopes, excavations, land slipping, ground subsidence, soft ground or desiccated/shrinkable soils.

All structures on the site should be inspected both internally and externally for any evidence of structural damage, such as tilting, cracking or chemical attack. Any evidence of underground features should be noted. Where practical, the local residents can often give valuable information, although caution should be used in respect of their 'memories'. Local place names can give useful indications of former uses, e.g. Gas Works Lane, Water Lane, Tannery Road, etc. Aerial photographs and their interpretation can also prove helpful.

A photographic record of the site, and any specific features of the site, should be included with the report.

Site history

The history of the site and the surrounding areas is extremely important when assessing the likelihood of contamination or geotechnical hazards. Historical Ordnance Survey maps date back to the mid-19th Century and often specify the actual industrial use of particular sites or buildings. They may show areas of quarrying or infilling, and indicate where buried obstructions, such as underground tanks or old foundations, can be expected.

The influence or impact of off-site past industrial use will depend upon the type of industry, the underlying geology and the topography. However, consideration should normally be given to any such features within a 250m radius of the site (or further where appropriate) with the potential to affect it.

Historical maps are available from libraries and commercial providers, such as Ground Sure or Envirocheck. The latter provide a cost-effective method of obtaining maps, and include the ability to superimpose current site boundaries on older maps. Issues regarding possible breaches of copyright are also avoided by using licensed products.

It should be remembered that historical maps only provide a snapshot in time, and care must be taken when interpreting what may have occurred in the intervening years. For example, a quarry may be shown on one map and infilled on the next. However, in the intervening period, it could have expanded prior to infilling; similarly, industrial uses may not always be recorded while many military or sensitive uses may have been omitted. Other sources of information may include the ubiquitous internet search and historical aerial photographs. Additionally, it may be necessary to search the libraries of Local Authorities and Local History departments.

Geology and mining

The geology of the site should be recorded by reference to published geological maps, which most commonly exist at 1:50,000 (1 inch to 1 mile) and 1:10,000 (6 inch to 1 mile). The British Geological Survey Geo-Index also provides existing ground investigation records, including logs and reports. It should be noted that these records can relate not only to the surrounding areas but may also include previous investigation of the site itself. The information on the geological maps can also be supplemented with British Geological Survey technical reports, flood risk appraisals and memoirs.

The bedrock geology, any overlying superficial deposits and the effects of weathering should all be described, together with any geological faults that may affect the site. An explanation of the likely ground conditions should be given, together with reference to any other mapped geological features, particularly if there are likely to be any natural cavities or solution features.

Mining areas

In former coalfields, or other areas of mineral extraction, the maps may not always record the presence of old or active workings. The likelihood of shallow coal workings affecting surface stability should be established in conjunction with a Coal Authority report. Such reports also record areas that have been affected by the extraction of brine, which is particularly prevalent in the Cheshire area. Other forms of mineral extraction will require site-specific research.

Key requirements for foundations constructed in mining areas

The foundations shall be designed to clearly demonstrate that the design loads are safely transferred to known soil strata that are, in turn, capable of supporting the loads. Foundations should be designed to ensure that long-term settlement does not exceed 25mm (or 10mm for piles) or 1:500 (differential), unless more stringent criteria are required by the Project Structural Engineer.

The potential for mine workings and mine entries within an influencing distance of the proposed development should be addressed by a suitably qualified and experienced engineer prior to commencement of works, and in accordance with CIRIA guidance (including CIRIA SP 32: Construction Over Abandoned Mine Workings, 2002), Coal Authority Technical Guidance Notes (including TGN01/2019) and our "Mining - Structural Requirements" document.

Reference should be made to reports on geological hazards, such as Envirocheck or GroundSure reports, both on-site and locally.

For further guidance on foundation proposals in mining areas, please refer to the Warranty Good practice guide: 'Mining - Structural Requirements' available on the Warranty website.

Solution features in chalk

Solution features (such as pipes, swallow holes and solution cavities, sometimes loosely infilled with drift deposits) are commonly found in chalk, caused by water draining through the chalk and dissolving it. They can also be found in Limestone and other soluble rocks. The British Geological Survey categorises the five main soluble rocks found in the UK as Chalk, Limestone, Gypsum, Dolomite, and Salt. The risk of solution features should be addressed in the Site Investigation Report (commonly from an Envirocheck or GroundSure report on geological hazards, both on-site and locally).

Hazard maps are available with different coloured areas representing different levels of risk. Where the risk is moderate or high, special precautions should be taken, which for strip foundations would include careful inspection of the excavation, probing and use of reinforcement to span potential voids.

Key requirements for foundations constructed in chalk areas

The foundation scheme shall be designed to clearly demonstrate that the foundations are capable of supporting and transferring the design loads safely to known soil strata that can be demonstrated from the appropriate project Site Investigation report to be capable of carrying the load, using the appropriate soil properties obtained from geotechnical testing. Where there is a moderate to high risk of voids being present, the foundations shall be designed in the first instance to span across a void of at least 5 metres without settlement greater than 25 mm (10mm for piles) or differential settlement tilt greater than 1:500 for low rise buildings unless more stringent criteria are required by the Project Structural Engineer. For buildings greater than three storeys please contact the Warranty surveyor.

The potential effects of soakaways, leaking drains, run off, etc. on the chalk will need to be considered and addressed in the design.

CIRIA C574: Engineering in Chalk, 2002 gives the following recommendations:

Concentrated ingress of water into the chalk can initiate new dissolution features, particularly in low-density chalk, and destabilise the loose backfill of existing ones. For this reason, any soakaways should be sited well away from foundations for structures or roads, as indicated below:

- In areas where dissolution features are known to be prevalent, soakaways should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations.
- Where the chalk is of low density, or its density is not known, soakaways should be sited at least 10m away from any foundations.
- For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipework.
- As the chalk is a vitally important aquifer, the Environment Agency and Local Authority must be consulted when planning soakaway installations where chalk lies below the site, even where it is mantled with superficial deposits.

For further guidance on foundation and drainage proposals in areas where solution features in soluble rocks are present or known to exist, please refer to the Warranty Good Practice Guide: 'Solution features in soluble rocks' available on the Warranty website.

Hydrogeology and flooding

The assessment should include the flood risk and hydrogeology of the site, particularly whether the site lies on a Principle Aquifer and/or Source Protection Zone, which are both, susceptible to pollution of ground water. The presence of surface water features and drainage should be described, and the overall risks of flooding to the site should be determined, primarily with reference to the Environment Agency flood map data and Local Authority-commissioned Strategic Flood Risk Assessments. Flood risk data is continually being updated by the Environment Agency and Local Authority.

Any ground water or surface water abstraction points 'downstream' of the site, particularly any potable (drinking water) abstraction points, should be recorded, as this may have liability implications should the development cause any pollution.

Environmental setting

The question as to whether a site poses an actual or potential environmental risk, or is at some external risk from pollution, will be determined by its environmental setting. This will in turn depend upon the site's topography, geology, hydrogeology and hydrology, amongst other site-specific considerations.

It is necessary to consider other potential sources of contamination, such as pollution control licenses, discharge consents, hazardous sites (COMAH, NIHHIS), pollution incidents, landfills, waste treatment sites and past and current industrial sites.

Current industrial operations rarely provide a risk of pollution to a site. Pollution is most likely to have been caused by historical activities and processes that were often deemed normal practice in the past, but which are considered unacceptable today. In this regard, the past history is invariably highly significant in respect of possible ground pollution.

The site should be considered in relation to any designated environmentally sensitive sites, such as Special Areas of Conservation, Special Protection Areas, Nature Reserves and Sites of Special Scientific Interest. In particular, could contamination on the site be affecting such sensitive areas, whether these are on or adjacent to the study site?

Data relating to current industrial licensing, consents and the like, together with information relating to environmentally sensitive sites, is typically available through commercial data suppliers. As with the historical maps, this is usually a cost-effective method of obtaining data.

For both the historical maps and datasets, there is usually little or no interpretation of the information, and it is essential that this interpretation is carried out by an experienced and qualified individual. Automated risk assessments do not include appraisal by qualified staff, and should therefore be viewed with caution and are not usually acceptable to Regulators.

An example of this was a contaminated former petrol filling station site recorded as having no past industrial use. The historical maps never recorded the site as a filling station, nor did the environmental data. However, the walkover quickly identified former bases for pumps and filling points for underground storage tanks (USTs).

Radon

The need to incorporate radon protection measures should be determined by reference to risk maps produced by the Health Protection Agency. Such information is also usually included within commercially available datasets.

Geoenvironmental risk assessment and conceptual site model

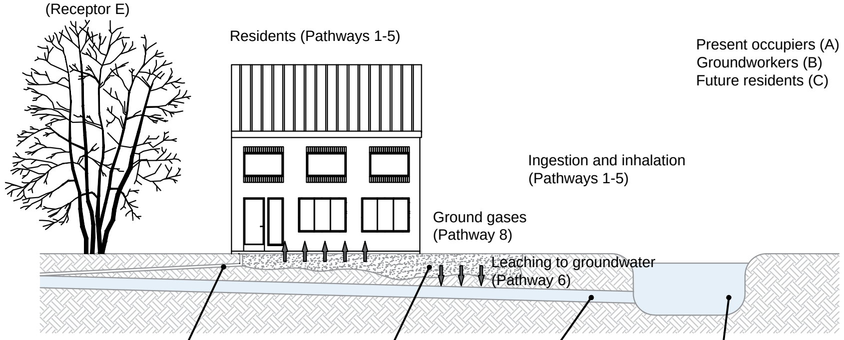
A quantitative health and environmental Risk Assessment should be carried out as part of the assessment. The process of a Risk Assessment is set out in Part IIA of the Environment Protection Act 1990, and amended in subsequent legislation.

This act introduces the concept of a pollution linkage, which consists of a pollution (contaminative) source or hazard and a receptor, together with an established pathway between the two. For land to be contaminated, a pollution linkage (hazard-pathway-receptor) must exist; this forms a so-called 'conceptual model' of the site.

Source → Pathway → Receptor

Examples of pathways and the effects of land contamination (after PPS 23) are shown on the diagram below 'Pathways of potential contaminants'.

Pathways of potential contaminants



Pathways

1. Ingestion of contaminated soil.
2. Ingestion of contaminated food.
3. Ingestion of contaminated water.
4. Inhalation of contaminated vapours.
5. Dermal contact with contaminated soil/dust or water.
6. Pollution of controlled water and off site migration.
7. Attack on building materials and services.
8. Migration of landfill gases and radon.

Receptors

A. Present site occupiers.
B. Site development personnel.
C. Future residents.
D. Controlled waters.
E. Flora and fauna.
F. Building and services.

Human health (pathways 1-5, receptors A-C)

There is an uptake of contaminants by food plants grown in contaminated soil. The uptake will depend on their concentration in the soil, their chemical form, soil pH, plant species and prominence in diet.

Ingestion and inhalation
Substances may be ingested directly by young children playing on contaminated soil if they eat plants that have absorbed metals or are contaminated with soil or dust. Ingestion may also occur via contaminated water supplies. Metals, some organic materials and radioactive substances may be inhaled from dusts and soils.

Skin contact
Soil containing tars, oils and corrosive substances may cause irritation to the skin through direct contact. Some substances, e.g. phenols, may be absorbed into the body through the skin or through cuts and abrasions.

Irradiation
As well as being inhaled and absorbed through the skin, radioactive materials emitting gamma rays can cause a radiation response.

Fire and explosion
Materials such as coal, coke particles, oil, tar, pitch, rubber, plastic and refuse waste are all combustible. Both underground fires and biodegradation of organic materials may produce toxic or flammable gases. Methane and other gases may explode if allowed to accumulate in confined spaces.

Buildings (pathways 7 and 8)

Fire and explosion
Underground fires may damage services and cause ground subsidence and structural damage. Accumulations of flammable gases in confined spaces leads to a risk of explosion.

Chemical attack on building materials and services
Sulphates may attack concrete structures. Acids, oils and tarry substances may accelerate the corrosion of metals or attack plastics, rubber and other polymeric materials used in pipework and service conduits or as jointing seals and protective coatings to concrete and metals.

Physical
Blast-furnace and steel-making slag (and some natural materials) may expand. Degradation of fills may cause settlement and voids in buried tanks, and drums may collapse as corrosion occurs or under loading.

Natural environment (pathway 6, receptors D-E)

Phytotoxicity
(Prevention/inhibition of plant growth)
Some metals essential for plant growth at low levels are phytotoxic at higher concentrations. Methane and other gases may give rise to phytotoxic effects.

Contamination of water resources
Soil has a limited capacity to absorb, degrade or attenuate the effects of pollutants. If this is exceeded, polluting substances may enter surface and ground waters.

Ecotoxological effects
Contaminants in soil may affect microbial, animal and plant populations. Ecosystems or individual species on the site, in surface waters or areas where migration has occurred may also be affected.

For any contaminant source identified, judgement is required to assess the probability of a pollution linkage occurring and the potential consequences of that linkage. Based on the probability and likely consequences, the overall risk (significance) can be established. The definitions that are used for this purpose should be clearly stated. The probability of a hazard, combined with its consequences, can be used to assess risk, and this forms the so-called Conceptual Site Model. This is in accordance with the Statutory Guidance for Contaminated Land (Defra 2006).

The following tables may be used to explain the decision-making process:

Consequences of pollution linkage

Severe	Damage to human health Substantial pollution of controlled waters Significant change in ecosystem population Irreparable damage to property
Moderate	Non-permanent damage to human health Minor pollution of controlled waters Change in ecosystem Damage to property
Mild	Short term health effects Slight pollution of controlled waters Slight effect on ecosystem Minor repairable damage to property
Near Zero	No noticeable effect on human health No significant pollution to controlled waters No measurable effect on ecosystem densities Non-structural cosmetic damage to property

Decision making

Probability of a hazard and an associated linkage	**Consequences of a pollution linkage (hazard pathway target)**			
	Severe	**Moderate**	**Mild**	**Near zero**
High	Very High	High	Medium/Low	Low/Negligible
Medium	High	Medium	Low	Low/Negligible
Low	High/Medium	Medium/Low	Low	Negligible
Unlikely	High/Medium/Low	Medium/Low	Low	Negligible

Final overall risk is based on an assessment of the probability of a hazard and its consequences.

Risk categories are shown shaded in the table 'Decision making', and are defined in the table 'Overall risk' below.

Overall risk

Risk	Description of risk levels
High	Site probably or certainly unsuitable for present use or environmental setting. Contamination probably or certainly present and likely to have an unacceptable impact on key targets. Urgent action needed.
Medium/Moderate	Site may not be suitable for present use or environmental setting. Contamination may be present, and likely to have unacceptable impact on key targets. Action may be needed in the medium term.
Low	Site considered suitable for present use and environmental setting. Contamination may be present but unlikely to have unacceptable impact on key targets. Action unlikely to be needed in present use.
Negligible	Site considered suitable for present use and environmental setting. Contamination may be present but unlikely to have unacceptable impact on key targets. No action needed while site remains in present use.

Geotechnical assessment

Although no intrusive investigation may have been carried out on the site at the desk study stage, it should be possible to give preliminary indications in respect of the geotechnical matters set out in the table 'Geotechnical Assessment: Preliminary Indicators' below.

Geotechnical Assessment: Preliminary Indicators

Foundations	Are normal to deep strip footings likely to be suitable or might piling or ground improvement be necessary? Will made ground, old foundations, cellars or services be encountered?
Mining and quarrying	Will the possibility of shallow mine workings or quarrying on the site need to be addressed?
Soakaways	Are soakaways likely to be suitable based on the mapped geology? (Actual on-site permeability tests would need to be carried out to determine suitability or not).
Roads	What is the sub-grade strength (CBR) likely to be? (The actual design will be dependent on the CBR measured on-site).
Excavations	Will soft ground plant be suitable or will rock breakers be needed for deeper excavation?
Ground water	Is shallow ground water expected?
Earthworks	Are any significant earthworks anticipated?
Gas protection	Will gas protection measures be required or would they be prudent in accordance with good practice?

The above can only be provided on the basis of limited site data, and it is recommended that the scope of any intrusive ground investigation is set out here if the desk study is to be presented as a stand-alone document.

Phase 2: Geoenvironmental Assessment (ground investigation)

Pre-ground investigation

The initial investigation should comprise a desk study as described in the flow chart of Site Investigation procedures at the beginning of this section.

The investigation

After the desk study has been carried out, the objective of the intrusive investigation is to provide detailed information for the safe and economic development of the site at minimum cost. Clearly, no guarantee can be given that all relevant conditions will necessarily be identified, but the work carried out should be aimed at reducing risk to acceptable levels.

Increasing expenditure on the Site Investigation will reduce the risk of unforeseen conditions, but professional judgement and experience is also required. Not all forms of investigation will be needed, and that which is necessary in the best interests of the client should be carefully assessed for each individual project.

The investigation must be designed to provide the appropriate level of information on ground and ground water conditions on the site, together with identifying potential areas of contamination. The investigation should be undertaken in accordance with the principles of:

- BS EN 1997-1: Eurocode 7 - Geotechnical design - Part 1: General rules.
- BS EN 1997-2: Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing.
- BS 5930 and BS 10175.

It will also require the full-time supervision of a Chartered Geologist or Chartered Engineer.

The dates of the investigation and the methods used should be stated, with the exploratory hole positions being shown on a drawing.

An intrusive investigation may comprise the following:

Trial pitting

Normally, these should be at least three times the foundation depth where possible, or sufficient to prove competent bedrock. They should be excavated outside proposed foundation positions where possible. On completion, the excavations are normally backfilled.

This method enables soil conditions to be closely examined at any specific point and samples to be taken. It also gives useful information on the stability of excavations and water ingress. In-situ gas, strength and California Bearing Ratio (CBR) tests can also be carried out.

Window sampling

Window sampling consists of driving a series of 1m and 2m long tubes into the ground using a dropping weight. On completion of each run, the tube is withdrawn. The next tube is then inserted and the process repeated to provide a continuous profile of the ground. On each run, the tube diameter is reduced in order to assist in its recovery. When complete, the borehole is normally backfilled. It is also possible to carry out standard penetration tests (SPT) using the window sampling equipment.

Shell and auger boring

This technique uses a tripod winch and a percussive effect with a variety of boring tools, where disturbed and undisturbed samples can be taken. This is the most suitable method for soft ground investigation as it enables the maximum amount of information to be obtained. However, minor changes in lithology may be overlooked unless continuous undisturbed sampling is used.

Disturbed samples of soils can be taken for identification and classification purposes. In cohesive soils, 'undisturbed' samples 100mm in diameter can be taken by an open drive sampler for laboratory testing of strength, permeability and consolidation characteristics.

SPT are used in granular and cohesive materials and in soft or weathered rocks. The resulting 'N' value can be compared to empirical data on strength and relative density. Difficulties in obtaining true 'N' values mean they should only be used as a guide, and not as an absolute value in foundation design.

Rotary drilling

Two main types of rotary drilling can be carried out in rock. Rock coring using a diamond or tungsten carbide-tipped core bit provides samples and information on rock types, fissuring and weathering. Open-hole drilling only produces small particles for identification purposes, and the information gained is therefore limited. The latter is, however, useful as a quick method of detecting major strata changes and the location of coal seams and old workings. Water, air, foam or drilling muds may be used as the flushing medium in either case.

Rotary open-hole drilling is carried out to determine the existence of any voids or broken ground that could affect surface stability. Due to the risk of combustion, the drilling is normally done using a water flush. On completion, the boreholes are backfilled with bentonite cement. A Coal Authority Licence is required in advance of any exploratory work intended to investigate possible coal workings.

Geophysics

Geophysics can be used in certain situations and is useful where significant anomalies exist in the ground. Ground-penetrating radar is probably the most common for defining near-surface features. The results from geophysics can be variable and, combined with the relative high cost, should be used advisedly.

Strata profile

Full strata descriptions should be given based on visual identification and in accordance with the requirements of:

- BS EN ISO 14688-1: Geotechnical investigation and testing - Identification and classification of soil - Part 1
- BS EN ISO 14688-2: Geotechnical investigation and testing - Identification and classification of soil - Part 2
- BS EN ISO 14689-1: Geotechnical investigation and testing - Identification and classification of rock - Part 1

Soil description

Samples from boreholes or trial pits should be fully described in accordance with the latest guidance from the British Standards and Eurocodes. They should include colour, consistency, structure, weathering, lithological type, inclusions and origin. All descriptions should be based on visual and manual identification as per recognised descriptive methods. The methodology for soil and rock description is given in more detail in the 'Ground Conditions - Site Investigation Requirements: Soil and rock descriptions' section.

In-situ and laboratory testing

In-situ gas monitoring

Methane is the dominant constituent of landfill gas, and can form an explosive mixture in air at concentrations of between 5% and 15%. Thus, 5% methane in air is known as the Lower Explosive Limit (LEL). Concentrations less than this do not normally ignite. Carbon dioxide can also be a potential problem, especially where it occurs in concentrations greater than 1.5%.

In-situ gas tests should be carried out in the boreholes on completion, and in probe holes made in the sides of the trial pits. Testing is with a portable meter that measures the methane content as its percentage volume in air. The corresponding oxygen and carbon dioxide concentrations are also measured. Care is needed with this, since the rapid mixing and dilution of any gases within the atmosphere can occur very quickly.

A more accurate method used to monitor over the longer term consists of gas monitoring standpipes installed in boreholes. These typically comprise slotted UPVC pipework surrounded by single sized gravel. The top 0.5m to 1m of pipework is usually not slotted and is surrounded by bentonite pellets to seal the borehole. Valves are fitted and the installations protected by lockable stopcock covers normally fitted flush with the ground. Monitoring is again with a portable meter and is usually done on a fortnightly or monthly basis, with at least six visits being appropriate for most sites.

The risks associated with the gases should be considered in accordance with documents such as:

- BS 8485: Code of Practice for the characterisation and remediation from ground gas in affected developments.
- CIRIA Report C665 Assessing risks posed by hazardous ground gases to buildings.
- NHBC Report No. 4 Guidance on evaluation of development proposals on-sites where methane and carbon dioxide are present.

In-situ strength testing

Hand vane and MEXE cone penetrometer tests can be carried out in trial pits in order to assess the strengths and CBR values of made ground, soils and heavily weathered bedrock materials.

Soakaway testing

If sustainable drainage is being considered, soakaway testing should be carried out. This is preferably done in trial pits, with the aim of intersecting permeable soils or naturally occurring fissures within bedrock.

Soakaway testing involves filling the trial pits with water from a bowser or such like, and measuring the fall in water over time. Where possible, two tests should be carried out to allow the immediate surrounding ground to become saturated. By knowing the dimensions of the trial pit, the permeability and/or rate of dissipation can be calculated.

Soakaway test results obtained from small hand-dug pits or shallow boreholes should be treated with caution.

Geotechnical laboratory testing

Soil testing should be carried out to BS 1377: Methods of test for soils for civil engineering purposes, and the laboratory used should be recorded and conducted by an approved UKAS laboratory. Normally, the results are summarised and the full results appended; a summary of the main types of test is presented in the 'Laboratory testing' page of this section.

Contamination laboratory testing

As with the investigation, the sampling should be under the full-time direction of either a Chartered Engineer or Chartered Geologist. All the recovered soil samples should be screened on-site for any visual or olfactory evidence of contamination, including the presence of Volatile Organic Compounds (VOCs). Samples should be selected from the trial pits and boreholes based on those most likely to be contaminated, and those that will give the most appropriate indication of the spread of any contaminants. The samples should be stored in either glass or plastic containers and where necessary kept in cooled conditions. Testing should be carried out by a UKAS accredited laboratory, in accordance with the Environment Agency's Monitoring Certification Scheme; MCERTS performance standards.

The aim of this is to make a preliminary assessment of the level of any contamination on the site, in order to determine if there are any significant risks associated with contaminants in respect of both human health and the environment, including controlled waters. In addition to the soil, ground water samples should be tested where appropriate.

Geoenvironmental risk assessment (conceptual site model)

The qualitative health and environmental risk assessment carried out as part of the desk study should be revised, based on the findings of the ground investigation and the results of the contamination testing, to produce a Detailed Quantitative Risk Assessment (DQRA). See table 'Example detailed quantitative risk assessment'.

The DQRA is again based on the conceptual site model, and might look similar to the following example summary of hazards, pathways and receptors. On-sites with known contamination, further investigation and testing may be necessary, together with recommendations for remediation and its validation.

Construction

During construction, if unforeseen conditions are encountered then the builder/developer should seek additional advice from the consultant as to whether the new conditions will affect the continued development of the site, and whether any additional investigation or testing is necessary.

Example detailed quantitative risk assessment

Source	Potential Pollutant	Pathways	Receptor	Risk
Potentially contaminated made ground Possible past minor spillages and metals	Oils, fuels, grease, hydraulic fluid, metals, asbestos	1-5	A. Present occupants	Site unoccupied
			B. Ground workers	Low risk involved with excavation work, provided personnel adopt suitable precautions, together with washing facilities
			C. Future residents/occupants	Low risk for residential use, provided made ground is capped by clean sub-soil and topsoil
		6	D. Controlled waters	Low to moderate risk at present. Provided on-site monitoring is undertaken throughout the piling and ground work phases of development show no adverse effects, the risk will be low
			E. Ecosystems	Low risk as leaching is not a problem
		7	F. Building materials and services	Low to moderate. Install pipes in clean bedding materials. Adequate precautions to be taken in respect of buried concrete
Organic material	Landfill gases, Radon, VOCs, SVOCs	8	A-F	Low to moderate. Low values of ground gases present during the investigation, although basic gas protection measures are recommended
Waste materials	Fly-tipping			All waste materials to be removed from site

Recommendations

The report must include a site location plan and a plan showing any special features plus borehole and trial pit locations (factual reports will describe the work carried out, and will include borehole/trial pit logs and the results of all in-situ and laboratory testing, but there will be no interpretation of the data and no recommendations).

The interpretative report should make recommendations in respect of the main points or issues related to design and construction:

- Normal strip or deep trench footings
- Piling
- Vibro replacement
- Raft foundation
- Building near trees
- Landfill and Radon gas
- Existing drains and services
- Road construction
- Sustainable surface water drainage (soakaways)
- Excavations and ground water
- Reuse of materials
- Contamination
- Capping mine shafts
- Site soil reuse
- Slope stability and retaining walls
- Further geotechnical considerations
- Change of use

Advice in respect of specific recommendations is given on the 'Phase 1 and 2 checklists' page of this section.

Main References

British Standards Institution
- BS 1377: Methods of test for soils for civil engineering purposes (Parts 1 to 8)
- BS 3882: British Standard specification for topsoil
- BS 5930: British Standard Code of Practice for Site Investigations
- BS 8485: British Standard Code of Practice for the characterization and remediation from ground gas in affected developments
- BS 10175: British Standard Code of Practice for the investigation of potentially contaminated sites
- BS EN 1997-1: Eurocode 7 - Geotechnical design - Part 1: General rules
- BS EN 1997-2: Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing
- BS ISO 14688-1: Geotechnical investigation and testing - Identification and classification of soil - Part 1
- BS ISO 14688-2: Geotechnical investigation and testing - Identification and classification of soil - Part 2
- BS ISO 14689-1: Geotechnical investigation and testing - Identification and classification of rock - Part 1

BRE
- Radon: Guidance on protective measures for new dwellings, BR 211
- Protective measures for housing on gas-contaminated land, BR 414, 2001
- Cover systems for land regeneration, 2004
- Concrete in aggressive ground, Special Digest SD1, 3rd Edition, 2005

CIEH
- The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition)

CIRIA
- Assessing risks posed by hazardous ground gases to buildings, CIRIA C665
- Shaft friction of CFA piles in chalk 2003, CIRIA PR 86
- Engineering in chalk 2002, CIRIA C574
- Construction over abandoned mine workings 2002, CIRIA SP 32

DoE
- CLR Reports 1-4
- Waste Management Paper No. 26A, Landfill Completion: A technical memorandum…
- Waste Management Paper No. 27, Landfill gas: A technical memorandum…

DEFRA
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- Using Soil Guideline Values, 2009

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- Environmental Protection Act 1990
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- UK Water Supply (Water Quality) Regulations 2000
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Joyce, M.D.
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- Planning Policy Statement 23: Planning and Pollution Control Annex 2: Development on Land Affected by Contamination

Phase 1 and 2 checklists

Checklist for Phase 1: Geoenvironmental assessment (Desk Study)

Site Description (and surrounding area of relevance)
- Location, O.S. grid reference and plans
- Topography, levels
- Site layout and main features
- Site infrastructure
- Site description and topography
- Made ground, erosion, cuttings or quarries
- Slope stability
- Evidence of faulting or mining
- Watercourses, seepages or sinks
- Marshy or waterlogged ground
- Type and health of vegetation
- Existing structures and condition
- Existing on-site processes
- Demolished structures/old foundations
- Visual evidence of contamination
- Existing site operations
- Underground and overhead services
- Trees

Mining
- Past, present and future mining
- Reference to geological sources
- Coal Authority Mining Report
- Register of abandoned mine plans and opencasts
- Shaft register
- Other mining, e.g. sand, sandstone, limestone, brine, etc.

Geology
- Geological maps (1:50,000 and 1:10,000 scale)
- Memoirs
- Technical reports
- Engineering geological maps
- Existing trial pit or borehole logs and reports
- Subsidence features

Hydrogeology and hydrology
- Ground water vulnerability
- Aquifer status
- Abstraction licences (within 1km)
- Flood risk, drainage and watercourses (within 1km)

Local Authority consultation
- Building Control, Planning and Environmental Health/Contaminated Land Officer
- Petroleum Officer

Archival research
- Past O.S. mapping and previous on-site and off-site usage possible contaminants associated with
- former use(s)
- town plans
- local history records, books and photographs (where relevant and practicable)
- Aerial photographs (where relevant)
- Archaeological register (where relevant)

Contamination
- Likely contaminants based on past history
- Hazard-Pathway-Receptor scenario
- Preliminary Conceptual Site Model

Environmental database
- Operational and former landfill sites, scrapyards and waste processing sites
- Radon protection measures

Checklist for Phase 2: Geoenvironmental assessment (Ground Investigations)

Trial pits
- Strata profile and description
- In-situ gas testing for methane, carbon dioxide and oxygen
- Landfill gas, marsh gas and mine gas
- In-situ shear strength testing
- In-situ Mexe Cone Penetrometer for CBR/in-situ shear strength
- Full description of ground and ground water conditions
- Soakaway testing
- Geotechnical contamination laboratory testing

Boreholes
- Cable percussive, window sampling, dynamic probing or rotary drilling to BS 5930
- Use of British drilling association accredited drillers
- Full description of ground and ground water to BS 5930
- Installations for long-term gas and water monitoring (if required)
- Geotechnical laboratory testing (BS 1377) and contamination testing if suspected by accredited laboratories

Other methods of investigation
- Geophysics
- Cone penetrometer

Recommendations for reports

Foundations and retaining walls
- Foundation type, depth, bearing capacity and settlement
- Ease of excavation
- Sulphate/acidity/concrete class
- Shrinkage/heave
- Effect of vegetation, including building Near trees
- Buoyancy or flotation effects
- Ground improvement options, e.g. Piling, Vibro, compaction, etc.

Mining
- Precautions for foundations in respect of past or future mining
- Treatment of shallow mine workings
- Capping of shafts

Landfill/mine gas/Radon
- Requirements for long term monitoring
- Protection measures for structure
- Venting measures

Road construction
- CBR of subgrade and its preparation
- Sub-base type and thickness
- Excavation of unsuitable material
- Soil stabilisation
- Frost susceptibility

Drainage and excavations
- Ground water regime including dewatering
- Use of soakaways
- Support and ease of excavation
- Rock levels
- Use of sheet piling, diaphragm, bored piles and ground anchors

Earthworks
- Compaction characteristics
- Surcharging and self-settlement
- CBR at formation level
- Slope stability and slope stabilisation
- Suitability of excavated material for re-use

Contamination
- Full assessment of contamination testing
- Hazard-Pathway-Target scenarios/Conceptual model
- Risk assessment and liability
- Precautions or remediation of contamination

Further investigation
- Is further investigation needed?
- Nature of further investigation

Soil and rock descriptions

Fine soils (cohesive soils)

The following field terms are used:

Soil type	Description
Very soft	Exudes between fingers
Soft	Moulded by light finger pressure
Firm	Cannot be moulded by the fingers but can be rolled in hand to 3mm threads
Stiff	Crumbles and breaks when rolled to 3mm threads but can be remoulded to a lump
Very stiff	No longer moulded but crumbles under pressure. Can be indented with thumbs

The following terms may be used in accordance with the results of laboratory and field tests:

Description	Undrained shear strength Cu (kPa)
Extremely low	<10
Very low	10-20
Low	20-40
Medium	40-75
High	75-150
Very high	150-300
Extremely high	>300

Fine soils can also be classified according to their sensitivity, which is the ratio between undisturbed and remoulded undrained shear strength:

Sensitivity	Ratio
Low	8
Medium	8-30
High	>30
Quick	>50

Granular soils (non-cohesive)

The following descriptions are used for granular soils:

Description	Normalised blow count (N) 60
Very loose	0-3
Loose	4-8
Medium	9-25
Dense	26-42
Very dense	43-58

Rock description

This is based on:

i. Colour (minor then principal colour)
ii. Grain size

Description	Predominant grain size (mm)
Very coarse	>63
Coarse grained	63 - 2
Medium grained	2 - 0.063
Fine grained	0.063 - 0.002
Very fine grained	<0.002

iii. Matrix
iv. Weathering

Term	Description
Fresh	No visible sign of weathering/alteration of the rock material.
Discoloured	The colour of the original fresh rock material is changed with evidence of weathering/alteration. The degree of change from the original colour should be indicated. If the colour change is confined to particular mineral constituents, this should be mentioned.
Disintegrated	The rock material is broken up by physical weathering, so that bonding between grains is lost and the rock is weathered/ altered towards the condition of a soil in which the original material fabric is still intact. The rock material is friable but the grains are not decomposed.
Decomposed	The rock material is weathered by the chemical alteration of the mineral grains to the condition of a soil in which the original material fabric is still intact; some or all of the grains are decomposed.

v. Carbonate content
vi. Suitability of rock
Stable indicates no changes when sample left in water for 24 hours. Fairly stable indicates fissuring and crumbling of surfaces. Unstable indicates complete disintegration of the sample.
vii. Unconfined compressive strength

Term	Field identification	Unconfined compressive strength (MPa)
Extremely weak [(a)]	Indented by thumbnail	<1
Very weak	Crumbles under firm blows with point of geological hammer; can be peeled using a pocket knife	2 - 5
Weak	Can be peeled using a pocketknife with difficulty; shallow indentations made by firm blow with point of geological hammer	6 - 25
Medium strong	Cannot be scraped or peeled using a pocket knife; specimen can be fractured with single firm blow of geological hammer	26 - 50
Strong	Specimen requires more than one blow of geological hammer to fracture it	51 - 100
Very strong	Specimen requires many blows of geological hammer to fracture it	101 - 250
Extremely strong	Specimen can only be chipped with geological hammer	>250
(a) Some extremely weak rocks will behave as soils and should be described as soils		

viii. Structure

Sedimentary	Metamorphic	Igneous
Bedded Interbedded Laminated Folded Massive Graded	Cleaved Foliated Schistose Banded Lineated Gneissose Folded	Massive Flowbanded Folded Lineated

ix. Discontinuities
x. Discontinuity spacing, persistence and roughness, infilling, and seepage
xi. Weathering of rock mass

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces	0
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces	1
Moderately weathered	Less than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones	2
Highly weathered	More than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones	3
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact	4
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soils have not been significantly transported	5

xii. Rock mass permeability

In addition to the description of the soils and rocks and their associated depth, ground water should be noted in terms of both where it was struck and changes over time. Any unusual colouration or odours of any of the soils encountered during the investigation should be recorded.

It should be noted that lateral and vertical changes can occur between exploratory points, and care is needed when extrapolation is used. This is particularly true of the 'made ground', which, by its nature, can be highly variable in its physical and chemical composition.

Laboratory testing

Natural or in-situ moisture content

The natural or in-situ moisture content of a soil is defined as the weight of water contained in the pore space, expressed as a percentage of the dry weight of solid matter present in the soil. Soil properties are greatly affected by the moisture content and the test can help provide an indication of likely engineering behaviour.

Liquid and plastic limits

Two simple classification tests are known as the liquid and plastic limits. If a cohesive soil is remoulded with increasing amounts of water, a point will be reached at which it ceases to behave as a plastic material and becomes essentially a viscous fluid. The moisture content corresponding to this change is arbitrarily determined by the liquid limit test. 'Fat' clays, which have a high content of colloidal particles, have high liquid limits; 'lean' clays, having low colloidal particle content, have correspondingly low liquid limits. An increase in the organic content of clay is reflected by an increase in the liquid and plastic limits.

If a cohesive soil is allowed to dry progressively, a point is reached at which it ceases to behave as a plastic material, which can be moulded in the fingers, and becomes friable. The moisture content of the soil at this point is known as the 'plastic limit' of the soil.

The water content range over which a cohesive soil behaves plastically, i.e. the range between the liquid and plastic limits, is defined as the plasticity index.

A cohesive soil with natural water content towards its liquid limit will, in general, be an extremely soft material, whereas a cohesive soil with natural water content below its plastic limit will tend to be a firm or stiff material.

Particle size distribution

Knowledge of particle size distribution is used to classify soils and indicate likely engineering behaviour.

British Standards define soils in relation to their particle size, as shown below:

Boulders >200mm Cobbles 200mm-63mm	Coarse sand 2mm-0.63 Medium sand 0.63mm-0.2mm Fine sand 0.2mm-0.63,,
Course gravel 63mm-20mm Medium gravel 20mm-6.3mm Fine gravel 6.3mm-2mm	Coarse silt 0.063mm-0.02mm Medium silt 0.02mm-0.0063mm Fine silt 0.006mm-0.002mm
	Clay <0.002mm

Bulk density

The bulk density of a material is the weight of that material per unit volume, and includes the effects of voids whether filled with air or water. The 'dry density' of a soil is defined as the weight of the solids contained in a unit volume of the soil.

Permeability

The permeability of a material is defined as the rate at which water flows through it per unit area of soil under a unit hydraulic gradient.

Consolidation characteristics

When subjected to pressure, a soil tends to consolidate as the air or water in the pore space is forced out and the grains assume a more densely packed state. The decrease in volume per unit of pressure is defined as the 'compressibility' of the soil, and a measure of the rate at which consolidation proceeds is given by the 'coefficient of consolidation' of the soil. These two characteristics, Mv and Cv, are determined in the consolidation test, and the results used to calculate settlement of structures or earthworks by a qualified person.

Strength characteristics

The strength of geological materials is generally expressed as the maximum resistance that they offer to deformation or fracture by applied shear or compressive stress. The strength characteristics of geological materials depend to an important degree on their previous history and on the conditions under which they will be stressed in practice. Consequently, it is necessary to simulate in laboratory tests, the conditions under which the material will be stressed in the field.

In general, the only test carried out on hard rocks is the determination of their compressive strength, but consideration must also be given to fissuring, jointing and bedding planes.

The tests currently used for soils and soft rocks fall into two main categories. First, those in which the material is stressed under conditions of no moisture content change, and second, those in which full opportunity is permitted for moisture content changes under the applied stresses.

Tests in the first category are known as undrained (immediate or quick) tests, while those in the second category are known as drained (slow or equilibrium) tests. The tests are normally carried out in the triaxial compression apparatus, but granular materials may be tested in the shear box apparatus.

The undrained triaxial test gives the apparent (cohesion) C_u and the angle of shearing (resistance) $Ø_u$. In dry sands, C_u = 0 and $Ø_u$ is equal to the angle of internal friction, whereas with saturated non-fissured clays $Ø_u$ tends to 0 and the apparent cohesion C_u is equal to one-half the unconfined compression strength qu. On site, the vane test gives an approximate measure of shear strength.

For some stability problems, use is made of a variant of the undrained triaxial test in which the specimen is allowed to consolidate fully under the hydrostatic pressure, and is then tested to failure under conditions of no moisture content change. This is known as the consolidated undrained triaxial test. Pore water pressures may be measured during this test, or alternatively a fully drained test may be carried out. In either case, the effective shear strength parameters C' and Ø' can be obtained, which can be used to calculate shear strength at any given pore water pressure.

Compaction

The density at which any soil can be placed in an earth dam, embankment or road depends on its moisture content and on the amount of work used in compaction. The influence of these two factors can be studied in compaction tests, which can determine the maximum dry density (MDD) achievable at a certain optimum moisture content (OMC).

California Bearing Ratio (CBR) Test

In flexible pavement design, knowledge of the bearing capacity of the sub-grade is necessary to determine the thickness of pavement for any particular combination of traffic and site conditions. The quality of the subgrade can be assessed by means of the CBR test, or approximately by the MEXE cone penetrometer.

Chemical tests

Knowledge of the total soluble sulphate content and pH of soils and ground water is important in determining the protection required for concrete or steel in contact with the ground. Other specialist tests may be carried out on sites suspected of being contaminated by toxic materials.

A.

Appendix A

Contents

Additional Functional Requirements to Finishes

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

No additional requirements.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

A.

Appendix A

A.1

Finishes

Plastered finishes

Introduction
This section covers all plastered finishes to walls and ceilings. Plastered finishes should be applied to a certain standard to receive a suitable decorative finish. It should be durable enough to prevent surface cracking and, if applicable as part of the whole element, meet the required levels of fire and sound insulation in accordance with current Building Regulations.

Substrate and background
Plasterwork should be applied to suitable substrates. The substrate may also require additional sealing or bonding agents, in accordance with the requirements set out in BS 8481: 2006.

Plaster proposed to be applied to backgrounds that are susceptible to thermal movement, such as lightweight concrete or aerated blockwork, may not be suitable and an independent dry lining or board on dabs system be adopted. Guidance on applications of plaster should be in accordance with the block manufacturer's instructions.

Where the background has a mix of varying materials, e.g. blockwork and brickwork, expanded metal should be provided to prevent differential movement in the plaster finish.

Plaster mixes
Plaster mix ratios should be in accordance with manufacturer's recommendations and be appropriate for the intended use.

Minimum plaster thickness
The thickness of plaster will vary depending on the evenness of the substrate. The finished element must meet the tolerances identified in the 'Tolerances' section, and be of a suitable quality so that a decorative finish can be applied. Minimum thickness should be in accordance with the table below.

Plasterboard and dry lining

Support of plasterboard
Supports for plasterboard should be designed so that the following span limits are not exceeded:

Thickness of plaster

Element	Minimum number of coats	Typical thickness
Walls - metal lath	3	13mm (nominal)
Blockwork	2	13mm (nominal)
Brickwork	2	13mm (nominal
Walls - plasterboard	1	Skim to provide suitable and durable finish
Walls - concrete	1	Minimum thickness to provide suitable and durable finish
Ceiling - plasterboard	1	Skim to provide suitable and durable finish
Ceiling - concrete	2	10mm maximum

Plasterboards joints and fixings

Board thickness (mm)	Timber support centres (mm)	Intermediate noggins required	Perimeter noggins required
9.5	400	No	Yes
	450	Yes	Yes
12.5	400	No	Yes
	450	No	Yes
	600	Yes	Yes
15	600	No	No

- Fix boards with decorative side out to receive joint treatment or a skim plaster finish.
- Lightly butt boards together and never force boards into position.
- Install fixings no closer than 13mm from cut edges and 10mm from bound edges.
- Position cut edges to internal angles whenever possible, removing paper burrs with fine sandpaper.
- Stagger horizontal and vertical board joints between layers by a minimum of 600mm.
- Locate boards to the centre line of framing where this supports board edges or ends.
- Plasterboard should be fixed to timber or metal studs using dry-wall screws.
- When dry lining, plasterboard can be fixed to walls using adhesive dabs or by screwing to metal or timber battens. Note; Where adhesive dabs are used the plasterboard manufacturers recommendations must be followed.

Alternatively, a proprietary wall system can be used, providing it has third-party certification. Gaps between boards should not exceed 3mm and consideration should be given to sealing all gaps to improve dwelling air tightness.

Painting and decorating

Timber
Painting or staining of external timber is required to provide protection and stability, even if the timber is preservative treated. Timber with moisture content greater than 18% is not suitable for painting or staining.

The paint and stain systems specified should be compatible with any timber preservatives and timber species used.
Where windows and doors are to be stained, proprietary sealants and beads should be used in glazing rebates in accordance with the manufacturer's instructions as an alternative to linseed oil putty.

Staining
Timber should be stained in accordance with the manufacturer's recommendations.

Painting
Painting of timber should consist of at least one primer coat, one undercoat and one finish coat, or alternatively in accordance with the manufacturer's instructions.

Masonry and rendering
External brickwork and render should be dry before paint is applied, and paint systems for external brickwork or render should be applied in accordance with the manufacturer's instructions.

Metal
Internal and external structural steel should be protected with at least two coats of zinc phosphate primer. A decorative paint finish may then be applied.

Internal and external steel that has been galvanised to a rate of at least 450g/m^2 is acceptable without further protection. Steel galvanised to a rate of less than 450g/m^2 should be protected with at least two coats of zinc phosphate primer and a suitable decorative finish, where required. This may need to be increased where a development is with a coastal location see 'Appendix B - Coastal Locations'.

Intumescent paint coverings must be applied in accordance with the manufacturer's instructions.

Plaster and plasterboard
Plaster and plasterboard surfaces should be prepared and made ready for decorating in accordance with the manufacturer's instructions.

External finishes in Coastal locations

Additional requirements may be necessary in coastal locations due to the aggressive environment effects on exposed finishes. Please see 'Appendix B - Coastal Locations' for further information if a project is within a coastal location.

Ceramic wall tiling

Tiles should be fit for purpose, have a suitable finish and be of an appropriate size and thickness.

The installation of the tiling should follow the guidance contained in BS 5385 - 3: 2014 Wall and floor tiling.

Background surfaces

Background surfaces should be adequate to support ceramic tiles, and as a minimum should:

- Be even, to adequately support the whole tile.
- Be strong and durable enough to support the tile.
- Have sufficient absorbency to ensure that adhesives will stick effectively or a suitable bonding agent applied.
- Be of the same construction type; where two construction types are present, e.g. blockwork and timber stud, light reinforcing should be provided over the junction between the two types.

In addition, where forming part of a framed wall to a shower enclosure, walk in shower or wet room:

- A moisture resisting plasterboard (or a third party product approved water resistant backer board) should be used for the area of the 'shower enclosure' wall that is to be tiled (up to a height of 1800mm above the floor level).
- In addition: the enclosure wall forming part of a walk in shower or wet room are required to be waterproof for a height of 150mm above the floor junction.

Ceramic floor tiling

Tile floorings shall provide a suitable surface and be fit for purpose.

The installation of the tiling should follow the guidance contained in BS 5385 - 3: 2014 Wall and floor tiling. Where Ceramic tiling is proposed on top of timber flooring, additional precautions are required over and above that for concrete floor substrates.

Background surfaces

Background surfaces should be adequate to support ceramic tiles, and as a minimum should be:

- Level and even enough to provide a plane surface; falls should be specified where required.
- Resistant to ground moisture; a Damp Proof Membrane (DPM) should be provided to all ground floors.
- Adequately dry, i.e. at least six weeks drying out time for concrete base, three weeks for screed.
- Movement joints will be required in the tile finishes where they continue over changes in the subfloor construction below. For example, below a door opening in an internal wall, where end bearings of beam and block joists may be found. If the tiled floor finish continues through into another room, a movement joint at the door threshold will be required to prevent cracking in the tiles occurring.
- For internal floors, which might be subjected to significant thermal changes i.e. direct sunlight in sunrooms, atria or underfloor heating, etc., the floor area should be divided up by intermediate movement joints into bays of size not greater than $40m^2$ with an edge length not greater than 8m.

Ceramic Tiles on wood-based substrate

The guidance below is for ceramic tiling only and does not apply to other heavier tiles such as marble, travertine or stone which would be considered too heavy for a traditional suspended timber floor construction.

The floor must be fit for purpose and should have adequate stiffness to support the tiles and adhesive.

For floors supported by joists up to 600mm maximum centres, the floor decking should be:

- 18mm exterior grade plywood screwed to the joists at 300mm centres with all square edges supported on joists or noggins. Plywood should be laid with a 1.5mm-2mm movement gap between boards and at abutments or,
- Moisture resistant floor decking overlaid with a minimum 10mm exterior grade plywood fixed to joists at 300mm centres or,
- A combination of one of the above with a proprietary separating/de-coupling layer, tile backer board or tile bedding reinforcement sheet used in accordance with third party product approved manufacturer's recommendations.
- The length of screw fixings should be at least 2.5 times the thickness of the combined decking material to ensure adequate penetration into the timber sub-floor or joist /strut supports.
- Additional solid timber strutting between the joists will be required to assist in stiffening the floor construction for the entire span of the joists between supports, this may include strutting beyond the area of the tiled room e.g. if the joist span continues over a landing area.
- Tiles should be suitable for laying over a timber base and deformable (flexible) tile adhesive (e.g. C2S1), and grout should be used in accordance with the adhesive manufacturer's recommendations.
- Tiles must be laid to a level finish except where required in a walk in shower/wet room (see below).
- For walk-in showers and wet rooms, timber floor deck substrate is not acceptable.

Walk in showers and wet rooms floors

The floor areas to a walk in shower or wet room (where the floor area is part of the shower floor) is required to be waterproof and drained, a timber floor deck substrate is not recommended. The floor deck must be a water stable component with a third party product approval confirming its use for this situation.

- The fall to the wet room area floor must prevent ponding and should be between 1:80 to 1:100 to a drainage point.
- The floor drainage point must be maintainable and adequate in size to take the intended water flow from the shower head without flooding occurring.
- Due to the need for a fall in the finished tiled surface to an outfall a suitable threshold may be necessary at the wet room door opening (which gives access to the rest of the accommodation).

Fixing of ceramic tiles

- Depending on the background, tiles should be fixed using cement mortar or a suitable adhesive purposely designed for ceramic tiling.
- Tiles to shower enclosures and other areas that will be exposed to water should be fixed with waterproof adhesive.
- Tiling adhesive must be compatible with the substrate construction e.g. anhydrite screeds may require that a suitable sealant to be applied before application of the tile adhesive (see below guidance).

Grouting

For shower enclosures where tiling can be saturated, grouting should be cement-based, epoxy resin or a proprietary waterproof product.

A sealing method should be specified for the joint between sanitary fittings and adjacent tiling. This is particularly important where movement can take place, e.g. where timber floors are used or where the upper edges/rims of baths or shower tray units may flex when loaded.

Ensure that design and specification information is issued to site supervisors and relevant specialist subcontractors and/or suppliers.

Anhydrite screeds/calcium sulphate screeds

Anhydrite screeds/calcium sulphate screeds need to be left to dry to allow for hydration to take place to gain its strength. Finishes should not be installed until the screed has gone below 75% relative humidity. The drying times should be in accordance with the manufacturers guidance, testing will be required to confirm the screed has been suitably cured before tiles are laid. If an OPC based adhesive or ceramic tile adhesive is to be used, then an acrylic or water dispersible epoxy penetrating sealer should be applied to seal the screed in 1 to 2 coats In accordance to the sealant manufactures instructions.

B.

Appendix B

Contents

Additional Functional Requirements where the development is within a coastal location

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Coastal location definition

For the purposes of this Technical Manual, this means any building works on:

- Any site within 500m of the shoreline;
- Other sites up to 5km Inland from the shoreline;
- Sites located in 'tidal' estuarine areas where they are within 5km of the general UK coastal shoreline.

Workmanship

No additional requirements.

Materials

1. Materials should be suitable for the aggressive environment that the building is located in. Materials should be in accordance with the relevant British Standard. The durability of the structure will require the provision of a periodic maintenance strategy that will need to be in place for the life span of the systems and components.

Design

1. For shoreline, sea front developments and developments within 500m of the shoreline the design team must provide specific proposals with detailed plans and specifications. These must demonstrate the durability, suitability and weather tightness of the construction with particular attention to the structural frame, window and door openings, balcony/roof abutments (particularly at balcony window openings), cladding and roof fixings, together with a planned maintenance programme to ensure the construction meets the requirements of this Technical Manual. The choice of materials and coatings must be appropriate for the aggressive environment.
2. For developments that are between 500m to 5km from the coastal shoreline; structures and protective coatings/claddings and detailing should be scrutinised for the potential enhanced risk of the effects of corrosion and reduced durability. The design team must provide a detailed assessment of the protection and maintenance arrangements required for a project that falls within these locations and identify suitably approved materials which are appropriate for use in the construction.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

B.

Appendix B

B.1
Coastal Locations

Additional requirements where the development is within a coastal location

Coastal location definition

For the purposes of this Technical Manual, we are considering any building works on:

- The shoreline and sites within 500m of the shoreline.
- Other sites up to 5km inland from the shoreline.
- Sites located in 'tidal' estuarine areas where they are within 5km of the general UK coastal shoreline.

Shoreline means:

- The foreshore.
- Land adjacent to the foreshore including in particular any cliff, bank, barrier, dune beach or flat which is adjacent to the foreshore.

Developments within coastal locations

A coastal location is considered as having an aggressive environment particularly with regard to environmental corrosion conditions as well as other risks.

Key risks to construction in coastal locations

Coastal locations are at risk from a combination of one or more of the following:

Wind speed

Coastal regions particularly in the South West, West and North Western areas of the UK are at greater risk of exposure to higher wind speeds than inland areas. Gust wind speeds in combination with rain from offshore can create particular design issues for buildings sited in shoreline locations, particularly for cladding and roof coverings and their associated fixtures and fittings.

Aggressive environment

Materials and fixings need to be protected from the saline rich environment particular in wind driven rain. This can effect and reduce the durability (and life expectancy) of materials and finishes compared to those located inland and non coastal locations.

UV

Higher levels of UV are to be expected in coastal locations which have an impact on durability and longevity of finishes. This has the effect of reducing the durability of a material or finish and requiring maintenance at more frequent periods than would otherwise be expected inland.

Rain penetration

Walls, claddings, external openings including windows and doors, construction junctions and roofs exposed to the prevailing wind driven rain are vulnerable to rain penetration unless correctly designed and constructed for the conditions of the site and orientation of the elevations. The level of exposure to rain penetration in coastal locations should be determined by using the calculation method in BS 8104. This determines the wind blown rain category for a specific site. It should be noted that not all coastal locations are classified in BS 8104 as severe or very severe. Non the less, a coastal and shoreline location is at much greater risk of exposure to higher wind speeds and driving rain than inland areas.

BS 8104 and the wind driven rain maps found in BR 262 are not to be used as a means to identify exposure to all the environmental factors associated with a coastal location.

There are numerous publications providing good practice guidance on methods of preventing rain penetration to internal surfaces of buildings in very severe exposure locations e.g. BRE publication: Thermal insulation: avoiding risks.

Workmanship

A high number of failures of the building envelope in coastal environments are directly due to poor workmanship rather than the failure of the actual material. Examples of this are:

- Poor installation of roof tiles or slates due to lack of correct fixings required for the location.
- Poor fixing of timber claddings resulting in splitting and warping of boards leading to wind and water ingress to the inner components of the wall construction.
- Lack of adequate preparation and protective finishes to external windows.
- Inadequate provision of correct damp proofing in walls around openings e.g. poorly fitted cavity trays.
- Incorrectly positioned flashings and DPC's at balcony decks, especially around external door opening junctions.

A defect that occurs due to poor workmanship, which is similar to those not in a coastal location, will manifest its self sooner and to a greater extent in a coastal location.

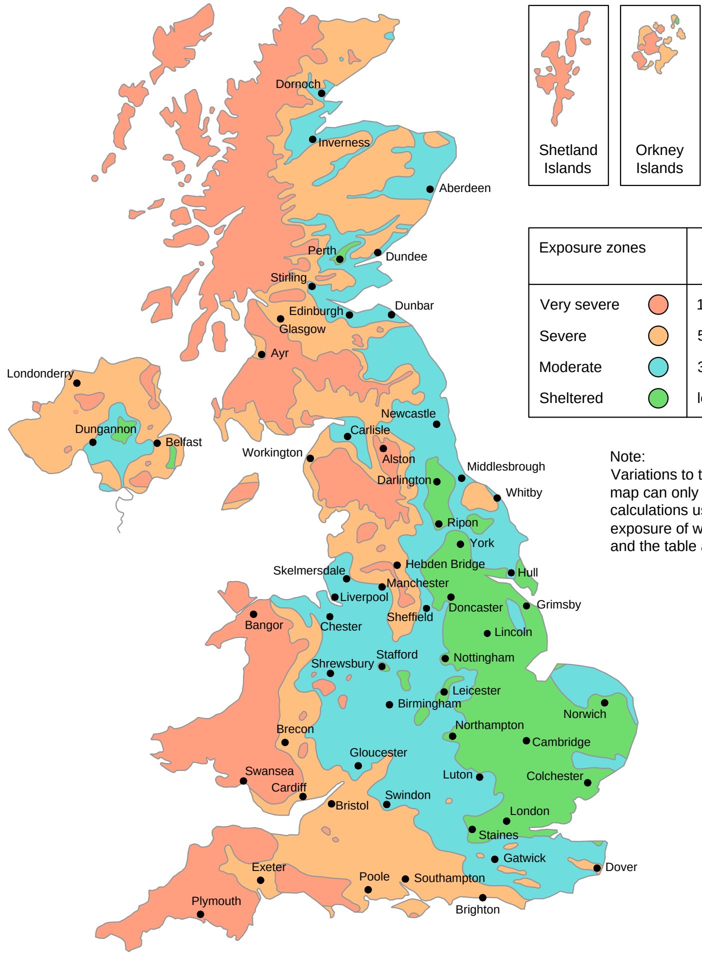
Maintenance

It is the designer's responsibility to ensure that exposed components forming part of the structure or waterproof envelope must perform to meet the Functional Requirements within this Technical Manual.

Certain materials and particularly the finishes may, due to the environment, require an on-going maintenance requirement in order to keep a satisfactory finish. In these circumstances it will be the building owner's responsibility to ensure that regular maintenance of exposed components and finishes is undertaken to ensure they perform correctly. Maintenance plans will need to be in place during the lifetime of the building to ensure premature failure of coatings or components is avoided. Typically dark coloured finishes will fade much sooner.

Debris build up, e.g. wind-blown sand, must be managed, particularly to balconies. These can lead to leaks and overflowing of blocked outlets which in turn cause damage to other parts of the structure and concentrate the potential for water ingress. Bi fold and patio type doors are known for the seals, mechanisms and drainage holes being affected by wind-blown sand if not regularly maintained.

Map showing exposure to wind-driven rain categories



Exposure zones		Exposure to wind driven rain (litres/m^2 per spell)
Very severe	(red)	100 or more
Severe	(orange)	56.5 to less than 100
Moderate	(blue)	33 to less than 56.5
Sheltered	(green)	less than 33

Note:
Variations to the exposure shown on the map can only be made by site-specific calculations using BS 8104 "Assessing exposure of walls to wind driven rain" and the table above.

The BRE Report BR 262 provides a simplified procedure for assessing exposure to wind-driven rain for walls up to 12 m high. It is primarily intended for low rise buildings but may also be considered suitable for other categories of buildings of a similar scale. This simplified guidance is based on a map which defines zones in which calculations in accordance with BS 8104, predict similar exposure conditions. The zones are numbered 1 to 4 and correspond with categories defined in the above table. Note: In table 14 of BS 8104 it does give reference to the BS EN 13914-1 Code of Practice for External Rendering which indicates that additional render thickness will provide additional weather resistance performance.

Please note: The wind driven rain exposure map is not an indication of the exposure of buildings to the aggressive environment risks that are associated with coastal locations.

Masonry walls

The guidance in BS EN 771 for masonry walls of bricks and/or blocks incorporating damp-proof courses and flashings may be adopted.

Fair faced masonry cavity walls incorporating insulation material within the cavity should only be constructed as a partial cavity fill in very severe exposure zones using an insulation material which has a current third party product approval certificate confirming its use for such conditions. Full fill cavity insulation is not permitted in very severe exposure zones (refer to BS 8104 or the wind driven rain map).

Masonry walls of natural stone or cast stone blocks should be constructed in accordance with the relevant recommendations of BS EN 771 and to suit the degree of exposure.

External masonry walls in severe and very severe categories of exposure will benefit from having additional protective features to avoid excessive wetting of the masonry. Features such as deep overhanging eaves, verges and projecting sills should be incorporated into the design.

The following should be avoided;

- Flush sills.
- Inadequate or non existent overhangs at verges.
- Large expanses of glazing or impermeable cladding with no effective means to shed run off water, clear of the masonry below.
- Areas of rendering abutting masonry with no effective seal at the junction to prevent water penetration to the rear of the render.

Insulated concrete formwork (ICF) structures

ICF structures rely on a suitable external cladding to provide the waterproof envelope. The external cladding, if masonry, should be constructed as described earlier in this guide. Direct render applications in a very severe exposure location are not recommended unless the render system has a third party product approval for installation directly applied to the ICF in these conditions, and:

- A full design specification for the render system is provided by the render manufacturer and installed by the manufacturers approved contractors.
- An insurance backed 10 year guarantee is provided.
- Detailing of all the window, door and roof junctions is provided as part of the design specification by the render manufacturer.

Rendering

External rendering to external masonry walls should conform to the relevant recommendations of BS EN 13914-1:2005.

Render angle beads should be appropriate for the environment when installed. Non corrosive render beading e.g. PVC or marine grade stainless steel should be specified. Any other products used must have a current third party product approval stating they are suitable for the environmental conditions proposed.

Fixings to render angle beads must be suitable to prevent corrosion occurring.

The durability of the rendering will also be dependent upon the type of background, the type of rendering, mix proportions and the method of application.

The 'background' or substrate which is to support the render must be suitable for bonding the render and be dry in condition. Materials of differing densities should be avoided in the substrate, if this latter point cannot be avoided, the render manufacturer must provide a specification for the render application over these areas to avoid future cracking.

The choice of render and render carrier boards (if used) must be correctly specified and installed.

Wherever possible, whatever the conditions of exposure, advantage should be taken of architectural features which protect the rendering. Such protective features become more important as conditions become more severe, adequate overhangs and drips will reduce the risk of frost damage.

With traditional renders the quality of the sands used and design mix is critical as is the reliance on good mixing techniques by the applicator. Poor mixing ratios and low quality materials is often the reason traditional renders fail, therefore, only a pre-blended bagged render system which has a third party accreditation such as a BBA or ETA certification and backed up with a manufacturer's specification, will be accepted.

Whilst traditional renders are applied in several layers and normally are 20 to 25mm thick to provide a 'physical waterproofing'; in a very severe location, a detailed specification from the render manufacturer will be required to justify it is suitable for the proposed conditions and the overall thickness.

Polymer modified, ready to use factory produced renders contain high quality raw materials and a range of admixtures (notably water repellents) which reinforce the waterproofing properties of the renders. The thickness of these renders may vary depending upon the particular application and guidance should be sought from the render manufacturer.

For these types of renders, a third party product approval certification will be required to identify the scope of approved use. It should be noted that a number of third party product approval bodies have a limitation of 75litres/m² applied, which equates to a 'severe' rating only. Therefore where the exposure zone exceeds 75 litres/m^2, any 'polymer modified' type render intended to be used must be supported by the render manufacturer's fully detailed specification and should only be applied by the render manufacturer's approved contractors. A 10 year insurance backed guarantee will also be required.

Note: adding additional water repellent which is not within the render manufacturer's specification into the mix on the worksite should not be carried out, it may even be harmful to pre-prepared render systems as it can lead to faults in the finish.

External cladding systems including rain screens

The materials used within the construction should be capable of withstanding weathering, atmospheric pollution and potential chemical attack for the intended design life.

The system must have a current third party product approval confirming the specification is suitable for a coastal environment.

The supplier and designer should provide evidence to satisfy the following:

- Evidence of the minimum design life of the enclosure as a whole for the particular environment location (with maintenance considered to allow for components that may have a lessor design life but are expected to be periodically replaced).
- Confirmation of what routine maintenance, repair and replacement is likely during the design life and who will be responsible for this.
- Details to confirm that the potential for electrolytic corrosion will be avoided within the system.
- The surfaces of the cladding system should be capable of resisting the action of chemicals with which it is likely to come into contact during its design life.

Components which should have a design life to meet the relevant Functional Requirements of this Technical Manual (60 years for components forming part of the structure, 15 years for components not integral to the structure) are:

- Secondary framing and its fixings.
- Panels and their fixings.
- Thermal-insulating components and materials.
- Vapour barriers.
- Flashings.
- Window sub frames.
- Door frames.
- Fixed window frames.
- Opening windows.
- Doors.
- External shading devices.
- Window and door equipment.
- Glazing.
- Gaskets and compression seals.
- Sills and closure pieces.
- Inlet and extract grilles.

Components which are likely to have a shorter design life of only a few years and will need to be periodically replaced as part of a planned maintenance programme are:

- Gun and knife-applied sealants.
- Site-applied external finishes.

The cavity behind a rain screen is deemed to be a moist zone and materials selected must not corrode, deteriorate or affect the performance of the cavity barrier during its design life.

Corrosion protection

All metals must have suitable corrosion protection for the intended environment. Further guidance can be found in 'Appendix C - Materials, Products, and Building Systems '.

Window and door openings

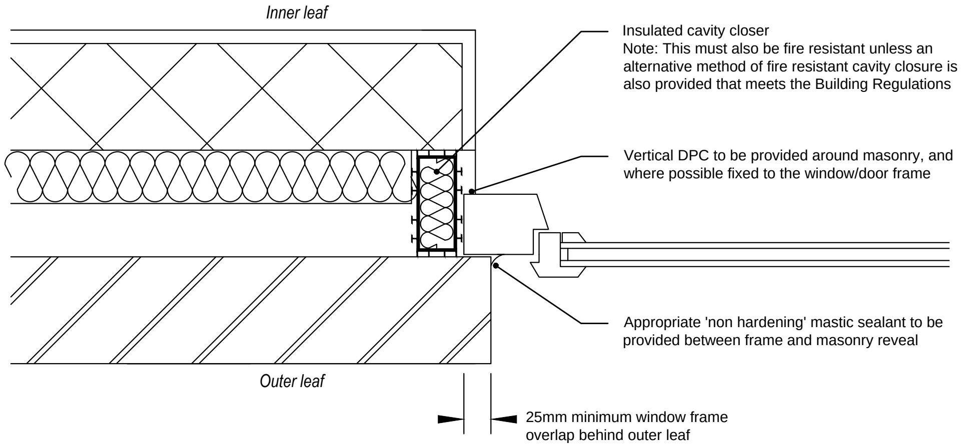
Reliance on effective weather proofing around openings must not be placed on mastic sealants alone and agreement for solutions should be sought from both Building Control and the Warranty provider prior to installation. A combination of appropriate durable external sealant and a continuous damp proof course will be required.

Cavity trays will require stopped ends and correctly positioned drainage to the external air via either full height open perpends or in very severe exposures appropriately specified proprietary ventilators (weeps).

Very severe exposure locations will require checked masonry reveals and robust DPC detailing.

External openings in solid wall/ICF structures will require specific DPC detailing with the use of a compriband or similar third party approved DPC solutions linked to internal vapour control layers to prevent water ingress to the internal finishes.

Traditional cavity wall with a checked rebate detail (insulation value of wall construction to meet relevant standards)



Windows and doors

The choice of windows and doors must be supported by the manufacturer's certification to confirm they meet the design weather conditions and be classified and tested in accordance with the following weather performance standards:

- BS 6375-1 Weather tightness.
- Air permeability - BS EN 12207 - Classification & BS EN 1026 - Test method.
- Water resistance - BS EN 12208 - Classification & BS EN 1027 - Test method.
- Wind resistance - BS EN 12210 - Classification & BS EN 12211 - Test method.

Site testing for water penetration of the joints to windows and doors in accordance with the CWCT test methods is recommended to check the site workmanship of the building envelope as constructed. See CWCT Technical Note No. 41 for guidance on site hose testing.

In addition to the above, workmanship should follow the recommendations of BS 1186-2. The design and construction of factory assembled windows must meet BS 644:2009. Non factory assembled units and 'bespoke' units are also expected to meet the same standard.

Window and door furniture and fittings must be resistant to the effects of the saline environment.

Where back ground ventilators (trickle vents) are installed, they must be correctly specified for the location and should be installed so as not cause potential damage to render finishes or restrict the ability to open the window/door.

Balconies

The following guidance is to be read in addition to the guidance found in the 'Balconies and Terraces' section.

Balcony construction

The materials used in balcony construction must comply with requirement B4 of the Building Regulations (England and Wales).

An adequate step or raised threshold must be provided to avoid the risk of penetrating moisture created by the high wind driven rain. A minimum of 75mm upstand between the highest point of the balcony roof waterproof surface and the underside of the door sill should be provided, 150mm in all other situations.

In very severe exposure locations/elevations:

- A flush fitting balcony floor finish abutting any door unit in the external wall of the dwelling must not occur as this could lead to a concentration of water against the window frame. A minimum gap of at least 10mm will be required which should be maintainable to ensure build up of any silt or other debris is avoided.
- Where a decorative walking surface deck is installed above; the balcony roof waterproof covering must be designed to fall away from any external doors opening into the building to prevent water pooling against the door units due to lack of fall.
- Drainage outlets must be easily accessible and maintainable even if decking/balcony floor finishes are applied.
- Fixings used in balcony decking or guarding must be appropriately specified to prevent adverse reaction with certain timbers.
- Regular maintenance of balcony floors will be required to avoid wind blown sand clogging up drainage outlets and balcony door seals and tracks.
- Balcony steelwork must be adequately protected against the potential for corrosion (Appendix C - Materials, Products, and Building Systems).

C.

Appendix C

Contents

Additional Functional Requirements for Materials, Products, and Building Systems and Suitability of Products and Systems

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

1. All MMC systems and products must be independently proven and have a third party product approval certification by a recognised UKAS or equivalent third party product conformity body.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

C.

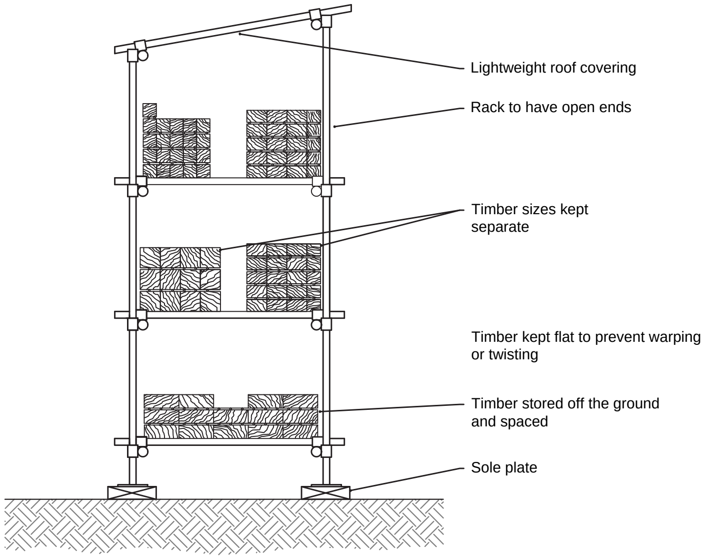
Appendix C

C.1
Materials, Products, and Building Systems

Timber

Storage
Timber should be stored correctly to ensure it does not deteriorate. It should be kept dry and covered in cold conditions to prevent surface freezing, and should be kept off the ground and spaced to allow air to move around freely. Timber should be kept flat to prevent warping or twisting.

Storage of timber on site



Timber durability
Timber should be appropriately treated to resist insect attacks. Some timber species have a natural ability to resist attack. Please refer to BS 8417 to determine the need for preservative treatment depending on the 'use class' of the timber component.

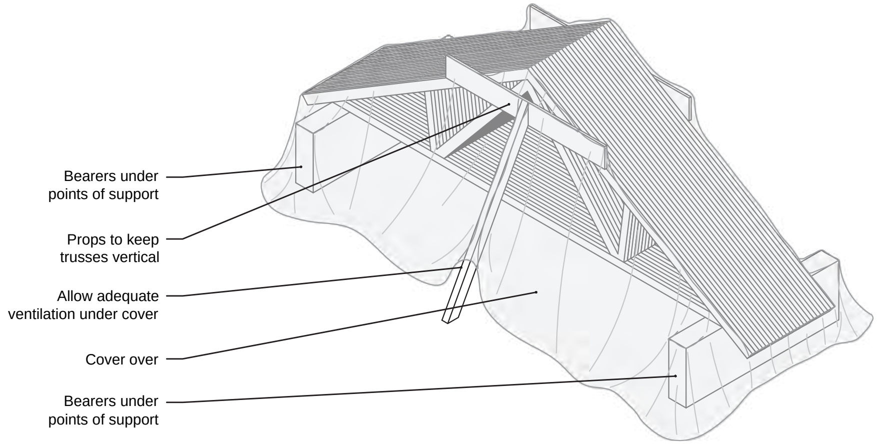
Timber grading
Timber should be of the appropriate strength classification in order to meet its design intention. For timber that is to be used for structural purposes e.g. floor joists, rafters and ceiling joists, the strength classification should be assumed to be C16 unless it is appropriately stamped with its specific strength classification.

Site storage of roof trusses
The delivery of trussed rafters should be planned so as to minimise the period of storage necessary on-site. When delivered the trusses should, at all times, be kept clear of the ground and vegetation and be supported by level bearers sited under or adjacent to the points of support assumed by the design.

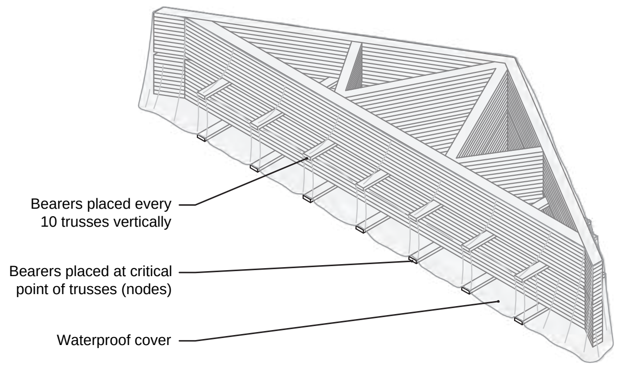
To prevent any distortion, there is a need to ensure that the trusses are stored in a vertical position, as in 'vertical storage of trusses' below.

Horizontal storage is sometimes possible, as in 'Horizontal storage of trusses' below. In both cases, stacks of trusses should be covered with a weather proof cover, whilst maintaining adequate ventilation to prevent the occurrence of condensation. Trusses should be checked visually upon arrival on the site for damage occurring during transportation, and again before site use for damage occurring during storage. Trusses with a moisture content exceeding 20% should not be installed.

Vertical storage of trusses



Horizontal storage of trusses



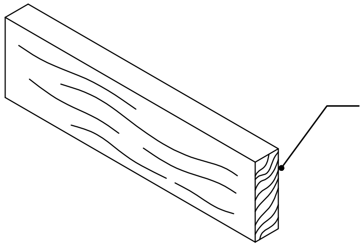
Green and air dried/seasoned oak

Green oak, air dried/seasoned oak is not acceptable for including in the external wall construction, frame, window/door construction, internal wall, or roof constructions, regardless of whether it forms part of the waterproof envelope or not. Projects incorporating green oak will not be acceptable for Warranty cover.

Timber treatment

Timber should ideally be preserved in a factory environment; it is accepted, however, that this is not always possible. Timber treatments should be approved according to the relevant Code of Practice or British Standard, or have third-party accreditation. Careful consideration should be given to Health and Safety when applying timber treatment products. It is important that any pre-treated timber be re-treated if it is cut to expose untreated end grain. The treatment should be coloured so it can be proven that the end grain has been treated.

Pre-treated timber exposing untreated end grain



Treatment of timber

Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice, and in the following circumstances:

- Roof timbers should be preservative treated where the insulation and ceiling line follow the roof pitch.
- Trussed rafter construction which is cut back at eaves or where the rafter 'feet' are trimmed to sit into the external walls. Preservative treatment will be required to the cut ends.
- The Approved Document of Regulation 7 of the Building Regulations for England requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle.

The areas at risk are:

- The District of Bracknell Forest.
- The Borough of Elmbridge.
- The Borough of Guildford (other than the area of the former Borough of Guildford).
- The District of Hart (other than the area of the former Urban District of Fleet).
- The District of Runnymede.
- The Borough of Spelthorne.
- The Borough of Surrey Heath.
- In the Borough of Rushmoor, the area of the former district of Farnborough.
- The District of Waverley (other than the parishes of Godalming and Haslemere).
- In the Royal Borough of Windsor and Maidenhead, the parishes of Old Windsor, Sunningdale and Sunninghill.
- The Borough of Woking.

The treatment should be impregnated with a preservative suitable for use in 'Use Class 1' in pitched roofs and 'Use Class 2 flat roofs', in accordance with BS 8417, for a 60 year anticipated service life. Cut ends must be liberally brushed or dipped with an end-grain preservative.

It is strongly recommended that, where punched metal fasteners are proposed to roof trusses, only micro-emulsion or organic solvent preservatives should be used for timber treatment, to limit the possibility of corrosion of the fasteners and so as not to adversely affect glued joints.

Where timber (that is required to be preservative treated) is cut, the exposed ends must be preservative treated to maintain durability of the timber.

Metal fixings

Metal components should be galvanised where they are to be fixed or used adjacent to treated timber.

Standards referred to

- BS EN 1912 Structural timber-strength classes - Assignment of visual grade and species.
- BS EN 1995-1-1 Eurocode Design of timber structures.
- BS 8417 Preservative of wood - Code of Practice.
- BS EN 335 Durability of wood and wood based products.

Concrete

Cold weather working
To meet the Functional Requirements, the minimum working temperature should not fall below 2°C. It is important that during cold weather periods, regular temperature readings should be taken. Thermometers should be placed away from direct sunlight, preferably in a shaded area. When assessing the temperature, it is also important to consider wind chill and weather exposure, and make the necessary allowances for sites that have a higher level of exposure.

Ready mixed concrete
It is a requirement of BS 8500 and BS EN 206-1 that the temperature of fresh concrete shall not be below 5°C at the time of delivery. Measures should also be put in place to ensure immature concrete is prevented from freezing before sufficient strength has been achieved.

Site mixed concrete
Site mixing is acceptable at low temperatures, provided:

- The minimum temperature is no less than 2°C.
- The concrete is appropriately protected during curing.
- Ground conditions are not frozen.

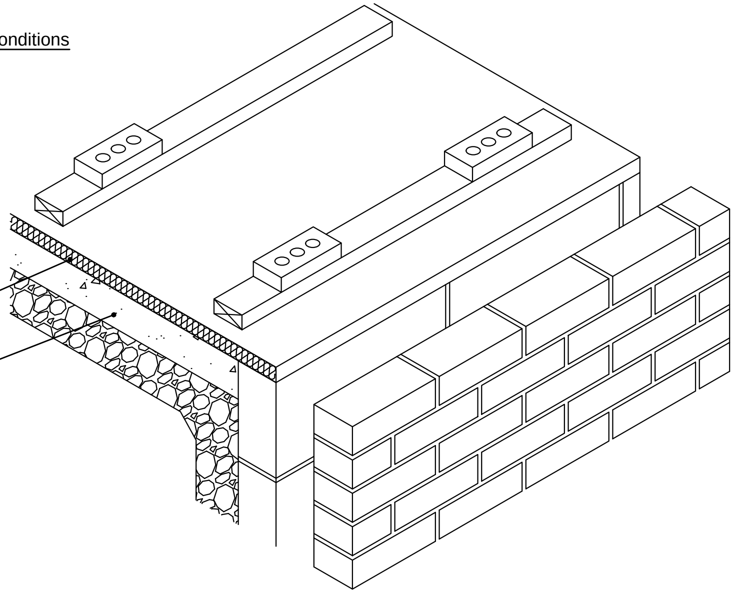
Concreting of foundations and oversite
Concrete should not be poured if the ground is frozen as frozen ground can change in stability and volume during thawing, and therefore may cause damage to the recently poured concrete.

During cold weather, it may be appropriate to cover the ground to prevent freezing and, in some extreme cases, heating of the ground may be required.

Other Concreting
Concrete reinforcing and formwork should not be frozen and be free from snow and ice.

Curing of concrete
Concrete may take longer to cure in cold conditions, and an additional six days may be required in extreme cases. Concrete may be covered with a rigid insulation to prevent freezing during curing periods. This is particularly useful for oversized slabs. Concrete should not be poured if the ground is frozen, or if the temperature is less than 2°C.

Concrete curing in cold weather conditions



Concrete suitability

Concrete of the appropriate durability and strength should be used in all circumstances. The Table below gives details of the correct concrete for varying applications.

Application	Ready mixed concrete	Site mixed concrete	Consistence class
Substructure Blinding (unreinforced) Backfilling	GEN1	N/A	S3
Substructure (unreinforced) Structural blinding Strip, trench, and mass filled foundations Concreting of cavity walls to ground level	GEN1	N/A	S3/S4[(1)]
Floor (building unreinforced and unsuspended) With screed added or other floor finish Floor slab as finish (e.g. power float)	GEN1 GEN2	N/A N/A	S2 S2
Garage floors (unreinforced and unsuspended)	GEN3	N/A	S2
Reinforced slabs (buildings and garages suspended or unsuspended)	RC35	N/A	S2
Superstructure	As specified by a Structural Engineer	N/A	As specified by a Structural Engineer
External works Pathways Bedding for paving slabs	PAV1 GEN1	ST5 ST1	S2 S1
Note: 1) Consistence class S3 should be used for strip foundation concrete and consistence class S4 should be used for trench fill foundation concrete.			

Concrete mixes

Site mixed concrete

Site mixed concrete should generally be avoided unless it is for non-structural applications e.g. backfilling or bedding of paving slabs etc. There may be exceptional circumstances where site mixing is unavoidable. Where this is the case, extra caution must be taken to ensure that the correct mix proportion is used; delivery notes should be provided if necessary, and a provision for testing may be required.

Ready mixed concrete

Concrete must be mixed using the correct proportions of cement, sand, aggregate and water. Ready mixed concrete should be delivered as close as possible to the site works and should be poured immediately to prevent settlement or separation of the mix. Ideally, ready mixed concrete should be poured within two hours of the initial mixing at the concrete plant.

Ready mixed concrete should only be sourced from a supplier who has a quality control system in place to ensure the correct standard of concrete is delivered. The quality control scheme should be either QSRMC (Quality Scheme for Ready Mixed Concrete) or a relevant British Standard Kite mark scheme.

It is important to pass all design specifications of the concrete to the ready mixed supplier to ensure that the delivered concrete meets the design intention.

Delivery notes should be kept and made available for inspection if required.

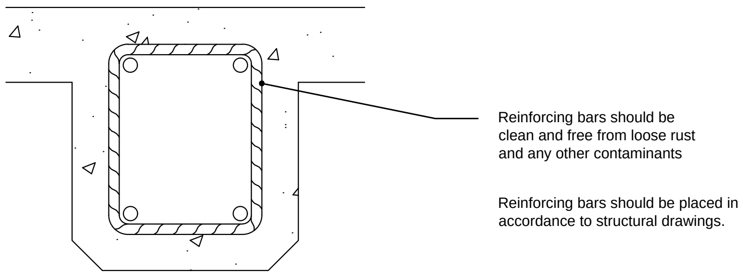
Additional water should not be added to the concrete on-site, nor should the ready mixed concrete be poured into water-filled trenches unless the concrete has been specifically designed for this purpose.

Reinforcing

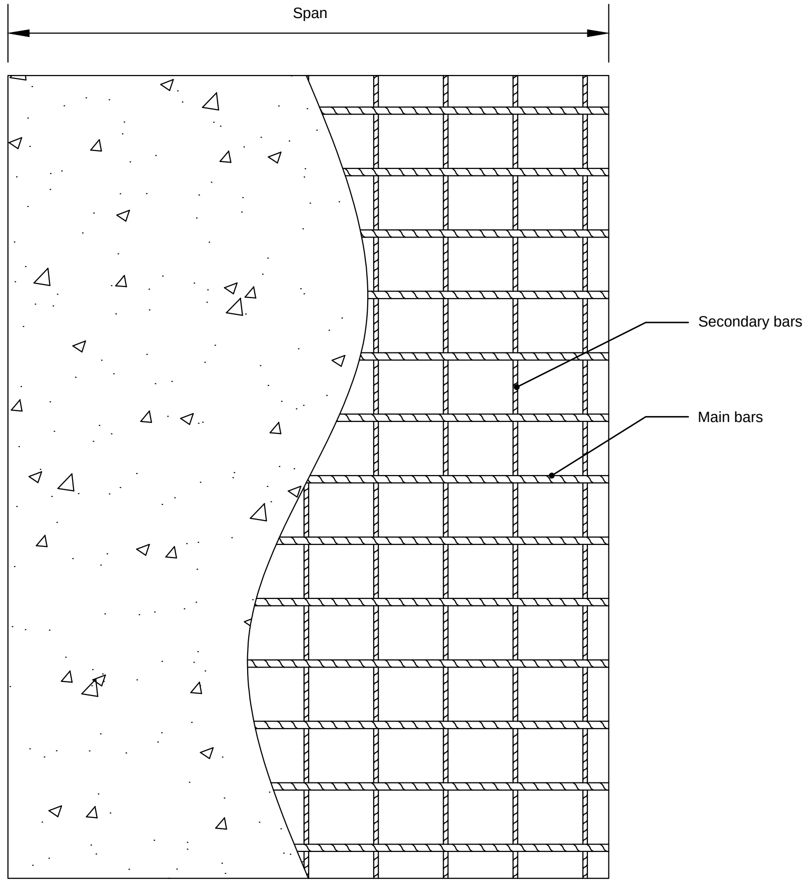
Reinforcing bars and mesh should be clean and free from loose rust and any other contaminants that may cause deterioration of the reinforcing material or the durability of the concrete.

Reinforcing bars and mesh should be placed in accordance with structural drawings; bars that are to be bent should be done so using the correct tools for the job.

Reinforcing bars in concrete beams



Position of bars on reinforced concrete slab



Reinforcing bars should be correctly positioned, ensuring there is appropriate concrete cover, and reinforcing mesh placed in the right direction (main bars parallel to span).

Reinforcing cover

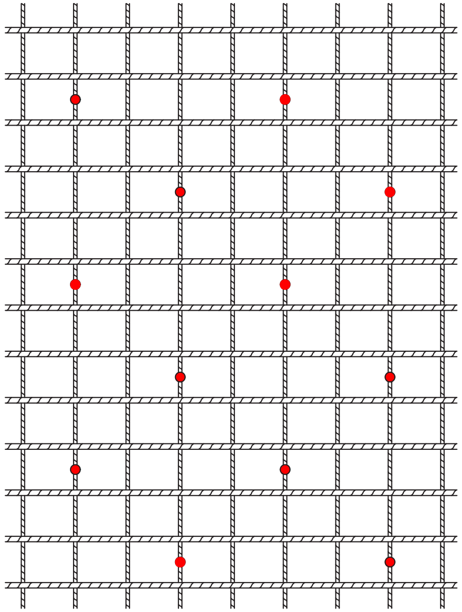
An appropriate level of concrete cover should be provided to the reinforcement; the cover thickness will depend on the exposure of the concrete and its application. Concrete cover should be specified by a qualified Structural Engineer, or alternatively by using the table below.

Minimum concrete reinforcing cover

Application (concrete position)	Minimum cover (mm)
Concrete in direct contact with the ground	75
All external applications e.g. shuttered walling	50
Floor slabs and other applications where concrete is cast onto a membrane	40
Concrete over blinding concrete	40
Internal conditions	25

Reinforcing should be supported by proprietary chairs or spacers, and can be made of concrete, plastic or steel. The thickness and depth of a concrete spacer should not exceed 50mm x 50mm. Spacers should be placed at a maximum of 1m centres, and when supporting mesh should be staggered.

Position of spacers



Spacers staggered to avoid planes of weakness

Admixtures

Admixtures should only be used if stipulated as part of the original design specification. If an admixture is to be proposed where it was not intended as part of the design, a Structural Engineer must confirm that the admixture is appropriate and required.

It is important that the appropriate amount of admixture is applied to any mix. Any overdosing may cause concrete deterioration or poor workability.

Common admixtures

- Plasticisers - improve the workability of concrete, especially when pumped; they can also improve concrete adhesion, which is particularly enhanced when concrete is reinforced.
- Air entraining agents - increase the air void volume of concrete, which in turn produces a surface more resilient to cold weather, and is therefore ideally suited to outdoor conditions where cold weather exposure is high, such as pathways or roads.
- Accelerators - provide an improved curing time, but caution should be taken to allow for reasonable time to 'finish' the concrete.

Admixtures in cold weather

Admixtures may be used in cold weather, but usually will not assist in preventing concrete from freezing; therefore, they should not be relied upon to compensate for freezing conditions. The guidance for cold weather working should be followed in these circumstances.

Admixtures and reinforcing

Admixtures containing chloride will cause corrosion to occur, meaning they should not be used in concrete containing reinforcing.

Expansion/movement joints

Joints in concrete should be provided to prevent cracking caused by shrinkage; shrinkage will be less significant if the concrete is reinforcement.

A larger number of expansion joints should be provided to concrete where weak spots may occur. This could include a narrowing width of floor slab for example.

Vibration and compaction of concrete

Reinforced concrete should be compacted using a vibrating poker, but care must be taken to ensure the concrete is not over-compacted and the concrete mix separated.

Curing of concrete

Concrete should be adequately cured before loads are applied. It is acceptable that masonry walls may be built up to damp proof course (DPC) on a foundation that is not fully cured; however, care must be taken to prevent any damage to the foundation. The concrete should be at least durable enough to carry the masonry.

The speed at which concrete mixes cure depends on the mix ratio and whether there are any additives within the concrete. Where curing time is critical, such as cast in-situ upper floors, curing times should be indicated as part of the design and formwork struck, as advised by a Structural Engineer.

To prevent concrete curing too rapidly after initial drying, exposed concrete should be covered with hessian, polythene or sand. This prevents the surface drying too quickly and protects the concrete. This level of protection is particularly critical in hot or adverse weather conditions.

Standards referred to:

- BS 8110 Structural use of concrete.
- BS EN 1992-1-1 Design of concrete structures, general rules and rules for buildings (incorporating UK National Annex to Eurocode).
- BS 8500 Concrete - Complementary British Standard to BS EN 206-1.
- BS EN 206-1 Concrete. Specification, performance, production and conformity.
- BS EN 12620 Aggregates for concrete.
- BS EN 197 Cement. Conformity evaluation.

Cold weather working

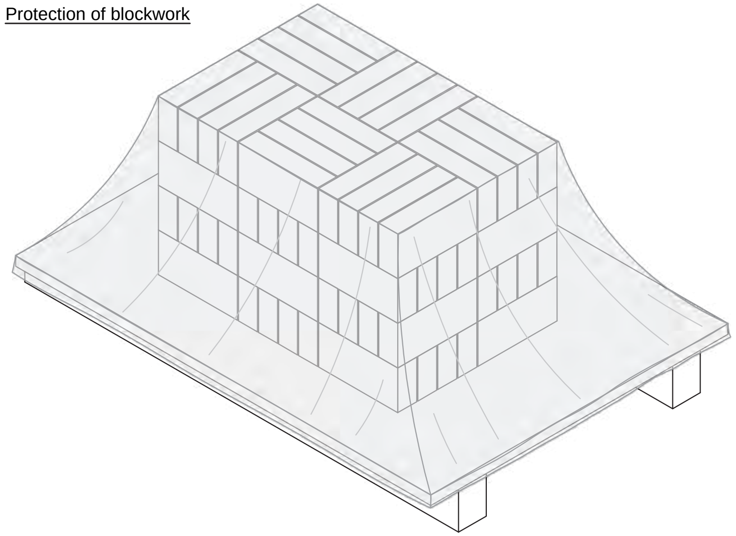
To meet the Functional Requirements of this Technical Manual, the minimum working temperatures should not fall below 2°C when working with masonry. It is important that during cold weather periods, regular temperature readings should be taken.

Thermometers should be placed away from direct sunlight, preferably in a shaded area. When assessing the temperature, it is also important to consider wind chill and weather exposure, and make necessary allowances for sites that have a higher level of exposure.

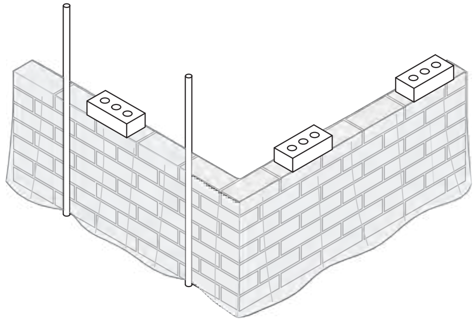
Protection of materials

Covers should be provided to protect materials from frost, snow and ice, particularly bricks, blocks, sand and cement. Frozen materials should never be used under any circumstances.

Protection of blockwork



Protection of masonry walls



Protection of masonry

Any new walls or other masonry construction will require protection against frost where temperatures are expected to drop below 2°C. Ideally, all masonry should be protected with polythene or hessian. If temperatures are expected to fall to an extremely low level, insulation boards may be required, and heating may even be considered.

Finishes including rendering, plastering and screeds

Rendering should only be completed if the outside temperature is at least 2°C; there should be no frost within the construction that is to be rendered and, where possible, rendering should not take place where freezing weather conditions are anticipated prior to adequate curing.

No plastering or screeding should take place unless the building is free from frost. It is acceptable to use internal heating to warm the building effectively; however, it is important to ensure that heaters do not emit excessive vapour into the building. Adequate ventilation should be provided to allow moist air to escape. The building should be appropriately pre-heated before plastering, and continue to be heated whilst the plaster dries.

Bricks

Bricks should be of an appropriate durability to meet the design intention. The type of brick to be used will affect the specification of the mortar. Bricks with greater durability should be used where there is a higher potential for saturation or severe exposure to wind-driven rain. Refer to the brick manufacturer when making this selection.

The following table is derived from PD 6697 - Durability of masonry in finished construction and provides guidance of the suitably of masonry in different areas of construction. This table should be read in conjunction with the following table 'Classification of micro conditions of exposure of completed masonry' which gives further guidance on the masonry condition or saturation.

Durability of masonry in finished construction (derived from PD 6697 - 2019)

Masonry condition or situation (A)	**Quality of masonry units and appropriate mortar designations**				
	Clay units	**Calcium silicate units**	**Aggregate concrete bricks**	**Aggregate concrete, autoclaved aerated concrete blocks and manufactured stone units**	Remarks
(A) Work below or near external ground level					
A1 - Low risk of saturation without freezing MX2.1	P – F0 and S0 or U – F0, F1 or F2 and S0, S1 or S2 in M12, M6 or M4	Without or with freezing Compressive strength class 20 or above in M4 or M2 (see remarks)	Without or with freezing Mean compressive strength 16.5 N/mm^2 or above in M4	Without or with freezing a) of net density ≥ 1500 kg/m^3; or b) made with dense aggregate conforming to BS EN 12620; or c) having a mean net compressive strength ≥ 7.3 N/mm^2; or d) most types of autoclaved aerated unit (see remarks) or e) all types of manufactured stone unit All in M4 or M2 (see remarks)	Some types of autoclaved aerated concrete block may not be suitable. The manufacturer should be consulted. In sulfate bearing ground conditions, the recommendations in 6.2.9.4 (see PD 6697:2019) should be followed. Where designation M2 mortar is used it is essential to ensure that all masonry units, mortar and masonry under construction are protected fully from saturation and freezing. Some manufacturers of clay units do not recommend the use of their U -F1 units for work below or near external ground level.
A2 - High risk of saturation without freezing MX2.2	U – F1 or F2, and S1 or S2 in M12, M6 or M4 unless a manufacturer advises against the use of F1	Compressive strength class 20 or above in M6 or M4	Mean compressive strength 16.5 N/mm^2 or above in M6 or M4	As for A1 in M6 or M4	Masonry most vulnerable in situations A2 and A3 is located between 150 mm above and 150 mm below finished ground level. In this zone masonry will become wet and can remain wet for long periods, particularly in winter. Where S1 clay units in designation M6 mortar are used in A2 or A3 locations, the recommendations in 6.2.9.4 (see PD 6697:2019) should be followed. In conditions of highly mobile groundwater, consult the manufacturer on the selection of materials (see 6.2.8.1.10 to 6.2.8.1.14).
A3 - High or low risk of saturation with freezing MX3.1, MX3.2	U – F2 and S2 in M12 or M6 (see remarks)	Compressive strength class 20 or above in M6 or M4	Mean compressive strength 22 N/mm^2 or above in M6 or M4	As for A1 in M6	
(B) Masonry DPCs (masonry DPC's are not acceptable for warranty purposes)					
(C) Unrendered external walls (other than chimneys, cappings, copings, parapets, sills)					
C1 - Low risk of saturation MX3.1, MX4, MX5	U – F2 and S2 in M12, M6 or M4	Compressive strength class 20 or above in M4 or M2 (see remarks)	Mean compressive strength 7.3 N/mm2 or above in M4	Any in M4 or M2 (see remarks)	To minimize the risk of saturation, walls should be protected by roof overhang and other projecting features. However, such details may not provide sufficient protection to walls in conditions of very severe driving rain (see 6.2.7.4 of PD 6697:2019). Certain architectural features, e.g. brick masonry below large glazed areas with flush sills, increase the risk of saturation (see 6.2.8.5 of PD 6697:2019).
C2 - High risk of saturation MX3.2, MX4, MX5	U – F2 and S2 in M12 or M6 (see remarks)	Compressive strength class 20 or above in M4	Mean compressive strength 18 N/mm2 or above in M4	Any in M4	Where designation M2 mortar is used it is essential to ensure that all masonry units, mortar and masonry under construction are protected fully from saturation and freezing.
(D) Rendered external walls (B) (other than chimneys, cappings, copings, parapets, sills)					
Rendered external walls. Any exposure condition.	U – F1 or F2 and S1 or S2 in M12, M6 or M4 (see remarks)	Compressive strength class 20 or above in M4 or M2 (see remarks)	Mean compressive strength 7.3 N/mm2 or above in M4	Any in M4 or M2 (see remarks)	Rendered walls are usually suitable for most wind-driven rain conditions (see 6.2.7.4 of PD 6697:2019). Where S1 clay units are used, the recommendations in 6.2.9.4 (see PD6697:2019) should be followed for the jointing mortar and the basecoat of render. Clay units of F1/S1 designation are not recommended for the rendered outer leaf of a cavity wall with full fill insulation (see 6.2.7.4.2.9 of PD 6697:2019) For Warranty purposes Render on an external leaf of clay bricks (F2, S1, or F1, S1 designation bricks BS EN771) in severe or very severe exposures is not permitted where the cavity is to be fully filled with insulation.
(E) Internal walls and inner leaves of cavity walls					
Internal walls and inner leaves of cavity walls MX1	P – F0 and S0 or U – F0, F1 or F2 and S0, S1 or S2 in M12, M6, M4 or M2 (see remarks)	Compressive strength class 20 or above in M4 or M2 (see remarks)	Mean compressive strength 7.3 N/mm^2 or above in M4 (see remarks)	Any in M4 or M2 (see remarks)	Where designation M2 mortar is used it is essential to ensure that all masonry units, mortar and masonry under construction are protected fully from saturation and freezing
(F) Unrendered parapets (other than cappings and copings)					
F1 - Low risk of saturation with freezing, e.g. low parapets on some single storey buildings MX3.1, MX4	U – F2 and S2 in M12, M6 or M4	Compressive strength class 20 or above in M4	Mean compressive strength 22 N/mm^2 or above in M4	a) of net density ≥ 1 500 kg/m^3; or b) made with dense aggregate conforming to BS EN 12620; or c) having a mean net compressive strength ≥ 7.3 N/mm^2; or d) most types of autoclaved aerated unit (see remarks); or e) all types of manufactured stone unit All in M4	Most parapets are likely to be severely exposed irrespective of the climatic exposure of the building as a whole. Copings and DPCs should be provided wherever possible. Some types of autoclaved aerated concrete block may not be suitable. The manufacturer should be consulted.
F2 - High risk of saturation with freezing e.g. where a capping only is provided for the masonry MX3.2, MX4	U – F2 and S2 in M12 or M6 (see remarks)	Compressive strength class 20 or above in M4	Mean compressive strength 22 N/mm^2 or above in M4	As for F1 in M6	

Masonry condition or situation [A]	**Quality of masonry units and appropriate mortar designations**				
	Clay units	**Calcium silicate units**	**Aggregate concrete bricks**	**Aggregate concrete, autoclaved aerated concrete blocks and manufactured stone units**	Remarks
(G) Rendered parapets (other than cappings and copings)					
Rendered parapets MX3.1, MX3.2, MX4	U – F1 or F2 and S1 or S2 in M12, M6 or M4 (see remarks)	Compressive strength class 20 or above in M4	Mean compressive strength 7.3 N/mm^2 or above in M4	Any in M4	Single-leaf walls should be rendered only on one face. All parapets should be provided with a coping. Where S1 clay units are used, the recommendations in 6.2.8.4 (see PD6697:2019) should be followed.
(H) Chimneys					
H1 - Unrendered with low risk of saturation MX3.1, MX4, MX5	U – F2 and S2 in M12, M6 or M4 (see remarks)	Compressive strength class 20 or above in M4 (see remarks)	Mean compressive strength 12 N/mm^2 or above in M4 (see remarks)	Any in M4	Chimney stacks are normally the most exposed masonry on any building. Because of the possibility of sulfate attack from flue gases the recommendations in 6.2.9.4 (see PD6697:2019) should be followed.
					Brick masonry and tile cappings cannot be relied upon to keep out moisture. The provision of a coping is preferable.
H2 - Unrendered with high risk MX3.2, MX4, MX5	U – F2 and S2 in M12 or M6 (see remarks)	Compressive strength class 20 or above in M4 (see remarks)	Mean compressive strength 16.5 N/mm^2 or above in M4 (see remarks)	a) of net density ≥ 1 500 kg/m^3; or b) made with dense aggregate conforming to BS EN 12620; or c) having a mean net compressive strength ≥ 7.3 N/mm^2; or d) most types of autoclaved aerated unit (see remarks) or e) all types of manufactured stone unit	Some types of autoclaved aerated concrete block may not be suitable for use in situation H2. The manufacturer should be consulted.
H3 - Rendered MX3.1, MX3.2, MX4, MX5	U – F1 or F2 and S1 or S2 in M12, M6 or M4 (see remarks)	Compressive strength class 20 or above in M4 (see remarks)	Mean compressive strength 7.3 N/mm^2 or above in M4 (see remarks)	Any in M6	Where S1 clay units are used, see 6.2.8.4.
(I) Cappings, copings and sills					
Cappings, copings and sills MX3	U – F2 and S2 in M12	Compressive strength class 30 or above in M6	Mean compressive strength 33 N/mm^2 or above in M6	a) of net density ≥ 1 500 kg/m^3; or b) made with dense aggregate conforming to BS EN 12620; or c) having a mean net compressive strength ≥ 7.3 N/mm^2; or d) all types of manufactured stone unit All in M6	Autoclaved aerated concrete blocks are not suitable for use in situation I. Where cappings or copings are used for chimney terminals, the recommendations in 6.2.8.4 (see PD6697:2019) should be followed. DPCs for cappings, copings and sills should be bedded in the same mortar as the masonry units.
(J) Freestanding boundary and screen walls (other than cappings and copings). (This section is not produced for warranty purposes. For further information please see PD 6697-2019)					
(K) Earth retaining walls (other than cappings and copings)					
K1 - With water-proofing on retaining face and coping MX3.1, MX3.2, MX4	U – F2 and S2 in M12 or M6 Refer to (B) for units from foundation to 150 mm above ground level.	Compressive strength class 20 or above in M6 or M4	Mean compressive strength 16.5 N/mm^2 or above in M6	a) of net density ≥ 1 500 kg/m^3; or b) made with dense aggregate conforming to BS EN 12620; or c) having a mean net compressive strength ≥ 7.3 N/mm^2; or d) most types of autoclaved aerated unit (see remarks); or e) all types of manufactured stone unit All in M4	Because of possible contamination from the ground and saturation by ground waters, in addition to subjection to severe climatic exposure, masonry in retaining walls is particularly prone to frost and sulfate attack. Careful choice of materials in relation to the methods for exclusion of water recommended in 6.2.8 (see PD6697:2019) is essential. It is strongly recommended that such walls be backfilled with freedraining materials. The provision of an effective coping with a DPC (see 6.2.8 of PD 6697:2019) and waterproofing of the retaining face of the wall (see 6.8.6 of PD 6697:2019) is desirable. Some types of autoclaved aerated concrete block are not suitable for use in situation K1; the manufacturer should be consulted.
K2 -With coping or capping but no water-proofing on retaining face MX3.1, MX3.2, MX4, MX5	Consult the manufacturer	Compressive strength class 30 or above in M6	Mean compressive strength 33 N/mm^2 or above in M12 or M6	As for K1 but in M12 or M6 (see remarks)	Some aggregate concrete blocks are not suitable for use in situation K2; the manufacturer should be consulted.
(L) Drainage and sewage, e.g. inspection chambers, manholes					
L1 - Surface water MX3.1, MX3.2, MX5	Max. water absorption 7 % in M12 (in line with historic DPC and engineering brick categories) or F2 and S2 in M12 (see remarks)	Compressive strength class 20 or above in M6 or M4	Mean compressive strength 22 N/mm^2 or above in M4	a) of net density ≥ 1 500 kg/m^3; or b) made with dense aggregate conforming to BS EN 12620; or c) having a mean net compressive strength ≥ 7.3 N/mm^2; or d) all types of manufactured stone unit in M4	If sulfate ground conditions exist, the recommendation in 6.2.8.4 (see PD6697:2019) should be followed. Some types of autoclaved aerated block are not suitable for use in situation L1; the manufacturer should be consulted."
L2 - Foul drainage (continuous contact with masonry) MX3.1, MX3.2, MX5	Max. water absorption 7 % in M12 (in line with historic DPC and engineering brick categories) or F2 and S2 in M12 (see remarks)	Compressive strength class 50 or above in M6 (see remarks)	Mean compressive strength 48 N/mm^2 or above with cement content ≥ 350 kg/m^3 in M12 or M6	Not suitable	Some types of calcium silicate brick are not suitable for use in situations L2 or L3; the manufacturer should be consulted.
L3 - Foul drainage (occasional contact with masonry) MX3.1, MX3.2, MX5	Max. water absorption 7 % in M12 (in line with historic DPC and engineering brick categories) or F2 and S2 in M12 (see remarks)	Compressive strength class 20 or above in M6 or M4 (see remarks)	Mean compressive strength 48 N/mm^2 or above with cement content ≥ 350 kg/m^3 in M12 or M6	Not suitable	
A) For the classification of micro conditions of exposure of completed masonry MX1, 2, 3, 4 and 5, see BS EN 1996-2:2006, Annex A, and NA to BS EN 1996-2:2006. B) For warranty purposes a specialist render system and mortar should be employed for parapets, chimneys, retaining walls and walls below DPC. LD - Clay masonry units with a low gross density for use in protected masonry. HD - Clay masonry unit for unprotected masonry as well as clay masonry unit with high gross dry density for use in protected masonry.					

The table below should be read in conjunction with table above 'Durability of masonry in finished construction'. The table below provides further information on the environment in which the masonry maybe suitable.

Classification of micro conditions of exposure of completed masonry (reproduced from BS EN 1996-2:2006)

Class	Micro condition of masonry	Examples of masonry in this condition
MX1	**In a dry environment**	Interior of buildings for normal habitation and for offices, including the inner leaf of external cavity walls not likely to become damp. Rendered masonry in exterior walls, not exposed to moderate or severe driving rain, and isolated from damp in adjacent masonry or materials.
MX2	**Exposed to moisture or wetting**	
MX2.1	Exposed to moisture but not exposed to freeze/thaw cycling or external sources of significant levels of sulfates or aggressive chemicals.	Internal masonry exposed to high levels of water vapour, such as in a laundry. Masonry exterior walls sheltered by overhanging eaves or coping, not exposed to severe driving rain or frost. Masonry below frost zone in well drained nonaggressive soil.
MX2.2	Exposed to severe wetting but not exposed to freeze/thaw cycling or external sources of significant levels of sulfates or aggressive chemicals.	Masonry not exposed to frost or aggressive chemicals, located: in exterior walls with capping's or flush eaves; in parapets; in freestanding walls; in the ground; under water.
MX3	**Exposed to wetting plus freeze/thaw cycling**	
MX3.1	Exposed to moisture or wetting and freeze/thaw cycling but not exposed to external sources of significant levels of sulfates or aggressive chemicals.	Masonry as class MX2.1 exposed to freeze/thaw cycling.
MX3.2	Exposed to severe wetting and freeze/thaw cycling but not exposed to external sources of significant levels of sulfates or aggressive chemicals.	Masonry as class MX2.2 exposed to freeze/thaw cycling.
MX4	**Exposed to saturated salt air seawater or de-icing salts**	Masonry in a coastal area. Masonry adjacent to roads that are salted during the winter
MX5	**In an aggressive chemical environment**	Masonry in contact with natural soils or filled ground or groundwater, where moisture and significant levels of sulfates are present. Masonry in contact with highly acidic soils, contaminated ground or groundwater. Masonry near industrial areas where aggressive chemicals are airborne.
Note: In deciding the exposure of masonry the effect of applied finishes and protective claddings should be taken into account.		

Acceptable assumed equivalent mixes for prescribed mortars (reproduced from BS EN 1996-1 UK National Annex to Euro Code 6: Design of Masonry Structures Table NA.2)

Compressive strength class a)	Prescribed mortars (proportion of materials by volume) (see note)				Mortar designation	Suitable for use in environmental condition
	Cement b): Lime : Sand with or without air entrainment	**Cement b): Sand with or without air entrainment**	**Masonry cement c): Sand**	**Masonry cement d): Sand**		
M12	1: 0 to ¼: 3	1 : 3	Not suitable	Not suitable	(i)	Severe (S)
M6	1 : ½ : 4 to 4 ½	1 : 3 to 4	1 : 2 ½ to 3 ½	1 : 3	(ii)	Severe (S)
M4	1 : 1 : 5 to 6	1 : 5 to 6	1 : 4 to 5	1 : 3 ½ to 4	(iii)	Moderate (M)
M2	1 : 2 : 8 to 9	1 : 7 to 8	1 : 5 ½ to 6 ½	1 : 4 ½	(iv)	Passive (P)

a) The number following the M is the compressive strength for the class at 28 days in N/mm^2.
b) Cement or combinations of cement in accordance with N.A>2.3.2, except masonry cements.
c) Masonry cement in accordance with N.A. 2.3.2 (inorganic filler other than lime).
d) Masonry cement in accordance with N.A. 2.3.2 (lime).

Note 1: When the sand portion is given as, for example, 5 to 6, the lower figure should be used with sands containing a higher proportion of fines whilst the higher figure should be used with sands containing a lower proportion of fines.

Note 2: For Class 2 of execution control site compressive strength testing is not required for these traditional mixes and checking of prescribed mortars should only be done by testing the proportions of the constituents

Specification of mortars for masonry

Mortar for masonry can be:

- General purpose or thin layer or lightweight.
- Factory made (pre-batched or pre-mixed) or semi-finished factory made (both to BSEN998-2) or site made (to BSEN1996-2).
- Designed (performance concept) or prescribed (recipe concept).

Designed masonry mortar has a composition and method of manufacture chosen by the producer in order to achieve specified properties.

Prescribed masonry mortar is made in predetermined proportions whose properties are assumed from the stated proportion of constituents.

Historically mortars were generally specified in terms of a prescription or recipe as, for example, in BS 5628. The updated British Standard for masonry mortar, BS EN 998-2, is a performance based standard.

Mortar should be specified, manufactured and installed in accordance with:

- BS EN 1996: Design of masonry structures.
- BS EN 998-2: Specification for mortar for masonry.
- PD 6678: Guide to the specification of masonry mortar.
- PD 6697: Recommendations for the design of masonry structures to BSEN1996-1-1 and BSEN1996-2.

Specification of factory-made or semi-finished factory-made to BS EN 998-2

For prescribed mortars:

- The prescribed mortar specification should be drafted so that the quality is controlled by stated compositional requirements.
- The compressive strength shall be declared using publicly available references establishing the relationship between same mix proportions of the same constituents and compressive strength. The proportion of the prescribed constituents required to provide the stated "M" values for prescribed masonry mortars are given in table NA.2 of the National Annex to BS EN 1996-1-1.
- The mix proportions by volume or by weight of all the constituents shall be declared by the manufacturer. The manufacturer shall verify the conformity of the mortar to the specification by referring to any production records and delivery documentation. CE marking of prescribed factory made mortar signifies that the product conforms to the European Commission's Construction Products Directive. Conformity is demonstrated by initial type testing and factory production control to BS EN 998-2.

For designed mortars:

- The compressive strength of masonry mortar shall be declared by the manufacturer. The manufacturer may declare the compressive strength class with the compressive strength designated by a 'M' followed by the compressive strength class in N/mm², which it exceeds.
- CE marking of a designed factory made mortar signifies that the product conforms to the essential requirements of the European Commission's Construction Products Directive (CPD). Producing designed factory made mortar in accordance with BS EN 998-2 ensures that the mortar conforms to the CPD and can therefore be CE marked.
- BS EN 998-2:2003, Annex ZA specifies that if designed mortar carries the CE mark, the factory production control system will have been certified by a notified body (third party certification body).

Specification of site-made mortar to BS EN 1996-2.

Prescribed and designed mortars:

- The design specification should state the required product performance characteristics and the means of their verification including the requirements for sampling and frequency of testing.
- Where the designer is satisfied that a prescriptive specification will provide the required performance, a detailed specification of the constituent materials, their proportions and the method of mixing may be given either on the basis of tests carried out on trial mixes and/or on the basis of authoritative publicly available references acceptable in the place of use.
- When the mix prescription is not given in the design specification, the detailed specification of constituent materials, their proportions and the method of mixing should be selected on the basis of tests carried out on trial mixes and/or on the basis of authoritative publicly available references acceptable in the place of use. When tests are required, they should be carried out in accordance with the design specification and BS EN 1015. When test results indicate that the mix prescription is not giving the required performance characteristics, the mix prescription should be amended and if it is part of the design specification any amendments should be agreed with the designer.
- Where designed mortars are manufactured on site, and not within a factory control system, the mortar specification should state how conformity is to be assessed. This can range from infrequent but regular testing of samples to visual inspection and random testing of samples with statistical analysis of results. The specification should describe the supervision, inspection and testing that is required in order to confirm that the mortar conforms to the specifiers chosen BS EN 998-2 requirements.

Testing and conformity evaluation

Conformity evaluation methods for both factory and site made masonry mortar can range from examination of production records to testing and comparison of the results with tabulated values for known compositions.

General Notes

Mortar in masonry shall be sufficiently durable to resist the relevant micro exposure conditions for the intended life of the building and shall not contain constituents which can have a detrimental effect on the properties or durability of the mortar or abutting materials. Acceptable masonry unit specifications and mortar can be selected from PD 6697:2019. It is strongly recommended that you check with the manufacturers for suitability in specific applications when making your selection.

Mortar should be designed to take account of any requirement for bed joint reinforcement.

Factory made mortars and pre-batched mortars shall be used:

- In accordance with the manufacturer's instructions, including mixing time and type of mixer.
- Before the expiry of the workable life stated by the manufacturer.
- Taking account of weather conditions.

Site made mortar shall be:

- Ready for use when it is discharged from the mixer, and no subsequent additions of binders, aggregates, admixtures or water should be made.
- Be mixed so as to have a sufficient workability for it to fill the space into which it is placed, without segregation.
- Used before its working life has expired.
- Used taking account of weather conditions.

Standards referred to:

- BS 6399 Loadings for buildings.
- BS 8103 Structural design of low rise buildings.
- BS 187 Specification for calcium silicate (sand lime and flint lime) bricks.
- BS 3921.
- BS 5628 Parts 1, 2 and 3 Code of Practice for use of masonry.
- BS EN 771-1.
- BS EN 998 Specification for mortar for masonry.
- BS EN 1996-1 Design of masonry structures.
- PD 6697:2019.

Corrosion protection and protective coatings

Corrosion protection to steelwork (Including Lintels)

All materials on buildings are subject to wear during use, this is caused by mechanical, chemical, electrochemical, thermal, microbiological and radiation related impacts. Mechanical reactions lead to wear, chemical and electrochemical reactions cause corrosion.

Corrosion is defined as the physical interaction between a metal and its environment which results in changes to the metals properties, and which may lead to significant functional impairment of the metal, the environment, or the technical system of which they form part of (BS EN ISO 8044).

Corrosion resistance is the ability of a metal to maintain its operational capability in a given corrosion system. When selecting suitable construction materials which are protected to resist corrosion during its service life, it is important to consider the building, its location, the surrounding environment, the atmosphere and climatic conditions.

There are several types of corrosion that must be considered to ensure that the material(s) selected will not corrode and lead to functional impairment.

- Uniform surface corrosion.
- Electrolytic corrosion.
- Crevice corrosion.
- Pitting corrosion.
- Stress corrosion.
- Contact corrosion.

Standards

- ISO 8044 - Corrosion of metals and alloys - Basic terms and definitions.
- ISO 9223 - Corrosion of metals and alloys - Corrosively of atmospheres - Classification.
- ISO 9224 - Corrosion of metals and alloys - Corrosively of atmospheres - Guiding values for the corrosively categories.
- ISO 12944-2: Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments.
- BRE Digest 301 - Corrosion of metals by wood.
- PD 6484 - Commentary on corrosion at bi-metallic contacts and its alleviation.

Note: The CWCT Technical Note 24 provides guidance on corrosion and corrosion protection to cladding.

Protective coatings and finishes to metals

All metals must have a suitable protective coating to minimise or prevent corrosion during its life and be selected to comply with the appropriate standards and with the corrosion category described in the following table.

The classification of environmental corrosion conditions has been taken from BS EN ISO 9223 Table 4 and BS EN ISO 12944-4 Table 1. This provides a verbal description of the corrosion categories. Note: to determine the corrosion rates for aluminium, copper, steel and zinc, please refer to the standards listed.

Classification of Environmental Corrosion Conditions - Reproduced from BS EN ISO 9223 Table 4 and BS EN ISO 12944-4 Table 1

Corrosion Category C	Corrosion Level	Indoor Environment	Outdoor Environment
C1	Very low	Heated spaces with low relative humidity and insignificant pollution. e.g. offices, schools, museums.	Dry or cold zones with a very low pollution environment or times of wetness.
C2	Low	Unheated spaces with varying temperature and humidity, low pollution and where condensation may occur e.g. storage depots, light industry, sports halls.	Temperate zones to dry or cold zones with a low pollution environment e.g. Rural areas and small towns more than 10km from the coast or an estuary.
C3	Medium	Spaces with moderate frequency of condensation and pollution from production processes e.g. Residencies, Food processing plants, laundries, breweries, dairies.	Temperate zones with a medium pollution environment or small effects from chlorides, e.g. Urban and industrial areas with moderate sulphur dioxide pollution, coastal areas and estuaries with low salinity (approximately 5-10km).
C4	High	Spaces with a high frequency of condensation and pollution from production processes e.g. Boatyards, industrial processing plants and swimming pools.	Temperate zones, atmospheric environment with medium pollution and medium effects from chlorides e.g. polluted urban areas, industrial areas, coastal areas and estuaries with moderate salinity (approximately 1-5km) and areas exposed to de-icing salts.
C5	Very High	Spaces with very high frequency of condensation and pollution from production processes, e.g. Buildings with high levels of pollution and condensation.	Temperate to sub-tropical zones, high pollution area or a substantial effect from chlorides, e.g. Industrial areas, coastal areas (approximately 500m-1km), sheltered positions on the coastline (without salt spray).
CX	Extreme	Spaces with almost permanent condensation or periods of exposure to extreme humidity effects and with a high concentration of pollution.	Tropical zones with high sulphur dioxide pollution including the effects of chlorides, e.g. industrial areas with high humidity and an aggressive atmosphere, coastal (approximately 0-500m) and offshore areas with high salinity (occasional salt spray).

For Warranty purposes:

- Steel frame construction used on sites with an atmospheric corrosivity of C4 or C5 to BS EN ISO 12944, including sites within 500m from a coastal shoreline, should be galvanised to a rate of 710 g/m^2.
- Steel lintels in coastal locations used in both leaves of an external wall should be austenitic stainless steel and, in addition, protected by a separate damp proof system/cavity tray.
- Decorative finishes must be compatible with the protective coat specification. Refer to BS EN 12944 'paints and varnishes: corrosion protection of steel structures by protective paint systems' and the manufacturers recommendations.
- Any section of previously galvanised or other protected steel which is then cut or drilled must be provided with appropriate remediation to the exposed parts of steel to ensure adequate corrosion protection is maintained.
- The designer should specify the protective coating system where any steelwork is to be welded.
- Surface preparation should be to BS EN 12944-4.
- The use of Intumescent paint for achieving fire protection should be compatible with any corrosion protective coating applied and the manufacturer's guidance should be followed.

Fixings

Fixings that are exposed to weathering, moisture and corrosive environments or applications where concentrations of corrosive agents may accumulate should be made from high grade austenitic stainless steel (e.g. A4) or a protective coating suitable for the corrosion category described in the table above

Roofs fixings

In addition to the guidance found in the 'Roofs' section, the following is applicable:

- For clay, concrete and slate roofing a full roof fixing specification from the slate or tile manufacture must be provided and the exposure and orientation of the site taken into account.
- All fixings must be durable for the environment location.
- For metal cladding:
    i. The designer must establish the environment's corrosivity when specifying metal cladding for roofs in coastal locations as well as the potential for wind uplift and movement in a cladding system during severe wind conditions, particularly over party wall positions.
    ii. The designer should ensure capillary action at the overlapped joints is prevented which with high saline water could also cause pitting corrosion to take place, leading to the failure of the roof panels.

Durability of fixings

ISO 12944 also classifies three different durability ranges 'low, medium & high' for protective paint systems. Therefore, in severe and very severe environments, external paints and varnishes, and other protective coatings must be chosen to have a 'high' durability rating.

Whilst the durability range is not a 'guarantee time', consideration has to be made to the Functional Requirements of this Technical Manual: If the component does not form part of the structure, then a minimum 15 year service life will be required. Otherwise, 60 years' service life is required, if forming part of the structure.

Due to the environment, certain materials and particularly the finishes may require on-going maintenance in order to keep a satisfactory finish e.g. balcony timber decking. In these circumstances it will be the building owner's responsibility to ensure that regular maintenance of exposed components and finishes is undertaken to ensure they perform correctly. Maintenance plans will need to be in place during the lifetime of the building to ensure premature failure of coatings or components is avoided.

C.

Appendix C

C.2
Suitability of Products and Systems

Suitability of 'products'

It is important to ensure that products used in construction:

1. Meet the requirements of British Standards, Codes of Practice or equivalent European Standards current at the time of application.
2. Hold full third party product conformity approval e.g. a BBA or KIWA BDA or similar, from an approval body which is accepted by the Warranty provider. This would either be a UKAS or European equivalent product conformity accredited organisation, which looks at the product/system as a whole and reports on its suitability.

Details of the testing body accreditation will need to be supplied, as well as the certification document.

Note: Products or systems with an ETA certificate may need to be reviewed as these do not always cover the full review that a full third party product conformity approval certificate covers and aspects such as durability or the quality management systems that are in place may not be included.

In addition:

- The independent third-party testing information must recognise UK Building Regulation requirements and additional Warranty standards. Details of the performance and the limitations of use of the material/product or system tested must be provided.
- Where bearing a CE marking in accordance with the Construction Products Directive, this shall be supported by evidence of the testing carried out on the product.

Construction products that do not meet the Warranty requirements may not be acceptable for Warranty approval. It is advised that the design team must approach the Warranty provider early in the design stage to discuss the viability of the use of such a material, and determine what further independent third-party testing may be required in advance of the final design proposal.

Products that hold full third-party product conformity approval will still need to be structurally approved on a site-by-site basis depending on the layout and loading of the component.

Thermal properties and measures to prevent condensation will also require specific assessment depending on exposure, orientation etc.

Modern methods of construction (MMC)

Introduction

Modern Methods of Construction (MMC) are pre manufactured/off-site produced systems and components which are used in the construction industry, particularly for housing, as they potentially represent savings in time and materials, and provide higher standards of quality than more conventional methods of construction.

Key points to note are:

- Off-site assembly means quick erection times on-site and a quick, weather tight construction achieved.
- The accurate setting out of foundations etc. needs to be managed.
- MMC, particularly modular systems and large panel systems, will require advanced planning of the site for access, off-loading, installation and possibly storage of systems.
- The construction, design and layout of a typical system is planned in advance, so last-minute changes have to be avoided by good project management and what is known as a 'design freeze', imposed in advance of production commencing in the factory.
- The quality of the final product will rely on accurate assembly on-site by factory-trained or authorised Specialist Contractors.
- MMC take advantage of standardised construction, and may not be adaptable for complex architectural or planning design requirements. Additional testing may be necessary to ensure standards for durability and weather tightness can be achieved e.g. incorporating flat roof drainage outlets through closed panel parapet extensions.

Suitability of 'systems' and components

It is important to ensure that MMC, products or systems:

- Meet the requirements of British Standards or equivalent European Standards current at the time of application.
- Materials/products or systems are to be covered by a 'current', third party Product approval from an independent third-party product conformity technical approval body which is accepted by the Warranty provider. This would be either a UKAS accredited or a European equivalent accredited organisation, such as ILAC (International Laboratory Accreditation Co-operation).
- Where a corresponding Euro Standard exists, bear CE marking in accordance with the Construction Products Directive. This shall be supported by evidence of testing carried out on the product.

Construction methods that cannot meet the requirements of this Technical Manual must be submitted for approval by the Warranty provider in advance, at the design stage, well before commencement on-site.

MMC, products or systems that have third-party approval will still need to be structurally approved on a site-by-site basis depending on the layout and loading of the component. Thermal properties and measures to prevent condensation will also require specific assessment depending on exposure, orientation etc.

Types of modern methods of construction (MMC)

The definition of MMC spans a range of approaches from, off-site, near site and on site pre manufacturing, process improvements and technology applications.

Some typical examples of MMC are defined below:

- Volumetric or modular construction.
- Panelised.
- Hybrid (semi-volumetric).
- Site-based systems.

Many MMC components are usually site-based assembled e.g. Insulated Concrete Formwork systems.

Volumetric - Pre manufactured 3D primary structural systems

Volumetric construction (also known as modular construction) involves the 'off-site' production of pre manufactured three-dimensional units. ISO 9001 accredited or equivalent quality controlled systems of production in the factory should be in place and expected as part of any third-party approval.

Modules may be brought to site in a variety of different forms, ranging from a basic structural shell to one where all the internal and external finishes and services are already installed.

Volumetric construction can consist of timber frame (including engineered timber), light gauge steel, and concrete or composite constructions. External cladding may form part of the prefabricated system, with only localised on-site specialist sealing required.

Alternatively, traditional masonry cladding may need to be constructed; in this case, specific detailing for the support of claddings, cavity barriers and DPCs must be pre-agreed, Building Control compliant and checked by Site Managers.

Panelised- Pre manufactured 2D primary structural systems

Panelised systems are a systemised approach using flat panel units used for basic floor, wall, and roof structures (sometimes referred to as cassettes). These can comprise of varying materials and are produced in a factory environment. The panels are assembled on-site at the final workface to produce a final three-dimensional structure. The most common approach is to use open panels, or frames, which consist of a skeletal structure only e.g. stick frame, with services, insulation, external cladding and internal finishes being installed on site.

More complex panels can be produced, these are typically referred to as closed panels. Closed panels involve more factory based fabrication and can include lining materials and insulation. These may also include services, windows, doors, internal wall finishes, and external claddings.

Hybrid

Again off-site manufactured, this combines both panelised and volumetric approaches, and typically volumetric units.

Sub-assemblies and components

This category covers factory-built sub-assemblies or components in an otherwise traditionally built structural form, typically schemes incorporating the use of floor or roof cassettes, precast concrete foundation assemblies, preformed service installations, and cladding systems etc.

Site-based systems

These are structural systems that fall outside the 'off-site manufactured' categories, such as Insulated Concrete Formwork (ICF). Only systems with independent third-party approval will meet the requirements of the Technical Manual. The acceptability of these systems relies heavily on the quality procedures in place for the installation of the system on-site, in accordance with third-party approval.

Suitability of systems to meet Warranty requirements

(Please also refer to the requirements in 'Appendix C - Materials, Products, and Building Systems).

Building systems including 'off-site' manufactured systems should have independent third-party product approval, which must also recognise UK Building Regulation requirements. The Independent third party product/system approval must provide details of performance and testing carried out in the following areas to demonstrate acceptability to the Warranty provider:

- Structural integrity.
- Performance in fire situations.
- Resistance to water penetration (consider exposure rating of location), vapour permeability and dangerous substances.
- Safety in use.
- Acoustic characteristics.
- Thermal and movement characteristics.
- Compatibility of materials (interaction between components, structural or otherwise).
- Durability and longevity of materials (60 year lifespan in accordance with UK Finance requirements).
- Maintenance requirements and provisions.

Structural performance must be identified against appropriate BS EN standards. The developer must provide structural calculations for each project on a case-by-case basis, and the design shall allow for robustness to disproportionate collapse.

Systems might not have an overall full third-party product conformity approval but the individual components used must have the required full third party conformity certification. There must also be a current ISO 9001 Quality management system in place for the design, manufacture and erection of the system. This may be checked by a factory visit as party of a Warranty system approval process.

Where third-party product conformity certification is provided for a system or product, and the independent certification does not recognise our Warranty requirements, additional checks may be required to confirm the system is acceptable e.g. the need to provide a drained cavity behind some insulated cladding systems and to external cladding systems on timber and steel-framed systems. Supporting evidence of testing undertaken to prove the system may be asked for.

Durability and weather tightness are key aspects of the Warranty requirements, and the track record of the system will need to be established. Evidence of experience gained elsewhere, where environmental conditions may be significantly different, will need to be assessed, in comparison with conditions here in the UK.

Treatment of timber components will need to be assessed with regard to the species of timber used. The natural durability and the need for preservative treatment are dependent on the component's location in the construction and the Warranty requirement for durability. Treatment for insect attack in certain parts of the country will also be required. Certain European countries do not accept use of preservatives however for our Warranty requirements preservative treatment may be necessary unless evidence can be provided to demonstrate the timber species, heartwood used in the system is sufficiently durable without treatment for the position used in the building.

Detailing is critical in providing integrity to the building e.g. connections between a wall panel and a window unit. Supporting documentation must show the make-up of the tested system. When assessing projects, a particular design detail may not have been covered by the certification e.g. a balcony junction. This information must be made known at an early stage.

Certain components of a building have particular functions and may not be replaced by components that look similar but might structurally behave in a different manner. Similarly, a product with a third party assessment for a particular use may not be acceptable in a different form of construction.

The continuation of Quality Management Systems from manufacture to erection on-site must be demonstrated. The level of supervision of the systems on-site is critical to meet the Warranty requirements.

Timber frame systems

'Conventional' timber frame open panel* systems made off-site under factory conditions. Such panel systems are required to be manufactured and erected on-site under quality assured systems either structural timber association (STA) 'gold or silver' level or approved under the BM TRADA 'Q Mark' approval system. Alternatively, any off-site manufactured timber frame kit, system or wall panel that has been approved via the Warranty Approval process will be acceptable.

*Open panel systems are defined as systems which may include the external breather membrane and sheathing board, insulation internally between the studs and a transparent VCL which is left unfixed in order that the connections between panels can be viewed upon inspection.

Timber frame panels which arrive to site with additional elements e.g external cladding or a non-transparent VCL will need to undergo our in house Warranty Approval process.

'Bespoke timber frame'/'traditional stick built' open panel systems that do not have any QA procedures and are not STA or BM TRADA approved (as above) will need either third-party accreditation or independent Structural Engineer supervision and monitoring of the installation, erection and completion (sign off) of the system. Where an independent Structural Engineer is engaged to monitor the design, installation, erection and completion of the Timber Frame system, the engineer must confirm, in writing prior to sign off, that the timber frame system has been installed:

- In accordance with the design.
- In accordance with the structural calculations provided.
- With all structural timbers appropriately preservative treated in accordance with BS 8417.
- By a trained contractor, experienced in the erection of timber frame panels.

Off-site manufactured or 'bespoke' timber frame kits that include Green Oak in the construction are not acceptable. See the 'External Walls - Timber Frame' section for further information.

Structurally Insulated Panels (SIPs)

Structurally Insulated Panels (SIPs) are a form of composite panel. Only systems which hold full third party product conformity approval will meet the requirements of the Technical Manual.

Cross Laminated Timber (CLT)

Cross laminated timber (CLT) can be used to create structural panelised systems. CLT is formed using small sections of timber bonded together with permanent adhesives. Only systems which hold suitable third party certification will meet the requirements of the Technical Manual.

Light gauge steel frame systems

Off-site manufactured systems for low rise buildings, must be provided with either independent UKAS or equivalent third party system approval. Any external wall make up incorporating external cladding, must meet our Warranty requirements in respect of weather resistance. Further guidance can be found in the 'External Walls' section.

All light steel frame systems must be provided with a detailed structural appraisal and supporting calculations on a site by site basis.

Provision of cavities to framed structures

All timber and light steel frame external wall panels must be provided with a drained cavity between the cladding and the structural frame. In addition; the cavity will be required to be ventilated for timber framed external walls. The frame should also be protected by a suitable approved breather membrane.

Insulated concrete formwork (ICF)

Insulated concrete formwork (ICF) utilizes polystyrene (mainly) as a temporary formwork, with concrete poured into the formwork core at staged lifts to provide the structural 'wall' component to carry the loads of the building down to foundations, this can be both external and internal walls.

The insulation formwork (usually either expanded or extruded polystyrene (EPS or XPS)) is left in place after the concrete has cured to form a permanent integral part of the insulation of the building. An external weatherproof cladding system will be required as the ICF system alone is not proven to be resistant to weather.

For the purposes of this Technical Manual:

- The system proposed must have a current third party 'product approval'.
- Only ICF systems that are members of the ICF Association are acceptable.
- ICF systems will be acceptable for a maximum of 3 storeys in height (including the ground floor level) and must be accompanied with a full structural engineers design package.

Types of ICF structure

The formwork is usually one of the following four formats; Blocks, planks, panels, or composites with planks or panels where tie devices are used to secure the 'outer and inner' components together.

It is expected that all ICF type structures are to be erected by the ICF manufacturer's approved contractors.

Weatherproof envelopes to ICF structures

Details of the type and construction of the external cladding system must be agreed with the Warranty Surveyor before installation:

- The provision for a horizontal damp proof course must be appropriate for the type of ICF system.
- The design must allow for effectively preventing water penetration at window/door openings. Using mastic as the only means of weather protection between the frame and the ICF will not suffice. The ICF manufacturer or the ICF association recommendations should be followed e.g. use of a compriband or similar third party product approved gasket DPC system around frame junctions. Particular attention should also be given to the joints between the windows and doors and the surrounding cladding system.
- The designer must provide details for prior approval of any lean-to/flat roof abutments, parapets or balcony constructions to determine how water penetration at these junctions to the inside of the building will be prevented.
- Claddings:
  - Masonry/stone cladding: a minimum 50mm cavity will be required and the wall tie fixings taken into the concrete core.
  - Timber cladding: a drained and vented 19mm minimum cavity will be required. If open boarding, additional weather protection to the ICF may be required e.g. a render coat or a suitable breather membrane.
  - External wall insulation systems (including a cladding finish) require a third party 'product approval' stating it will provide a weather resistant cladding specifically for ICF structures and clearly state in which exposure zones it can be used. The method of fixing the EWI system may require both mechanical and bonded systems. Dot and dab adhesive will not suffice.
  - Direct render cladding:
    - Only use a third party product approved render system which is accepted by the Warranty provider.
    - Any projects in a very severe exposure location must also have the render installers insurance backed guarantee.

Installation

The ICF system must be installed by the ICF manufacturers recommended contractors. The height of lifts (stages of filling with concrete) must be properly controlled to avoid distortion to the formwork and honeycombing in the concrete core (due to incorrect placement). The installation of the formwork must ensure that after pouring the concrete core the requirements of the 'Tolerances' section of our Technical Manual will be met.

D.

Appendix D

Contents

Additional Functional Requirements applicable to work undertaken on conversions and refurbishment projects covered by the Warranty Policy

In addition to the general Functional Requirements, the following additional Functional Requirements are also applicable to this specific Building Part section as follows:

D.1 Existing elements

Workmanship

1. Any new work must meet the tolerance requirements detailed in the Technical Manual. Tolerances will not apply to existing finishes e.g. walls and floors that have not been upgraded or altered, or where the supporting elements will not allow for the tolerances to be met.

Materials

1. The structure, regardless of whether it is a new or existing element, shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. A Structural Engineer will need to explicitly confirm this in a written report. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances less than 15 years.
2. Existing elements that are to be retained must provide a 'waterproof envelope' to the building and be structurally adequate.

Design

1. The design and specifications should give clear indication of the design intent and demonstrate a satisfactory level of performance with regards the renovation of components and the interaction of new elements.
2. Specialist reports are required to confirm that existing elements will have an adequate level of structural stability, as defined in the materials section above, the reports must confirm the adequacy of the existing 'waterproof envelope'.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

D.2 New elements connecting to existing structures

Workmanship

No additional requirements.

Materials

No additional requirements.

Design

1. The design and specifications should give clear indication of the design intent and demonstrate a satisfactory level of performance with regards the renovation of components and the interaction of new elements.
2. Specialist reports are required to confirm that existing elements will have an adequate level of structural stability, as defined in the materials section above, the reports must confirm the adequacy of the existing 'waterproof envelope'.
3. There should be a Party Wall Agreement in accordance with the Party Wall etc. Act (please note that this requirement will be relevant where the applicant is not the owner of the adjoining property).
4. The separating wall between the new and existing building must meet the relevant requirements of the regional Building Regulations.
5. The existing foundations and wall structure must be suitable to support any proposed increased loading resulting from the construction of the new building.
6. The junction of the new walls to the existing walls must ensure that dampness cannot track back into the new or existing building.
7. An effective Damp Proof Course should be present in the existing wall, linked to the new Damp Proof Course and Damp Proof Membrane of the new building.
8. At the junction of the existing and new structures, detailing should allow for differential movement without cracking. Any settlement should be limited to 2mm-3mm, which would not normally adversely affect the roof covering.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

D.3 Buildings with Historic significance

Workmanship

1. Any new work must meet the tolerances requirements set out in this Manual. Tolerances will not apply to existing finishes that have not been upgraded or altered, or where the supporting elements will not allow for the tolerances to be met.

Materials

1. The structure, regardless of whether it is a new or existing element, shall, unless specifically agreed otherwise with the Warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability, but not in any circumstances under 15 years.
2. Existing elements that are to be retained must provide a 'waterproof envelope' to the building and be structurally adequate.

Design

1. The design and specifications should give clear indication of the design intent and demonstrate a satisfactory level of performance with regards the renovation of components and the interaction of new elements.
2. Specialist reports are required to confirm that existing elements will have an adequate level of structural stability, as defined in the materials section above, the reports must confirm the adequacy of the existing 'waterproof envelope'.

Limitations of Functional Requirements

1. The Functional Requirements are limited by the recommendations applied in this specific Building Part guidance.

D.

Appendix D

D.1

Conversions and Refurbishments - Existing Elements

The guidance that follows is for buildings that do not have any Historic or Conservation Planning restrictions. It is expected that the building can be appropriately upgraded in accordance with current Building Regulations with respect to structure, fire, resistance to moisture, sound, ventilation, drainage, heat producing appliance, conservation of fuel and power, access and security.

The following building types will not be considered suitable for warranty cover:

- Cob construction.
- Through wall oak/timber frame.
- Wattle and daub.
- Former agricultural buildings of any nature.

Conversions and refurbishments are projects that involve work to existing buildings or parts of existing buildings. This could include the conversion of industrial or commercial buildings into housing, the conversion of an existing residential building into flats, an additional storey to an existing building, the refurbishment of an existing residential building, or a façade retention project.

The process

The Warranty includes cover for the retained structural elements and water proof envelope of any existing building for the duration of the policy. Any conversion or refurbishment will be the subject of a Refurbishment Assessment by our Warranty Technical Surveyors and this should occur before you start planning or building.

The Warranty Surveyor will always undertake an initial assessment of the existing fabric to ascertain in general terms if the proposal is capable of representing a standard risk to the Underwriter. If deemed acceptable, the development is then subject to a technical audit process during construction, and the following guidance is intended to assist all parties in ensuring the relevant requirements are met, as well as providing an element of consistency in approach.

Depending on the condition of the original building; an expert survey may be required for the different elements of the building as described in the following guidance. If the survey concludes that any of these elements are unable to meet the life expectancy of 60 years for structure and 15 years for non-structural elements, they should be systematically replaced or repaired.

Existing buildings and structures can present particular problems both initially and on an ongoing basis. Therefore, it is essential that thorough and comprehensive survey work is undertaken prior to new works commencing to understand both the current condition of any structure and the impact any proposed works may have. Although initially this may be considered an unnecessary early expense, the savings in reconstruction costs can greatly outweigh the cost of the preparatory work.

Elements of the retained structure and proposed works should not be considered in isolation, as a solution for one problem may cause issues elsewhere. Past performance is no guarantee of ongoing adequate performance because different expectations and changing living conditions can all impact on both the actual and perceived performance of a converted/refurbished structure.

It is not possible to cover every building type within this guidance, therefore, the guidance is general, and certainly will not apply in every scenario. It is strongly recommended that early discussions are held to determine exact requirements and to enable a full review of the proposed strategy and development.

Where new work is proposed, it should follow the guidance for those elements in the various Building part sections earlier in this Technical Manual. Where new work is applied to, or meets, existing elements, consideration on how these areas will interact must be made; for example, new cavity masonry that abuts an existing solid wall construction.

Please note that the requirements of the technical audit are quite different from those undertaken for the purposes of compliance with Building Control and Planning legislation. If any such bodies have imposed restrictions on the areas above, we suggest that you contact the Technical Services Department before undertaking any works.

General guidance for retained elements

Foundations and load-bearing structures (including floors, walls and roofs)

Any areas of cracking or suspected movement are to be assessed and remedial measures provided by a suitably qualified and experienced Structural Engineer that will confirm a 60 years life expectancy once the remedial works have been satisfactorily completed will be achieved. Any additional loads must be catered for. Consideration of the impact of any landscaping and drainage works is required. Spalling masonry can be locally repaired, with units cut out and replaced, or re-used with sound face showing. Larger areas will require a schedule of repair to be submitted and agreed.

Damp Proof Course's (DPC) and membranes

All walls, floors and basements should include a DPC. Ground levels and ventilation should be checked before any remedial DPC treatments are considered. However, where remedial DPC treatments are required, these must be appropriate to the type of construction, independently tested/approved and provided with a 10 year insurance-backed guarantee. Remedial DPC treatments must be installed by a member of the Property Care Association and the guarantees must cover workmanship and materials. A copy of the guarantees should be provided for our records upon completion of any remedial treatment carried out. The construction of any existing ground floor will need to be assessed, and details provided to the Warranty Surveyor for consideration. Remember ventilation, and clearance of sub floor voids, all should be inspected by your PCA member.

Timber treatment against insect and fungal attack

All retained timbers will need to be assessed, logged and the remedial treatment noted. Timbers that are embedded should be exposed or removed and replaced with masonry. Where this is not possible, core samples should be taken to assess the moisture content, and remedial works considered. Any remedial treatment must be provided with a 10 year insurance-backed guarantee and undertaken by a member of the Property Care Association, where guarantees must cover workmanship and materials. A copy of the guarantees must be provided for our records upon completion of any remedial treatment carried out.

During the build process we may expect you to expose and replace, wall plates, rafter feet, valley boards etc.

Roof coverings

Coverings and support systems should be replaced unless a specialist report compiled by an independent, competent and appropriately experienced Chartered Building Surveyor concludes that the roof covering system can provide a life span of at least 15 years. This should include the covering, battens, felt, flat roof decking, fascia's, soffits, flashings, nails and clips, etc.

Note: we will not accept any existing roof covering that does not have a breather membrane/sarking felt.

Weather resistance of walls, including claddings, render, re-pointing, etc.

The remedial works for the external walls must have regard for the exposure rating provided in BS 5628. Any retained cladding system (note this includes render) must be surveyed to determine a minimum 15 year life expectancy. Provision of additional thermal insulation must also be considered.

External doors and windows

A condition survey should be provided by an independent, competent and appropriately qualified Surveyor or Specialist to confirm life expectancy of 15 years. Consideration must be given to improving the thermal characteristics.

Where repairs to windows are required we will ask you to prepare a sample repair on site so our Risk management Surveyor can bench mark the required standard and this can be rolled out across the site refurbishment. Note painting windows does not make them newly constructed.

Sound testing

Party walls and party floors should be sound tested in accordance with National Building Regulations to determine compliance. Access maybe required into adjacent buildings in order that sound testing is completed.

External and internal services

Any services to be retained should be suitably tested and reported by a specialist. The specialist should also confirm fire compartmentation requirements as necessary.

Drainage

Drainage systems should be replaced unless it can be demonstrated that the existing drainage system is fit for purpose, have suitable falls and the required rodding facilities.

Where private drains are retained, a CCTV survey should be undertaken to ensure the integrity and design of any retained system. Where the lengths of existing retained drainage do not have rodding access in accordance with current requirements, additional access points should be provided. Inspection chambers and manholes located within habitable parts of the building will not normally be acceptable. Existing septic tanks and cesspools should be replaced with a new sewerage treatment system.

Where some of the elements are new and replaced as part of the conversion/refurbishment, no report is necessary.

Foundations

An appraisal of the existing building and its foundations should be carried out by a Structural Engineer. A copy of the report should be provided and retained for our records.

This appraisal should address:

- Settlement.
- Heave.
- Foundation depth and type.
- Soil type.
- Basement walls and floors.
- Trees adjacent to buildings.
- Undermining due to new floor structures or building services.

When carrying out the appraisal, the person responsible should take into account any proposed increased loading on the structure and foundations, alterations to existing load paths and any alterations to the existing stability of the building.

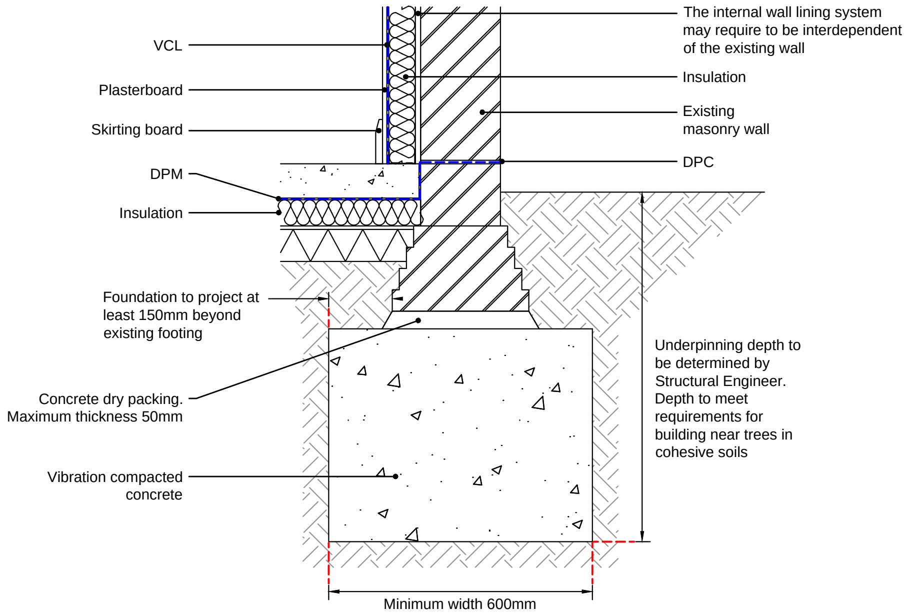
Where the existing foundations are inadequate and the building has moved/cracked, and/or the proposals are to increase the load on the foundations, a Structural Engineer should design a suitable solution, which should certify a 60 year life expectancy once the remedial works have been satisfactorily completed. This must be discussed with the Warranty Surveyor prior to implementation. Proposals for underpinning should be prepared by an expert and be in accordance with BS 8004.

Where trees are within close proximity of the existing structure, the potential risk of movement must be fully assessed. A detailed analysis supported by comprehensive structural designs and calculations should be provided supported by soil samples to determine the plasticity of the ground and the extent of the root intrusion beneath or around the building.

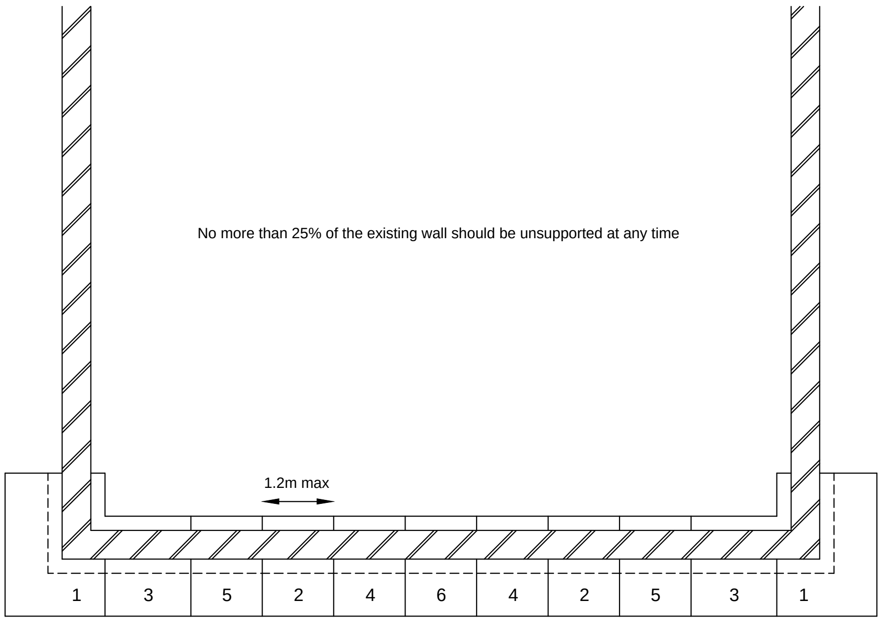
Partial Underpinning

Partial underpinning will only be considered where it is fully supported by full structural details and calculations and that the superstructure is assessed for differential movement. Movement joints should be provided between existing and underpinned/new foundations.

Typical traditional underpinning detail



'Hit and miss' underpinning sequence



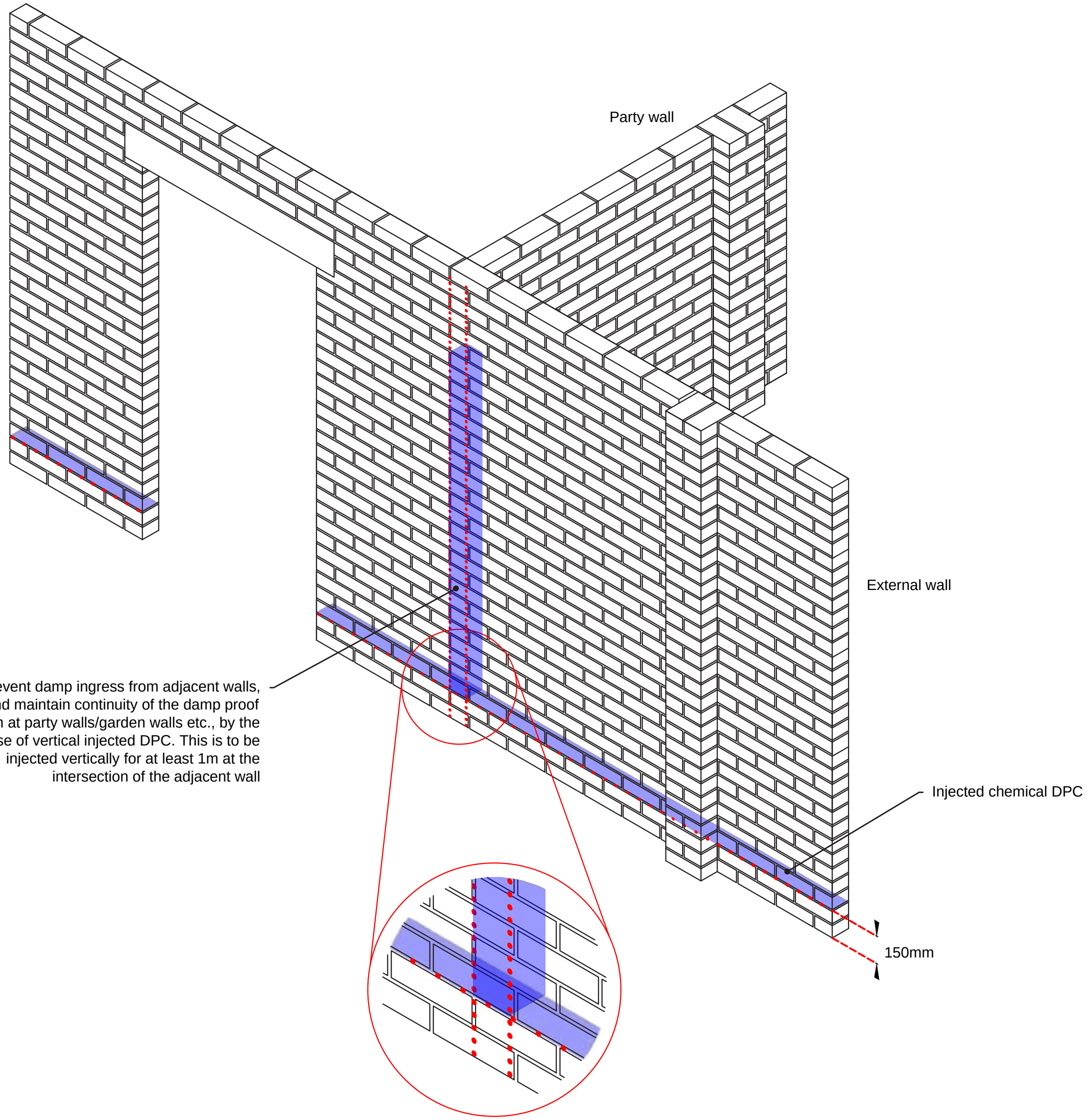
Basement Structural Waterproofing

Our standards to basement conversion are no different to our New Homes approach, where it is intended that there will be any useable space below ground level (fully or partially), then the design should be such that adequate resistance to the passage of water/moisture to the inside is achieved, following the guidance in BS 8102. Please refer to the 'Basement' section for further information for basement provision. You must appoint a CSSW expert to design, inspect and certify the waterproofing.

Where a basement area on a converted or refurbished site is not habitable, any damp/water ingress occurring is specifically excluded from the Policy.

Excluded is; Water entry, dampness or condensation to the enclosing walls, floors and ceilings of any underground: car-parking and any associated underground refuse stores, cycle stores, plant rooms (that do not house items of plant that directly service the Home and for which the failure of such plant would prevent the normal use of the home), lifts/escalators, associated access stairs and lobbies; where a continuous structure entails the conversion, refurbishment or renovation of an existing building(s) and where the structural integrity of the Home is not affected.

Typical chemically injected DPC



Damp proofing in walls

Where an existing DPC cannot be identified or is found to be defective, a remedial DPC should be provided; it should have an insurance-backed guarantee and be installed by a Property Care Association Member. A copy of the guarantees must be provided for our records upon completion of any remedial treatment carried out.

A suitable DPC should be provided to existing walls, placed at least 150mm above external ground level to ensure that ground moisture does not enter the inside of the building. Consideration must be given to the height of the ground floor.

Some types of wall are not suitable for treatment by a remedial DPC system. These include:

- Walls of exceptional thickness i.e. greater than 600mm.
- Rubble-filled walls.
- Random flint/granite walls, or those of other similar impermeable materials.
- Mud walls (cob), wattle and daub.
- Rat trap bond.

Where it is not suitable to provide a remedial DPC, the wall should be assessed to demonstrate that it prevents rising dampness from entering into the building. The assessment should include the following:

- Damp Proof Survey from a member of the Property Care Association or RICS Chartered Surveyor to confirm that there is no evidence of rising damp and a copy of the report should be provided and retained for our records, and;
- Suitable detail of the ground floor construction and independent internal lining system that keeps the internal environment of the dwelling dry.

Advice should be sought from the Property Care Association Member as to the suitability of their proposed products/system. Products used in chemically injected systems should always hold current independent third-party certificates.

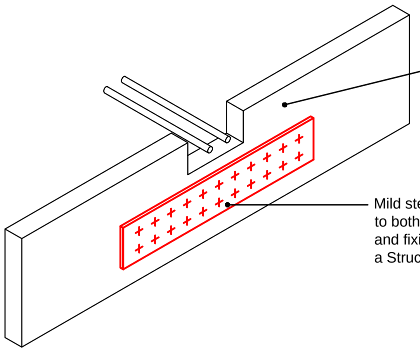
Condition and treatment of floor timbers

Where it is proposed to keep the existing ground floor, the existing floor boards/finish should be lifted to ascertain the condition of the timber joists/wall plates. A report compiled by a Structural Engineer must be provided to confirm that the floor construction will be adequate to take the proposed loadings. A Timber Specialist report from a PCA member will also be required to identify if insect infestation and fungal attack is present and if so, what remedial treatment will be required. A copy of the report should be provided and retained for our records.

When deciding if an existing ground floor is adequate, there are a number of areas that should be addressed, including:

- An adequate DPC to walls/sleeper walls.
- All timbers must be free from rot and insect infestation.
- Adequate ventilation to the sub-floor (please note, many sub-floor voids will require cleaning out to achieve ventilation and reduce dampness).
- Adequate foundations supporting sleeper walls.
- Joists are of sufficient size and span.
- Are any load-bearing internal walls built off floor joists?
- Have joists been weakened by excessive notching or drilling?
- Adequate trimming to hearth.
- Adequate strutting of joist.

Strengthening an excessively notched joist



An intrusive timber survey is required to demonstrate the overall condition of timber members, the survey should be completed by a member of the Property Care Association or a RICS Chartered Building Surveyor. The survey should include the following:

- An intrusive investigation to identify the overall condition of the timber.
- Core samples where timber is embedded to confirm that the timber remains durable at bearings.
- Causation and remediation of timber defects.

Where any remedial timber treatment is proposed, it shall be carried out by a registered member of the Property Care Association in accordance with their Code of Practice for Remedial Treatment and associated technical leaflets. A 10 year insurance-backed Warranty shall also be provided.

A copy of the report and the 10 year insurance-backed Guarantee shall be provided and retained for our records.

In order to obtain insurance, it is necessary to undertake detailed investigation of all timber members to identify the presence of any insect or fungal decay, and to treat the affected areas as appropriate. It is essential that the type of fungal attack is correctly identified, as treatment methods vary for dry rot and wet rot.

An alternative method of detecting any dry rot is by seeking the expertise of:

- Hutton & Rostron: Tel No. 01483 203221, Fax No. 01483 202911, www.handr.co.uk, or;
- An alternative suitably qualified expert. Approval of the expert must be approved by our Technical Surveying department.

These expert consultants must be retained until the end of the project to verify that the works that they have recommended have been carried out to their satisfaction. Commencement and completion reports should be retained on our systems.

Fungal attack covers wet rot and dry rot. Wood rotting fungi can be divided into two categories according to their effects on the wood. These are:

- Brown rot - causes the wood to become darker in colour and crack along and across the grain when dry. Badly decayed wood will crumble to dust, and the majority of wet rot and dry rot instances fall within this group.
- White rot - the wood becomes lighter in colour, and cracks along the grain. All white rots are wet rot.

The cause of fungal attack is dampness, which may be caused by the following:

- Rain penetration.
- Condensation.
- Hygroscopic salts.
- Defective rain water goods and roofs.
- Bridging of existing DPCs, or no DPC.
- Defective renders.
- Direct penetration of rain water through solid walls, particularly those facing prevailing winds.
- Leaking drains and internal plumbing.
- Incorrect external levels.

Fungal attack is controlled by two sets of measures, primary and secondary.

Areas that have not been inspected should be clearly identified to enable a subsequent inspection to be carried out when the structure has been fully exposed. This could include rafter feet and wall plates that are particularly prone to rot.

Primary measures

These consist of locating and eliminating sources of dampness and promoting the rapid drying out of the structure. Where the timber becomes wet and remains wet, e.g. the moisture content exceeds 20%, then it is likely to decay. By eliminating the source of dampness and the drying of timbers to below 20%, the fungus will normally stop growing and will eventually die.

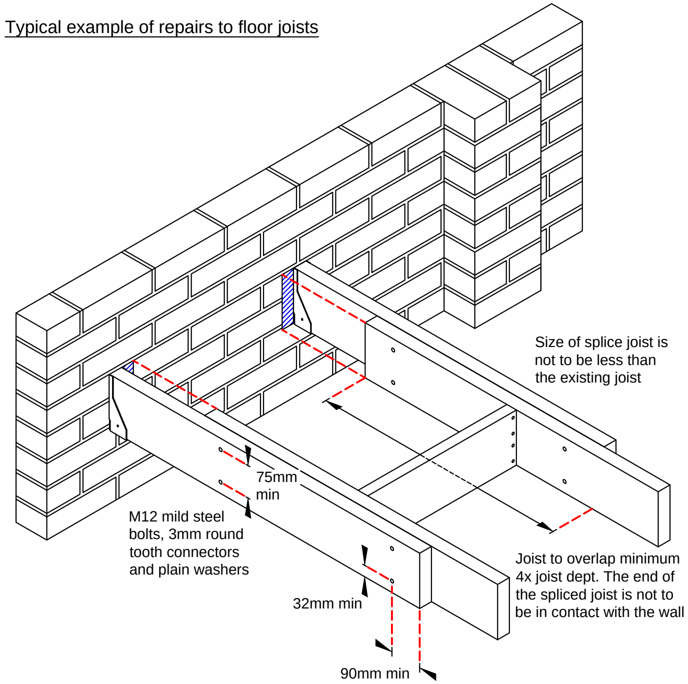
Secondary measures

These consist of determining the full extent of the outbreak and a combination of:

- Removing all decayed timbers.
- Treating of walls to contain fungi within the wall (only applicable to dry rot).
- Treating of sound timbers with preservative on a localised basis where required.
- Using preservative-treated replacement timbers (pre-treated).
- Introducing support measures, such as isolating timbers from walls and the provision of ventilation between timbers and the walls.

Dry rot commonly occurs when timber is in contact with damp brickwork and where ventilation and heating are inadequate. Therefore, particular attention should be paid to cellars, basements and sub-floors, and also behind panelling. A full intrusive survey of such areas will be required. A copy of the report should be provided and retained for our records.

Typical example of repairs to floor joists



Ventilation to floor voids

Existing timber floors are required to be cross ventilated, this is often an issue where the existing building is to be split up into various building compartments. In such cases a ventilation strategy should be considered.

Options for cross ventilation could include:

- Intumescent air bricks.
- Vertical stack pipes that provide ventilation to the floor.

In both cases consideration should be given to the passage of fire and sound.

The void beneath the timber floor must be clear to allow a free flow of air beneath the joists and floor structure.

Existing solid floors

Only existing concrete floors are considered suitable for refurbishment, any stone, earth or tiled floors should be removed and replaced with a new concrete floor, Existing stone or tiled floor coverings may be used as a decorative finish.

Existing concrete floors will be required to meet the following requirements:

- That the floor has a suitable damp proof membrane. Where this cannot be confirmed a new DPM should be installed. A liquid applied membrane to the surface of the concrete would be suitable in most cases subject to the liquid membrane having appropriate third party certification.
- That the floor is free of any structural distress or movement. Where there are signs of movement, the floor should be replaced unless it can be proved by a Chartered Structural Engineer that the floor is suitable for carrying imposed loads and supporting its own weight without any further movement or cracking.

Structural repairs

Prior to undertaking structural repairs, it is essential that the root cause of the structural defect has been remedied by underpinning, addition of adequate lateral restraint, buttressing, etc. Strengthening works to the structure may also be necessary to accommodate increased or modified loads.

All assessment and design of remedial works must be carried out by a suitably qualified Structural Engineer and upon completion certified that the remediated structure will have a 60 year life expectancy.

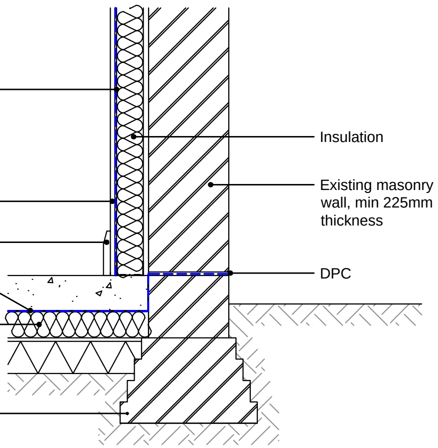
External walls

Solid walls

To provide an acceptable level of protection against the ingress of rain water, any retained solid masonry external walls should either:

- Be fully lined internally with an independent timber or metal stud wall.
- Be clad externally with a rain screen or other protective measure.
- Comply with the requirements of BS 5628 (as outlined below).

Typical independent internal lining



An independent lining system should also be provided where party walls between buildings, project above adjacent roof coverings (thus becoming external walls).

Where damage has occurred to walls, the cause needs to be investigated.

Likely reasons for the damage include:

- Ground movement - foundation failure, settlement, subsidence, chemical attack.
- Thermal movement - thermal expansion of wall due to temperature changes.
- Roof spread - pitched roofs not properly tied, spreading at eaves.
- External and internal walls not bonded together.
- Wall tie corrosion.
- Lintels inadequate over openings.
- Sulphate attack - water-soluble sulphates attack cement-based mortar, normally in a wet environment, i.e. below ground level and parapet walls.
- Frost attack.
- Bonding timbers present and subject to rot and shrinkage.
- Ineffective or no lateral support at floor and roof level.
- Moisture ingress.

Weather resistance of walls and cladding

Existing solid brick or stone walls are unlikely to be acceptable as weather-resisting, although consideration of the exposure category of the building and porosity of the masonry will be given, i.e. do existing non-gypsum-based internal linings allow for greater insulation and evaporation than gypsum plasters alone?

It is anticipated that in all buildings, at least one of the additional treatments noted below will be required, and this must include appropriate insulation.

However, all solid masonry wall situations will require a Specialist's report to identify the extent of any necessary remedial treatment. A copy of the report shall be provided and retained for our records.

External treatments

Existing claddings can be retained if it can be shown by a suitably qualified expert that:

- The system is maintaining the integrity of the building.
- It is adequately fixed and the expected life span of the fixings, where appropriate, is in excess of 15 years.
- The cladding material is free from any defects.
- Adequate provision for movement has been allowed.

A copy of the expert report shall be provided and retained for our records.

If the above situations cannot be satisfied, a new external cladding or render system will need to be installed.

Internal treatments

An alternative to preventing moisture penetration by using externally applied claddings and renders is to adopt internally applied methods.

Systems are available that are installed on the inside of existing walls to prevent moisture penetration reaching the internal accommodation. These include:

- Independent metal or timber framed systems: these should not be fixed to the existing masonry walls, but fixed at the 'head and base' to avoid direct contact. Ventilation should be provided to avoid a build-up of condensation between the masonry and the inner lining system.
- New internal walls: these would normally be formed in blockwork, must be adequately founded and, where necessary, tied to the retained and new elements of structure.

Control of damp penetration

Measures should be taken to ensure that thermal insulation in cavities does not encourage the passage of damp from the ground or from the exterior of the building to the inside of the building.

Thermal insulation of walls and claddings

Various methods exist to upgrade the thermal insulation of existing walls and floors. Regardless of the methods adopted, it is essential that risks associated with increased thermal insulation are minimised, including:

- Surface condensation caused by improvements to draught proofing of the building.
- Interstitial condensation caused by moisture-laden air passing from the dwelling to within the fabric of the structure and condensing on cooler surfaces.
- Increased risk of damp penetration caused by the filling of cavities with insulation.
- Maintaining the robustness of the external and internal wall surfaces by the provision of adequate mechanical protection over insulation materials, e.g. externally applied insulation systems with render coat mechanical protection.
- Avoidance of cold bridges around openings and where structural elements extend through the thickness of the building envelope.
- Repeating thermal bridging must be considered, e.g. internal metal-framed walls should be used in conjunction with thermally insulated plaster board.

Render and plaster application finishes

Plaster for conversions/refurbishment

Where the condition and bond of the existing plaster can be shown to be adequate, it can remain, with the exception of the following:

- Where rising damp is present.
- Where a chemical DPC is installed.
- At the junction of external walls and party walls to see if they are properly bonded.
- Above openings to examine the make-up and condition of lintels.
- Where there is a possibility that bond timbers may have decayed.
- Where the wall is solid and the plaster is gypsum-based.

Where a chemically injected DPC is installed, it is necessary to remove the plaster one meter above the DPC level or 600mm above any apparent salt line/dampness, whichever is higher. Re-plastering work should be delayed as long as possible in order to encourage rapid evaporation of residual moisture, and the building should be well ventilated during the drying period.

Plastering work must comply with an independent third-party certification and the chemical DPC must meet the manufacturer's recommendations. Recommended plasters usually incorporate adhesives to increase resistance to the passage of hygroscopic salts from the wall into the plaster. They should not, however, act as a vapour barrier. Gypsum plaster should not be used in conjunction with chemically injected DPC.

The plaster should not bridge the DPC or be in contact with the ground floor slab.

Final redecoration should not be carried out until residual moisture has disappeared. Matt emulsion paint is recommended for use during this period.

Internally drilled holes concealed by skirting boards, etc. should not be plugged. Other visible holes and external holes should be plugged.

Rendering for conversion/refurbishment

Where the condition and bond of the existing render can be shown to be adequate, it can remain, subject to the following exceptions:

- If the render bridges the DPC.
- Above door and window openings where it is necessary to examine the type and condition of the lintels.
- Where there are signs of structural movement in the building, and further investigation is required.

Cracking in masonry walls

Minor cracking can be defined as cracking that occurs in the mortar joints and which does not extend through the masonry components. Providing that the crack is no wider than 4mm, and there has been no lateral displacement of the wall, the wall can be re-pointed.

Major cracking affects the structural integrity of the wall, and investigation should be undertaken by a suitably qualified structural Engineer to find the cause of the problem. Once any specified remedial works are carried out, the appointed Structural Engineer should confirm that the structure has a 60 year life expectancy.

Walls out of plumb/bulging

Where walls are more than 25mm out of plumb or bulge more than 10mm within a storey height, a Structural Engineer should comment on the stability. The wall may need to be rebuilt or strengthening works undertaken.

Where it is intended to provide buttressing walls to support out of plumb and/or bulging walls, they should be designed by a suitably qualified structural Engineer. Once any specified remedial works are carried out the appointed Structural Engineer should confirm that the structure has a 60 year life expectancy.

In raised tie roofs (where no ceiling ties are provided at eaves level), lateral spread of the brickwork just below eaves level may have occurred because the roof has deflected. In such cases, it is necessary to prop the roof and rebuild the affected part of the wall.

Bonding timbers

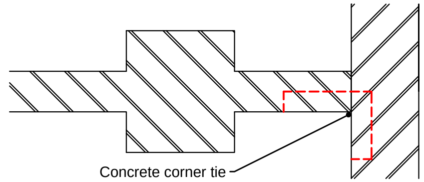
These are common in Georgian buildings, and were laid in the internal skin of the wall to reinforce it and to provide fixings for panelling, etc. With the low compressive strength of lime mortar and general timber decay, the bond timber compresses under load. As the timber is on the inner skin, the compression causes bulging outwards, which may be apparent on the external face. Normally, bond timbers should be exposed during the conversion and removed in short lengths, and replaced with bonded masonry.

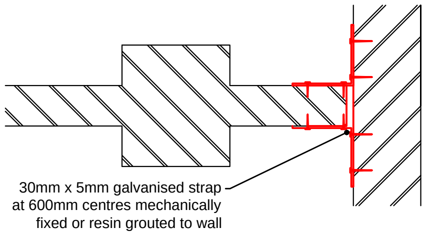
External and internal walls not bonded together

A common defect in properties up to the 1920s is the lack of bonding/tie of party walls to the external wall.

Different bricks and bricklayers were often used, with the poorer quality materials and labour being used on the party walls. This junction should be exposed when undertaking a conversion and if the bond is inadequate, a suitable stitching detail incorporated. A design by a suitably qualified Structural Engineer may be required supported by confirmation the remedial works has a life expectancy of 60 years.

Typical examples of rectifying unbonded walls





Arches and lintels

The existing timber lintels can be retained if they support the structural walls and it can be shown that the lintel is adequate for its purpose, i.e. there is no sign of any structural movement, loads will not be increased and the timbers are free from rot and insect infestation.

In order to ensure that a lintel is free from rot, a percentage of all lintels should be exposed at both ends and on the inner (hidden) face of the timber embedded in the wall for openings in external walls.

Where movement has occurred and the timber lintel is inadequate, the lintel should be replaced with either a concrete or steel lintel.

Where cracking has occurred in masonry arches, it will be necessary to rebuild the arched construction. In cases where failure has occurred due to the low pitch of the arch, it may be necessary to incorporate a lintel.

Alterations to existing openings

Where existing openings are to be filled with masonry, the new work should be adequately bonded to the existing and the weather resistance of the wall maintained. However, if the opening then becomes part of a party wall it should comply with the requirements for sound insulation.

Cavity Walls

Wall tie corrosion

Cavity walls have been constructed since 1850, but it was not until 1920 that this form of construction was widely adopted. It is important when undertaking a conversion to confirm the construction of the external wall. In cases where headers are incorporated into the bond of the external brickwork, an investigation of the wall construction must be undertaken to clarify the actual wall make up and the Warranty surveyor advised of the findings. Many properties in the Victorian period were built with either a 215mm outer leaf and cavity behind, or a 215mm inner leaf, cavity and a half brick outer leaf with snapped headers.

Initial evidence of cavity wall failure can include cracking of bed joints in mortar (typically every sixth course). This is due to the expansion of the wall tie as it corrodes.

Bulging of the external leaf could also indicate that the ties have failed.

Where there is wall tie corrosion or inadequate ties, or where wall ties have corroded to an extent serious enough to threaten the stability of the wall or building, a suitably qualified Structural Engineer should be appointed to determine the necessary remedial works and state that the structure following the remedial works has a life expectancy of 60 years.

Insulation to cavity walls

Most cavity walls constructed after 1985 should already be insulated, however where a cavity wall is required to be thermally upgraded, it should be lined internally. The injection of cavity wall insulation is not acceptable as the overall condition of the cavity is not known.

Other structures

Timber Framed walls

Timber framed elements must be structurally durable and free from rot.

The timber frame must be assessed as part of any timber survey as described earlier in this guidance. Particular attention should be given to sole plates and timber framed elements that are close to the ground.

Curtain Walling

Curtain walling must be assessed by a cladding and façade specialist to determine the following:

- The structural durability of the façade.
- The adequacy of the façade in forming a suitable waterproof envelope.
- The fire performance of the façade, particularly with respect to external fire spread and ensuring cavity barriers are correctly installed in line with current Building Regulations.

No fines construction and other non-traditional methods

It is essential that any "no fines" construction is correctly assessed and tested to determine the durability and integrity of the structure by a suitably qualified Structural Engineer to determine the structure will have a life expectancy of 60 years.

Internal walls and upper floors

Existing masonry

Where a wall is adequately founded or supported on a beam that shows no signs of distress, it can remain providing there is no increase in load onto the wall. Any increase in load should be justified by calculation by a suitably qualified Structural Engineer. New masonry supported on existing timber beams should be avoided.

In older properties, it is possible that flitch beams and Bessemer's may be supporting masonry walls, and these should be examined by suitably qualified Structural Engineer to ascertain their capability to carry the load.

Existing studwork

Many properties built before 1880 have trussed internal partitions, usually located approximately halfway back in the depth of the property. Often, these walls are load-bearing, continue up through the building and carry floor and roof loads onto the foundations.

If a timber partition is load-bearing, providing it is adequate, the loads are not being increased and the timber is free from rot and insect infestation, it can remain. Where there are defects i.e. the floor sags on the line of the partition and there is distortion of door heads, then additional strengthening works should be undertaken.

New door openings cut into an existing trussed partition should be overseen by a suitably qualified Structural Engineer, as this can adversely affect the triangulation of the truss.

Timber floors above ground level

Existing timber floor joists can be retained within the building, providing they are adequate for their purpose.

The following points should be considered:

- Joists are of sufficient size for the span.
- Load on the floor is not being increased.
- Joists have not been weakened by excessive notching and/or drilling.
- Ends of joists are free from rot.
- All timbers to be treated for insect infestation and wood rot.
- No masonry walls are built off timber joists.
- Appropriate strutting is provided.

Filler joist floors

Many buildings of the late Victorian and Edwardian periods were built with floors constructed of clinker concrete supported by embedded iron or steel joists. The concrete produced with clinker aggregate was porous, and therefore provided poor corrosive protection to the metal.

The clinker also contains particles of un-burnt or partially burnt coke or coal, which contain substantial proportions of sulphur. As the concrete is porous, the sulphur oxidises to form sulphur dioxide (SO_2), and if moisture is present, this then forms sulphuric acid (H_2SO_4). Where floors have been subject to the weather for any length of time, severe corrosion of the embedded iron or steelwork is likely to have occurred.

When considering a conversion in a building with filler joist floors, it is important to first investigate whether the floors have been subject to damp conditions and whether any significant corrosion has taken place.

Particular attention should also be paid to ensuring that the floor remains dry during the conversion, and this could include providing a temporary covering if removal of the existing roof is necessary.

Rooms containing areas of high humidity use or potential areas where water spillage can occur, e.g. wet rooms, bathrooms, ensuites, kitchens, utility rooms should not be constructed over such filler joist floors.

Where the scheme involves converting a concrete or steel-framed building into dwellings or other uses, the following guidance is given.

An appraisal of the existing building should be carried out by a suitably qualified Structural Engineer, taking into account the proposals for the change of use.

This will include:

- Condition of the structural frame, including joints.
- Proposals to increase loadings on the structure and foundations.
- Alterations to existing load paths.
- Alterations to stability systems.
- Changes in environmental exposure.
- Recommendations to cover additional reports and testing by Specialists.

The floor loads on the building may decrease, as they could be converted for domestic use only where previously they were, for example offices.

A statement from the Structural Engineer confirming, where appropriate, that the existing foundation design is acceptable for the new loads subject to the building showing no signs of distress, i.e. movement, cracking etc. will be acceptable in such circumstances.

Where the intention is to increase the load on the existing structure e.g. by the introduction of an additional floor, then structural calculations should be provided to prove the adequacy of the building and foundations.

In all cases, the Structural Engineer should confirm the building structure will achieve a 60 years life expectancy once the remedial works have been satisfactorily completed.

Concrete-framed buildings

Where the building is of concrete construction, additional reports are needed for:

- Carbonation
- Chlorination

The two major causes of corrosion in concrete are carbonation, in association with inadequate depth of cover to the reinforcement, and chlorine penetration due to the de-icing salts and admixtures used to accelerate the setting and hardening of concrete in temperatures at or below freezing point.

Carbonation involves a reaction of carbon dioxide in the air with the free lime present in the concrete. Over a period of time this reduces the pH level of the concrete.

With a reduction in the alkalinity, and the presence of both water and oxygen, corrosion of the embedded steel will occur.

A visual survey undertaken by a suitably qualified Structural Engineer on concrete structures are a starting point to gather information. However, care should be taken as although the concrete structure may not show any obvious signs, corrosion of the reinforcement may be occurring.

It is important that a second-stage survey incorporates the following:

- Chemical tests on the concrete structure to ascertain if corrosion of the steelwork is occurring or likely to occur.
- Depth of carbonation can be assessed either on-site or in the laboratory, and the depth of the reinforcement measured. This allows areas of risk to be identified.
- Chloride ion content can be determined by analysis of a drilled dust sample taken from the concrete.

Where concrete repairs are necessary, they should be carried out by a Specialist Contractor.

High alumina cement concrete (HACC)

Where HACC has been used in a building, and the intentions are to keep the existing structure, an appraisal should be carried out by a suitably qualified Structural Engineer to take into consideration to the following:

- The structure being free from obvious signs of deterioration.
- The building being weather tight.
- Structural calculations being provided to show that the floors and roof can solely carry the loads imposed on them.

Alkali silica reaction (ASR)

The ASR occurs when the strongly alkaline cement begins to dissolve susceptible sand and aggregate within the concrete itself. The chemical reaction creates a gel material that absorbs water, expands and in turn creates tremendous pressures in the pores of the concrete surface and subsequent cracking. For a damaging reaction to occur, the following need to be present in sufficient quantities:

- High alkali cement or a high cement content; it may also arise from salt contamination during batching/mixing.
- Reactive aggregate - siliceous materials such as flint and quartz, as well as recycled aggregates.
- Moisture, through exposure to rain or condensation.

If any one of these factors is absent then the ASR cannot take place. Once cracking occurs, the structure can deteriorate further as water entering the cracks generates reinforcement corrosion and this, in conjunction with the freeze/thaw cycle, can result in additional cracking and so on.

Affected concrete often exhibits surface cracking in the pattern of a star, and heavily loaded sections may exhibit cracks along the line of the main reinforcement.

Defects in structures attributable to the performance of concrete are relatively rare in the UK. Increased awareness of ASR, and the publication of guidance on avoidance, has reduced the risk of problems in new buildings to very small proportions.

Consequently, on any refurbishment project where the existing structure is concrete-frame, the Warranty Surveyor will request copies of the following to identify the presence or otherwise of ASR:

- Desk studies undertaken to identify materials used in the original construction.
- Core sampling and detailed chemical testing.

If ASR is identified, the following possible remedial works will need to be assessed by the project's Design Engineer, and the details put to Warranty Surveyors for consideration:

- Critical examination of the robustness of the reinforcement.
- Measures to the amount of water available to the structure - any weather proofing or cladding should not impair the ability of the structure to dry naturally.
- Limited strengthening of the structure.
- Partial or full demolition, followed by rebuilding.

Furthermore, any alterations to the waterproof envelope will need to be considered to ensure that the concrete elements are not exposed to additional sources of moisture.

Steel-framed buildings

In addition to any structural reports, a visual inspection of the steel frame should be carried out to assess the extent of any corrosion of the framework.

Where corrosion is present, accurate measurements can be made using an ultrasonic gauge. Data collected can then compare the thickness of steel sections against the original steelwork drawings, British Standards and the Historical Structural Steelwork Handbook to ascertain if the structural frame is adequate for the proposed loads.

Where steelwork has corroded, further analysis must be sought to determine if any expansion of the frame will/has occurred. In such scenarios cathodic protection may need to be considered which will required to be carried out by a suitably qualified expert to confirming that a 60 year life expectancy once the work has been completed will be achievable.

Steelwork generally

Exterior steelwork: should be inspected; where corrosion is visible, the steel can be grit blasted, cleaned and recoated.

Perimeter steelwork: in direct contact with the outer leaf of the building can be prone to corrosion, particularly in older properties. A sign indicating that this has happened is the displacement of the external masonry due to the expansion of the steelwork caused by corrosion. During the conversion process, the appropriate repairs/replacement should be carried out.

Interior steelwork: normally, corrosion of unprotected steelwork within the interior of a building is low, with only superficial rusting. Providing that a visual inspection confirms this, and the environment intends to remain dry, no further treatment of the steel will be required. Where the proposals involve the steelwork in a 'wet' environment, such as kitchens and bathrooms, it should be adequately protected.

Bimetallic corrosion

This should be considered in the existing and proposed structure.

Bimetallic corrosion occurs where two different metals are in electrical contact and are bridged by water or water containing other chemicals to form an electrolyte. A current passes through the solution from the base metal to the noble metal and, as a consequence, the noble metal remains protected and the base metal suffers increased corrosion.

Where there is a possibility of this occurring, or if it has already occurred, advice should be taken from a Specialist on how to deal with it.

Cast iron, wrought iron and mild steel structures

Many older buildings that are converted into dwellings or other uses, e.g. warehouses, cotton mills etc. were built using cast iron, wrought iron or mild steel.

When the intention is to keep the existing structural elements, an appraisal of the existing building is necessary.
In addition to this, the Engineer should comment on the following:

- Determine the age of the building and the materials used.
- Assess how its construction has fared.
- Justify the loadings by calculation.
- Identify areas where additional testing and/or opening up is necessary.

If the proposed loads remain unchanged or are reduced, as will probably be the case, and it can be shown that the existing structure has not suffered any deterioration due to corrosion or deflection of structural members etc. the building may only require localised structural alterations.

Where the intention is to increase loads, carry out major structural alterations or the existing building is under-designed, a Structural Engineer should comment on this and provide calculations to justify the proposals.

Surveying roof timbers

All roof timbers should be surveyed by a qualified Structural engineer or Specialist surveyor that is a registered member of the Property Care Association and provide a report detailing any necessary treatment to be carried out. Particular attention should be given to rafter feet, wall plates and valley timbers, as these often show signs of rot.

Roof structure

It is essential that the roof structure has adequate strength, stiffness and dimensional accuracy appropriate for the new roof covering. All strengthening work should be designed by a suitably qualified Structural Engineer that will result after the work has been completed that a structural life expectancy of 60 years for the structure will be achieved.

Common problems encountered include:

- Excessive spans of rafters, purlins, binder and ceiling joists.
- Inadequate ties between rafters and ceiling ties.
- Insufficient number of collar ties at purlin level.
- Decay of rafter feet and valley beams.
- Settlement of purlin supports.
- Lateral spread of raised-tie roofs.

Roof coverings

Traditional slate and tiled roofs

Roofs should generally be re-covered in accordance with the 'Roofs' section of this Technical Manual. Where roofs are to be re-covered, it is required that existing gable walls are appropriately supported during the construction works and lateral restraint straps are fitted to any gable walls.

There may be exceptional circumstances where an existing tiled roof covering can be retained; however the following requirements would apply namely:

- That the tiled roof shows no sign of deterioration that suggests that the roof covering has passed its useful life.
- That the roof has a suitable roofing membrane/roofing felt beneath the tiles which is functioning correctly and not damaged.
- That ridges and hips are well bedded and mortar has not eroded. Please note, it may be reasonable in some circumstances that ridges and hips are re-fitted, mechanical fixing should also be provided in such circumstances.
- That timber laths and nails are in good condition and fit for purpose.
- That existing flashings and weathering's are assessed, particular attention should be given to valleys and parapets, if there is any doubt of the condition of any weathering's, they should be replaced.

Please note:

1. A report should be provided on the condition of the tiles and stating that they have a life expectancy of at least 15 years remaining. The report should be by a suitably qualified expert.
2. Fibre cement tiles would generally not be accepted for retention.
3. Adequate provision for ventilation to the roof voids should be considered.
4. The requirements for resisting fire spread in the relevant Regional Building Regulations must be considered e.g. how will fire stopping at heads of party walls etc. be achieved?
5. Wet bedded hips and ridges must be demonstrated to be adequately fixed or if found to be poorly bedded then they should be stripped and mechanically fixed (or if subject to listed restriction then they should be re-bedded in accordance with BS 5534.
6. All parapets should be removed, new DPMs provided and re-fixed with mechanical fixings. Inside face of parapets to be waterproofed, lined lapped under DPM etc.

Continuous membrane roofs, and balconies and terraces (forming a roof)

Membrane for roofs and balconies and terraces (forming a roof) should be replaced in accordance with the 'Roofs' and 'Balconies and Terraces' sections within this Technical Manual, unless the following provisions can be met:

- That the existing membrane is tested for water ingress and condition report is provided to confirm a remaining life expectancy of at least 15 years will be achieved (testing requirements can be found in the 'Roofs' and 'Balcony and Terraces' sections of this Technical Manual).
- There are no signs of excessive ponding.
- The roof has a fall, adequate upstands and suitable drainage outlets.
- That balconies and terraces are fitted with overflows.
- That any thermal upgrade via inverted insulation does not compromise roof drainage or upstands.

Windows and Doors

Where windows and doors are replaced they should be replaced in accordance with the 'Windows and Doors' section of this Technical Manual.

Any retained windows and doors must meet the following provisions:

- Should be no more than 15 years old.
- Be in good condition and free from any damage rot or decay.
- Be able to perform as part of the waterproof envelope.
- Provide adequate ventilation where the building ventilation system relies on purge ventilation.
- That window mechanisms and catches operate correctly.

D.

Appendix D

D.2

Conversions and Refurbishments - New Elements Connecting to Existing Structures

Introduction

Where new developments are attached to existing buildings, and the existing elements that form part of the new structure must meet the Functional Requirements of the Warranty. The details below give some guidance on the minimum information and standards required to meet the Functional Requirements.

Party Wall Agreement

It is highly likely that improvements to an existing wall are necessary to meet the requirements of the Warranty. This may include underpinning, injected DPC and internal linings.

Where a wall is shared by two or more owners, the requirements of the Party Wall etc. Act may apply. This is separate legislation with different requirements to the Building Regulations or Warranty requirement. Further guidance on the Party Wall etc. Act can be found on the Planning Portal website www.planningportal.gov.uk

Separating walls

The separating wall between the new and existing building must meet the relevant requirements of the regional Building Regulations.

Confirmation should be provided where the existing wall is to be upgraded to meet current regional Building Regulations, particularly in meeting the relevant sound insulation and fire separation requirements. The structural integrity of the existing wall and its resistance to ground moisture should also meet current standards.

Existing foundations

The existing foundations and wall structure must be suitable to support any proposed increased loading resulting from the construction of the new building.

Foundations to the existing wall should be exposed and assessed for suitability to support additional loadings. It is important to protect existing foundations at all times, and care must be taken not to 'undermine' existing foundations when clearing the site or reducing levels.

Where existing foundations require underpinning, a design by a suitably qualified Structural Engineer should be provided and approved by the Warranty Surveyor prior to work commencing on-site.

The existing wall should also be appraised by a suitably qualified Structural Engineer to determine whether it is structurally stable and suitable to support additional loadings.

New wall junctions

The junction of the new walls to the existing walls must ensure that dampness cannot track back into the new building or existing building.

The detailing of this junction is critical to ensure that moisture ingress does not occur between the new and existing walls. Typical acceptable details are shown to the right.

Damp Proof Course (DPC)

An effective DPC should be present in the existing wall, linked to the new DPC and Damp Proof Membrane (DPM) of the new building.

Acceptable existing DPCs are considered as:

- A continuous felt or proprietary DPC material.
- A chemically injected DPC supported by an insurance-backed guarantee.
- A slate DPC is considered acceptable if the existing wall incorporates an independent wall lining system to the inner face of the new building.

The new DPC should lap the existing DPC by at least 100mm.

Existing and new structure junctions

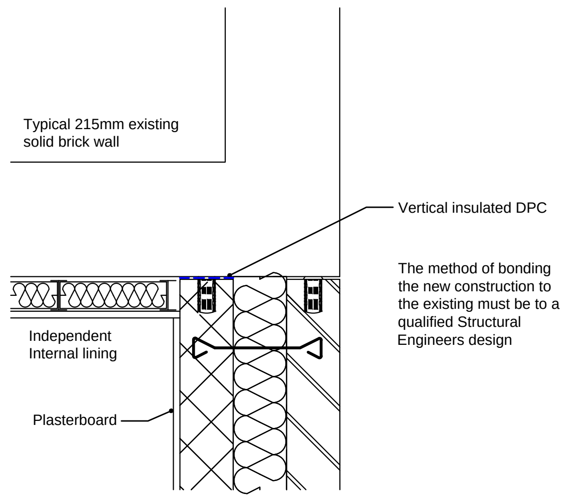
At the junction of the existing and new structures, detailing should allow for differential movement without cracking. Any settlement should be limited to 2mm-3mm, which would not normally adversely affect the roof covering.

Typical details of bonding new walls to existing are indicated to the right.

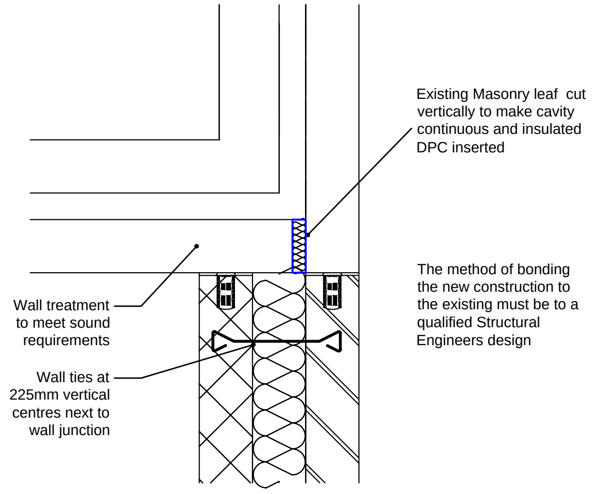
In order to prevent excessive differential movement, the new building should have the same foundation type as the existing building. Where the foundation types are different, e.g. new building pile and beam, existing building traditional strip foundation, the new building should be completely independent of the existing building.

The foundation design should be confirmed by a suitably qualified structural engineer and a copy of the report provided to the Warranty surveyor before construction works commence.

Bonding new walls to existing solid masonry wall



Bonding new walls to existing masonry cavity wall



D.

Appendix D

D.3

Conversions and Refurbishments - Buildings with Historic Significance

Introduction

The guidance that follows is for buildings that have Historic or Conservation Planning restrictions, where due to such restrictions it is not possible or feasible to upgrade the building.

The guidance in this section is applicable to those elements that cannot be improved or altered, In all cases there are some types of construction that will not be suitable for warranty cover these are as follows:

- Cob construction.
- Through wall oak/timber frame.
- Wattle and daub.
- Former Agricultural Buildings of any nature.

Conversions and refurbishments are projects that involve work to existing buildings or parts of existing buildings. This could include the conversion of industrial or commercial buildings into housing; the conversion of an existing residential building into flats; an additional storey to an existing building; the refurbishment of an existing residential building; or a façade retention project.

The Warranty includes cover for the retained structural elements and water proof envelope of any existing building for the duration of the policy. Any conversion or refurbishment will be the subject of a Refurbishment Assessment by our Warranty Technical Surveyors and this should occur before you start planning or building.

The Warranty Surveyor will always undertake an initial assessment of the existing fabric to ascertain in general terms if the proposal is capable of representing a standard risk to the Underwriter. If deemed acceptable, the development is then subject to a technical audit process during construction, and the following guidance is intended to assist all parties in ensuring the relevant requirements are met, as well as providing an element of consistency in approach.

Depending on the condition of the original building; an expert survey may be required for the different elements of the building as described in the following guidance. If the survey concludes that any of these elements are unable to meet the life expectancy of 60 years for structure and 15 years for non-structural elements, they should be systematically replaced or repaired.

Existing buildings and structures can present particular problems both initially and on an ongoing basis. Therefore, it is essential that thorough and comprehensive survey work is undertaken prior to new works commencing to understand both the current condition of any structure and the impact any proposed works may have. Although initially this may be considered an unnecessary early expense, the savings in reconstruction costs can greatly outweigh the cost of the preparatory work.

Elements of the retained structure and proposed works should not be considered in isolation, as a solution for one problem may cause issues elsewhere. Past performance is no guarantee of ongoing adequate performance because different expectations and changing living conditions can all impact on both the actual and perceived performance of a converted/refurbished structure.

It is not possible to cover every building type within this guidance, therefore, the guidance is general, and certainly will not apply in every scenario. It is strongly recommended that early discussions are held to determine exact requirements and to enable a full review of the proposed strategy and development.

Where new work is proposed, it should follow the guidance for those elements in the various Building part sections earlier in this Technical Manual. Where new work is applied to, or meets, existing elements, consideration on how these areas will interact must be made; for example, new cavity masonry that abuts an existing solid wall construction.

Please note that the requirements of the technical audit are quite different from those undertaken for the purposes of compliance with Building Control and Planning legislation. If any such bodies have imposed restrictions on the areas above, we suggest that you contact the Technical Services Department before undertaking any works.

Retained elements, foundations and load-bearing structures (including floors, walls and roofs)

Planning Restrictions

Where building renovation or thermal upgrade is limited by planning restrictions, a copy of the planning permission and supporting conditions must be provided.

The Structure

Any areas of cracking or suspected movement are to be assessed and remedial measures provided by a suitably qualified Structural Engineer. Any additional loads must be catered for. Consideration of the impact of any landscaping and drainage works is required. Spalling masonry can be locally repaired, with units cut out and replaced, or re-used with sound face showing. Larger areas will require a schedule of repair to be submitted and agreed.

Damp Proof Course's (DPC) and membranes

All walls, floors and basements should include a DPC. Ground levels and ventilation should be checked before any remedial DPC treatments are considered. However, where remedial DPC treatments are required, these must be appropriate to the type of construction, independently tested/approved and provided with a 10 year insurance-backed guarantee. Installed by a member of the Property Care Association, the guarantees must cover workmanship and materials. A copy of the guarantees should be provided for our records upon completion of any remedial treatment carried out.

The construction of any existing ground floor will need to be assessed, and details provided to the Warranty Surveyor for consideration. Remember ventilation, and clearance of sub floor voids, all should be inspected by your PCA member.

Timber treatment against insect and fungal attack

All retained timbers will need to be assessed, logged and the remedial treatment noted. Timbers that are embedded should be exposed or removed and replaced with masonry. Where this is not possible, core samples should be taken to assess the moisture content, and remedial works considered. Any remedial treatment must be provided with a 10 year insurance-backed guarantee and undertaken by a member of the Property Care Association, where guarantees must cover workmanship and materials. A copy of the guarantees must be provided for our records upon completion of any remedial treatment carried out.

During the build process we may expect you to expose and replace, wall plates, rafter feet, valley boards etc.

Roof coverings

Coverings and support systems should be replaced unless a specialist report compiled by an independent, competent and appropriately experienced Chartered Building Surveyor concludes that the system can provide a minimum life span of at least 15 years. This should include the covering, battens, felt, flat roof decking, fascias, soffits, flashings, nails and clips, etc.

Note: we will not accept any existing roof covering that does not have a breather membrane/sarking felt.

Weather resistance of walls, including claddings, render, re-pointing, etc.

The remedial works for the external walls must have regard for the exposure rating provided in BS 5628. Any retained cladding system must be surveyed to determine a minimum 15 year life expectancy achievable. Provision of additional thermal insulation must also be considered.

External doors and windows

A condition survey should be provided by an independent, competent and appropriately qualified Chartered Surveyor or Specialist to confirm a minimum life expectancy of 15 years will be achievable.

Where repairs to windows are required we will ask you to prepare a sample repair on site so our Risk management Surveyor can bench mark the required standard and this can be rolled out across the site refurbishment. Note painting windows does not make them newly constructed.

Sound testing

Party walls and party floors should be sound tested in accordance with Regional Building Regulations to determine compliance, access maybe required into adjacent buildings in order that sound testing is completed. Where Planning restrictions do not permit upgrading of internal walls for sound purposes, the declaration of sound test results in accordance with current Regional Building Regulations must be provided at completion.

Drainage

Drainage systems should be replaced unless it can be demonstrated that the existing drainage system is fit for purpose, have suitable falls and the required rodding facilities.

Where private drains are retained, a CCTV survey should be undertaken to ensure the integrity and design of any retained system. Where the lengths of existing retained drainage do not have rodding access in accordance with current requirements, additional access points should be provided. Inspection chambers and manholes located within habitable parts of the building will not normally be acceptable. Existing septic tanks and cesspools should be replaced with a new sewerage treatment system.

Where some of the elements are new and replaced as part of the conversion/refurbishment, no report is necessary.

Substructure

Foundations

Please refer to the guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' which applies to existing foundations.

Basement Structural Waterproofing

Please refer to 'Appendix D - Conversions and Refurbishments - Existing Elements', and also the 'Basements' section in the main body of this Technical Manual for further guidance.

Where a basement area on a converted or refurbished site is not habitable, any damp/water ingress occurring is specifically excluded from the Policy.

Excluded is; water entry, dampness or condensation to the enclosing walls, floors and ceilings of any underground: car-parking and any associated underground refuse stores, cycle stores, plant rooms (that do not house items of plant that directly service the building and for which the failure of such plant would prevent the normal use of the Home), lifts/escalators, associated access stairs and lobbies; where a continuous structure entails the conversion, refurbishment or renovation of an existing building(s) and where the structural integrity of the building is not affected.

Walls

Damp proofing

For details of remedial DPCs please refer to 'Appendix D - Conversions and Refurbishments - Existing Elements' which applies to damp proofing.

Where planning restricts the inclusion of an independent lining system and where it is not feasible to insert a chemical injection DPC, A full assessment must be completed by Chartered Building Surveyor who has proven experience in historic and Listed Buildings (RICS Accredited Building Conservation Surveyor or equivalent). The assessment must identify the risk of rising damp and propose solutions where applicable.

Condition and treatment of floor timbers

The guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' applies also to this section.

Existing solid floors

The guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' applies also to this section.

Superstructure

Structural repairs

Prior to undertaking structural repairs, it is essential that the root cause of the structural defect has been remedied by underpinning, addition of adequate lateral restraint, buttressing etc. Strengthening works to the structure may also be necessary to accommodate increased or modified loads.

External walls

Solid walls

Where walls cannot be upgraded in accordance with the guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements', and where the existing thickness of the external wall does not meet the required exposure rating in BS 5628, a full survey of the wall will be required by a Chartered Building Surveyor with proven experience in Historic and Listed Buildings (RICS Accredited Building Conservation Surveyor or equivalent). The report should not only identify the potential issues or defects but also provide solutions to ensure that the external walls remain durable.

The specialist Historic Building Surveyor services must be retained until the end of the project and verify that the works that they have recommended have been carried out to their satisfaction.

The report should include the following information:
- Overall condition of the exiting external walls.
- The quality of existing mortar.
- The quality of existing masonry with respect to the durability of bricks/stone/render.
- Potential high risk areas or areas of concern where there is potential for future water ingress with particular attention focussed towards the following:
  - a. Parapets.
  - b. Roof/wall abutments.
  - c. Penetrations and openings.
  - d. Stone feature-work.
  - e. Window and door reveals.
  - f. Rain water outlets and rain water pipes.

The following information should accompany the building survey:
- A scope of works clearly identifying any remedial measures.
- Details of any ongoing maintenance requirements for the walls.
- Confirmation of the level of supervision during the remediation process.

It should be noted that although the external walls may be proven as acceptable without independent internal lining systems, particular attention should be given to window and door reveals and it is likely that in all cases an independent lining will be necessary to window heads, cills and reveals. Consideration can be given where the reveals are already lined such as oak panelling adjacent to existing sash windows providing that the lining is free from dampness and decay and is considered in the above report requirements.

Internal walls

The guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' equally apply to this section.

Timber floors above ground level

The guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' equally apply to this section.

Other framed buildings

The guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' equally apply to this section.

Filler joist floors

The guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements' equally apply to this section.

Timber roofs

Surveying roof timbers

All roof timbers should be surveyed by a qualified Structural engineer or Specialist surveyor that is a registered member of the Property Care Association and provide a report detailing any necessary treatment to be carried out. Particular attention should be given to rafter feet, wall plates and valley timbers, as these often show signs of rot.

Roof structure

It is essential that the roof structure has adequate strength, stiffness and dimensional accuracy appropriate for the new roof covering. All strengthening work should be designed by a suitably qualified Structural Engineer that will result after the work has been completed that a structural life expectancy of 60 years for the structure will be achieved.

Common problems encountered include:
- Excessive spans of rafters, purlins, binder and ceiling joists.
- Inadequate ties between rafters and ceiling ties.
- Insufficient number of collar ties at purlin level.
- Decay of rafter feet and valley beams.
- Settlement of purlin supports.
- Lateral spread of raised-tie roofs.

Roof coverings

Traditional slate and tiled roofs

Where roofs cannot be recovered or meet the requirements of 'Appendix D - Conversions and Refurbishments - Existing Elements', a specialist survey is required to determine durability against future water ingress and failure of components. Roofs should generally be re-covered in accordance with the 'Roofs' section in the main body of this Technical Manual.

Where roofs are to be re-covered, it is required that existing gable walls are appropriately supported during the construction works and lateral restraint straps are fitted to any gable walls.

There may be exceptional circumstances where an existing tiled roof covering can be retained; however the following requirements would apply namely:
- That the tiled roof shows no sign of deterioration that suggests that the roof covering has passed its useful life.
- That the roof has a suitable roofing membrane/roofing felt beneath the tiles which is functioning correctly and not damaged.
- That ridges and hips are well bedded and mortar has not eroded, (please note it may be reasonable in some circumstances that ridges and hips are re-fitted, Mechanical fixing should also be provided in such circumstances).
- That timber laths and nails are in good condition and fit for purpose.
- That existing flashings and weathering's are assessed, particular attention should be given to valleys and parapets, if there is any doubt of the condition of any weathering's, they should be replaced.

Please note:
1. A report should be provided on the condition of the tiles and stating that they have a life expectancy of at least 15 years remaining. The report should be by a suitably qualified expert.
2. Fibre cement tiles would generally not be accepted for retention.
3. Adequate provision for ventilation to the roof voids should be considered.
4. The requirements for resisting fire spread in the relevant Regional Building Regulations must be considered e.g. how will fire stopping at heads of party walls etc. be achieved?
5. Wet bedded hips and ridges must be demonstrated to be adequately fixed or if found to be poorly bedded then they should be stripped and mechanically fixed (or if subject to listed restriction then they should be re-bedded in accordance with BS 5534.
6. All parapets should be removed, new DPCs provided and refixed with mechanical fixings. Inside face of parapets to be waterproofed, lined lapped under DPC etc.

Continuous membrane roofs and balconies and terraces (forming a roof)

Membrane roofs and balconies and terraces (forming a roof) should be re-covered in accordance with the 'Roofs' and 'Balconies and Terraces' sections within this Technical Manual unless the following provisions can be met:
- That the existing membrane is less than five years old and is tested for water ingress (testing guidance requirements can be found in the 'Roofs' or 'Balcony and Terraces' sections of this Technical Manual.
- There are no signs of excessive ponding.
- The roof has a fall, adequate upstands and suitable drainage outlets.
- That balconies and terraces are fitted with overflows.
- That any thermal upgrade via inverted insulation does not compromise roof drainage or upstands.

Windows and doors

Where windows and doors do not meet the guidance in 'Appendix D - Conversions and Refurbishments - Existing Elements', the following information must be provided to determine adequacy of performance:
- A full survey of the windows and doors by a suitable specialist to determine the current condition and the windows and door ability to be resistant against water ingress for 15 years.
- Where windows are to be repaired, a full repair schedule must be provided detailing the extent of the repairs. A completion report from the suitable specialists shall be provided, confirming the repairs are adequate and that the windows will now have a life of not less than 15 years.
- Full details if the window repair specialist to be provided, the repair specialist must demonstrate that they have suitable experience for the specialist repairs of windows and doors.
- Where the window and door system includes feature stone mullions, full details prior to any repairs being carried must be provided to confirm that the mullions are resistant to moisture and will have durability against water ingress for at least 15 years.

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