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TECHNICAL MANUAL VERSION 15

# 11.

## Roofs

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## 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.
2. The guidance provided in this Section, 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.
3. For Warranty purposes, flat cold deck roofs over 3m<sup>2</sup> in area are not acceptable.

## Workmanship

1. A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings. Where the third party accreditation requires this to be in place.
2. Flat roof membranes will be required to be weather and waterproof and tested at completion where stipulated in the guidance.
3. All workmanship must be within the tolerance requirements set out in this Technical Manual.
4. All work is to be carried out by a technically competent person in a workmanlike manner.
5. Concreting shall not take place during cold weather periods where the working temperature is below 2°C or where ground conditions are frozen.

## Materials

1. All materials should be stored, installed and protected 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. All load bearing structural elements providing support to the Home will have a service life of not less than 60 years, unless specifically agreed otherwise with us. All other parts of the Home will have a lesser durability and need planned maintenance, repair or replacement during that reduced period.
4. Whilst there is and can be no Policy responsibility and/or liability for any roof covering, window/ door or 'Decorative external cladding' (i.e. Cladding which is decorative only and the substrate wall provides the main weather proof barrier) to achieve a performance service life of 60 years or less, such elements shall be designed and constructed so they have an intended service life of not less than where stipulated within this Manual.
5. 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.
6. Timber used in the building to provide support to the structure must be appropriately seasoned to prevent excessive shrinkage and movement.
7. All materials should be suitable for the relative exposure of the building in accordance with the relevant British Standards.
8. Reclaimed materials may only be reused with the prior agreement with the Warranty Surveyor. Independent certification and/or testing of the suitability may be required.

## Design

1. 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. Have an adequate thermal performance;
  - d. Have adequate resistance to fire penetration and the spread of flame across their external surfaces;
  - e. Do not allow fire spread across the tops of separating walls;
  - f. Adequately discharge rainwater from the roof area to a suitable drainage system.
  - g. Have adequate provision for ventilation in pitched roofs.
2. In addition to point 1f: 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.
3. The following additional elements shall be supported by structural calculations designed by an Engineer:
  - a. Structural elements outside the parameters of Building Regulations.
  - b. Specialist structural works.
  - c. Reinforced concrete elements.
  - d. Precast structural elements.
  - e. Any engineered beams/posts manufactured off-site.
4. Damp proofing works should prevent any external moisture passing into the internal environment of the building.
5. 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. These types of constructions must be declared before commencement.

# 11.

## Roofs

### 11.1

#### Pitched - Pre-formed Truss

### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. This may include:

1. Full details of the roof layout inclusive of the layout of trusses, any intersecting roof construction such as hips and valleys, details of girder trusses, multiple trusses and diminishing trusses, including how they are to be fixed together and supported on truss shoes, lay boards or all associated bracing requirements, details of restraint/holding-down strapping and fixings.
2. An Engineer's full set of structural calculations for the roof construction.
3. Details for any required trimming work around chimneys, formation of access hatches, details for the formation of supportive structure for equipment and access to equipment requiring periodic maintenance and inspection contained within the roof space, etc.
4. Waterproofing and flashing details around abutments, chimneys, service penetrations etc.
5. Detailed sections and material specification for all components to be used in the construction of the pitched roof including but not limited to, vapour control layers, breather membranes, insulation etc.
6. Details of all fire stopping which should include specification and a detailed location layout drawing showing positioning of all fire stopping.

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### Statutory requirements

#### Roof structure and loading

Roof framing and rafter design must be in accordance with current relevant 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, 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<sup>2</sup> for spans not exceeding 12m, and 1.50kN/m<sup>2</sup> 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 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' estuarine 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, Eurocode 5 design of timber structures. General. Common rules for buildings.

### Typical trussed roof design

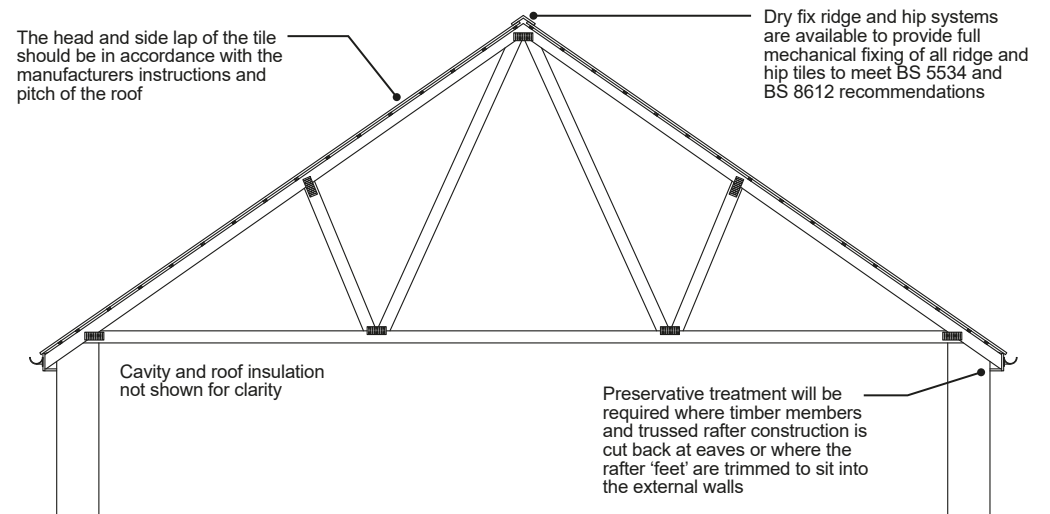
Approved Document A of the Building Regulations for England requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle. See 'Appendix C - Materials, Products, and Building Systems' for further information.

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, Eurocode 5 design of timber structures. General. Common rules for buildings.

The roof coverings should be designed in accordance with:

- BS 5534 Code of practice for slating and tiling (including shingles).
- BS 8000-6 Workmanship on building sites. Code of practice for slating and tiling of roofs and claddings. BS 5250 Control of condensation in 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 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/m<sup>2</sup>.
- Roofs pitched 31° to 75°: 0.75kN/m<sup>2</sup> - 0 kN/m<sup>2</sup> (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 or the 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.

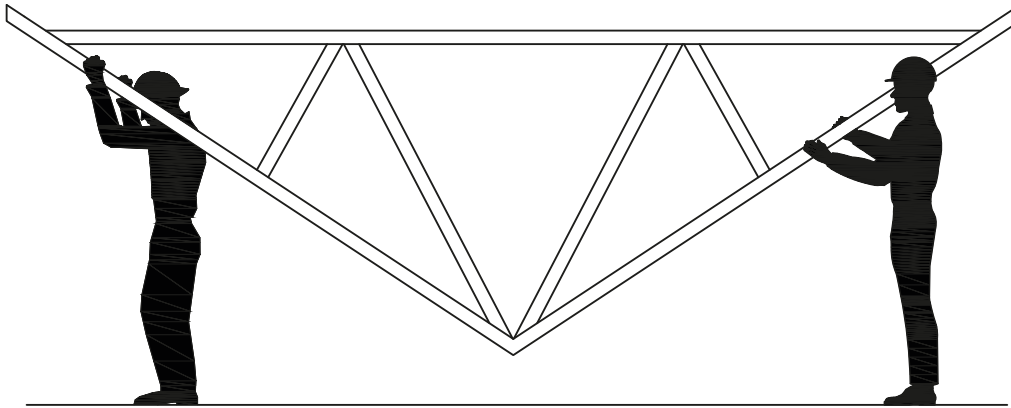
### Handling and transportation

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 position unless support can be provided to every joint.

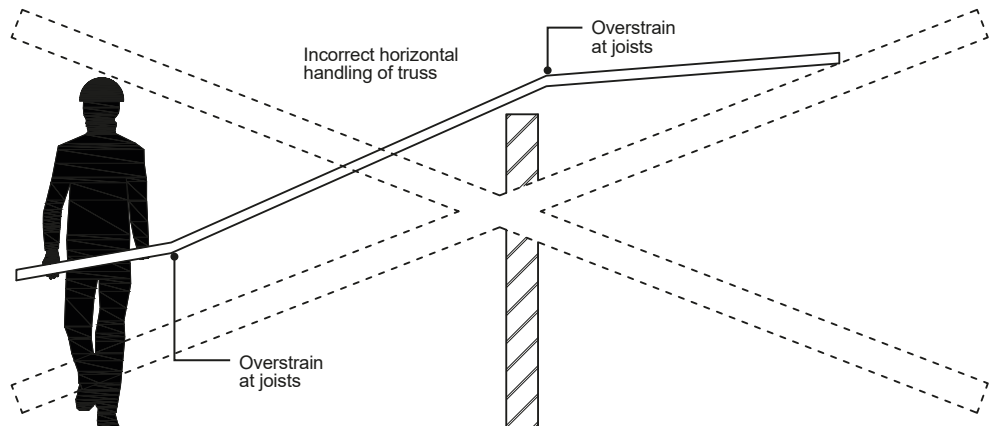
### Manual lifting

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



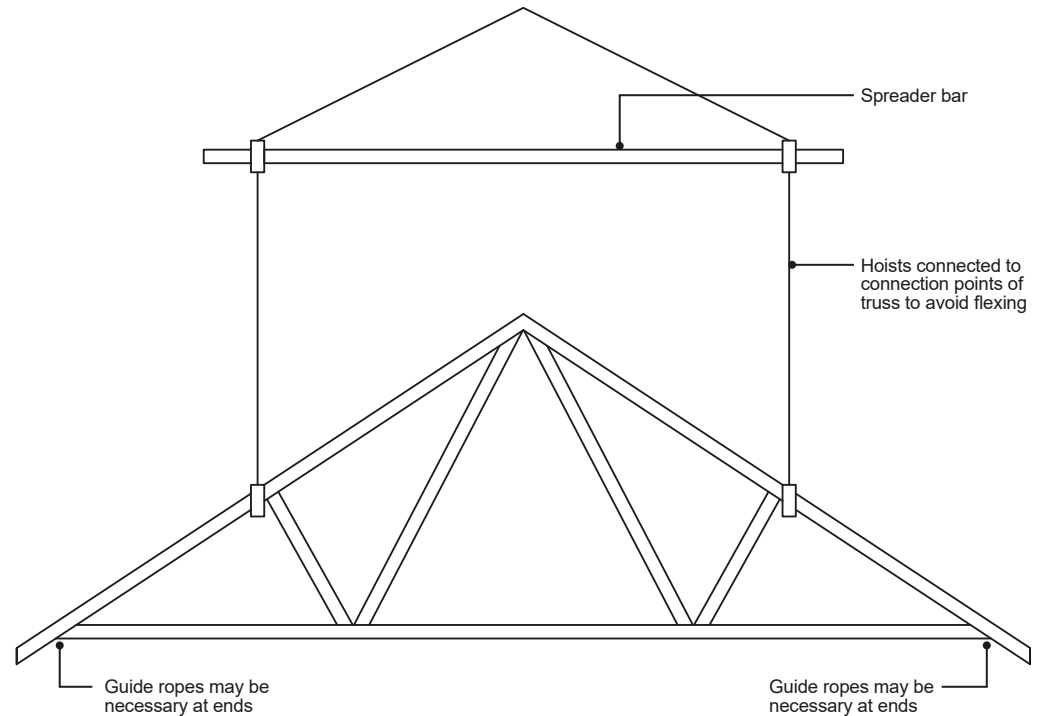
### Avoid bending or see-sawing of trusses



### 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.

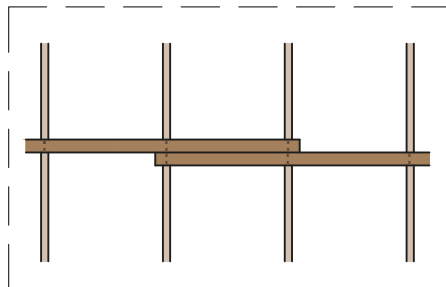
### Trussed roof installation

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.

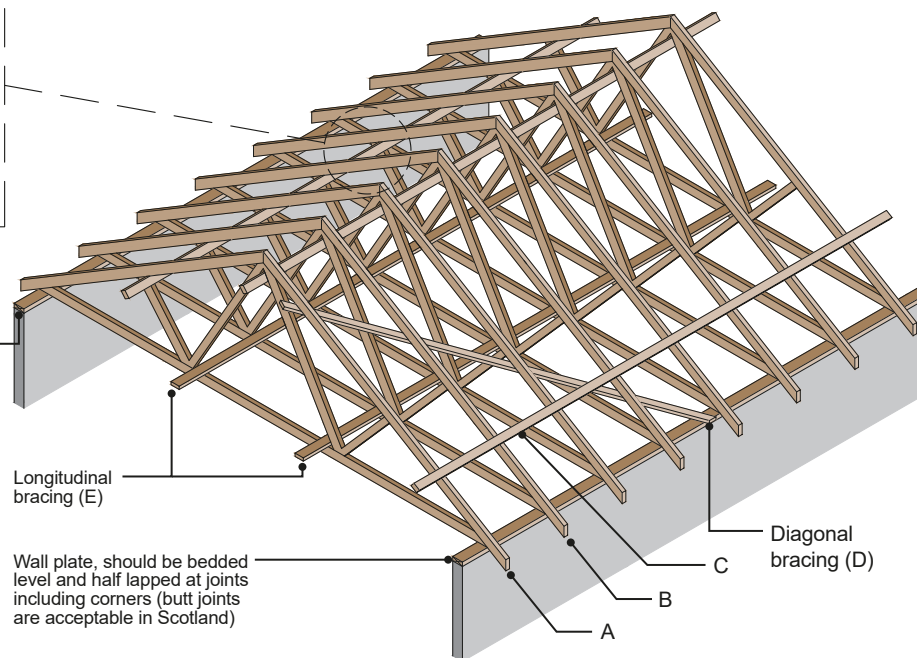


Where binders and bracing is not continuous they should be lap jointed and nailed over a minimum of two trusses.

The wall plate may, as good practice, 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 1,000mm long at maximum 2m centres) nailed to the wall plate and securely fixed to the inner surface of the wall with compatible fixings.

Multiple trussed rafters should be fixed in accordance with the manufacturer's instructions

Trussed rafters, including attic trusses, should never be cut, altered, notched, or repaired for use without the full agreement of the Trussed Rafter Designer.



Longitudinal bracing (E)

Wall plate, should be bedded level and half lapped at joints including corners (butt joints are acceptable in Scotland)

Diagonal bracing (D)

### 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.

### Bracing to mono-pitched roofs

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 an 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 30°), 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.

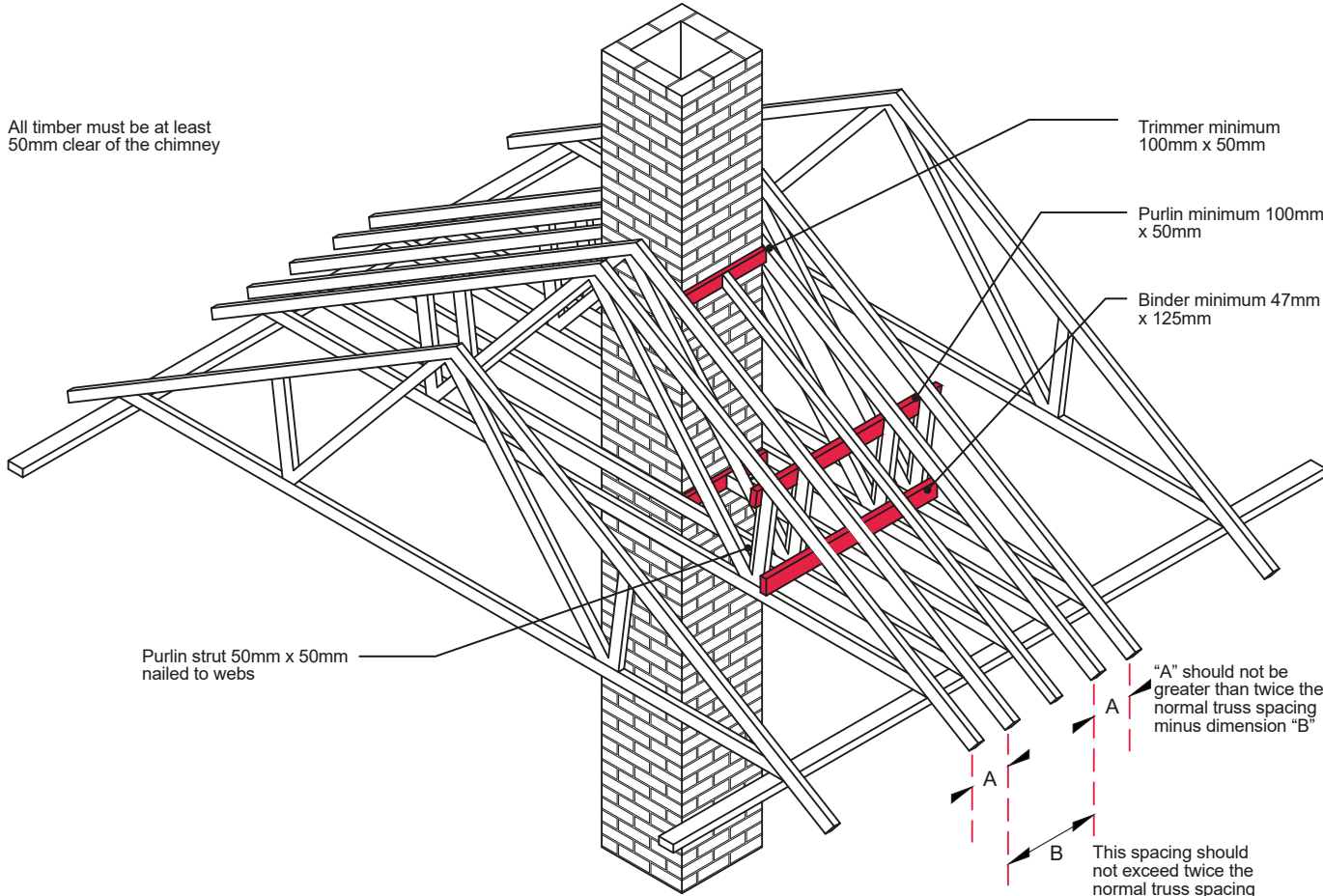


**Mono-pitch and girder trusses on trussed rafter hipped-end roofs**

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**

All timber must be at least 50mm clear of the chimney



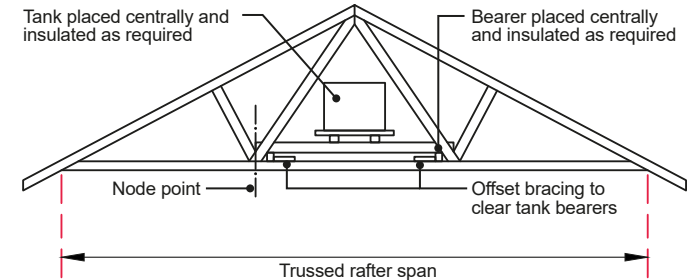
**Provision for openings, i.e. loft hatches, chimneys, etc.**

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**

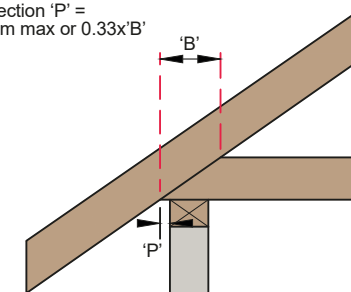


**Tank stands**

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**

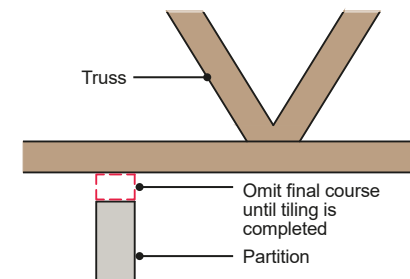
Projection 'P' = 50mm max or 0.33x'B'



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-load-bearing walls**

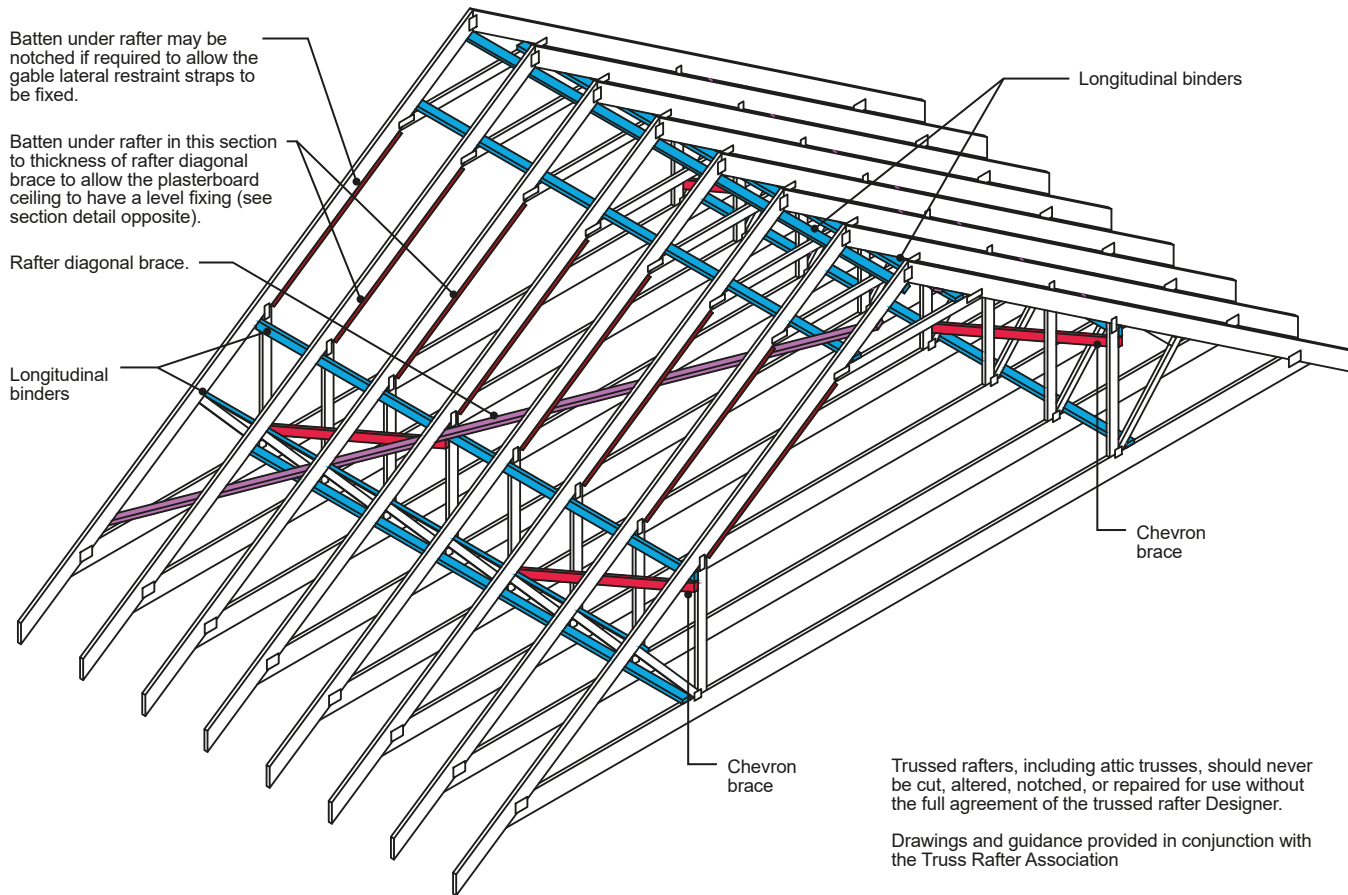


It is advisable to erect non-load bearing walls after the tiling has been completed thus allowing deflection to take place under dead load, thereby reducing the risk of cracking appearing in the ceiling finishes. If partitions are of brick or block, then alternatively the final course can be omitted 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.

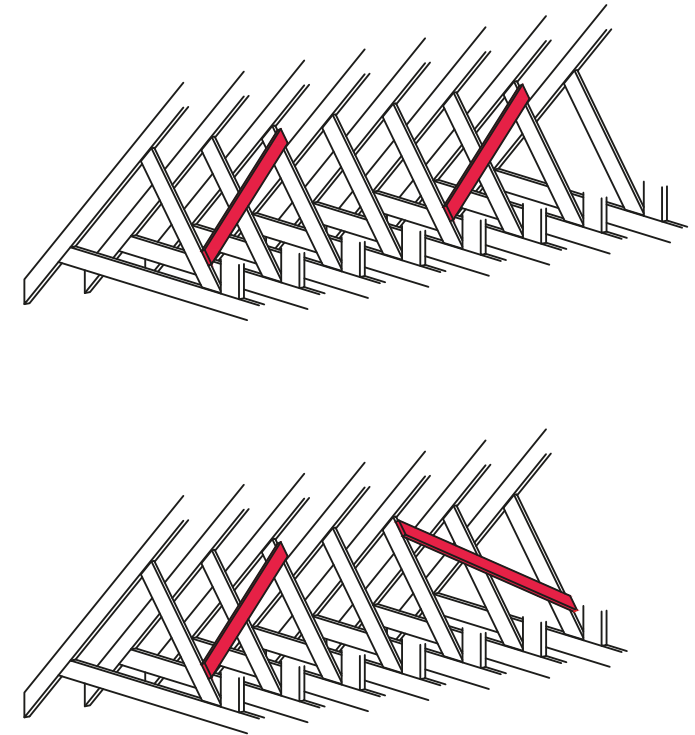
**Attic truss bracing**



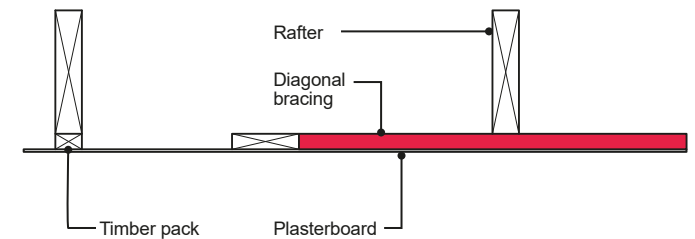
Trussed rafters, including attic trusses, should never be cut, altered, notched, or repaired for use without the full agreement of the trussed rafter Designer.

Drawings and guidance provided in conjunction with the Truss Rafter Association

**Chevron bracing**



**Section of diagonal bracing battened out for plasterboard**



## Condensation and ventilation

### Statutory requirements

The roof should be designed and constructed in accordance BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250.

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 a well-sealed ceiling 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.
- Loft access doors and hatches should not be located in rooms with high rates of moisture generation such as kitchens and bathrooms.
- 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 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

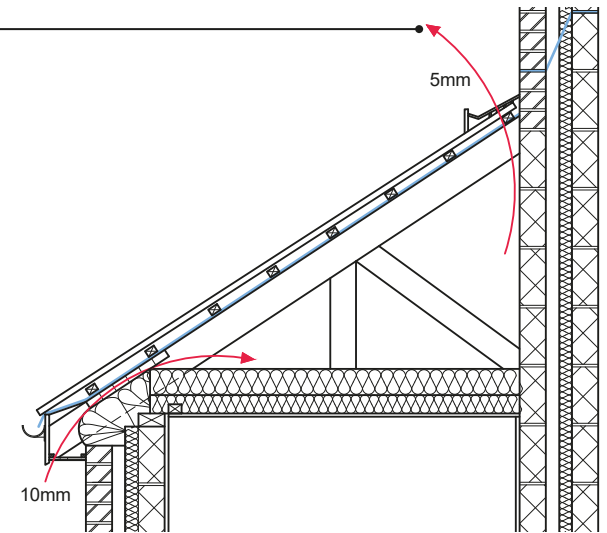
The following suggest the correct positioning of vents and the precise amount of free airspace required for 'cold roof' construction, in accordance with current Building Regulations and BS 5250.

These recommendations apply if a high water vapour resistance (type HR) underlay is used.

### Mono pitched/lean to roof

A free airspace of  $5,000\text{mm}^2/\text{m}$  should also be provided at high level (equivalent to a continuous 5mm opening)

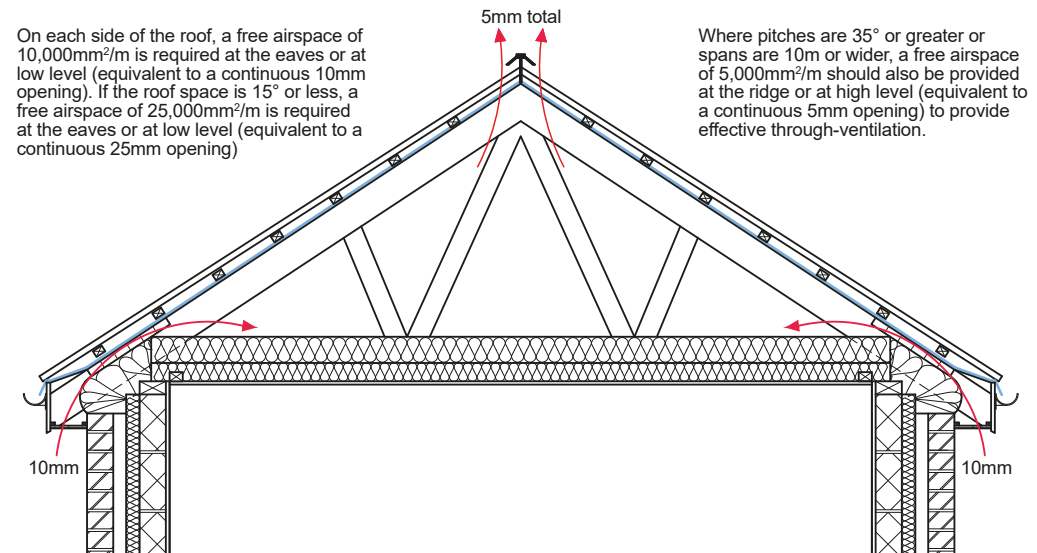
If the roof space is  $15^\circ$  or less, a free airspace of  $25,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 25mm opening). If the roof pitch is more than  $15^\circ$ , a free airspace of  $10,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 10mm opening)



### Duo pitched roof

On each side of the roof, a free airspace of  $10,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 10mm opening). If the roof space is  $15^\circ$  or less, a free airspace of  $25,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 25mm opening)

Where pitches are  $35^\circ$  or greater or spans are 10m or wider, a free airspace of  $5,000\text{mm}^2/\text{m}$  should also be provided at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation.

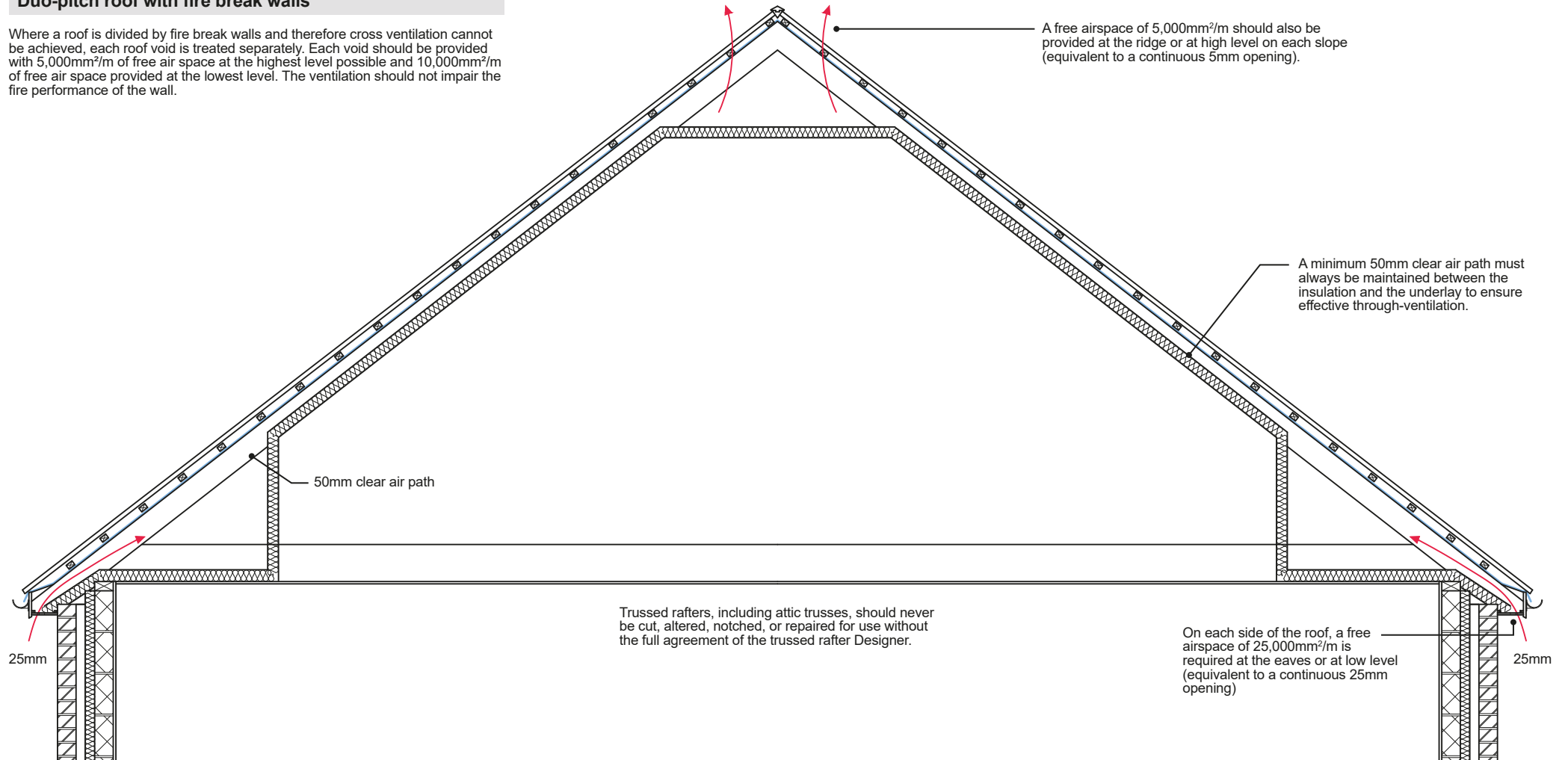


### Duo pitched roof with sloping insulated ceilings

Roofs should be designed and constructed in accordance with BS 5250 and BS EN ISO 13788. Detailed information on methods to control harmful condensation is provided in BS 5250.

### 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  $5,000\text{mm}^2/\text{m}$  of free air space at the highest level possible and  $10,000\text{mm}^2/\text{m}$  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.

A third party product conformity certificate should be obtained to prove and demonstrate any performance for the low resistance underlays used.

### 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.

Written confirmation and evidence must be sought from the manufacturer confirming the tiles/slates are considered air permeable or air impermeable as stipulated in BS 5250.

### 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 manufacturer's 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.

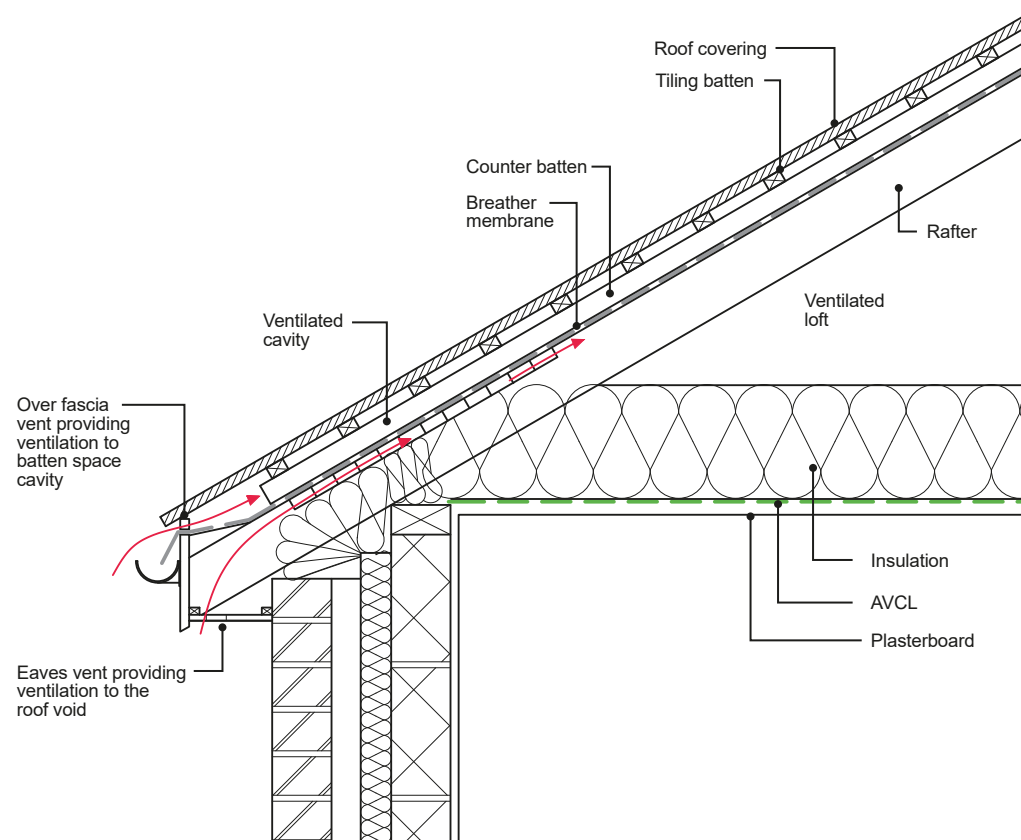
If ventilation is not provided to the batten space there needs to be an increased level of ventilation to the roof space and that should be in accordance with BS 5250. The underlay manufacturer's 3rd party accreditation also needs to be followed.

It is very difficult to determine a HR or LR underlay by sight alone and the manufacturer's third party accreditation should be referred to if ventilation requirements are in doubt.

### Cold pitched roof with HR underlay with a close fitting roof covering

A 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.

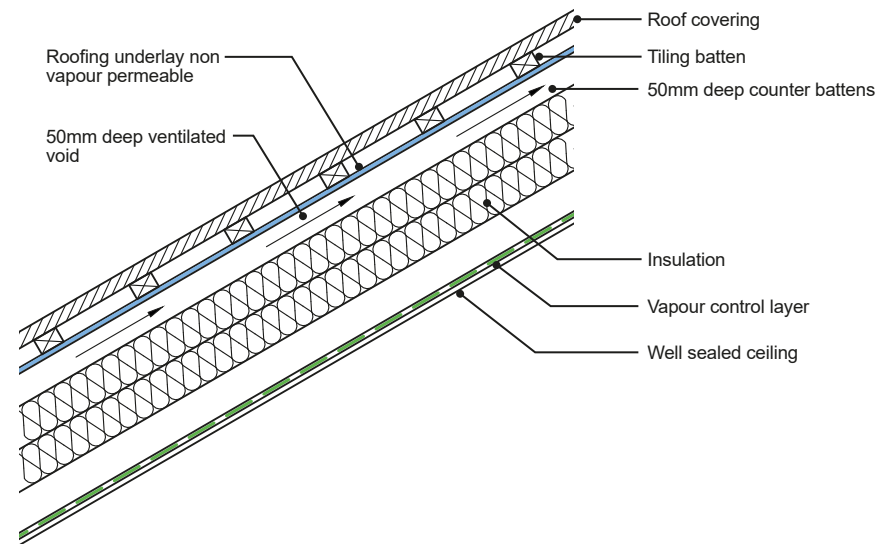
### Thermal insulation provisions for the compliance with the Building Regulations

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:

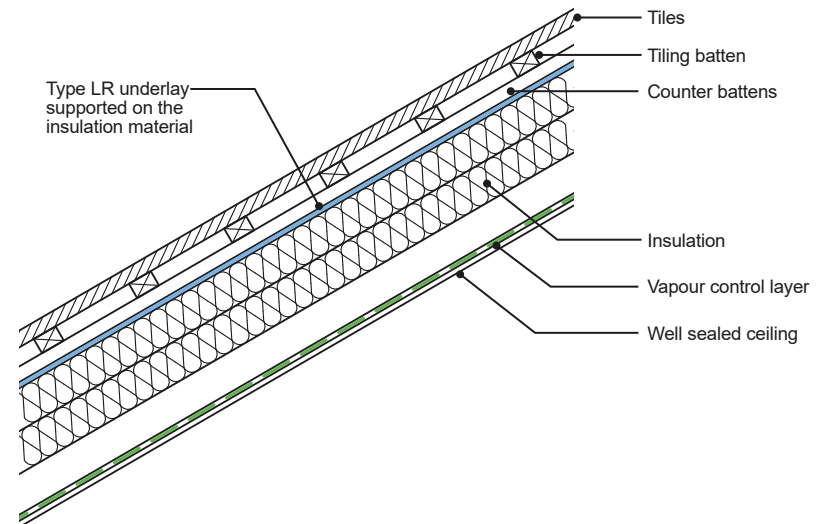
- The use of over joist and under rafter insulation is considered best practice, as it eliminates the cold bridge caused by the joist/rafter.
- If required by BS 5250, use a vapour control plasterboard or a separate VCL behind the plasterboard.
- Use a proprietary eaves ventilator to ensure ventilation 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)



## 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 Management of moisture in Buildings: Code of Practice. 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.

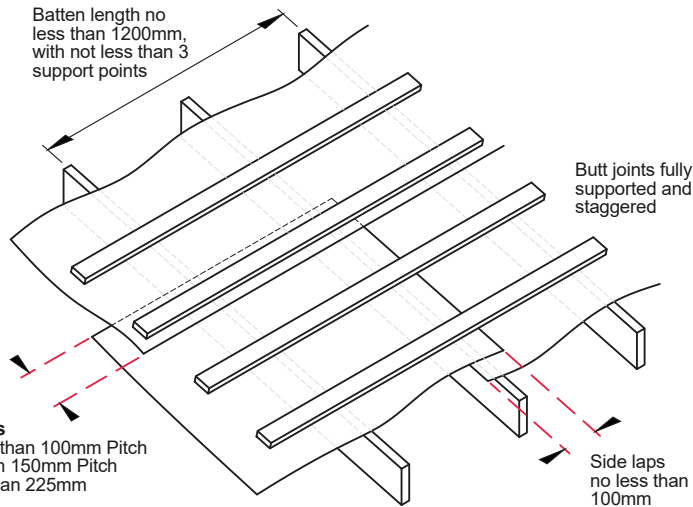
## Relevant British Standards

- 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

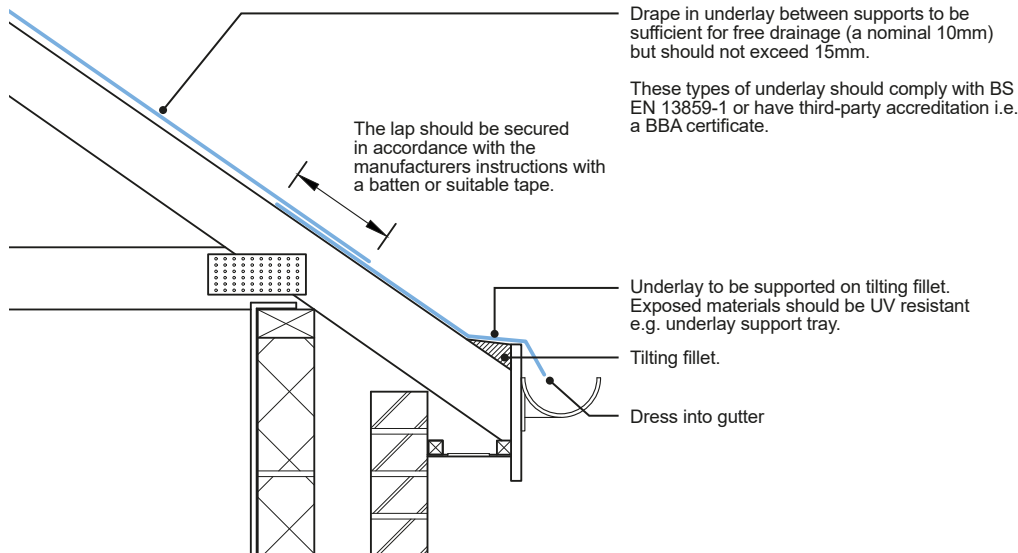
Practical guidance on the application of single-lap and double-lap tiling can also be obtained from CITB/CS Trainer Resource Package for Operatives in the Construction Industry Manuals, Construction Industry Training Board.

**Roof underlay provision**



Lap of underlay should be secured in accordance with the manufacturers 3rd party certification.

**Roof covering (underlay)**



**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).

**Minimum horizontal laps for 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

**Specification for underlays**

Fully supported and unsupported 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 manufacturer's 3rd 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 suitably 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 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

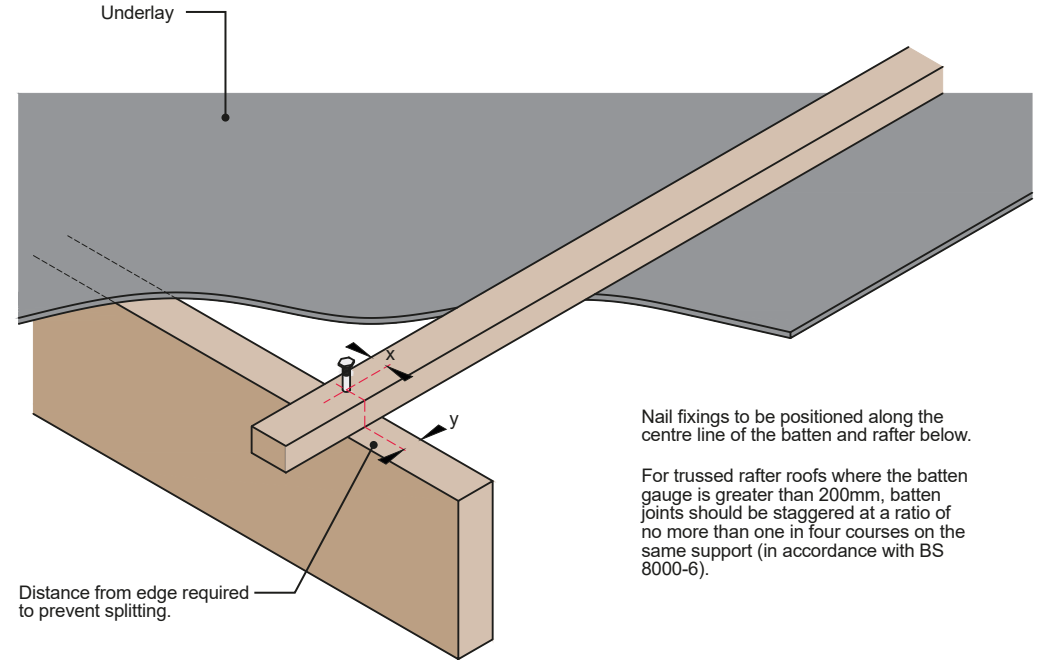
Battens should be at least 1200mm in length and supported at each end and intermediately by at least three rafters or walls. Stagger butt joints over intermediate supports, splay nail each batten end and nail battens to each rafter.

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*			
	450mm span		600mm span	
Rafter/supports	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

### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. This may include:

1. A full set of Engineers drawings and calculations for the roof. This should also include fixing methodology and specification, full details of all associated bracing requirements, restraint/holding-down strapping and associated fixings.
2. Full details of the roof layout inclusive of the layout of cut roof members, any intersecting or supportive roof structure such as hips, ridges, purlins, valleys and associated timbers e.g. lay boards, trimming members.
3. Details for any required trimming work around chimneys, formation of access hatches, details for the formation of supportive structure for equipment and access to equipment requiring periodic maintenance and inspection contained within the roof space, etc.
4. Waterproofing and flashing details around abutments, chimneys, service penetrations etc.
5. Detailed sections and material specification for all components to be used in the construction of the pitched roof including but not limited to, vapour control layers, breather membranes, insulation etc.
6. Details of all fire stopping which should include specification and a detailed location layout drawing showing positioning of all fire stopping.

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### Statutory requirements

#### Roof structure and loading

Roof framing and rafter design must be in accordance with current relevant 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 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, Eurocode 5 design of timber structures. General. Common rules and rules for buildings.

### Design Criteria

The design of pitched roofs should:

- 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.
- 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 Engineer and be incorporated within the structural calculations.

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.

### Additional requirements in a coastal locations

Where developments are within a coastal location additional Warranty requirements should be met.

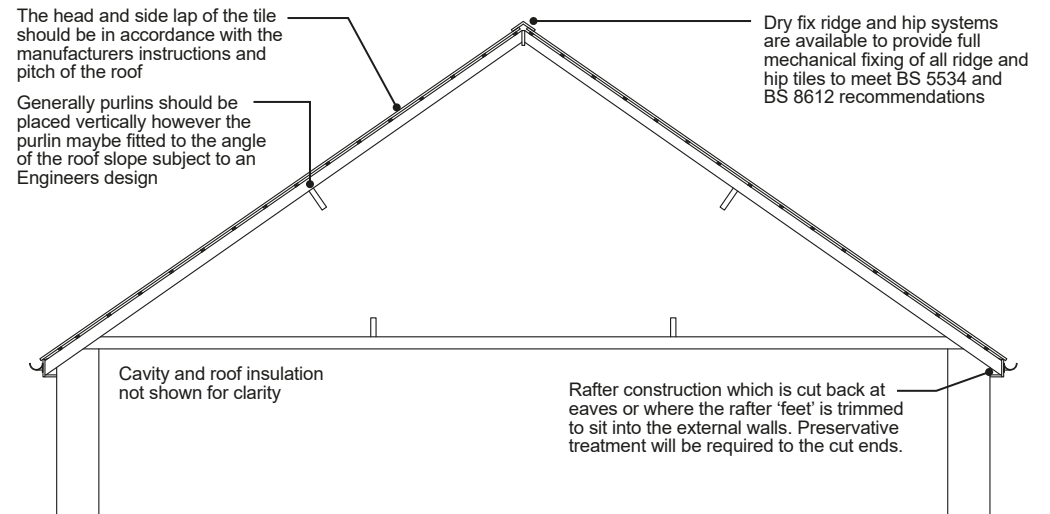
For the purpose of this Technical Manual we are considering sites within 5km inland from the shore line or sites located in 'tidal' estuarine areas where they are within 5km of the general shoreline. Further information on Warranty requirements within a coastal location can be found in 'Appendix B - Coastal Locations'.

### Typical cut roof design

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 coverings should be designed in accordance with:

- BS 5534 Code of practice for slating and tiling (including shingles).
- BS 8000-6 Workmanship on building sites. Code of practice for slating and tiling of roofs and claddings.
- BS 5250 Management of Moisture in Buildings - Code of practice



## 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 an 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 or 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.

## The use of oak in the external wall construction

Green oak, air dried (seasoned)/kin dried oak is not acceptable in the external wall construction, frame, window/door construction, internal wall or roof constructions, regardless of whether it forms part of the weather proof envelope or not. Projects incorporating such oak will not be acceptable for Warranty cover except where described in 'Appendix C - Materials, Products, and Building Systems' of this Manual.

### 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.

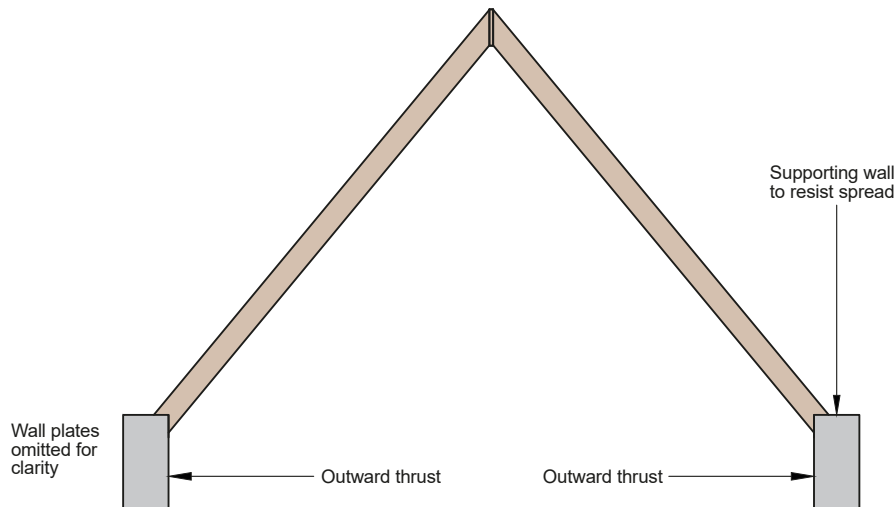
Always ensure that the correct strength class of timber is both ordered and used. Structural timbers are allocated a strength class by BS 5268-2. The most common strength classes used are C16 and C24.

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.

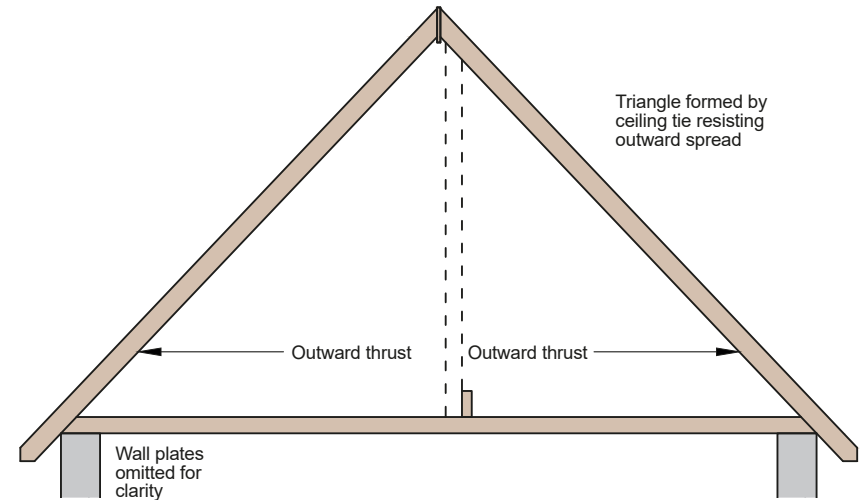
### Couple roof

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 an Engineer should be provided to demonstrate how eaves spread will be prevented.



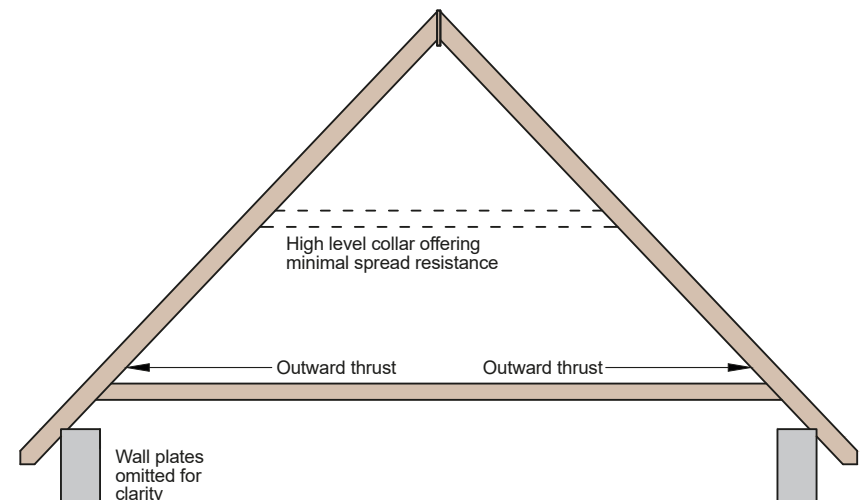
### Close couple

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.



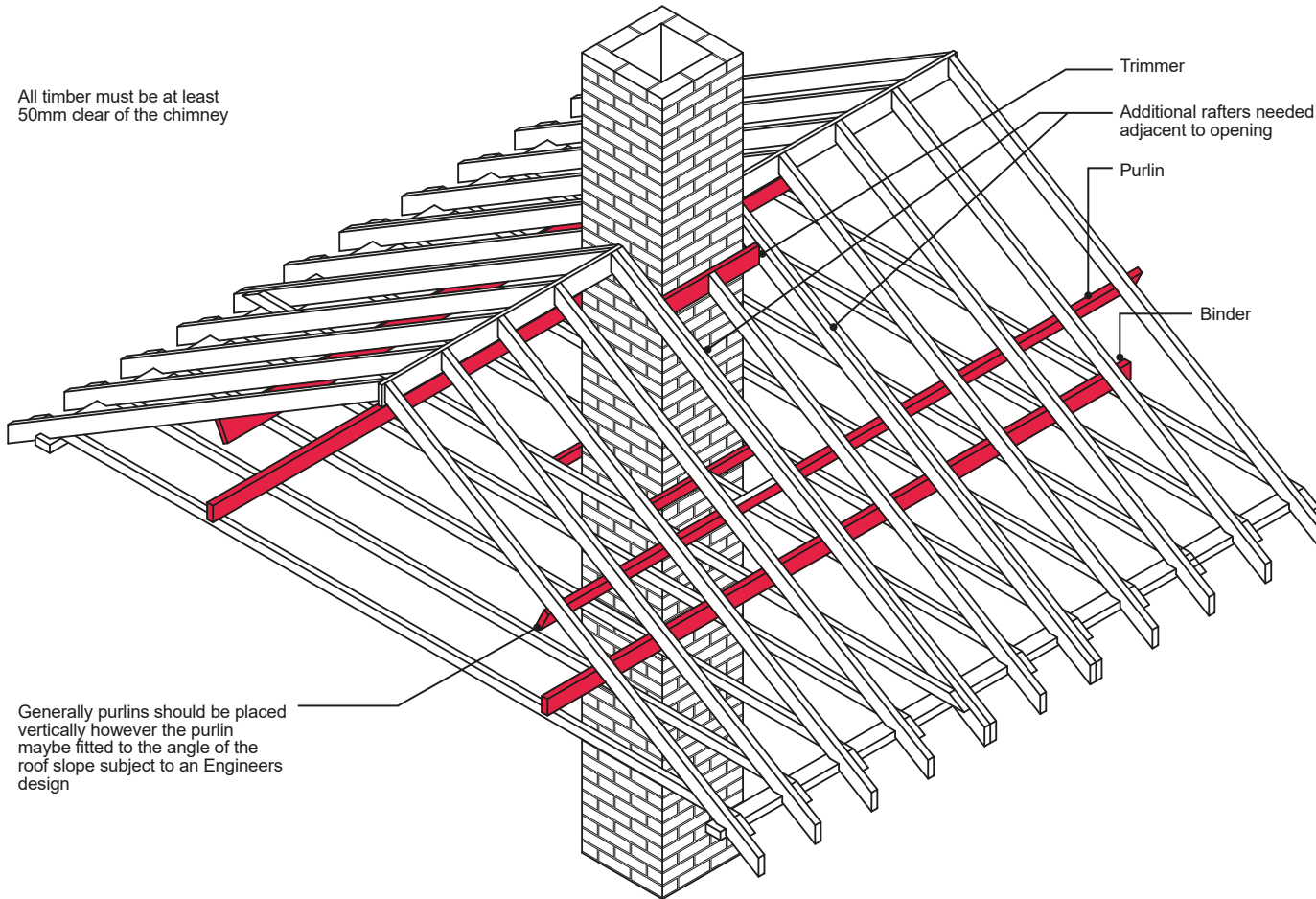
### Raised collar roof

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 an 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**

All timber must be at least 50mm clear of the chimney



Generally purlins should be placed vertically however the purlin may be fitted to the angle of the roof slope subject to an Engineers design

**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.

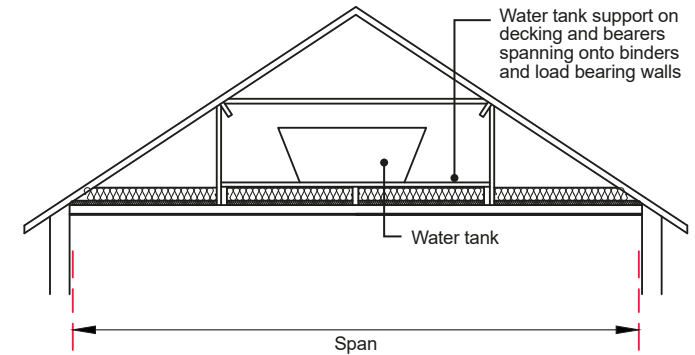
**Roof lights formed in traditional cut roofs**

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**

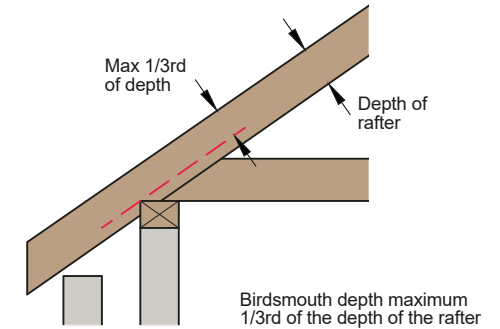
The design of tank stands should be provided as part of the Engineers roof design.

**Tank stand configuration**

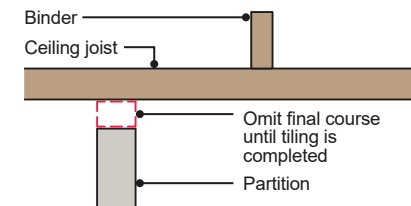


The tank platform should not be constructed from chipboard as it may become wetted by condensation, plumbing leaks, or rainwater ingress and lose its strength.

**Maximum depth of birds mouth**



**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.

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.
- Loft access doors and hatches should not be located in rooms with high rates of moisture generation such as kitchens and bathrooms.
- 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 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

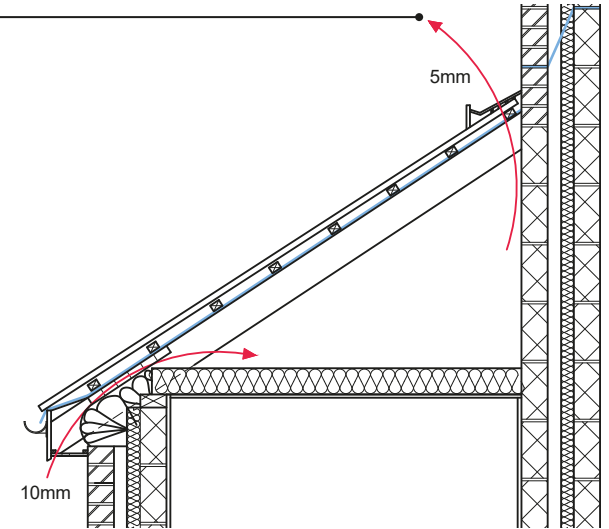
The following suggests the correct positioning of vents and the precise amount of free airspace required for 'cold roof' construction, in accordance with current Building Regulations and BS 5250.

These recommendations apply if a high water vapour resistance (type HR) underlay is used.

### Mono pitched/lean to roof

A free airspace of  $5,000\text{mm}^2/\text{m}$  should also be provided at high level (equivalent to a continuous 5mm opening)

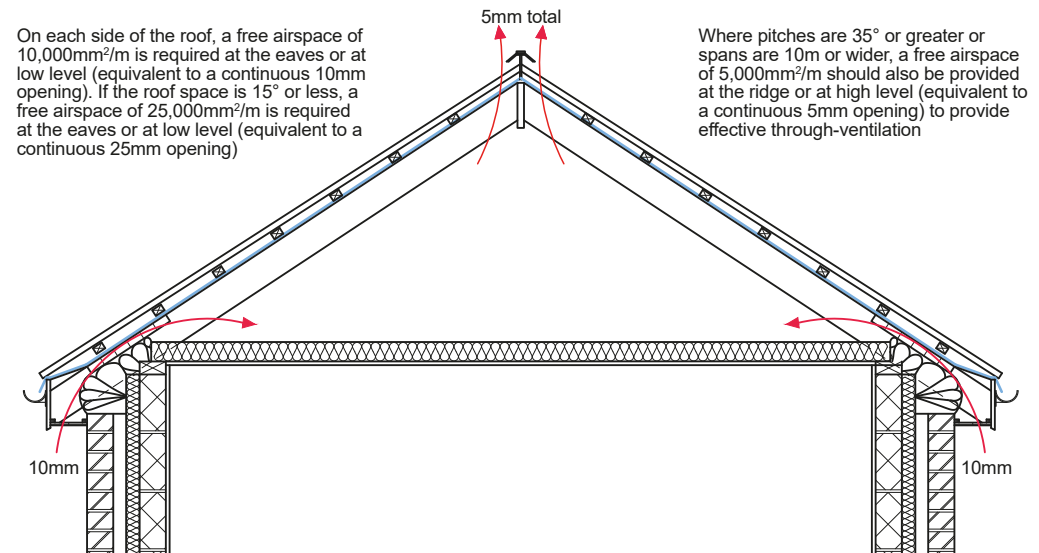
If the roof space is  $15^\circ$  or less, a free airspace of  $25,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 25mm opening). If the roof pitch is more than  $15^\circ$ , a free airspace of  $10,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 10mm opening)



### Duo pitched roof

On each side of the roof, a free airspace of  $10,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 10mm opening). If the roof space is  $15^\circ$  or less, a free airspace of  $25,000\text{mm}^2/\text{m}$  is required at the eaves or at low level (equivalent to a continuous 25mm opening)

Where pitches are  $35^\circ$  or greater or spans are 10m or wider, a free airspace of  $5,000\text{mm}^2/\text{m}$  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.

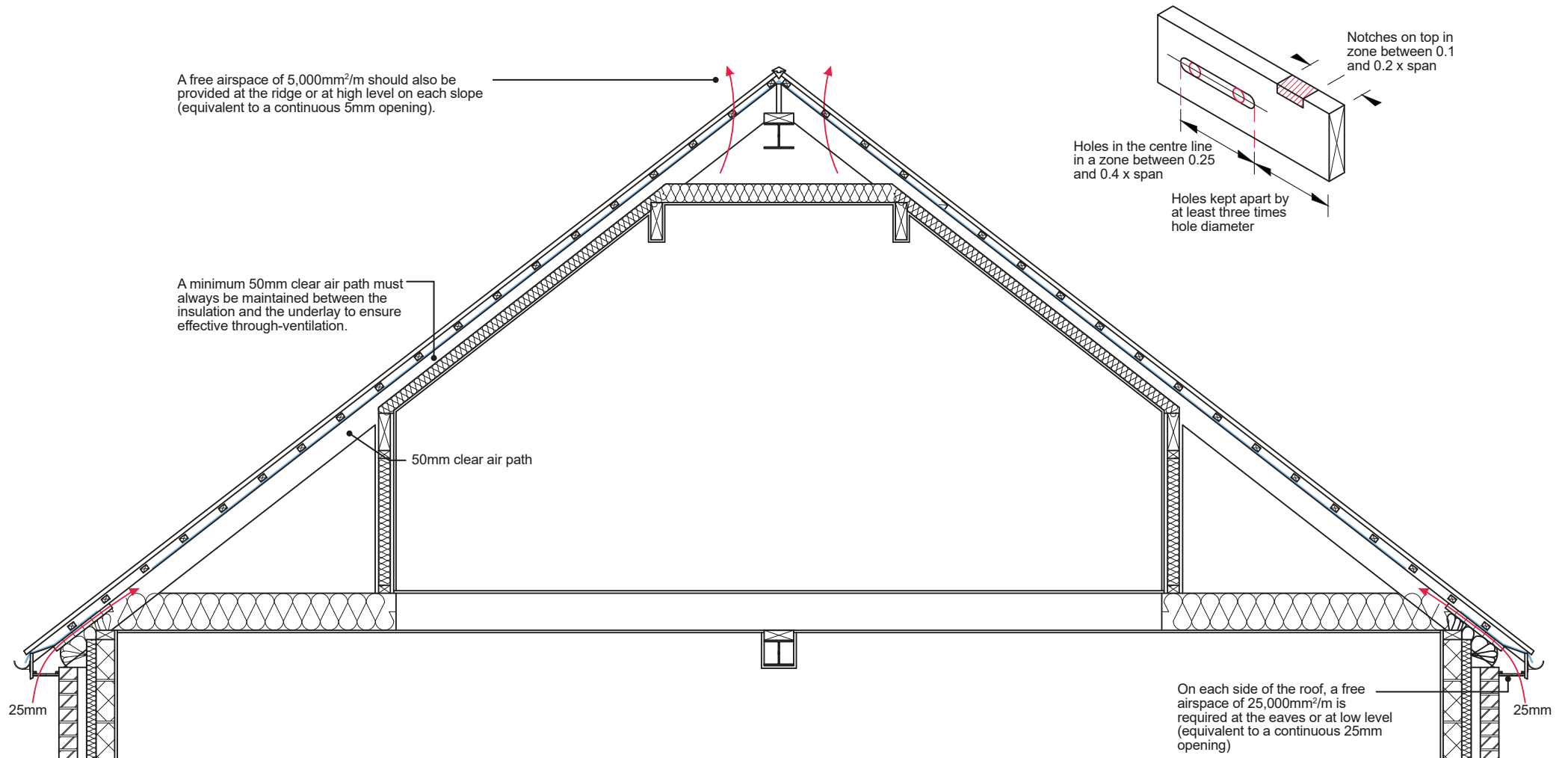
**Duo-pitch roof with fire break walls**

Where a roof is divided by fire 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  $5,000\text{mm}^2/\text{m}$  of free air space at the highest level possible and  $10,000\text{mm}^2/\text{m}$  of free air space provided at the lowest level. The ventilation should not impair the fire performance of the wall.

**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.

- Maximum diameter of hole should be  $0.25 \times$  joist depth.
- Maximum depth of notch should be  $0.15 \times$  joist depth.





### 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.

A third party product conformity certificate should be obtained to prove and demonstrate any performance for the low resistance underlays used.

### 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.

Written confirmation and evidence must be sought from the manufacturer confirming the tiles/slates are considered air permeable or air impermeable as stipulated in BS 5250.

### Cold pitched roof with a LR underlay with a close fitting roof covering

If a 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 manufacturer's 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.

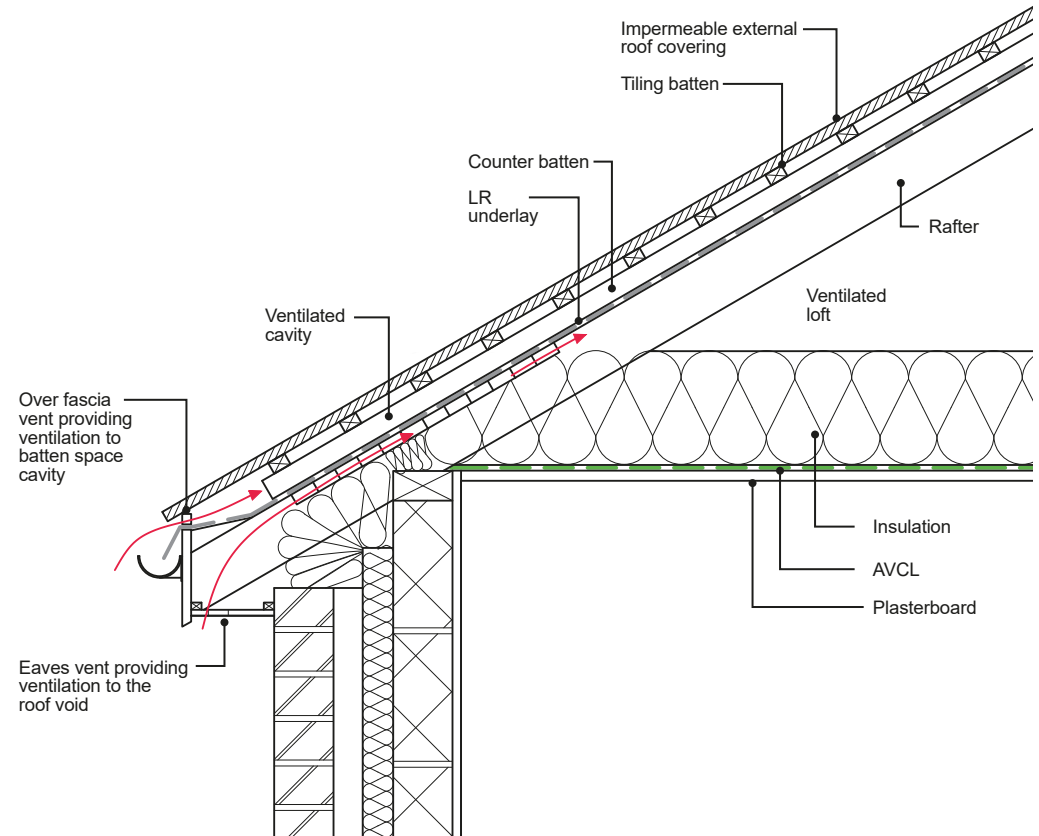
If ventilation is not provided to the batten space there needs to be an increased level of ventilation to the roof space and that should be in accordance with BS 5250. The underlay manufacturer's 3rd party accreditation also needs to be followed.

It is very difficult to determine a HR or LR underlay by sight alone and the manufacturer's third party accreditation should be referred to 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 a LR underlay and tight fitting roof covering

In warm pitched roofs with a 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 a 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.

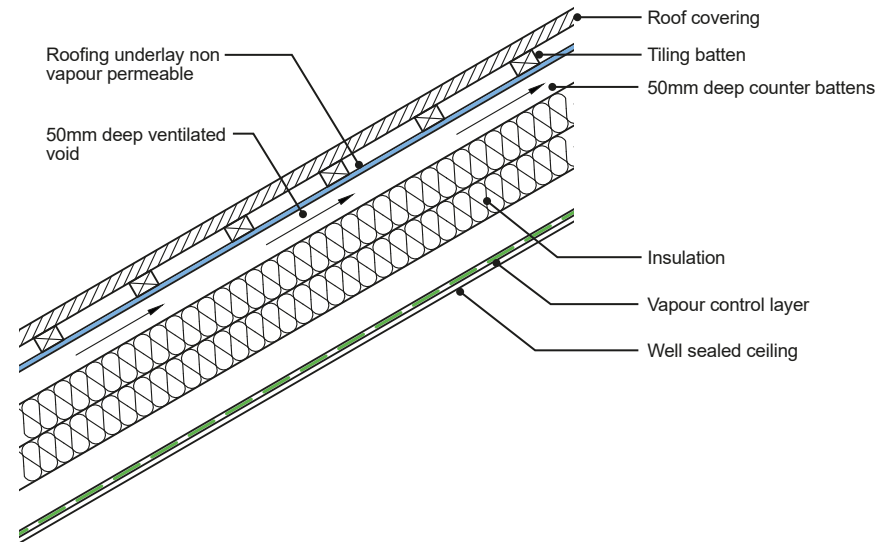
### Thermal insulation provisions for the compliance with the Building Regulations

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:

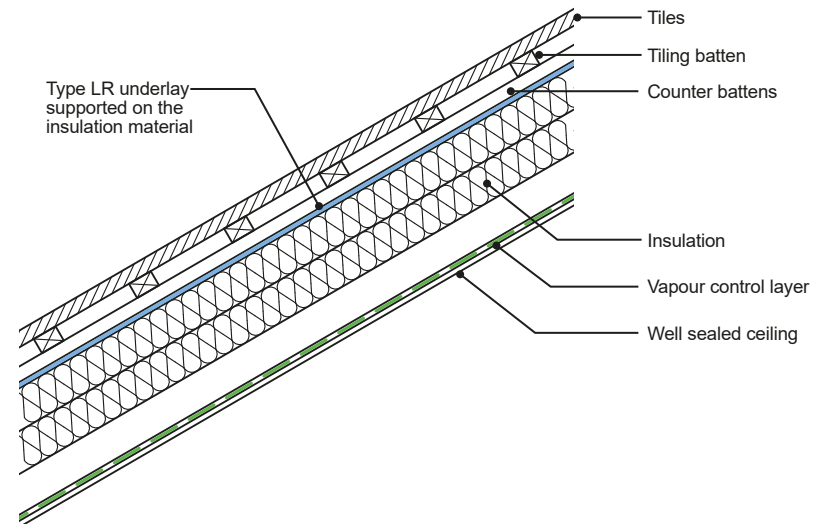
- The use of over joist and under rafter insulation is considered best practice, as it eliminates the cold bridge caused by the joist/rafter.
- If required by BS 5250, use a vapour control plasterboard or a separate VCL behind the plasterboard.
- Use a proprietary eaves ventilator to ensure ventilation 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)



## 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 Management of moisture in buildings: Code of Practice. 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.

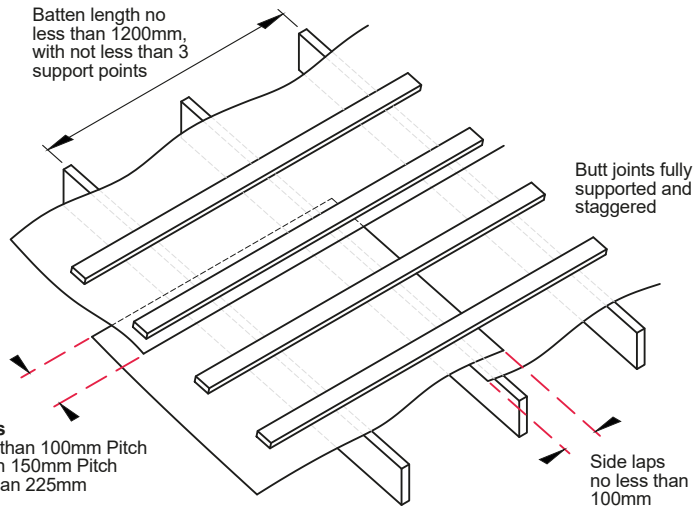
## Relevant British Standards

- 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

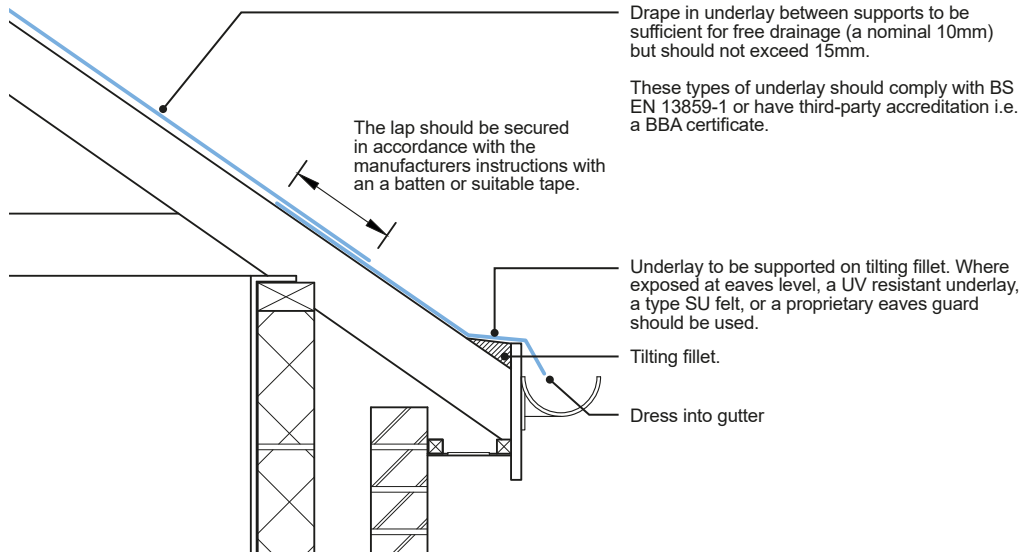
Practical guidance on the application of single-lap and double-lap tiling can also be obtained from CITB/CS Trainer Resource Package for Operatives in the Construction Industry Manuals, Construction Industry Training Board.

**Roof underlay provision**



Lap of underlay should be secured in accordance with the manufacturers 3rd party certification.

**Roof covering (underlay)**



**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).

**Minimum horizontal laps for 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

**Specification for underlays**

Fully supported and unsupported 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 - >0.25MN/g.

† LR (low water vapour resistance) underlay - <0.25MN/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 manufacturer's 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 suitably 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 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

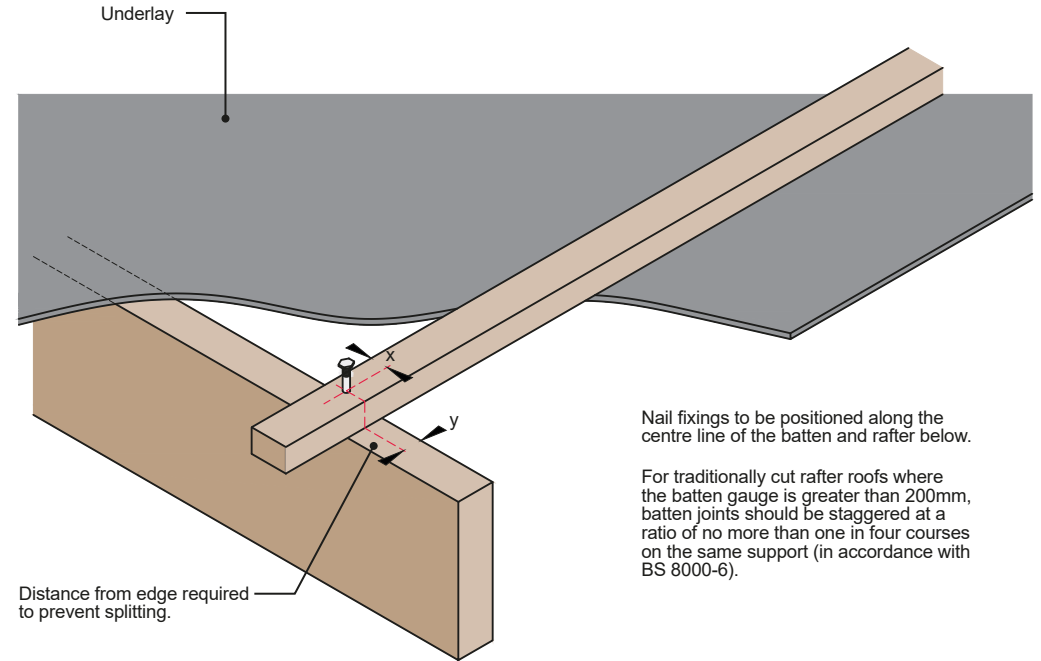
Battens should be at least 1200mm in length and supported at each end and intermediately by at least three rafters or walls. Stagger butt joints over intermediate supports, splay nail each batten end and nail battens to each rafter.

For traditionally cut rafters 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 traditionally cut rafters 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*			
	450mm span		600mm span	
Rafter/supports	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 and lap requirements

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.

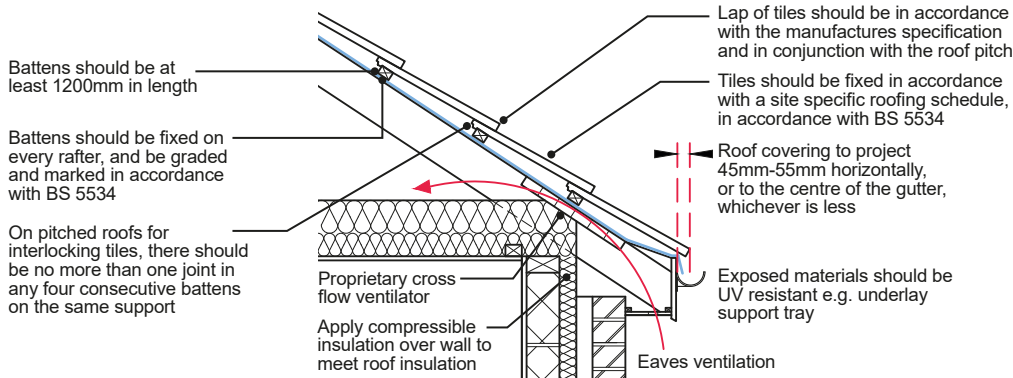
Lap of tiles should be in accordance with manufacturer's specification and in conjunction with the roof pitch.

### 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.

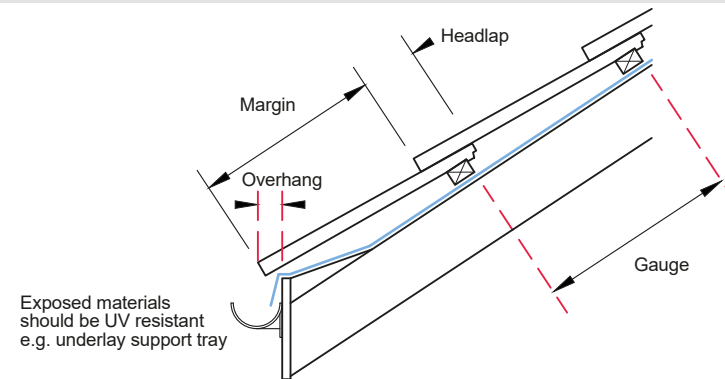
### Tile details - key check points

Eaves and bottom edge (in accordance with BS 5534 and BS 8000-6).

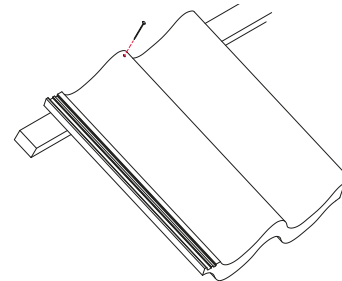
At the eaves (bottom edge), the batten should be set to provide the required overhang of the tiles into the gutters. The recommended overhang is 45mm-55mm horizontally or to the centre of the gutter, whichever is less.

- 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

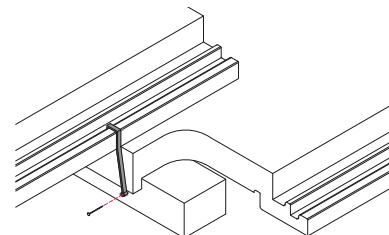


### Nailing tiles to battens



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 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 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.

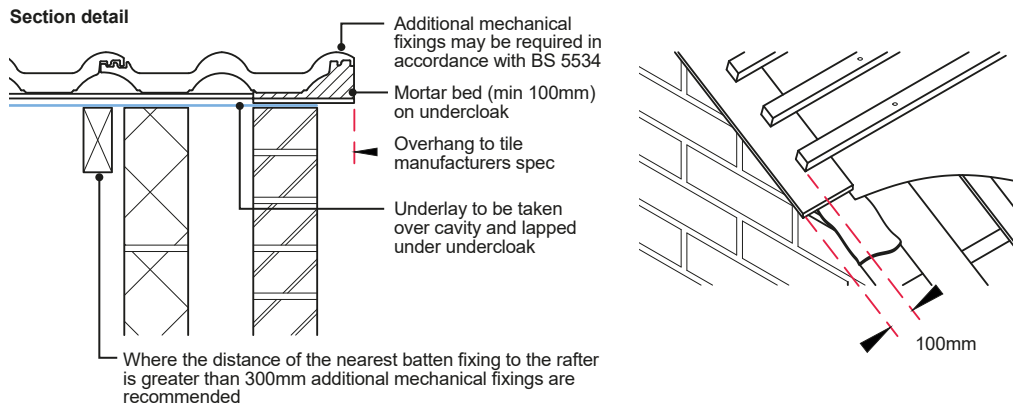
Note: Where proprietary verge tiles or systems are specified, the detailing should be in accordance with manufacturers' recommendations that are relevant to UK conditions of use.

- 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.

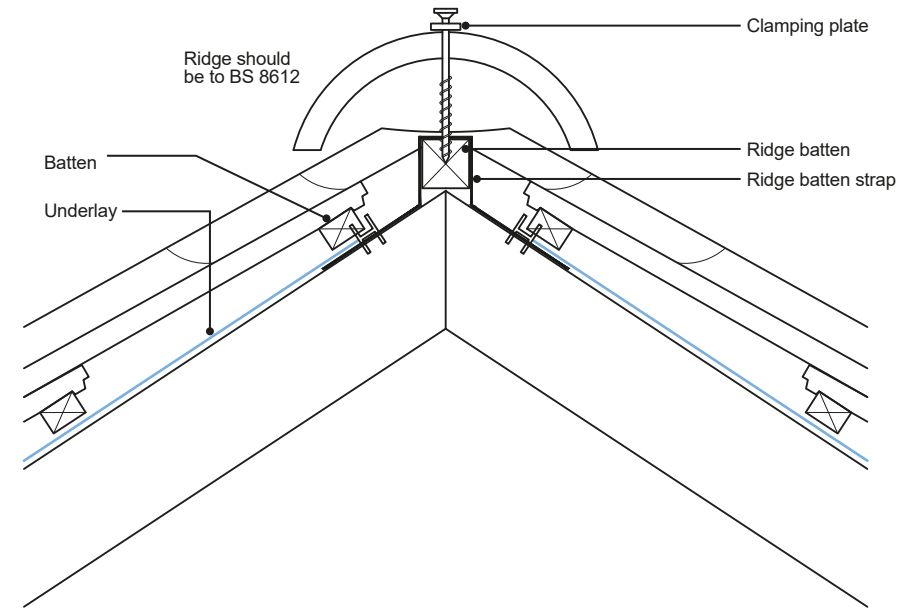
### Verge detail



Where proprietary verge tiles or systems are specified the detailing should be in accordance with the manufacturer's 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.

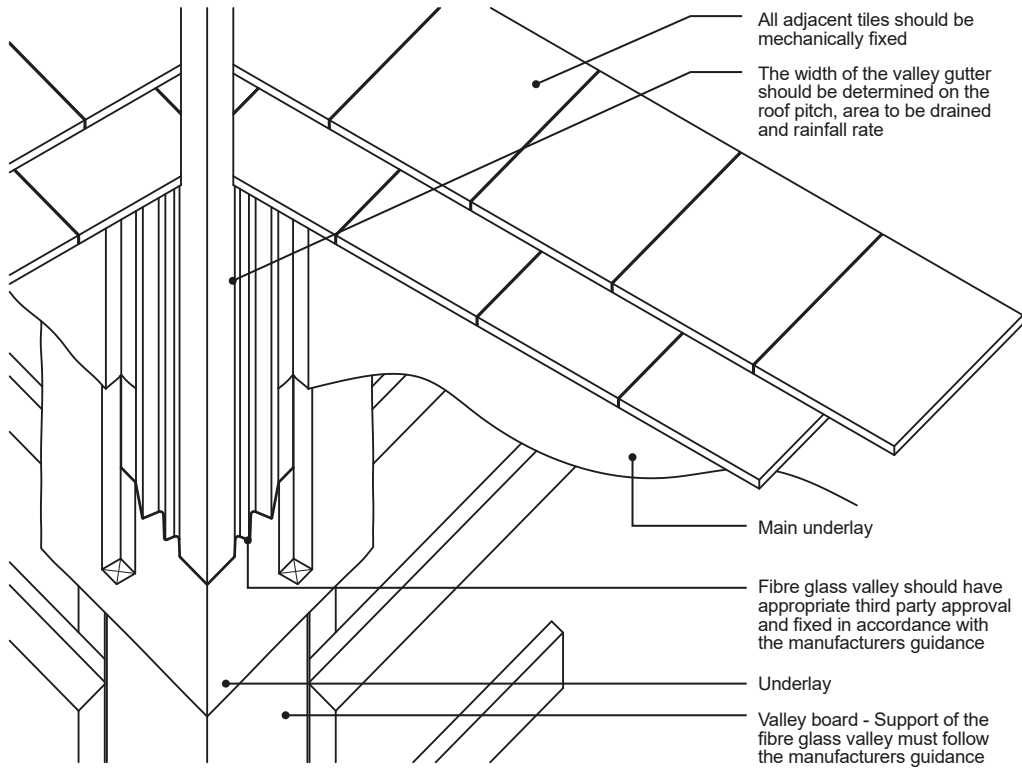
For ridge tiles:

- 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:

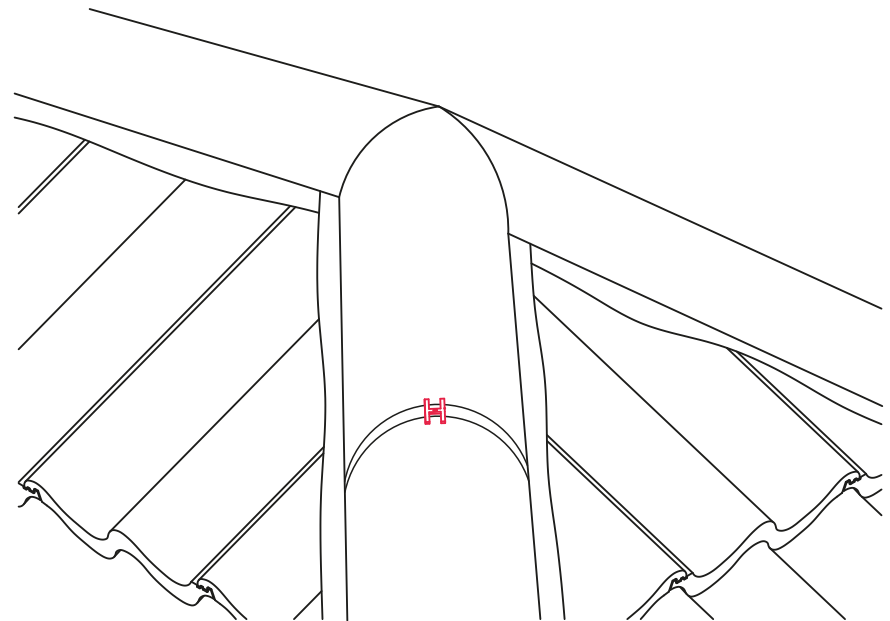
- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure roof structure provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay 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 manufacturer's 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.



### Compartmentation

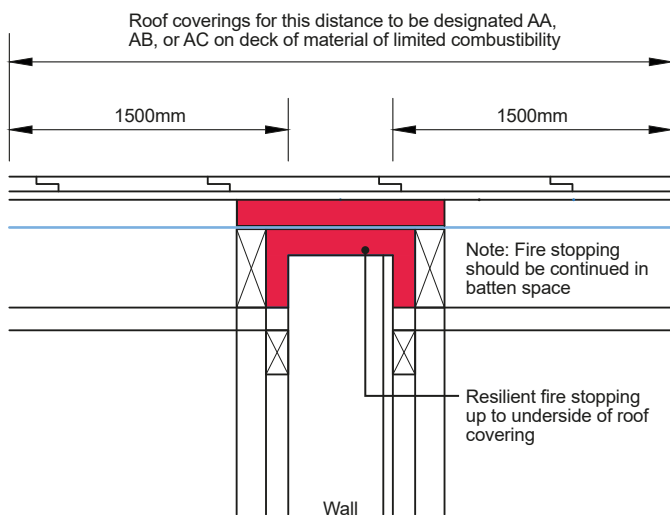
The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed 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.

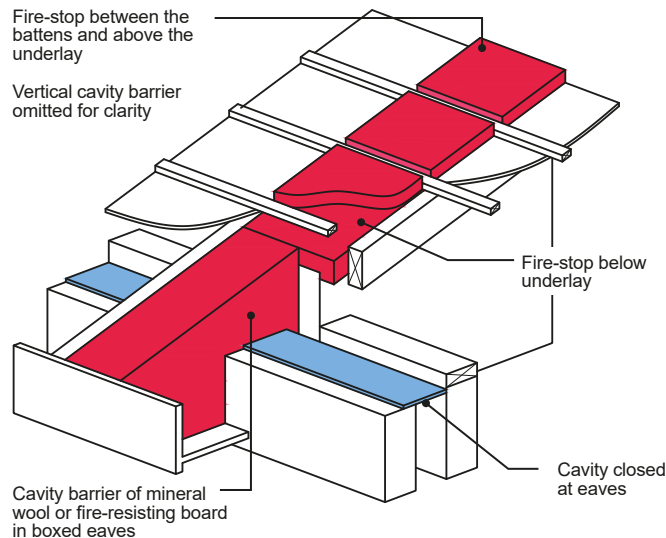
#### Junctions of compartment walls with roof

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 BROOF (t4) to BS EN 13501-5 classification.

Note: AA, AB or AC to BS 476-3 classification on a substrate or deck of a material of limited combustibility can still be used as an alternative in Wales, Scotland and for some products on older projects in England.

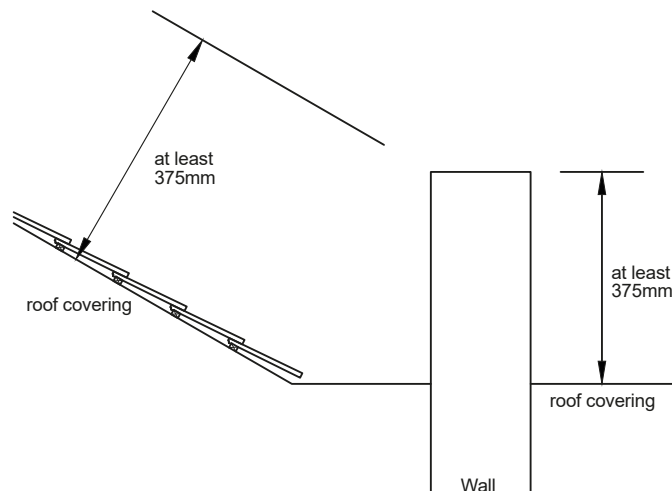


### Fire stopping at roof level between party walls



#### Fire stopping should be provided in accordance with the relevant 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 weatherings 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 weatherings**

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.
- Re-point 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.

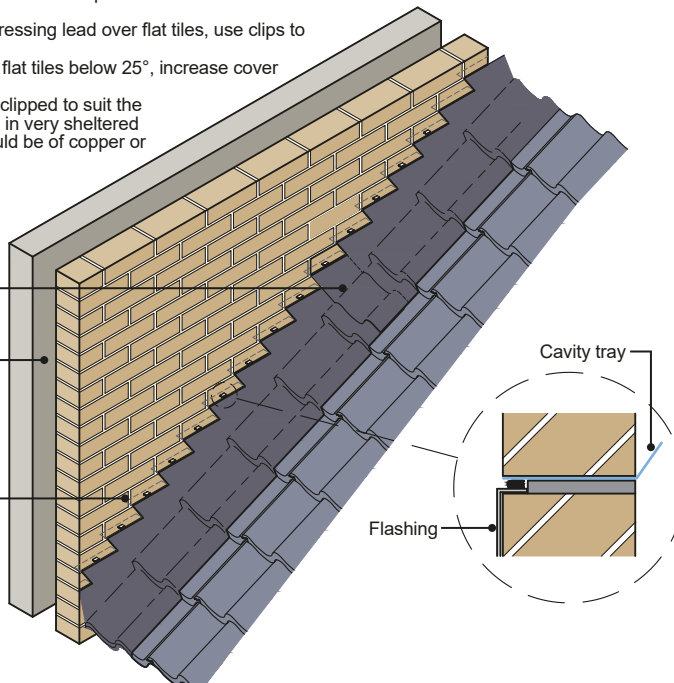
Lap length joint of flashing should be calculated to suit the roof pitch

Cavity brick wall construction shown as an example

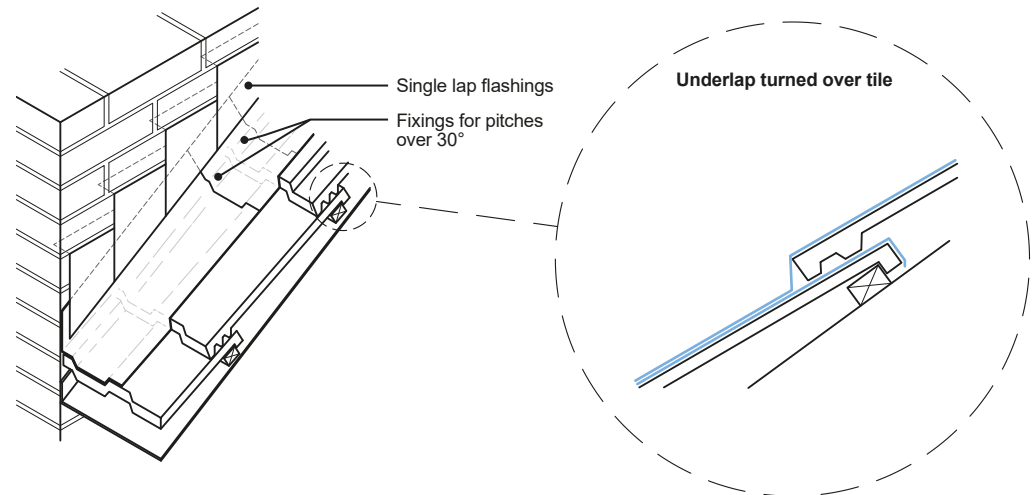
Patination oil is recommended to reduce staining

Ensure flashings are fitted correctly in relation to cavity trays

Single stepped flashings should be used in areas of severe exposure



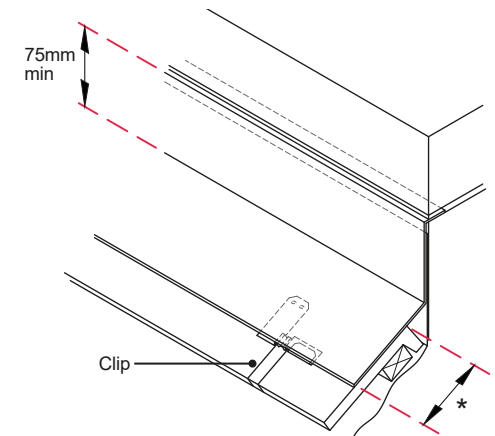
**Single step and cover flashing for areas of severe and very severe exposure**



**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

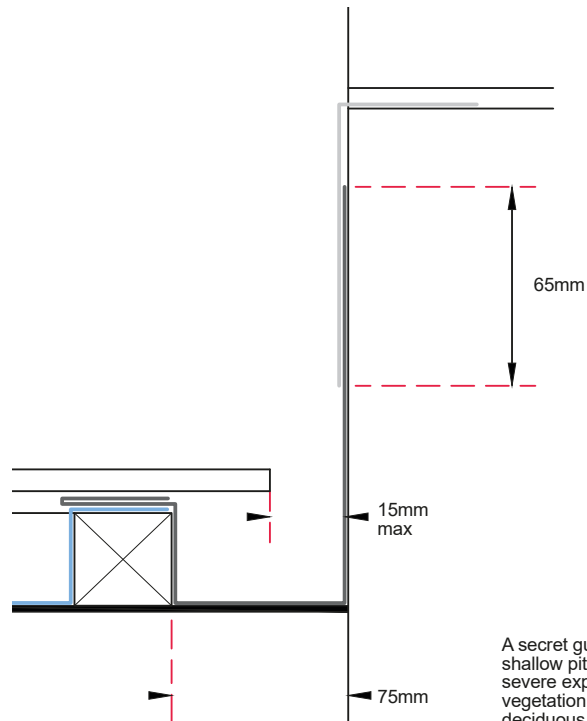
Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited).

### 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.

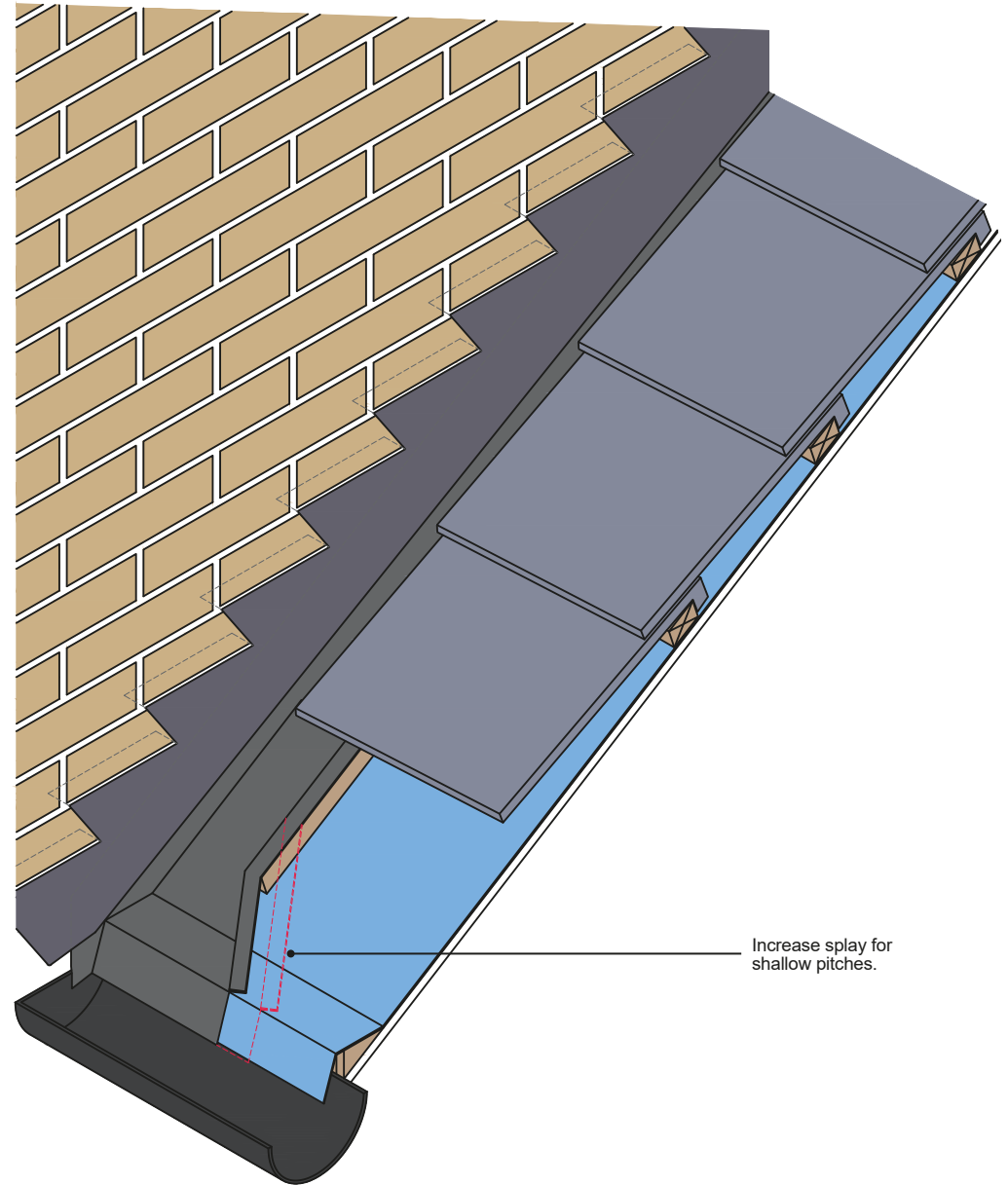
- Form secret gutters before starting tiling.
- Fix a support between the last rafter and the abutment; this should be a minimum of 75mm wide and run the full length of the abutment.
- Fix a splayed timber fillet at the discharge point to raise lead lining to the right height; avoid backward falls.
- 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.

### Typical detail for normal exposure (section)



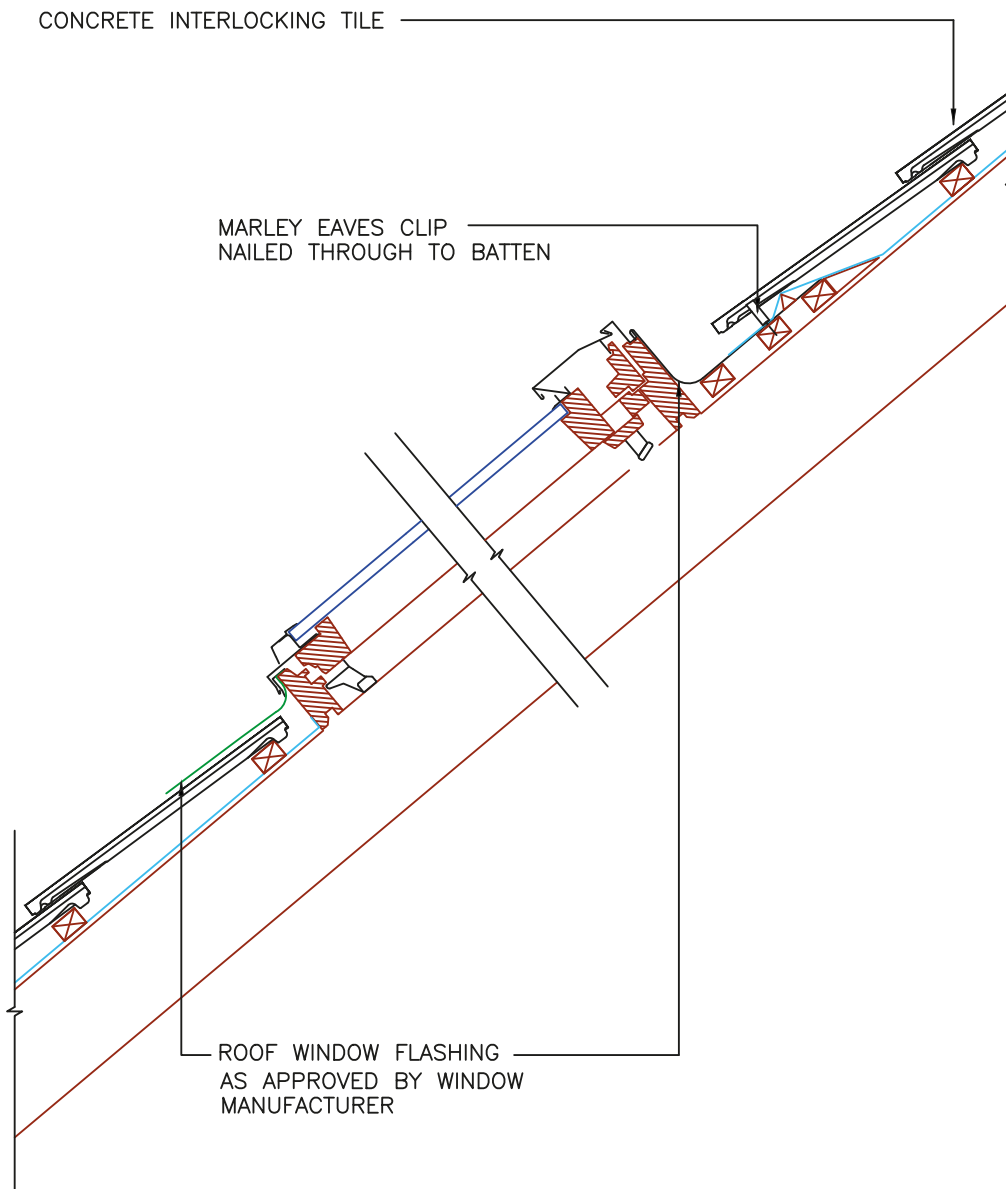
A secret gutter is not recommended for shallow pitches, areas of severe or very severe exposure, or areas where surrounding vegetation may cause risk of blockage e.g. deciduous trees.

### 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 manufacturer's 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 and lap requirements

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.
- 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.

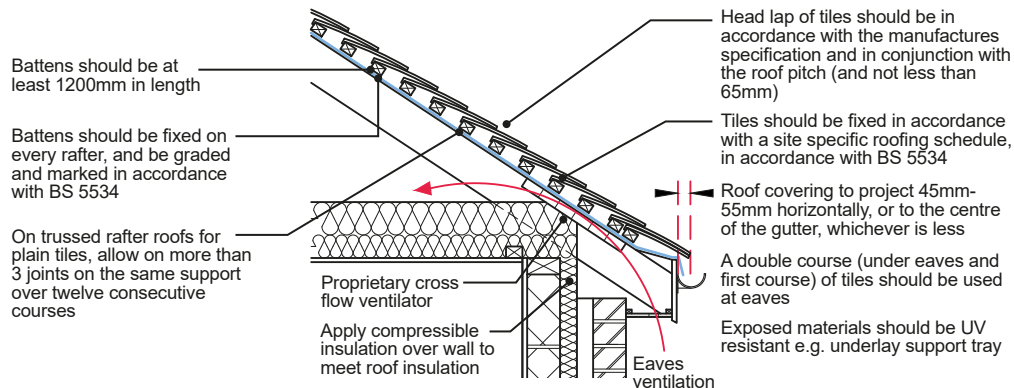
Lap of tiles should be in accordance with manufacturer's specification and in conjunction with the roof pitch.

### 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.

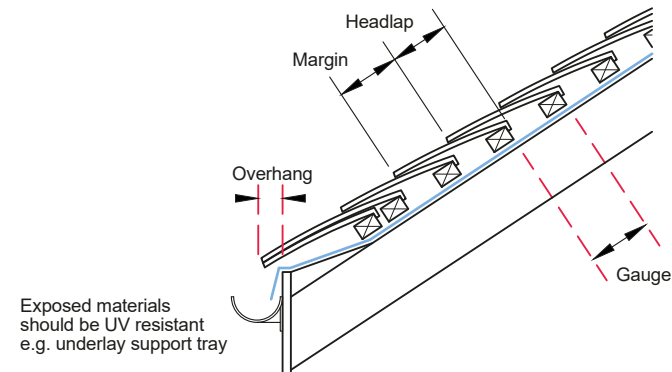
### Tile details - key check points

Eaves and bottom edge (in accordance with BS 5534 and BS 8000-6).

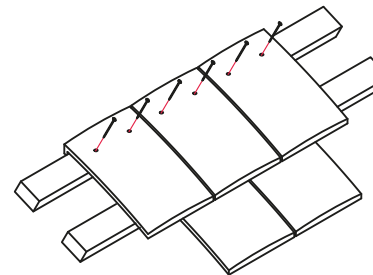
At the eaves (bottom edge), the batten should be set to provide the required overhang of the tiles into the gutters. The recommended overhang is 45mm-55mm horizontally or to the centre of the gutter, whichever is less.

- 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.

### Eaves and bottom edge detail

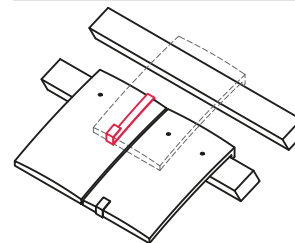


### Nailing tiles to battens



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 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 may need to be utilized to achieve a suitable 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 ribbed 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.

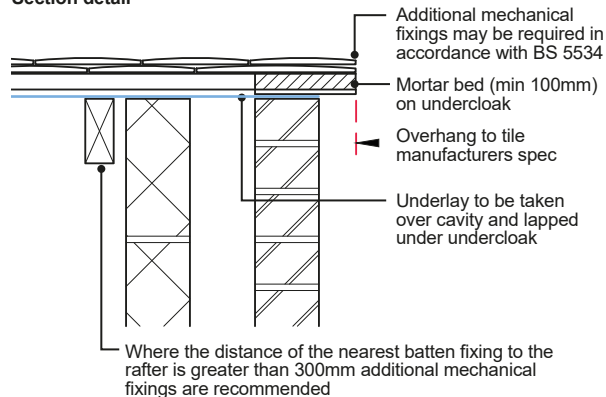
- Use recommended undercloak for mortar.
- Level off irregularities in brickwork.
- Carry underlay over gable wall or bargeboard, and fit undercloak.
- Use the correct mortar mix.
- Bed and point tiles in one operation.
- Keep mortar clear from the ends of tiling battens.
- Fix all perimeter tiles (clip 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.

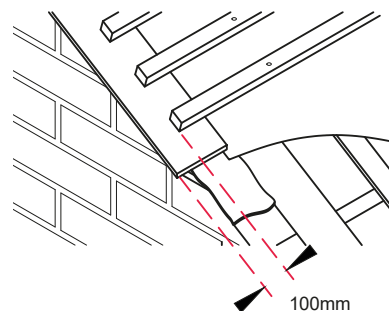
### Verge detail

#### Section detail



For plain tiles:

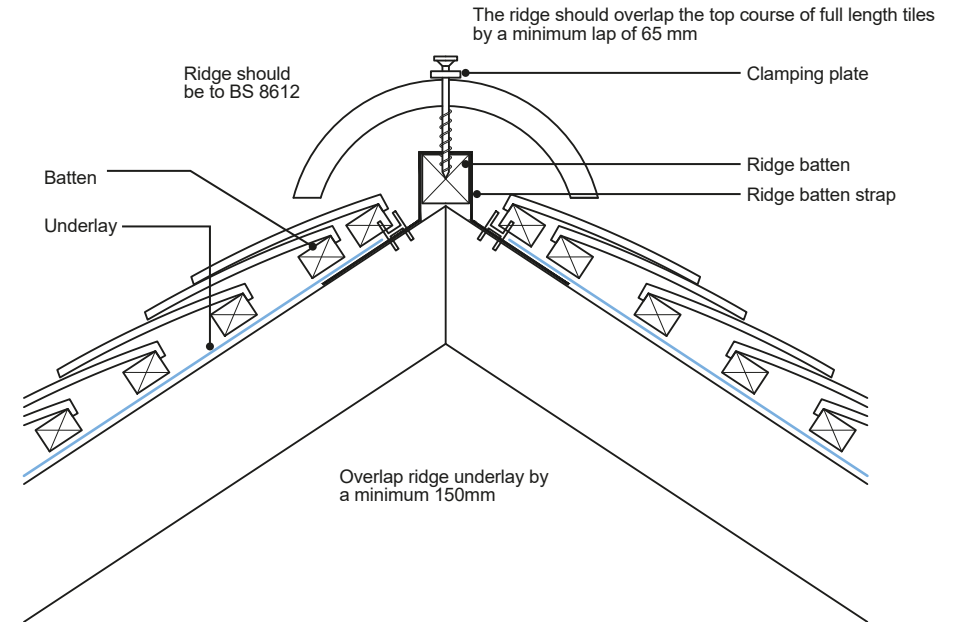
- The verge overhang, when unsupported, should be not less than 38mm and not greater than 50mm
- The verge should be detailed with a tile-and-a-half and a full tile in alternate course



Where proprietary verge tiles or systems are specified the detailing should be in accordance with the manufacturer's 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 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.

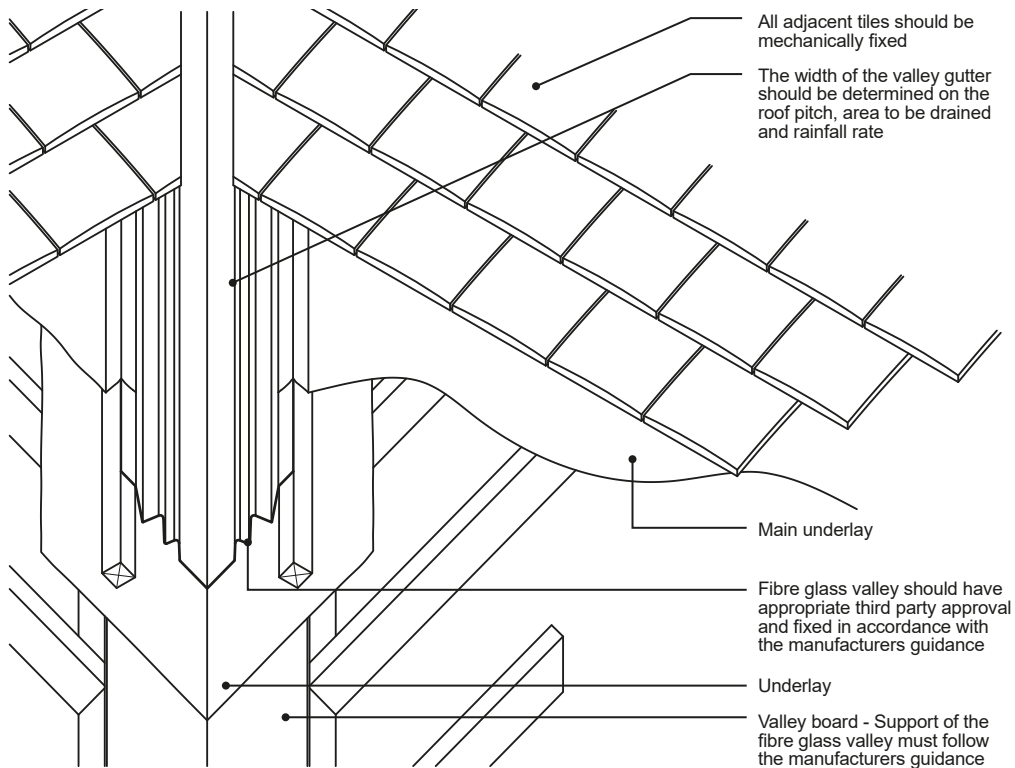
For ridge tiles:

- 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:

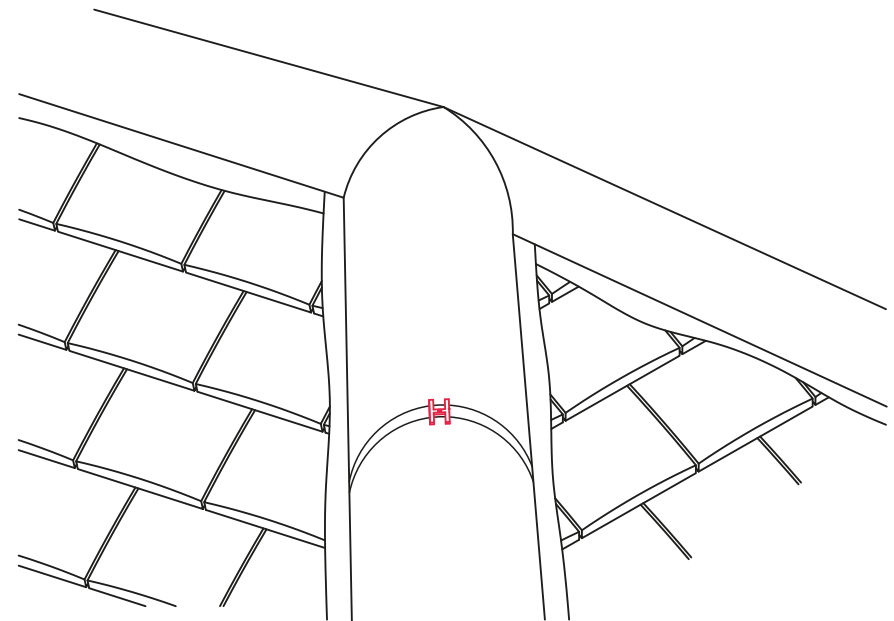
- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure roof structure provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay 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 manufacturer's 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.



### Compartmentation

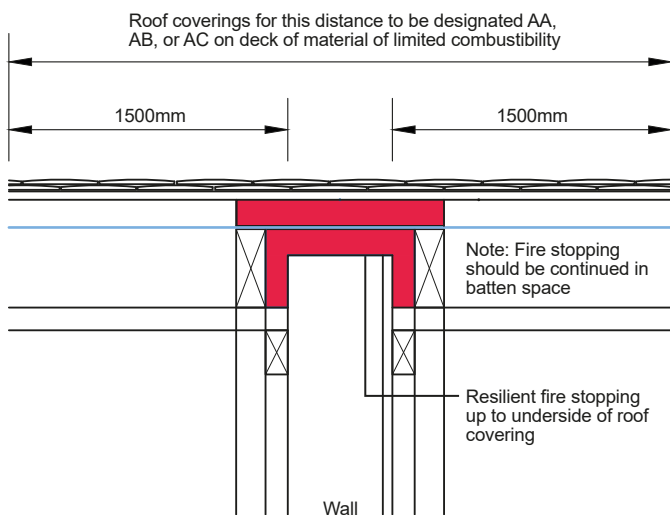
The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed 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.

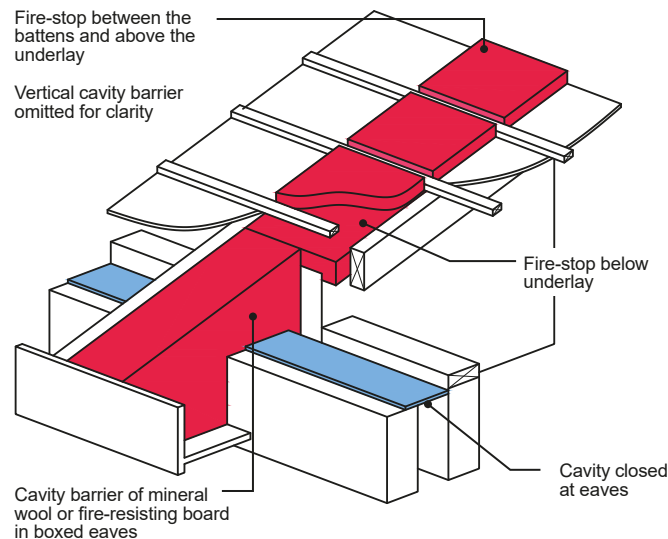
#### Junctions of compartment walls with roof

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 BROOF (t4) to BS EN 13501-5 classification.

Note: AA, AB or AC to BS 476-3 classification on a substrate or deck of a material of limited combustibility can still be used as an alternative in Wales, Scotland and for some products on older projects in England.

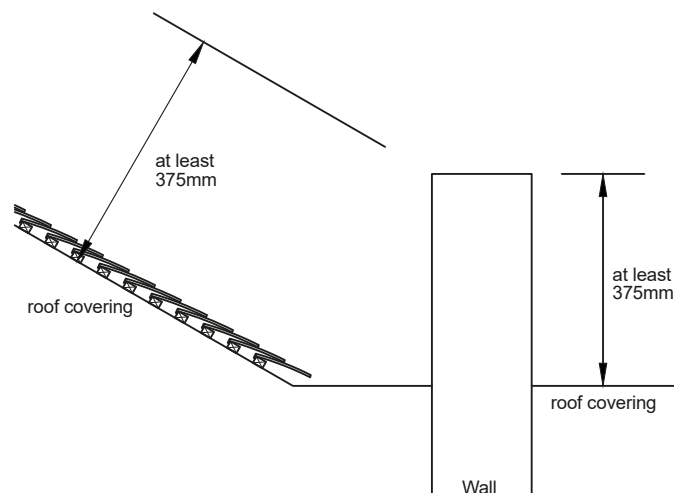


### Fire stopping at roof level between party walls



#### Fire stopping should be provided in accordance with the relevant 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 weatherings 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 weatherings**

The following is a brief summary of metal flashing details.

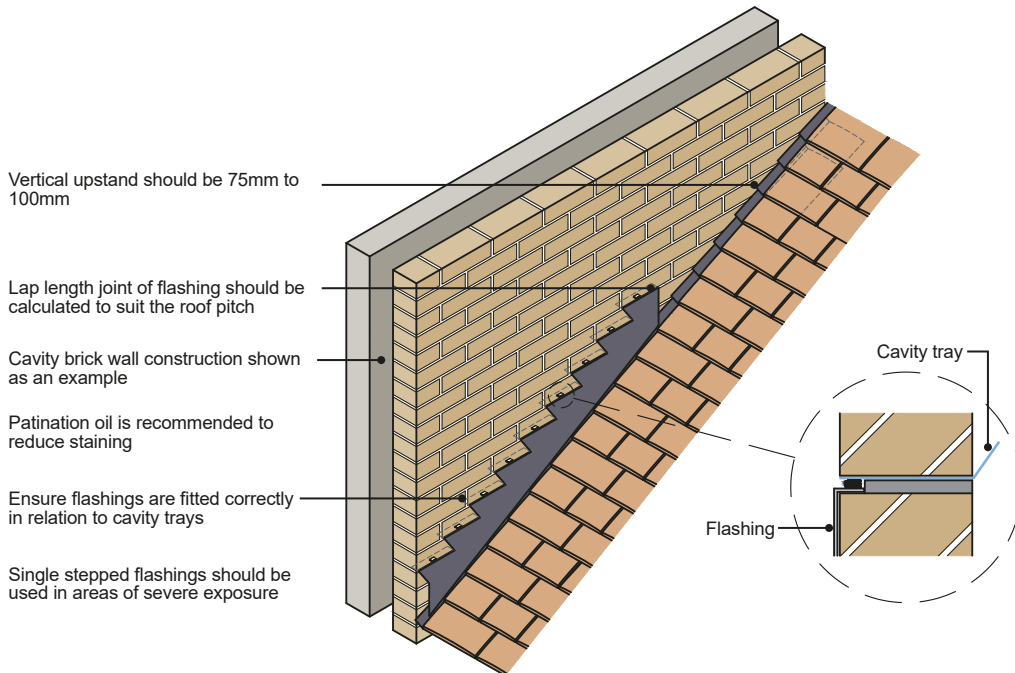
A coat of patination oil should be applied to lead flashings after fixing. Lead can be used in contact with other metals, such as copper and stainless steel, without risk of bimetallic corrosion, but should not be used with aluminium in a marine or coastal environment.

**Side abutments**

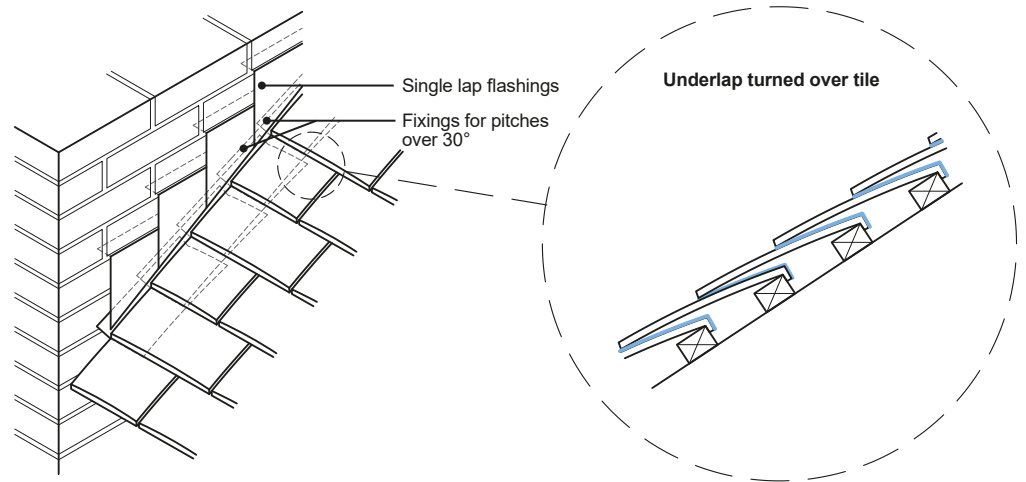
There are three common ways of weathering a side abutment with interlocking tiles; stepped cover flashings, secret gutters and a combination of stepped cover flashing above secret gutter.

**Side abutment (soakers and step flashings)**

- 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.



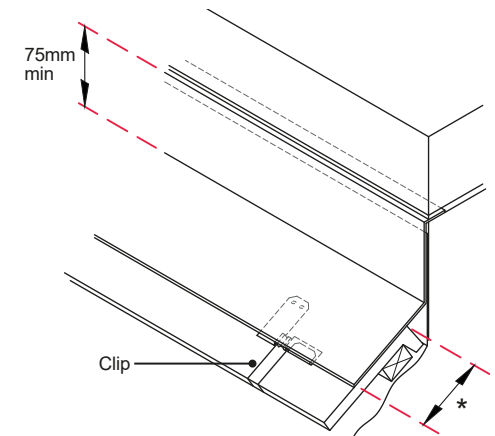
**Single step and cover flashing for areas of severe and very severe exposure**



**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.



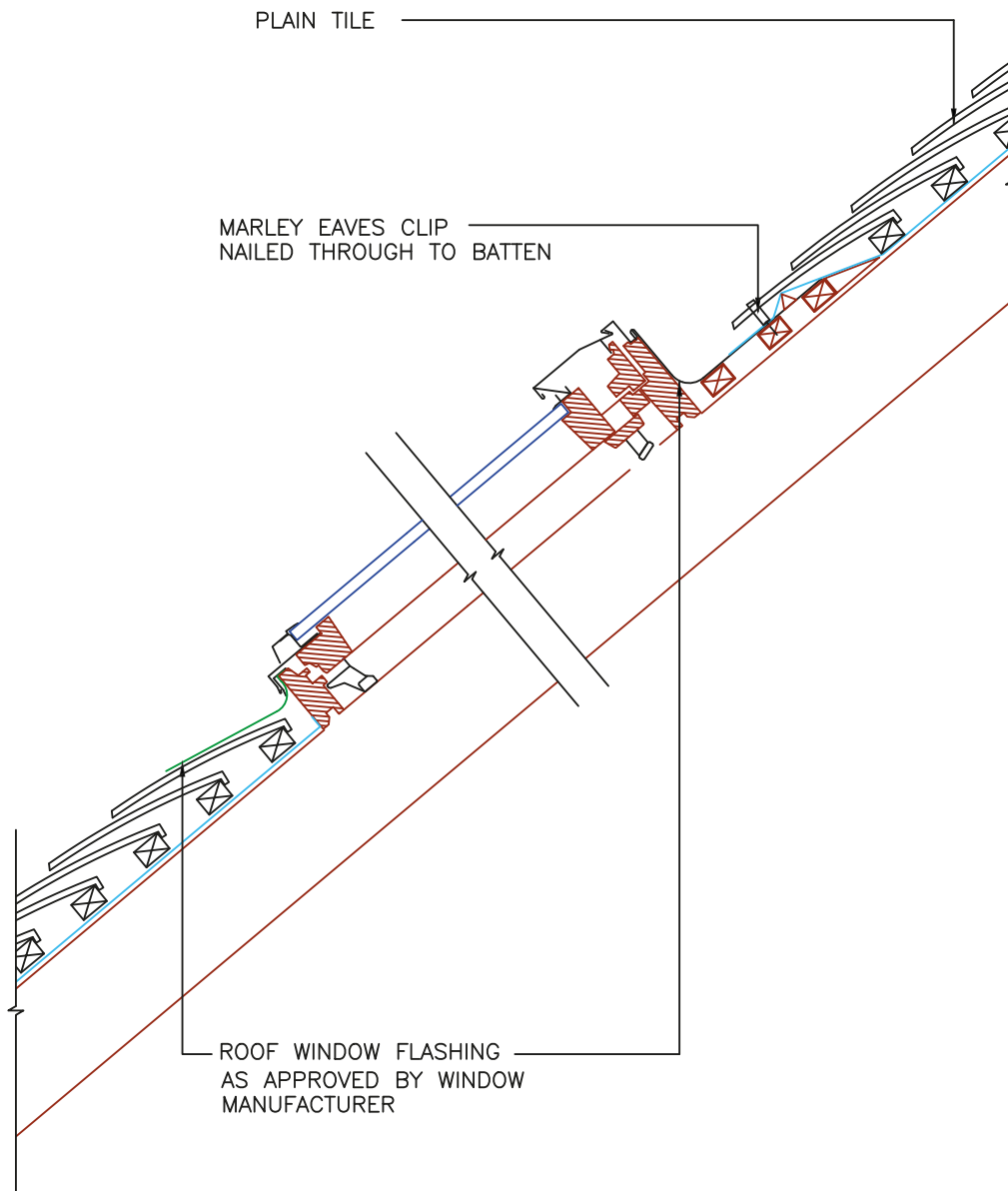
**Minimum lap of the flashing with the roof covering**

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 manufacturer's 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 'Sulphur dioxide Exposure' 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 and lap requirements

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.

Lap of tiles should be in accordance with manufacturer's specification and in conjunction with the roof pitch.

### Wind

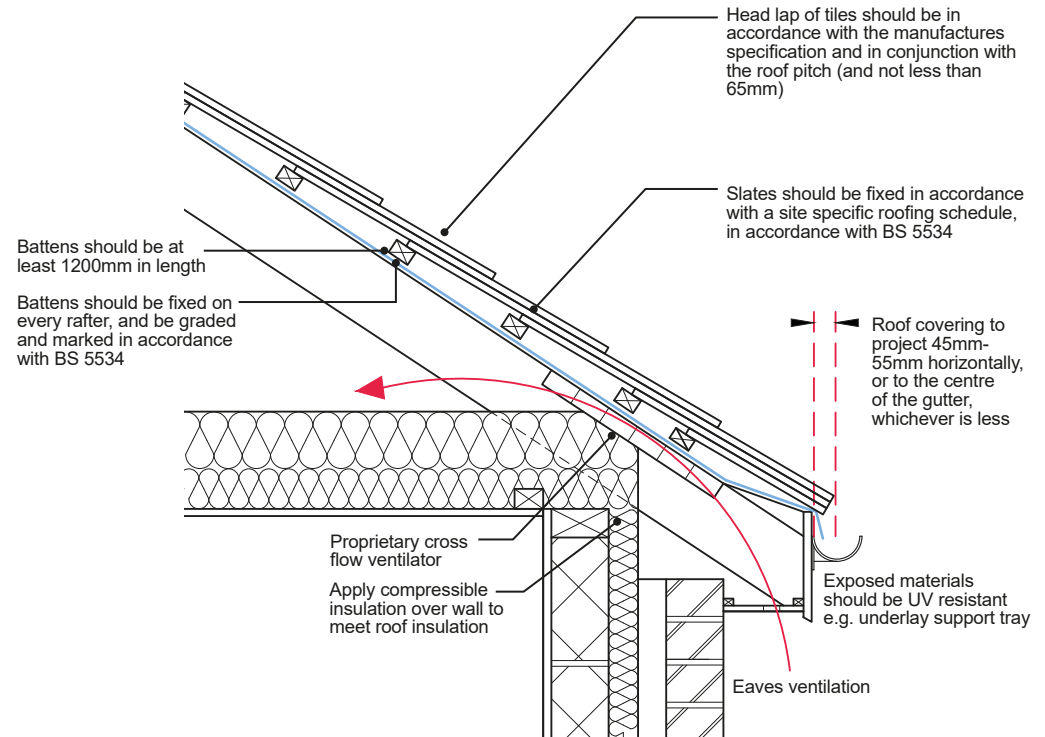
#### Design for wind loading

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.

### 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.

### Roof coverings (battens and tiling)



For trussed rafter roofs where the batten gauge is greater than 200mm, batten joints should be staggered at a ratio of no more than one in four courses on the same support (In accordance with BS 8000-6)

### Workmanship

Slate 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).

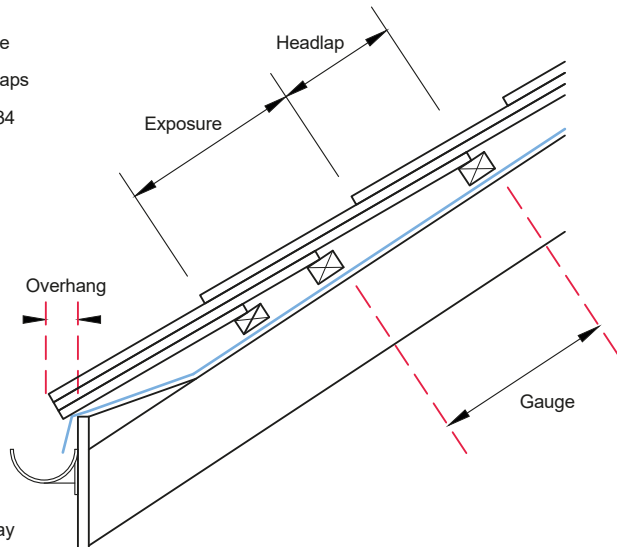
At the eaves (bottom edge), the batten should be set to provide the required overhang of the slates into the gutters.

The recommended overhang is 45mm-55mm horizontally or to the centre of the gutter, whichever is less.

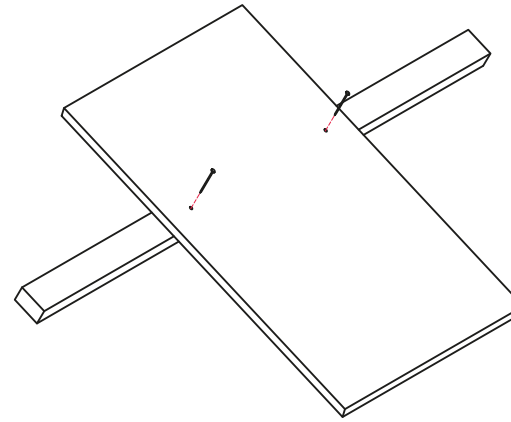
- Ensure fascia board is to correct height so as to prevent tiles/slates kicking up or drooping.
- Fit duct trays to retain insulation.
- Fix underlay protector trays, fascia vents and comb fillers (profiled tiles).
- Clip eaves course where required.
- Ensure vent path to roof space is achieved.
- Ensure exposed materials are UV resistant.

### Eaves and bottom edge detail

The top edge of the slate should be supported on battens. Side and headlaps should be calculated in accordance with BS 5534

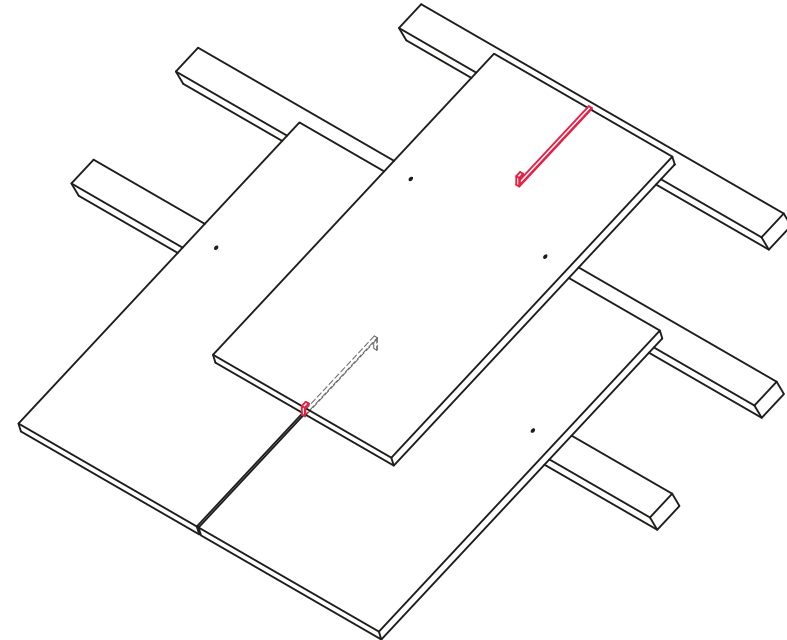


### Slate nails and rivets



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



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.

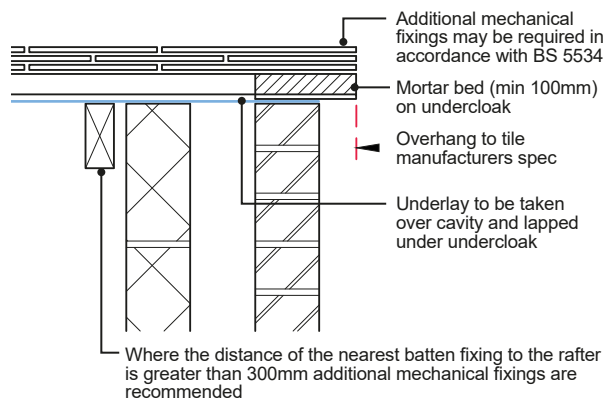
- Use recommended undercloak for mortar.
- Level off irregularities in brickwork.
- Carry underlay over gable wall or bargeboard, and fit undercloak.
- Use the correct mortar mix.
- Bed and point tiles in one operation.
- Keep mortar clear from the ends of tiling battens.
- Fix all perimeter slates (clip 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

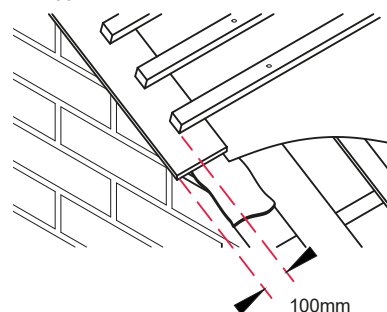
Where an undercloak is used it should comprise plain tiles, slates or fibre cement sheet strip. It is usually fixed at verges beneath the battens and on top of the underlay to support the mortar onto which the slates are bedded, if batten ends are cut, treat with a suitable preservative. A 100mm wide bed of fully compressed width should be neatly laid on the undercloak, this should be bedded solidly and finished neatly.

### Verge detail

#### Section detail



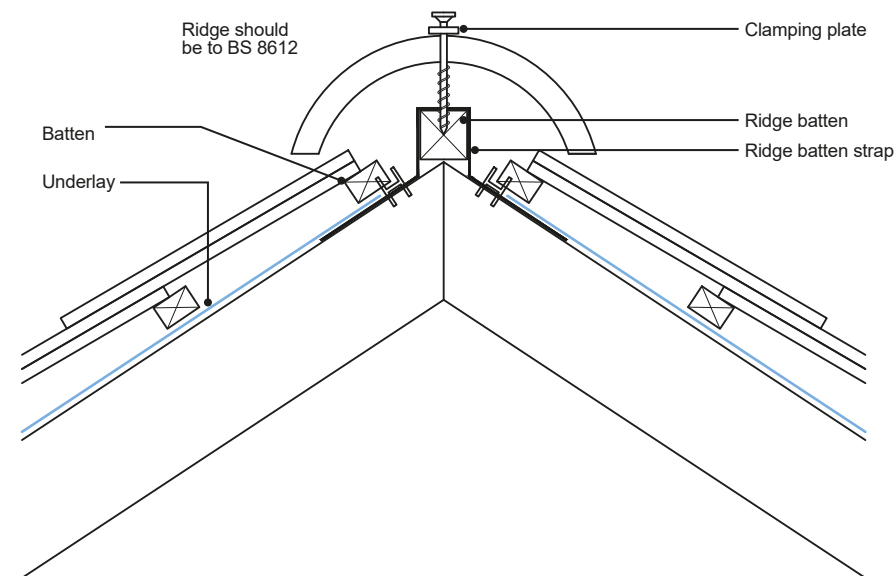
Note: the verge overhang, when unsupported, should be not less than 38mm and not greater than 50mm.



Where proprietary verge tiles or systems are specified the detailing should be in accordance with the manufacturer's 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.

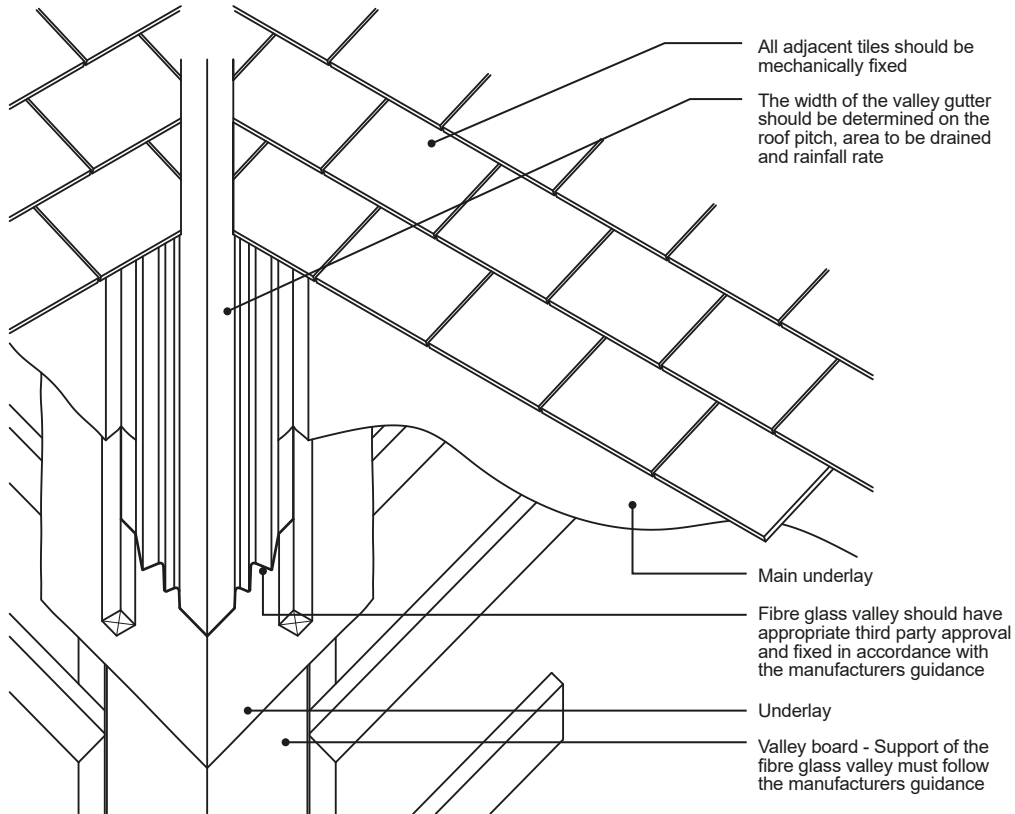
For ridge tiles:

- 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:

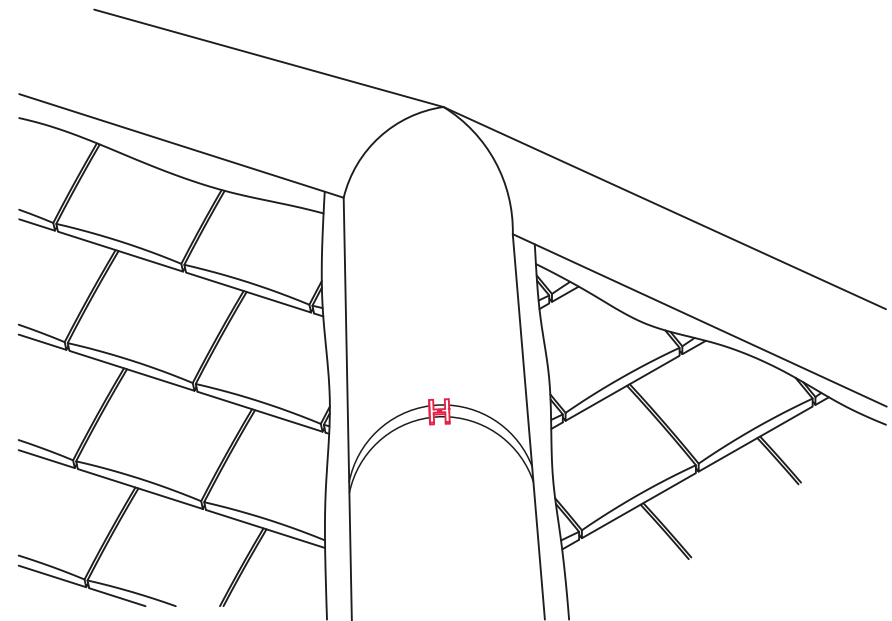
- Check roof pitch, area to be drained and rainfall rate to determine width of valley gutter.
- Consider length of valley when choosing proprietary valley troughs (over 8m).
- Ensure roof structure provides adequate support for valley lining; make flush with top of rafter.
- Do not place bitumen underlay 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 manufacturer's 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.



### Compartmentation

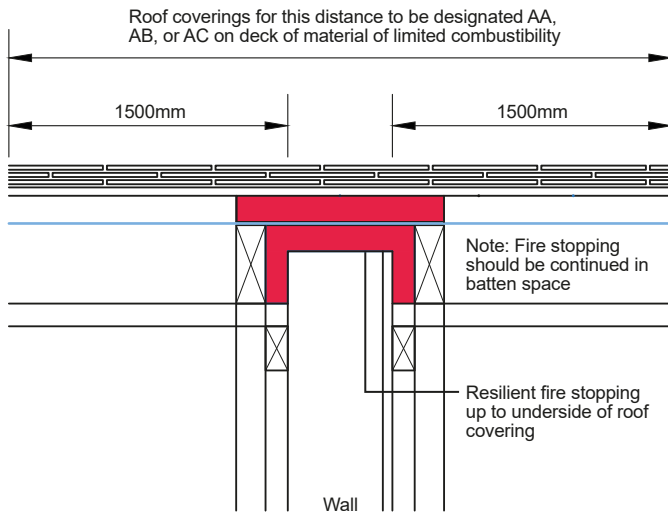
The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire-resisting construction. The roof void, like most spaces within a building, can provide a route for the spread of fire and smoke. As an often-concealed 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.

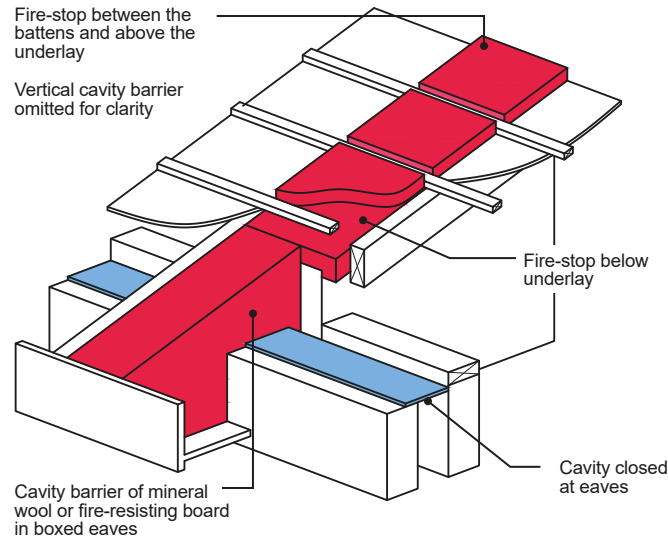
#### Junctions of compartment walls with roof

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 BROOF (t4) to BS EN 13501-5 classification.

Note: AA, AB or AC to BS 476-3 classification on a substrate or deck of a material of limited combustibility can still be used as an alternative in Wales, Scotland and for some products on older projects in England.

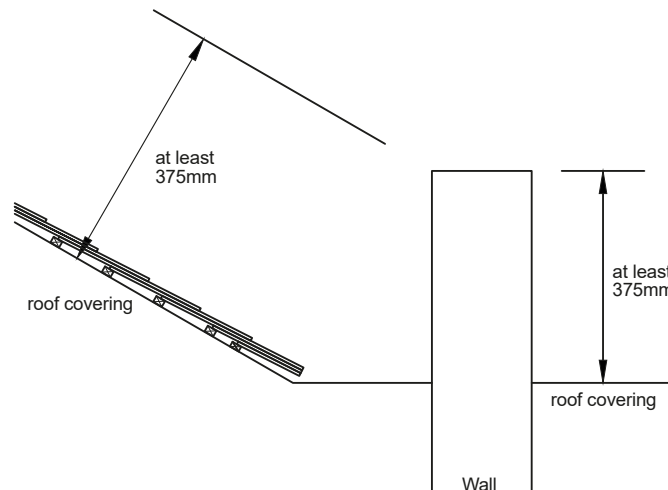


### Fire stopping at roof level between party walls



#### Fire stopping should be provided in accordance with the relevant 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 weatherings 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 weatherings**

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.

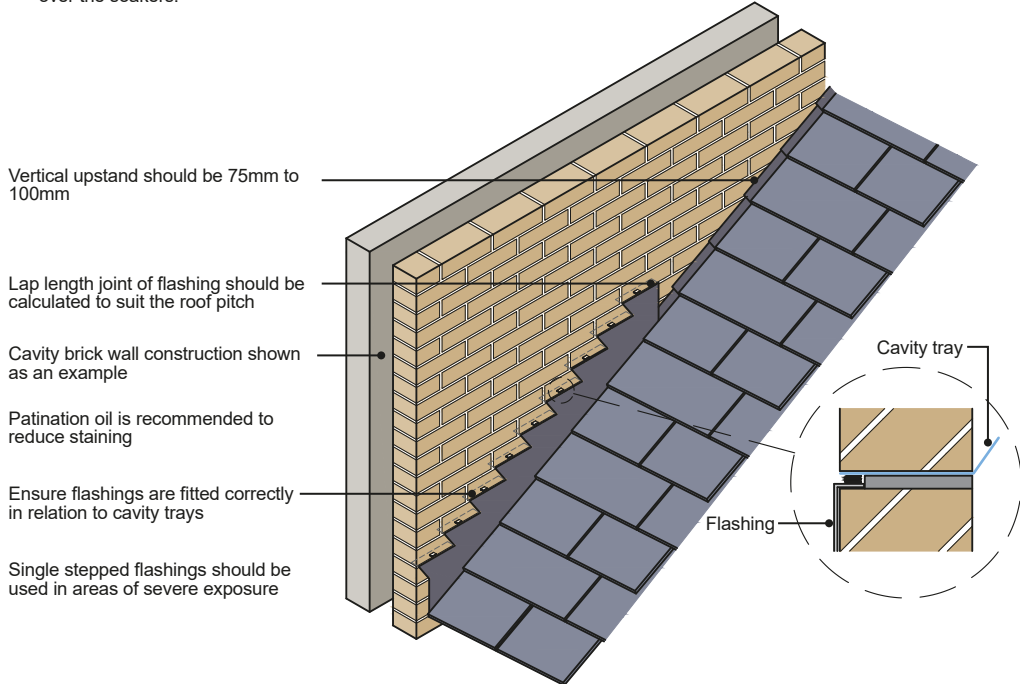
**Side abutments**

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.

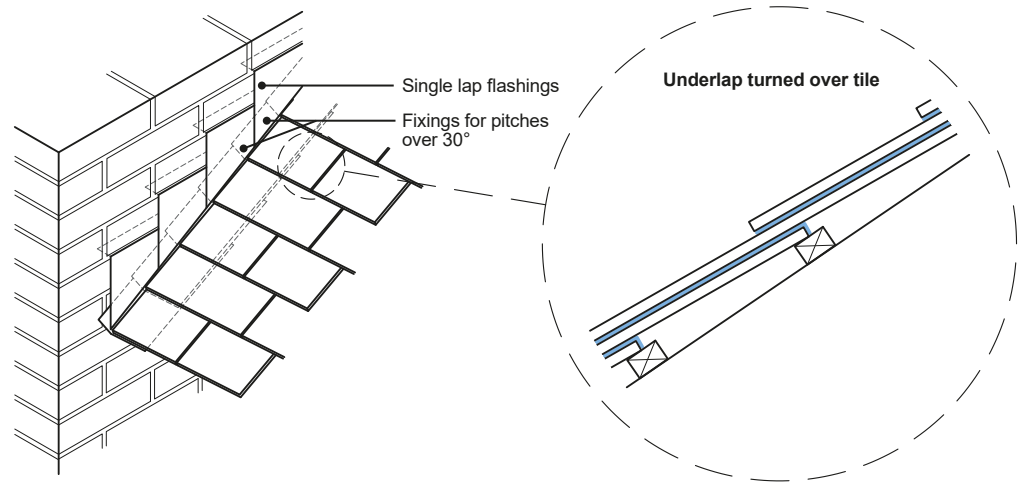
**Fibre cement and natural slates**

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.



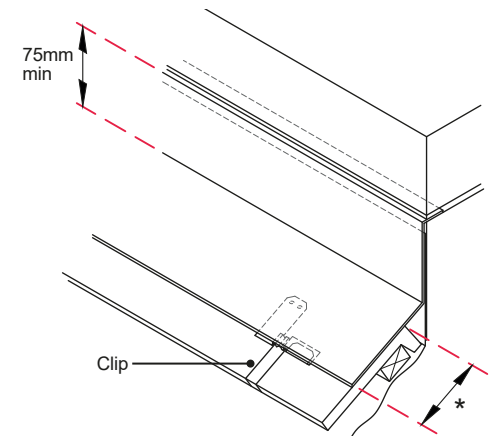
**Single step and cover flashing for areas of severe and very severe exposure**



**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

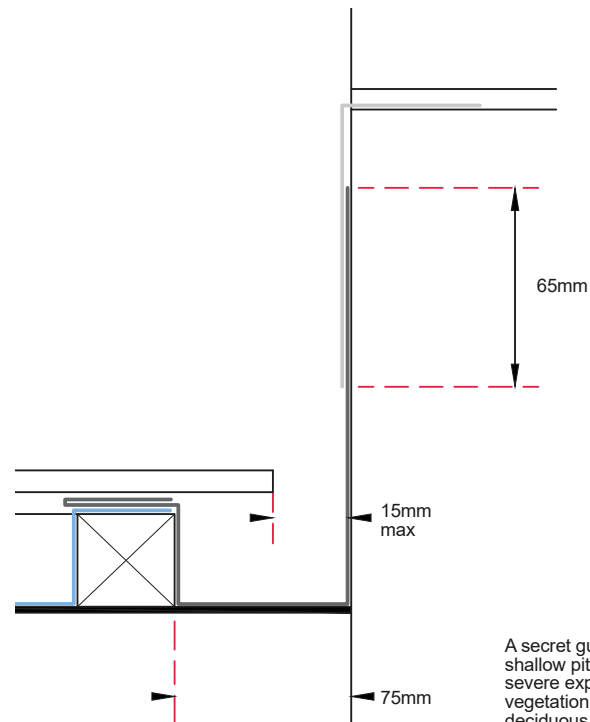
Drawings and guidance provided in conjunction with Calder Lead (Calder Industrial Materials Limited).

### 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.

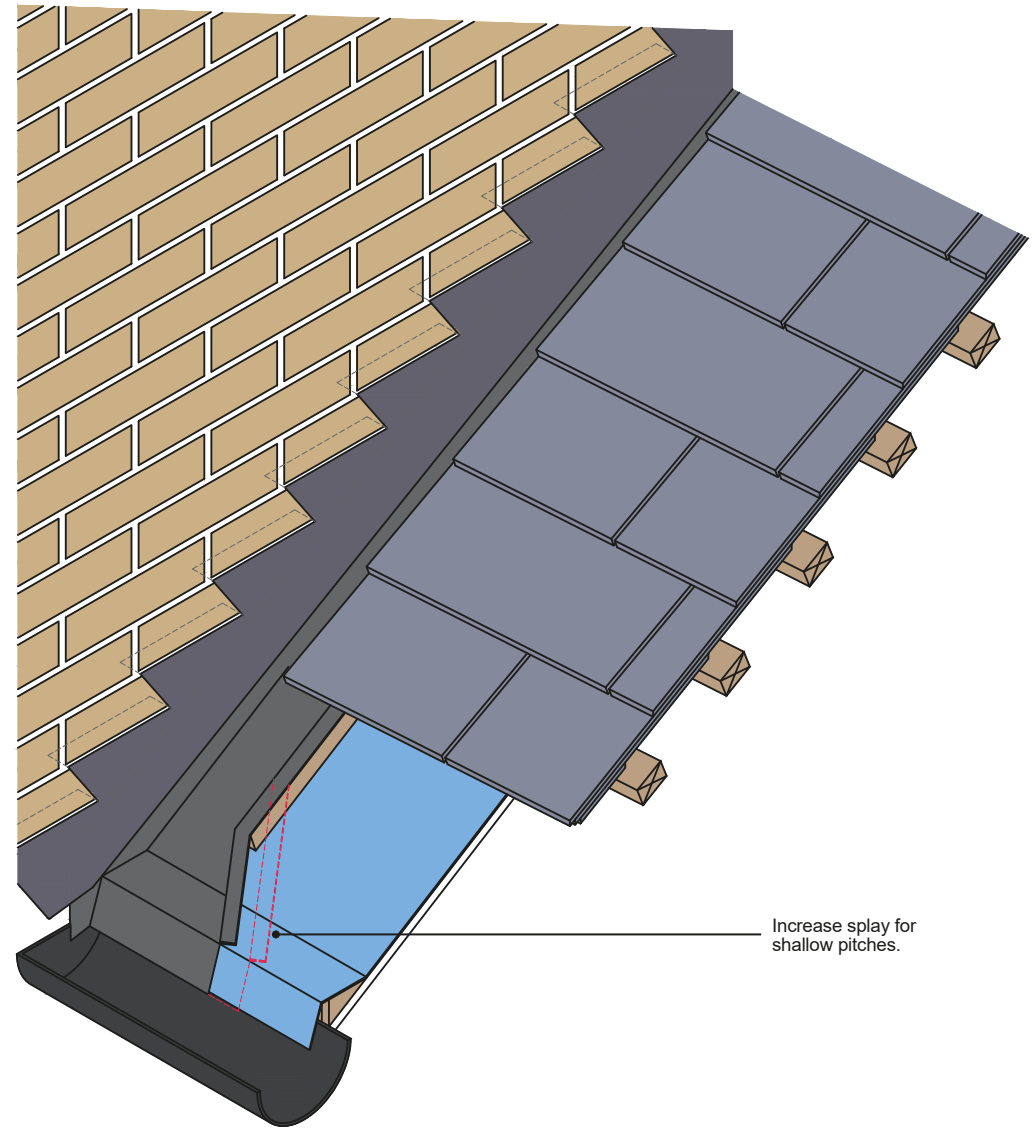
- Form secret gutters before starting tiling.
- Fix a support between the last rafter and the abutment; this should be a minimum of 75mm wide and run the full length of the abutment.
- Fix a splayed timber fillet at the discharge point to raise lead lining to the right height; avoid backward falls.
- 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 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)



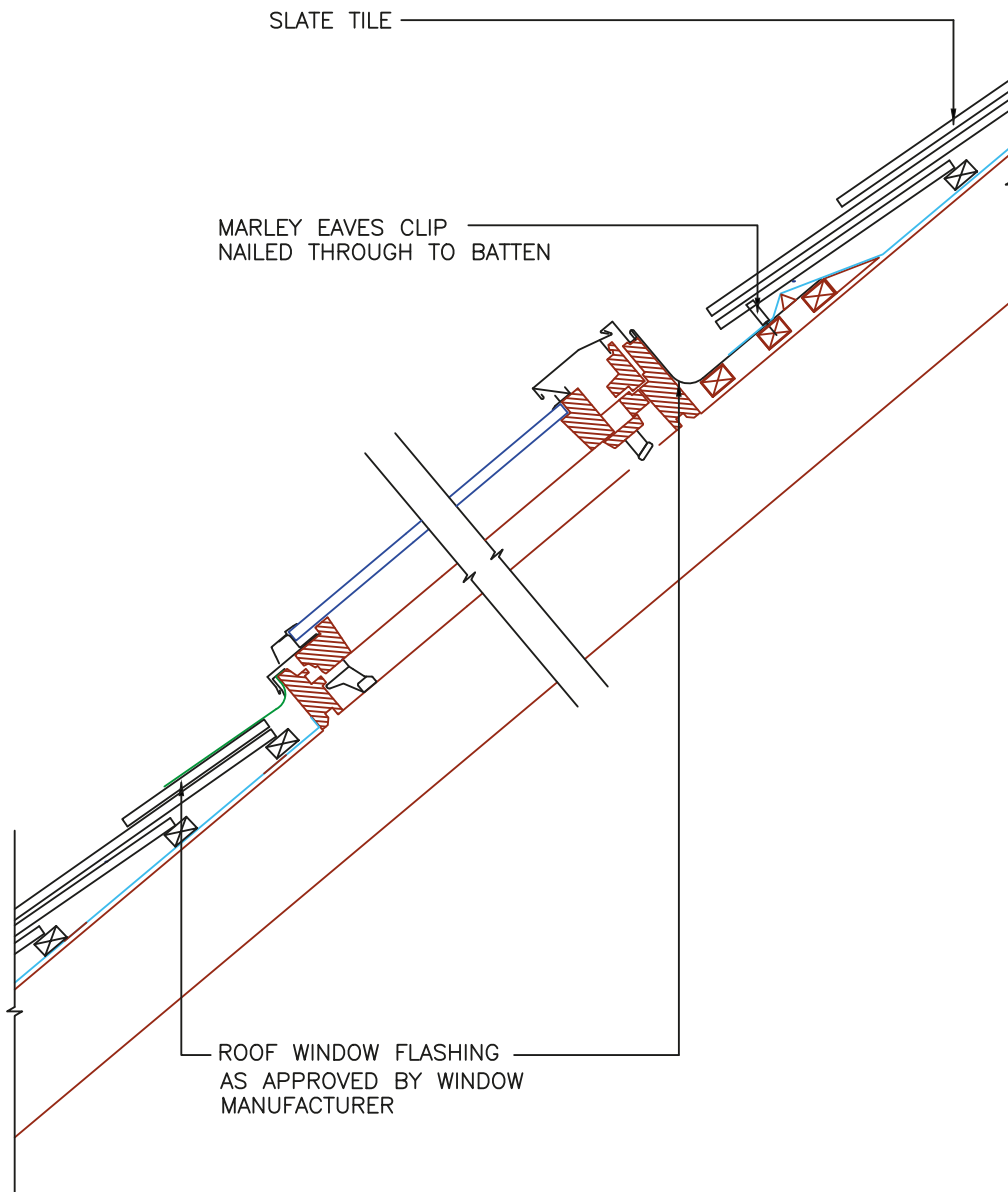
A secret gutter is not recommended for shallow pitches, areas of severe or very severe exposure, or areas where surrounding vegetation may cause risk of blockage e.g. deciduous trees/leaf fall.

### 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 manufacturer's 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

### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. This may include:

- A full set of detailed drawings including:
  - Roof plan showing direction of falls and position of outlets and overflows
  - Sections showing roof build up and how falls are to be created. Sectional details should show all components to be used in flat roof build up (insulation type and thickness, vapour control layer, waterproofing membrane/layers etc.)
  - Site specific detailing for all junctions, outlets and penetrations
- Details of all components to be used in the construction of the flat roof should be provided
- Engineers drawings and calculations for the roof structure
- Third party accreditation for the waterproofing membrane/layer
- Details of all fixings, their frequency and fixing method, including those for insulation and surfacing. Fixing methodology should be supported by appropriate wind uplift calculations.
- Details of all fire stopping which should include specification and a detailed location layout drawing showing positioning of all fire stopping.
- Outline of method and plan for testing the integrity of the waterproofing layer.
- A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.
- A roof deflection analysis should be provided for medium to large roofs, those with complex roof layouts and for any roof areas that carry items of plant or are subject to access provisions beyond periodic maintenance of the roof area.

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### 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 10° 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.

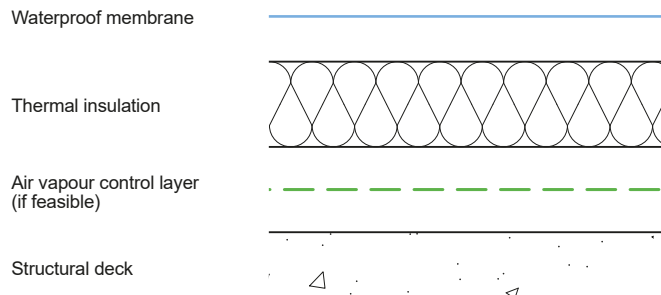
**Water control membrane (WCM):** construction material (usually a sheet membrane) that substantially reduces the transfer of rain water to the insulation in an inverted warm deck roof.

### 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:

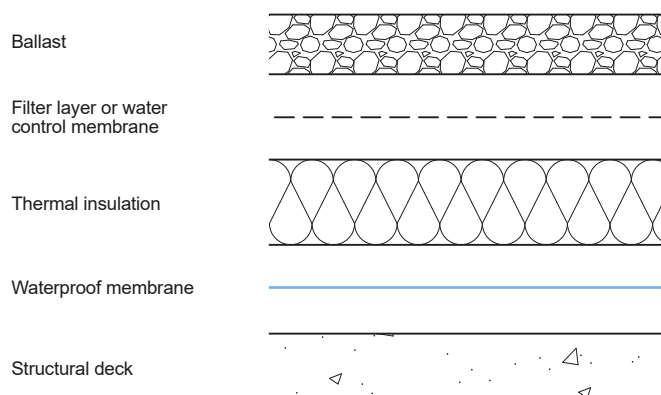
- The waterproof membrane has sufficient resistance to temperature to suit the conditions created by a substrate of insulation.
- The insulation has sufficient mechanical characteristics to resist loading.
- The AVCL is provided by the deck or by a membrane placed above the deck.
- The structural deck 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'.

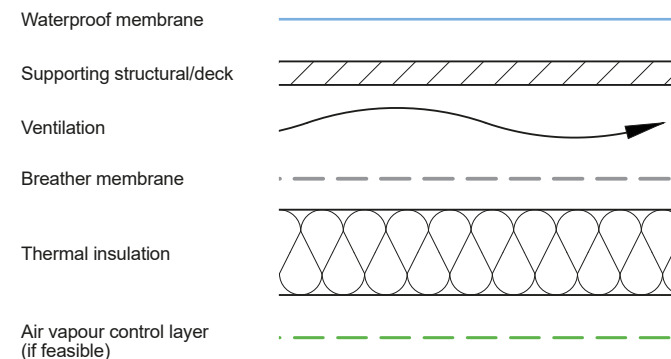
There is an increased risk of interstitial condensation with a hybrid roofs and therefore where these types of roof systems are used a full condensation risk analysis should be carried out.

### Cold deck roof

Cold deck roofs are not recommended and an alternative form of flat roof should be adopted.

Where allowed under the Functional Requirements (roof areas less than 3m<sup>2</sup>), the following approach to cold deck roofs 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 relevant 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 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

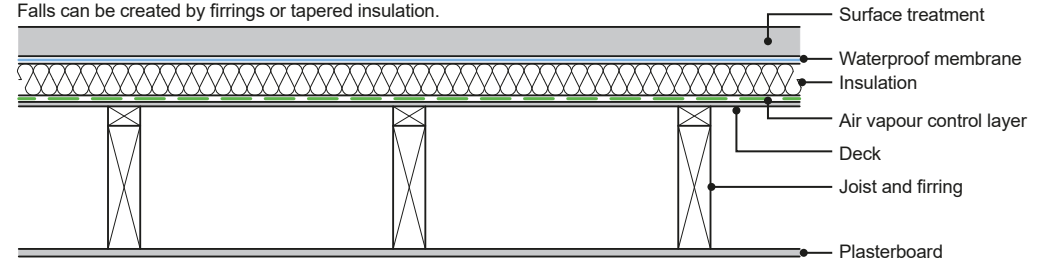
Preservative treatment of roof timbers is normally unnecessary, except where specifically required under relevant standards and Codes of Practice further information can be found in 'Appendix C - Materials, Products, and Building Systems'.

### Insulation of warm decks

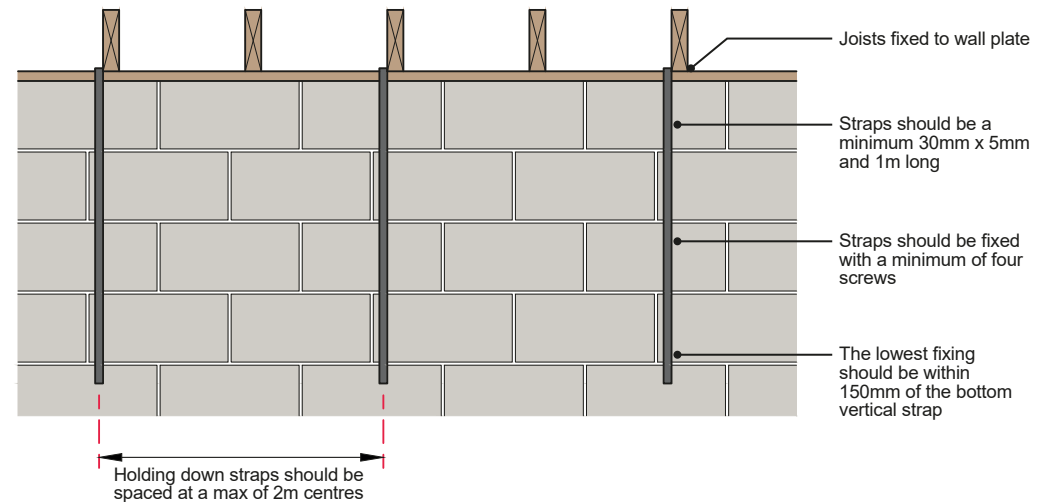
The insulation should be suitably specified taking into account the roof type, having regard to its load-bearing capacity and, where relevant, its water absorption characteristics. Compressible materials cannot support imposed loads and their use in flat roofs is limited to cold flat roofs - which are 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

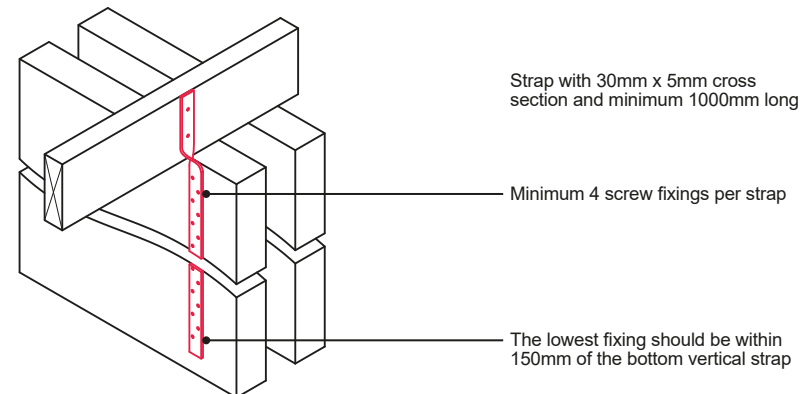
Falls can be created by firrings or tapered insulation.



### 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 firing 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.

Pre-treated timber planking, tongue and groove (close boarded timber) should have a minimum thickness of 19mm. Suitable floor boards and decking include:

- Pre-treated 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.

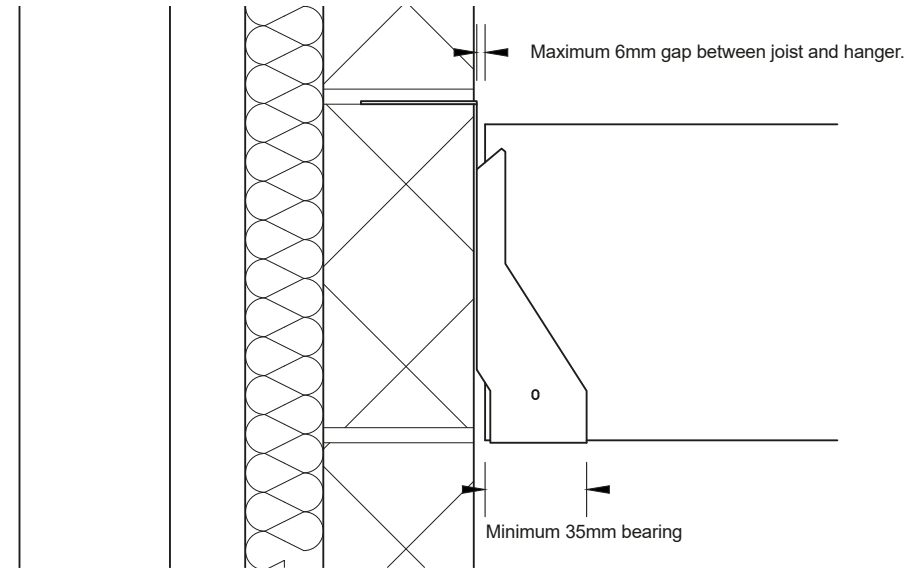
All fixings should be a minimum of 50 mm or 2 times the thickness of the board, whichever is greater; and the diameter of the fixing should be a minimum of 0.16 times the thickness of the board.

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 sherardized steel, austenitic stainless steel, phosphor bronze and silicon bronze.

### Joist hanger bearing

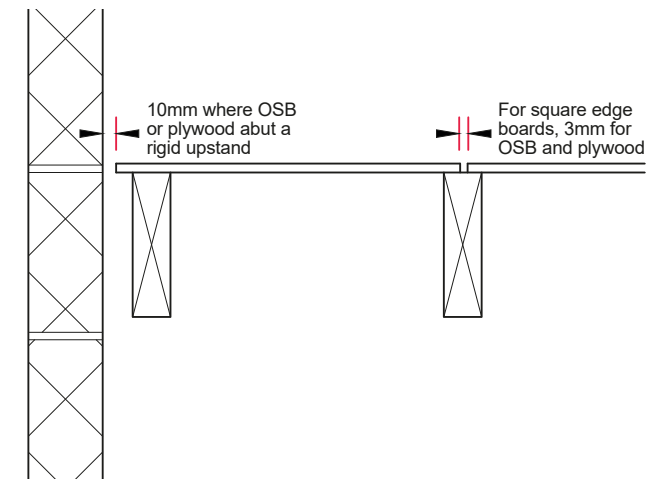
Joist hangers should be:

- In accordance with BS EN 845.
- The correct size for the timber joist or trimmer.
- Fixed in accordance with the design.

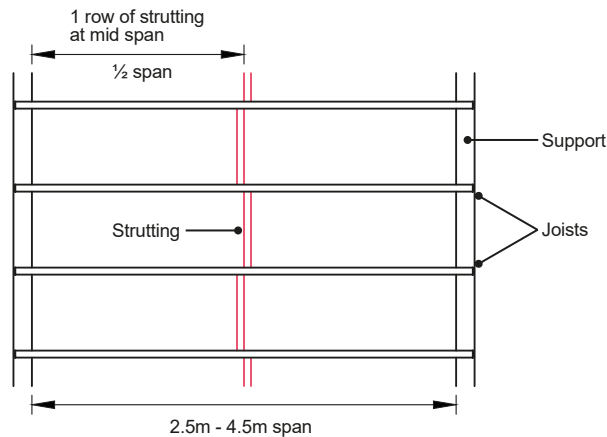


### Allowance for expansion at ridged abutments

- OSB should be installed at the direction indicated on the boards with the strongest direction perpendicular to the joists.
- 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.
- 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 noggings at the perimeter where they run at right angles to roof joists.

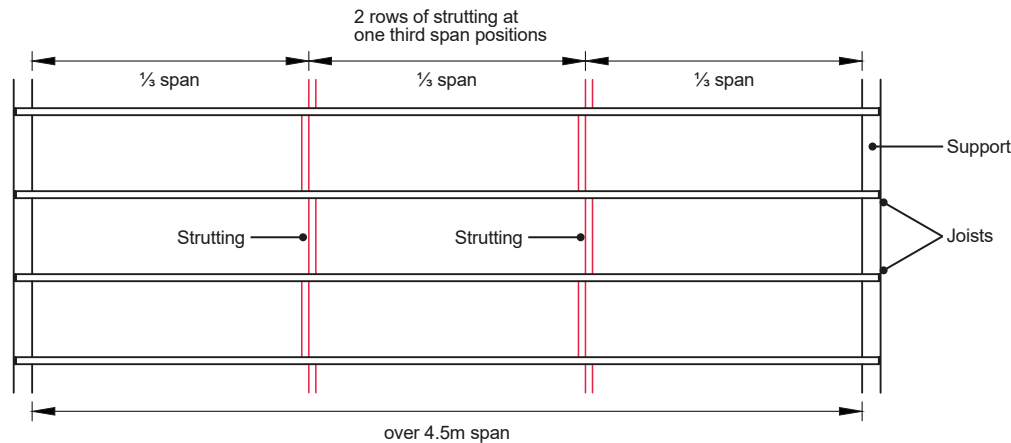


**Strutting of joists with a span between 2.5m and 4.5m**



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

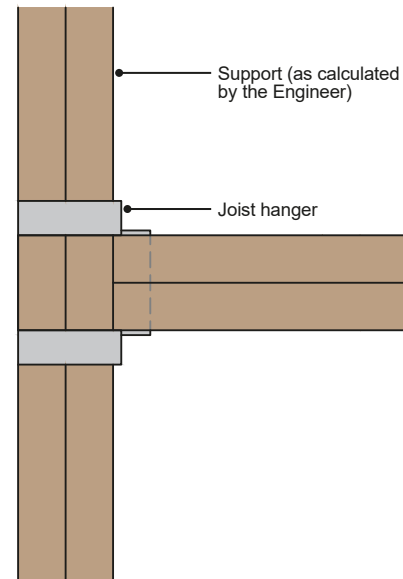
**Strutting or bridging of solid timber roof joists**

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 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)**

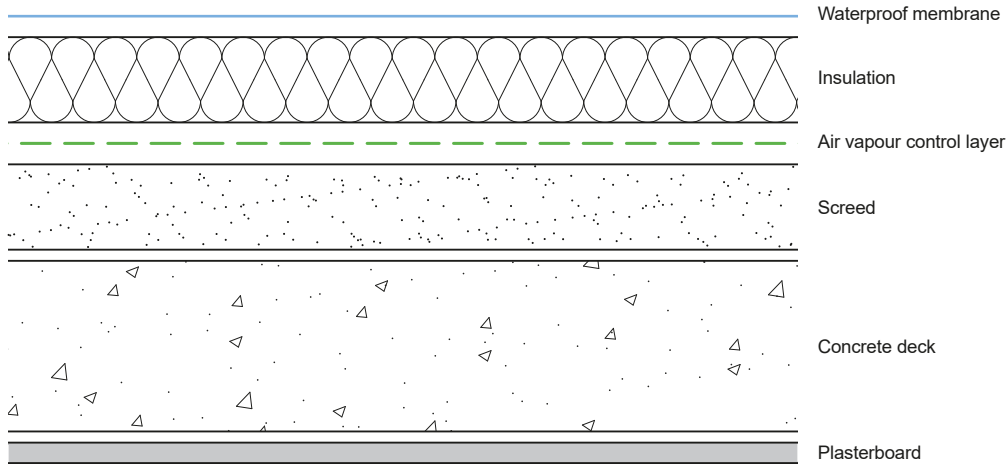


Double joists should be bolted together at 600mm centres using minimum 10mm diameter bolts with large washers that will prevent the bolt head and nut from penetrating the joist. It is recommended that the bolting of double joists is along the centre line of joists. Suitably sized trimmer joists shall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

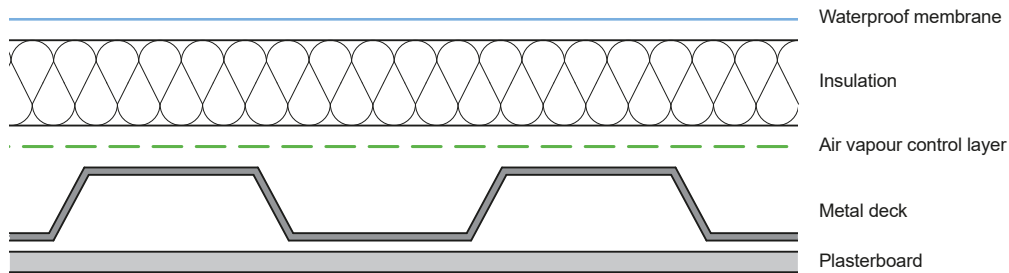
Screeds should be suitably specified for the anticipated loadings, further information can be found in 'Appendix C - Materials, Products, and Building Systems'. Moisture from the construction can become trapped in a roof if the waterproof layer is applied before a concrete slab or screed has had sufficient 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)

Note: Permanent waterproofing should not be installed until the deck has fully dried.



### 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.

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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.

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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

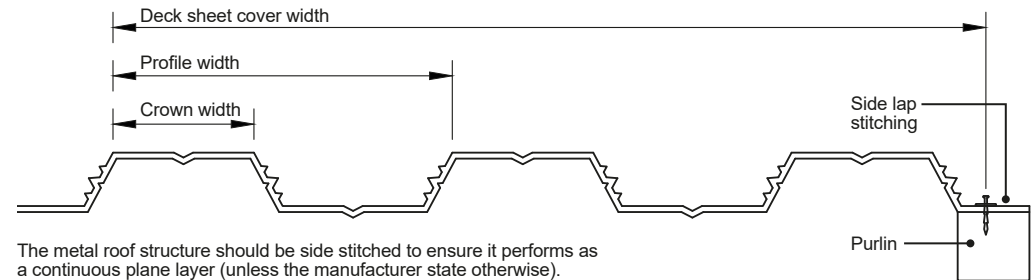
#### General

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 relevant Building Regulations, as appropriate.

### Thermal insulation

The thermal insulation should be selected with regard to the following minimum criteria:

- Thermal insulation must have a relevant third party product approval confirming suitable for use in proposed situation.
- 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 'Roof Terraces and Balconies' 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/m<sup>2</sup> and there shall be no net accumulation in any annual cycle.

### 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 tightly 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 membrane	Profiled metal	S2P3 <sup>(2)</sup>	Partial bond by 3G or approved proprietary alternative
	Concrete	S2P3	Fully bonded
	Timber panel <sup>(1)</sup>	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 relevant 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 inclusive of gutter beds and cross falls.

Where two roof planes intersect at a cross fall, the line of the cross fall junction that is formed must achieve a minimum 1:80 fall along its length. In order to achieve this, the adjoining roof planes should be designed to achieve a minimum installed finished fall of 1:60 or 1:40.

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 and general falls of 1:80 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 30-35mm). 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 or structural overloading. 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.

Overflows should be conspicuously positioned for inspection and as close to the outlets as practicable to avoid rainwater build up on roofs.

The overflow level should be set at the design water level for the rainwater outlets, which in most instances is typically 30-35 mm above the outlet. Where there is a sump included at the rainwater outlet position, the overflow should be set at the level of the lip into that sump.

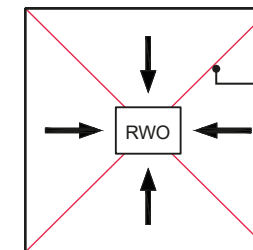
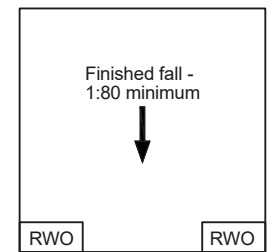
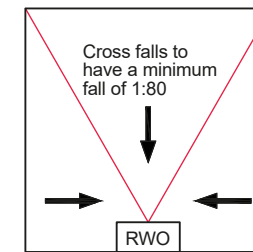
The level of overflows should be 25 mm below the underside of the any sill positions e.g. thresholds.

## Box gutters

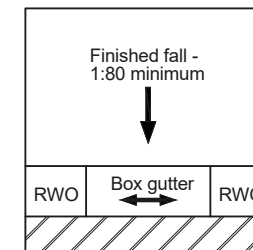
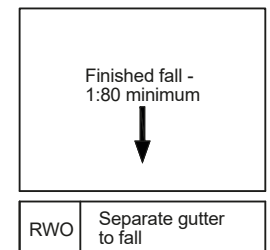
It is not generally necessary to provide separate box gutters where two planes of roofing intersect, or where a single plane falls to an abutment. In the latter case, there will be no fall between outlets, so consideration should be given to creating these in the structure or insulation. Box gutters 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



Cross falls to have a minimum fall of 1:80



Note: Gutters must also have a minimum 1:80 fall towards the RWO.

## 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](http://www.siphonic-roof-drainage.co.uk)

These roof proposals 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.

## Rainwater discharge

The management and disposal of rainwater discharge from the roof drainage system should be in accordance with the requirements of the section covering Drainage – Above Ground Storm Drainage – Rainwater drainage requirements.

## 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 EAD, (previously a European Technical Assessment Guideline, ETAG) and has an affixed 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.

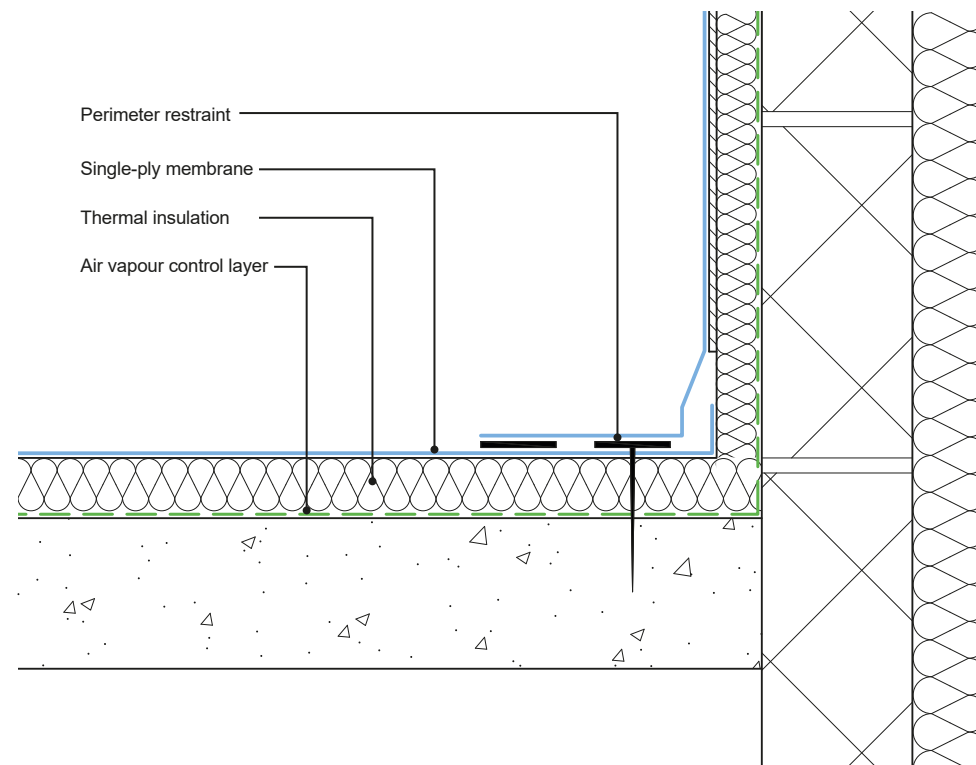
The upper termination of the single ply membrane at linear details such as plinths, parapets, abutments and door openings should be secured by one of the following mechanical means:

- 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.

## Methods of restraint of a single-ply membrane at perimeters



### 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.

### Liquid applied roof waterproofing kits

Liquid applied roof waterproofing kits (LARWK) consist of a material or combination of materials where at least the main component is a liquid form. These LARWK are not covered by a harmonised European standard (hEN).

As a result, overall guidance on assessment of fitness for use, including methods of verification and attestation of conformity on such systems should utilise a relevant European Assessment Document.

European Assessment Document (EAD) 030350-00-0402 should be used for systems that are:

- Polymer modified bitumen emulsions and solutions.
- Glass reinforced resilient unsaturated polyester resins.
- Flexible unsaturated polyesters or Reactive poly(methyl) methacrylate (PMMA)
- Hot applied polymer modified bitumen.
- Polyurethane, Polyurea or Polyaspartic.
- Silane modified polymers (SMP)
- Water dispersible polymers.
- Thermoplastic block copolymer.

European Assessment Document (EAD) 030019-00-0402 should be used for systems that are:

- Polysiloxane (waterproofing on the basis of a silicone).

The manufacturer of a product for use in flat roofing should declare compliance with the relevant parts of the relevant European Assessment Document (EAD). 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<sup>2</sup> 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.

In all cases, where a LARWK roof product/system is proposed, the designer will be required to distribute the following information to all appropriate contractors, site supervisors and suppliers, in a clearly understandable format to demonstrate the installed system provides an adequate level of performance:

- A full third party product conformity approval certificate for the system.
- A full specification for the proposed works prior to works starting on site – this must be accompanied by a full set of drawings covering aspects of detailing.
- The installing contractor must provide evidence of inclusion into an Approved Installer scheme, which is controlled and verified by the system manufacturer.

### Insulation for use with LARWK

Any proposal that requires on site installation of an OSB or plywood sheet over a proprietary rigid insulation board **should only be accepted** when supported by a site specific Condensation Risk Analysis calculation.

The type of insulation used for LARWK systems must be confirmed by the manufacturer of both the LARWK system and insulation board manufacturer as being compatible. The insulation core must also be capable of giving support to the completed LARWK system in order to ensure that applied loads do not give rise to cracking or indentation of the finished waterproofing system.

It should be noted that some LARWK systems use an adhered carrier or preparation membrane prior to application of the LARWK system. Where this is the case, confirmation should be sought from the manufacturer of the insulation board regarding the compatibility of any roofing system primers or adhesives used for the attachment of the carrier material.

In both instances, the manufacturers of the insulation board should provide any performance data for inclusion into the specification which has been produced for the roofing system.

Insulation products must be manufactured in controlled factory conditions, with manufacturing facilities holding evidence of appropriate Factory Control Certification from a UKAS accredited 3rd Party which confirms they are manufactured to the relevant industry standard. The product itself must be covered by a full third party product conformity approval certificate.

### Typically acceptable build-ups

Cold flat roof build ups are only acceptable with a roof area up to 3m<sup>2</sup> with cross flow ventilation maintained.

For the purposes of Warranty, a warm flat roof build up is recommended for site applied LARWK roof coverings. The insulation should be compatible with the chosen LARWK waterproofing system and method of application.

### Detailing

The Warranty Surveyor must receive a full set of sectional drawings, which should be accompanied by the specification. These sectional details should be produced by the system manufacturer for all aspects of detailing specific to the project.

### Compatibility with other materials – penetration detailing

For instances where the LARWK system is required to bond onto lead pipe sleeves, flashings, steel balusters, anchoring system, etc., the LARWK manufacturer's guidance should always be sought prior to works taking place. Incompatible material will often need special preparation and need to be primed with a system specific primer to facilitate a good adhesion of the LARWK to the material in question.



### 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 <sup>(1)</sup>	Venting layer <sup>(2)</sup>	Underlayer <sup>(3)</sup>	Cap sheet <sup>(4)</sup>
Warm deck	Profiled metal	Thermoplastic foam	3G	S2P3 <sup>(5)</sup>	S4P4 <sup>(5)</sup>
		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<sup>2</sup>.
- Full bitumen bond: up to 3.6kN/m<sup>2</sup>.

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. 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.

### EPDM roof coverings

EPDM products are only acceptable for Warranty purposes where the roof does not exceed a 100m<sup>2</sup> maximum roof area (Gross flat roof area of the project – not individual plots).

The EPDM water proofing membrane product should be CE marked in accordance with harmonised Standard BS EN 13956, AND must hold a current third party product conformity certificate.

The membrane must only be installed:

- As a fully adhered bonded only membrane to the roof deck (not mechanically fixed with ballast covering) and
- Installed only by the EPDM membrane manufacturers approved installer.

EPDM roofs should only be proposed where a simple open plan laid to fall roof is proposed (i.e. no parapets, changes of levels or plant installations).

EPDM membranes are not acceptable where any pedestrian access is proposed (other than occasional maintenance) and are not acceptable for use in the following constructions:

- Balcony / Terrace deck
- Blue roof
- Green roof
- Podium deck

**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.

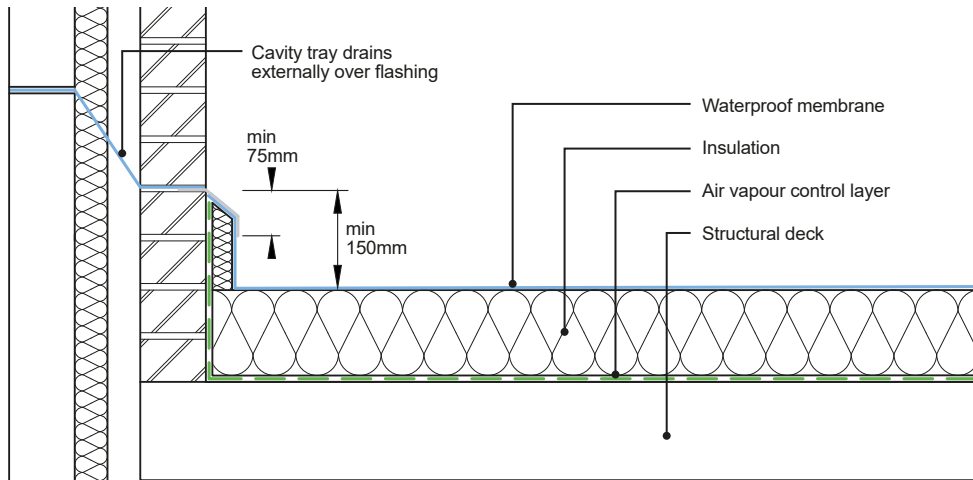
It is important that this minimum 150mm upstand is maintained at all points around the waterproofed area, except at continuous water checks and verges.

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**

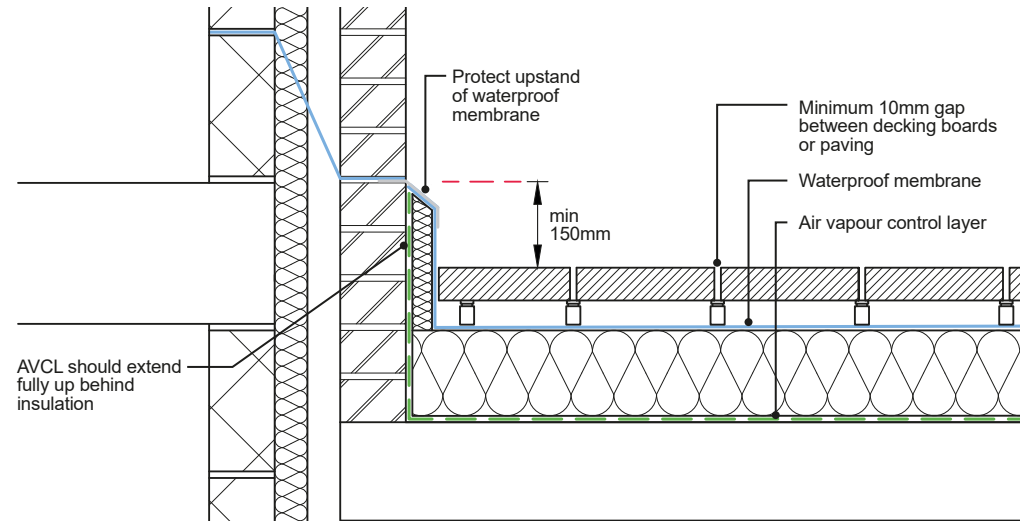


Insulation fully wrapped around by air vapour control layer waterproof membrane

**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.

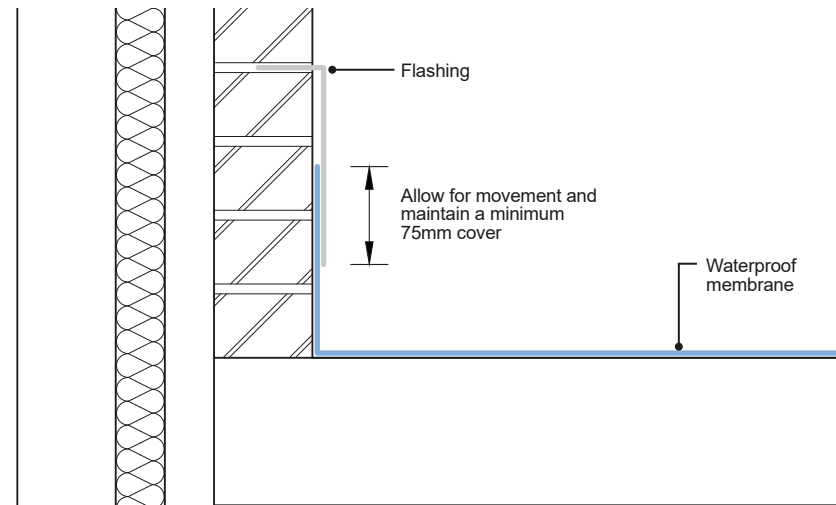
**Upstand to decking and paving finishes - e.g. where access is required**



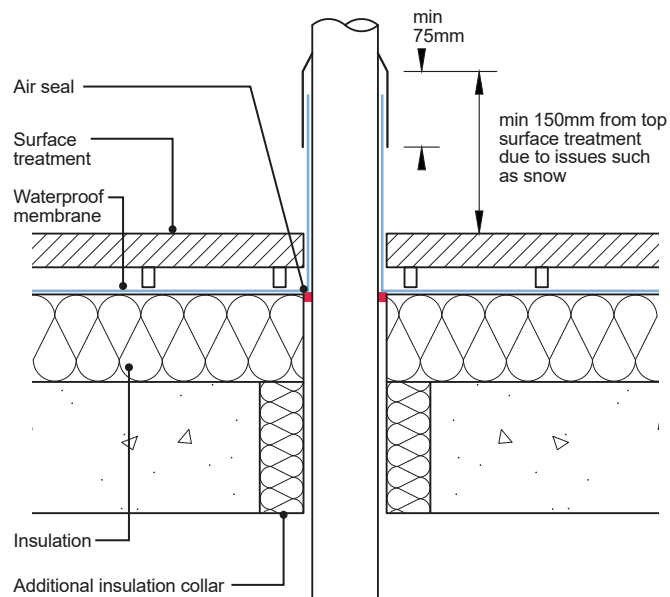
**Allowance for movement where a timber frame with masonry cladding abuts a flat roof**

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. Roof membrane manufacturer specification should be followed.
- 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

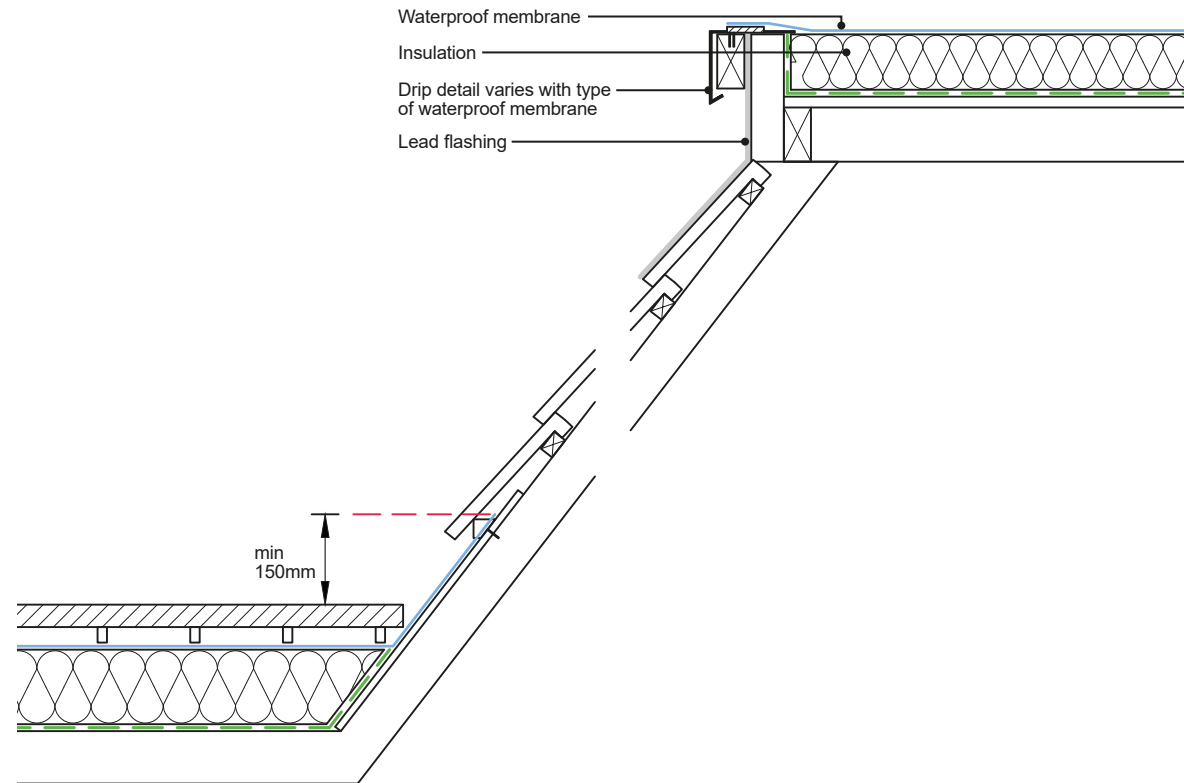
Detailed design should take account of the installation of such equipment by other (usually following) trades, as follows:

- 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.
- 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 (all types of waterproofing systems)

Testing is required in the following situations:

- On low rise housing: Detached/semi-detached/terraced housing 3 stories or less in height (including the ground storey) when:
  - The roof areas exceed 50m<sup>2</sup>, or;
  - Where the project consists of 10 or more properties: one test per ten houses (with a minimum of two tests per site) are required.
- On large developments: Apartments etc. over 3 stories in height (including the ground storey), where the total combined roof areas exceed 50m<sup>2</sup>. In this case, a minimum of 20% of the roof areas must be tested.
- On developments involving our Major Projects Team, all flat roofs will require low voltage testing.
- Where, after completion of the site risk assessment, the Warranty Surveyor has identified areas of complexity in relation to the roof and its ancillary components that present a higher risk to Warranty (e.g. service penetrations, abutments with claddings, and penetrations from fixed items such as man safe systems).

These areas of complexity may be resultant of elements of:

Design, 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/balustrading fittings etc.
- 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, where:

- There are to be/have been, follow on trades on the roof after completion of the roof covering.
- Secondary items such as fall protection devices, PV supports, balustrades etc. are to be attached.

## Where EPDM roof coverings are installed

For Warranty purposes:

- Only a Third party product approved (BBA, etc.) membrane shall be installed
- Be a fully adhered bonded EPDM roof covering only
- Are acceptable for roofs up to 100m<sup>2</sup> maximum roof area (Gross flat roof area of the project – not individual plots)
- They must be installed by the manufacturers approved installers and a sign off certificate provided by the installer to confirm the roof is defect free.
- Must be tested at completion to demonstrate waterproofing integrity. The testing provider will need to demonstrate their chosen technique is suitable for testing EPDM roof coverings as electronic leak detection techniques are not suitable.

## 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
- A detailed testing regime that includes integrity testing of detailing, specifically where the Warranty Surveyor has raised these as elements of particular complexity within the site risk assessment.
- 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.

### Voltage field mapping

Voltage field mapping uses a generator, trace wire and field electrodes on a roof with a thin layer of water spread across the selected test area. The trained operator uses electrodes and generated voltage flow to determine the presence and precise location of defects in the area being tested.

### High voltage electrical discharge

High voltage electrical discharge method is a versatile and effective method of testing. It can be used on steep slopes or inverted surfaces, provided the underlying structure will provide the necessary ground. Can be used for single ply, reinforced bitumen membranes and liquid applied coatings.

### 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

A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings.

Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.

## Periodic inspections and maintenance

Periodic inspections and maintenance should be completed in line with the advice provided within the Operation and Maintenance Manual for the project, by an appropriately skilled or trained party.

As a minimum it is advisable that a flat roof is inspected at least twice yearly. Typically in the autumnal period of the year to ensure outlets are operational and the roof is free draining to deal with any subsequent inclement weather conditions in coming winter months. A further inspection is then carried out in spring to discover and rectify any damage due to weather. Extra inspections are advisable following any extreme weather events or where it is suspected that vandalism, and/or theft may have occurred on the roof.

As a minimum, it is advisable that any inspections should include the following elements:

- An examination of ceilings for signs of water damage;
- An examination of external walls, eaves and soffits for signs of movement;
- Signs of damage to the roof surface and subsequent layers of construction along with associated flashings;
- Mounted or ballasted roof top installations e.g. safety equipment, communications and renewable energy installations should be examined to ensure their attachment and associated work remains waterproof.
- Extensive build-up of leaves, moss, plants or debris should be recorded along with any influencing factors such as the effect of overhanging trees, mounted plant items, etc.

It is advisable that when additional construction work is planned on or near to the roof, an appropriate and specific inspection regime is established to cover the aspects of risk associated with the work at hand.

### Where provision for access is required to flat roofs

#### 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.

##### 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 suitability of finishes for temporary access can be found in the 'Roof Terraces and Balconies' section.

### Ancillary components installed on top of waterproof layer

#### 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 installation of any lightning protection measures must not compromise the water proof membrane of the roof.

The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- 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

### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. This may include:

1. A full set of detailed drawings including:
  - a) Roof plan showing direction of falls and position of outlets and overflows
  - b) Sections showing roof build up and how falls are to be created. Sectional details should show all components to be used in the green roof build up (insulation type and thickness, vapour control layer, waterproofing membrane/layers etc.)
  - c) Site specific detailing for all junctions, outlets and penetrations.
2. Details of all components to be used in the construction of the green roof.
3. Engineers drawings and calculations for the roof structure.
4. Third party accreditation for the waterproofing membrane/layer. This must confirm the membrane can be used in a green roof build up.
5. Details of all fixings, their frequency and fixing method, including those for insulation and surfacing. Fixing methodology should be supported by appropriate wind uplift calculations.
6. Details of all fire stopping within structure and fire mitigation measures made within the green roof elements e.g. vegetation free zones. This should include specification and a detailed location layout drawings showing positioning.
7. Outline of method and plan for testing the integrity of the waterproofing layer.
8. A flat roof membrane manufacturer's approved installer must be used for all flat roof coverings. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.
9. A roof deflection analysis should be provided for medium to large roofs, those with complex roof layouts and for any roof areas that carry items of plant or are subject to access provisions beyond periodic maintenance of the roof area.

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### 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 (structural deck).

Cold deck roof systems are not acceptable for Warranty where green roofs are proposed.

### 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 10° 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 water-logging 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 Landschaftsbau (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.

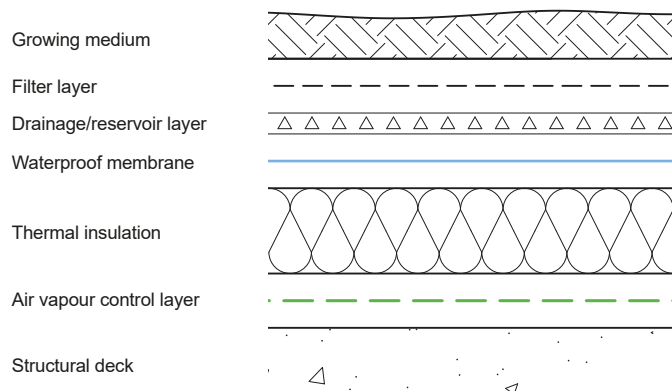
### Design and system types

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:

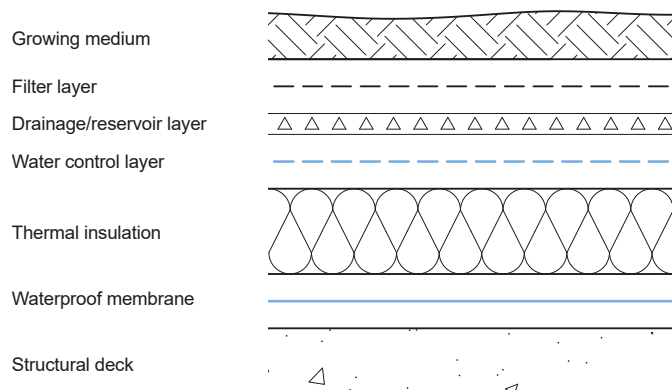
- Biodiverse roof.
- Brown roof.
- Extensive green roof.
- Semi-intensive green roof.
- Intensive green roof.

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 relevant 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.

### 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 relevant Building Regulations, as appropriate.

### Provision for access

#### Statutory requirement

Design should comply with the current relevant 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

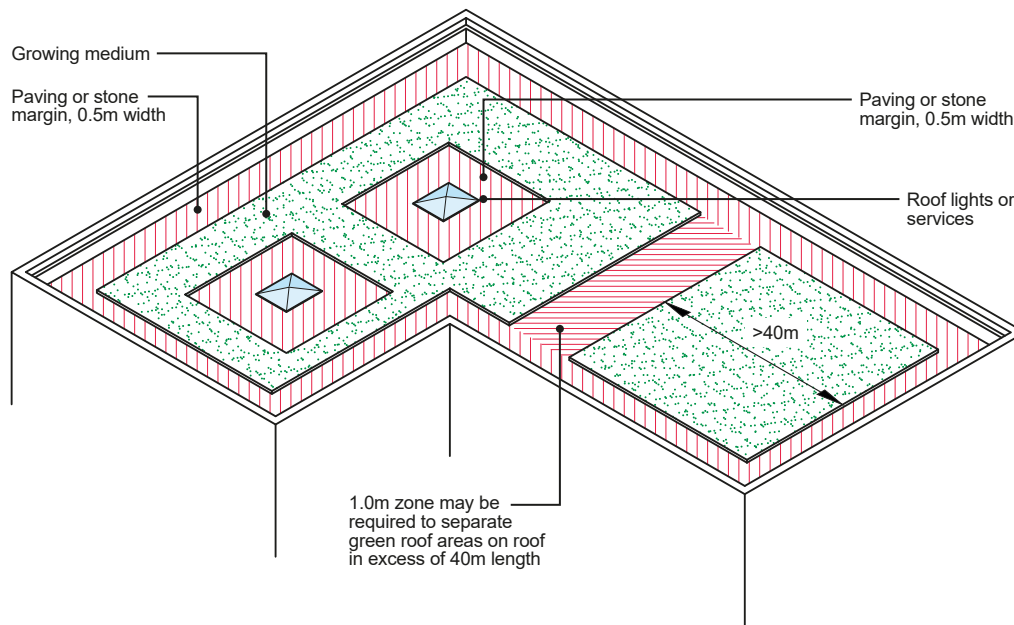
The design of green roof systems can influence the fire performance of the overall roof system. The rate of growth and moisture content of natural vegetation is unpredictable and determined by irregular weather conditions. The substitution of planted species with others is also unpredictable. Design 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.

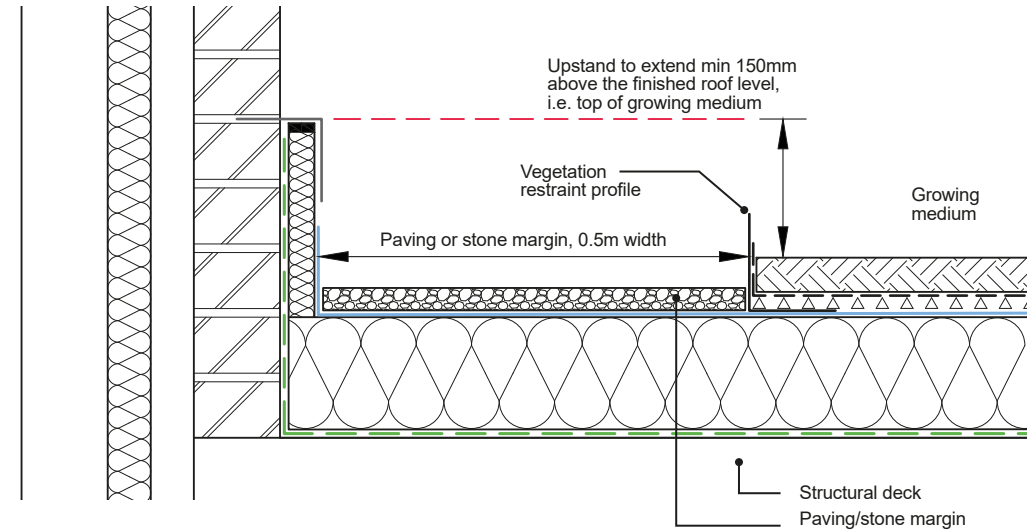
### Green roofs: Vegetation-free zones (Plan, zone width: not to scale of building)



#### 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 waterproofing.

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 relevant 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:

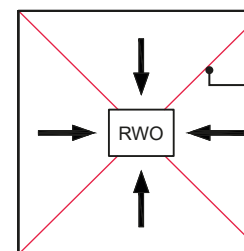
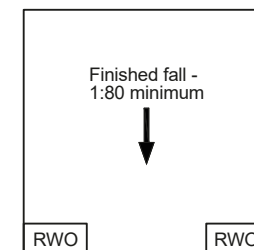
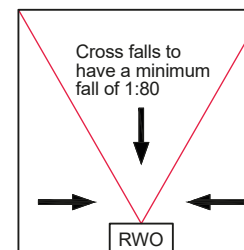
- Capacity in litres per second at a range of typical water heads.
- Compatibility with the waterproof membrane.
- Integral insulation to avoid condensation.
- Method of attachment.
- Rainwater outlets for inverted roofs should be of the dual height type, designed to maximise removal of rainwater at 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



## 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](http://www.siphonic-roof-drainage.co.uk)

These roof proposals 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 at completion to demonstrate waterproofing integrity 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 and a detailed testing regime that includes integrity testing of all detailing, specifically where the Warranty Surveyor has raised these as elements of particular complexity within the initial site risk assessment.
- 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.

### Voltage field mapping

Voltage field mapping uses a generator, trace wire and field electrodes on a roof with a thin layer of water spread across the selected test area. The trained operator uses electrodes and generated voltage flow to determine the presence and precise location of defects in the area being tested.

### High voltage electrical discharge

High voltage electrical discharge method is a versatile and effective method of testing. It can be used on steep slopes or inverted surfaces, provided the underlying structure will provide the necessary ground. Can be used for single ply, reinforced bitumen membranes and liquid applied coatings.

### 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<sup>2</sup>.

## 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.

# 11.

## Roofs

### 11.8

#### Metal Deck Roofing

### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. This may include:

1. A full structural design for the roof, including (but not limited to) sizing of timber members for spans and loads, fixing methodology/specification, bracing and restraint requirements.
2. A full set of detailed drawings including:
  - a) Manufacturer's pre-formed truss layout drawings or full details of the roof layout inclusive of any intersecting or supportive roof structure such as hips, ridges, purlins, valleys and associated timbers e.g. lay boards, trimming members.
  - b) Sectional details showing roof build-up with all materials to be used in the construction of the single skin metal roof.
  - c) Details of the ventilation strategy where applicable.
  - d) Details for any required trimming work around chimneys, formation of access hatches, details for the formation of supportive structure for equipment and access to equipment requiring periodic maintenance and inspection contained within the roof space.
  - e) Waterproofing and flashing details around abutments, chimneys, service penetrations etc.
  - f) Details of all fire stopping which should include specification and a detailed location layout drawing showing positioning of all fire stopping.
3. A detailed site specific design from either the manufacturer or the designer (see checklist within this section).
4. Third party accreditation for the single skin metal roofing system where applicable.
5. Details of all materials to be used in the construction of a fully supported single skin metal roof including (but not limited to, the metal sheet, insulation, separation layers/membranes, vapour control layers, structural deck, ancillary components etc.)
6. In all circumstances, the fully supported single skin metal roof will need to be installed by an approved contractor who is recognized by the manufacturer as competent. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### Approved installers

Due to the complex nature of external metal sheet roofing, we require the installer to be approved by the manufacturer.

Where the manufacturer doesn't retain a list of approved installers, evidence should be provided showing the installer is competent and trained with external metal sheet roofing.

### Single skin metal roofing

This section covers single skin metal roof covering, which are not self-supporting in nature.

Fully supported single skin metal roofing materials include zinc, copper, lead, and powder coated aluminium. They are used as the weatherproofing element of build-ups consisting of a structural deck (usually metal or timber), fully supported vapour control layer, insulation such as mineral board or PIR, separation membrane and an external metal sheet.

### Product conformity

For fully supported zinc warm roof systems, the product must have a third party product conformity certificate from a UKAS accredited body which covers the complete build-up and clearly details all of the components used.

The certificate should carefully be reviewed by all interested parties to ensure all of the conditions within the certificate are satisfied. Where materials or components have been substituted with alternatives not covered within the certificate, the build-up should not be accepted.

Cold pitched roof build ups do not require a third party product conformity certificate, however the building designer should carefully consider all of the information contained within this section e.g. incompatible materials, separation layers, underside coating to the external metal sheet and ventilation to the cold roof space.

All products and components should have UKCA marking in accordance with UK Construction Product Regulations.

### Design

#### Permitted Build-ups

For the purpose of Warranty, the use of fully supported single skin metal roof covering are not permitted in a cold flat roof build up.

In all other instances, a site specific design should be provided as early as possible so it can be reviewed by the Warranty Surveyor before any works to the roof covering is started. A checklist is present within this section highlighting the areas the site specific design must cover as a minimum for our Warranty purposes.

All designs should follow best practice as per the guidance available within the UK Guide to Good Practice in Fully Supported Metal Roofing and Cladding, published by the Federation of Traditional Metal Roofing Contractors (FTMRC).

#### Avoidance of underside corrosion

All metal roofs are prone to underside corrosion (to varying degrees) by various means:

- Moisture becomes trapped between the metal and the supporting material.
- An inability for the product to develop a protective layer to the underside (Patina).
- The use of incompatible materials.

The following sections are offered as guidance on how to mitigate the risk of underside corrosion occurring.

#### Determination of internal humidity classes

The influence of the type of building occupation cannot be underestimated when considering condensation risks. Occupants and their many activities create a moisture load for the structural elements to deal with, and unsurprisingly as occupants increase in number, the moisture load on the building increases.

For the purpose of Warranty, 'Humidity Class 3' should be adopted as the internal humidity class for a residential property. In all other instances, the guidance of the Humidity Class table should be used to determine an appropriate humidity classification.

Humidity class	Building type
1	Storage areas.
2	Offices, shops, dwellings with low occupancy.
3	Dwellings with high or unknown occupancy.
4	Sports halls, kitchens, canteens, school classrooms, hospitals, buildings heated with flue less gas heaters.
5	Special buildings (laundry, brewery, swimming pools).

#### Deck selection

Equally, the structural deck material should be considered with great care. The use of fully supported metal roofing systems on large span commercial buildings was routinely coupled with metal deck materials, which have an inherent resistance to moisture and vapour.

The adoption of fully supported metal roof coverings into the residential sector has resulted in wood based panels being used as a structural deck instead of metal (e.g. plywood, OSB, square edged timber boards). This switch to the use of timber decks plus the increased levels of humidity can result in moisture reaching the underside of the metal sheet roof covering.

For the purpose of Warranty, the use of timber as a structural deck should be restricted and only considered when a condensation risk analysis has been carried out.

#### Air and vapour control layer

As moisture can accelerate the onset of corrosion to unprotected metal sheets, this creates an increasing importance on the arrangement of vapour control layers within the built element in controlling this risk. Many fully supported metal roofing systems use a product specific air and vapour control layer (AVCL) to reduce this risk so particular attention should be paid to the correct and system specific requirements in this area.

AVCL's should always be on the warm side of the insulation. For continuity of detailing, typically the use of self-adhesive aluminium foil backed modified bitumen membranes is predominant within manufacturer's guidance literature with specific termination detailing for penetrations, etc.

For the purpose of Warranty, the Air and Vapour Control Layer (AVCL) should be strictly in accordance with the third party product conformity certificate and have a minimum vapour resistance between 5000-7000 MN.s.g. All detailing should be strictly in accordance with the manufacturer's guidance literature.

**Compatibility of materials**

Underside corrosion can also be caused by incompatible materials being specified together. The table below shows which metals should not be used together.

	Al	Pb	Cu	Zn	S.S	G.S
<b>Aluminium (Al)</b>	✓	✓	✗	✓	✓	✓
<b>Lead (Pb)</b>	✓	✓	✓	✓	✓	✓
<b>Copper (Cu)</b>	✗	✓	✓	✗	✓	✗ <sup>(1)(2)</sup>
<b>Titanium Zinc (Zn)</b>	✓	✓	✗	✓	✓	✓
<b>Stainless Steel (S.S)</b>	✓	✓	✓	✓	✓	✓
<b>Galvanised Steel (G.S)</b>	✓	✓	✗ <sup>(2)</sup>	✓	✓	✓

1. Steel hollow rivets are not compatible when used externally.
2. Galvanic copper plating of galvanised components can increase corrosion development; they do not provide corrosion protection.

It's important to consider both direct contact and surface run off from incompatible materials; for example with the use of rain water goods. If the use of incompatible materials cannot be avoided, they should be separated from each other by either non-conducting, non-metallic isolators (e.g. seals and grommets in fixing systems) or coated with compatible or inert materials.

Timber treated with certain types of preservative, particularly of copper-chrome-arsenic formulation, can cause corrosion of zinc, carbon steel and aluminium in contact with the timber. As such, external metal sheets supported on any timber deck such as plywood must have a factory applied coating specified and be separated from the timber deck by a compatible separation membrane as specified by the system manufacturer.

In addition to the incompatibility issues highlighted above, external metal sheets can also be susceptible to incompatibility issues with other common materials. Zinc for example may be incompatible with materials such as, bituminous membranes, mortar and building paper.

In all situations, the metal sheet manufacturer should be consulted with regards to incompatible issues and this should be highlighted in the site specific design.

**Separation layers and low resistance membranes**

Separation layers are employed to avoid the metal sheet roof covering from sitting directly on the supporting material. Underside corrosion can manifest itself where either incorrect membranes have been specified, or the correct membranes have been specified but they've been substituted for an inferior product post design approval. Low resistance (Type LR) membranes, also referred to as 'breather membranes' will be employed in between insulation layers and any ventilated void serving the underside of the material supporting the metal roof covering. Due to the opportunity for increased temperatures created within ventilated voids inherent of the metal roof covering, any breather membrane specified must be tested for use within metal roof covering build-ups.

For the purpose of Warranty, separation layers and Type LR membranes specified in the site specific design must align with products that are set out within the third party product conformity approval certificate.

They must not be substituted and they should be subject to strict on-site quality assurance measures, which should include but not limited to, verification of product specification.

For cold pitched roofs without a third party product conformity approval certificate, membrane specification and compatibility should be carefully considered by the designer and consultation with the metal sheet manufacturer is recommended. Once specified, they must not be substituted and should be subject to the same strict on-site quality assurance measures.

**Typical build-ups**

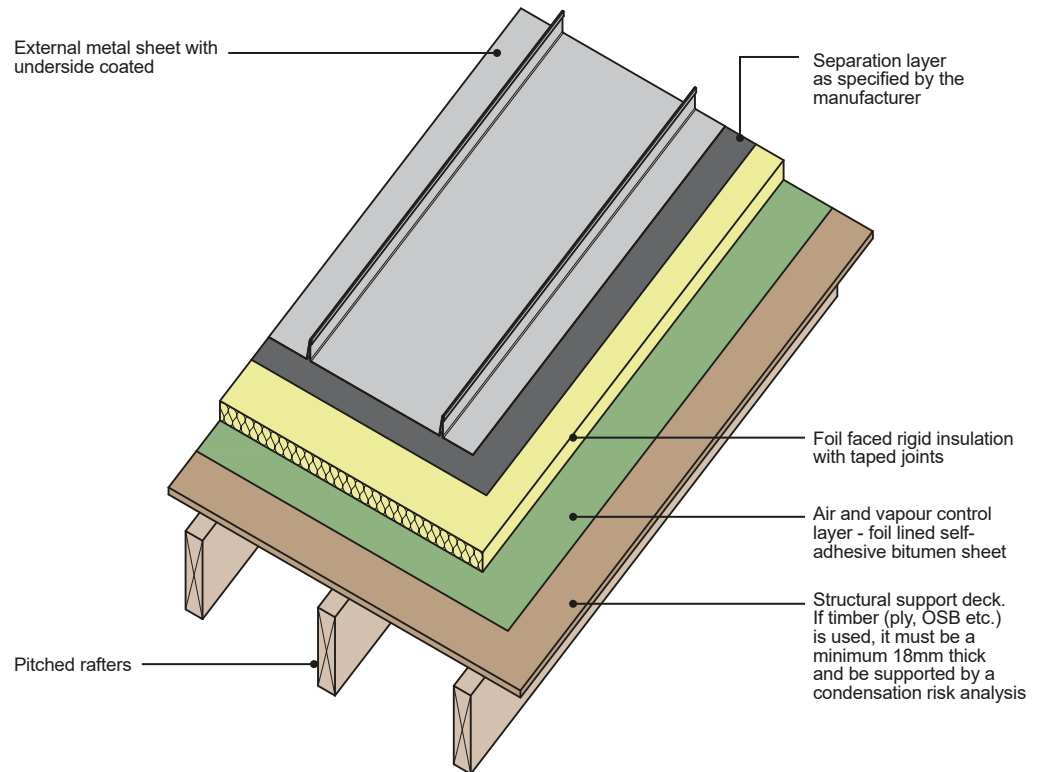
The following illustrations and associated narratives are given only as guidance to typically employed build-ups.

**Warm non-ventilated roof – Pitched or flat.**

Constructed without ventilation provision, the warm deck roof relies on the moisture resistant properties of the fully sealed AVCL that sits beneath the insulation. It is critical that this layer is as specified in the system manufacturers' guidance, with its integrity remaining undamaged during construction.

Any fixings from layers above must be fully considered in design with provisions for sealing penetrations, as untreated, they may give risk to moisture transfer and increase the risk associated with interstitial condensation and a premature failure of both the external metal sheet and supporting material.

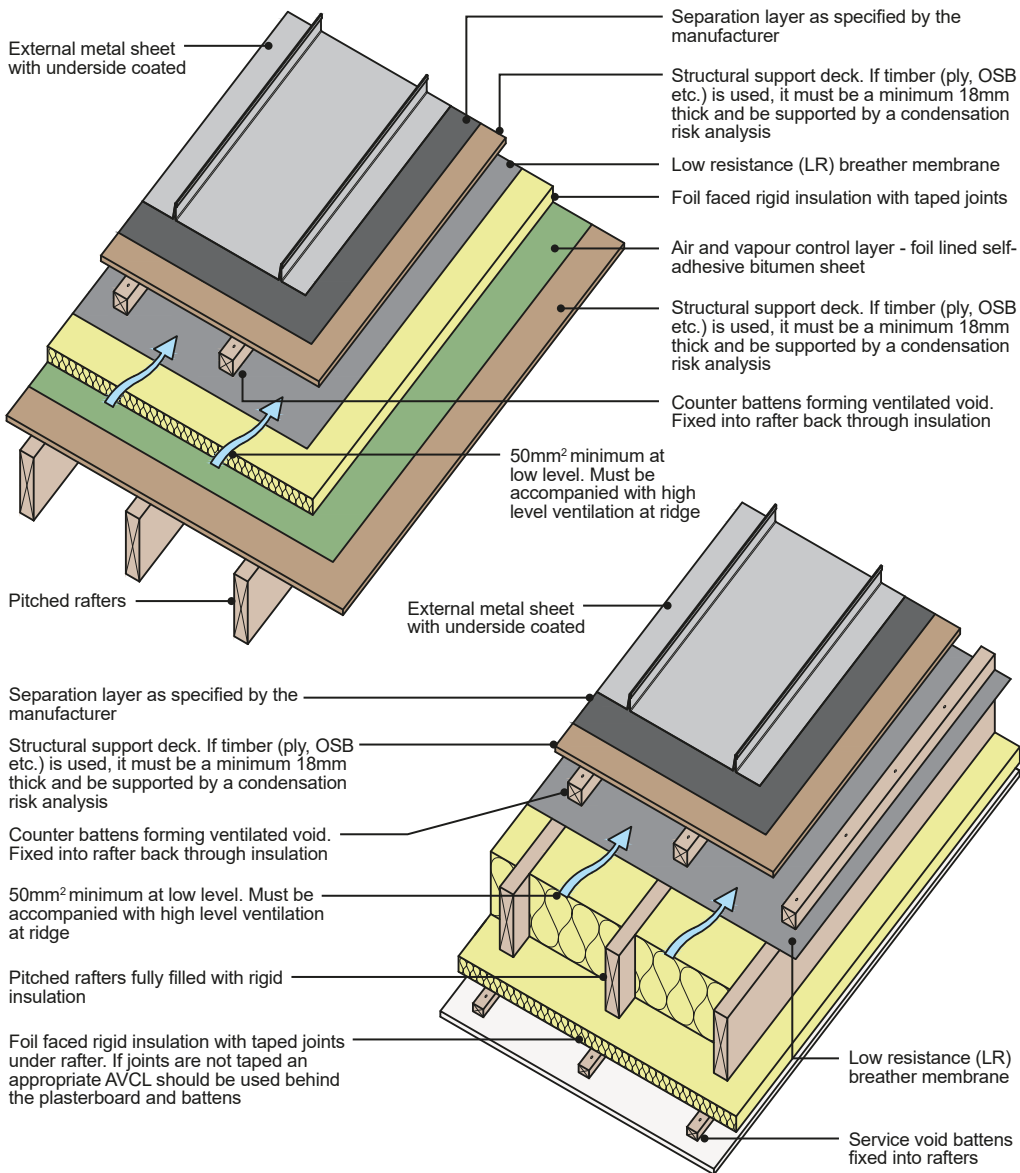
Mechanical fasteners should be avoided above conditioned spaces with high humidity e.g. swimming pools, gymnasiums. This approach, subject to an appropriate supporting site specific design, may be employed on both flat and pitched roofs.



**Ventilated warm roof**

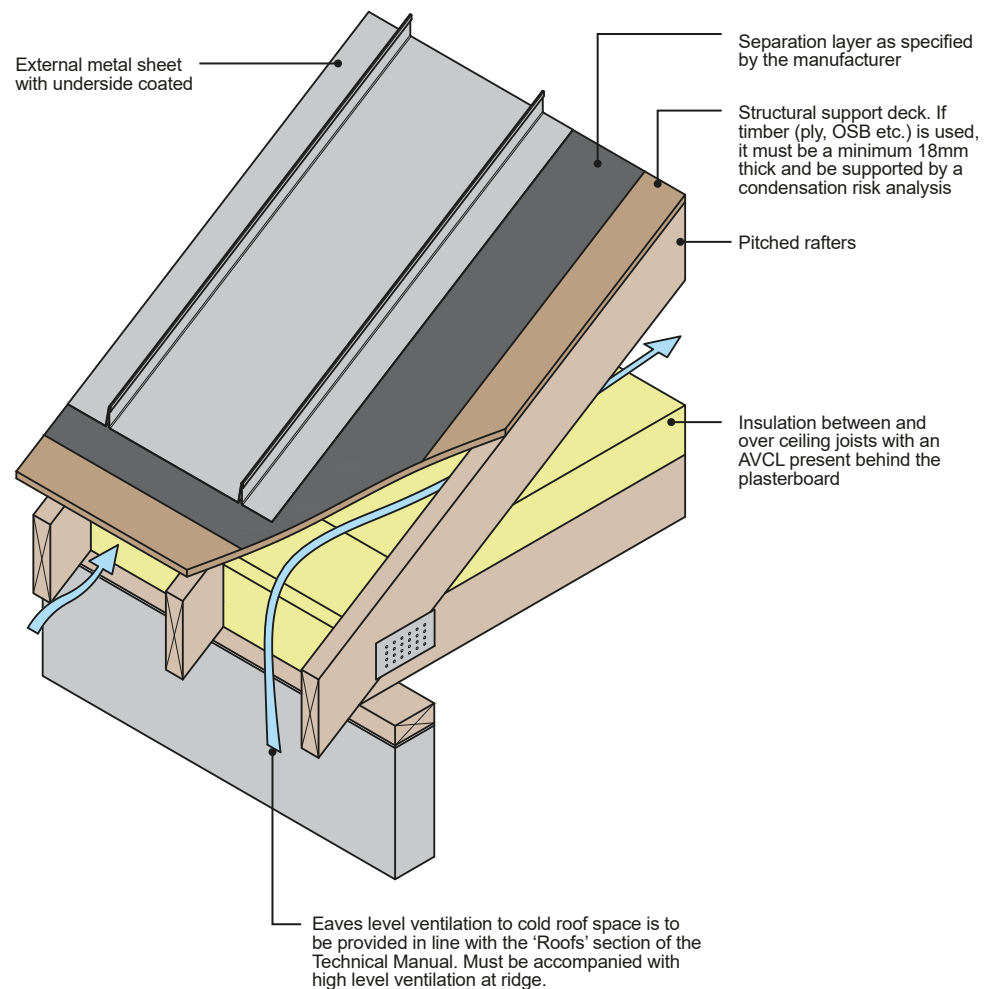
The ventilated warm roof arrangement incorporates a well-sealed AVCL directly on top of the structural deck and a well ventilated void between the supporting board to the underside of the external metal sheet and the overlying low resistance breather membrane layer.

This ventilated roof void allows for any moisture escaping through the fabric to be expelled by a cross flow of air. The span of the roof should be considered when using this approach as larger spans will require an increase to the void depth and eaves ventilation provisions.



**Cold ventilated 'pitched' roof**

The cold pitched roof arrangement requires ventilation at low level and at high level as per guidance in the 'Roofs' section, as the timber deck prevents any warm air escaping.



### Other considerations

#### External environments

External metal sheets can degrade at a faster rate in coastal locations. In addition, certain chemically corrosive environments, such as sites in close proximity to manufacturing facilities such as chemical works, cement works, copper foundries or coal mines can also cause external metal sheets to degrade at a faster rate.

Where external metal sheets are used within 5km of the coast or when they're used in chemically corrosive environments as specified above, a third party product conformity certificate must be available for the external metal sheet (for both warm and cold pitched roofs).

For the purpose of Warranty, the third party product conformity certificate must be made available to the Warranty Surveyor prior to the selection of the system and explicitly state the product has been assessed for use in the environment it is intended to be used and it has at least a minimum life expectancy of 25 years.

In instances where the third party product conformity certification does not explicitly state the metal sheets are suitable for use in the above environments, the product should not be specified within 5km of the coast or in chemically corrosive environments as it has not been assessed for use in that location.

Where external metal sheets are specified in the above environments, periodic cleaning may be necessary; and a man safe system should be included as part of the design to aid in the periodic cleaning. Advice should be sought from the external metal sheet manufacturer.

#### Fire classification

The entire system (not just the external metal sheet) should be assessed to meet the requirements of the Building Regulations, Approved Document B in England and Wales. In particular, the entire system must meet B4 of Approved Document B. For further guidance, advice should be sought from the appointed Building Control Body.

#### Deck exposure during construction

Any membrane applied during construction that is left open should be capable of resisting moisture penetration. In the event that a LR membrane is used, the deck should be assessed in relation to its moisture content before any further layers of building fabric are applied. Moisture content of timber boarding should not exceed 20% at point of roof covering being applied.

#### Ply bonded on insulation

Ply or timber topped insulation should not be a site formed configuration. Ply or timber topped insulation boards must be produced in a controlled factory environment which holds all the necessary accreditation for production and has a demonstrable quality control procedures to ensure they are fit for purpose. Such documentation may be requested by the Warranty Surveyor to prove and demonstrate the above is achieved.

The overall performance of such insulation boards, inclusive of structural capabilities, compatibility and durability should be subject to assessment utilising suitable third party product conformity certificate as a minimum.

#### Expansion

If timber such as plywood is used for the structural support deck, movement gaps should be considered for square edged boards at rigid upstands and between boards. A minimum gap of 3mm needs to be maintained between boards and 10mm with rigid abutments.

### Checklist for manufacturer's site specific design

As a minimum, the site specific design should include all of the following points:

- The document must reference the third party product conformity certificate (for the complete system, not only individual components) to confirm this has been reviewed in line with our Warranty requirements (not applicable to cold pitched roofs).
- The location of the development must be reviewed - if the location is a chemically corrosive environment (as described within this section), reference should be made to the third party product conformity certificate confirming it is suitable for use with a minimum life expectancy of 25 years.
- The manufacturer should be consulted with regards to the site specific fixing specification for the external metal sheets.
- Roof build up needs to be detailed to be aligned with the third party product conformity certificate (for the complete system, not only individual components).
- A list of components to be used needs to be provided and any incompatible components should be clearly highlighted. Details for methods of separation between incompatible materials (location, type and method of fixing) must be specified.
- Details of protective coating applied to the underside of the external metal sheeting needs to be highlighted (type and thickness of coating). Protective coatings must be factory applied.
- Air and Vapour control layers (AVCL's) should have a minimum vapour resistance of 5000-7000 MN.s.g. This must be detailed in the site specific design.
- A condensation risk analysis must be provided with reference to the humidity class used.



### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. As a minimum, we require the following:

- A full structural design for the roof, including (but not limited to) sizing of timber members for spans and loads, fixing methodology/specification, bracing and restraint requirements.
- A full set of detailed drawings including:
  - Manufacturer's pre-formed truss layout drawings or full details of the roof layout inclusive of any intersecting or supportive roof structure such as hips, ridges, purlins, valleys and associated timbers e.g. lay boards, trimming members.
  - Sectional details showing roof build-up with all materials to be used in the construction of the double skin metal roof.
  - Details for any required trimming work around chimneys, formation of access hatches, details for the formation of supportive structure for equipment and access to equipment requiring periodic maintenance and inspection contained within the roof space.
  - Waterproofing and flashing details around abutments, chimneys, service penetrations etc.
  - Details of all fire stopping which should include specification and a detailed location layout drawing showing positioning of all fire stopping.
- Details of all materials to be used in the construction of a double skin metal roof including (but not limited to, the metal sheet, insulation, separation layers/membranes, vapour control layers, support system, ancillary components etc.)

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### Approved installers

Due to the complex nature of external metal sheet roofing, we require the installer to be approved by the manufacturer.

Where the manufacturer doesn't retain a list of approved installers, evidence should be provided showing the installer is competent and trained with external metal sheet roofing.

### Double skin insulated roof

A double skin insulated roof is constructed 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.

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 composite metal panel which is manufactured 'off-site' in a factory controlled environment, and is delivered as a complete material/sheet incorporating the top

weathering sheet, insulated core and liner sheet to its underside. 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.

Component/Inspection	Rectification needed		Comments
	Yes	No	
Check bearing width of purlin			
<b>Check minimum overlap of linear decking sheets:</b> 1. Light gauge steel 2. Hot rolled steel 3. Timber - check for minimum penetration			
Check that side laps are stitched at the correct centres			
<b>Vapour control checks using the liner:</b> 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			
<b>Vapour control checks using a separate VCL:</b> 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			
<b>Spacer systems:</b> 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
<b>Insulation:</b> 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			
<b>Breather membranes:</b> 1. Ensure the membrane is laid in the correct direction and in accordance with the manufacturer's instructions			
<b>Roof sheets - standing seam and secret fixed:</b> 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			
<b>Roof sheets - pierced fixed:</b> 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			
<b>Penetrations for vents, sun pipes etc.</b> <b>A - Aluminium sheets:</b> Check sheets are site welded and area post coated where colour sheets are used Check that the VCL and breather membrane are maintained around the welded area Check upstands are at least 150mm <b>B - Steel sheets:</b> 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	
<b>Flashings:</b> 1. Check end overlap 2. Check frequency of fixings 3. Check correct type of fixing is used			
<b>General:</b> 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			
<b>Fasteners correct for the purlin:</b> 1. Light gauge steel 2. Heavy gauge steel 3. Timber			
<b>Fastener material:</b> 1. Coated carbon steel 2. Stainless steel			Check with a magnet
<b>Fastener frequency main roof:</b> 1. Main fixings 2. Side lap stitchers			
<b>Fastener frequency roof lights:</b> 1. Main fixings 2. Side lap stitchers			
Bearing area of purlin at end lap; is a supporting bearing plate required?			Is the building square?
<b>End laps:</b> 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			
<b>Roof light tape positions:</b> 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)?			
<b>Provision of fire-retardant gun foam:</b> 1. Eaves level 2. Verges 3. Gutters 4. Internal verge positions 5. Foam insulation at ridge			
<b>Gutter junctions:</b> 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			
<b>Roof penetrations:</b> 1. Check seals around cut foam insulation internally 2. Check internal flashing closures 3. Check weather penetrations externally			
<b>Flashings:</b> 1. Check end overlaps 2. Check frequency of fixings			
<b>General:</b> 1. Check roof covering for cuts and abrasions 2. Check for hot swarf damage			

# 11.

## Roofs

### 11.9

#### Blue Roofs

## Introduction

A Blue Roof is a flat roof or podium deck which is designed to provide controlled attenuation and management of rainfall to the sewer or outfall system, as part of a Sustainable Urban Drainage System (SuDS) proposal. This is particularly relevant on developments located in dense urban environments.

This guidance provides information to designers, developers and surveyors to assist in meeting the Functional Requirements of the Technical Manual where a Blue roof is proposed on a project covered by our Warranty.

## Definitions

The requirement of any roof or deck that is to be waterproofed, is to protect the structure and space underneath from the ingress of water.

A Blue Roof is defined as:

*A roof design that is explicitly intended to store rainfall temporarily at a level not exceeding the designed hydraulic head, for a defined period of time above a thermally conditioned space.*

A Blue Podium deck is defined as:

*A deck design that is explicitly intended to store rainfall temporarily at a level not exceeding the designed hydraulic head, for a defined period of time above a thermally unconditioned space.*

Therefore, Blue roofs systems manage rainfall by temporarily attenuating rainfall at a controlled predetermined rate and capacity before discharging into the rainwater sewers. Blue roofs may be classified as either 'Active' or 'Passive' depending on the types of control devices used to regulate drainage of water from the roof and overflows. Active or 'smart' approaches are discouraged due to reliance on technological infrastructure and are reviewed on a case by case basis. They should only be proposed where it is not possible to specify a passive approach.

## Design considerations

Scope of application:

- All other retention and 'within-site' surface water release strategies should have been explored, before a Blue Roof is considered.
- The use of space on the roof or deck surface – 'the amenity space' must be identified.
- The design of site drainage controls may be determined by flood risk strategies in planning consents with run-off rates typically in the range 5-10 l/s/hectare.
- Provisions for positive falls – falls not less than 1:80.
- Provisions for zero-falls — falls between 0 and 1:80\*.

\*Certain criteria need to be met by an appointed contractor in order to qualify as acceptable to our Warranty, to design and install zero falls. Projects which propose elements of zero fall should be limited to inverted roofs and must be agreed in advance with the Warranty at an early stage in the design and before the offer of Warranty is made.

It should be noted that the degree of fall on a roof is absolutely critical to the functionality of a blue roof and warm blue roofs tapered or laid to fall have several beneficial advantages such as the avoidance of flotation risk and the removal of standing water. However, the designer should note a positive fall will increase water depths on the roof, and lead to an uneven loading on the slab as water is stored in the tapering storage zone a fall creates which must be considered in the structural design approach for the slab.

Great care must be taken on long roofs with a slope to ensure that the fall is adequately designed into the storage, and that water depths at the downstream end are not excessive, either in terms of the vertical or horizontal loading.

Where a 'Blue roof' system is proposed above an unheated space these would be considered a podium deck. The designer should ensure that the deck is able to be sufficiently drained to limit ponding and back falls.

### Performance required

To satisfy our Warranty requirements:

- All aspects of the design are to conform to BS 6229 and the 'Roofs' section of this Warranty Technical Manual.
- Blue roofs should half empty in no more than a 12-hour period from the end of the specified design storm, AND should manage water for no more than a 24-hour period from the end of a 1:100 year storm profile for the roof (+40% minimum factor for climate change).
- There must be a concealed void to contain the designed attenuation capacity of storm water.
- Rainfall at the exposed surface level must be managed to ensure that it does not accumulate or pond water on the final finishes.
- There must be a multi-directional flow path above the waterproofing membrane, for water to reach the drainage points.
- All component materials and products used for a Blue roof system must include a recognised third party accreditation certification or other harmonised European Standard.

- Flotation risk for inverted roofs should be calculated and addressed by providing loading to the insulation such that it cannot become buoyant. A warm roof to falls is encouraged to avoid the risks associated with flotation in an inverted warm blue roof.

### Design intent

The design for a Blue roof system on a roof or deck slab must demonstrate:

- A satisfactory level of structural performance for the surface finishes.
- Applied loadings to the roof or deck slab including saturated material loads.
- Management of surface water into the attenuation layer.
- A controlled drainage discharge from the roof or deck slab.
- Architectural detailing to prevent water ingress at abutments, thresholds and joints.
- How will water be managed around potential landscaped features installed on the roof or deck, such as planters.
- A clear indication of the surface usage.
- Its possible future use.
- Thermal performance of space below in particular to an Inverted roof construction proposal.
- Meet the Warranty Functional Requirement: the roof coverings shall be designed and constructed so they have an intended service life of not less than 25 years.

### Technical standards

For the design of a Blue Roof, reference to other associated technical standards may be appropriate. Examples include:

- Continuous Membrane Roofing
- Green Roofs
- Podium Decks
- Drainage

### Waterproofing design

If the space beneath the Blue Roof is situated below ground level, the design may require to be coordinated alongside a CSSW qualified structural waterproofing specialist.

### Associated design principles

- The principles of BS6229 Flat roofs with continuously supported flexible waterproof coverings - Code of practice: are to be applied to waterproofing of roof and deck slabs to ensure water ingress does not occur.
- BS 8102 – Code of practice for protection of below ground structures against water ingress to be applied to ensure continuity of waterproofing at junctions with below ground construction.

### Limitations of this guidance

- For Warranty purpose, where insulation is required, 'Cold Deck' applications are not an acceptable approach in any circumstance in the design of Above Ground Attenuation Surfaces such as Blue Roofs.
- Blue Roofs used in conjunction with Green Roof finishes can be effective. In these situations, the Green Roof build-up may be usable as part of the attenuation storage. However, the attenuated water must not exceed the designed water head.
- Loadings applied must be checked and approved by the Engineer for the design and deflected form of the roof or podium slab.
- Attenuation cells have commonly a water head not exceeding 100mm (1.0KN.m-2). (Note: 60mm of water is approximately equivalent to the minimum imposed snow load of 0.6 KN .m-2). Total loading for the design of the reinforced concrete roof or deck must be checked and approved by the Engineer.
- Inverted Blue Roofs where water storage is layered above the insulation and the waterproofing, will have to withstand potential buoyancy up thrust. This may restrict the depth of insulation which can be used as, a ballast weight of 1.0kN.m2 is required for every 100mm thickness of insulation (in addition to the water loading).
- Inverted insulated roofs will require additional insulation to satisfy Building Regulation requirements through reduction of thermal performance of the insulation due to saturation and the cooling effect of water at the waterproofing layer.
- This guidance is not intended as a standalone design guide and does not include full details of what must be considered to comply with other associated design guides.
- All proposals for Above Ground Attenuation Surfaces are considered on a case by case basis due to the developing nature of guidance available.

## Design requirements

### 'Design Information Submission Pack' required

For Warranty purposes, developers must provide information at the earliest opportunity and, it should be noted, only installers with a demonstrable history of installing blue roof systems are to be permitted.

A full design submission must include:

1. Written demonstration that all other retention and within-site attenuation and release strategies have been explored before a blue roof has been proposed.
2. A full set of section details detailing each proposed build up for the above ground attenuation layers and blue roof areas and junctions with adjoining structures. Including:
  - a) GA plan details for each above ground attenuation surface areas, noting build up types if these vary.
  - b) GA plans and detail sections must show locations of movement joints proposed.
  - c) Details of large obstructions such as planters, M&E equipment or similar and method to ensure water is diverted around these obstructions where applicable.
3. Full details of component products used, including details of third party accreditation certification for all components of the all elements of complete proposed waterproofing and drainage system.
4. Engineers design philosophy statement including but not limited to calculation of substrate deflection, Design wind loads, supply of long-term deflection gradient drawings and required installation tolerances. The design team must also collaborate with the drainage consultant to demonstrate clearly that ponding or back falls will not occur.
5. Drainage design drawings and peak flow calculations for entire slab including:
  - a) Drainage drawings must show position of outlets, Multi-directional drainage flow available above waterproof membrane.
  - b) Position of emergency overflow provision. The overflow facility with capacity to peak rainfall discharge rate (usually BSEN12056-3 Cat 1 rainfall for that area). Overflows must be placed in a conspicuous location.
  - c) Calculation of drainage load using a dynamic storage assessment method to find critical duration using FEH13 (preferred) or FSR rainfall data, and based on 1:100 year risk +40% climate change allowance. This method should examine a series of storm durations from 5 minutes to 48 hours, and for each one model inflow storage and outflow, to determine the storm, which creates the largest depth, and is thus the critical duration for that system.
6. Waterproof membrane threshold detailing linked back to damp proof course which is to be 150mm above the datum of the highest level of attenuated water proposed in all circumstances.
7. Detail for pipe penetrations through wall and floor and detail showing 150mm waterproofing upstand around penetrations which is to be 150mm above the datum of the highest level of attenuated water proposed in all circumstances.
8. Details of locations of any fixings into slab.
9. Details showing waterproofing upstand around penetrations which is to be 150mm above the datum of the highest level of attenuated water proposed in all circumstances.
10. Details of access and repair plan from the building management to address how remedial works could be undertaken in the event of a defect.
11. Details of proposed maintenance strategy, including an undertaking from the building management to ensure that frequent maintenance to the above ground attenuation surfaces are evidenced to be implemented.
12. A condensation risk assessment through the roof, or otherwise demonstrate how the risk of condensation will be limited.
13. Warm roofs only: isolation of rainwater outlet (RWO) from insulation
  - a) Air and vapour control layer to be sealed to waterproof membrane at a square (plan) exclusion zone to all RWOs.
  - b) Zone to be not less than 250mm from RWO.
14. Inverted roofs only: drainage discharge provision
  - a) Provision for drainage at waterproof membrane level.
  - b) Provision of clearly marked access to RWO, free of obstruction.
15. Sufficient ballast to prevent insulation flotation where inverted roofs are proposed.

### Substrate – the roof slab or podium deck

The introduction of a Blue Roof system may have loading implications for the structure of the building. It is vital to consult an Engineer at an early stage, especially when designing for a SuDS solution where water will be attenuated within the roof structure. For example: Designing for heads of water and drainage from the roof can result in an uneven distribution load across the substrate and can lead to large horizontal forces on parapet walls and building upstands

Substrates constructed of reinforced concrete and correctly designed by a competent Engineer have proven to be the most reliable, designed in accordance with BS EN 1992-1-1 Design of Concrete Structures.

Other substrates will require specialist involvement to demonstrate that the substrate will be dimensionally stable and be suitable for a Blue roof proposal.

For Warranty purposes, roof or deck slabs constructed using pre-cast block and beam systems or pre-cast concrete planks are not acceptable for Blue Roof substrate applications.

Where there is any risk for potential excessive movement as a result of the substrate selection or any subsequent usage of the deck area, the designer must ensure through clear evaluation and demonstration that the system is able to cope with the worst case anticipated movement to avoid inducing tensile and shearing stresses in the water proof membrane.

The hydraulic design must take into account any deflections, and re-evaluate peak water depths and loadings in light of this deflection.

### Waterproofing

All aspects of the design of the waterproofing membrane to conform to BS 6229 Flat roofs with continuously supported flexible waterproof coverings – Code of Practice.

Fully bonded or monolithic systems are typically appropriate for 'above ground attenuation surfaces' such as those provided for Blue roof waterproofing membranes. Any certified system MUST NOT allow 'tracking' of water between the substrate and the waterproof membrane.

Curing agents may, on occasion, be applied to the top surface of the concrete substrate to:

- Enhance the concrete quality and durability.
- Reduce the curing period.

The curing agent essentially forms a membrane across the concrete surface of the laid concrete to increase the density of the cement paste and lower the porosity at the surface. This increases resistance to external influences, surface stresses and attack.

Applied curing compounds are not always compatible with a proposed hot-melt application. Adhesion may be reduced causing delamination from the substrate and potentially cause water to track under the waterproof layer following a membrane failure.

Compounds based on a Sodium Silicate base are generally acceptable for a direct applied hot-melt waterproofing application. Adhesion reduction is likely when the base component of the curing agent is:

- Acrylic and Chlorinated rubber
- Resin
- Wax
- Wax/Resin

All systems provided must have 3rd party product approval accreditation referencing the proposed use.

As soon as is practically possible, the waterproof membrane will require protection against damage from either follow on trades or the deck being used as material storage space.

Prior to applying surface finishes above the waterproof layer, the waterproof membrane must be integrity tested and verified by an independent third party. Additional testing may be required where by inspection there is potential that defects may have occurred as a result of damage from follow on trades or the deck being used as storage.

The waterproofing membrane must be linked to any cavity tray to avoid discontinuity resulting in moisture ingress.

### Drainage

It is important that the Blue Roof system is effectively designed to adequately deal with the predicted rainwater for the sites geographical location. Analysis calculations to determine the drainage load using a dynamic storage assessment method to find the critical duration can be determined by using data models:

- FEH13 (preferred)
- FSR rainfall data

Analysis is based on 1:100-year risk + 40% climate change allowance. This method examines a series of storm durations from 5 minutes to 48 hours. Each model calculates flow storage and outflow to determine the storm which creates the largest depth becomes the critical duration for Blue Roof system.

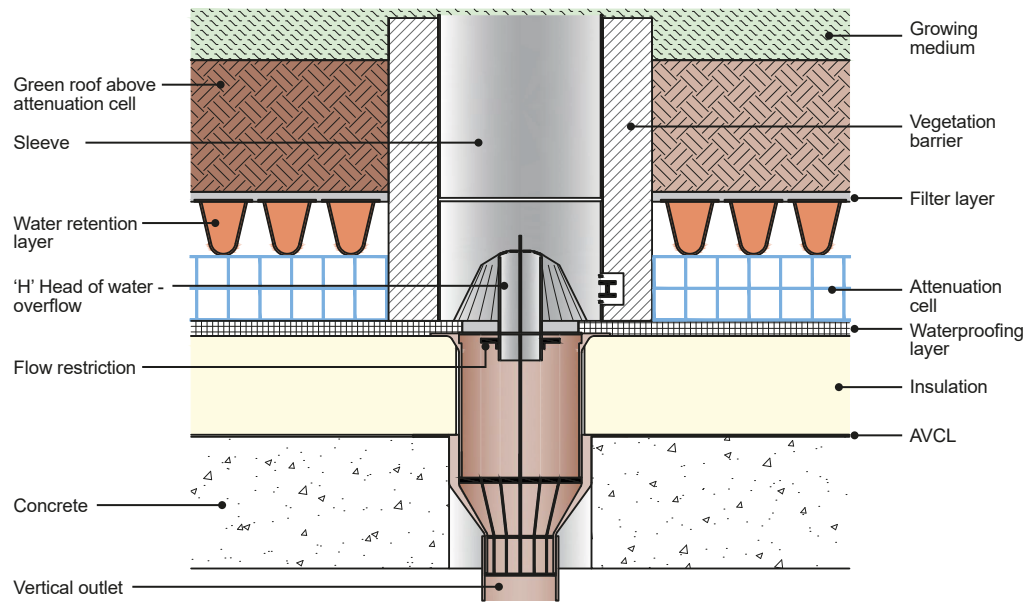
A drainage design must be provided for the blue roof element by a suitably qualified and experienced engineer using the methods set out above, with overflow provision being calculated in accordance with BS EN 12056-3.

The design is to specify the following:

- A retention of no more than 100mm water head (1.0 kN.m<sup>2</sup>) should be used. In all cases, the total loading must be checked and approved by the Engineer for the project.
- Drainage flow calculations accompanied with an explanatory statement including assumptions made.
- Multi directional drainage flow above waterproof membrane.

The specified hydraulic head must never be exceeded and therefore drainage outlets must be designed and positioned to remove excess water. Overflows must be conspicuously positioned.

Drainage from Blue Roofs should not discharge onto lower roof or decks.

**Blue roof drainage section (warm) - in conjunction with a green roof**

Note: This section is only indicative of the construction - reference to supplier system installation and design must be referenced.

**Rainwater outlets**

The choice of outlet is critical in a Blue Roof construction. Rainwater outlets must be designed so as to allow:

- No significant retention after 24 hours in the water reservoir.
- Retention of water reduced by a minimum 50% after 12 hours.
- Have an overflow facility with a capacity to discharge a peak rainfall discharge rate. (BS EN12056-3 Category 1)
- Certification of rainwater outlet to include water head test of the seal to the waterproof membrane.

Rainwater outlets are also to be:

- Positioned in the locations of maximum deflection.
- Countersunk into the deck surface level under the waterproof layer.
- Waterproofing membrane must be dressed into the outlets.
- Surface water from roof and deck finishes should not discharge directly onto the waterproof membrane.

Particular care and attention is required to demonstrate the fixing method between the outlet and flow rate restrictors are fitted to achieve a homogeneous seal between the waterproofing and the outlet.

**Outlets on warm roofs**

Insulation should be isolated from the rainwater outlet:

- Air and vapour control layer to be sealed to the waterproof membrane at a square (plan) exclusion zone to all rainwater outlets.
- The exclusion zone is to be not less than 250mm from the rainwater outlet.
- A condensation risk in these locations is to be reviewed and avoided.

**Outlets on inverted roofs**

Drainage discharge provision should be made to ensure:

- The provision for drainage occurs at waterproof membrane level.
- The provision of clearly marked access to rainwater outlets, which are free of obstruction.
- Sufficient ballast to prevent flotation of insulation.

**Insulation, condensation risk and flotation**

Insulation specified must be proposed as part of a compatible system from a manufacturer.

The U-value achieved in an inverted roof, greatly depends upon the amount of water that passes through the joints of the insulation and sits on the waterproofing is available in test method Appendix C of ETAG 031-1.

Following BS 6229, it is deemed reasonable to apply an increase 10% correction factor to the thickness of the insulation on what might normally be applied to address the potential reduction in performance of the U-Value of the system.

Condensation risk assessments should be undertaken in the roof build up at an early stage to eliminate the potential risk Interstitial Condensation should calculations show it occur.

Thermal bridge loss factors (for drainage via the water flow reducing layer WRFL and insulation) need to be considered in the U-Value calculation and the designer should demonstrate that the necessary U-Value will be provided.

Measures to achieve this could include the applying the following parameters:

- Insulation boards butted:  $0.04W_{day.m-2.K-1.mm-1}$  ( $f=1$ )
- Insulation boards twice-rebated:  $0.03W_{day.m-2.K-1.mm-1}$  ( $f=0.75$ )

The warm roof insulation compressive strength must be greater than the proposed loads including additional safety factors for a fully saturated blue roof and allow for the proposed pedestrian surface finish and traffic.

In a warm roof construction, abutting insulation can cause localised depressions in the waterproofing membrane which can promote ponding in these areas which may have a detrimental effect on the lifespan of the waterproofing membrane.

Inverted blue roofs with water storage above the insulation will have to withstand the buoyant up thrust of that insulation. The Water Flow Reducing Layer (WFRL), even where fully taped or glued, properly lapped and with no folds or creases has been shown by testing not to be able to fully resist standing water above it allowing significant rates of water to pass to the waterproofing layer under the insulation. This causes a tendency to produce a buoyant effect and providing uplift and therefore floatation on the system which is not acceptable.

It can take some time for this to occur over the lifespan on the building and so robust measures in inverted roofs are required to ensure the integrity of the WFRL are in place.

The water separation layer is not fully waterproof. Water penetration of that layer should be expected during the longer duration storms which can lead to uplift and so conservative assumptions should be taken on the efficacy of the ability of the WFRL to disperse water for the purposes of avoiding floatation.

Without controls, full floatation of the insulation should be expected, as water level in the insulation will be the same as that at the control. In all cases sufficient loading must be applied to any inverted blue roof, such that uplift of the system due to floatation cannot occur.

This floatation risk may require the designer to consider the depth of insulation that can be used, as every 100mm of insulation thickness will typically require a ballast weight of around  $1.0 \text{ kN.m}^2$ , which will be in addition to the water loading. Thus, an inverted roof with 200mm of insulation and 100mm water storage will have a total loading of nearly  $3.0 \text{ kN.m}^2$ . It should be noted that this will also act as the horizontal loading on all parapets and upstand walls, which must be checked to ensure they can resist the pressure of the water build up against them.

**Movement Joints**

Structural movement joints are required in large areas of reinforced concrete roofs and decks. Detailing of all movement joints must be provided to demonstrate that ingress or accumulation of water adjacent at or local to the joint will be prevented to limit the risk of frost-thaw action.

Materials forming movement joint must be durable and be able to flex with the waterproofing membrane. Joints must be accessible for inspection and maintenance to allow for a repair in the event of a defect.

**Slab penetrations and access provisions**

Where possible it is best to avoid penetrations for service provisions and where required, the designer should look to group the services to minimise the necessary number of penetrations. Back falls are not acceptable at service penetrations.

Waterproofing must allow also for potential movement with the service penetration detailing, be fully bonded and compatible with the service pipe material. Waterproofing to extend 150mm above Blue Roof surface finished level.

Access and inspections provisions should be incorporated into the design at surface level to allow for routine maintenance to outlets. Surface Finishes should be demountable to allow for routine maintenance whilst meeting the requirements to resist wind uplift.

**Surface Finishes**

Blue Roofs should have a surface finish above the water attenuation layers, this surface finish can be constructed from any suitable permeable pedestrian surface. An impermeable surface can be used but adequate measures should be taken to ensure the water can filter into the Blue Roof attenuation void. The requirements of the Building Regulations should be considered with regard to The Building Regulations Part B (Fire Safety) part B4.

Research demonstrates that blue roofs with green roof finishes can be effective. In these circumstances, the green roof build up may be usable as part of the attenuation storage, however the reservoir storage must be assumed to be full for blue roof design. Silting and biological growth in the reservoir is to be avoided. A root barrier is to be provided.

Excess water accumulation in a Green or Brown Roof system can have an adverse effect on the imposed dead load and planting. In extreme conditions it could change the whole green roof ecosystem, making the system ineffective. Separate maintenance requirements should be considered in a dual green/blue roof to ensure that both systems achieve the minimum required lifespan.

**Building abutment joints and detailing**

Abutment joints with isolated vertical construction adjacent to the roof or deck slab, should not permit the ingress of water to the space below.

Allowance therefore in the waterproofing detailing for anticipated movement between the roof slab or deck and the vertical façade must be allowed for to prevent the waterproof layer shearing. Blue Roof to Wall façade abutments are often breached by water between the cavity tray and the waterproofing membrane, therefore continuity is essential.

Additional waterproofing maybe required for any water passing the cavity tray to discharge to the Blue Roof waterproofing membrane. The detailing shall ensure that in the event of a defect in the cavity tray it will not result in moisture ingress into a conditioned space.

Level door access from the Blue Roof level to occupied spaces should provide:

- A drainage channel in front of the door cill.
- A 10mm gap between the drainage channel and the cill.
- The door cill should have a minimum 45mm overhang of the construction below.

The designer should check that in all areas there is an upstand height able to provide a waterproofing upstand at least 150mm in height. At critical points, such as the top of drainage slopes may potentially compromise this upstand height.

**Architectural features**

At the pre-construction phase, an audit should be established of the surface treatments, architectural features, planters and landscaping that are placed on roof or deck slab. Such detailing will require the necessity for:

- Weatherproofing - incorporating an upstand and cover flashing arrangement for solid features placed on the Blue Roof slab.
- Waterproofing – provide continuous waterproofing under the architectural feature.
- Diversion – measures should be taken to divert water around large structures to ensure that it is directed to outlets provided.

Where structures are built off the Blue Roof slab a suitably designed monolithic upstand or kicker rising above the waterproofing membrane must be provided.

Attenuated water should fall away from any structures built off the roof slab or deck.

**Installation and testing requirements**

A quality assurance and record keeping system should be provided at pre-construction to ensure that standards of workmanship can be demonstrated throughout installation.

1. Main contractor to provide report of testing for integrity of waterproof membrane, including credentials of test Engineer, method statement, full description of defects found and their location, evidence of repair and re-test.
2. Installer of blue roof system to provide signed certificate of satisfaction with roof finishes over blue roof if these are installed by others.
3. Installer of roof system to provide final inspection report of waterproof membrane manufacturer.
4. Inverted roofs only: Water Flow Reducing Layer (WFRL)
  - a) WFRL to be dressed up to finished roof level at all abutments and penetrations noting the requirement for upstands and thresholds to be 150mm above the greatest expected height of the water line datum. Checks to be undertaken to assess the integrity of the WFRL.
  - b) WFRL to be dressed down at all Rain Water Outlets.
5. The Engineer is to provide confirmation that the final construction satisfies the design deflection analysis prepared for drainage provisions.

An approved 'installation contractor' recognised by the material manufacturer with installers with a demonstrable history of installing blue roof systems are to be permitted to install the manufacturer's waterproof membrane Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty surveyor at the earliest opportunity.

**Testing**

Testing is required to demonstrate the integrity of the waterproof membrane undertaken by a suitably qualified and experienced third-party certified test agency independent of the roofing contractor.

Certification should be made available to the Warranty surveyor prior to handover.

The testing service provider should provide in their report:

- Date of test.
- Project name, address and reference number.
- Name, address and contact details of the test provider.
- Experience and training of tester.
- Membership of trade association which sets a code of conduct for the service.
- Description and efficacy of the waterproof installation.
- Details and large, clear photographs of defects identified (where applicable).
- Number of tests undertaken.
- Confirmation of result of testing.

**Final inspection**

At practical completion of the waterproofing membrane to the Blue Roof. All areas should be cleared of stored material, site operations and all protection. A thorough, visual and photo graphic recorded inspection of all areas, including deck surface architectural and landscaped features, must be carried out with representation from the main and roofing contractors in attendance.

A deflection analysis will be required, 'before' and 'after' completion by the Engineer to confirm the minimum falls are achieved and that no back falls to the waterproofing surface occur.

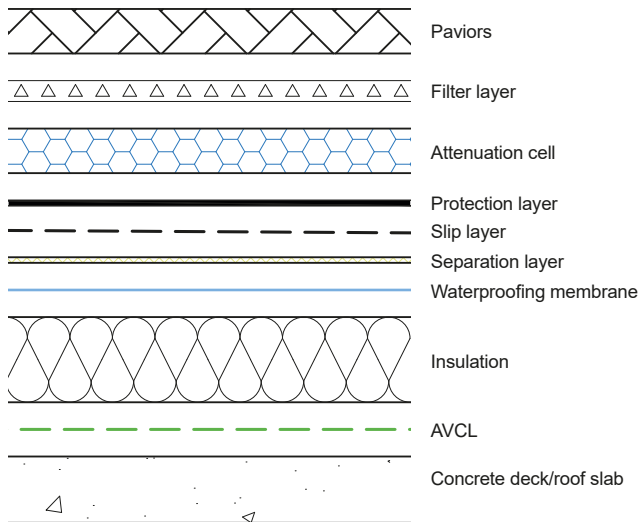
**Operations and maintenance**

The Developer should have in place an Operation and maintenance manual (O&M) and should identify areas of risk including:

- Failure of maintenance and cleansing of rainwater outlets.
- Failure of filter membranes leading to obstruction of storage units.
- Flotation of inverted roof insulation.
- Blockage of small diameter control holes to drains.
- Removal of controls, leading to unrestricted discharge (risk to wider community rather than the project building).



## Blue roof (warm) – Layering



**Filter layer:** Protects the attenuation cell - reservoir against clogging by fine particles from the sub-base or layering course. It also ensures effective horizontal drainage. If topsoil is used, special measures should be taken for fine soil particles clogging the filter layer.

**Attenuation cell reservoir:** Attenuation to be designed to discharge the maximum designed head of water within a 24 hour period.

**Protection layer:** The layer protects the waterproofing membrane from damage caused by the static and dynamic loads. Protection layers may also fulfil the function of the slip and separation layers.

**Slip layer:** Horizontal loads occur by temperature change and dynamic forces. Waterproofing materials cannot withstand these loads and therefore care should be given for its specification.

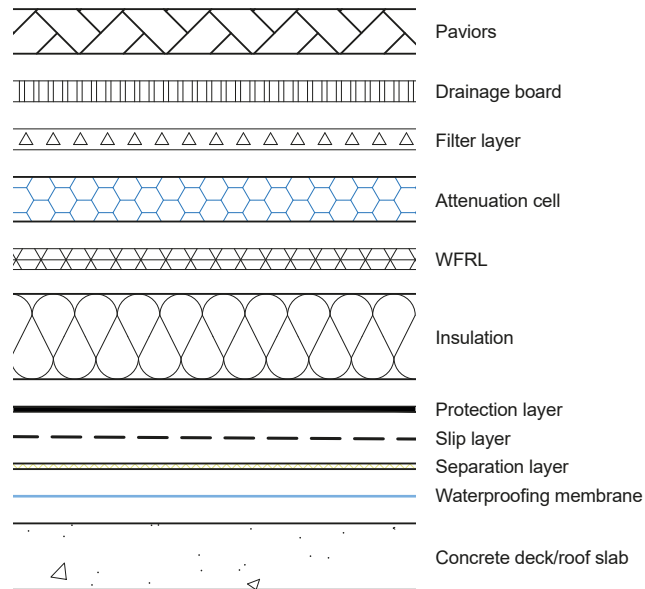
**Separation layer:** Separates incompatible materials.

**Waterproofing membrane:** Bonded elastomeric system: Underlay - Self-adhesive; Capping sheet - Torch on.

**Insulation:** Compressive strength to support increased loadings. Tapered to falls. Thermal requirements to meet Approved Document L.

**AVCL:** Tear resistant air and vapour control layer.

## Blue roof (inverted) – Layering



**Drainage board:** Allows free multi-directional dispersal of water.

**Filter layer:** Protects the attenuation cell - reservoir against clogging by fine particles from the sub-base or layering course. It also ensures effective horizontal drainage. If topsoil is used, special measures should be taken for fine soil particles clogging the filter layer.

**Attenuation cell reservoir:** Attenuation to be designed to discharge the maximum designed head of water within a 24 hour period.

**WFRL:** Water Flow Reducing Layer. A barrier to rainwater reducing the volume of water that can reach the waterproof roof deck.

**Insulation:** Compressive strength to support increased loadings. Tapered to falls. Thermal requirements to meet Approved Document L.

**Protection layer:** The layer protects the waterproofing membrane from damage caused by the static and dynamic loads. Protection layers may also fulfil the function of the slip and separation layers.

**Slip layer:** Horizontal loads occur by temperature change and dynamic forces. Waterproofing materials cannot withstand these loads and therefore care should be given for its specification.

**Separation layer:** Separates incompatible materials.

**Waterproofing membrane:** Bonded bitumen.

## References

- BS EN 1992-1-1 - Eurocode 2: Design of concrete structures. General rules and rules for buildings
- BS 6229 – Flat roofs with continuously supported flexible waterproof coverings - Code of practice
- BS 8102 – Code of practice for protection of below ground structures against water ingress
- BS EN 12056-3 – Gravity drainage systems inside buildings - Roof drainage, layout and calculation.

## Guidance notes

- Technical Guidance Note for the construction and design of Blue Roofs - NFRC
- The SuDS Manual - CIRIA

## Rainfall models

- The Flood Estimation Handbook (FEH) – UK SuDS
- Flood Studies Report (FSR)
- OFWAT - Changes in the frequency of extreme rainfall events for selected towns and cities

# 11.

## Roofs

### 11.10

#### Podium Decks

### Provision of information

A full set of design drawings and specifications shall be made available to the Warranty Provider and all other interested parties prior to the associated works starting on site. This may include:

1. A full structural design for the podium deck.
2. A plan or plans which detailed drainage provisions showing falls and their direction, and the position of accessible outlets to provide effective drainage with no back falls. Due to complexity and additional loadings, deflection and drainage analysis should also be provided.
3. Sections through the construction, detailing how falls are formed e.g. created by the structural deck, additional bonded screed layers. This should include outline levels survey requirements and preparation treatment of deck before application of waterproofing.
4. Sectional details that show thickness, specification and position of the components inclusive of all materials relating to the podium (see definitions for extensive material listing).
5. Details of all fixings, their frequency and fixing method.
6. Methodology and evidence of pull testing for fixings and pull/peel testing for bonded materials.
7. A suite of site specific details for all junctions, outlets and penetrations.
8. Details of all fire stopping within structure and fire mitigation measures. This should include specification and a detailed location layout drawings showing positioning.
9. Outline of method and plan for testing the integrity of the waterproofing layer.

The Warranty Surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

### Introduction

This section provides technical guidance for the design, use of materials and workmanship for podium decks to meet the functional requirements of the Technical Manual.

Examples of podium decks include:

- An open amenity space above a sub-terrain car park.
- A terrace.

### Definition

#### Podium deck

Podium decks are an open spaced amenity structural slab/deck and are defined for Warranty purposes as: An externally weathered elevated platform over an unconditioned (unheated or soundproofed) space.

The requirement to waterproof is to:

- Protect the deck surface from water accumulation, and,
- Prevent the ingress of water to the space below, and,
- Prevent ingress of water to adjacent buildings.

Where a space below a proposed deck is conditioned (heat and sound), it would no longer be considered as a 'podium' and instead is classified as an insulated flat roof deck.

Please refer to BS 6229 – Flat roofs with continuously supported flexible waterproof coverings - Code of practice and the 'Roofs' section of this Technical Manual.

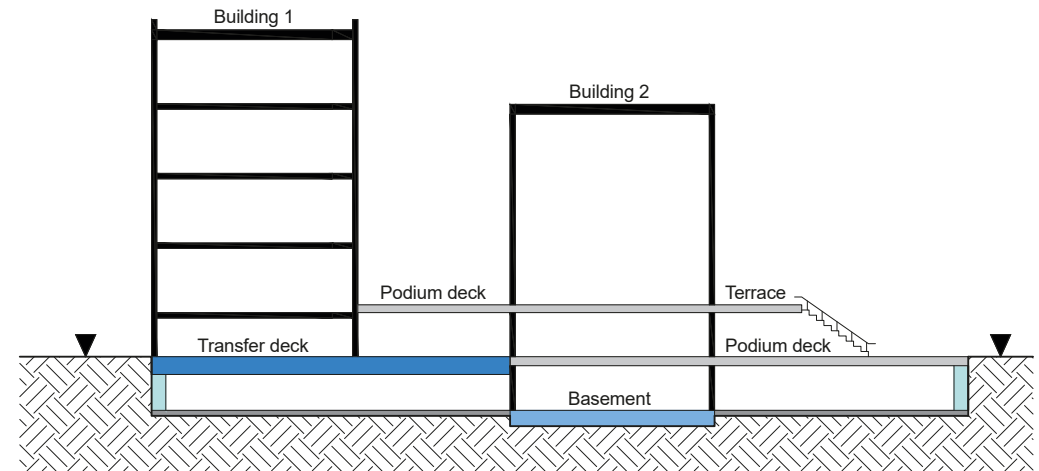
#### Transfer deck

A transfer deck is a uniquely loaded supporting podium deck. The designed vertical superstructure loads supported from the deck are transferred along a horizontal load path along designed beams integral with the slab to new supports.

The requirement to waterproof is to:

- Protect the deck surface from water accumulation, and,
- Prevent the ingress of water to the space below, and,
- Prevent water ingress into buildings supported on and adjacent to the deck.

### Typical podium deck and transfer desk examples



### Design considerations

#### Design intent

For the elemental design of a Podium Deck, the client must provide a clear indication of the surface usage and its possible future use.

The design should demonstrate a satisfactory level of:

- Structural performance of the slab for surface treatment, finishes and drainage.
- Architectural and landscaping placed on the podium deck.
- Management of surface water around landscaped features to drainage points.
- Drainage from the podium deck.

#### Technical standards

In the design of a podium deck, reference to other associated technical standards may be appropriate. Examples include:

- Continuous Membrane Roofing
- Green Roofs
- Blue Roofs
- Drainage
- Basements

#### Waterproofing design

If the space beneath the podium deck is below ground, the design of the waterproofing layer must be coordinated alongside a CSSW qualified structural waterproofing specialist.

#### Associated design principles

- The principles of BS 6229 Flat roofs with continuously supported flexible waterproof coverings – Code of Practice, are to be applied to waterproofing of podium decks to ensure water ingress does not occur.
- BS 8102 – Protection of below ground structures against water ingress – Code of practice are to be applied to ensure the continuity of waterproofing of junctions of basements to podium decks is managed to ensure that water ingress does not occur.

Further practical guidance on this and compliance with Warranty requirements for podium decks is included herein.

#### Guidance limitations

This guidance is not intended as a standalone design guide and does not include full details of what must be considered to comply with other associated design guides.

## Design requirements

### Information required

To allow a Warranty assessment to be undertaken in a timely manner, developers must provide information at the earliest opportunity. At submission a full design should include:

### Drawings

General arrangement plans for each podium deck area showing:

- Deck features and landscaping.
- Directions of falls for surface water management.
- Drainage provisions.
- Deck finishes.
- Below slab space.

General sections and section details for:

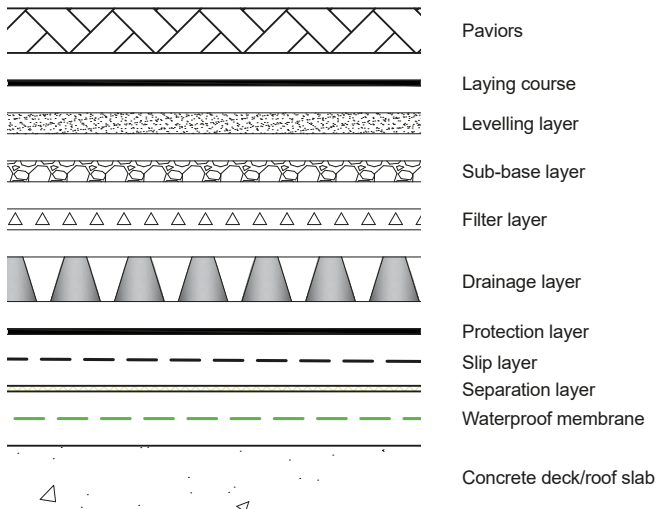
- Layering/build up types above the slab showing waterproofing, water flow control and finishes.
- Variance of build-up types.
- Movement joints.
- Entrance thresholds.
- Building abutments and upstands on and adjacent to podium deck.
- Through slab services and pipe penetrations.
- Planters and Green Landscaping.
- Slab fixings.
- Other base details for architectural features placed on the slab.

### Design and materials

- Slab design and deflection analysis.
- Surface water drainage design philosophy and peak flow calculations for entire podium slab (including countersunk outlets).
- Specification of component materials and products used, including third party accreditation certification.
- Maintenance plan to address how remedial works could be undertaken in the event of a defect.

## Design requirements

The compatibility and co-operation of each individual layer is critical to determining a reasonable life span for a flexibly paved surface. Each layer must have the ability to absorb and constrain potential dynamic and static loading.



Note: Manufacturers will provide systems which are a combination of elemental layers i.e. protection layer + slip layer + separation layer.

**Layering course:** Accommodates variation in thickness of paviour units.

**Levelling layer:** To overcome any height differences combination of the laying and sub-base layer.

**Sub-base layer:** Absorbs and spreads static loads to prevent deformation of the paving.

**Filter layer:** Protects the drainage layer against clogging by fine particles from the sub-base or layering course. It also ensures effective horizontal drainage. If topsoil is used, special measures should be taken for fine soil particles clogging the filter layer.

**Drainage layer:** Relieves hydrostatic pressure. Discharges excess water under the sub-base layer, prevents ponding, and risk of frost heave affecting the surface.

**Protection layer:** The layer protects the waterproofing membrane from damage caused by the static and dynamic loads. Protection layers may also fulfil the function of the slip and separation layers.

**Slip layer:** Horizontal loads occur by temperature change and dynamic forces. Waterproofing materials cannot withstand these loads and therefore care should be given for its specification.

**Separation layer:** Incompatible materials need to be isolated.

## Design requirements

### Podium deck use

At the earliest possible pre-construction stage, the client design should define the range of potential uses of the podium deck with reference to the worst case of dead loads (permanent finishes), live imposed (use types) and rolling (traffic) loads. Detailing should be undertaken to ensure that in the event of a defect, a repair can be feasibly undertaken and should be at the forefront of the design process.

Landscaped areas requiring water irrigation will require additional control of surface water. Please refer to the Warranty Green Roofs guidance for further information.

Surface water attenuation systems – Blue roofs on the Podium Deck will require additional structural analysis of the deck and drainage control. Please refer to the Warranty Blue Roofs guidance for further information.

### Substrate - the podium deck slab

Podium Decks constructed from reinforced concrete and correctly designed by an Engineer have proven to be the most reliable when designed in accordance with BS EN 1992-1-1:2004 Eurocode 2 Design of Concrete Structures (+A1:2014). In any event the substrate in all cases must be proven to be dimensionally stable.

For Warranty purposes, Podium Decks constructed of pre-cast block and beam systems or pre-cast concrete planks are not acceptable for any podium deck applications.

Other approaches such as pre-cast concrete hollow core planks with a structural screed and ribbed metal deck formwork require additional specialist involvement to demonstrate that the construction will meet the requirement to show that the substrate will be dimensionally stable.

When there is any risk for excessive movement as a result of the substrate selection or any potential future use of the deck area increasing slab movement, the designer must ensure through clear evaluation and demonstration that the system is able to cope with the worst case anticipated movement.

### Deck falls

Drainage falls should be constructed in a manner that they fall away from any structures built off the podium. Water standing on the deck, can exert pressures laterally on the external walls of structures built over the deck, therefore, the waterproofing line from the podium deck surface must be continuous to DPC level.

Cementitious screeds provide a stable substrate to mitred falls and are recommended. Screeds to be in accordance with BS 8204. Surface water should always fall away from any above deck protrusions or abutments.

The finish surface is to have a minimum design fall 1:80 prior to applying the waterproofing layer. This will ensure that adequate flow of surface water is maintained to the drainage system and that no ponding occurs on the deck.

Consideration should be given to height differences between the top and bottom of the falls. Where there are large height differences in the screed forming the falls the height for dressing the waterproof membrane up an abutment wall may be reduced.

On large podium decks it may be necessary to increase the number of drainage outlets to avoid excessive fall heights in the screed.

### Waterproofing

Fully bonded or monolithic systems are typically appropriate for Podium Deck waterproofing. Any waterproofing system must not allow the 'tracking' of water under the waterproof membrane.

Curing agents may, on occasion, be applied to the top surface of the concrete substrate to:

- Enhance the concrete quality and durability.
- Reduce the curing period.

The curing agent essentially forms a membrane across the concrete surface of the laid concrete to increase the density of the cement paste and lower the porosity at the surface. This increases resistance to external influences, surface stresses and attack.

Applied curing compounds are not always compatible with a proposed hot-melt application. Adhesion may be reduced causing delamination from the substrate and potentially cause water to track under the waterproof layer following a membrane failure.

Compounds based on a Sodium Silicate based are generally acceptable for a direct applied hot-melt waterproofing application. Adhesion reduction is likely when the base component of the curing agent is:

- Acrylic and Chlorinated rubber.
- Resin.
- Wax.
- Wax/Resin.

In all cases a Hot-melt waterproofing membrane must be applied to a primed concrete surface with reference to BS EN 13670 Execution of Concrete Structures (E) - 8.5 Curing and protection states (10) (11)

All 'systems', specified products and materials require a 3rd party product approval certification which references the areas the material can be used. In the selection of a system, it should be considered whether that system is reliant on insulation or a 'Water Flow Reducing Layer' (WFRL) to disperse water to the outlets.

For Podium Deck applications, loose laid or partially bonded waterproofing materials are not acceptable.

The use of a 'waterproof concrete' is not considered to be an acceptable approach for Podium Deck waterproofing.

As soon as is practically possible, the waterproof membrane will require protection against damage from either follow on trades or the deck being used as material storage space.

Prior to applying surface finishes above the waterproof layer, the waterproof membrane must be integrity tested and verified by an independent third party.

The waterproofing layer must be linked to any cavity tray to avoid discontinuity which could result in moisture ingress.

### Drainage

A complete drainage design for the Podium Deck must be provided, by an Engineer and in accordance with BS EN 12056-3. Drainage calculations should be accompanied with a short explanatory statement including assumptions made.

It is important that the Podium Deck be designed to adequately deal with the predicted rainwater for its geographical location. Additional consideration should be made for drainage from upper areas such as façade run off or external balconies from the adjacent structure(s).

Surface water from upper podium levels or roofs must not discharge onto lower podium deck levels.

Podium deck surface finishes shall be positively drained to discharge surface water so that it does not accumulate and it does not compromise the use of the space at surface level.

Where a green/blue roof proposal forms part of a podium deck proposal, our Warranty guidance on Green and Blue roofs must be followed as such proposals may impact on the Podium deck performance (loadings and effective drainage).

### Rainwater outlets

- Should be positioned in the locations of maximum deflection.
- Outlets within the slab must be designed to be countersunk and discharge at deck level, not at surface finish level.
- The waterproofing layer must be dressed into the outlets.
- Inlet gullies which collect water from the deck and finishes level and then discharge directly onto the waterproof membrane should be avoided.

Where podium decks form part of an enclosed area, an overflow for each outlet required, should be provided to ensure that surface water does not accumulate in the event of a blockage. Surface water should be discharged through the external perimeter in a readily apparent location to allow for maintenance to be undertaken at the earliest opportunity.

### Movement joints

Structural movement joints are required in large area reinforced concrete Podium Decks. Detailing of all movement joints are required to demonstrate they will prevent water ingress or accumulation of water adjacent at or local to the joint to limit the risk of frost-thaw action.

Materials forming the movement joint must be durable and be able to flex with the waterproofing membrane. Joints must be accessible for inspection and maintenance to allow for repair in the event of a defect.

### Abutment joints

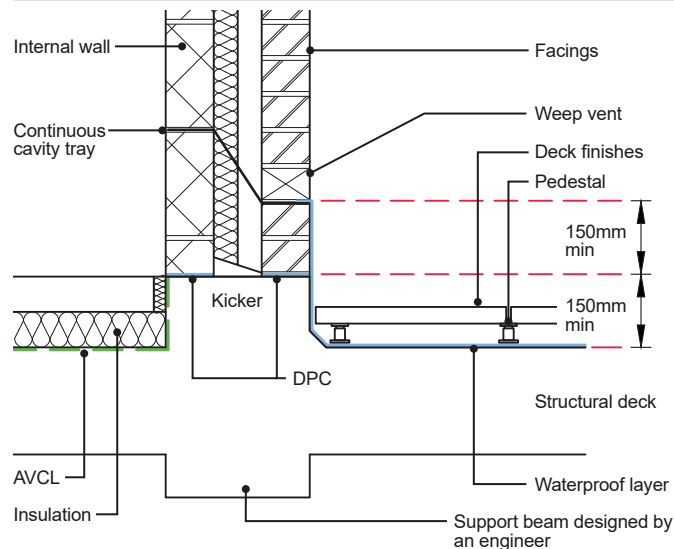
Abutment joints with isolated vertical construction adjacent to the Podium Deck should not permit the ingress of water to the space below.

Allowance should be made in the detailing for anticipated movement between the Podium Deck and the vertical façade, to prevent the waterproof layer from shearing.

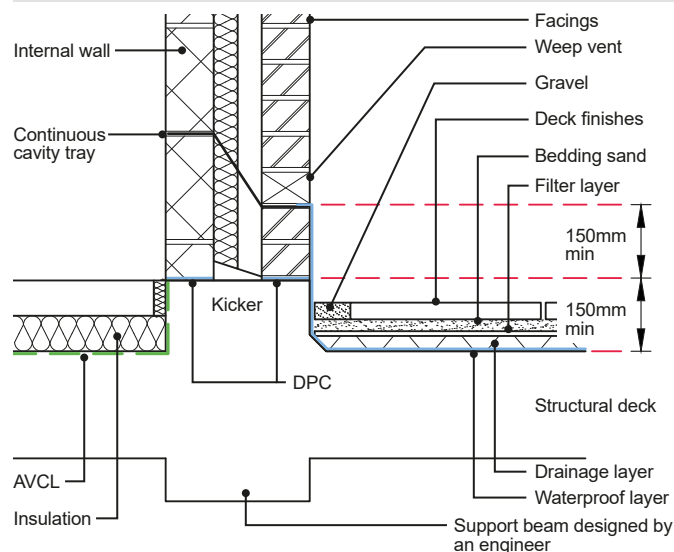
Where structures abut or are built off the podium deck, the waterproofing must be dressed up the vertical surface of the facade to a minimum of 150mm above the finished Podium Deck level.

Cavity trays above abutments (Podium Deck to wall junctions) are often breached at the podium deck level, allowing water to seep into the building. Continuity is therefore essential between these two elements and waterproofing detailing is required to ensure any water passing the cavity tray is discharged to the podium deck adequately. Waterproofing layers must be linked with the DPC which should be at least 150mm above the finished surface level. The masonry should be durable against saturation in accordance with BS EN 771-1.

### Wall waterproofing detail (slabs on pedestals)



### Wall waterproofing detail (bedded slabs)



### Threshold abutments

All level door accesses formed from the podium deck level to occupied spaces should provide:

- A 10mm gap between the drainage channel and the door cill.
- The door cill should have a minimum 45mm overhang of the construction below.
- In order to have a reduced upstand of 75mm max from the underside of the

door cill to the top of the structural deck, there must be a fall on the structural deck away from the door opening.

- Waterproofing to be dressed and linked with DPC at reveals.
- Waterproofing may be continuous under door threshold as creep (gradual deformation under stress) is likely to be minimal.

### Slab penetrations

Where possible, it is best to avoid Podium Deck penetrations for service provisions. Where required, the designer should look to group the services to minimise the necessary number of penetrations.

Detailing of the penetration or group to prevent ingress or accumulation of water at the penetration requires consideration and should ensure:

- Back falls are not created at service penetrations.
- Waterproofing must allow for potential movement with the service penetration detailing
- Waterproofing must be fully bonded and compatible with the service pipe material.
- The waterproofing must extend 150mm above Podium Deck surface finished level.

### Architectural features

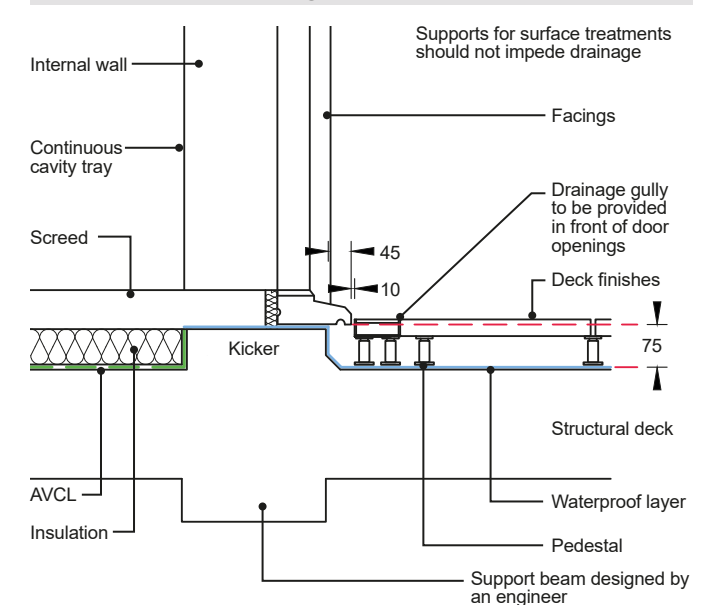
At the pre-construction phase, an audit of the surface treatments, architectural features and planters that are placed on the podium should be established. Such detailing will require the need for:

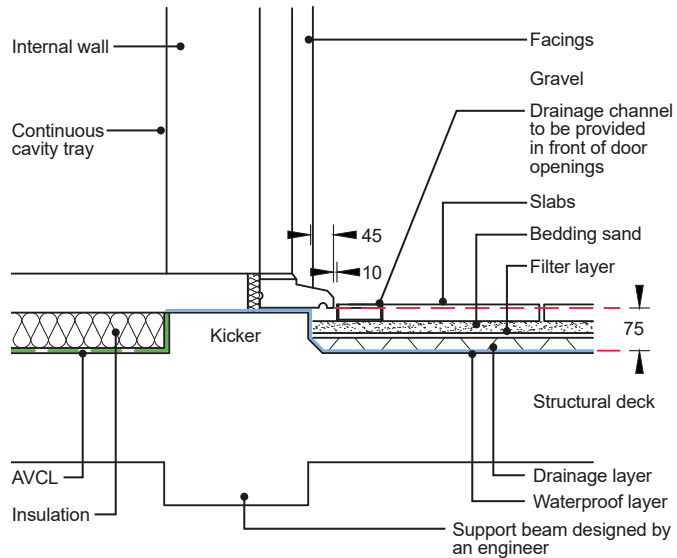
- Weatherproofing - incorporating an upstand and cover flashing arrangement for solid features placed on the Podium Deck, or
- Waterproofing - providing continuous waterproofing under the architectural feature.
- Diversion - measures should be taken to divert water around large structures to ensure that it is able to reach the outlets provided.

Where structures are built off the Podium Deck, a suitably designed 150mm upstand above the waterproofing layer must be provided. Surface water should be designed to fall away from any structures built off the podium.

Planters should be built off a 150mm monolithic kicker with the Podium Deck slab.

### Threshold waterproofing detail (slabs on pedestals)



**Threshold waterproofing detail (bedded paviers)**

- Details and provision of large- clear photographs of defects identified (when applicable).
- Number of tests undertaken.
- Confirmation of result of testing.

**Final inspection**

At practical completion of the waterproofing to the Podium Deck. All areas should be clear of stored material, site operations and all protection. A thorough, visual and recorded inspection, of all areas, including deck surface architectural and landscaped features, to be carried out with representation from the main and roofing contractors in attendance.

**References and further guidance****References**

- BS EN 1992-1-1 Eurocode 2: Design of concrete structures. General rules and rules for buildings
- BS 6229 - Flat roofs with continuously supported flexible waterproof coverings - Code of practice
- BS 8102 - Code of practice for protection of below ground structures against water ingress
- BS EN 12056-3 - Gravity drainage systems inside buildings - Roof drainage, layout and calculation.
- BS 8204-1 Screeds, bases and in situ floorings. Concrete bases and cementitious levelling screeds to receive floorings – Code of Practice
- BS EN 13670 Execution of Concrete Structures

**Guidance notes**

- SWG2/12.13 – Property Care Association Podium Decks

**Installation requirements****Construction evidence**

A quality assurance and record keeping system should be provided at pre-construction to ensure that standards of workmanship can be demonstrated.

An approved installation contractor recognised by the material manufacture as being competent to install the manufacturer's waterproof membrane should be used. Evidence of the manufacturer's approval of the contractor to install their products should be provided to the Warranty Surveyor.

The waterproof layer of the podium deck shall achieve a minimum design fall of 1:80 – 'as built'. A levels survey should be undertaken to demonstrate this is achieved.

**Testing**

Testing is required to demonstrate the integrity of the waterproof membrane.

It must be undertaken by a suitably qualified and experienced third party certified test agency who is independent of the roofing contractor using either:

- Low Voltage Earth Leakage, or,
- High voltage electrical discharge.

Additional testing may be required where by inspection, there is potential that defects may have occurred as a result of damage from follow on trades, or the deck being used as storage.

Certification should be made available to the Warranty Surveyor prior to handover. The testing service provider should provide in their report:

**Date of test**

- Project name, address and reference number.
- Name, address and contact of certifier.
- Description and efficacy of the waterproof installation.
- Experience and training of tester.
- Membership of an appropriate trade association, which sets a Code of Conduct for the service.



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