CHAPTER 7: Superstructure

CONTENTS

FUNCTIONAL REQUIREMENTS

7.1 EXTERNAL MASONRY WALLS

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Cavities should be clear from mortar droppings to prevent moisture ingress.
iv. Masonry walls should not be laid in extreme weather conditions.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. Materials should be suitable for the relative exposure of the building in accordance with the relevant British Standard.
iv. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The design and construction of masonry walls must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.1.1 General

Protection

All new masonry work should be protected during construction by covering to ensure that walls are not allowed to become saturated by rainwater, dry out too quickly in hot weather, are protected against frost attack and the risk of efflorescence, line staining and movement problems are reduced.

Any temporary cover should not disturb the new masonry.

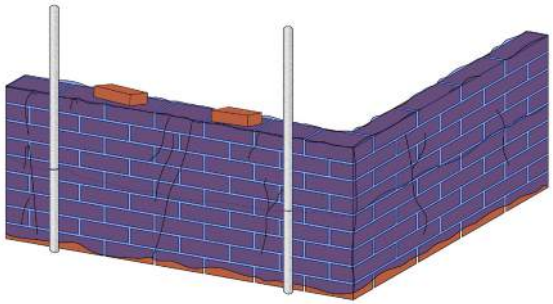


Figure 1: Protection of masonry

Stability during construction

Gable walls should be appropriately propped prior to the construction of any roof. When a floor or roof slab of a building is used for the temporary storage of building materials, the loading should not exceed the design loading for the element.

7.1.2 Brick and block suitability

Exposure

Facing bricks must have a suitable level of durability and particular attention should be paid to the brick's resistance to frost and moisture. Further guidance can be found in Chapter 2 - Materials of this Manual.

Non-rendered blockwork

All external blockwork should be rendered or otherwise finished with a cladding that is appropriately durable, unless the block manufacturer can provide third party certification confirming that the blockwork can be left unfinished, or finished in an alternative way.

Colour variation of bricks

There is usually a variation in colour of bricks of the same style. To prevent patching of colour, it is recommended that at least three packs of bricks are opened at any one time and mixed randomly to ensure that the wall is of an even colour.

Frogs and perforations

Frogged bricks have a depression in the face of the brick. Normally, they should be laid with the major depression, or frog, facing up so that it is fully filled with mortar during laying. This ensures optimum strength and helps to increase the mass of the wall (to give good sound insulation) and prevents the possibility of standing water within the structure which could freeze. Bricks with a directional surface texture are intended to be laid frog up.

Care should be taken with the use of perforated bricks where the exposure rating of the wall is high, as water retention / collection has been found to exist in the perforations.

Efflorescence

Efflorescence is a white deposit on the face of masonry brought about by water moving through the wall, dissolving soluble salts and depositing them when the water evaporates during drying out.

Efflorescence is best prevented by:

- Keeping all units dry prior to use;
- Protecting the head of newly constructed work with some form of cover to prevent saturation, refer to Chapter 2 - Materials of this Manual.

7.1.3 Mortar

General

Mortar type above DPC should be chosen in accordance with guidance given in Chapter 2 - Materials, of this Manual, or as recommended by the brick or block manufacturer. To ensure adequate durability, strength and workability, lime and / or air entraining plasticisers may be added to cement in accordance with manufacturer's recommendations. Cement and sand alone should not be used unless a strong mix is specifically required by the design.

Batching

Keep batching and mixing equipment clean to avoid contamination with materials used previously. Mortar should be mixed by machine or use ready-mixed retarded mortars.

Mixing

Mortar should be carefully and consistently proportioned, and then thoroughly mixed using a mechanical mixer, except for very small quantities.

7.1.4 Adverse weather

Working in adverse weather

Precautions should be taken when necessary to maintain the temperature of bricks, blocks and mortar above 3°C. The use of anti-freeze as a frost resistant additive in mortar is not permitted. Further guidance can be found in Chapter 2 - Materials of this Manual.

During prolonged periods of hot weather when masonry units can become very dry, absorbent clay bricks may be wetted to reduce suction. Low absorption bricks, i.e., engineering bricks, should not be wetted. For calcium silicate and concrete units, the mortar specification may need to be changed in order to incorporate an admixture to assist with water retention. On no account should masonry units or completed work be saturated with water.

Dealing with areas of high exposure to frost and wind driven rain

Frost attack

Frost resistant bricks should be used in areas that are prone to prolonged periods of frost.

If there are any doubts about the suitability of facing bricks in areas of severe frost exposure, written clarification by the brick manufacturer confirming the suitability of the brick should be provided.

Wind driven rain

To ascertain the risk relating to wind driven rain, the following should be determined:

- The exposure to wind driven rain using Figure 2;
- Ensuring that the correct type of construction is used, including the correct application of insulation;
- The correct level of workmanship and design detailing particularly around window and door openings.

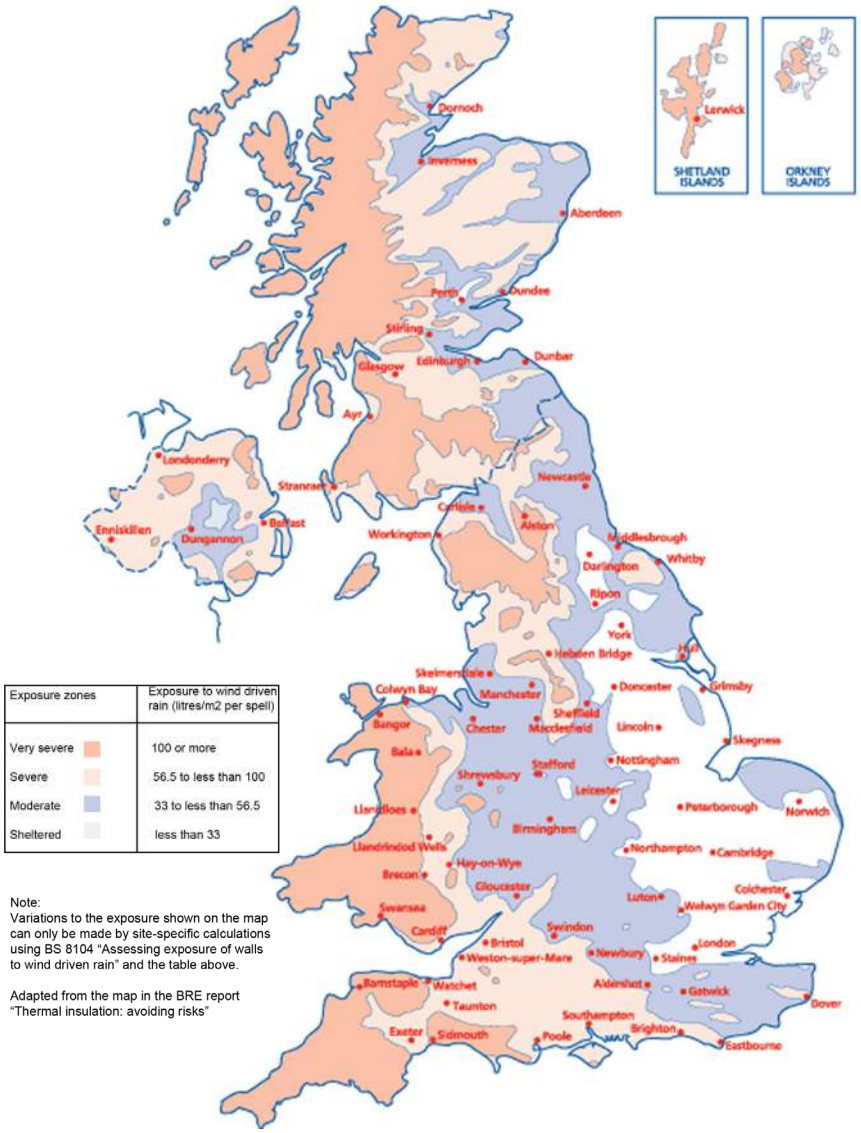


Figure 2: Map showing exposure to wind driven rain categories

		Minimum insulation thickness (mm)		
Exposure category	**Suitable wall construction**	**Built-in insulation**	**Retro-fill (other than UF foam)**	**UF foam**
Very Severe	Any wall with impervious cladding	50	50	50
	Fair-faced masonry with impervious cladding to all walls above ground storey	100	100	N/A
	Any wall fully rendered (2)	75	75	N/A
	Fair-faced masonry (1)	N/A	N/A	N/A
Severe	Any wall with impervious cladding or render (2)	50	50	50
	Fair-faced masonry with impervious cladding or render (2) to all walls above ground storey	50	75	50
	Fair-faced masonry	75	75	N/A
Moderate	Any wall with impervious cladding or render	50	50	50
	Fair -aced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fair-faced masonry	50	75	75
Sheltered	Any wall with impervious cladding or render	50	50	50
	Fair-faced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fair-faced masonry	50	50	50

Notes:

(1) In very severe exposure locations, fair-faced masonry with full cavity insulation is not permitted.

(2) Render on an external leaf of clay bricks (F2, S1, or F1,S1 designation bricks BS EN 771) in severe or very severe exposures is not permitted where the cavity is to be fully filled with insulation.

- This table covers walls where the external leaf does not exceed 12m in height.
- The exposure category of the dwellings is determined by its location on the map showing categories of exposure to wind driven rain.
- Fair-faced masonry includes clay, calcium silicate and concrete bricks and blocks and dressed natural stone laid in an appropriate mortar, preferably with struck, weathered or bucket handle joints. Cavity walls of random rubble or random natural stone should not be fully filled.
- Recessed mortar joints should not be used.

Table 1: Suitable cavity wall construction depending on exposure

7.1.5 Cavities

A traditional masonry wall should be constructed using an inner and outer leaf and a cavity should be provided between them, which meet the following provisions:

- The cavity to have a minimum width of 50mm;
- To be kept clear from mortar snots to ensure that the cavity is not bridged;
- The two leaves should be appropriately tied in accordance with section 7.1.8 of this Chapter;
- The cavity can be fully insulated or partially insulated, depending on exposure to wind driven rain. For partial fill insulation, a minimum clear cavity of 50mm should always be provided. Further information can be found in BS 8104.

7.1.6 Structural design of walls

A method of meeting the requirements of the warranty is to design and construct walls to the relevant Approved Document depending on the region. For example, in England and Wales, the masonry units should be built in accordance with Approved Document A (Structure). Alternatively, justification of design by a Chartered Structural Engineer can be used as an alternative solution.

7.1.7 Restraint of walls

Walls should be adequately restrained at floors, ceilings and verges in accordance with the relevant Building Regulations.

Restraint can be provided by:

- Restraint type joist hangers;
- Lateral restraint straps;
- Other forms of restraint proven by a Chartered Engineer.

Restraint type hangers

It is necessary to ensure that:

- The hanger is bedded directly on the masonry and there is no gap between the hanger back-plate and the face of the masonry;
- At least 450mm of masonry should be provided above the hanger;
- Hangers are spaced at centres of floor joists included in the design;
- The hanger is suitable for the loadings and masonry strength.

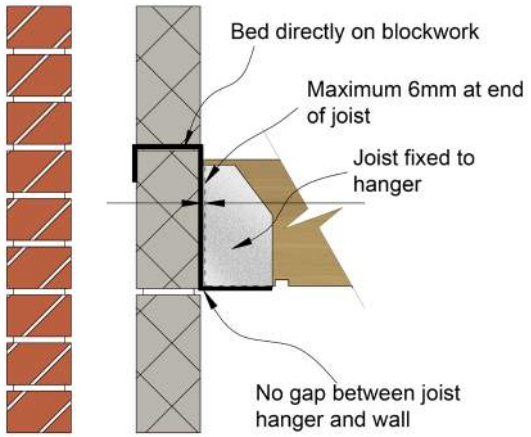


Figure 3: Typical restraint type joist hanger

Do not:

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

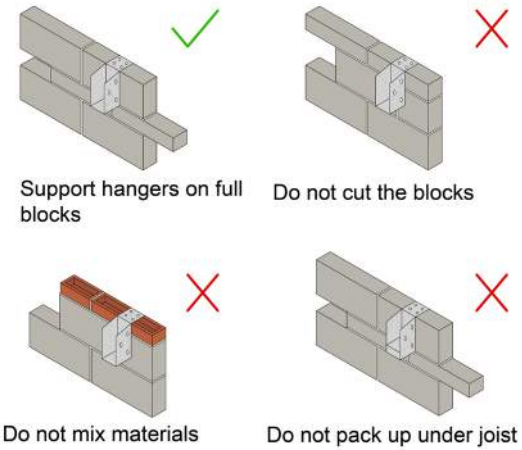


Figure 4: Correct use of hangers

Lateral restraint straps

Floors including timber, block and beam, and roofs should provide lateral restraint to all walls running parallel to them, by means of 30mm x 5mm galvanized or stainless steel restraint straps at 2m centres (see Figures 5, 6 and 7). Straps need not be provided to floors at, or about, the same level on each side of a supported wall and at the following locations.

Timber floors in two storey dwellings where:

- Joists are at maximum 1.2m centres and have at least 90mm bearing on supported walls or 75mm;
- Bearing on a timber wall plate;
- Carried by the supported wall by restraint type joist hangers as described in BS 5268:7.1;
- Concrete floors with minimum 90mm bearing on supported wall.

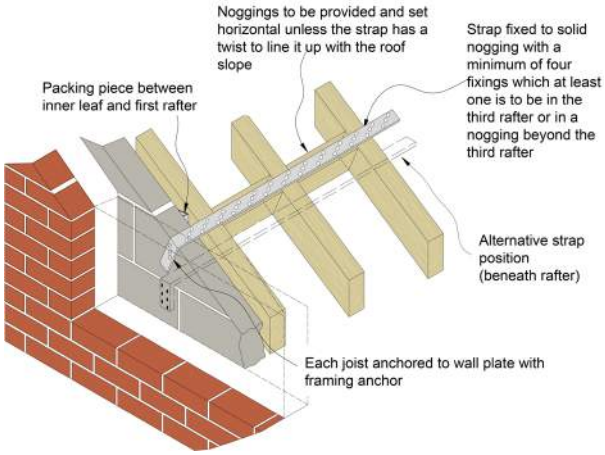


Figure 5: Lateral restraint strap to gable wall

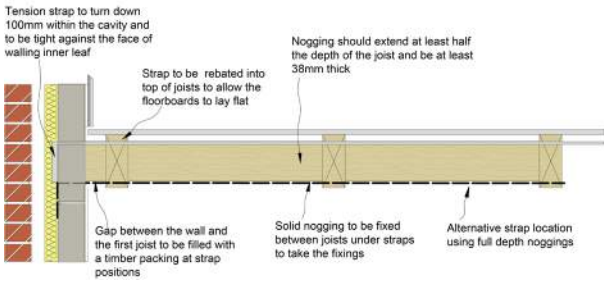


Figure 6: Lateral restraint to floors

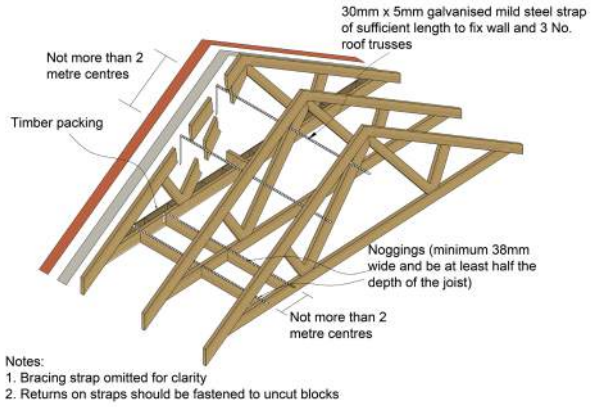


Figure 7: Lateral restraint to gable wall via roof trusses

7.1.8 Wall ties

Wall ties should meet the following provisions:

- Wall ties should be to BS EN 845-1 or have appropriate third party certification;
- Ties should be appropriate for the width of cavity and have at least 50mm bearing on each leaf;
- To be laid to a slight fall towards the outer leaf and have the ability to hold insulation against an internal leaf for partial fill scenarios.

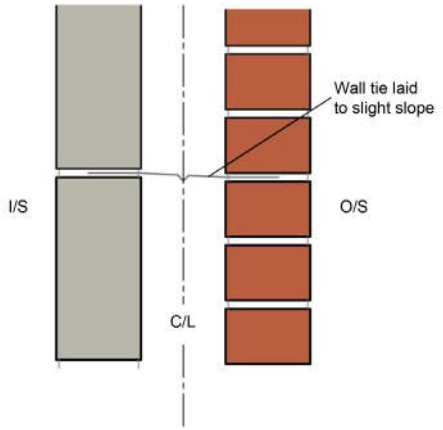


Figure 8: Wall tie provision

Stainless steel wall ties should always be used.

It is important to note that only BS EN 845-1 type wall ties or specifically manufactured (and tested) party wall ties are permitted in cavity separating walls between dwellings to reduce the transfer of sound.

Suitability and spacing of wall ties

Unfilled or fully filled cavities		Spacing of ties	
Width of cavity	**Recommended tie**	**Horizontal**	**Vertical**
50mm to 75mm wide	Butterfly Double triangle Vertical twist Proprietary ties	900mm	450mm (increased to 300mm at reveals and movement joints)
75mm to 100mm wide	Double triangle Vertical twist	900mm	450mm (increased to 300mm at reveals and movement joints)
100mm to 150mm wide	Vertical twist	750mm	450mm (increased to 300mm at reveals and movement joints)
Greater than 150mm	Wall tie specification and design to be provided by a Chartered Structural Engineer, or in accordance with appropriate third party certification. Design will be determined by location and site specific conditions.		

Table 2: Wall tie spacing

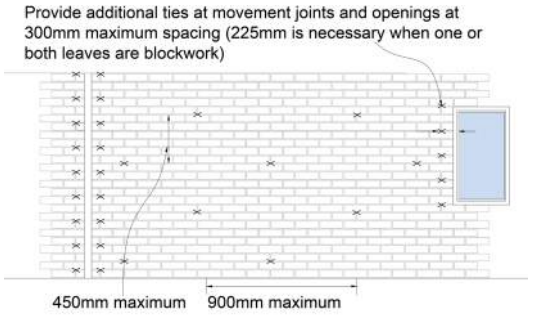


Figure 9: Provision of wall ties

Proprietary ties are to have appropriate third party certification.

Wall ties are to have the correct thickness in accordance with BS 5628-2005.

Proprietary insulation retaining clip compatible with the tie should be used where the cavity is partially filled.

7.1.9 Bonding internal walls to external walls

Bonded walls in brickwork are comparatively easy to construct but with block work this can be more difficult, either:

- Tooth every alternative course (see Figure 10) or butt and tie (see figure 11);
- Where blocks are of a different density, a butted joint should always be used; on party walls carry the separating wall through and butt up the inner leaf using a proprietary bed joint, reinforcement or suitable ties at each block course.

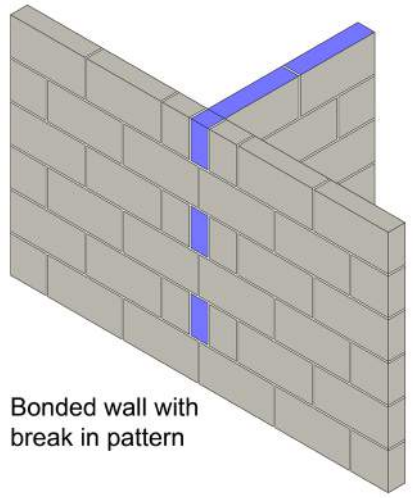


Figure 10: Block bonding internal masonry walls to inner leaf

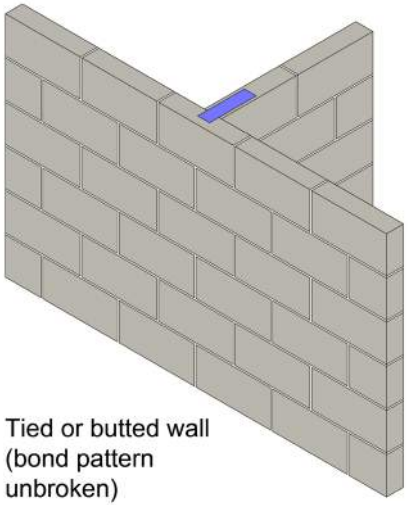


Figure 11: Bonding internal walls to inner leaf using ties

7.1.10 Corbelling

The extent of corbelling of masonry should not exceed that indicated in Figure 12 unless supported or reinforced. Reinforced corbels should be designed by a Chartered Structural Engineer.

Figure 12: Typical corbelling arrangements

7.1.11 Allowing for movement

Vertical movement joints should be provided to the outer leaf of cavity walls as indicated in Table 3. The first joint from a return should be no more than half the dimension indicated in the table.

Where the finished ground level is 600mm or greater below the horizontal DPC, the movement joint should be continued within the external leaf of the substructure. The DPC should be lapped a minimum of 100mm to accommodate any movement.

Movement joints below the DPC should also be provided at major changes in foundation level and at changes in foundation design. Wall ties at a maximum of 300mm centres should be provided each side of movement joints. Compressible filler such as polyurethane foam should be used to form the joint and be sealed to prevent water penetration.

Fibreboard or cork are not acceptable materials for forming movement joints in masonry.

Elastic sealants (Type E) are suitable as they allow for reversible movement. Where a back-up material is used to control the sealant depth, it will also provide a compressible space into which the sealant can deform.

The following must be considered:

- The material is compatible with the sealant;
- It will not adhere to the sealant preventing cracking within the sealant;
- Provides sufficient density to allow the sealant to be applied;
- Allows sufficient flexibility so as to not impede lateral movement (compressible to about 50% of its original thickness). Fibreboard is not acceptable.

Material	Normal spacing	Joint thickness
Clay brickwork	12m (spacing up to 15m may be possible if sufficient restraint is provided – consult Designer)	15mm
Calcium silicate and concrete brickwork	7.5m–9m	10mm
Concrete blockwork (used in outer leaf)	6m	10mm
Stone	12m	15mm
Note: It is not normally necessary to provide movement joints to the internal leaf of cavity walls but should be considered where rooms occur with unbroken lengths of wall in excess of 6m. The first joint from a return should be not more than half the dimension indicated in the table. Movement joints are not acceptable in solid party or separating walls; however, where cavity wall construction is adopted, offset movement joints with a solid rubber compressible strip may be acceptable.		

Table 3: Spacing of expansion joints

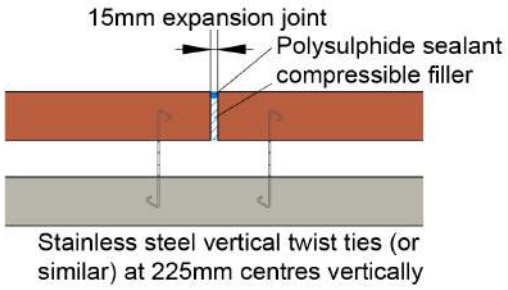


Figure 13: Typical expansion joint detail

7.1.12 Lintels

Bearing length

Use the correct length and width of lintel for the opening and cavity width. The bearing length should be at least 150mm. Do not let masonry overhang lintels by more than 25mm. Continuity of masonry bond should be maintained at supports to beams and lintels (see Figures 14 and 15). Lintels should be insulated to prevent excessive thermal bridging.

Do not:

- Support lintels and beams on short lengths of cut block and make up pieces;
- Apply load to the lintels or beam before the masonry supporting has hardened.

Timber lintels

The use of timber lintels.

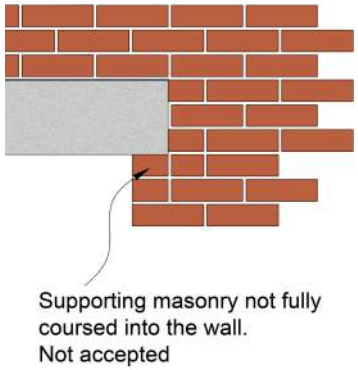


Figure 14: Incorrect method of brick bond around lintels

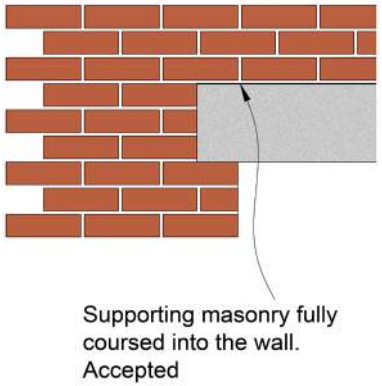


Figure 15: Correct method of brick bond around lintels

7.1.13 Cavity trays

Cavity trays, associated weep-holes and stop ends prevent the build-up of water within a cavity wall and allow the water to escape through the outer leaf. They are used in conjunction with lintels above openings, to protect the top surface of cavity insulation at horizontal cavity barriers and where the cavity is bridged.

Cavity trays are to be provided:

- At all interruptions which are likely to direct rainwater across the cavity, such as rectangular ducts, lintels and recessed meter boxes;
- Above cavity insulation which is not taken to the top of the wall, unless that area of wall is protected by impervious cladding;
- Above lintels in walls in exposure zones 4 and 3 and in zones 2 and 1, where the lintel is not corrosion-resistant and not intended to function as its own cavity tray;
- Continuously above lintels where openings are separated by short piers;
- Above openings where the lintel supports a brick soldier course;
- Cavity trays to rise at least 150mm from the outer to the inner leaf, to be self-supporting or fully supported, and have joints lapped and sealed.

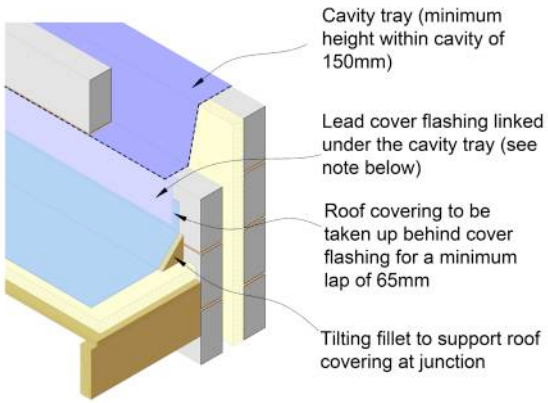


Figure 16: Cavity tray over a flat roof / wall abutment

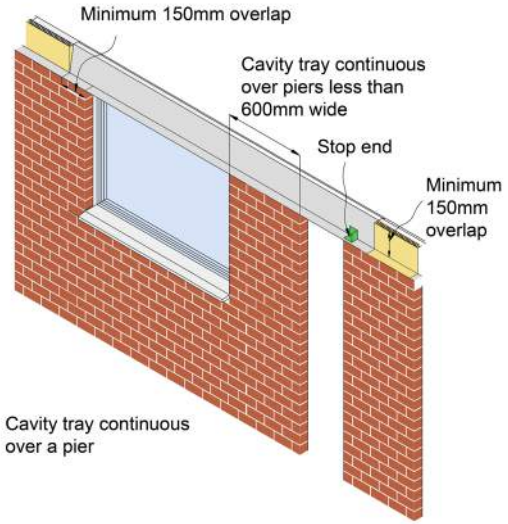


Figure 17: Continuous cavity tray over two openings and a small pier

7.1.14 Weep-holes

Weep-holes must be installed at no more than 900mm centres to drain water from cavity trays and from the concrete cavity infill at ground level. When the wall is to be cavity filled, it is advisable to reduce this spacing.

At least two weep-holes must be provided to drain cavity trays above openings. Where the wall is externally rendered the weep-holes are not deemed as necessary for cavity wall construction.

Weep-holes in exposure zones 3 and 4 should be designed to prevent ingress of wind driven rain (including ground level).

7.1.15 Stop-ends

Cavity trays should have watertight stop-ends to prevent water from running into the adjacent cavity. Stop-ends need to be bonded to the cavity tray material or clipped to the lintel, such that a stop to the structural cavity of at least 75mm high is provided. Normally the stop-end is located to coincide with the nearest perpend to the end of the cavity tray. Stop-ends can be formed by sufficiently turning up the end of a DPC tray into the perpend joint. Surplus mortar should be removed from cavities and wall ties cleared of mortar droppings and debris as the work proceeds.

Ring beams or floor slabs which partially bridge the cavity, e.g., when dimensional accuracy cannot be guaranteed, should be protected by a continuous cavity tray, especially when full cavity insulation is employed.

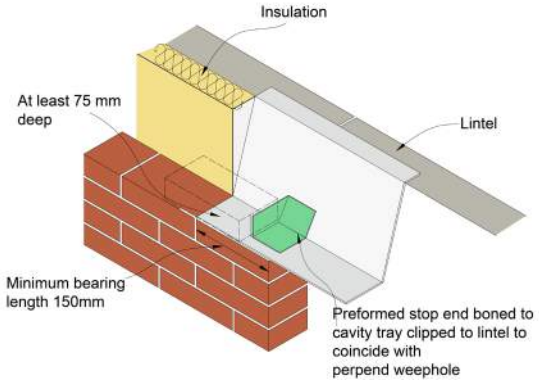


Figure 18: Stop end to cavity tray

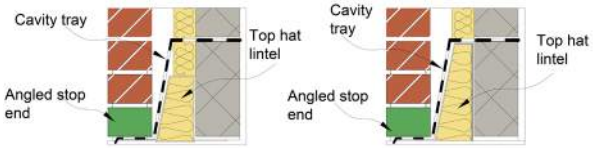


Figure 19: Stop end in relation to cavity tray and lintel

7.1.16 Steps and staggers

Particular care is needed in adequately preventing the ingress of water in a terrace of dwellings with steps and staggers. A proprietary cavity tray system should be used, or alternatively, a suitable tanking system. Stepped cavity trays are required at all pitched (stepped) roof abutments with external cavity walls, e.g., attached garages or staggered terraces. The bottom (last) cavity tray must be supplied with two stop-ends and an associated weep-hole, allowing all water to escape

over the lower roof covering. For brickwork, blockwork and stonework, lead cover flashings should be linked into the cavity tray (lapped in below).

Other perforations of the building envelope

Proprietary elements such as ventilators, soil pipes, etc., which perforate the building envelope should be installed and sealed to prevent ingress of moisture or vermin in accordance with the manufacturer's instructions. External meter boxes should be of a type approved by the Service Supply Authority and provided with a cavity tray and a vertical DPC between the back of the box and the wall.

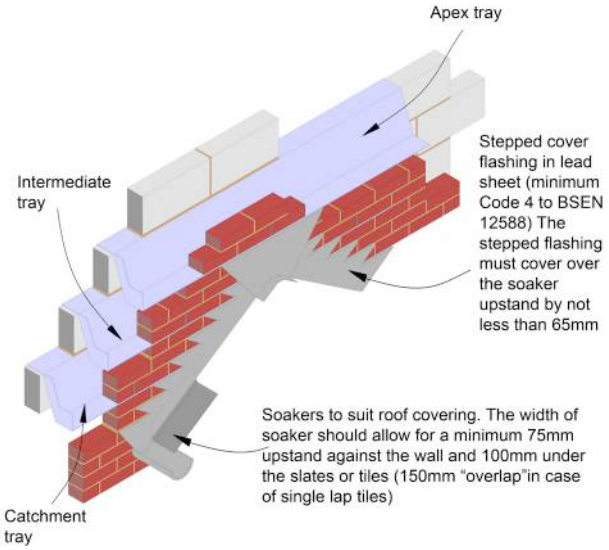


Figure 20: Stepped cavity at roof / wall abutments

7.1.17 Thermal insulation

Thermal insulation to cavity walls should be inserted to a high standard of workmanship to avoid poor insulation performance and to prevent dampness migrating to the inside of the building.

Insulation should have appropriate third party certification and be installed in accordance with manufacturer's instructions.

Insulation should not be cut or pierced to accommodate wall ties, unless increased centres at reveals or expansion joints are required. The wall ties should coincide with insulation joints. Partial fill insulation should be clipped or retained to the inner leaf using proprietary fixings in conjunction with wall ties.

For full fill cavities it is recommended that mortar joints to facing brickwork are not recessed.

7.1.8 Parapets

The minimum thickness and maximum height of parapet walls should be in accordance with Figures 21 and 22. The materials used in the construction of parapet details should be suitable for the location and exposure. Where possible, the use of raking parapets should be avoided due to the need for high standards of detailing and workmanship required to prevent the ingress of moisture. In very severe exposure zones, it is recommended that a parapet construction is avoided altogether.

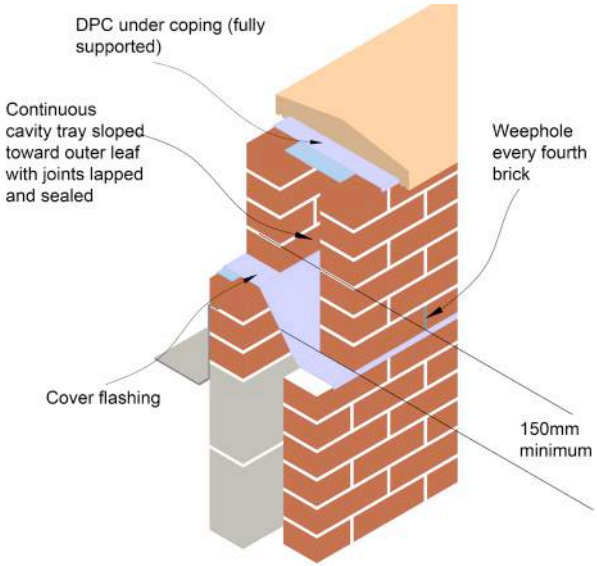


Figure 21: Parapet wall detail

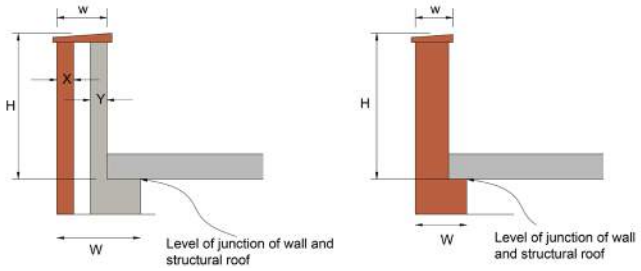


Figure 22: Maximum height of parapet walls (to be read in conjunction with Table 4)

Wall type	Thickness (mm)	Parapet height to be not more than (mm)
Cavity wall	x + y equal or less than 200 x + y greater than 200 equal or less than 250	600 860
Solid wall	w = 150 w = 190 w = 215	600 760 860
Note: w should be less than W - as showed in Figure 22		

Table 4: Parapet walls / height ratios

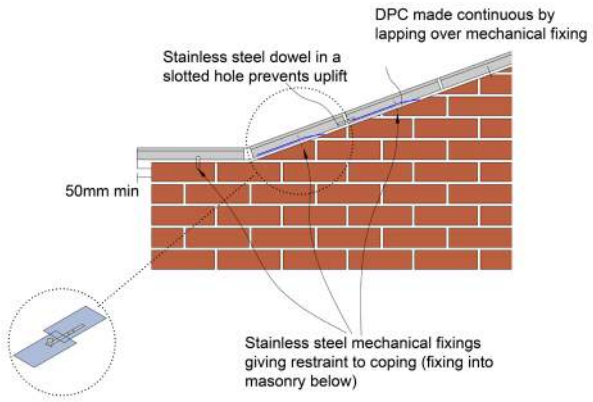


Figure 23: Fixing of copings to sloping parapets

7.1.19 Natural stone

General

The following additional guidance for natural stone shall be used in conjunction with any other information in this Manual. When selecting stone for cavity wall house building, it is important to consider the exposure rating for the area.

It is not recommended to use a soft, porous type stone in a severe exposure zone. Consideration should be given to the compatibility of different stone to prevent staining and premature decay. Limestone and sandstone should not be mixed together.

It is advisable to use a stone that has been quarried within a reasonable location of the development, ensuring both weathering qualities and the visual blending with existing buildings.

Natural stone has a grain or natural bed which is determined during its formation in the strata of the quarry.

It is important that the stone is laid with the grain running horizontal to the bed. In the case of jambs and mullions, the grain should be vertical.

Walls constructed with a cavity are essential where the location is likely to be of moderate exposure or worse. A sawn bed of 100mm minimum thickness is to be used as the outer leaf of a cavity wall, although 150mm is recommended. Where dressed stone is used and the bed falls below 90mm due to the irregularities of the stone, the stone should be backed with either a brick or 50mm minimum thickness block wall to maintain the structural stability. It is not acceptable for the stone to be packed or wedged to maintain line and level without the backing wall being in place.

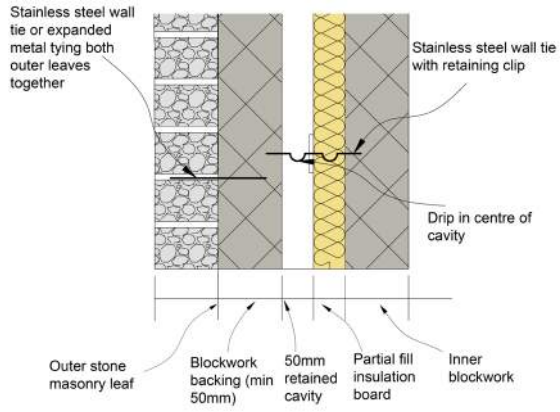


Figure 24: Masonry cavity wall with stone outer leaf

Mortar

The mortar for use with stone should comply with the relevant British Standards for sand, lime and cement as set out in BS 5390.

This can vary in strength from 1:1:6 to 1:3:12 depending on the softness of the stone. It is important to use correct mortar to allow for movement and associated shrinkage. Ensure that wall ties are stainless steel and are of sufficient length to maintain a 50mm embedment. It may be necessary to double up the wall ties where the coursing is out of line due to the varying thickness of natural stone at the reveals, i.e., every other course, and to ensure that wall ties do not slope inwards.

Insulation

Full fill cavity insulation should only be considered where the outer leaf is backed by brick / blockwork, although this is still dependent on exposure, i.e. either partial fill, leaving a residual cavity of 50mm, or a clear cavity should always be the preferred option.

In movement control where sealants are used, it is important to select a non-oil based sealant to help prevent any staining to the stone.

Cavity trays

In addition to the previous guidance for cavity trays, the following shall apply:

When stone heads are being used, it is advisable to double up the cavity trays, one below and one above the stone head, and to provide stop-ends and weep-holes.

Jambs and mullions

Stone jambs and mullions should be fixed at the top and bottom with stainless steel pins. Stainless steel frame type cramps can also be used to give extra stability at jambs.

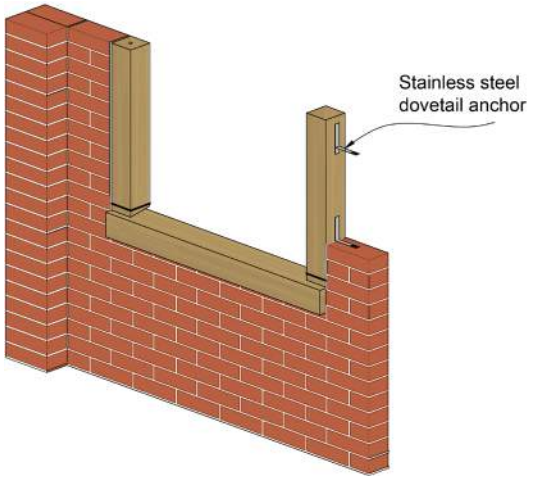


Figure 25: Stone jamb and mullion, fixing to walls

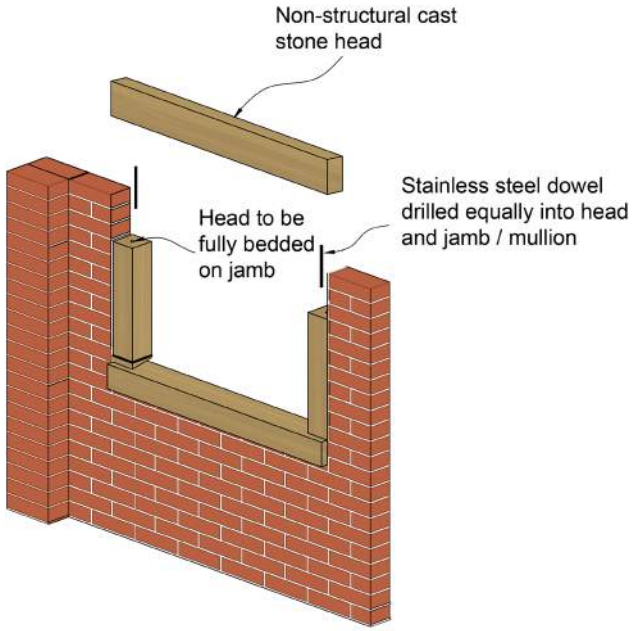


Figure 26: Joining stone jambs to sills and head

FUNCTIONAL REQUIREMENTS

7.2 STEEL FRAME

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. Steel frames should be appropriately treated to prevent corrosion.
iv. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The design of the steel frame must be supported by structural calculations completed by a suitably qualified Engineer. The design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.2.1 Steel frame

General

Galvanised strip steel should be designated either grade S280GD or 350GD to BS EN 10326. Structural design should be in accordance with BS 5950 –5:1998, imposed loads should be calculated in accordance with BS EN 1991, including:

- Dead loads;
- Imposed loads;
- Wind loads.

Steel and fixings should be suitable for the design and adequately protected against corrosion. Load-bearing walls should be designed to support and transfer loads to foundations safely and without undue movement.

Wall panels may provide resistance to racking forces using one or more of the following techniques:

- Internal bracing;
- Cross flat bracing;
- External sheathing board;
- Internal sheathing board;
- Rigid frame action.

The design should detail how joints between the wall panels and other elements are to be securely fixed:

- To the structure;
- To adjacent panels;
- To the floor and roof.

The design should ensure that the structure is adequately protected from the effects of moisture. Exterior claddings should be compatible with the steel frame. Suspended floors should be designed to support and transmit loads safely to the supporting structure without undue deflection.

Services should be adequately protected from damage. Walls and floors should resist the spread of fire. Internal walls and floors should be designed to adequately resist the passage of sound.

7.2.2 Site tolerances

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

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

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

Some packing may be needed to achieve the required tolerances:

- Less than 10mm – pack under each steel with pre galvanised steel shims;
- 10mm-20mm – pack under each steel with steel shims and grout over length of sole plate;
- Over 20mm – refer to Frame Designer.

7.2.3 Fixing of frames to substructures

The oversite DPM should be attached to the side of the slab and returned under the DPC on which the frame is placed. The DPC / DPM detail requires careful attention to prevent the cavity being bridged and providing a ledge for mortar droppings.

Holding down anchors may be galvanised, or preferably stainless steel straps which are fixed to the stud wall and attached to masonry supports or concrete foundation, or holding down bolts fixed to the concrete slab.

7.2.4 Walls

If stainless steel straps are used, they should be grade 1.4301 steel to BS EN 10088 and isolated from the studs with neoprene gaskets or similar. Non-stainless connections should be isolated from the straps with suitable grommets and washers.

Resin or expanding anchors should be used in an in-situ concrete raft of a minimum C20 / GEN3 grade concrete. If required, steel frames can be fixed to timber sole plates.

For guidance on fixing sole plates, refer to the timber frame section in this Manual. The metal frame should be located entirely above DPC level. Where this is not possible, Z460 galvanising or equivalent, or a suitable bituminous coating should be applied to all components below DPC level. It is recommended that the inner leaf DPC is turned up approximately 30mm above the screed to protect the bottom of the studs from construction

moisture and spillage, and weep-holes are provided at 900mm centres to drain cavities at ground level.

7.2.5 Metal stud framework

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

- Recommended site connections include self-drilling, self-tapping screws or 10mm - 12mm diameter grade 4.6 bolts. Welding is not recommended on-site;
- Workmanship should comply with BS 8000:5;
- Framed walls should be accurately aligned, plumb, level without twist and securely fixed to adjacent elements.

Vertical tolerances are:

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

A lintel should be provided where one or more studs is cut or displaced to form an opening. A lintel is not required where an opening falls between studs. Non load-bearing walls should have adequate strength and support.

Non load-bearing walls should not bridge movement joints in the main structure. A movement joint should be constructed between the frame and any chimney flue lift shaft to prevent load transfer. Cavity barriers and fire stops should be provided in accordance with relevant Building Regulations and steel joists should be spaced at centres no greater than 600mm.

Cutting holes for services on-site is not recommended, but where essential should be carried out with specialist tools. Maximum size of rectangular holes should not exceed 40% of the overall section and length should not exceed 60% of the overall section or be the depth of the section apart. No holes should be closer than 1.5 times the depth of the section to the end of the member. Notches are not acceptable.

7.2.6 Thermal insulation

Rigid thermal insulation material should be fixed to the outside face of the steel studs to create a ‘warm frame’ construction.

Where the condensation risk has been assessed and shown to be negligible, additional insulation may be placed between the studs. The additional insulation should be placed in contact with the studs to minimise air gaps and to prevent local condensation.

The following are acceptable:

- Mineral wool to BS EN 13162;
- FR (flame retardant) grade expanded polystyrene to BS EN 13163;
- FR (flame retardant) grade extruded polystyrene to BS EN 13164;
- Rigid polyurethane foam and polyisocyanurate to BS EN 13166;
- Cellular glass to BS EN 13167.

7.2.7 Breather membranes

Breather membranes should be capable of allowing water vapour from within the frame to pass out into the cavity and protect the sheathing and frame from external moisture. These should be:

- Vapour resistant to less than 0.6MNs/g when calculated from the results of tests carried out in accordance with BS 3177 at 25^{o}C, and with a relative humidity of 75%;
- Capable of resisting water penetration;
- Self-extinguishing;
- Durable;
- Adequately strong when wet to resist site damage;
- Type 1 to BS 4016 in areas of very severe exposure to wind driven rain.

If foil faced insulation is not used, then an independent breather membrane should be provided to the ‘cold side’ of the insulation.

7.2.8 Vapour control layers

Vapour control layers resist the passage of water vapour from within the dwelling and should be a minimum of 500 gauge polyethylene sheet or vapour control plasterboard. The vapour resistance (not resistivity) of the vapour control material should not be less than 250MNs/g-1 or 0.25 Pa m^2.

Installation

A sheet membrane VCL should be:

- Lapped and sealed by at least 100mm at joints;
- Lapped over studs, rails or noggins;
- Sealed around service penetrations;
- Lapped and sealed fully into window and door reveals;
- Lapped and sealed with DPM / DPC at the junction with the ground floor / foundation;
- Able to accommodate differential movements.

Small holes in the vapour control layer should be sealed with a suitable self-adhesive tape. Larger holes should be re-covered with new laps located over adjacent studs and rails.

7.2.9 Plasterboard

Plasterboard should be to BS 1230 and not less than:

- 9.5mm for stud spacing up to 450mm or;
- 12.5mm for stud spacing up to 600mm.

To provide fire resistance, fire rated boards should be used and installed in accordance with the manufacturer's instructions.

7.2.10 Masonry cladding

- Cavity trays must be provided above all cavity barriers, windows and door openings, etc.;
- Cavity trays should extend 150mm either side of the door or window openings and have stopped ends;
- A continuous cavity tray should be provided where intermediate floors meet the external wall;
- External skin of brickwork should be attached to the metal frame with either epoxy coated galvanised ties or austenitic stainless steel ties (to DD140, BS 1243, BS 5268, BS 8200);
- Ties are normally fixed in vertical channels. These channels are then fixed directly to sheathing boards or attached through insulation boards with stand-off screws (screws should be isolated from the channels with neoprene or similar washers);
- Ties should be spaced at jambs of openings, a maximum of 300mm vertically within 225mm of the masonry reveal.

Additional studs may be needed to achieve this:

- Ties should be inclined away from the frame;
- Ties should be fixed to the studs, not the sheathing;
- Ties should accommodate differential movement between the frame and the cladding;
- Soft joints should be provided to allow for differential movement. A gap of 1mm per metre of masonry should be provided at openings and soffits;
- All brick support angles should be installed by the Manufacturer or Specialist Contractor.

7.2.11 Claddings

More traditional claddings can include amongst others timber boarding, plywood and tile hanging. These types of cladding should be fixed to battens and suitably attached at stud positions. For further details, refer to the timber frame section of this Manual and the manufacturer's recommendations.

Render on metal lath combined with a breather membrane should also be fixed to battens attached to studs.

Breather membranes should be provided in areas of severe exposure or worse.

Other claddings should only be used if they are provided with an acceptable third party accreditation certificate.

FUNCTIONAL REQUIREMENTS

7.3 TIMBER FRAME

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product. Timber frame elements should be appropriately covered to keep components dry.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance, and supported by structural calculations provided by a suitably qualified expert.
ii. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.
iii. Any off-site manufactured engineered beams / posts must have structural calculations which have been endorsed by the manufacturer.

7.3.1 Specifications

7.3.1.1 Introduction

For the purpose of this Chapter, timber frame external walls are generally considered to consist of load-bearing solid timber studs at regular centres with insulation between them, lined with a structural sheathing board; breather membrane; cladding; vapour control; and fire resistant linings. For guidance on other forms of timber construction, e.g., SIPs, I section studs, Glulam, etc, please refer to Chapter 3 - Modern Methods of Construction, in this Manual.

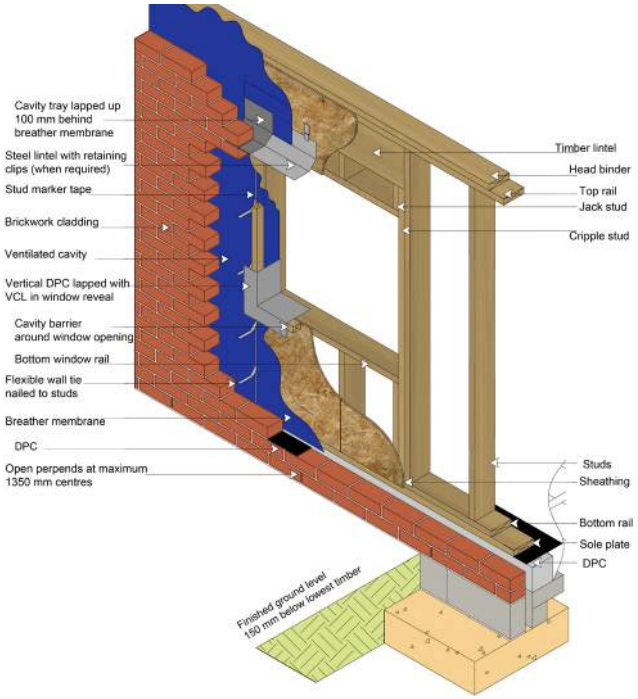


Figure 1: Typical timber frame external wall

7.3.1.2 General specifications

Please note: Bespoke timber frame open panel systems which do not have such QA procedures will need either third party accreditation or independent Structural Engineer supervision to be provided to monitor the installation, erection and completion (sign off) of the system.

Structurally Insulated Panels (SIPs) are a form of composite panel. Only systems which have independent third party approval will meet the requirements of the Technical Manual.

7.3.1.3 Structural design

Wind, roof and floor loads should be considered in the design. All timber frame structures shall be designed in accordance with Euro-Code 5. Structures designed in accordance with BS 5268 may still be acceptable, although these standards have now been superseded by Euro-Code 5. When published, PD 6693: Complementary information for use with Euro-Code 5 (currently in draft with BSI) will reference complementary non-contradictory information found in BS 5268.

Quality assurance

All Timber Frame Designers, Manufacturers and Erectors should possess current certification from at least one of the following quality assurance schemes:

- BM TRADA QMark for timber frame;
- ISO 9001;
- CE Marking.

7.3.1.4 Timber specifications

Grading of structural timber

All structural timber, whether machine or visually graded, shall be graded in accordance with BS EN 14081: Timber structures - Strength graded structural timber with rectangular cross section.

All load-bearing solid timber studs, rails, binders and sole plates should be of a minimum dry graded C16.

Figure 2: Typical grading stamp

Sizing of structural timber

Timber studs and rails shall be:

- A minimum of 37mm in width.

Treatment of structural timber

All load-bearing timber components shall either be naturally durable or treated in accordance with BS 8417: Preservation of wood. Code of Practice. Sole plates and load-bearing timber studwork are considered to be in 'Use Class 2'. Sole plates are normally considered to be included in

'Service Factor Code C', while load-bearing timber studwork is included in 'Service Factor Code B'.

All structural timber should be treated with a preservative suitable for the 'Use Class' and 'Service Factor' applicable to its use.

Where treated timber is cut, the exposed end will not be protected by the original preservative treatment. When treated, timbers are cut in the factory or on-site; the cut ends shall be pre-treated with a preservative that is compatible with the original treatment used.

Sole plates

Sole plates are the first structural timber component installed on-site. Its purpose is to set out the building, transfer loads to the foundations and provide a level base for erecting the wall panels. All structural timber should be located at least 150mm above finished external ground level, except for localised ramping (incorporating satisfactory drainage and ventilation detailing) around door openings.

Sole plates should be fixed to the foundations with shot fired nails. Proprietary sole plate fixings, anchors, brackets or straps may be used, subject to suitable third party certification or as specified by a Structural Engineer.

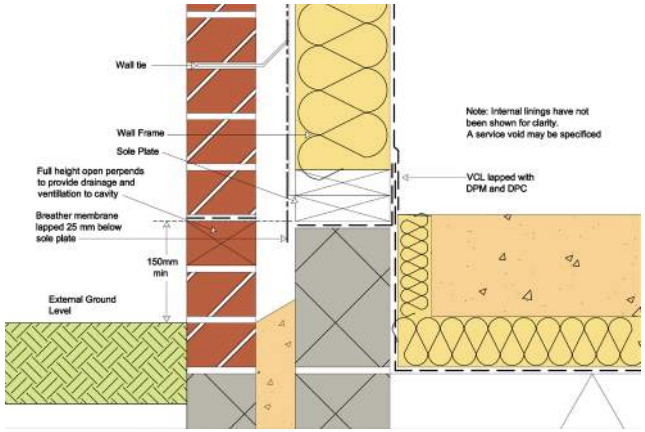


Figure 3: Sole plate / foundation junctions

Sheathing boards

Sheathing boards are fixed to the timber frame in order to provide racking resistance to the structure.

Structural sheathing board materials may be any of the following:

- Orientated Strand Board (OSB);
- Plywood;
- Impregnated soft board;
- Medium board;
- Tempered hardboard;
- Other board material with suitable third party certification for primary racking resistance.

All wood-based panel products should comply with BS EN 13986: Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking.

OSB should be grade 3 or 4 in accordance with BS EN 300: Oriented Strand Boards (OSB) - Definitions, classification and specifications.

Plywood should be Class 3 Structural in accordance with BS EN 636: Plywood. Specifications.

Impregnated soft boards should be Type SB.HLS in accordance with BS EN 622-4: Fibreboards. Specifications. Requirements for soft boards.

Medium board should be type MBH.HLS1 or MBH.HLS2 in accordance with BS EN 622-3 Fibreboards. Specifications. Requirements for medium boards.

Tempered hardboards should be Type HB.HLA1 or HB.HLA2 in accordance with BS EN 622-2: Fibreboards. Specifications. Requirements for hard boards.

7.3.1.5 Other material specifications

Fixings

All sole plate fixings and holding down products should be austenitic stainless steel.

Timber components and structural sheathing boards may be fixed with:

- Nails;
- Staples.

Nail fixings should be:

- Austenitic stainless steel;
- Galvanised;
- Sheradized.

Staple fixings should be:

- Austenitic stainless steel or similar.

Breather membrane

A breather membrane is a water resistant, moisture vapour permeable membrane used to provide temporary weather protection during construction, and secondary protection from moisture once the building is complete.

The timber frame structure should always be protected by a breather membrane.

Breather membranes should be:

- A Type 1 membrane in accordance with BS 4016: Specifications for flexible building membranes (breather type);
- Self-extinguishing;
- Securely fixed to protect the outside face of the timber frame structure with austenitic stainless steel staples.

Cavity barriers

Cavity barriers are required to prevent the spread of smoke and flame within concealed spaces. Cavity barriers may be constructed from:

- Steel at least 0.5mm thick;
- Timber at least 38mm thick;
- Polythene sleeved mineral wool;
- Mineral wool slab;
- Calcium silicate, cement-based or gypsum based board at least 12mm thick;
- An independently assessed and certified proprietary product.

Insulation materials

Insulation materials should be chosen with consideration for their breathability and interaction with the timber frame.

Thermal insulation products typically used are:

- Mineral fibre (glass or rock);
- Wood fibre / wool;
- Blown cellulose.

Other insulation materials may be used, subject to relevant third party certification.

Insulation may be specified in any or all of the following locations:

- Between the load-bearing studs;
- On the outside of the timber frame;
- On the inside of the timber frame.

Insulation installed to the outside of the timber frame structure should have third party certification for this application, and retain a clear cavity dimension as detailed in Table 1 in Chapter 7.3.4.

External walls should be subject to U-Value and condensation risk calculations. A wall build up will be considered satisfactory if there is no calculated risk of surface or interstitial condensation at any time of the year, and it fulfils the minimum National Requirement for thermal performance.

Special consideration should be given to condensation risk, where non-breathable insulation products are installed on the outside of the timber frame structure.

Vapour control layer

A vapour control layer (VCL) is a moisture vapour resistant material located on or near the warm side of the thermal insulation.

Its purpose is to:

- Restrict the passage of moisture vapour through the structure of the wall;
- Mitigate the risk of interstitial condensation.

The vapour control layer should have a minimum vapour resistance of 250MNs/g-1 or 0.25 Pa m^2. It is also typically used as an air tightness layer.

The VCL may take the form of:

- A vapour control plasterboard comprising a metallised polyester film bonded to the back face of the plasterboard;
- A minimum 125 micron thick (500 gauge) polythene sheet;
- A third party approved proprietary vapour control membrane product.

Subject to a favourable condensation risk analysis, a novel or reverse wall construction may not require the use of a high moisture vapour resistant vapour control membrane.

Wall linings

The internal lining of the timber frame wall may be required to perform four functions:

- To provide the finish or a substrate to accept the finish on the inner face of the wall;
- To contribute to the racking resistance of the wall;
- To contribute to the fire resistance of the wall;
- To contribute to the acoustic performance of the wall.

Wall linings are typically:

- Gypsum plasterboard;
- Cement bonded particle board.

Other lining materials may be used subject to the material satisfying any relevant performance criteria, e.g., fire resistance and possessing relevant third party certification.

Masonry supporting timber frame, foundations, kerb up stands, etc.

Foundations and masonry supporting timber frame structures should be in accordance with the relevant Technical Manual Chapter as indicated below:

Chapter 2 - Materials
Chapter 4 - Site Investigation
Chapter 5 - Foundations
Chapter 6 - Substructure
Chapter 7 - Superstructure

Claddings

Timber frame external walls should be finished externally with a cladding system. This cladding system may take the form of masonry or a lightweight rain screen system. Regardless of the cladding system used, a cavity with provision for drainage and ventilation should be provided between the cladding and the timber frame.

Wall ties

External wall ties and fixings between the timber frame and masonry cladding shall:

- Comply with BS EN 845: Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets;
- Be constructed from austenitic stainless steel;
- Accommodate all anticipated differential movement;
- Be of adequate length and masonry bond to provide a clear cavity of at least 50mm.

7.3.2 Manufacture

Timber

All structural timber components should be specified in accordance with the requirements of Chapter 7.3.1.

Timber frame external wall panels shall:

- Be manufactured in accordance with the Structural Engineer's design;
- Consist of solid timber studs and rails;
- Have studs at a maximum of 600mm centres;
- Be braced with a structural sheathing board.

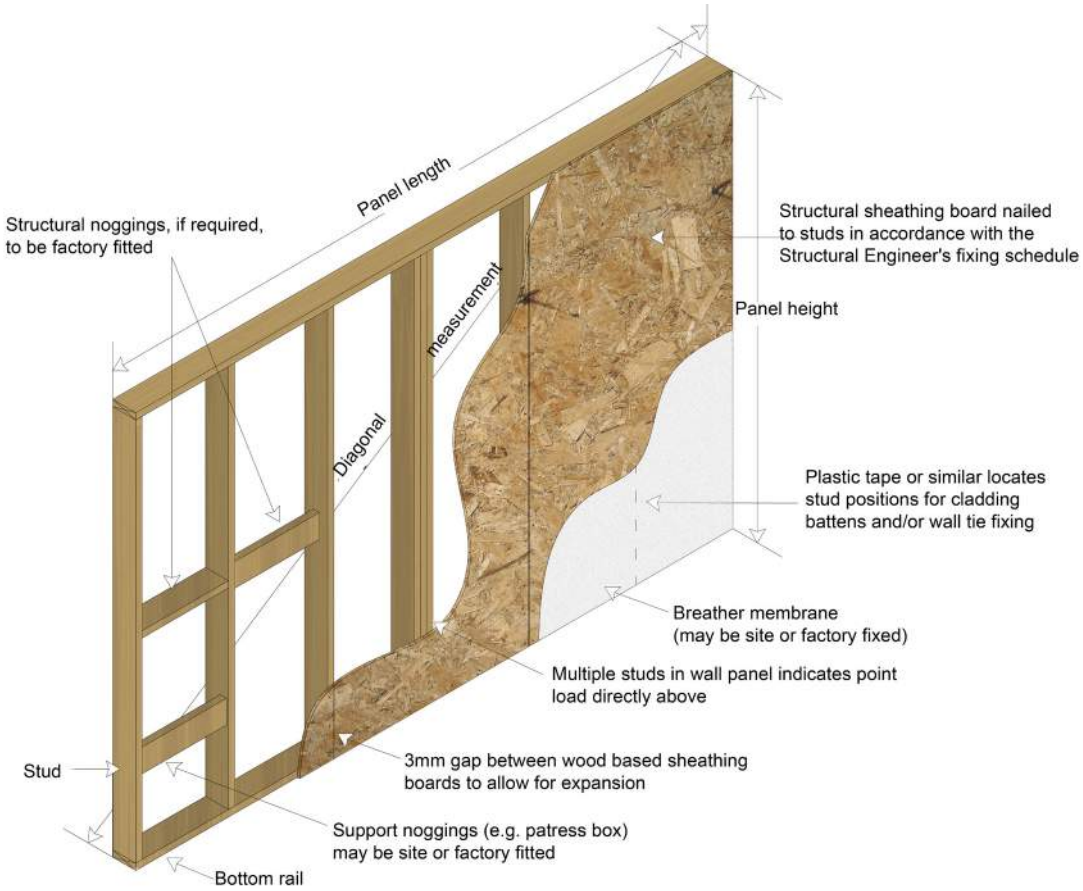


Figure 4: Typical wall panel

7.3.2.2 Panel moisture content

All structural timber components should be at a moisture content of 20% or less at the time of manufacture. Once panels are manufactured, they should either be stored in a covered storage area, or loosely covered with a waterproof sheet material as shown in Figure 6.

7.3.2.3 Manufacturing tolerances

Based on the tolerances given in pr EN 14732, wall panels shall be manufactured to the following tolerances:

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

7.3.2.4 Sheathing

The fixings securing the structural sheathing board to the timber studwork wall panels provide racking resistance as calculated by the Structural Engineer.

The sheathing board shall be fixed to the timber studwork in strict accordance with the Structural Engineer's fixing schedule. Fixing centres should not exceed 150mm around the perimeter of the board and 300mm centres in the field of the board. Sheathing fixings must not be over-driven through the face of the sheathing board.

Wood-based board materials used for sheathing should be fixed to the studwork frame leaving a minimum of 3mm gap between boards to allow for moisture related movement.

7.3.2.5 Studs

Any point load imparted onto the timber frame should be transferred down through the building to the foundations with the use of multiple studs. If these are not installed during the manufacture of the panels, the requirement for installation must be clearly conveyed to site.

Wall panels should be designed to minimise thermal bridging. Gaps between studs within the wall panel and at wall panel junctions should be large enough to allow the installation of insulation.

7.3.2.6 Openings

All openings including doors, windows, flues and ventilation ducts should be designed and constructed to maintain structural performance:

- A lintel may be required where openings do not fall between studs, unless vertical load is adequately transferred by other elements;
- Lintels will require support by cripple studs;
- Studs should be provided around window and door openings and adjacent to movement joints to allow the installation of wall ties or other cladding fixings.

7.3.2.7 Breather membrane

Breather membranes should be lapped by a minimum of 100mm at horizontal joints and a minimum of 150mm at vertical joints. If breather membranes are trimmed flush with the edges of wall panels, additional strips of breather membrane, at least 300mm wide should be supplied and site fixed over panel junctions.

The location of solid timber studs should be clearly marked on the outer face of the breather membrane to ensure that cladding fixings are installed into solid timber.

7.3.2.8 Closed panel construction

If wall panels are to be of closed panel construction, the guidance in Chapter 7.3.4 applies equally to manufacture. For the purposes of this Manual, closed panels are classified as open panels with at least insulation installed in the factory.

Special precautions must be taken to protect closed panels from moisture during storage, transportation and erection on-site.

7.3.3 Site preparation and erection

7.3.3.1 Pre-commencement

To allow the building to be constructed as designed, all necessary drawings, specifications and fixing schedules shall be provided to site before work commences.

Foundations

It is important that the tight tolerances for timber frame are understood. Getting the location and level of the foundation correct is one of the most important parts of the build process.

The foundations or upstands which support the timber frame should be set out to the dimensions noted on the timber frame drawings:

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

If ground conditions require gas membranes, they should be located so as not to inhibit drainage and ventilation to all areas of the timber frame structure.

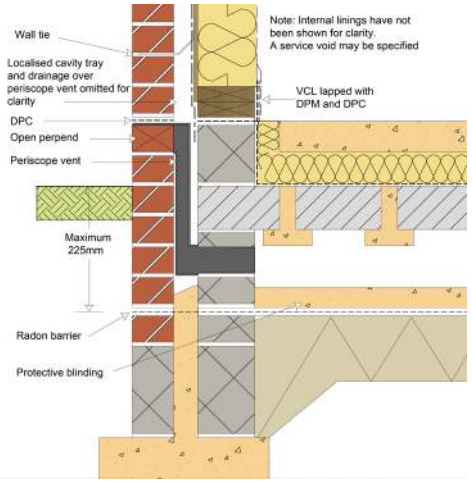


Figure 5: Possible gas membrane detail

Timber frame delivery and storage

Timber frame components should be:

- Carefully unloaded to avoid damage or distortion of components;
- Stored off the ground on an adequate number of level bearers;
- Have packs loosely covered with a waterproof membrane to allow protection from moisture while allowing ventilation if they are not to be used for a prolonged period;
- Unwrapped if tightly bound in polythene and loosely recovered with a waterproof membrane to allow ventilation;
- Below 20% moisture content;
- Confirmed as square by sample checking for equal diagonal measurements, lengths and heights.

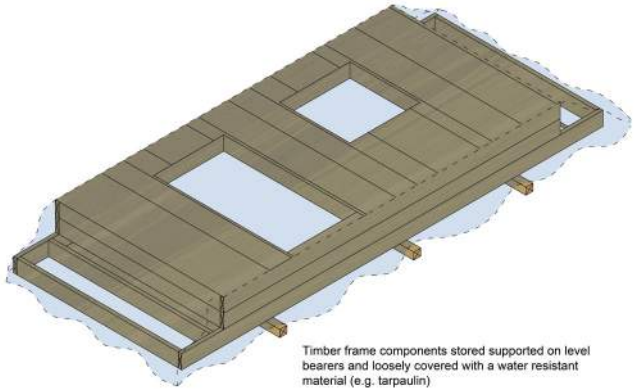


Figure 6: Storage of wall panels

7.3.3.2 Timber frame erection

Sole plates

The sole plate should be accurately levelled, located and securely fixed to the substructure as specified by the Structural Engineer. Where no sole plate is specified, the following guidance applies equally to wall panel bottom rails. Timber sole plates should be treated in accordance with Chapter 7.3.1.3 - Timber Specifications, Treatment of Structural Timber.

Location

Sole plates should:

- Be located so that all structural timber is at least 150mm above external ground level (except for localised ramping at door openings). The use of a foundation kerb upstand may be an appropriate method to achieve this;
- Be levelled to +/- 5mm from datum;
- No overhang or be set back from the foundation edge by more than 10mm;
- Be set out within +/- 10mm in length and in line within +/- 5mm, as defined by the timber frame drawings;
- Diagonals should be within +/- 5mm up to 10m, and +/- 10mm more than 10m.

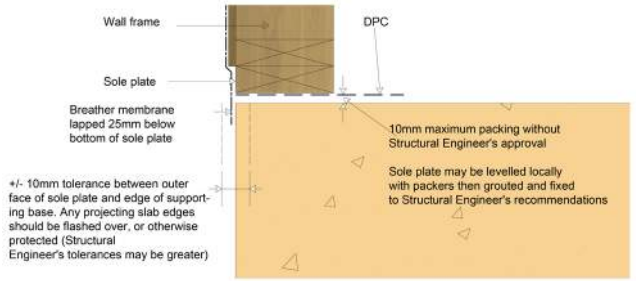


Figure 7: Locating sole plates

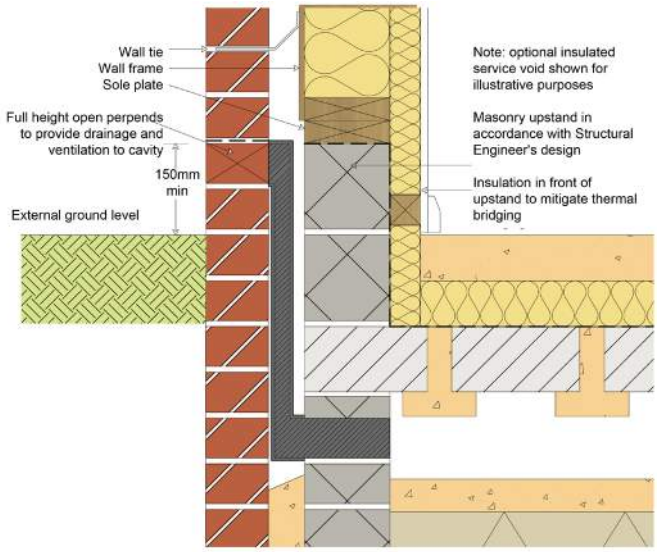


Figure 8: Kerb upstand detail to allow level threshold

Damp proof course

A DPC should:

- Be located directly below all timber sole plates bearing on other materials which may transfer moisture;
- Overlap at DPC junctions by at least 100mm;
- Be located flush to the outside edge of the sole plate.

Packing

Structural shims or grout may be required under sole plates to level them and transfer vertical load. Longer sole plate to foundation fixings may be needed to allow for the size of the gap.

Structural shims should:

- Be non–compressible and inert;
- Be located under every stud;
- Provide equal cross sectional area to the studs they support;
- Be located under sole plates to provide full width bearing to studs;
- Provide full bearing under point loads;
- Not exceed a total of 10mm in height without a Structural Engineer's approval.

Structural grout should be:

- Considered for use by a Structural Engineer for gaps exceeding 10mm;
- Non shrinkable;
- Full bearing under sole plates;
- Packed under the DPC.

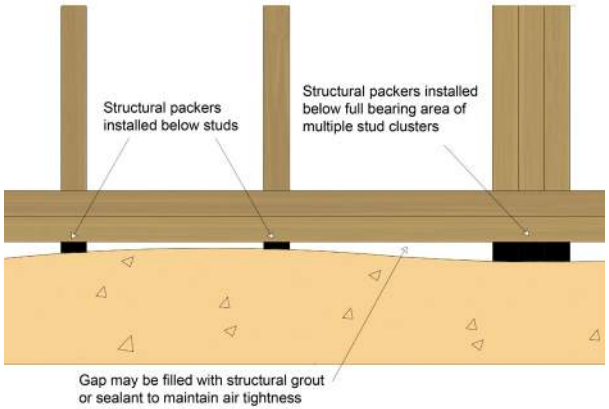


Figure 9: Packing of sole plates

Please note: The use of structural grout is not considered suitable for gaps less than 10mm due to installation difficulties.

Fixings

Fixings should:

- Be installed to the Structural Engineer's specification;
- Not damage the substructure or sole plates during installation.;
- Be placed to provide adequate lateral restraint at door openings;
- Be specified with consideration for use with gas membranes where appropriate.

Wall panel erection tolerances

Wall panels should be erected to the following tolerances:

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

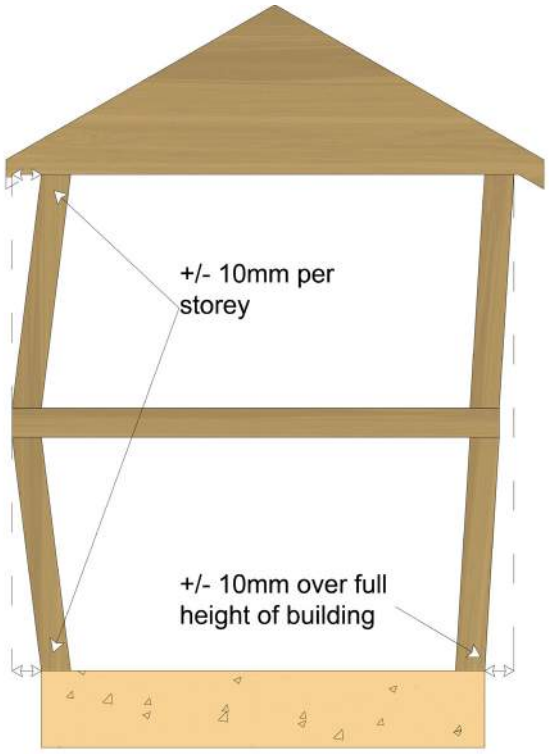


Figure 10: Wall panel erection tolerances

Fixings and junctions

All fixings are to be installed to the Structural Engineer's specification.

Unless otherwise justified:

- Junctions of wall panels and sole plates / head binders should not occur together;
- Head binder laps should wherever possible occur over a stud, preferably at least 600mm from the panel junction;
- Wall panel to wall panel connections should be a maximum of 300mm centres;
- Bottom rail to sole plate fixings should be one or two per stud bay;
- Wall panels should be adequately braced during erection to maintain tolerances;
- Disproportionate collapse fitting and fixings must be installed if specified;
- Multiple stud clusters must be installed to the full width of point load-bearings;
- Point loads must be transferred down through wall panels and floor zones to foundations;
- Closed panel walls manufactured off-site must be fixed together as specified;
- Closed panel walls should not be exposed for longer than necessary to avoid moisture ingress;
- Engineered timber components should not be exposed to moisture for longer periods than those stated by the manufacturer;
- Roof trusses / rafters should be adequately fixed to wall panels;
- Floor joists should be nailed down to wall panels;
- If no head binder is present, floor joists must bear directly over studs;
- Waistbands and alignment of floors over walls should remain within tolerances for wall panels.

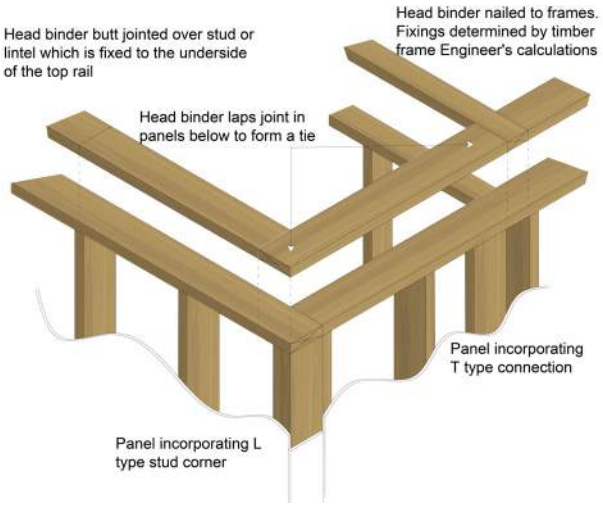


Figure 11: Head binder lapping

Air leakage

Detailing and installation instructions must be followed to achieve adequate air tightness.

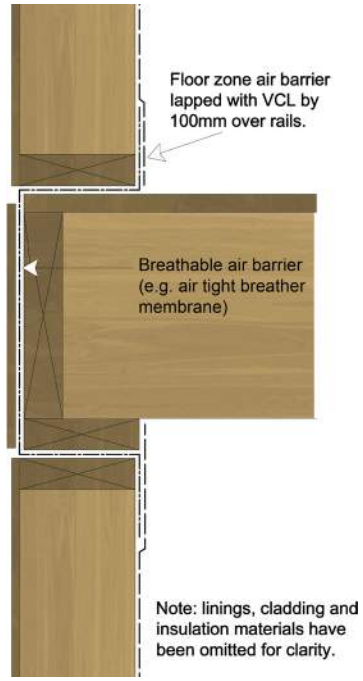


Figure 12: Typical floor zone air tightness detail

Breather membrane

Breather membrane should be:

- Lapped to deflect moisture away from the timber frame structure;
- Lapped by a minimum of 100mm at horizontal joints and a minimum of 150mm at vertical joints;
- Trimmed leaving a 25mm lap below the lowest timber sole plate;
- Repaired if damaged.

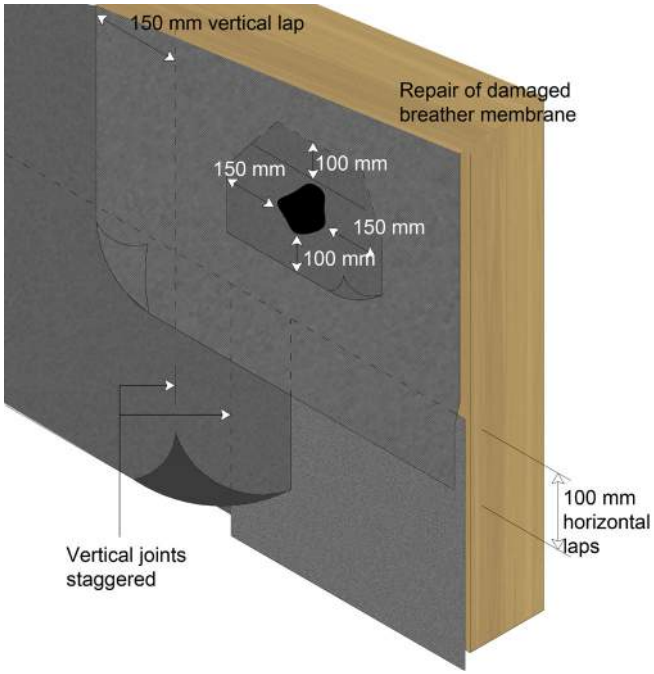


Figure 13: Lapping and repair of breather membrane

7.3.3.3 Cavity barriers

Location

In England and Wales, cavity barriers shall be installed:

- At the edges of all cavities including around openings. e.g., windows, doors;
- Between an external cavity wall and a compartment wall or compartment floor;
- Around meter boxes in external walls;
- Around service penetrations in external walls, e.g., extract or boiler flue;
- To sub-divide extensive cavities. Please refer to National Regulations for specific requirements.

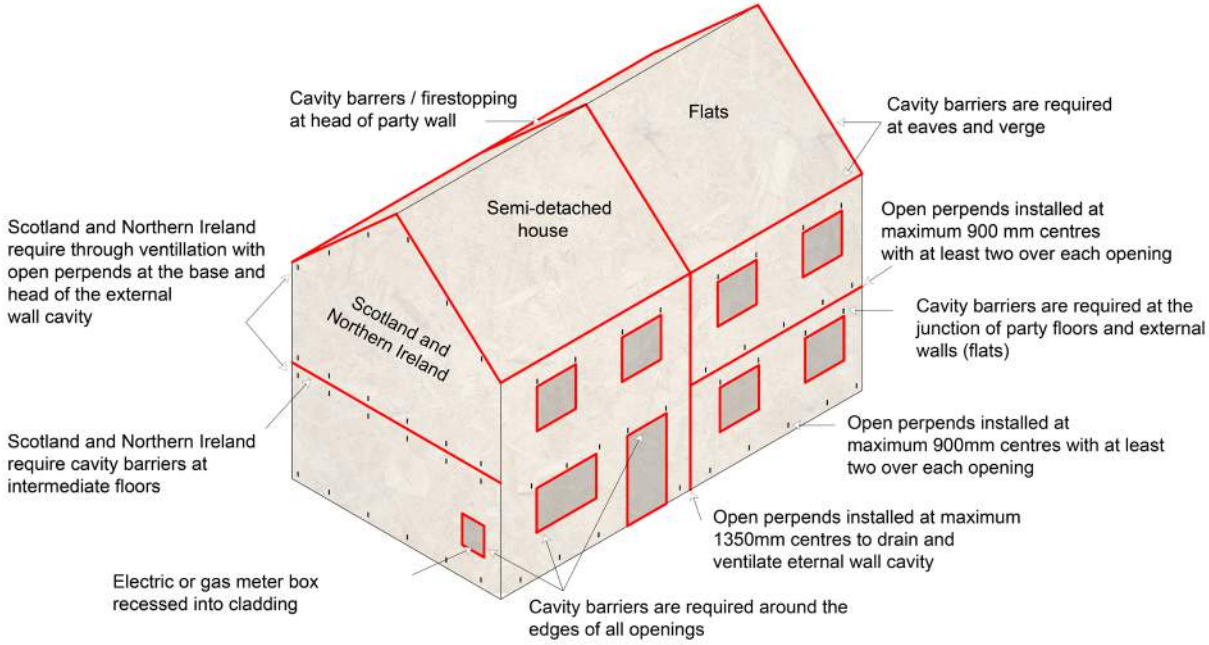


Figure 14: Locations of cavity barriers and open perpends

Please note: Cavity barriers may also be required between walls and floors within the building. Consult National Regulations for further guidance.

Installation

Cavity barriers shall be installed:

- So they fully close the cavity;
- So the ends are tightly butted to form a continuous barrier;
- Backed by solid timber studs, rails or floor joist at least 38mm wide;
- In accordance with manufacturer or independent certifier's guidance.

A cavity tray should be proved directly above a horizontal cavity barrier, lapped at least 100mm behind the breather membrane (except at eaves and verge).

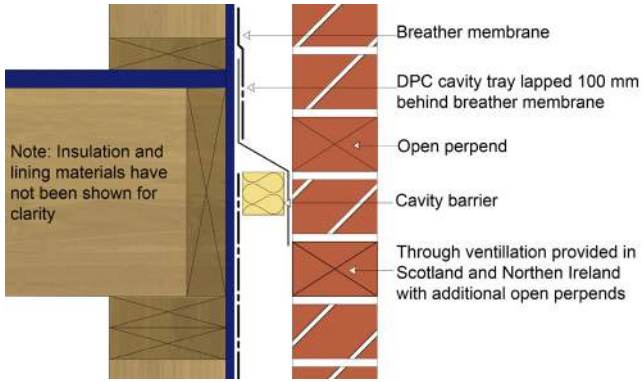


Figure 15: Cavity tray above horizontal cavity barrier

Timber cavity barriers should be protected from masonry cladding by the use of a DPC. The cavity face of the cavity barrier should be left uncovered to allow drainage and ventilation of the timber.

The use of timber cavity barriers around openings allows for effective sealing to be installed between them and the opening frame.

7.3.4 Main contractor

7.3.4.1 Insulation

If insulation is specified between external walls studs, all voids shall be filled with insulation to maintain the thermal envelope of the building. When noggings or boards are installed between studs to support services or heavy fittings, the void behind them shall be fully insulated.

Insulation should not be installed until the structural timber frame is below 20% moisture content and the building is as wet insulation can retain moisture. If closed panel timber frame is specified, additional care must be taken to protect the panels from exposure to moisture during construction.

If external wall insulation is to be used:

- Insulation should be installed in a manner to maintain its stated performance by minimising gaps which lead to thermal bridging and air washing;
- Installation should not allow external wall cavity moisture to become trapped between it and the timber frame;
- Cavity trays should be fixed and lapped to deflect cavity moisture away from the timber frame;
- Allowance should be made for differential movement to occur at floor zones;
- Cavity barriers should be tightly fitting and remain effective in a fire;
- It should not retain or transmit moisture to cause the timber structure to exceed 20% moisture content;
- It's stated thermal performance should not be affected by cavity moisture. A breather membrane installed over the insulation may be required to assist in this;
- A method of installing wall ties through the insulation directly into the studs should be used.

7.3.4.2 Services

In addition to general provisions for the installation of services, the following are of particular note for timber frame construction external walls:

- The routing and termination of services should not affect the fire resistance of the structure;
- Electrical services are to be rated for their location with consideration for insulation;
- Wet services are not to be installed on the cold side of the insulation;
- Service penetrations through the vapour control layer should be tight fitting to reduce air leakage and the passage of moisture vapour;
- Avoid running electrical services in the external wall cavity, except for meter tails;
- Services should be protected with metal plates if they pass within 25mm from face of stud;
- Adequate allowance for differential movement to occur without causing damage should be provided for rigid services rising vertically through a building;

- Services which pass through the external wall cavity and provide an opening (such as flues / vents) should be enclosed with a cavity barrier and protected with a cavity tray.

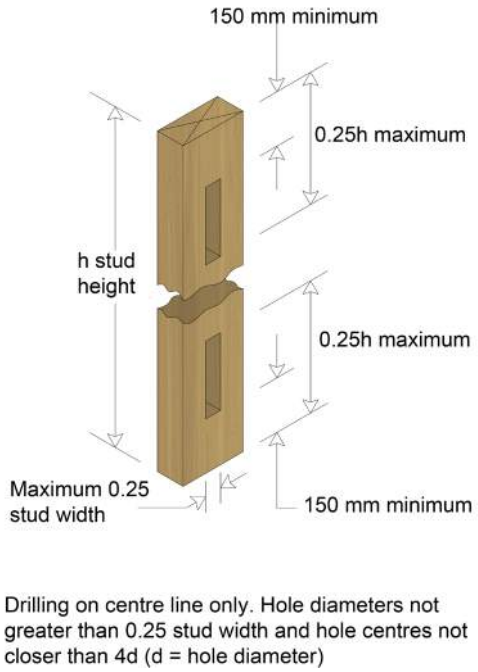


Figure 16: Drilling of studs

7.3.4.3 Vapour control layer (VCL)

A vapour control layer should not be installed until the structural timber frame is below 20% moisture content and the building is weather tight.

Installation

A sheet membrane (polythene or proprietary) VCL should be:

- Securely fixed to and cover all areas of the timber frame external walls, including all sole plates, head binders and window / door reveals;
- Lapped and sealed by at least 100mm at joints;
- Lapped and sealed over studs, rails or noggings;
- Sealed around service penetrations;
- Lapped and sealed fully into window and door reveals;
- Lapped and sealed with DPM / DPC at the junction with the ground floor / foundation by a minimum of 100mm.

Please note: Small holes in the vapour control layer should be sealed with a suitable self adhesive tape. If a proprietary membrane is being used, the manufacturer's proprietary sealing tape should be used. Larger holes should be recovered to lap over adjacent studs and rails.

Vapour control plasterboard should be:

- Fixed in accordance with the plasterboard manufacturer's installation guidance;
- Tightly cut and fitted around service penetrations;
- Discarded if the vapour control backing is damaged.

7.3.4.4 Plasterboard

Installation

In order to provide the specified period of fire resistance, the plasterboard must:

- Protect all areas of the timber frame structure;
- Have all edges supported by timber studs or rails;
- Be fixed in accordance with the plasterboard manufacturer's guidance;
- Be cut and tightly fit around service penetrations;
- Have junctions of wall and ceiling linings detailed to maintain continuity;
- Be installed using the specified number of layers to achieve the required fire resistance;
- Have all joints staggered when installing multiple layers.

Fixing of plasterboard

When installing plasterboard linings:

- Each layer must be fully and independently fixed;
- Fixings of the correct length and centres should be installed in accordance with the plasterboard manufacturer's installation instructions;
- Walls requiring plasterboard to provide racking resistance should be clearly identified with plasterboard installed to the Structural Engineer's specification or plasterboard manufacturer's specification, whichever is more onerous.

7.3.4.5 Openings

All openings, including doors, windows, flues and ventilation ducts should be designed and constructed to maintain:

Fire performance

- Internal reveals require equal fire resistance to the rest of the structure;
- Window fixing straps should not compromise the integrity of any fire resistant reveal linings;
- Cavity barriers should be installed in the external wall cavity around the perimeter of openings;
- If profiled steel lintels are used as cavity barriers, triangular gaps behind lintels which occur at each end should be closed with careful positioning of adjacent cavity barriers.

Acoustic performance

- Seal gaps between timber frame wall and the element being installed into the opening;
- The element being installed into the opening may have a minimum acoustic requirement.

Weather tightness and thermal performance, including thermal bridging and air tightness:

- The element being installed into the opening is likely to have a minimum thermal performance;
- Seal gaps between the timber frame wall and the element being installed into the opening to provide thermal performance, weather tightness and air tightness;
- Cavity trays should be installed over the heads of all openings, lapped behind the breather membrane by a minimum of 100mm. A flashing may be acceptable for some types of claddings;
- Lap cavity barrier DPC with internal VCL around openings. Where no DPC is used, breather membrane should be lapped with internal VCL.

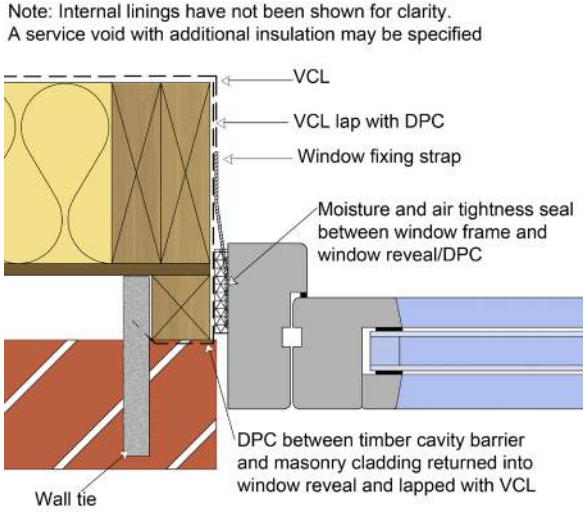


Figure 17: Window / wall junction (jamb)

7.3.4.6 Claddings

All external wall claddings should be separated from the timber frame structure by a drained and ventilated clear cavity. If partial fill cavity insulation is to be used, the same width of clear cavity is to be maintained in addition to the insulation depth.

In some locations, for example close to boundaries, National Regulations require claddings to provide fire resistance to the structure from the outside in.

Cavity barriers must be provided to meet National Regulations.

Self-supporting claddings (Masonry)

Self-supporting (masonry) claddings should be connected to the timber frame using wall ties:

- Installed into studs provided around openings and movement joints, not just through sheathing;
- Angled to drain moisture away from the timber frame, even after differential movement has occurred;
- Installed at a minimum density of 4.4 per/m^2 (a maximum of 375mm vertically with studs at 600mm centres and a maximum of 525mm with studs at 400mm centres). In accordance with BS 5268-6, closer centres may be required in exposed locations;
- Installed at a maximum of 300mm centres vertically and 225mm horizontally around openings and movement joints;
- Installed within 225mm of the head of a wall.

Cavity drainage and ventilation in masonry cladding should:

- Be provided with the use of full height open perpends at a maximum of 1350mm centres or equivalent open area;

- Be fitted in the brick or block course below the lowest timber sole plate, above external finished ground level and below DPC;
- Be provided to ensure drainage and ventilation to each external wall concealed space, directly above horizontal cavity barriers / trays;
- Be installed over openings in the external wall cavity, e.g., windows and doors at a maximum of 900mm centres;
- Maintain a clear cavity, with care taken to reduce mortar droppings at the base of the wall.

Weep-holes alone are unsuitable for timber frame construction. Open perpends should be used. Proprietary open perpend inserts are available with insect screening incorporated. Their equivalent open area must be considered.

In areas of severe or very severe exposure, check reveals should be constructed to provide additional weather protection.

Vertical loadings from masonry claddings must not be supported by the timber frame structure.

Claddings supported on the timber frame

Claddings which are supported on the timber frame should be connected to it on vertical treated timber battens, or a carrier system, to form a drained and ventilated cavity to all areas of the external timber frame wall. These should be fixed into structural timber, not just through the sheathing to the Structural Engineer's specification.

Cavity drainage and ventilation should provide an open area of not less than 500mm^2 per metre run:

- At the base of the external wall concealed space;
- Above horizontal cavity barriers / trays;
- Over openings in the external wall cavity, e.g., windows and doors;
- Allowing differential movement to occur while retaining an adequate gap;
- With openings protected by a mesh to prevent the passage of insects.

Timber frame with external wall minimum cavity widths	
Masonry	50mm
Render on unbacked lath	50mm
Render on backed lath or board	25mm
Timber	19mm
Tile hanging	25mm

Table 1: Minimum cavity widths

7.3.5 Differential movement

Appropriate allowances must be made for differential movement to occur without causing damage to the building.

Differential vertical movement occurs as a result of compression, closing of gaps and shrinkage of the timber frame structure and occurs during the first 24 months following completion. Shrinkage occurs across the grain and is due to a reduction in the moisture content of timber elements. The shrinkage of plates, rails, binders, floor and roof joists should be considered. The building should be designed to ensure that differential movement occurs evenly to external elevations and the internal structure.

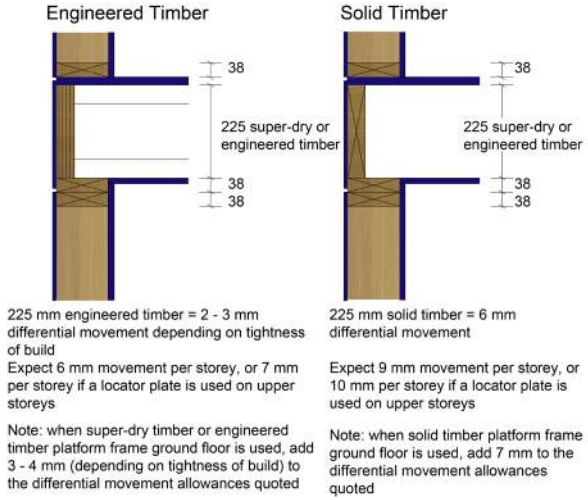


Figure 18: Differential movement at floor zones

Anticipated differential movement can be calculated using the allowance of 1mm for every 38mm of horizontal cross grain timber. As solid timber joists contribute significantly to anticipated differential movement, engineered timber joists should be considered where it is desirable to reduce differential movement.

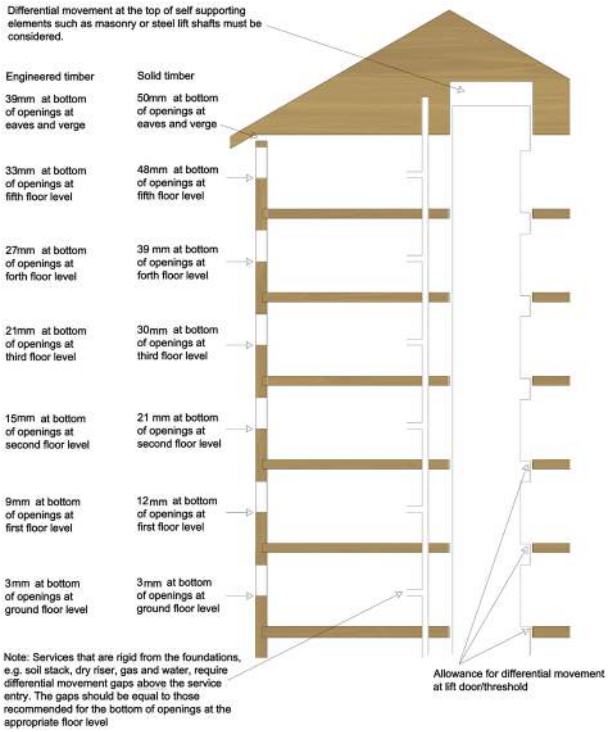


Figure 19: Anticipated differential movement dimensions

If fillers or seals are to be installed into differential movement gaps, their fully compressed dimension, considering the area of the seal and force required to compress it, must be added to the calculated gap size. Materials should be chosen to provide an effective weather tightness seal dependant on whether they are to be subjected to compression, expansion or shear forces. Cover strips may also be used.

Self-supporting claddings (Masonry)

Any material or component attached to the timber superstructure which overhangs the brick or block work (for example, cladding attached to the timber frame; window sills; roof eaves and verges; or projects through the masonry, balcony supports; flues; extractor fan vents or overflow pipes) should have a clear gap beneath and at the top of the masonry cladding to allow differential movement to take place, avoiding damage to the component or cladding.

The size of the gap should be calculated by allowing 1mm for every 38mm of horizontal cross grain timber which is present between the gap location and the lowest structural timber. Gaps will therefore increase in size up the building. The dimensions noted in Figure 19 should be used if site specific calculations have not been provided.

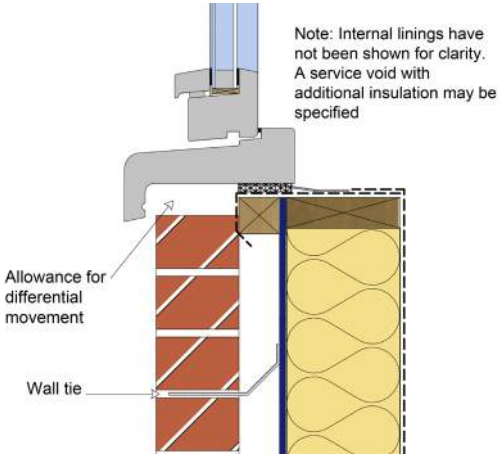


Figure 20: Differential movement gap under sill

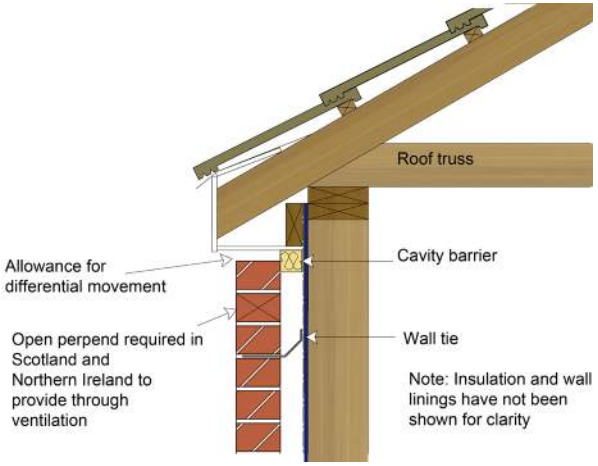


Figure 21: Differential movement at eaves

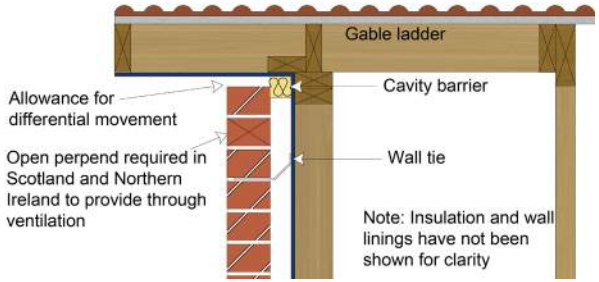


Figure 22: Differential movement at verge

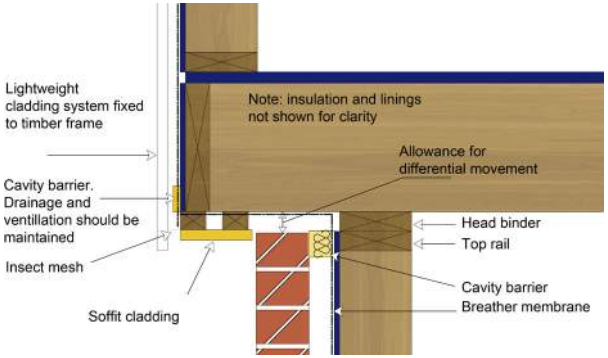


Figure 23: Differential movement at cantilevered overhang

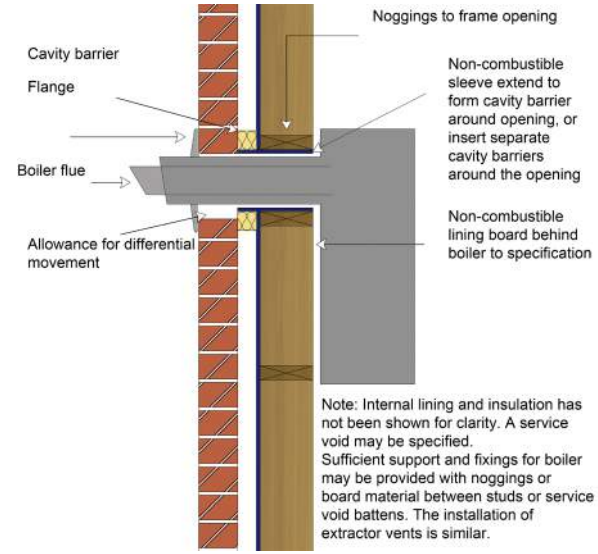


Figure 24: Differential movement at service penetration

Masonry cladding should not be supported on the timber frame structure, but claddings do need to be supported.

Horizontal cross grain timber and construction gaps are concentrated at floor zones and this is where the majority of movement occurs. Vertical timber battens or other rigid cladding support systems should not span over the floor zones of timber frame buildings. Gaps should be provided to accommodate anticipated differential movement. Unlike self-supporting claddings, movement is not cumulative, but should be calculated individually for each floor zone using the formula above of 1mm for every 38mm of horizontal cross grain timber.

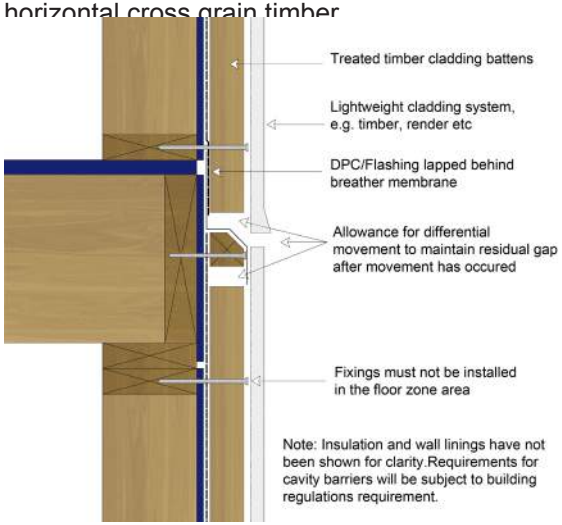


Figure 25: Differential movement at floor zone with cladding supported on timber frame

Gap sizes should allow for anticipated differential movement while allowing for drainage and ventilation requirements. Insect infestation should be avoided by using screens to cover gaps exceeding 4mm.

Services

Rigid services within the timber frame structure also require an equal allowance for differential movement as shown in Figure 19. Examples include copper gas and water pipes, dry risers, internal downpipes, SVPs and block work lift shafts. While gap allowances externally are allowed below, for example, a sill, when a branch comes off a rigid stack internally, the gap needs to be left above a service to allow the timber frame to drop around it.

7.3.6 References

- BS EN 1995-1-1:2004+A1:2008 Euro-Code 5 Design of timber structures. General. Common rules and rules for buildings
- BS 5268-2:2002 Structural use of timber. Code of practice for permissible stress design, materials and workmanship.
- BS 5268-3:2006 Structural use of timber. Code of practice for trussed rafter roofs.
- BS 5268-4 Section 4.1:1978 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.1 Recommendations for calculating fire resistance of timber members.
- BS 5268-4 Section 4.2:1990 Structural use of timber. Part 4 Fire resistance of timber structures. Section 4.2 Recommendations for calculating the fire resistance of timber stud walls and joisted floor constructions.
- BS 5268-6.1:1996 Structural use of timber. Code of Practice for timber frame walls. Dwellings not exceeding seven storeys.

- BS 5268-6.2:2001 Structural use of timber. Code of Practice for timber frame walls. Buildings other than dwellings not exceeding four storeys.
- BS EN 14081-1:2005 Timber structures. Strength graded structural timber with rectangular cross section. General requirements.
- BS 8417:2003 Preservation of timber. Recommendations.
- BS EN 13986:2006 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking.
- BS EN 300:2006 Oriented strand boards (OSB). Definitions, classification and specifications.
- BS EN 636:2003 Plywood. Specifications.
- BS EN 622-4:2009 Fibreboards - Specifications. Requirements for softboards.
- BS EN 622-3:2004 Fibreboards - Specifications. Requirements for medium boards.
- BS EN 622-2:2004 Fibreboards - Specifications. Requirements for hardboards.
- BS 4016:1997 Specification for flexible building membranes (breather type).
- BS EN 845-1:2003+Amendment 1:2008 Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets
- pr EN 14732:2011 Timber structures. Prefabricated wall, floor and roof elements. Requirements Draft for comment

FUNCTIONAL REQUIREMENTS

7.4 WINDOWS AND DOORS

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.4.1 Windows and doors

Timber used for external joinery should be a species classified as suitable in BS EN 942 and preservative treated, if not, use a moderately durable species or better (sapwood excluded). Guidance on selection is provided in TRADA Wood Information Sheets 3.10 and 4.16.

Workmanship should follow the recommendations of BS 1186:2. Preservative treated joinery which is cut or adjusted on-site should be liberally brushed with an appropriate and coloured preservative. Where the colour of the preservative will adversely affect the final appearance of the joinery, an appropriately clear preservative should be used.

Bay, oriel and dormer windows require particular care in detailing and fitting so that they are stable, weather tight and reasonably airtight.

Roof lights should be proprietary components, fixed within prepared openings in accordance with manufacturer's instructions, and have effective weather-sealing.

Non-timber components should comply with the following British Standards (as appropriate) and be installed and fixed in accordance with manufacturer's recommendations:

- BS 4873 Aluminium windows;
- BS 5286 Specification for aluminium framed sliding.

Glass doors

- BS 6510 Steel windows and doors;
- BS 7412 PVC-U windows;
- BS EN 514 PVC-U windows.

PVC-U windows and doors should also be subject to independent third party certification.

Windows should comply with the current Building Regulations taking into consideration:

- Means of escape in the event of a fire;
- Thermal insulation;
- Ventilation;
- Safety.

7.4.2 Thresholds and sills

Thresholds and sills should be at least 150mm above ground level. Where the top of a threshold is more than 225mm above ground level, the following steps are necessary:

- Where level (threshold) access is required, Builders can follow the general guidance given in Figures 1,2 and 3 ensuring a high level of supervision and workmanship, together with the correct specification of materials and consideration given to design, location and exposure.
- Wherever possible, locate the entrance door away from the prevailing weather and provide a storm porch.

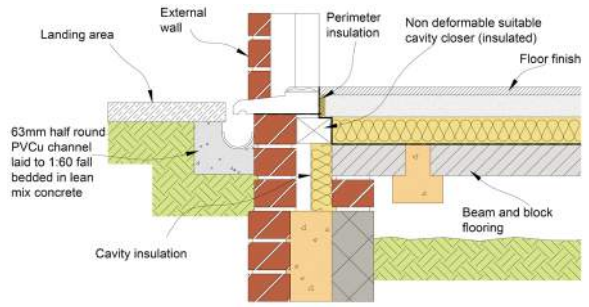


Figure 1: Typical level threshold suspended beam and block floor

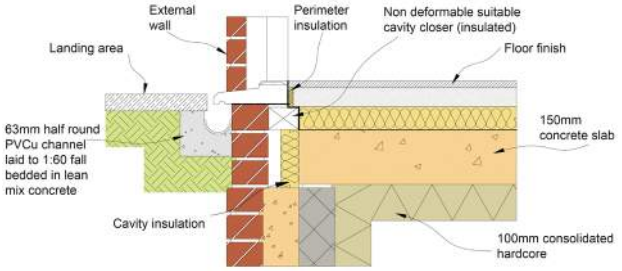


Figure 2: Typical level threshold suspended concrete slab

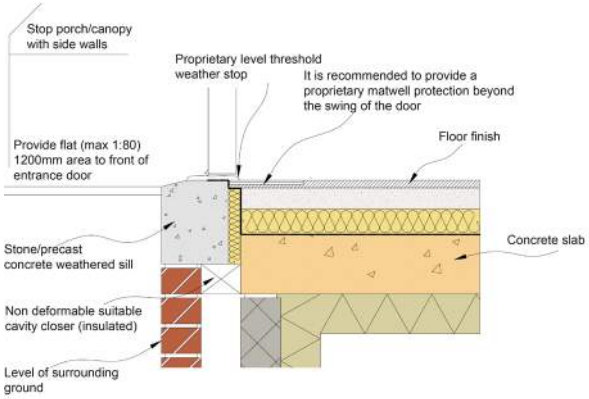


Figure 3: Typical level threshold with canopy protection

It is recommended that a matwell be constructed within the entrance hall to accommodate the swing of the door without fouling the carpet and / or the proprietary door seal to maintain the integrity of the seal.

External doors and opening lights to windows should be reasonably airtight by ensuring that effective draught seals are fitted.

External joinery should be designed and constructed in accordance with the requirements of the following British Standards:

- BS 4787:1 Internal and external wood door sets, door leaves and frames;
- BS 6262 Code of Practice for glazing for building;
- BS 6375:1 Performance of windows;
- BS 644:1 Wood windows;
- BS 8213:1 Windows, doors and roof lights.

7.4.3 Security

External door leaves should be of a robust construction. Timber doors should be no less than 44mm thick (or equivalent strength for other materials). Flush doors should be of solid core construction. Door stiles to which locks are fitted should be of sufficient width so as not to create a weak point in the general robustness of the door (119mm minimum width recommended for timber). Non-glazed panels should be sufficiently small to prevent access into the dwelling. Additional security may be provided within the design if required.

7.4.4 Protection from falling

For houses and flats, the guidance in Approved Document K2 specifies a minimum guard height of 800mm to window openings in the external wall. This would normally be achieved by forming window openings of at least 800mm above finished floor level. The wall beneath the opening is therefore considered to be the barrier to falling.

Where window openings are formed less than 900mm from the finished floor level, permanent guarding should be provided to the opening in accordance with the design requirements specified in the relevant Building Regulations.

Where window openings are formed less than 900mm from finished floor level and no permanent guarding is provided and the glass is required to act as the barrier and provide containment to persons falling against it the glass shall be designed in accordance with the requirements of BS 6180. The Designer shall determine the potential impact energy by establishing the perpendicular unhindered distance that could be travelled prior to impact.

In the absence of an assessment by a suitably qualified person any glass that is required to provide containment shall be designed to meet BS EN 12600 Class 1(C)1.

7.4.5 Control of condensation

Minimise the effects of condensation on glazing and frames by:

- Using insulated metal frames;
- Using details which prevent condensation running on to walls or floors;
- Housing window boards into frames to prevent condensation entering the joint;
- Providing thermal insulation to walls at lintels, sills and jambs. Guidance on this subject is provided in BRE report, “Thermal Insulation: Avoiding Risks”.

7.4.6 Security

Door frames should be securely fixed and the rebate formed preferably from a solid section. Where planted stops are used, they should be glued, screwed and pelleted. Door and window frames should be fixed to vertical reveals with corrosion-resistant fixings at a minimum of 600mm centres, with the end fixings being located within 150mm of the top and bottom of the frame.

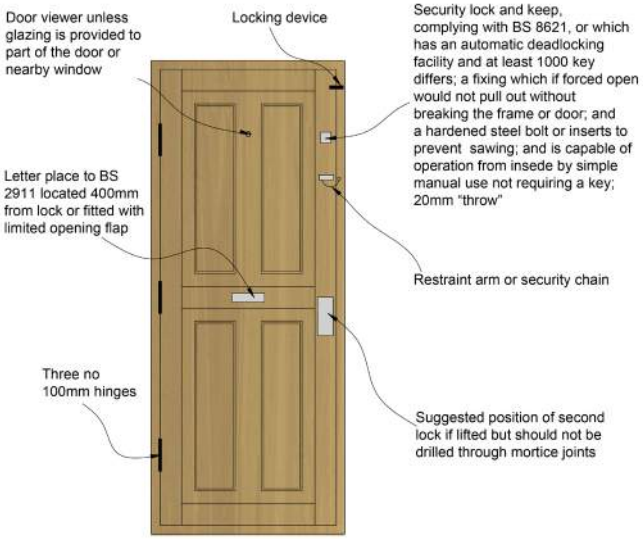


Figure 4: Security provisions to an entrance door

External doors should be hung on 3 no. 100mm hinges. A restraint arm or security chain should be provided to main entrance doors. Main entrance doors should be provided with at least one security lock and key.

If a second lock is fitted, it is suggested that this is positioned 600mm away. A 5 lever deadlock should be provided to other external doors, including patio doors. The lock should comply with BS 8621 (and Euro Norm - 12209) or be of a similar performance standard. Locks to entrance doors of flats should not operate automatically and the deadlock mechanism on the dwelling side of the door should be non key operated (this is a fire precaution requirement).

On the ground floor, with the exception of kitchens, all habitable rooms should either open directly onto a hall leading to the entrance or other suitable exit, or be provided with a suitable window or door.

External doors (except main entrance doors) and sliding patio doors should be provided with robust bolts at the top and bottom of the closing edge of the door, e.g.,100mm barrel bolts fixed with 30mm No. 8 screws (see Figure 4). Where espagnolette multi-locking points are provided, the bolts can be omitted.

Sliding doors should be designed so that they cannot be lifted out of the frame from the outside. Letter plates should comply with BS 2911 and either be located no closer than 400mm from the door lock or be fitted with a limited opening flap. Where fitted to a fire resistant door, e.g., flats, the letter plate should not adversely affect the fire resistance of the door. Windows should be provided with a securing device which cannot be sprung by levering the casement or sash from the outside of the building when in a closed position. A key operated lock should also be provided to all ground floor windows and others which are readily accessible from the outside, either as part of the securing device or as a separate unit.

Roof lights should not be used on single storey or other accessible roofs unless they are specifically designed to provide a deterrent against forced entry and can be locked with a removable key. Externally located hinge pins should be non-demountable, e.g., welded or disturbed ends.

7.4.7 Means of escape

Emergency egress windows in two storey dwellings - with the exception of kitchens, all habitable rooms in the upper storey served by one stairway shall be provided with a window:

- Which has an unobstructed opening area of at least 0.33m^2;
- Be at least 450mm high x 450mm wide;
- The bottom of the opening area should not be more than 1100mm above the floor.

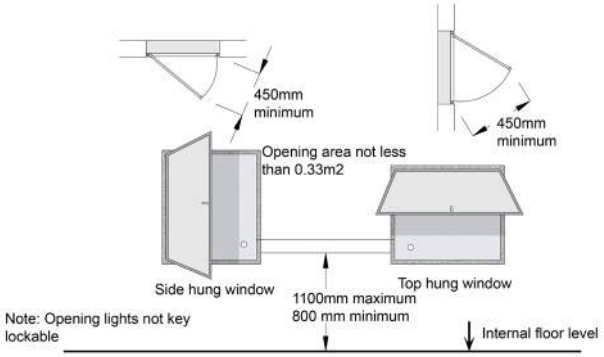


Figure 5: Emergency egress window provision

7.4.8 Installation of doors and windows

Window and door frames should be installed so that:

- They do not carry loads unless designed to do so;
- The face of the frame is set back at least 38mm from the masonry face. Masonry on the external side of a vertical DPC should not be in contact with internal finishes;
- The window head is set back behind the edge of the cavity tray;
- The frame to wall junction is weather tight and reasonably airtight;
- In areas of very severe exposure, checked rebates should be provided;
- The frame should be set back behind the outer leaf and should overlap it as shown in Figure 6. Alternatively, an insulated finned cavity closer may be used that has third party certification;
- Distortion is minimised by not locating radiators or other heaters close to doors;
- The water drip to window and door sills projects beyond the wall or sub-sill by at least 10mm and the sill edge by at least 25mm.

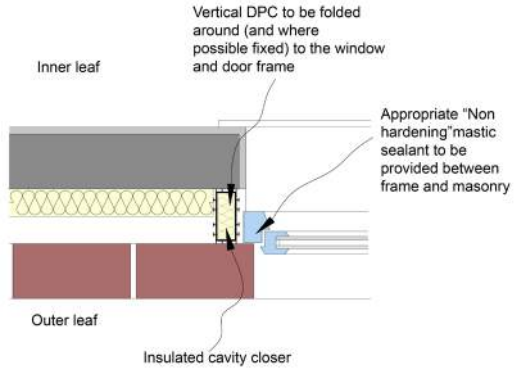


Figure 6: Rebated window framed for areas of very severe exposure

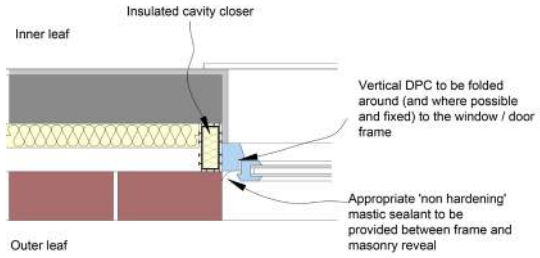


Figure 7: Typical window reveal detail (normal exposure)

Proprietary materials, possessing third party should be used to close cavities at window and door openings. They should also be installed in accordance with the manufacturer's recommendations.

7.4.9 Fire doors

Any door between a dwelling and an attached or integral garage should be a half hour fire resisting door and frame.

7.4.10 Bay windows

The vertical DPC and cavity closer should be installed as shown in Figure 8.

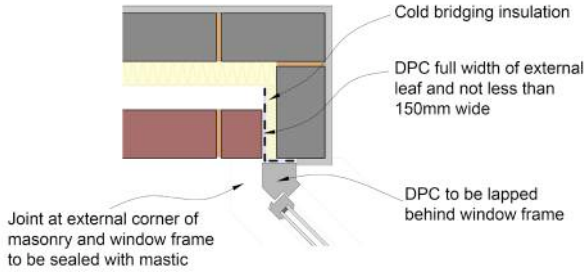


Figure 8: Typical bay window detail

7.4.11 Workmanship

Window and door frames should be installed either by building in tightly as work proceeds, or by fitting into preformed openings, suitably dimensioned to provide an accurate fit for the frame plus the perimeter weather tight joint.

Timber frame windows and doors can be installed so they abut the masonry. Any gap provided should not exceed 10mm. For gaps less than 5mm, the sealant must cover both the frame and the masonry by 6mm. For gaps greater than 5mm, a backing strip should be provided behind

the sealant. The sealant should have a minimum depth of 6mm.

PVC-U frame windows and doors should be installed with a gap of between 5mm and 10mm to allow for thermal expansion. For large framed units such as patio doors, the gap can be up to 15mm.

Frames should be fixed in accordance with the manufacturer's recommendations or, if no instructions are given, with the following guidance:

- Fixings should be at 600mm maximum centres and within 150mm of corners of the frame;
- Frames should be fixed either by galvanized steel cramps or by non-corrodible screw fixings to the surrounding wall.

7.4.12 Glazing

Critical locations

Glazing in doors and windows in areas known as 'critical locations' need to be given special consideration in order to prevent potential injury to people within or around the building.

These 'critical locations' as shown in Figure 9 are:

- In a door or side panel within 300mm of it between floor level and a height of 1500mm;
- In an internal or external wall or partition between floor level and a height of 800mm.

It is important that any glazing within these 'critical locations' should be either:

- Provided with permanent protection;
- Small panes;
- Robust;
- Break safely.

If permanent protection is provided there is no requirement for the glazing itself to be of a special type. Permanent protection may take the form of railing or barriers and should:

- Be designed to be robust;
- Have a maximum opening or gap in any railing of 75mm or less;
- Be a minimum of 800mm high;
- Be non-climbable (especially where floor is acting as a balcony).

Small panes, either an isolated pane within glazing bars or copper or lead lights, should be restricted in size so that any breakage would be strictly limited.

Small panes should be:

- No more than 0.5m^2 in area, and;
- No wider than 250mm.

Where concealed glass is used, a minimum of 6mm thickness is recommended (4mm for lead or copper lights). Some materials are inherently strong such as glass blocks or polycarbonates, whereas concealed glass will need to be of an increased thickness as the area of the panel increases to be considered 'safe'. As an alternative to any of the above solutions, it is possible for the material to break 'safely' when tested to BS EN 12600 which would mean that:

- Only a small opening was created with a limited size of detached particles;
- The balance would create only small pieces that are not sharp or pointed;
- The pane disintegrates with only small detached particles.

Detailed guidance on this aspect of glazing can be found in Approved Document K : 2013 to the Building Regulations.

A glazing material would be suitable for a critical location if it meets the requirements of BS EN 12600 Class 3 or of BS 6206. Glass that is installed in a door or in a side panel to a door that exceeds 900mm wide must meet the requirements of BS EN 12600 Class 2 or BS 6206 Class B.

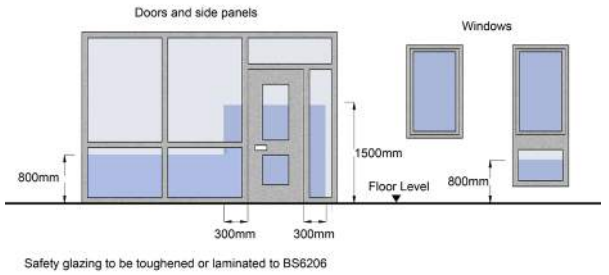


Figure 9: Glazing to critical locations

Glazing should be in accordance with BS 6262. Insulated glass units (IGU) should meet requirements of BS EN 1279 - Glass in building-insulating glass units. IGU's should carry third party accreditation. This includes windows in possession of a BBA certificate and timber windows.

- They should have dual seals - single seal units are not acceptable;
- Desiccant should be provided to every spacer bar;
- Any glazing on-site must have a drained and ventilated bottom bead;
- Any glazing with an area greater than 1m^2 must have a drained and ventilated bottom bead;
- Glazing with an area less than 1m^2 may be solid bedded;
- All spacer bars should be stamped with BS EN 1279;
- PVC-U frames and spacer bars should be stamped with BS 7412, 7413 and 7414.

Linseed oil putty glazing should not be used when the joinery is finished with vapour permeable paint or stain; putty glazing should also not be used with organic solvent based stains. Putty should be neatly finished to receive a protective paint coat.

Putty is not suitable for double glazed units. Workmanship should be in accordance with BS 8000:7. To ensure compatibility of the whole glazing system, with a high level of workmanship and control, it is recommended that factory pre-glazed systems be installed in all external openings.

External glazing beads should be pinned at a maximum of 150mm centres (a maximum of 50mm from corners) or screwed at 200mm centres (maximum 50mm from corners).

The preferred method of installation for double glazed units is either:

- Drained and ventilated frames as recommended by the Glass and Glazing Federation (GGF). Where possible, this method should be adopted for external glazing;
- Solid bedding of units in 16mm-18mm deep frame rebates. 18mm rebates are recommended by the GGF to allow for tolerances. In all cases, sealants should not be sensitive to ultra-violet light. External glazing beads should be fixed at a maximum of 150mm centres and the glazing bedded in non-setting putty. Louvred windows should not be used. Double glazing should be fixed and bedded as recommended by the GGF.

Control of condensation

Minimise the effects of condensation on glazing and frames by:

- Using insulated metal frames;
- Using details which prevent condensation running onto walls or floors;
- Housing window boards into frames to prevent condensation entering the joint;
- Providing thermal insulation to walls at lintels, sills and jambs;
- Using trickle ventilators or similar, to provide background ventilation where required by the Building Regulations. Further guidance on this subject is provided in BRE report, BR262 Thermal Insulation: Avoiding Risks 2002.

Glazing

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

Faults include:

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

When assessing the appearance of glass:

- The viewing distance used shall be the furthest stated in any of the BS EN Standards for the glass types incorporated in the glazed unit. In the event of doubt the viewing distance shall be three metres.
- The viewing shall commence at the viewing distance and shall not be preceded by viewing at a closer distance.
- The viewing shall be undertaken in normal daylight conditions without use of magnification.

The above does not apply within 6mm of the edge of the pane, where minor scratching is acceptable. Scratches on doors, windows and frames, factory finished door and window components should not have conspicuous abrasions or scratches when viewed from a distance of 0.5m.

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

Where window openings are formed less than 900mm from finished floor level and no permanent guarding is provided and the glass is required to act as the barrier and provide containment to persons falling against it the glass shall be designed in accordance with the requirements of BS 6180. The Designer shall determine the potential impact energy by establishing the perpendicular unhindered distance that could be travelled prior to impact.

In the absence of an assessment by a suitably qualified person any glass that is required to provide containment needs to meet with BS EN 12600 Class 1(C)1 standard.

7.4.13 Cast stone jambs and mullions

Stainless steel dowels in the sides of the jambs should be bedded into adjacent mortar joints as the masonry is constructed.

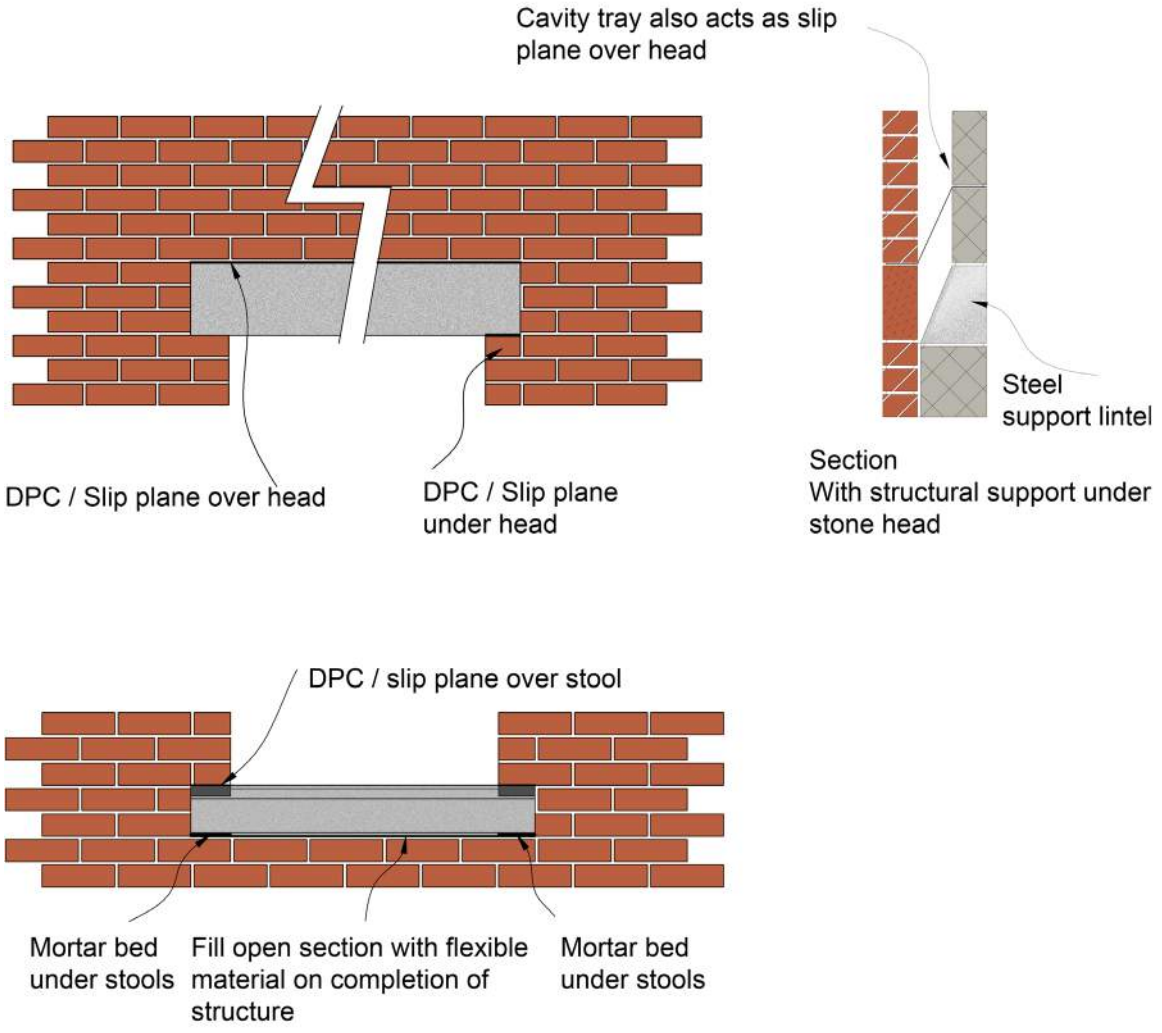


Figure10: Stone heads and sills

Cast stone heads

A cavity tray must be provided above all heads as this discharges water to the outside face of the masonry, but also acts as a slip plane. A slip plane will be required at the end of the cast stone head as well as a soft joint between the top of the head and the steel support lintel.

Cast stone window / door surrounds

Where cast stone butts up to other materials, allowance must be made to accommodate differential movement, e.g., where cast stone abuts clay brickwork, a slip surface between the two materials must be incorporated or the cast stone should be flexibly jointed.

Sills

The DPC should be overlapped by the vertical DPC at the jambs and should be turned up at the back and ends for the full depth of the sill.

The mortar bed below sills should be trowelled smooth, allowed to set, cleaned off and then a DPC laid over. The open section below the sill should be sealed with a flexible material only at completion of the structure.

To control water penetration through joints in window surrounds, e.g., at junctions between jambs and mullions and sills, rectangular and T-shaped water bars should be provided.

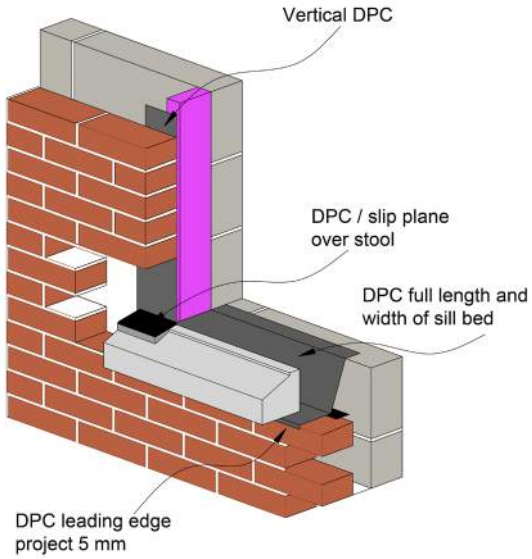


Figure 11: Stone sill with insulated cavity closer

FUNCTIONAL REQUIREMENTS

7.5 CHIMNEYS

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.5.1 Support

If a chimney is not provided with adequate support by ties or securely restrained, it's height (measured to the top of the chimney) should not exceed 4.5 times it's least horizontal dimension, when measured from the highest point of intersection with the roof surface (density of masonry must be a minimum of 1,500kg/m^3).

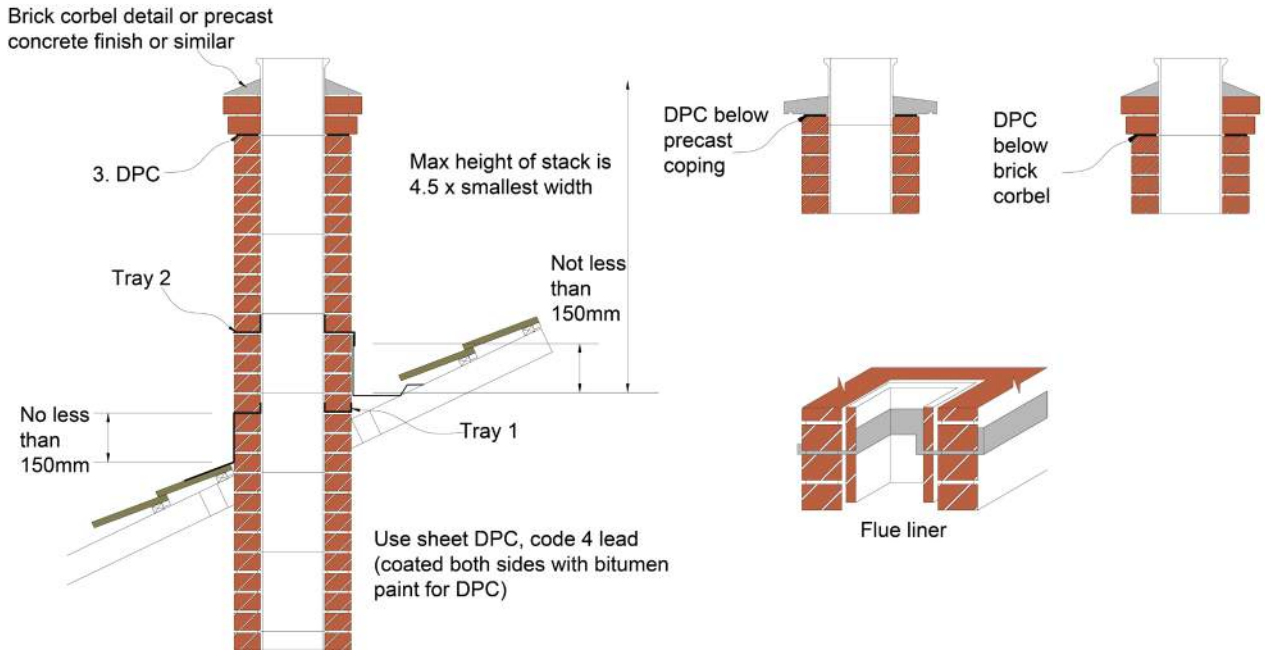


Figure 1: Typical chimney details

7.5.2 Chimneys and flues

Ensure that all gas flues terminate to the open air, i.e., flue blocks must terminate at an appropriate ridge vent or similar even where no appliance is fitted prior to the sale / occupancy of the property. To demonstrate that flues comply with Building Regulations, reports showing flues have passed appropriate tests are to be made available.

A suggested checklist for these reports are provided in Approved Document J. Special blocks are made to accommodate gas fire flues which tend to be slightly thicker than normal units. When used in external walls, care should be taken not to reduce the clear cavity width below 50mm.

If the chimney is in a severe exposure zone, the cavity should extend around the outside of the stack and be continuous up to roof level as per BS 5628, Part 3:2001. Where the chimney breast is gathered in, the lower projecting masonry should be protected with a suitable capping and cavity trays. A 50mm cavity at the back of the chimney breast is maintained to prevent rainwater penetration.

Flue liners are used as specified with sockets upper most and jointed with fire resisting mortar and flue liners should be:

- Non-combustible;
- Reasonably smooth internally;
- Correctly jointed with mortar with the space between the liners and the brickwork filled with weak insulating concrete, unless the

manufacturer recommends an alternative specification;
- Properly jointed at the junctions with the starter block or lintel and outlet terminal.

A notice plate containing safety information about any hearths and flues should be securely fixed in an unobtrusive but obvious position within the home.

Where a chimney forms part of a wall, the foundation should project at least 100mm wider than the chimney base and should be the same depth as the adjacent wall foundation. Factory made insulated chimneys should have a life of at least 30 years and be designed in accordance with BS 4543, BS EN 1859 and installed in accordance with BS 7566. Where a chimney is not directly over an appliance or opening, a soot box accessible for emptying should be formed.

7.5.3 Corrosion of lead work

Where free lime from mortar comes into contact with lead trays or flashings (due mainly to the continual saturation of the brickwork) in areas such as chimneys, the lead should be protected from corrosion by the use of a thick coat of bitumen paint covering the faces likely to be in contact with the mortar. The protection against corrosion of lead work buried in mortar is suggested in guidance issued by the Lead Sheet Association. This treatment can also reduce staining of lead and brickwork. It is unnecessary to treat flashings buried only 40mm–50mm into mortar joints (cover flashings), as this close to the drying surface carbonation of free lime is rapid and there is no risk of corrosion in such circumstances.

7.5.4 Chimney tray, low level

Required at low level where a cavity-walled chimney with brick shoulders is built on to an external wall; the tray prevents water which may enter the shoulders from penetrating to the inner leaf of the wall.

Material: 1mm aluminium alloy sheet to BS EN 485-2:1995 ‘Aluminium and aluminium alloys. Sheet strip and plate. Mechanical properties’. This has a higher melting point than lead, so is suitable for installation close to a heat source.

A high level may be required to prevent the entry of water at high level where a chimney rises through a pitched roof; suitable for new build or remedial work minimises disturbance to surrounding construction in remedial work.

Material: Lead sheet to BS 1178:1982 ‘Specification for milled lead sheet for building purposes’. Code 4 as standard. Standard sizes: 800mm x 800mm, 900mm x 900mm, 950mm x 950mm to suit either 195mm square or 195mm diameter circular flue.

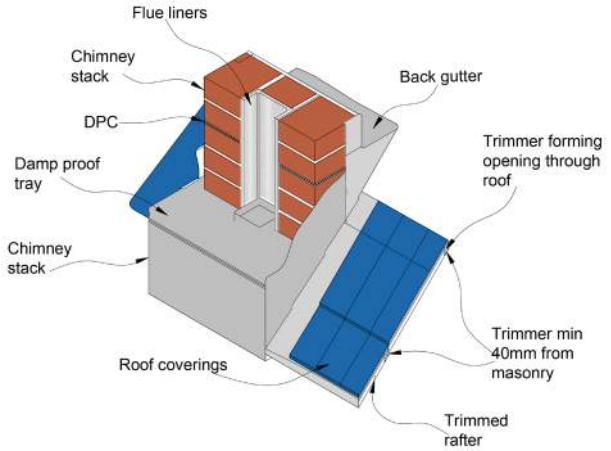


Figure 2: Typical flashing to chimneys

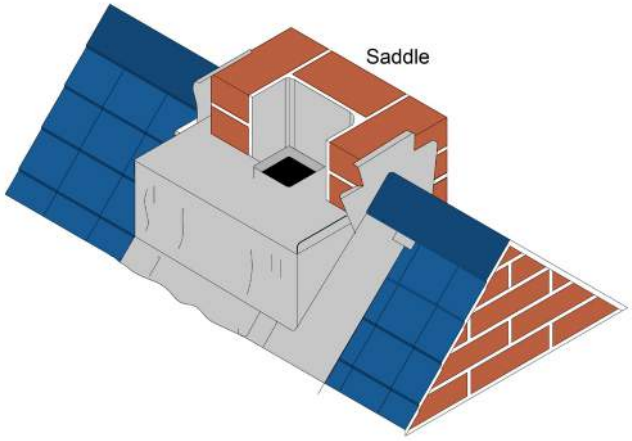


Figure 3: Flashings to chimneys at ridge

FUNCTIONAL REQUIREMENTS

7.6 BALCONIES

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. Balconies must have appropriate guarding meeting the relevant Building Regulations.
iv. The balcony design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.6.1 Balconies, public access terraces and podium decks

Introduction

This Chapter should be read in conjunction with Chapter 7.10. Where appropriate, cross reference will be provided to the relevant Chapter in 7.10. This provides specific advice and requirements in respect of balconies and terraces of three types as follows:

- Where the balcony or terrace forms part or the entire roof to other occupied parts of a building;
- Warm deck;
- Inverted warm deck system;
- Where the balcony or terrace projects beyond the building elevation;
- Cold deck roof system.

7.6.2 Design

7.6.2.1 Selection of system type

The cold deck roof system is not permitted on balconies or terraces that form part of the entire roof to other occupied parts of the building. In these circumstances, the selection of system type (warm deck or inverted warm deck) should be based upon the following criteria:

- Roof zone depth (height from ceiling to termination of waterproofing);
- Likely point loading;
- Construction process (a complete inverted warm deck roof, with suitable protection, and which may be suitable for storage or access by other trades. A warm deck roof may not be suitable for storing heavy loads).

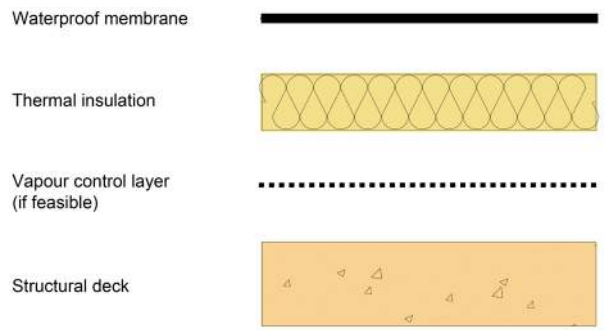


Figure 1: Warm roof (section)

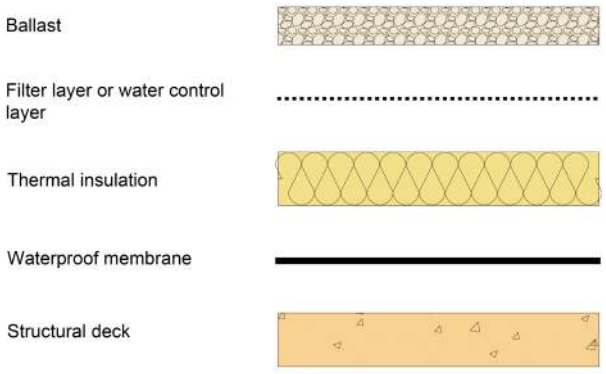


Figure 2: Inverted warm roof (section)

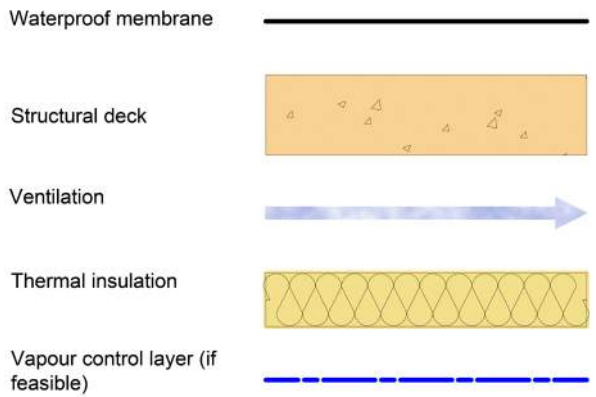


Figure 3: Cold roof (section)

7.6.2.2 Loading

Statutory requirement

Design for loading must comply with Statutory Building Regulations.

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 balcony will be affected significantly by the design of the perimeter and by the geometry and finishes on the elevations of the building. Any changes to these elements will necessitate a review of the calculation output.

Resistance to imposed loads

At the earliest possible stage, the employer should define the range of potential imposed loads for which the balcony is to be designed, such as planters, storage and public access. In the absence of such a performance requirement, the loading limits of the balcony should be defined.

7.6.3 Falls and drainage

7.6.3.1 Statutory requirement

Design for drainage should comply with the Building Regulations 2000, Approved Document Part H – Drainage and Waste Disposal – Part H3 – Rainwater Drainage.

7.6.3.2 British and industry standards

The requirements of BS 6229 should prevail in respect of balconies and terraces, whether or not they form part or the entire roof to occupied parts of a building and irrespective of the type of waterproof membrane.

Falls are not required for podium decks provided:

- They are designed with pedestrian finishes, which allow rainwater to drain rapidly from the finished surface and not to accumulate upon it;
- The waterproof membrane has current certification (see Chapter 7.10 - Roof Coverings – Continuous Membranes), for use at zero falls in this application.

Wherever practical, balconies and terraces should be designed to fall away from the building elevation. If this is not practical for reasons of continuity of rainwater services, the falls should be arranged across the balcony, parallel to the elevation.

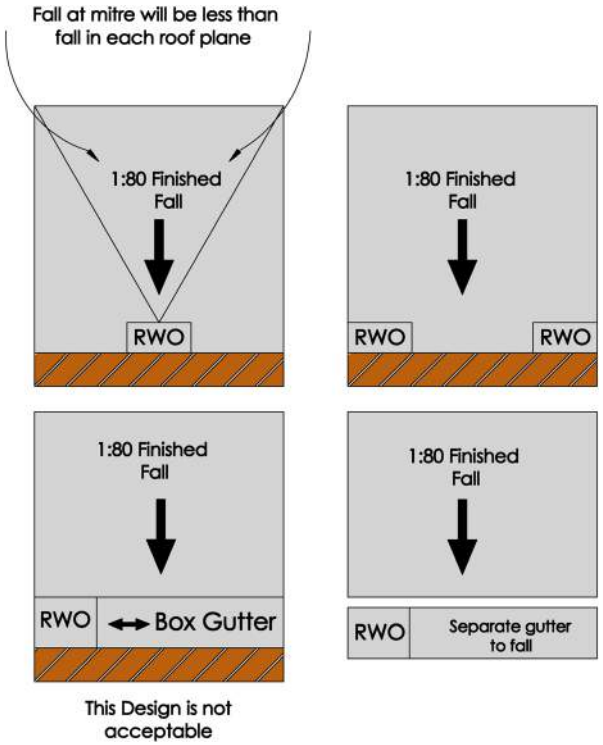


Figure 4: Drainage layout options

7.6.3.3 Creation of falls

Roof falls may be created either during the construction of the deck or alternatively by the use of tapered insulation systems (warm deck roof systems only).

Where the roof finish is to include paving on supports, consideration should be given to the height difference created by the falls and spacing of rainwater outlets. In order that the maximum height of paving supports is not exceeded, the minimum height of upstands is not affected or trip hazards created. On large balconies and terraces, it may be necessary to increase the number of outlets in order to reduce maximum roof zone depth.

7.6.3.4 Drainage

If a balcony is served by a single rainwater outlet, an overflow facility of equivalent capacity and clearly visible externally should be provided at or near the same location, no more than 50mm above the level of the waterproof membrane.

Rainwater outlets should be readily accessible without disruption to the pedestrian finish. On finishes raised above the waterproof membrane (warm deck roofs) or water control membrane (inverted roofs), this may be achieved by a suitably marked paving slab or demountable section of decking.

Where rainwater downpipes from other higher roof areas or balconies discharge via a lower balcony or terrace, an open downpipe shoe is not

permitted. The downpipe should be connected directly to the downpipe serving the lower balcony or terrace.

7.6.4 Thermal performance

Design for thermal performance must comply with the current Building Regulations, as appropriate.

7.6.5 External fire performance

7.6.5.1 Statutory requirement

Design for external fire performance must comply with the current Building Regulations.

7.6.6 Provision for access

7.6.6.1 Statutory requirement

Balconies should have suitable access and drainage meeting the requirements of the current Building Regulations.

7.6.6.2 Edge protection

The guarding to the perimeter of balconies, terraces and podium decks should be designed to provide the simplest means of achieving waterproofing integrity, given that installation of balustrade or glazing stanchions may occur after the installation of the roof system.

Acceptable examples include the following, in order of preference:

- Full height parapet walls;
- Stanchions or rails secured to low parapet walls above the level of the waterproof membrane (incorporated in copings or secured to elevation);
- Stanchions secured, clamped and sealed to stainless steel (SS) bolts set in raised plinths, which were constructed prior to application of waterproof membrane (suitable for warm deck and inverted warm deck roof systems).
- Stanchions secured, clamped and sealed to SS bolts set at deck level, which were installed prior to application of waterproof membrane (suitable for warm deck roof systems only).

If the design requires a collar of waterproof membrane at the stanchion, the stanchion should be of circular section at this point and should incorporate a weathering apron.

7.6.6.3 Protection of waterproof system during construction

At the earliest possible stage, the anticipated loading of the balcony, terrace or podium area by plant and access during service should be assessed in terms of:

- Load, e.g., foot traffic, equipment;
- Frequency;
- Risk of impact.

If such usage is intense or long-lasting, during the construction phase, consideration should be given to temporary works only, with completion occurring after all non-roofing usage has ceased, as follows:

- **Warm deck roof system:** installation of temporary vapour control layer, to be overlaid when remainder of system is installed;

- **Inverted warm deck roof system:** overlay of completed waterproof membrane with geotextile and continuous temporary decking such as plywood, oriented strand board or compatible recycled thermoplastic board.

7.6.6.4 Pedestrian access finishes

The design should include protection to suit the anticipated conditions as appropriate:

	Roof system type			Waterproof membrane type			
Finish	Warm	Inverted	Cold (podium)	Single ply membrane	Bitumen membrane	Mastic asphalt	Liquid applied
Porous concrete tiles adhered to waterproof membrane (1)	Y	N	Y	N	Y	Y (2)	Y
Fired tiles bedded in screed and grouted (1)	Y	N	Y	Y	Y	Y (2)	Y
Precast concrete paving slabs on adjustable supports (3)	Y	Y	Y	Y	Y	Y	Y
Timber decking on timber supports (4)	Y (6)	Y (5,6)	N	Y (7)	Y	Y	Y

Notes:

(1) Product should be certified for use with waterproof membrane (see Chapter 7.10);
(2) Consideration should be given to the effects of solar gain on the stability of mastic asphalt under point loading in this situation;
(3) Paving support pad bearing area should be suitable for the compressive strength of the insulation under design loadings;
(4) Bearers should not impede drainage and should be sized to suit the compressive strength of the insulation under design loadings;
(5) Decking should be of sufficient dead load to provide resistance to wind load and temporary flotation of insulation;
(6) Suitable certification for external fire performance should be provided;
(7) Membrane manufacturer's recommendations should be followed, regarding the protection layers required to isolate the waterproof membrane from spillage of liquids or timber preservatives.

Table 1: Pedestrian finishes for balconies, terraces and podium decks

7.6.7 Detailing

7.6.7.1 General principles

At an early stage in the design process, an audit of balcony, terrace or podium 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 the design of all details:

- Upstands to extend 150mm above finished roof level except at door access to balconies and terraces (see details section below);
- Downstands (of separate metal or other flashings) should lap the upstand by minimum. 75mm;
- Where the balcony or terrace forms part of the entire roof of an occupied building, a continuous barrier to air leakage should be maintained;
- Reliance on sealant as the sole means of protection 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 door access to

balconies (see continuous water checks and verges). Balconies are a frequent and acceptable exception due to the need for level or unobstructed access, provided the recommendations in this section are followed.

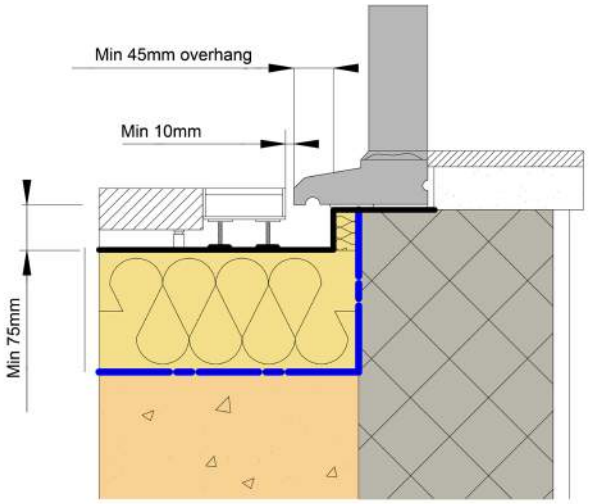


Figure 5: Details Principles – Upstand at door access - Warm deck roof – Level threshold

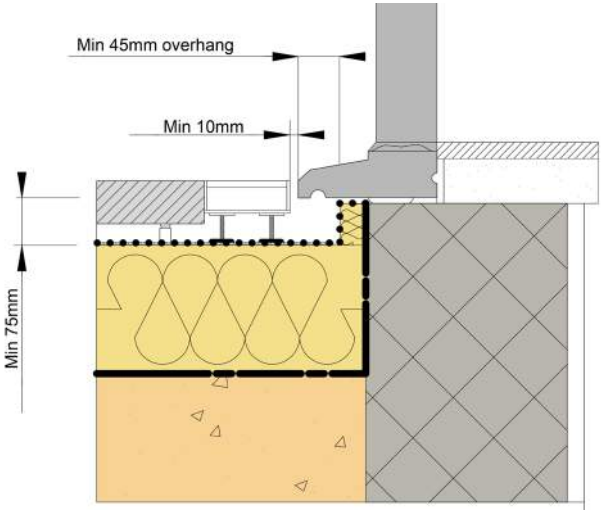


Figure 6: Details - Principles – Upstand at door access - Inverted warm deck roof

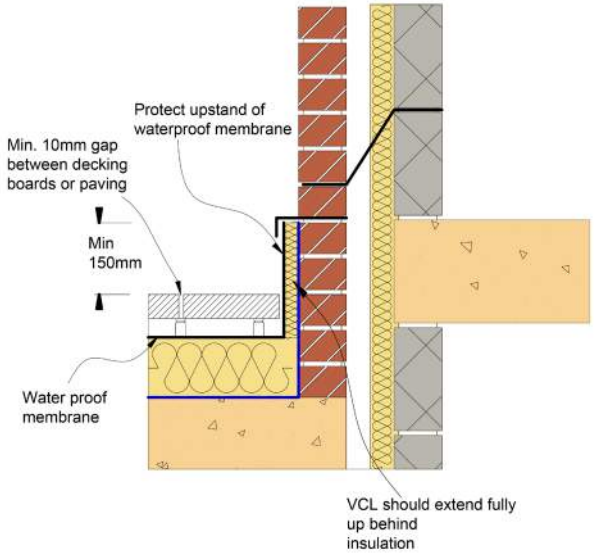


Figure 7: Details - Principles – Upstands to decking and paving finishes, (e.g. balcony parapet) – Warm roof.

7.6.8 Design for sustainability

As per Chapter 7.10 - Roofing

7.6.9 Materials

As per Chapter 7.10 - Roofing

7.6.10 Installation

7.6.10.1 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. It should not be laid on routes where temporary ponding is likely, e.g., near parapet walls in the absence of cross falls between rainwater outlets.

It is recommended that concrete paving is laid on support pads as this allows adjustment, reducing risk of trip hazard. Recommendations are as follows:

- The height of support pads should not exceed the maximum recommended by the manufacturer;
- Paving should not be cut;
- Paving should be firmly butted up against support pad separating pegs;
- Support pad separating pegs should provide clear space for rapid disposal of rainwater between paving slabs;
- Provision for movement at perimeters should comprise either a 75mm margin of washed stone or a compressible rubberised fill. In either case, drainage should not be obstructed and a suitable restraint trim should be used to ensure stone does not fall beneath the paving adjacent.

7.6.10.2 Vapour control layer (VCL)

As per Chapter 7.10 - Roofing

7.6.10.3 Thermal insulation

As per Chapter 7.10 - Roofing

7.6.10.4 Waterproof membrane

As per Chapter 7.10 - Roofing

7.6.11 Testing

7.6.11.1 Final inspection

At practical completion of the balcony, terrace or podium deck, 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.

7.6.11.2 Procurement of testing services

If testing to demonstrate waterproofing integrity is required, it should be undertaken by a third party that is independent of the roofing contract. The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project;
- Experience and training of operator;
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

7.6.11.3 Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs, where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been

overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is a suitable method of demonstrating the integrity of balconies, terraces and podium decks. However, consideration should be given to the effect of ingress on programme and risk of entrapped water in insulation (warm deck roofs) and decks (all types). The area under any one test should not exceed 50m^2.

7.6.12 Provision of Information

7.6.12.1 Operation and maintenance manual

The following information is required:

- Specification, as-built:
  - Waterproof membrane: generic type, product(s) and (as appropriate) thickness;
  - Thermal insulation: generic type, product(s) and thickness;
  - Acoustic insulation: generic type, product and (as appropriate) thickness;
  - Vapour control layer: generic type, product (as appropriate) and thickness (as appropriate);
  - Rainwater outlets: type, product, capacity, location and means of access;
- Procedure for maintenance of waterproof membrane including (where appropriate) recommended frequency and method of application of solar reflective finish;
- Procedure for repair of waterproof membrane.

FUNCTIONAL REQUIREMENTS

7.7 CLADDING

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be handled and stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies that can be inspected and replaced and which are not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. The cladding materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.
iii. The design of primary framing members (e.g. mullions and transoms, backing wall framing sections, etc.) and the connections of these members / panels to the structure must be supported by structural calculations provided by a suitably qualified professional.

7.7.1 Render

Rendering should be in accordance with BS 5262 and workmanship in accordance with BS 8000. In particular, the following should be considered:

- Abutments between cement render and other cladding materials or components should be weather tight and allow for differential movement;
- Any joints in the wall where movement may occur should be continued through the rendering;
- Render should not bridge the damp proof course (DPC) and be finished onto a durable render stop;
- External rendering should comply with BS 5262;
- Sand for rendering should be stored separately from other building and concreting sands;
- For bellcasts, a galvanised steel bead is acceptable;
- For other beads and stops an epoxy or PVC coated galvanised steel is acceptable;
- Render systems that include a cavity as secondary defence system should also incorporate cavity barriers within the cavity to prevent the spread of fire through the cavity. The cavity barriers should not obstruct more than 50% of the cavity. The cavity must retain its ability to drain. The cavity barrier must activate and fully close the cavity when exposed to fire;
- Renders will be reinforced at corners and penetrations;
- Renders installed between pedestrian level and 6m above ground level will be designed to accommodate higher maintenance and impact loads in accordance with Table 2 of BS 8200.

7.7.1.1 Timber frame background

A drained and vented cavity should be provided behind render on timber framed construction. Mesh or metal lathing should be approved by an independent authority and fixed to vertical battens at stud centres. The minimum size of the cavity should be 19mm when the mesh or metal lathing is backed by a water-resistant membrane and 50mm when the mesh or metal lathing is unbacked. A DPC should be provided between unbacked render and timber battens.

Battens should be either 25mm x 38mm or 50mm x 50mm, preservative treated (BS 8417, or equivalent, hazard class 2) and fixed at spacings recommended in BS 5262. Fixings and preservatives should be compatible.

Battens should be fixed to each stud with annular ring nails of length at least twice the batten thickness plus the sheathing thickness. Nails should be hot dipped galvanised, stainless steel or equally durable. Where cavity barriers are required, they should be correctly fitted without gaps, fill the cavity and be fixed with stainless steel staples or equally durable fixings. Maintain settlement joints below external frames and soffits.

Where cement render spans across an intermediate floor zone in timber frame construction, allow for differential movement due to timber shrinkage by incorporating a movement joint. Vertical movement joints should also be provided at maximum 5m horizontal centres.

7.7.1.2 Masonry background

Walls should be examined for excessive moisture content prior to rendering. This is particularly important where the masonry background has no upper limit on its soluble salts content, e.g., N designation clay bricks. Parapets, chimneys, retaining walls and walls below DPC level with this background should employ sulphate resisting cement in the render and mortar.

It is recommended that:

- The backs and exposed horizontal surfaces of parapets are not rendered;
- Throats or drips to copings of parapets and chimneys should project beyond the finished faces to throw water clear;
- Rendering to chimneys should only be carried out where brickwork contains little or no sulphates. Splatterdash treatment should be used;
- As before, horizontal damp proof courses (DPC) and damp proof membranes (DPM) must not be bridged;
- Rendering is not used below DPC. However, where this is not practical the render must still not be allowed to bridge the DPC. A bellcast must be formed in the render above the DPC.

7.7.1.3 Other construction detailing

Ensure that drips and throating to sills, coping etc. project beyond the face of the finished render above the DPC.

Notwithstanding wind loadings, the larger the eaves overhang the better. This will provide protection to the top joint and prevent rainwater percolating behind the render.

Angles, stop beads and jointing sections should be secured with drilled or shot-fired fixings and not with gypsum plaster.

Check whether the rendering can be applied directly onto the wall or whether any preparatory treatment is required in accordance with the manufacturer's instructions. The surface should be checked for suction by dampening the wall with clean water.

7.7.1.4 Vertical and horizontal flatness

Rendering should have a maximum vertical and horizontal deviation from flatness of +/- 10mm in 5m and is measured in a similar way to straightness on plan and plumb of masonry.

7.7.2 Curtain walling

7.7.2.1 General

Curtain walling systems should have third party certification confirming satisfactory assessment and comply with the requirements of the CWCT Standard for Systemised Building Envelopes. Including the following sections:

Part 1: Scope, terminology, testing and classification
Part 2: Loadings, fixings and movement
Part 3: Air, water and wind resistance
Part 4: Operable components, additional elements and means of access
Part 5: Thermal, moisture and acoustic performance
Part 6: Fire performance
Part 7: Robustness, durability, tolerances and workmanship
Part 8: Testing

The CWCT Standard provides detailed guidance on performance and testing.

Dead and live loads should be transferred safely to the building structure without undue permanent deformation or deflection of any component.

Imposed loads should be calculated in accordance with BS EN 1991. Movement should be accommodated without any reduction in performance.

Fixings and supports should be designed to accommodate specified loads and take account of product manufacturer's recommendations.

CE marking is to be provided for all curtain walling covered by EN 13830 in buildings constructed after July 2013, and will therefore include the following curtain wall types:

- Stick construction;
- Unitised construction;
- Double skin walls;
- Structural sealant glazing;
- Bolted glazing.

Cavity barriers and fire stops should be provided in accordance with relevant Building Regulations.

7.7.2.2 Testing

The Curtain wall system will have been tested and will have been provided with a classification given in BS EN 13830.

Pull-out or destructive testing of anchors should be carried out in accordance with BS 5080 and the construction Fixings Association Guidance Note 'Procedure for Site Testing Construction Fixings'.

Packing of brackets to achieve surface tolerance should be permitted only in accordance with the manufacturer's recommendations, and should not exceed the maximum depth stated in the designer's calculations.

All packers for brackets supporting or restraining the curtain wall must be metal.

The completed curtain wall system should resist the passage of water to the inside of the building, allowing free drainage and not trap water and should have:

- External and internal air and water seals;
- Drained and ventilated glazing rebates;

- Sealants should be specified in accordance with BS 6213 or BS EN 15651, and its performance determined by BS EN 11600 and the manufacturer's recommendations.

It should be designed to minimise the risk of surface and interstitial condensation by the use of thermal breaks and a continuous vapour control layer. The system should be designed to resist the passage of airborne and impact sound within the building; particular attention should be given to flanking transmission at:

- The edges of separating floors;
- The outer edges of separating walls;
- The outer edges of partition walls;
- The junctions with roof constructions and parapets.

Where curtain wall members run uninterrupted past floor slabs and partition walls, consideration must be given to structure borne sound (impact sound).

It should comply with BS 7671 'Requirements for Electrical Installations' for electrical continuity and earth bonding, and where it is required to form part of a lightning protection system it must be designed to comply with the requirements of BS 6651.

The risk of bimetallic corrosion should be avoided by isolation of dissimilar metals.

The curtain wall system should not include materials liable to infestation attack by micro-organisms, fungi, insects or vermin.

7.7.2.3 Tolerances

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

Line: +/- 2mm in any one storey height or structural bay width; and +/- 5mm overall.

Level: +/- 2mm of horizontal in anyone structural bay width; and +/- 5mm overall.

Plumb: +/- 2mmm of vertical in anyone structural bay width; and +/- 5mm overall.

Plane: +/- 2mm of the principle plane in anyone storey height, or structural bay width; and +/- 5mm overall.

7.7.3 Insulated render systems

These are systems which are applied to the exterior walls of existing or new buildings, comprising of an insulant and a weather protective finish, of which there are three main types:

- Traditional renders and finishes;
- Thin coat renders and synthetic finishes;
- Preformed cladding materials.

All Insulated render systems must have appropriate third party certification.

7.7.4 Timber cladding

Timber and boards for exterior use should be of a durable species, with sapwood excluded, or preservative treated by pressure impregnation using preservatives suitable for use in hazard Class 3 in compliance with BS 8417:2003, or equivalent. Further guidance on the durability of timber is provided in Chapter 2 - Materials.

Where timber boarding or plywood spans across an intermediate floor zone in timber frame construction, allow for differential movement caused through timber shrinkage, by incorporating a movement joint.

Where cavity barriers are required they should be correctly fitted without gaps, fill the cavity and be fixed with stainless steel staples or equally durable fixings.

Abutments between cladding and other weather-resisting elements should be neatly made, be weather tight and allow for differential movement. Workmanship should comply with BS 8000:5.

7.7.4.1 Timber boarding

Timber boarding should be at least 16mm thick and allowance for moisture movement in boarding should be made by making tongues, joints or overlaps at least 10% of the board width.

Timber boarding should be battened off the supporting background to provide a minimum 19mm cavity for draining and venting.

Battens should be a minimum 38mm wide, preservative treated and at maximum 600mm centres. A breather membrane should always be installed when horizontal battens are located

against the sheathing. Battens on timber frame should be fixed to each stud (and not to the sheathing) with annular ring nails of length at least twice the batten thickness plus the sheathing thickness (or plain shank nails of length 2.5 times the batten thickness plus the sheathing thickness).

Boards should be fixed to battens by face or secret nailing with annular ring nails at least twice the board thickness or plain shank nails at least 2.5 times the board thickness.

Butt joints at board ends should occur at battens. Nails should be either hot dipped galvanised, stainless steel or equally durable. Aluminium nails should not be used with copper containing preservative treated timber and galvanised nails should not be used with Western Red Cedar.

FUNCTIONAL REQUIREMENTS

7.8 ROOF STRUCTURE

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iii. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes

7.8.1 Statutory requirements

Roof structure and loading

Roof framing and rafter design must be in accordance with current Building Regulations.

The building roof 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 will impair the stability of any part of another building.

Section 2A of Approved Document A (England and Wales) gives basic requirements for the stability of low rise residential buildings. With respect to the roof, it requires that the structure should be of such construction that it has adequate interconnection with the walls, so that it can act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

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 especially for single-hipped and non-hipped roofs of more than 40° for detached houses.

Section 2B of Approved Document A (England and Wales) contains advice on 'sizing of certain timber members in floors and roofs for dwellings' and refers the Designer on to the following sources:

- 'Span tables for solid timber members in floors, ceilings and roofs (excluding trussed rafter roofs) for dwellings'. Published by TRADA;
- BS 8103-3, Structure design of low-rise buildings, Code of Practice for timber floors and roofs for dwellings;
- BS EN 1995-1: 2004+A1, Euro-Code 5 design of timber structures. General. Common rules and rules for buildings.

Section 2C of Approved Document A

The design criteria set out is intended to be adequate for imposed roof loads of 1.00kN/m^2 for spans not exceeding 12m and 1.50kN/m^2 for spans not exceeding 6m.

All structural timber 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 either stamped as '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 Manual and secured to the structure, as detailed, with walls adequately restrained.

Securing of roofs to the supporting structure roof timbers are normally supported on 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 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 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.

7.8.2 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;
- The Approved Document of Regulation 7 of the Building Regulations for England and Wales requires that in certain geographical areas, all softwood roof timbers should be treated against attack by the House Longhorn Beetle.

The areas at risk are:

- The District of Bracknell Forest;
- The Borough of Elmbridge;
- The Borough of Guildford (other than the area of the former Borough of Guildford);
- The District of Hart (other than the area of the former Urban District of Fleet);
- The District of Runnymede;
- The Borough of Spelthorne;
- The Borough of Surrey Heath;
- In the Borough of Rushmoor, the area of the former district of Farnborough;
- The District of Waverley (other than the parishes of Godalming and Haslemere);
- In the Royal Borough of Windsor and Maidenhead, the parishes of Old Windsor, Sunningdale and Sunninghill;
- The Borough of Woking.

The treatment should be impregnation with a preservative suitable for use in hazard Class 2, in accordance with BS 8417:2003, or equivalent, 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.

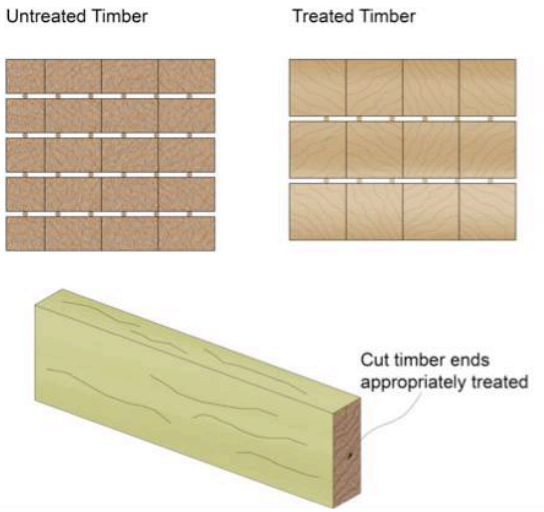


Figure 1: Timber treatment

7.8.3 Trussed rafter design

7.8.3.1 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 as well as tying together the supporting walls.

Whilst it is the supplier of the rafters who generally has the knowledge and expertise required to achieve the best engineering solutions, the Designer must be certain that the loading calculations and resultant configuration is fit for purpose.

The following checklists, derived from BS EN 1995-1: 2004+A1, set out:

- Information required by the manufacturer from the Designer; and
- 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 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: 2004+A1.

7.8.3.2 Spans

Maximum permissible spans for the most common building types and rafter configurations are given in BS EN 1995-1: 2004+A1 Section 9.

For designs that fall outside BS EN 1995-1: 2004+A1 conditions, the trussed rafter must demonstrate adequate jointing and structural integrity by calculation.

7.8.3.3 Loads

Trussed rafters and the framed roof must support the dead loads as specified in BS EN 1991-1 and BS EN 1991-1-7, the wind loads in BS EN 1991-1-4:2005+A1, and the imposed loads in BS EN 1991-1-3. Loads acting on rafters are dead loads (tiles/slates, battens, underlay and rafter self-weight), and imposed loads (snow load and maintenance) and the wind uplift load. Other dead loads 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.

BS EN 1991-1 and BS EN 1991-1-7 specifies 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^2
- Roofs pitched 31° to 75°: 0.75kN/m^2 - 0kN/m^2 (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.

7.8.3.4 Bracing, support and typical roof openings (BS EN 1995-1-1:2004+A1)

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,

Appendix A and further information can be found in BRE Defect Action Sheets 83 and 84.

Re-covering of roofs 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.

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 spacings, etc., to accommodate openings;
- Support details for water tanks;
- Any special handling equipment.

7.8.3.5 Site storage

The delivery of trussed rafters should be planned so as to minimise the period of storage necessary on-site. When delivered, the trusses should, at all times, be kept clear of the ground and vegetation and be supported by level bearers sited under or adjacent to the points of support assumed by the design.

There is a need to ensure that to prevent any distortion, the trusses are stored in a vertical position as in Figure 2.

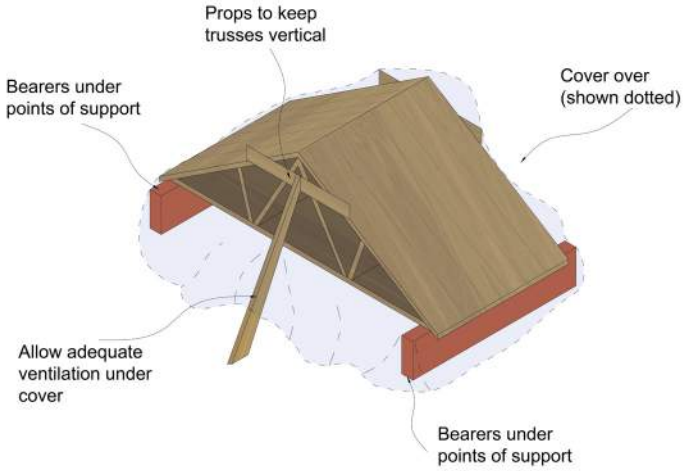


Figure 2: Site storage of trusses

Horizontal storage is sometimes possible as in Figure 3. In both cases, stacks of trusses should be covered with a weatherproof cover, whilst maintaining adequate ventilation to prevent the occurrence of condensation. Trusses should be checked visually upon arrival at site for damage occurring during transportation and again, before site use to check for damage occurring during storage. Trusses where moisture content exceeds 20% should not be installed.

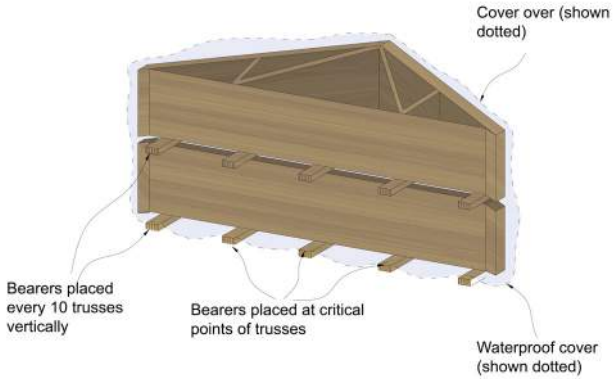


Figure 3: Horizontal storage of trusses

7.8.3.6 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.

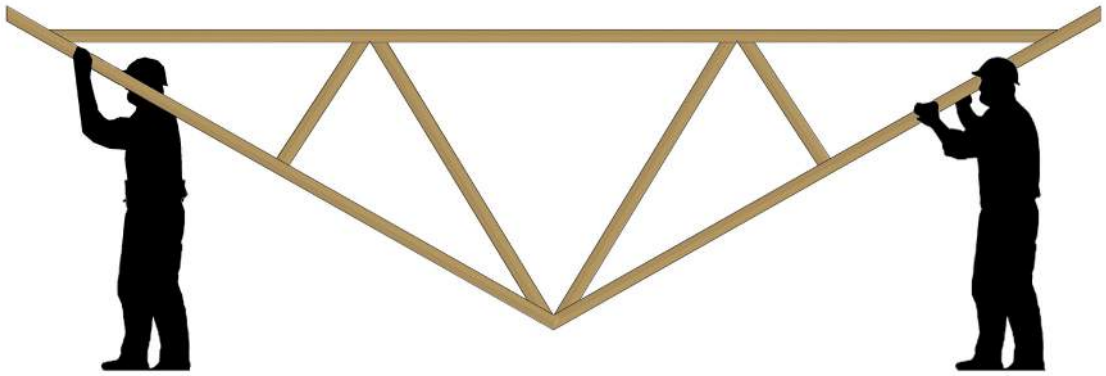


Figure 4: Suggested method of manual lifting

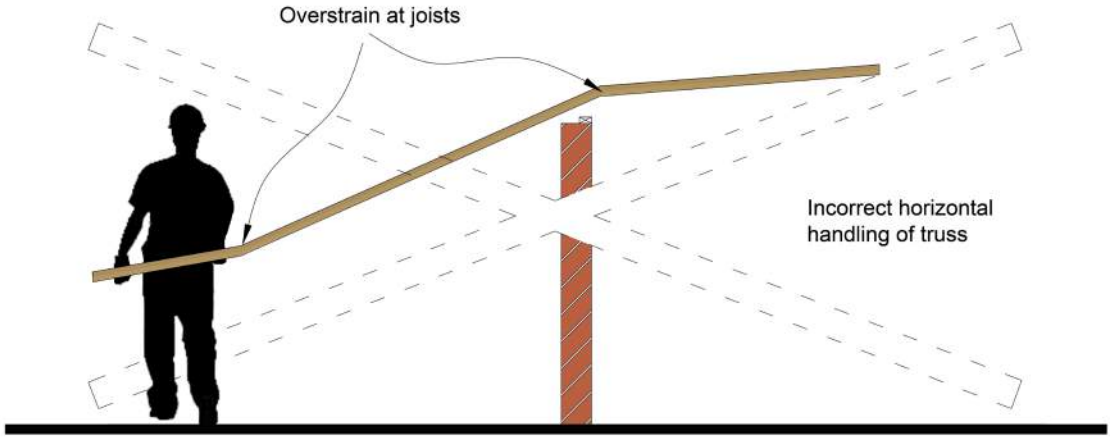


Figure 5: Avoid bending or see-sawing of trusses

Mechanical lifting

Ideally where mechanical lifting is used, 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 but where unavoidable a suitable spreader bar should be used to withstand the sling force.

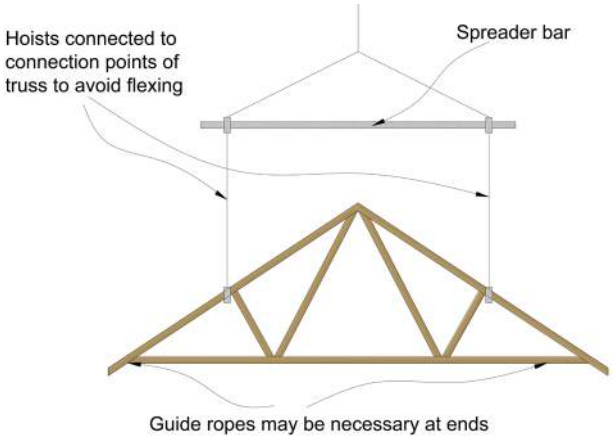


Figure 6: Mechanical lifting

7.8.3.7 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.

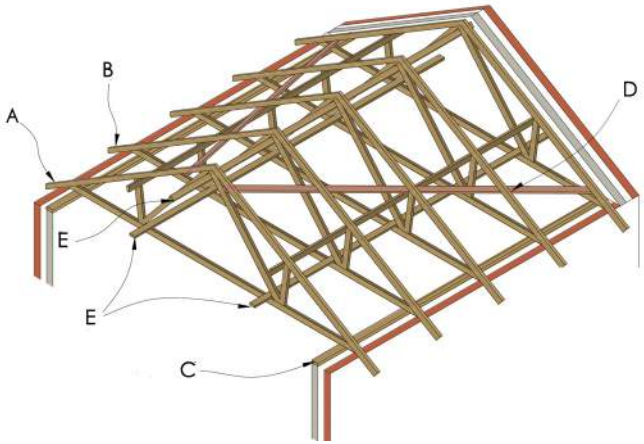


Figure 7: Trussed roof installation

Procedure for erection using Figure 7

- 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 in position;
- Fix permanent diagonal bracing (D) (only one brace shown for clarity);
- Fix longitudinal bracing (E). (Only 3 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.

7.8.3.8 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, 3.35mm diameter galvanised wire nails. Where nail guns are used 3.1mm x 75mm long 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 is shown in Figure 7; it 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. Chevron bracing 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.

Mono-pitched roof bracing

In mono-pitched trussed rafter roofs, the diagonal bracing pattern for narrow fronted houses should be adopted. The requirement for longitudinal bracing is the same as for duo-pitched trussed rafter roofs.

Chevron bracing is required to the webs in roofs exceeding 5m span and also to upright members where inadequate lateral restraint is provided at the apex of the roof.

7.8.3.9 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 which 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 2 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 to 2 no 3.35mm diameter x 75mm. Galvanised wire nails should be used for the fixing.

7.8.3.10 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 by 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).

7.8.3.11 Multiple-trussed rafters

Multiple-trussed rafters may be specified for a particular purpose. The trussed rafters may be delivered to site already fastened together. Alternatively, fixing together on-site of multiple rafters may be necessary; in which case full details will be necessary from the Roof Designer.

7.8.3.12 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. If this is not possible, the spacing of trussed rafters may be extended to accommodate an opening. The Roof Designer should provide all necessary details.The Roof Designer should provide all necessary details

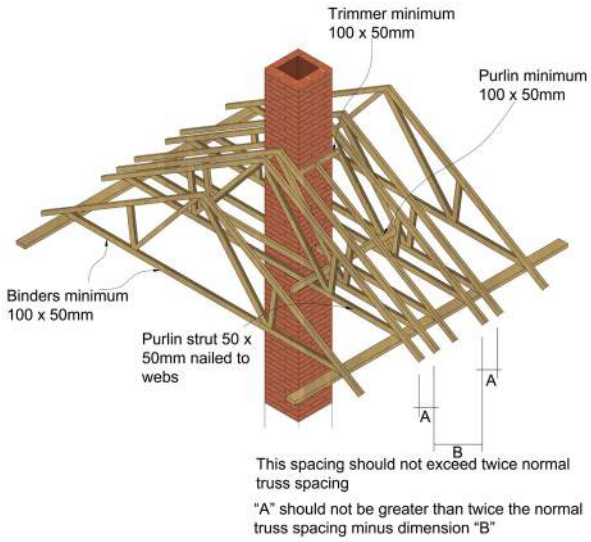


Figure 8: Roof trusses trimming around a chimney

7.8.3.13 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, supported 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.

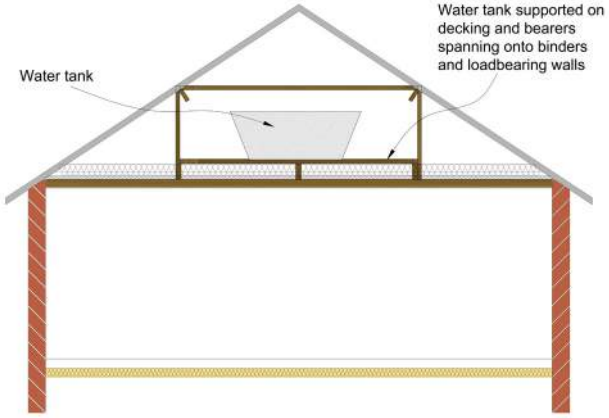


Figure 9: Tank stand configuration

7.8.3.14 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.

7.8.3.15 Combined trussed rafter and traditionally framed roofs

Extra care is necessary where the two principal timber pitched roof types are being 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.

7.8.4 Traditional pitched roofs

7.8.4.1 General

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 marked 'KD' (Kiln Dry) or 'DRY'.

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.

7.8.4.2 Definitions

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 is structurally limited as heavy supporting walls are required to resist outward spread. When a steep pitch is combined with low eaves, the resulting clear roof space can be used to advantage. Where such roofs are designed, full structural calculations prepared by a Chartered Structural Engineer should be provided to demonstrate how eaves spread will be prevented.

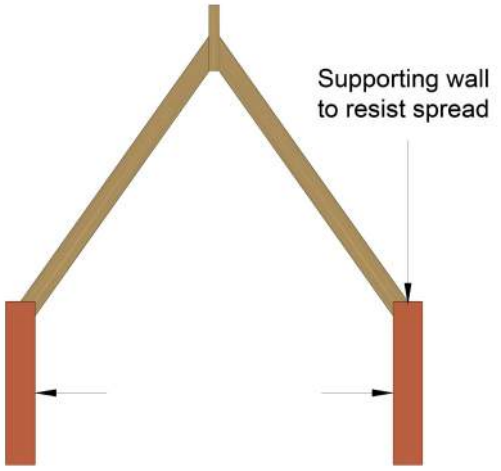


Figure 10: Couple roof

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'.

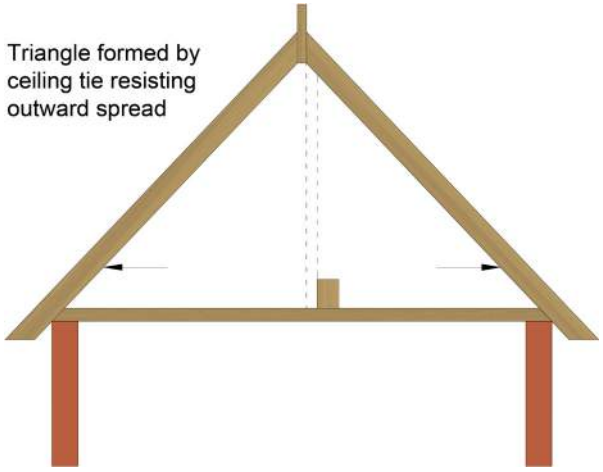


Figure 11: Close couple roof

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 1/3 of the vertical height between the wall plate and ridge. Rafters supporting collar ties should be designed by a Chartered Structural Engineer taking into account the additional point load imposed by the collar. The collar should be fixed to the rafters using 10mm bolts incorporating large washers to prevent the bolt from being pulled through the timber.

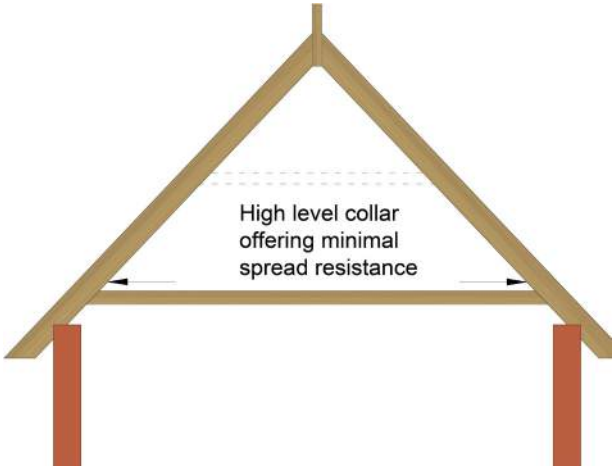


Figure 12: Raised collar roof

7.8.5 Fire stopping

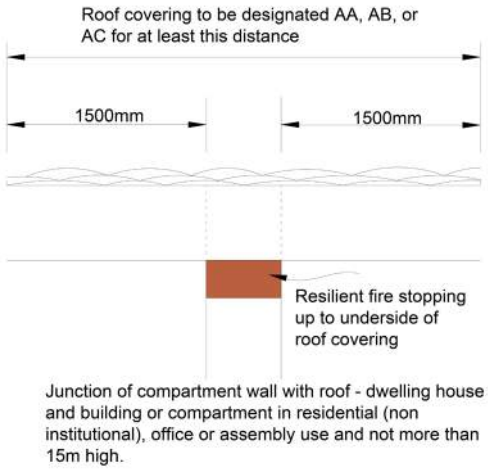
Compartmentation

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and / or floors of fire-resisting construction. The roof void, like most spaces within a building can provide a route for the spread of fire and smoke. As an often concealed space, it is particularly vital that fire resistant cavity barriers are provided at the following points:

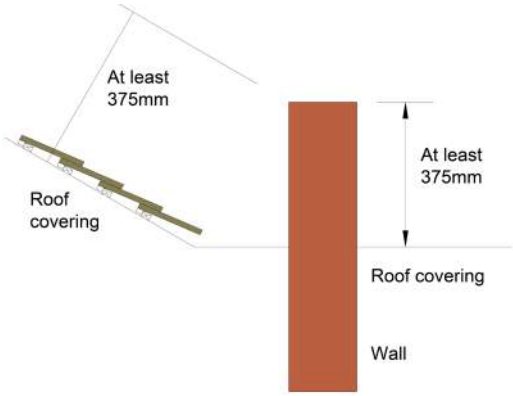
- At junctions of separating wall and external cavity wall;
- At junctions of compartment wall and compartment floor (not illustrated);
- At junctions of separating wall with roof, under roof tiles;
- Within boxed eaves at separating wall position.

Junctions of compartment walls with roof

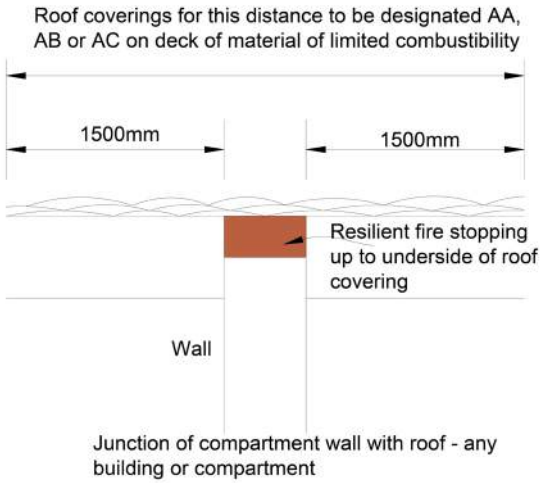
A compartment wall should be taken up to meet the underside of the roof covering or deck, with fire-stopping, where necessary, at the wall / roof junction to maintain the continuity of fire resistance. The compartment wall should also be continued across any eaves cavity. If a fire penetrates a roof near a compartment wall, there is a risk that it will spread over the roof to the adjoining compartment. To reduce this risk, a zone of the roof 1500mm wide on either side of the wall should have a covering of designation AA, AB or AC on a substrate or deck of a material of limited combustibility.



Junction of compartment wall with roof - dwelling house and building or compartment in residential (non institutional), office or assembly use and not more than 15m high.



Junction of compartment wall with roof - any building or compartment



Junction of compartment wall with roof - any building or compartment

Figure 13: Typical fire stopping details

FUNCTIONAL REQUIREMENTS

7.9 ROOF COVERINGS – TRADITIONAL SLATE AND TILES

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents A must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.9.1 Legislation and planning

Tiled and pitched roof coverings should be in accordance with the relevant Building Regulations.

The principal British Standards relevant to this document are: BS 5534: 'Code of Practice for slating and tiling (including shingles)' which 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'. Applies to the laying and fixing of clay and concrete tiles, natural and fibre cement slates and their associated fixings and accessories. Common Arrangement of Work Section (CAWS) classifications H60, H61 and H65. BS 5250: 'Control of Condensation in Buildings'. This describes the causes and effects of surface and interstitial condensation in buildings and gives recommendations for control of condensation in roofs.

To ensure safe working practices during construction, the Designer should consider relevant safety regulations. These include the Construction (Design and Management) Regulations and the Health & Safety Executive's Approved Code of Practice for Management of Health & Safety at Work.

Certain advisory bodies such as Loss Prevention Council, Building Research Establishment Ltd (BRE) and Timber Research and Development Association (TRADA) also produce recommendations and guidance on roof construction.

7.9.2 Weather exposure

7.9.2.1 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 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 two 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 1991-1-4:2005+A1.

Performance of tiles and slates

Rain penetration of the roof covering is dependent on a combination of the rainfall rate, wind speed, and the ability of the roof tile or slate to resist the ingress of snow and rainwater. 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 rainwater creep;
- Raindrop bounce and negative pressure rain suction;
- Driving rain, deluge rain and flooding;
- Surcharging of rainwater over laps on long rafter roofs;
- Wind-driven snow.

Roof pitch

When determining the pitch, head-lap and / or side-lap of a tile or slate, the roof pitch is taken to be equal to the rafter pitch. Hence, all references to pitch refer to the rafter pitch, with the laid angle of the roof tile or slate always being less than roof pitch.

The actual pitch of a slate or tile should be determined in accordance with the following guidelines:

- Tile / slate to rafter pitch angles;
- Plain tiles: 7° less than rafter pitch;
- Interlocking single-lap tiles and slates: 5° less than rafter pitch;
- 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 tile or slate, then they can only be considered to have an aesthetic function. 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.

7.9.2.2 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 or slate as a uniformly distributed load, and also takes into account the porosity of the tiles or 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 1991-1-4:2005+A1 'Euro-Code 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.

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, places a requirement for the underlay to have an adequate tensile strength for the specific application. The tensile strength of the underlay, it's air permeability factor and withdrawal resistance of batten nail fixings is therefore important when determining the overall resistance to wind uplift of the roof system.

Ridges, hips, verges and valleys

The use of mortar for the bedding of concrete or clay ridge and ridged hip tiles on concrete or clay tiles or fibre cement slates, 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 use of mortar bedding should be supplemented by suitable mechanical fixings to ensure the component is mechanically fixed.

Please 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.

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 calculated wind loads 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 1991-1-4:2005+A1 and BS 5534 are complex to undertake. Designers are advised to obtain a full roofing fixing specification either from the slate or tile manufacturer or by reference to the Zonal Fixing Method tables, which provide a conservative interpretation of the fixing requirements in BS 5534.

Zonal fixing method

The Zonal method is a method for obtaining a fixing specification for roof tiles and is a simplification of the calculations defined in BS 5534, 'Code of Practice for Slating and Tiling (including shingles)' and BS EN 1991-1-4:2005+A1 'Euro -Code 1. Actions on structures. General actions. Wind actions'. The assumptions made in the simplification process may produce a specification with more or stronger fixings than

that required if the full BS 5534 calculation is undertaken.

Zonal fixing specification	Single lap tiles	Double lap tiles
A	No fixings required	Refer to manufacturer
B	Each tile once nailed (right hand nail hole – flat tiles)	
C	Each tile twice nailed (flat tiles only)	
D	Each tile clipped	
E	Each tile once nailed and clipped	
F	Each tile twice nailed and clipped	

NOTE:
1) The manufacturer may also specify the use of improved nails for fixing tiles, e.g., ring shank nails. Where these are required, the Zonal fixing specification letter will be marked with an asterisk, e.g., C*.
2) Manufacturers may define additional fixing specifications to those in the table and assign fixing specification letters from 'G' onwards.
3) In some cases, the manufacturer may specify a 'proprietary fixing system' and this will be marked 'PS'. The manufacturer should be contacted for details of the requirements for this fixing method

Table 1: Zonal fixing specification

7.9.3 Condensation and ventilation

7.9.3.1 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 given in British Standard BS 5250 'Code of Practice for Control of Condensation in Buildings' Section 8.4 'Roofs'.

Prevention of condensation in roof voids is best achieved by 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;
- Temporary condensation occurring when cold weather conditions are followed by warm, humid weather.

Sealed ceilings

BS 9250 emphasises the importance of well-sealed ceilings as a means to curb the transfer of moisture into a roof space by means of moisture laden air.

This means:

- The avoidance of gaps and holes in a ceiling;
- The siting of access doors or hatches into the roof space away from moisture producing areas such as bathrooms or kitchens;
- That hatch covers must be effectively sealed;
- High levels of workmanship.

Air tightness of ceilings

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 manufacturer's recommendations.

BS EN 13141-1 - Ventilation for buildings. Performance testing of components / products for residential ventilation. Externally and internally mounted air transfer devices:

- 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 transfer of warm moist air into the loft.

It is recommended that Designers should undertake a Condensation Risk Analysis in accordance with BS 5250 to determine the level of ventilation required.

7.9.3.2 Cold roof

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

These recommendations apply if an HR underlay is used.

Mono-pitch / lean-to roof

If the roof space is 15° or less, a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening). If the roof pitch is more than 15°, a free airspace of 10,000mm²/m is required at the eaves or at low level (equivalent to a continuous 10mm opening). A free airspace of 5000mm²/m should also be provided at high level (equivalent to a continuous 5mm opening).

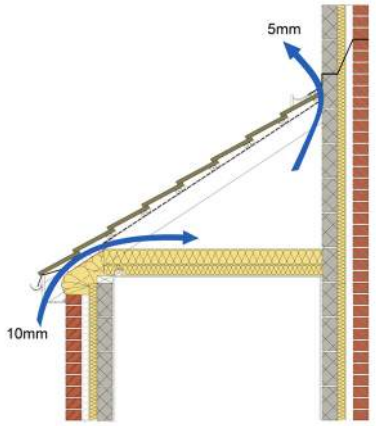


Figure 1: Mono-pitch / lean-to roof

Duo-pitch roof A

On each side of the roof a free airspace of 10,000mm²/m is required at the eaves or at low level (equivalent to a continuous 10mm opening). If the roof space is 15° or less, a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening).

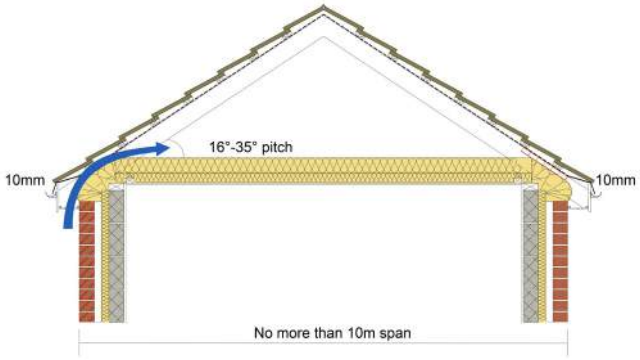


Figure 2: Duo-pitch roof A

Duo-pitch roof B

Where pitches are 35° or greater and spans are 10m or wider, a free airspace of 5000mm²/m should also be provided at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation.

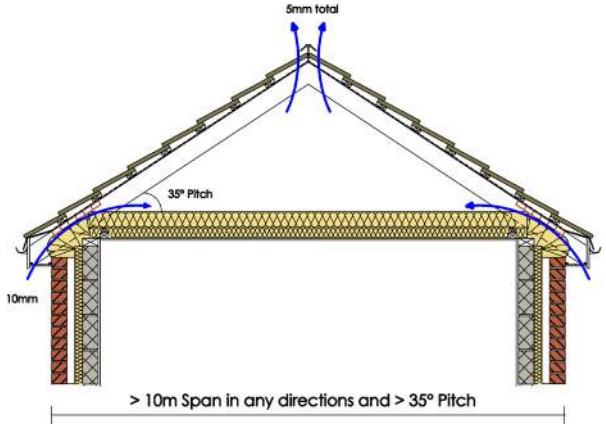


Figure 3: Duo-pitch roof B

Duo-pitch roof with fire break walls

This is similar to examples A and B, but with a fire wall beneath each roof pitch. The roof now comprises three voids instead of one and for the purposes of ventilation each roof void is treated separately. The two smaller voids each require 10,000mm²/m of free airspace at the eaves or at low level and also 5000mm²/m at high level below the firewall.

The larger void requires 10,000mm²/m of free airspace immediately above the firewall at low level and also 5000mm²/m at the ridge or at high level (equivalent to a continuous 5mm opening) to provide effective through-ventilation.

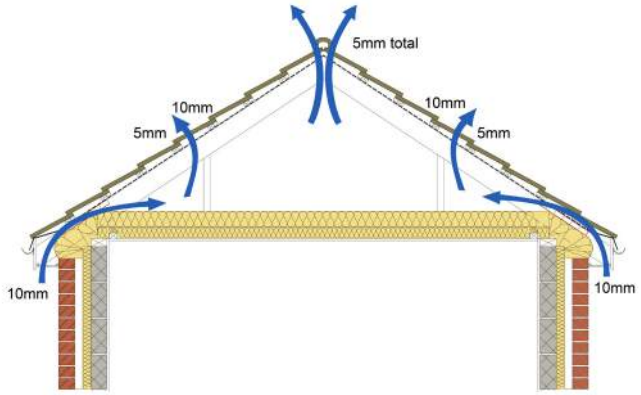


Figure 4: Duo-pitch roof with fire break walls

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 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.

7.9.3.3 Roof with sloping ceilings

The following illustrations suggest the correct positioning of vents and the precise amount of free airspace required for three types of 'warm roof' construction in accordance with BS 5250.

Duo-pitch roof

On each side of the roof a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening).

A free airspace of 5000mm²/m should also be provided at the ridge or at high level on each slope (equivalent to a continuous 5mm opening). A minimum 50mm clear air path must always be maintained between the insulation and the underlay to ensure effective through-ventilation.

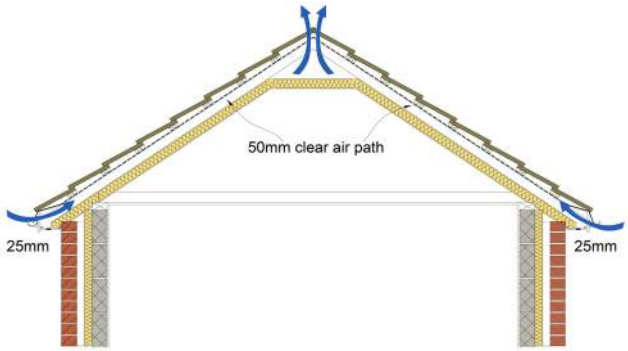


Figure 5: Duo-pitch roof with sloping ceilings

Mansard roof

Mansard ventilation is similar to that for duo-pitch constructions, requiring a free airspace of 25,000mm²/m on each side at the eaves or at low level (equivalent to a continuous 25mm opening) and 5,000mm²/m at the ridge or at high level (equivalent to a continuous 5mm opening).

A minimum 50mm clear air path must be maintained between the insulation and the underlay at mansard level to ensure effective through-ventilation.

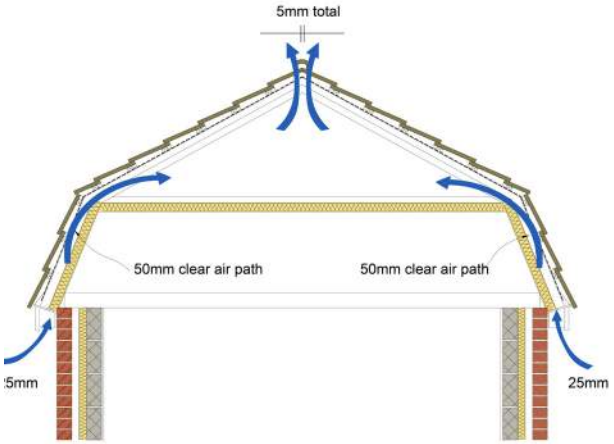


Figure 6: Mansard roof

Pitched roof with pitched and flat dormers

For the main roof, a free airspace of 25,000mm²/m is required at the eaves or at low level (equivalent to a continuous 25mm opening) plus 5000mm²/m at the dormer sills and also 5000mm²/m on each side of the ridge or at high level on each slope (equivalent to a continuous 5mm opening). For dormers with cold pitched roofs, a free airspace of 10,000mm²/m is required at the dormer eaves (equivalent to a continuous 10mm opening). For dormers with flat roofs a free airspace of 25,000mm²/m is required at the roof edges (equivalent to a continuous 25mm opening).

A minimum 50mm clear air path must always be maintained between the insulation and the underlay to ensure effective through-ventilation.

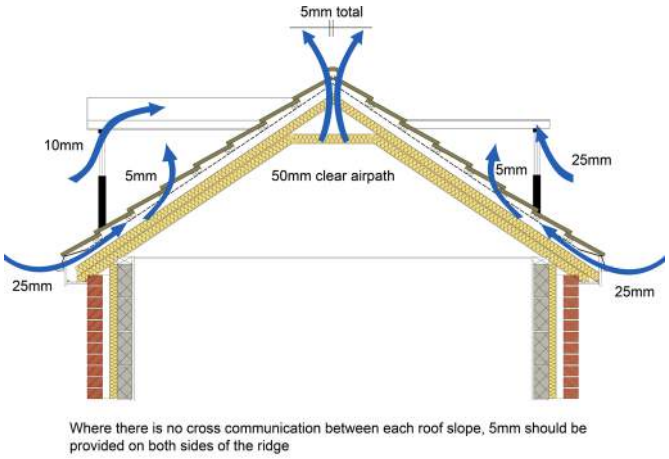


Figure 7: Pitched roof with pitched and flat dormers

Tiled and slated roofs containing rooms

These should be ventilated as in accordance with Figures 5-7, but if an obstruction to a ventilation path occurs, such as fire separating walls, additional ventilation openings should be provided:

- Immediately below the obstruction equivalent to 5mm along the length of the obstruction;
- Immediately above the obstruction equivalent to 25mm along the length of the obstruction.

7.9.3.4 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 must be strictly in accordance with 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.

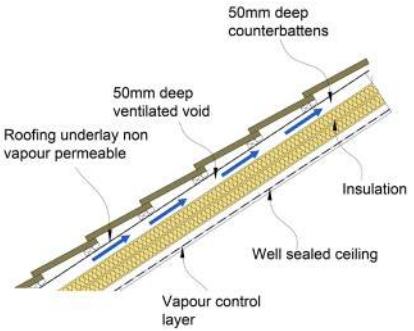


Figure 8: Warm roof construction (vented battens)

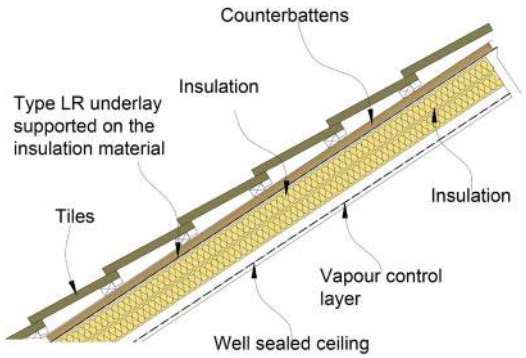


Figure 9: Warm roof construction (vapour breathable underlay)

7.9.4 Thermal insulation

7.9.4.1 Building Regulations

Thermal insulation must be installed to meet current Building Regulations to an acceptable level of workmanship avoiding cold bridges and meet the following provisions:

- If required by BS 5250, use a vapour control plasterboard or a separate vapour control layer behind the plasterboard;
- Use a proprietary eaves ventilator to ensure ventilation is in accordance with BS 5250;
- The use of over joist and under rafter insulation is considered best practice as it eliminates the cold bridge caused by the joist / rafter;
- The installation of the eave's ventilator must not prevent free water drainage below the tiling battens.

7.9.4.2 Compliance

The requirements of the regulations are designed to reduce carbon emissions from new buildings and to improve the performance of existing buildings where new work is carried out.

7.9.5 Materials

7.9.5.1 Underlay

Underlay nails

Nails for use with roofing underlay's should be clout head-nails of no less than 3.0mm 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 (for example, Type 1. For Type 5U (as described in BS 5534); and type LR, vapour permeable. These types of underlay should comply with BS EN 13859-1, or have third party accreditation, i.e., a BBA certificate. It 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 draped over rafters / counter battens, and should meet the conditions as detailed in Figure 10.

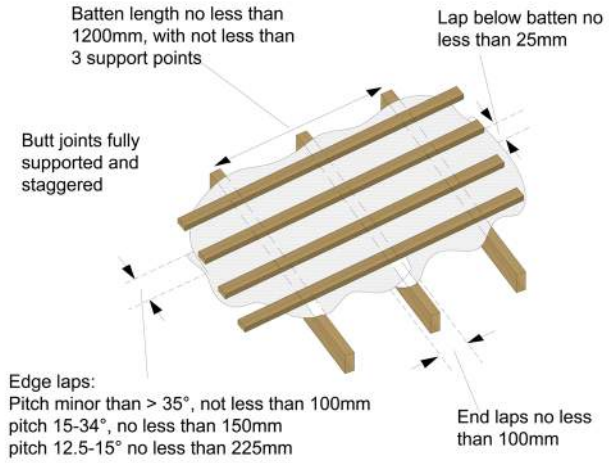


Figure 10: Roof underlay provision

Fully supported underlays

- BS 8747 Class 1B Bitumen (Fiber base).
- 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.

Unsupported underlays

- BS 8747 Class 1F reinforced bitumen or Class 5U polyester reinforced bitumen.
- HR* underlay to BS EN 13859-1 Class W1 water penetration classification with third party certification for the use intended.
- LR† 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.s/g

† LR (low water vapour resistance) underlay - <0.25MN.s/g

(LR underlays are sometimes referred to as 'vapour permeable' or 'vapour open')

Vapour control layer (VCL)

If a VCL is installed it should be placed on the warm side of the insulation. Installation of a VCL at ceiling level will increase the need for sufficient ventilation below it during the drying out of wet trade construction phases. Performance of a VCL depends not only upon the material selected, but also on workmanship and the ability of the construction to be assembled on-site (see BS 5250). It is essential that a VCL be adequately lapped and all joints sealed and that its integrity is maintained. Particular care should be given to detail design and installation around penetrations through the VCL, e.g., services, compartment walls and to the sealing of punctures caused by fixings.

7.9.5.2 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 C of BS 5534.

Sizes

Timber battens should be graded and marked in accordance with BS 5534. Timber batten sizes should be not less than the minimum values recommended in BS 5534 for the common applications listed therein.

Other sizes

Battens for large spans or special loading conditions should be designed by structural calculation for strength and stiffness in accordance with Annex E of BS 5534.

Preservatives

BS 8417:2011 provides recommendations for preservatives for timber. Indicative preservative treatment schedules are given in Annex D of BS 5534. Battens that have been treated with preservatives can contain toxic substances that could introduce an environmental hazard, and should be disposed of safely.

7.9.5.3 Tile and 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, where it is known that certain timber preservative treatments may corrode steel, zinc or aluminium.

Tile nails

Nails for use with tiles should be of copper, aluminium, stainless steel, phosphor or silicon bronze. Aluminium nails intended for use with tiles should conform to BS 1202-3 and should be clout head nails of 3.35mm or 2.65mm diameter. The length of nail will be determined by the required wind uplift and the design of the tile. Stainless steel nails for use with tiles should conform to BS 1554, grade 302, 304, 315, 316, 321 or 347, and should be specified for coastal areas, areas of high exposure, or where there is a risk from chemical reaction.

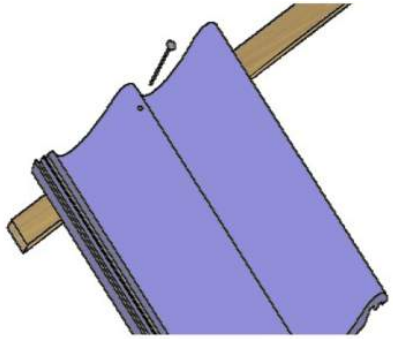


Figure 11: Nailing tiles to battens

Tile clips

Located over the side lock 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.

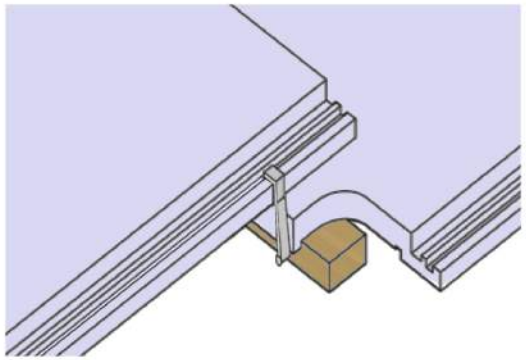


Figure 12: Tile clips

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.

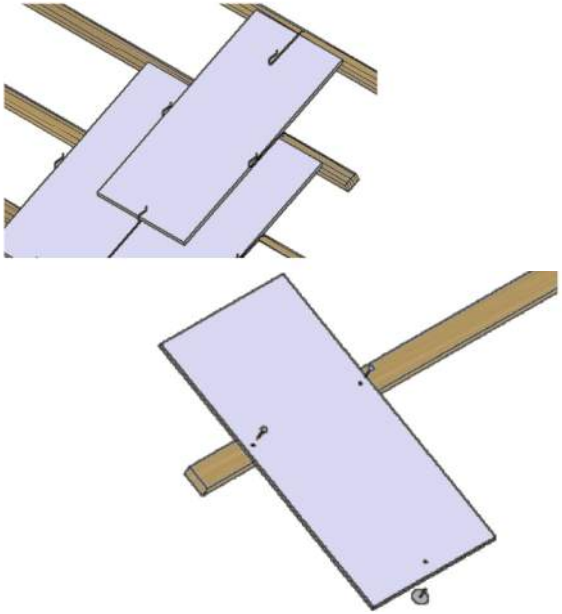


Figure 13: Fixing slates

Slate hooks

Hooks are formed from stainless steel wire conforming to BS 1554, grades 316 S11 or 316 S19. For further advice on the use of slate hooks - refer to BS 5534 Section 4.13.3 'Hooks and rivets for slates.'

7.9.5.4 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, even thicker codes may be necessary.

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 0.6mm thick (minimum) 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 x 12 gauge. Screws should be brass or stainless steel, minimum 25mm long x 10 gauge.

7.9.5.5 Mortar

The mortar used in roof construction should conform to the recommendations given in BS 5534. Mortar should typically consist of the following mixes:

- **Cement and sand**

The mix should be based on sharp sand with soft sand added to achieve workability. The proportion of sharp sand should not be less than 1/3 of the total sand content.

Alternative proprietary mortar mixes may be accepted if they are shown to have similar strength, durability and workability.

7.9.6 Workmanship

7.9.6.1 Slate and tile fixing

Slate and tile fixing should be in accordance with BS 8000-6.

7.9.6.2 Fixing timber batten

Battens and counter battens should be graded to meet requirements as recommended in BS 5534 in respect to timber species, permissible characteristics and defects and preservative treatment. Battens should be at least 1200mm in length and supported at each end and intermediately by a total of at least three rafters, trusses or walls. Stagger butt joints over intermediate supports. Splay nail each batten end and nail battens to each rafter.

On trussed rafter roofs for interlocking tiles, allow not more than one joint in any four consecutive battens on same support. On trussed rafter roofs for plain tiles, allow no more than three joints together in any twelve consecutive battens on same support. Batten sizes given in Table 2 should be taken as minimum dimensional requirements. Take care that nails used to secure tiles do not penetrate underside of battens or underlay.

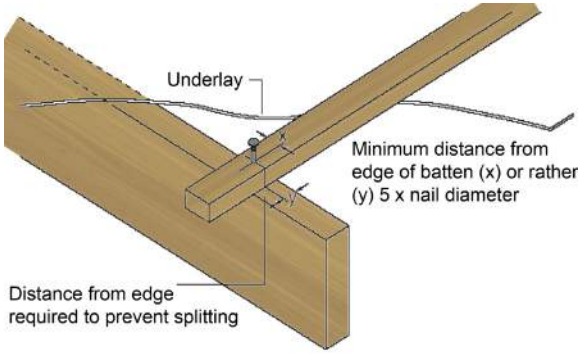


Figure 14: Fixing battens to rafters

Recommended batten sizes for pitched roofs and vertical work (BS 5534 in accordance with clause 4.12.4.1).

Tile type	Basic minimum sizes*			
Rafters / supports	450mm span		600mm span	
	width	depth	width	depth
Plain pitched / vertical	38	25	38	25
Single lap interlocking tiles / slate	38	25	50	25
Fibre cement slates	38	25	50	25

*All dimensions subject to re-sawing allowance: width + 3mm depth - 0 or + 3mm based on measurement at a reference moisture content of 20%.

Table 2: Minimum sizes of timber battens

Fixing roof battens

Fix specified battens up roof slope on top of rafters ensuring minimum 40mm nail penetration into rafters (smooth shank). Nail counter battens at maximum 300mm centres vertically up roof slope where boarding is used to coincide with line of rafters.

Fixing wall battens

Fix specified battens to boarding / sheathing / sarking in line with vertical supports, or to masonry wall as specified. Secure counter battens to masonry walls with improved nails or with plugs and screws.

7.9.6.3 Underlays

Lay specified roofing underlay parallel to eaves or ridge with horizontal overlaps as specified in Table 3. Vertical side laps should be 100mm(minimum). Minimise gap at laps resulting from different tautness between underlay courses. Drape in underlay between supports to be no less than 10mm and no greater than 15mm. Fix underlay with fixings specified, keeping the number of perforations to a minimum. Handle and fix underlay with care to ensure no tears or punctures. Repair any tears or punctures prior to tiling. Ensure that underlay does not obstruct flow of air through ventilators located at eaves, ridge or in main roof. Weather appropriately all holes formed in underlays for soil vent pipes, etc. Avoid contact between underlay and underside of tiles. To prevent wind uplift, fix additional battens or timber strips where laps occur between tiling battens.

Minimum horizontal lap for underlays: (BS 5534 in accordance with clause 6.2.1.1).

Rafter pitch	Not fully supported (mm)	Fully supported (mm)
12.5° to 14°	225	150
15° to 34°	150	100
35° and above	100	75

Table 3: Minimum horizontal laps for underlays

7.9.7 Slate and tile details – key check points

7.9.7.1 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, slates or shingles into the gutters. The recommended overhang is 45mm - 55mm horizontally or to the centre of the gutter, whichever is the lesser.

- 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.

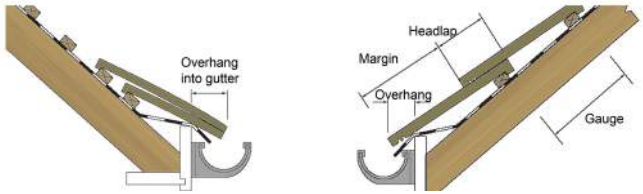


Figure 15: Eaves and bottom edge details

7.9.7.2 Verge (in accordance with BS 5534 and BS 8000-6)

Battens should overlap onto the outer skin of the brickwork or the under cloak material; for plain tiles the verge should project 38mm–50mm; 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.

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

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

Undercloak

Where an under cloak 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 on to which the verge tiles or slates are bedded.

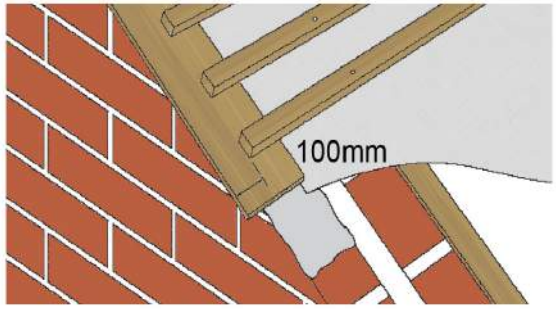


Figure 16: Verge detail

7.9.7.3 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 has been 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 valley trough appropriate for discharging the rainwater from the adjacent roof covering to the eaves gutter.

- 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 groundwork provides adequate support for valley lining. Make flush with top of rafter;
- Don't place bitumen underlay beneath lead sheet valley;
- Keep open gutter width 100mm - 250mm;
- 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 an undercloak or tile slips;
- Don't block tile laps with mortar to avoid water damming;
- Mechanically fix all tile and slates adjacent to valleys.

7.9.7.4 Ridge (in accordance with BS 5534 and BS 8000-6)

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, slates or shingles by the overlap necessary for the main tiles, slates or shingles. 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.

- Check ridge tile is suitable for pitch of roof;
- Edge bed components onto tiles or slates;
- Ensure top course tiles or slates are mechanically fixed;
- Mitre tiles neatly at hip ridge junctions and use a lead saddle under for protection;
- Use correct mortar mix;
- Use dentil slips in deep profiled tiles into all joints in excess of 25mm thick to reduce mortar and risk of shrinkage;
- All ridge tiles that are mortar bedded must also be mechanically fixed (screws, nails, clips, etc.).

Please note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

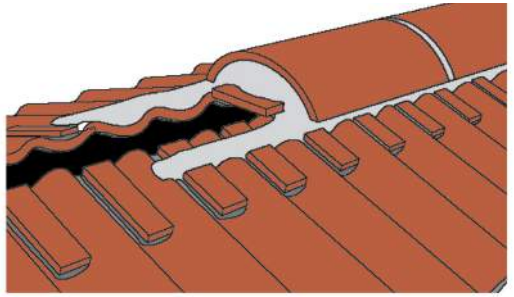


Figure 17: Ridge detail

7.9.7.5 Hip (in accordance with BS 5534 and BS 8000-6)

- Check hip tile is suitable for pitch of roof;
- Mitre tiles neatly at hip ridge junctions and use a lead saddle under for protection;
- Use correct hip iron at base of hip;
- Use correct mortar mix;
- Use dentil slips in deep profiled tiles into all joints in excess of 25mm thick to reduce mortar and risk of shrinkage;
- All hip tiles that are mortar bedded must also be mechanically fixed (screws, nails, clips, etc.).

Please note: Dry fix ridge systems are available to provide full mechanical fixing of all ridge and hip tiles to meet BS 5534 recommendations.

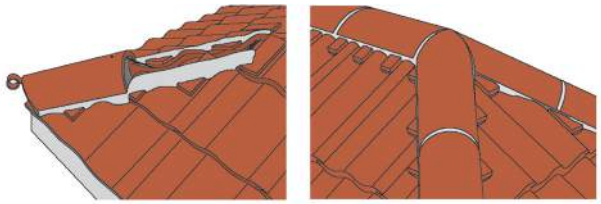


Figure 18: Hips

7.9.7.6 Flashings and weatherings

The following is a brief summary of metal flashing details; for the best advice on the use of lead, reference should be made to the Lead Sheet Association:

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 bi-metallic corrosion, but should not be used with aluminium in a marine environment.

Interlocking tile

Side abutment

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 50mm (minimum) up abutment;
- Finish tiling battens as close to abutment as possible;
- Lay tiles to butt as close as possible to 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 and wedge in with small pieces of lead;
- Dress cover flashing as tightly as possible to tile profile;
- Repoint brickwork;
- In areas of high exposure or when dressing lead over flat tiles, use clips to hold cover flashing in place. When using this type of flashing with flat tiles below 25°, increase cover of flashing over tile to 200mm.

Side abutment: (secret gutter; with and without cover flashing)

A secret gutter may be formed as an alternative to a step and cover flashing, when using single lap flat interlocking tiles and slates. In view of the increased risk of water penetrating under the lead, especially on low pitches in exposed locations, maximum security can be achieved by a combination of both secret gutter and cover flashing.

- Form secret gutters before starting tiling;
- Fix a support between last rafter and abutment. This should be a minimum of 75mm wide and run full length of abutment;
- Fix a splayed timber fillet at discharge point to raise lead lining to the right height. Avoid backward falls;
- Fix a counter batten along outer edge of rafter;
- Line gutter with Code 4 or 5 lead, in lengths of not more than 1.5m;
- Lap each strip offered over the lower one by a minimum 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 or slates;
- Fit a stepped flashing, chased into brickwork as before and dressed over vertical upstand;
- Turn roofing underlay up side of counter battens and butt tiling battens up to counter batten;
- Lay tiles to leave a gap of 15mm by the side of abutment;
- A lead cover flashing above secret gutter is advisable for interlocking tiles and slates, particularly in areas of high exposure or on roofs under trees, where risk of blockage is high. If this is done, width of secret gutter may be reduced to 50mm.

Top edge abutment

- Turn roofing underlay 50mm (minimum) up abutment;
- Fix top tiling batten as close as possible to abutment;
- Complete tiling in the usual way;
- Chase abutment and insert lengths of Code 4 lead, no more than 1.5m long and wedge in with small pieces of lead no less than 450mm apart;
- Lead should be wide enough to give at least 150mm cover to top course of tiles, e.g., below 30° this increases to 290mm at 15° rafter pitch;
- Vertical upstand should be 75mm-100mm;
- Lap each length of lead by not less than 100mm;
- Dress lead to profile of tiles;
- Secure lead flashings with copper or stainless steel clips with frequency dependent on exposure (see Lead Sheet Association recommendations).

Double lap plain tiles

Side abutment: (Soakers and step flashings)

Soakers are used where double-lap plain tiles abut a wall.

- Turn underlay 50mm up abutment and cut tiling battens 10mm-25mm short of the wall and fix securely;
- Lay tiles close to abutment with a soaker fitted between each tile;
- Form Code 3 lead soakers with an upstand of 75mm to place against abutment. They should be 175mm wide and 190mm long allowing a 25mm downturn over back of tile. After all tiles and soakers have been fixed, insert a stepped flashing into abutment wall and dress down over upturned edges of soakers.

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 50mm (minimum). 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, minimum width 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.

Top edge abutment flashings

- Continue underlay 50mm (minimum) up the wall;
- Position two battens downslope from the abutment, the upper to receive the top edge of the top course slate and the lower the top of the full length slate;
- Head nail the top course slate and use a disc rivet to secure the tail in the usual manner. Centre nail and rivet the full length slate below in the normal way;
- Dress Code 4 lead cover flashing over the top course slates and turn up the wall face 100mm (minimum), with the top edge turned into the brickwork bed joint and secured with wedges;
- Extend lead down over the slate to lap the surface a minimum of 150mm and secure the bottom edge with a clip to resist wind uplift.

Dormers

Treat tiled dormer roofs in a similar way to the main roof work. However, single lap tiling is less suitable for small covered areas and for a dormer, it is generally preferable to adopt an alternative form of covering.

- When dormer cheeks are tile hung, close cut vertical tiles to rake of roof over a flashing fixed to side of dormer and dress well into the adjacent tiles. Formation of a secret gutter is not recommended.

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 abutment to flatten pitch of lead;

- Dress a sheet of Code 5 lead (width of abutment plus 450mm) into position with a vertical upstand of at least 100mm up abutment;
- Dress extra width of lead around corner of abutment after any side abutment weathering has been fitted;
- Dress upper edge of lead over tilting fillet and turn it back to form a welt;
- Chase abutment, insert a cover flashing of Code 4 lead and dress it over vertical upstand of gutter.

Roof protrusions

The treatment of tiling 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 by 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^2 and large enough to give a lap of at least 150mm over gutter lining on each side;
- Saddles should be capable of being readily dressed down when in position.

7.9.7.7 Vertical tiling and slating

Vertical slating with fibre cement slates

Fibre cement slates can be fixed to vertical surfaces and provide an attractive and weatherproof cladding on both timber frame and masonry constructions.

The following guidance notes apply to this detail:

- Use counter battens over masonry construction (38mm x 25mm minimum) to reduce direct fixing. Special masonry fixings may be required;
- Slate-and-a-half should be used in alternate courses at internal and external corners and adjacent to openings;
- Use Code 3 lead soakers to weather internal and external corners;
- Fix slates by two nails and one rivet, and slate and-a-half by three nails and two rivets;
- Code 4 lead cover flashings should be used above and below openings in accordance with Lead Sheet Association recommendations.

Vertical tiling with plain tiles

Plain tiling is an excellent, weatherproof and attractive cladding to the vertical walls of any building. Feature and ornamental tiles may also be used with normal plain tiles to create decorative patterns. Fibre cement slates can also be used for vertical cladding.

- Use counter battens over masonry construction (38mm x 25mm minimum) to reduce direct fixing. Special masonry fixings may be required;
- Ensure tiling details do not interfere with the opening of windows and doors;
- Lead flashings and soakers should be used around openings in accordance with Lead Sheet Association details;
- Use double course of tiles at eaves, by laying first course of eaves / tops tiles with course of full tiles over;
- At top of wall or under a sill, use a course of eaves / tops tile laid over a course of full tiles
- Dress a Code 4 lead cover flashing over by 100mm;
- Use internal and external angle tiles at all 90° corners. Purpose made 135° angle tiles are also available. For other angles, close mitre tiles and use Code 3 lead soakers;
- All tiles should be twice nailed.

7.9.7.8 Dry fix systems

Proprietary dry roofing products and systems may be used as an alternative to 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.

Specifiers should seek evidence that this will not be the case and should use dry roofing products only if such evidence is available.

Please note:

- There are no British Standards for these products. Specifiers should seek evidence of third party testing.
- Users should pay particular attention to the resistance to wind load and durability performance of dry roofing products.

Appendix

British Standards:

- BS EN 490
- BS EN 492
- BS EN 1304
- BS 5250
- BS EN 1990:2002+A1
- BS 5534:2003+A1
- BS EN 1991-1-4:2005+A1
- BS 8000-6
- EN 13859-1
- BS 6399–2

Further guidance

NFRC Zonal Method User Guide: available from NFRC website **www.nfrc.co.uk**

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, 2002:

- CTP 036/1 – Roof Slating and Tiling – Common Materials and Methods;
- CTP 036/2 – Roof Slating and Tiling – Single–lap, Variable Gauge, Interlocking Tiles;
- CTP 036/3 – Roof Slating and Tiling – Double-lap, Variable Gauge, Plain Tiles;
- CTP 036/5 – Roof Slating and Tiling – Single-lap, Fixed Gauge, Interlocking and mitred tiles.

FUNCTIONAL REQUIREMENTS

7.10 ROOF COVERINGS – CONTINUOUS MEMBRANE ROOFING

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.10.1 Definitions

For the purposes of this standard, the following definitions shall apply:

Flat roof: a roof having a pitch not greater than 10° to the horizontal.

Condensation: process whereby water is deposited from air containing water vapour, when its temperature drops to or below dew point.

Interstitial condensation: condensation occurring within or between the layers of the building envelope.

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.

Structural deck: continuous layer of the construction (comprising concrete, profiled metal or timber panel) which is supported by the building structure and which supports the roof system.

Vapour control layer (VCL): construction material (usually a membrane) that substantially reduces the transfer of water vapour through the roof.

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

Protection layer: construction material (usually a geotextile all rigid board) which isolates another construction material from mechanical damage.

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.

Separation layer: construction material (usually a geotextile) which separates two construction materials which are not chemically compatible.

7.10.2 Design criteria – system type

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 structural deck is maintained at a temperature above that which could cause condensation to occur at this level during service;
- A vapour control layer is provided by the deck or by a membrane placed above the deck;
- The insulation has sufficient mechanical characteristics to resist loading;
- The waterproof membrane has sufficient resistance to temperature to suit the conditions created by a substrate of insulation.

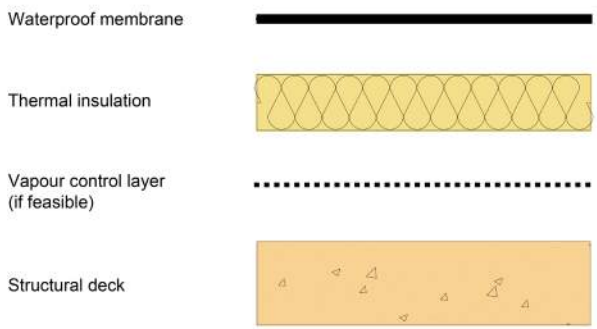


Figure 1: Warm roof (section)

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 water control membrane (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 rainwater run-off, which may allow 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 rainwater across the product and to rainwater outlets.

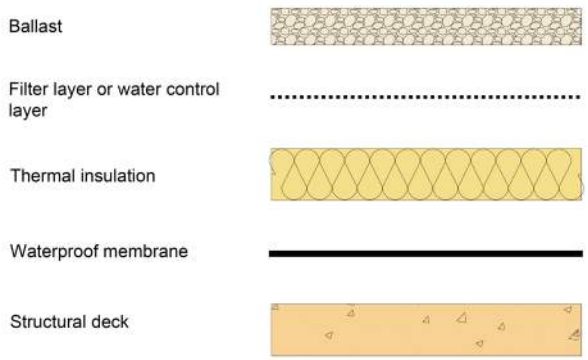


Figure 2: Inverted warm roof (section)

Cold deck roof

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. Therefore, it is not recommended.

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, for example, 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.

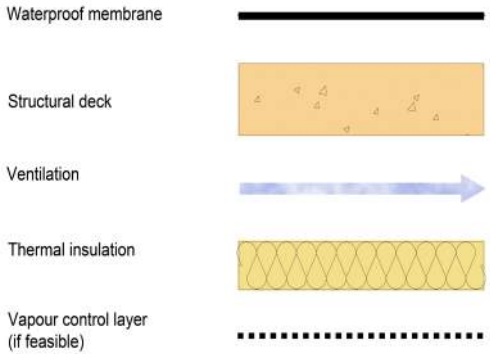


Figure 3: Cold roof (section)

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 ’.

7.10.3 Loading

7.10.3.1 Statutory requirement

Design for loading complies with the current Building Regulations.

7.10.3.2 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.

7.10.3.3 Resistance to imposed loads

At the earliest possible stage, the employer should define the range of potential functions of the roof as 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.

7.10.4 Falls and drainage

7.10.4.1 Statutory requirement

Design for drainage should comply with the current Building Regulations.

7.10.4.2 British and industry standards

BS 6229 states that a minimum finished fall at any point of 1:80 (1.25%) should be achieved. Since adjoining roof planes at 1:80 will meet at a mitre of less than 1:80, the intended finished fall at such intersections should be considered at an early stage.

Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculation, 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 to ensure that deflection of the deck and/or construction tolerances are overcome. This is particularly important in design for inverted roofs, where calculation of dead loading should be based upon the ballast type and depth that is to be used.

The manufacturers of certain waterproofing products have certification for their use in 'completely flat' or 'zero falls' applications. For the purposes of this standard, the design conditions of BS 6229 shall be assumed to prevail.

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;
- Avoidance of ponding behind wide obstructions to the drained slope such as plant plinths or roof lights;
- Avoidance of gutters by designing with intersecting roof planes;
- Falls between rainwater outlets along a perimeter.

Since the primary function of the roof is to exclude water, it is important to consider how best to direct this into the drainage system.

Ponding on membrane roofs should be avoided because:

- It encourages the 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.

7.10.4.3 Creation of falls

Roof falls may be created either during the construction of the deck or alternatively by the use of tapered insulation systems.

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 vapour control layer will also be to fall and will act as a temporary line of defence to water ingress during construction;
- If mechanical fasteners are to be used for the waterproof membrane, their length will be constant, which facilitates planning and installation.

Cementicious 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:sand) screed topping of 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 rainwater to single points where outlets are to be located.

Where falls are created by tapered insulation, the design should ensure that 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 rainwater outlets in order that the maximum height of paving supports is not exceeded or trip hazards created.

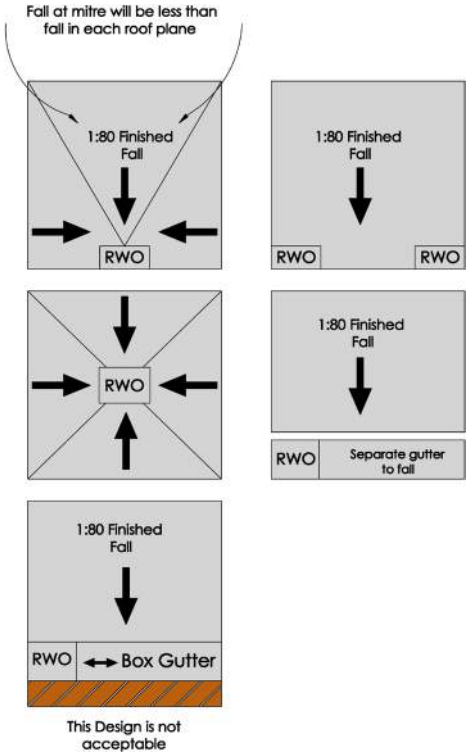


Figure 4: Drainage layout options

7.10.5 Drainage

Drainage design should be based upon calculation in accordance with BS EN 12056 Part 3 given a design head of water (typically 30mm). Rainwater outlet capacity should be taken from properly certificated information provided by manufacturers and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes such as walkways.

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 to comply with the energy requirements of the Building Regulations may be difficult to achieve.

All waterproof membranes are compatible with siphonic roof drainage systems. For larger roofs, siphonic drainage offers many advantages:

- Very high capacity, enabling fewer outlets and so less detailing work on-site;
- Smaller bore horizontal collector pipe work, enabling reduced roof void depth;
- Self-cleaning in many situations.

For further information, see **www.siphonic-roof-drainage.co.uk**

7.10.6 Thermal performance

7.10.6.1 Statutory requirement

Design for thermal performance must comply with current Building Regulations, as appropriate.

7.10.6.2 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 rainwater or snow-melt through insulation in inverted roofs. The use of water control membranes beneath ballast, to reduce thermal bridging, is recommended;
- Locations of above-average thermal transmittance at sumps, gutters or areas of minimum thickness of tapered insulation.

Manufacturers of thermal insulation and water control membranes provide calculation 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 2002 edition.

7.10.6.3 Air permeability

Relevant contract drawings should define the position of the component – the air barrier - which 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.

7.10.6.4 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. Calculated maximum accumulation of moisture within thermal insulation should not exceed the limits defined in BS 6229.

7.10.7 External fire performance

7.10.7.1 Statutory requirement

Design for external fire performance must comply with current Building Regulations.

7.10.7.2 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.

7.10.8 Provision for access

7.10.8.1 Statutory requirement

Design for access must comply with current Building Regulations.

7.10.8.2 Edge protection

In the absence of suitable parapet walls, permanent edge protection should be provided along pedestrian routes to equipment at roof level which requires regular access for servicing.

7.10.8.3 Protection of roof system

At the earliest possible stage, the anticipated loading of the roof by plant and access during service 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;
- Reinforced bitumen membranes: heavy-duty mineral surfaces sheets or tiles;
- Liquid-applied membranes: additional coating with textured finish;
- Mastic asphalt: heavy-duty mineral surfaces sheets or tiles;
- 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.

7.10.9 Detailing

7.10.9.1 General principles

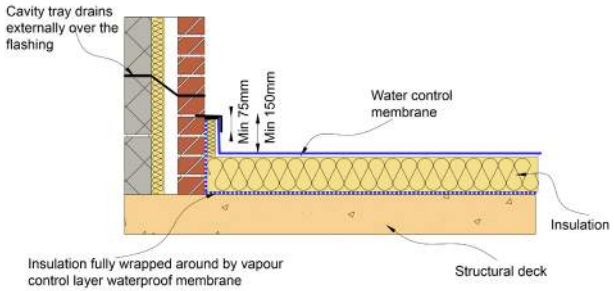
At an early stage in the design process, an audit of roof geometry should be carried out to establish what types of details will be required and whether they are to be weatherproof (incorporating an upstand / cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

The following key principles should be followed in design of all details:

- Upstands to extend 150mm above finished roof level;
- Down stands (of separate metal or other flashings) should lap the upstand by 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. Balconies are a frequent exception due to the need for level or unobstructed access (see Chapter 7.6 - Balconies). 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.

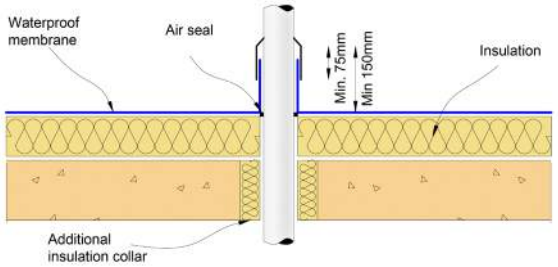


Notes:
A fillet is required at the base of the upstand for certain types of waterproof membrane.
Vertical insulation may not be required.
VCL, Waterproof membrane or both may form the air seal to the abutting wall
The principles for a parapet wall are similar but the cavity tray may be detailed differently
Discharging the cavity tray in the course above the cover flashing (a) avoids it being damaged during the roofing works and (b) allows for increase in insulation depth at refurbishment

Figure 5: Principles of detailing. An example of warm deck roof at an abutment

Special design features are essential, depending upon the generic type of waterproof membrane, including:

- Minimum clearances to enable waterproof membrane to be installed;
- Termination of waterproof membrane at interfaces to other elements;
- Penetrations;
- Supports.



Notes:
- A fillet is required at the base of the upstand for certain types of waterproof membrane.
- An effective seal is required between the vapour control layer and the 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.

Figure 6: Penetration through roof system

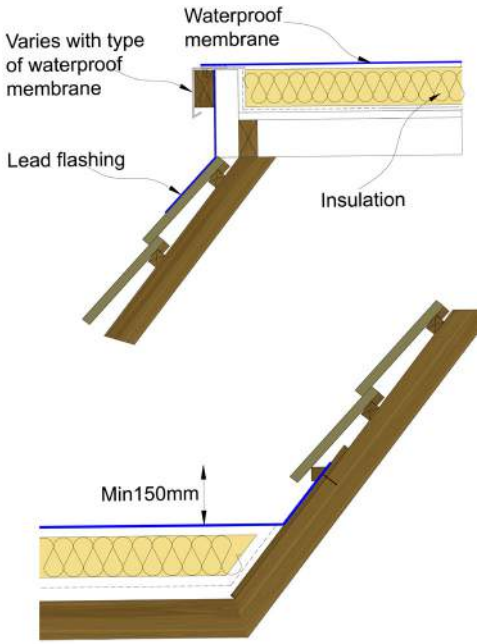


Figure 7: Detail – principles – flat roof interface to pitched roof

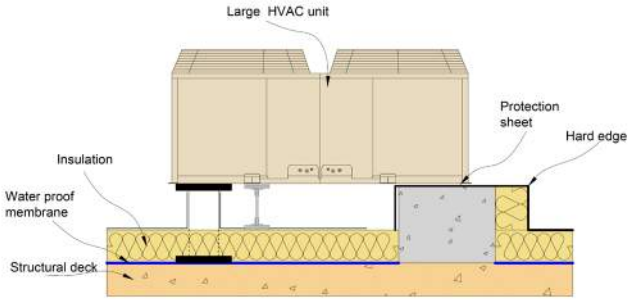


Figure 8: Detail – principles – plant support

7.10.9.2 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 which transfer their load directly to the structure. The roof system and waterproof membrane should be designed to enable equipment to be demounted without loss of integrity of the roof waterproofing. Support systems based on 'top-fixed' plate and post components should be accompanied by documentation to demonstrate their compatibility with the waterproof membrane.

7.10.9.3 Handrails and balustrades

See Chapter 7.6 - Balconies.

7.10.9.4 Mechanical and electrical services

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

- Services entry / exit points should be suitably weathered to enable connection without loss of integrity of the waterproof membrane;
- The upstand of the waterproof membrane at risers should be arranged to enable a separate down-stand or weathering flashing to be formed in ductwork;
- Cladding to insulation placed around ductwork should not be sealed to the waterproof membrane;
- Sufficient clearance should be provided to horizontal ductwork to ensure it does not rest upon the waterproof membrane or roof finish.

7.10.10 Materials

7.10.10.1 Requirement

Materials for use in the flat roofing systems are suitable only if the manufacturer has declared compliance with the relevant harmonised European Product Specification and has affixed the CE Mark to the product. Where no relevant harmonised European Product Specification exists, the product should either be in compliance with a relevant British Standard or be independently certificated for fitness for purpose by the British Board of Agrément or other notified body.

7.10.10.2 Structural deck

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 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.

Concrete

Precast concrete construction should be designed in accordance with BS 8110. Information on span capability and 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. It is more difficult to lay to a fall and is more common to create falls in the insulation (warm roofs only) or by use of 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.

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 membrane.

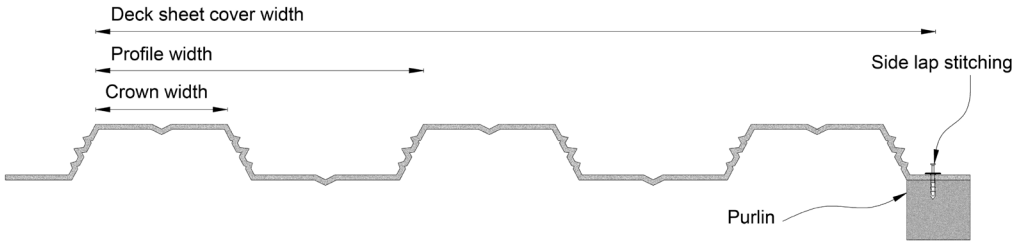


Figure 9: Profiled metal decks - critical dimensions

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.

Timber panels

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 Euro-Code 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'.

Composite panels (deck / vapour control / insulation)

The suitability of composite panels providing a combined deck, vapour control layer and thermal insulation in a single component should be assessed with reference to the loading and hygrothermal conditions in the application. There is no relevant 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.

7.10.10.3 Vapour control layer

The vapour control layer 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;
- Method of attachment;
- Condensation risk, expressed as calculated vapour pressure based on notional conditions pertaining to the project building;
- Compatibility with 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.

Roof system type	Deck type	VCL	Attachment
Reinforced bitumen [1] membrane	Profiled metal	S2P3 [2]	Partial bond by 3G or approved proprietary alternative
	Concrete	S2P3	Fully bonded
	Timber panel	S2P3	Partial bond by 3G or approved proprietary alternative
High Density Polyethylene	All	200µ	Loose laid beneath mechanically-fixed insulation
High Density Polyethylene and metal foil laminate	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions.
Coated metal foil laminate – self-adhesive	As per certification	Proprietary	Fully bonded to prepared substrate all as per manufacturer's instructions.

Note:
[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.

Table 1: Minimum recommended specification for vapour control layer for warm deck roofs.

7.10.11 Thermal insulation

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

- Thermal resistance (and therefore thickness) to suit minimum clearances at details;
- Resistance to compression;
- Compatibility with the vapour control layer 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 Chapter 7.6 - Balconies).

Please note: the alternative of a separate acoustic attenuation layer should be considered where appropriate.

Roof system type	Insulation type [1], [2]	Insulation code	Minimum compression resistance [3] (KPa)
Warm deck roof	Polyisocyanurate foam	PIR	150
	Expanded Polystyrene	EPS	150
	Extruded Polystyrene	XPS	200
	Mineral wool	MW	75
	Cellular glass	CG	N/A
Inverted warm deck roof	As per certification	XPS	200

Note:
(1) As defined in the appropriate European Product Specification.
(2) Results for composite products should meet or exceed the minimum for each component when tested separately.
(3) Results should be expressed at CS (10), i.e. at 10% compression when tested to BS EN 826.

Table 2: Minimum recommended resistance to compression of thermal insulation.

7.10.12 Waterproof membrane

7.10.12.1 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.

7.10.12.2 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.

7.10.12.3 Reinforced bitumen membranes

The manufacturer should declare compliance with the harmonised European Product Specification for single ply 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 the BS 8747.

The following specifications will be acceptable as a minimum:

Roof system type	Deck type	Insulation type [1]	Venting layer [2]	Underlayer [3]	Cap sheet [4]
Warm deck	Profiled metal	Thermoplastic foam	3G	S2P3 [5]	S4P4[5]
		Mineral fibre	-	S2P3	S4P5
	Concrete	Thermoplastic foam	-	S2P3	S4P4
		Mineral fibre	-	S2P3	S4P4
	Timber panel	Thermoplastic foam	3G	S2P3	S4P5
		Mineral fibre	-	S2P3	S4P4
Inverted warm deck	Profiled metal	Extruded Polystyrene (XPS)	3G	S2P3	S4P5
	Concrete		-	S2P3	S4P5
	Timber panel	Deck type not suitable for inverted roofs			

Note:
(1) Insulation type: Thermoplastic foam: PIR, EPS, PF. Mineral fibre: MW.
(2) Venting layer: BS8747 3G or proprietary equivalent with suitable certification.
(3) Under layer: as defined in BS8747. SBS-modified products are recommended.
(4) Cap sheet: as defined in BS8747. 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.

Table 3: Minimum recommended specification for reinforced bitumen membranes

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.

7.10.12.4 Liquid-applied membranes

There is no harmonised European Product Specification for liquid-applied membranes for roofing. The European Technical Approval Guideline ETAG 005 Part 1 – 'General' gives overall guidance on assessment of fitness for use, including methods of verification and attestation of conformity. The remaining seven parts, known as the Complementary Parts or the ETA Parts, deal with specific requirements for particular families of products and are the generic types covered primarily by this Guidance Note, shown following:

- Part 2: Polymer modified bitumen emulsions and solutions;
- Part 3: Glass reinforced resilient unsaturated polyester resins;
- Part 4: Flexible unsaturated polyesters;
- Part 5: Hot applied polymer modified bitumens;
- Part 6: Polyurethanes;

- Part 7: Bitumen emulsions and solutions;
- Part 8: Water dispersible polymers.

The manufacturer of a product for use in flat roofing should declare compliance with the relevant parts of ETAG 005. In the absence of this declaration, the product should have a current certificate of fitness for purpose issued by one of the following:

- British Board of Agrément;
- Another member of the UEAtc;
- Another notified body.

Such certification should be accompanied by full instructions for installation.

7.10.12.5 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.

7.10.12.6 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;
- Comprehensive instructions for installation.

As these systems comprise a multi-layer application (usually a base coat, reinforcement and top coat), detailed specification for the system should be available prior to commencement of the works to enable its suitability for the project to be confirmed.

7.10.13 Ancillary components

7.10.13.1 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 or water control membrane in warm ballasted and inverted warm roofs respectively.

7.10.13.2 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 manufacturer's instructions.

7.10.13.3 Access areas: porous concrete tiles (for use on reinforced bitumen sheets and mastic asphalt only)

Porous concrete tiles should be fully bonded in hot bitumen in accordance with the manufacturer's instructions.

7.10.13.4 Access areas: flexible walkway tiles

Evidence of the compatibility of the tile with the waterproof membrane is required. Tiles for walkways or terrace deck paving should be bedded in a bonding compound compatible with the waterproof membrane and fixed in accordance with the tile manufacturer's recommendations.

7.10.13.5 Rainwater outlets

The following should be confirmed by reference to 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.

7.10.13.6 Fall-arrest and edge protection equipment

The following should be confirmed by reference to 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.

7.10.13.7 Lightning protection

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

- Design in compliance with BS EN 62305;
- Method attachment to the waterproof membrane, including arrangements for self-ballasting of conductors and finials (centres, compressive loads);
- Recommended detailing at penetration of roof system.

7.10.13.8 Support for renewable energy capture equipment

Renewable energy 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 which transfer their load directly to the structure. Support systems based on 'top-fixed' plate and post components are acceptable only if accompanied by documentation to demonstrate their dead and live loading capacity and compatibility with the waterproof membrane.

7.10.14 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.

7.10.15 Installation

7.10.15.1 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. It should not be laid on routes where temporary ponding is likely, e.g., near parapet walls in the absence of cross falls between rainwater outlets.

It is recommended that concrete paving is laid on support pads as this allows adjustment, reducing risk of trip hazard:

- The height of support pads should not exceed the maximum recommended by the manufacturer;

- Paving should not be cut;
- Paving should be firmly butted up against support pad separating pegs.

7.10.15.2 Vapour control layer (VCL)

The attachment of the VCL should be designed to resist calculated wind load by a declared margin of safety. All laps should be sealed and the VCL should be sealed to the adjoining element which forms the continuation of the resistance to air permeability. The VCL 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 VCL is used, its installation should be in accordance with BS 8217.

7.10.15.3 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 broken bond pattern. Where two or more layers are laid, the joints in each layer should be offset. On substrates of profiled metal, the short dimension should be parallel to the deck crowns and supported across half the crown width.

Insulation should be lightly butted so as to avoid thermal bridging caused by gaps. If large gaps are created by damaged or undersized boards, any infill sections should be attached in accordance with manufacturer's instructions.

Warm roof systems with reinforced bitumen membrane waterproofing

The limiting wind load for the different methods of attachment of insulation is prescribed by BS 8217 as follows:

- Partial bitumen bond: up to 2.4kN/m^2
- Full bitumen bond: up to 3.6kN/m^2

Where the method attachment is outside the scope of BS8217, the manufacturer should demonstrate that the method attachment provides sufficient resistance to wind load.

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 calculation in all situations.

Warm roof systems with polymeric single ply waterproofing

Where the insulation is mechanically fixed, the number and arrangement of fasteners to resist wind load will be prescribed by the manufacturer. This arrangement may vary across the roof according to wind load, but should be followed in all areas.

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. 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.

7.10.15.4 Waterproof membrane

Polymeric single ply membranes

There is no British Standard for the installation of single ply membranes. Installation should be in accordance with the Single Ply Roofing Association '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 margin of safety. This design will normally be provided by the membrane manufacturer.

Whatever the means of attachment, mechanical 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).

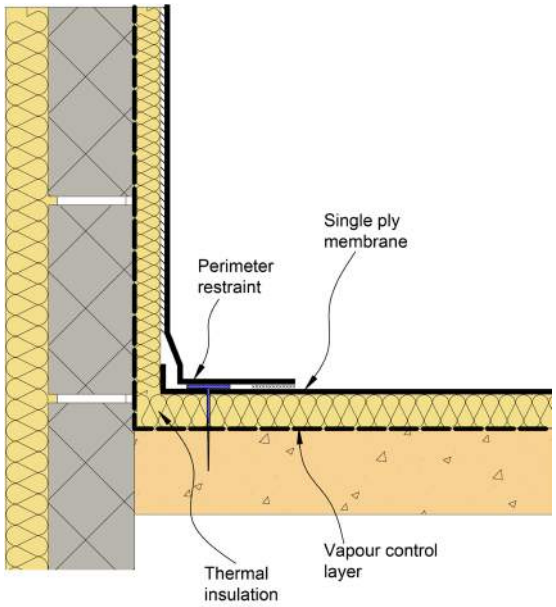


Figure 10: Methods of restraint of single ply membrane at perimeters

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.

Reinforced bitumen membranes

Installation should be in accordance with BS 8217. In case of doubt, or where the waterproof membrane is out of 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 & 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.

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’

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.

Site-applied hot-melt coverings

There is no British Standard for the application of proprietary hot-melt waterproof membrane systems. Reference should be made to independent certification and the manufacturer's detailed instructions.

7.10.16 Testing

7.10.16.1 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.

7.10.16.2 Procurement of testing services

If testing to demonstrate waterproofing integrity is required, it should be undertaken by a third party that is independent of the roofing contract.

The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project;
- Experience and training of operator;
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

7.10.16.3 Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs); therefore testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films such as liquid-applied coatings. Its use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is not recommended as a method of demonstrating the integrity of flat roofs. It may be used to test balconies (see Chapter 7.6 - Balconies).

7.10.17 Provision of information

Operation and maintenance manual

The following information is required:

- Specification, as-built:
  - Waterproof membrane: generic type, product(s) and (as appropriate) thickness;
  - Thermal insulation: generic type, product(s) and thickness;
  - Acoustic insulation: generic type, product and (as appropriate) thickness;
  - Vapour control layer: generic type, product (as appropriate) and thickness (as appropriate);
  - Rainwater outlets: type, product and capacity.
- Procedure for maintenance of waterproof membrane including (where appropriate) recommended frequency and method of application of solar reflective finish;
- Procedure for repair of waterproof membrane.

FUNCTIONAL REQUIREMENTS

7.11 ROOF COVERINGS – GREEN ROOFING

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.11.1 Scope

This part of the Manual should be read in conjunction with Chapter 7.10 - Roof Coverings. Where appropriate, cross reference will be provided to the relevant section.

This Chapter 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, but the advice of Chapter 7.10 - Roof Coverings applies:

Warm deck, comprising:

- Waterproof membrane;
- Principal thermal insulation;
- Vapour control layer;
- Continuously supporting deck.

Inverted warm deck roof systems:

- Ballast;
- Water control membrane;
- Principal thermal insulation;
- Waterproof membrane;
- Continuously supporting deck.

Cold deck roof systems (not recommended):

- Waterproof membrane;
- Continuously supporting deck;
- Ventilation externally;
- Principal thermal insulation;
- Vapour control layer.

7.11.2 Definitions

For the purposes of this standard, the following definitions shall apply:

Bio-diverse 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 bio diverse 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 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 100mm) 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.

FLL: Forschungsgesellschaft Landschaftsentwicklung Landschaftbau's (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; bio diverse roofs; brown roofs; 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 that 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 rainwater outlet designed to constrain the surrounding landscaping but allows 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), 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 100mm to 200mm substrate depth, sometimes irrigated, occasionally managed, and usually planted with a range of species.

SuDS: Sustainable (Urban) Drainage Systems.

Vapour control layer (VCL): construction material (usually a membrane) that substantially reduces the transfer of water vapour through the roof.

Wildlife roof: a version of a bio-diverse that is designed to provide a specific habitat to attract a wildlife species.

7.11.3 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 but it should be noted that they are in effect a continuous range of types:

- Bio-diverse roof;
- Brown roof;
- Extensive green roof;
- Semi-intensive green roof;
- Intensive green roof.

The roof system may be of warm deck, inverted warm deck or cold deck configuration (see Chapter 7.10 - Continuous membrane roofing). Generally, the warm deck configuration is recommended unless there are specific design circumstances for which inverted and cold roofs are better suited. A technical justification for any departure from warm deck will be required.

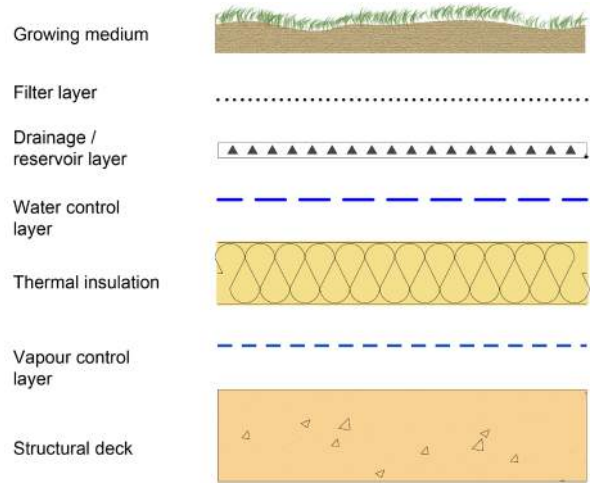


Figure 1: Extensive green roof - warm roof system (section)

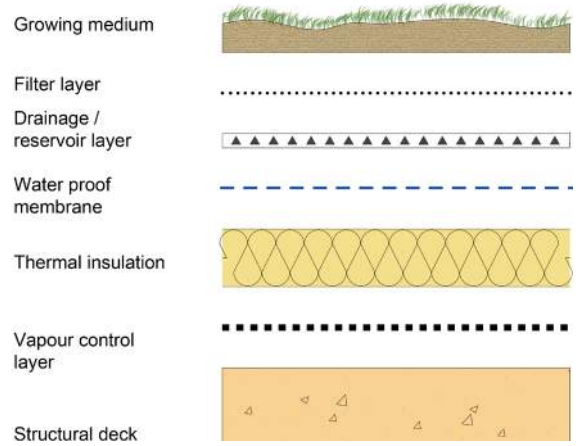


Figure 2: Intensive green roof - inverted warm roof (section)

7.11.4 Loading

7.11.4.1 Statutory requirement

Design for loading should comply with current Building Regulations.

7.11.4.2 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 provision of supplementary ballast or netting restraint. Information on loading is available from horticultural suppliers.

7.11.4.3 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.

7.11.5 Falls and drainage

7.11.5.1 Statutory requirement

Design for drainage should comply with current Building Regulations

7.11.5.2 British and industry standards

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, potential slip hazard and retention of mineral fines in vegetation-free zones, which in turn may encourage growth of weeds.

7.11.5.3 Creation of falls

Roof falls may be created either during the construction of the deck or alternatively by the use of tapered insulation systems (warm deck roof systems only).

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 rainwater 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.

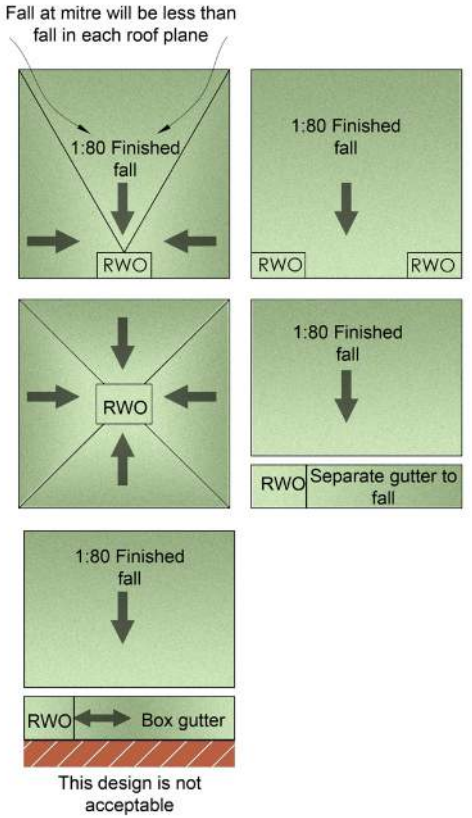


Figure 3: Drainage layout options

7.11.6 Drainage

Drainage design should be based upon calculation to BS EN 12056 given a design head of water (typically 30mm). Rainwater outlet capacity should be taken from properly certificated information provided by manufacturers and the resulting number and layout of outlets should allow for obstruction and drag due to any additional surface finishes such as walkways.

Green roofs are proven to reduce the volume and rate of transfer of rainwater to rainwater 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 rainwater drainage in accordance with EN is conducted as follows:

- Brown, bio-diverse and extensive green roof systems: no allowance for rainwater attenuation;
- Intensive green roof systems: attenuation as advised by 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 co-efficient to factor down the drainage infrastructure, to account for factors such as the additional retention performance of green roofs. However, the co-efficient that is used to reflect this reduction would 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 would therefore need to 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.

Rainwater 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.

Rainwater 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.

Green roofs are compatible with siphonic roof drainage systems. In the right circumstances these can offer advantages of:

- Very high capacity, enabling fewer outlets and so 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 of small-bore pipework.

For further information, see **www.siphonic-roof-drainage.co.uk**

7.11.7 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, rainwater or grey water storage facility should be provided at roof level.

7.11.8 Thermal performance

7.11.8.1 Statutory requirement

Design for thermal performance must comply with current Building Regulations, as appropriate.

7.11.9 External fire performance

7.11.9.1 Statutory requirement

Design for external fire performance must comply with current Building Regulations.

7.11.9.2 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 by 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 length;
- Design of flexible walkways, hard paving and ballasted areas so as to minimise root and plant spread.

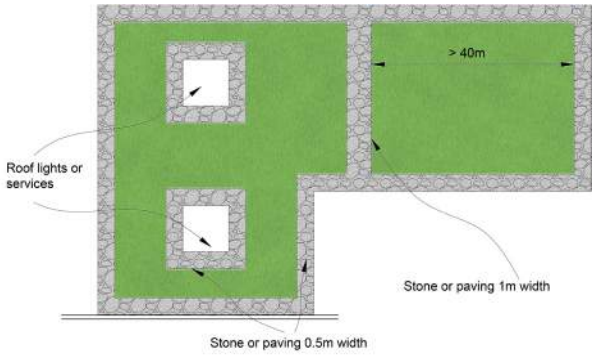


Figure 4: Green roofs – vegetation-free zones (plan, zone width - not to scale of building)

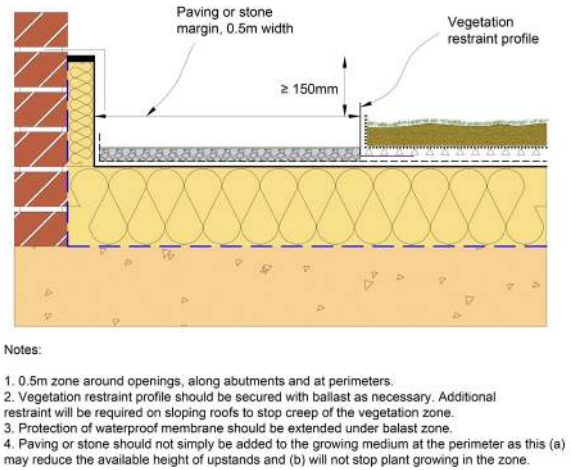


Figure 5: Green roofs – vegetation-free zone – warm roof (elevation)

7.11.10 Provision for access

7.11.10.1 Statutory requirement

Design should comply with current Building Regulations.

7.11.10.2 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:** installation of temporary vapour control layer, to be overlaid when remainder of system is installed;
- **Inverted warm deck roof system:** overlay of completed waterproof membrane with geotextile and continuous temporary decking such as plywood, Oriented Strand Board or compatible recycled thermoplastic board.

7.11.10.3 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 upon the waterproof membrane and roof system type).

7.11.11 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 finished roof level, i.e., top of growing medium;
- Downstands (of separate metal or other flashings) should lap the upstand by minimum 75mm;
- Reliance on sealant as the sole means of protection should be avoided;
- Consideration of the effect of vegetation growth on the integrity of the weatherproofing.

The total roof zone depth should be measured from the surface of the growing medium and assessed at critical points, such as the top of drainage slopes to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level. It is important that this minimum 150mm upstand is maintained at all points around the area of the green roof, except at continuous water checks and at verges.

7.11.12 Design for sustainability

As per Chapter 7.10 - Continuous membrane roofing.

7.11.13 Materials

As per Chapter 7.10 - Continuous membrane roofing.

Please note: if the waterproof membrane is intended also to provide root resistance, suitable certification of testing in accordance with BS EN 13948 should be available.

7.11.14 Installation

7.11.14.1 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 manufacturer's 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)

See Chapter 7.11.14.1.

7.11.14.2 Vapour control layer (VCL)

As per Chapter 7.10 - Continuous membrane roofing.

7.11.14.3 Thermal insulation

As per Chapter 7.10 - Continuous membrane roofing.

7.11.14.4 Waterproof membrane

As per Chapter 7.10 - Continuous membrane roofing.

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.

7.11.15 Testing

7.11.15.1 Final inspection

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.

7.11.15.2 Procurement of testing services

The waterproof membrane should be tested for integrity before the application of any other components above it. Testing should be undertaken by a third party that is independent of the roofing contract. The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project;
- Experience and training of operator;
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

7.11.15.3 Methods of test

Low voltage earth leakage

Low voltage earth leakage is a safe and effective method for the testing of waterproofing integrity, in roofs where the waterproof membrane is an electrical insulator and the deck provides an electrical earth. It is not suitable for testing flat roofs where the waterproof membrane has been overlaid with insulation and ballast (inverted roofs) or ballast only (ballasted warm roofs). Therefore, testing should be carried out prior to completion of the roofing system.

High voltage electrical discharge

The high voltage electrical discharge method is best suited to the testing of continuous thin films such as liquid-applied coatings. It's use is not recommended with polymeric single ply, reinforced bitumen membranes and mastic asphalt.

Vacuum

Vacuum testing of seams of membranes manufactured off-site is an effective means of quality assessment, but is not recommended as a method of demonstrating the integrity of flat roofs.

Flood testing

Flood testing is a suitable method of demonstrating the integrity of small areas of roof to which green roof system is to be applied. However, consideration should be given to the effect of ingress on programme and risk of entrapped water in insulation (warm deck roofs) and decks (all types). The area under any one test should not exceed 50m^2.

7.11.15.4 Testing after installation of green roof system

No reliable method is available for testing the integrity of a green roof following application of the green roof components. 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 waterproof membrane during the application of the green roof components.

7.11.16 Provision of information

7.11.16.1 Operation and maintenance manual

The following information is required:

- Specification, as-built:
  - Waterproof membrane: generic type, product(s) and (as appropriate) thickness;
  - Thermal insulation: generic type, product(s) and thickness;

    - Acoustic insulation: generic type, product and (as appropriate) thickness;
    - Vapour control layer: generic type, product (as appropriate) and thickness (as appropriate);
    - Rainwater outlets: type, product, capacity, location and means of access.
- Procedure for maintenance of waterproof membrane including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproof membrane.
- Instructions for irrigation (method / frequency), weed control and application of fertiliser (type / season / frequency).

FUNCTIONAL REQUIREMENTS

7.12 ROOF COVERINGS – METAL DECK ROOFING

Workmanship

i. All workmanship must be within defined tolerances as defined in Chapter 1 of this Manual.
ii. All work to be carried out by a technically competent person in a workmanlike manner.
iii. Certification is required for any work completed by an approved installer.

Materials

i. All materials should be stored correctly in a manner which will not cause damage or deterioration of the product.
ii. All materials, products and building systems shall be appropriate and suitable for their intended purpose.
iii. The structure shall, unless specifically agreed otherwise with the warranty provider, have a life of not less than 60 years. Individual components and assemblies, not integral to the structure, may have a lesser durability but not in any circumstances less than 15 years.

Design

i. Design and specifications shall provide a clear indication of the design intent and demonstrate a satisfactory level of performance.
ii. Roof coverings must prevent any external moisture passing into the internal environment of the dwelling.
iii. Structural elements outside the parameters of regional Approved Documents must be supported by structural calculations provided by a suitably qualified expert.
iv. The materials, design and construction must meet the relevant Building Regulations and other statutory requirements, British Standards and Euro-Codes.

7.12.1 Introduction

Generally metal roofing is usually built to a decent standard, but occasionally things go wrong especially where site workmanship has not been up to standard.

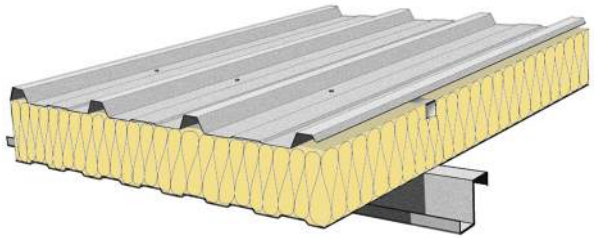


Figure 1: Typical metal double skin insulated roof

7.12.2 Double skin insulated roofs

7.12.2.1 What is a double skin insulated roof?

A double skin insulated roof is made up on-site from separate components generally comprising liner sheet; vapour control layer; 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 fix sheets are still widely used; these 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. Liner sheets are fixed directly to purlins and can act as a vapour control layer if a separate vapour barrier is not specified. If the liner is not used as a vapour control layer, a reinforced vapour control sheet should be incorporated within the roof.

Insulation must be installed between the vapour control layer 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.

7.12.2.2 Workmanship

Top weathering sheets

Ensure that the top weathering sheets are installed in accordance with manufacturer's instructions.

These must be long enough to discharge into the gutter correctly and to allow for an eaves angle if required by the system.

Check end and side lap tape sizes conform to 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. 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

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, the number of rows dependant on the application. Check the integrity of these tapes and that they are continuous and are 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 make sure 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. Check the Lambda value against the specification.

Ensure that no packaging or debris is left in the roof void prior 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. Check that they are the correct type of fixing.

With standing seam roofs, the halter may be fixed with a stainless steel fixing; check 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 - there must be one on-site to get the correct gauging of the halters.

Roof penetrations

These must be sealed to maintain the vapour control layer (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 GRP in-situ weathering.

Roof lights

With standing seam roof sheets, these 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. 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 of steel sheets and marks aluminium and rapidly turns to rust. Flashings should have sufficient overlap or butt straps, 150mm wide, and be sealed and supported. Check frequency of fixings and that they are of the correct type.

7.12.3 Composite panel metal roofing

7.12.3.1 What is a composite panel roof?

A simple sheet roof system with ensured insulation thickness which is delivered with top weathering sheet, insulation and white liner all in one sheet. With the increase in insulation, thickness panels are being made shorter in length so they can be handled into position. This means that there are more end laps to be checked.

Standard manufacturer's details are to be adhered to, but the following need to be checked.

7.12.3.2 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. All fixings are different.

Check 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 which is fixed to the purlin and will support the end lap.

Check that the right number of fixings have 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. Check with the end of a hacksaw blade to locate the rows of mastic tape.

On roof lights, mastic tape is visible; check its location and 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 isn't 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. 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 an inner ridge suitably sealed.

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. Manufacturer's details may not be achievable, but an alternative must be devised to maintain air tightness. A degree of confidence for 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 air seal at the junction of the two. Gutter joints are not always level; any gaps are 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 over sailing into gutter correctly.

Roof penetrations

Penetrations such as flues, vents, up stand 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. 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 frequency of fixings and that they are of the right type.

Check for closure from gutters and sheet over sails. There should be suitable shrouds to prevent birds or vermin from getting into the building which can be often over looked.

Appendix A - Inspection checklists for metal roof coverings

Checklist 1 for double skin Insulated roof systems in steel or aluminium

Component / Inspection	Rectification needed		Comments
	Yes	No	
Check bearing width of purlin			
Check minimum overlap of linear decking sheets: 1. Light gauge steel 2. Hot rolled steel 3. Timber - check for minimum penetration			
Check that side laps are stitched at the correct centres			
Vapour control checks using the liner: 1. Check tape to side laps, minimum width 50mm air and moisture barrier tape 2. Check tape to end laps 3. Check inner fillers to ridge, eaves and verge 4. Check for sealing around the perimeter with fire resisting foam			
Vapour control checks using a separate vapour control layer: 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 vapour control layer and building elements, e.g., upstands, eaves, verge, etc. 5. Check for puncture and repair where necessary			
Spacer systems: 1. Check for correct height of bracket or halter 2. Correct number of fixings per bracket or halter 3. Check for stainless steel if specified 4. Check for gauging of halters for standing seam and secret fix roof sheets			Use a magnet
Insulation: 1. Check that the correct thickness is being used 2. Check that insulation is the correct type and has the same properties as specified 3. Check for compression 4. Check that insulation joints are staggered 5. Ensure that insulation designed to support load has been correctly installed to eaves, ridge, penetrations and walkways 6. Ensure all packaging and debris is removed prior to fitting of the roof sheets			
Breather membranes: 1. Ensure the membrane is laid in the correct direction and in accordance with manufacturer's instructions			

CHAPTER 7: Superstructure

Component / Inspection	Rectification needed		Comments
	Yes	No	
Roof sheets- standing seam and secret fixed: 1. Check that sheets are long enough so that water effectively drains into the gutter 2. Check the direction of lay of sheets in relation to the direction of prevailing wind 3. Check eaves detail, in accordance with manufacturer's details including eaves drips and fixing 4. Check ridge detail including turn up fillers and ridge dams, in accordance with manufacturers details 5. Check verge detail and adequacy of support for cut sheets 6. Check flashing supports, sheet / verge flashing seals and frequency of fixings			
Roof sheets - pierced fixed: 1. Check overlap dimension 2. Check end lap tape and correct number of rows of tape 3. Check for side lap tape 4. Check quantity of fixings per sheet per purlin 5. Check washer size of main fixings and side lap stitchers 6. Check frequency of side lap stitchers 7. Inspect for correct tightening of main fixings and side lap stitchers			
Penetrations for vents, sun pipes, etc. **A - Aluminium sheets:** 1. Check sheets are site welded and area post coated where colour sheets are used. 2. Check that vapour control layer and breather membrane is maintained around the welded area 3. Check upstands to be at least 150mm **B - Steel sheets:** Ideally use GRP in-situ weathering flashings; however, if folded flashings are used, check: 1. Overlap 2. Sealing and fixing of overlaps 3. If a flat sheet back to the ridge is used, check for insulation under the sheet 4. Check frequency of fixings 5. Check sealing of overlapping sheets			
Flashings: 1. Check end overlap 2. Check frequency of fixings 3. Check correct type of fixing is used			
Generally: 1. Check roof surface for cuts and abrasions 2. Check for hot swarf damage			

Checklist 2 for composite panel roofing works

Component / Inspection	Rectification needed		Comments
	Yes	No	
Panel laps to be tight when viewed from inside the building.			
Constant straight line on side laps to be achieved.			
Fasteners correct for the purlin: 1. Light gauge steel 2. Heavy gauge steel 3. Timber			
Fastener material: 1. Coated carbon steel 2. Stainless steel			Check with a magnet
Fastener frequency main roof: 1. Main fixings 2. Side lap stichers			
Fastener frequency roof lights: 1. Main fixings 2. Side lap stichers			
Bearing area of purlin at end lap is a supporting bearing plate required.			Is the building square?
End laps: 1. Correct number of rows of joining tape 2. Correct size of end lap tape 3. Correct position of end lap tape in relation to fixing			
Roof light tape positions: 1. Correct number of rows of joining tape 2. Correct size of end lap tape 3. Correct position of end lap tape in relation to fixing			
Is the roof adequately air tight (visual inspection and air tightness test where necessary)			
Provision of fire retardant gun foam: 1. Eaves level 2. Verges 3. Gutters 4. Internal verge positions 5. Foam insulation at ridge			

CHAPTER 7: Superstructure

Component / Inspection	Rectification needed		Comments
	Yes	No	
Gutter junctions: 1. Adequacy of seals at gutter junctions 2. Correct provision of weir overflows to gutter runs 3. Correct junction detail between gutters and verge flashings 4. Gaps sealed to prevent vermin infestation 5. Correct discharge of water from roof sheets into gutter			
Roof penetrations: 1. Check seals around cut foam insulation internally 2. Check internal flashing closures 3. Check weather penetrations externally			
Flashings: 1. Check end overlaps 2. Check frequency of fixings			
General: 1. Check roof covering for cuts and abrasions 2. Check for hot swarf damage			