Introduction

This section provides guidance on meeting the performance requirements for flat roof constructions with a weathered surface at no more than 10˚ to the horizontal.

Types of flat roof systems covered by this section are:

- Warm roof systems
- Inverted roof systems
- Cold roof systems
- Hybrid roof systems

11.4.1 Compliance

Flat roofs shall comply with the performance requirements of this section. Cold deck roofs shall be no larger than 3m^2.

11.4.2 Information to be provided

The Designer shall provide sufficient design details to demonstrate it meets the requirements of this section.

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

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

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

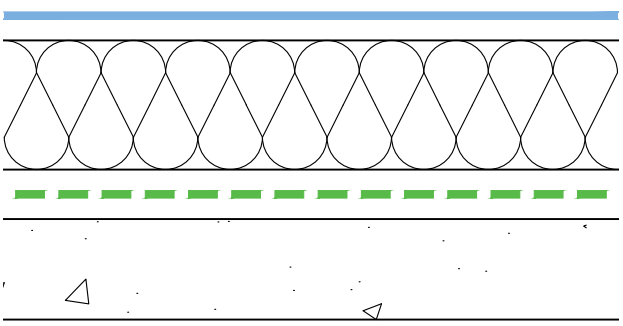
11.4.3 General design

Flat roof design and construction shall be appropriate for the intended use.

The design of a flat roof should be one of the following forms of construction.

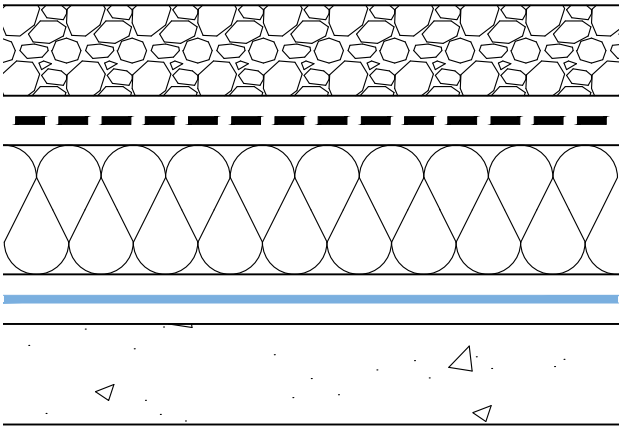
Warm deck roof

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.



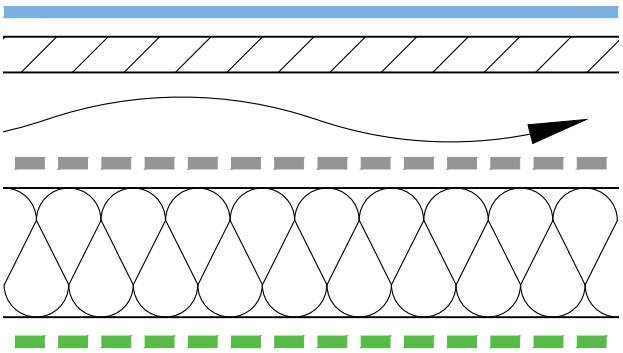
Inverted warm deck roof

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, gravel, or blue/green roof - minimum 80 kg/m^2).



Cold deck roof - only acceptable for roof areas less than 3m^2

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.



11.4.4 Structural design requirements for all flat roofs

Flat roof structures shall be designed and constructed so that all loads are sustained and transmitted to supporting structure(s) without causing instability, deflection or deformation. Factors to be considered are:

- Wind loading.
- Dead and imposed loading.
- Structural movement.
- Openings and penetrations.
- Fixing/attachment of ancillary structures and plant or equipment.

General

Flat roof structures should be designed and constructed so that combined dead, imposed and wind loads are sustained and transmitted to supporting and/or adjoining structure(s) without causing instability, deflection or deformation of any part of the building.

The roof structure should have adequate interconnection at all jointing within its structure and at all junctions with interfacing structure. It should be provided with appropriate bearing and support where it bears onto any supporting walls or intermediate beams. Bearing dimensions and connections should be carried out in accordance with the designing Engineers specification.

The designing Engineer should design in accordance with the principles of relevant standards and their relevant national annexes, such as:

- BS EN 1990 Eurocode – Basis of structural and geotechnical design.
- BS EN 1991-1-1 Eurocode 1: Actions on structures - General actions - Densities, self-weight, imposed loads for buildings.
- BS EN 1991-1-2 Eurocode 1: Actions on structures - General actions - Actions on structures exposed to fire.
- BS EN 1991-1-3 Eurocode 1: Actions on structures - General actions – Snow loads.
- BS EN 1991-1-4 Eurocode 1: Actions on structures - General actions – Wind actions.

Wind loading

Flat roof structures should withstand wind pressure and suction, and have adequate interconnection with supporting structure to allow it to act as a horizontal diaphragm capable of transferring the wind forces to buttressing elements of the building.

The roof structure should be:

- Supported by adequately restrained load bearing structure e.g. walls, beams.
- Secured to the supporting structure e.g. via a wall plate, hangers, metal straps.
- Effectively strapped, braced and strutted to withstand the effects of wind loading e.g. uplift force, lateral force, suction force.

In all situations, 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. Engineers should design structural connections and fixing methodology to resist the site specific wind loads.

Dead and imposed loading

Flat roof structures should be designed to withstand all dead loads and imposed loads. It should remain structurally stable and remain within designed and acceptable deflection limits. Loading should not impede the service life of the roof structure, its structural performance and/or the functionality of any waterproofing, and associated drainage capabilities.

Designing Engineers should take account of any potential use and functionality of the roof with regards to imposed loading created by access related to use of a space, and/or placement of plant and equipment, servicing, and withstand the effect accordingly through appropriate structural design and material selection.

Structural movement

Where movement joints are required, they should be designed by an Engineer. The rate of expected movement, type of movement joint(s), the materials used and their locations should be communicated to the waterproofing system designer for inclusion into the design process of any roof drainage strategy falls and detailing, and the waterproofing system.

Openings and penetrations

Structural openings (e.g. rooflights or vents, staircase openings, lift overrun shafts) and penetrations created by services through any part of the roof structure should be designed by an Engineer.

Fixing/attachment of ancillary structures and plant or equipment

Any item (e.g. balustrades, safety systems to facilitate access, items of plant or equipment) fixing into and/or through a flat roof structure should not impede the roofs overall structural performance. Any loads should be accounted for in the design and should not damage or reduce durability or stability of any element of the roof.

The structural fixings for any element located on or around the roof structure which imposes a load or structural stress (e.g. rotation) should be designed by an Engineer to ensure fixings are robust and are suitable for the performance required.

Fixings should only be located into an element of structure capable of providing the required support and restraint to any imposed and/or operational loading and/or structural stress created by the element being fixed.

Structural fixing(s) for such elements should not impede the roofs overall structural performance, and should not damage or reduce durability of any element of the roof, and must be fully protected by the final waterproof roof covering on completion. Penetrations created by these elements should be detailed and sealed in accordance with the waterproof covering manufacturer's recommendations.

Roof structure and deck survey

Prior to the waterproofing, the deck erector should carry out a deck survey to ensure a minimum 1:80 as built fall is maintained. Any foreseeable and likely deflection of the deck should be confirmed and any back falls should be addressed prior to laying any waterproofing layers.

If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

A formal handover procedure should be undertaken between the deck erector and the waterproofing contractor.

11.4.5 Timber flat roofs - material specifications and performance

All materials used to construct a timber flat roof structure shall be appropriately specified and approved for their intended purpose.

Timber – structural members

Timber structural roofing members should be durable and fit for purpose. Any timber used must be:

- Strength graded and suitable for its position/function within the roof structure.
- Dimensionally stable and appropriately sized.
- Suitably protected from foreseeable risks where required e.g. insect attack.

All structural timber members used should carry demarcation of the strength grading information in line with BS EN 14081-1 ‘Timber structures - Strength graded structural timber with rectangular cross section – General Requirements’. All such timber must also be stamped as either ‘DRY’ or ‘KD’ (Kiln Dry).

The use of ungraded or ‘green’ timber is not acceptable.

Structural connections

Joist hangers, horizontal and holding down tension straps, and brackets for the interconnection of a flat roof structure to walls, beams, and/or columns should be in accordance with BS EN 845-1 ‘Specification for ancillary components for masonry’.

Timber treatments

Preservative treatments of roof timbers or any treatments applied to resist insect attack should be carried out where specifically required under relevant standards and Codes of Practice. Further information can be found in ‘Appendix C - Materials, Products, and Building Systems’.

Structural timber decks

Structural timber decks must be as one of following materials as listed below:

- Plywood board to BS EN 636, Use Class 3.
- Oriented strand board, to BS EN 300 type OSB3.
- Pre-treated tongue and grooved softwood boarding. Moisture content between 16-20% at time of fixing.

Notes:
- The thickness of the board may need to be increased to resist pull out forces on fixings.
- The timber deck must be protected against wetting until the final roof covering has been laid.
- Any damaged or saturated timber decks must be replaced.
- Cut edges should be treated to prevent moisture ingress.

11.4.6 Timber flat roofs - strength and durability

Timber flat roof structures shall be constructed to be durable, robust and capable of receiving the specified waterproofing system.

The guidance on timber structures is limited to buildings of not more than three storeys above ground.

Sizing of structural members

Structural timber members should be appropriately sized for their function and span. For guidance on sizing of certain timber members in roofs, the designing Engineer should refer to the following sources:

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

Strutting

All timber joists should be appropriately strutted in accordance with the Engineers design or where engineered joists are specified, in accordance with the manufacturer’s site specific specification.

Traditional solid timber joists and I-Joists

Where the span of a flat roof joist is more than 2.5m, strutting should be included at mid-span. Where the span of the flat roof joist is more than 4.5m, two rows of strutting at ⅓ the span position will be necessary.

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

Timber strutting shall be in accordance with the guidance of BS 8103-3, or by a suitable alternative proprietary system. Its inclusion where required should not prevent cross ventilation in cold deck roofs.

Metal web joists

Where the span of a flat roof joist is between 4-8m, 1 row of strutting should be provided at mid span. Where the span of the flat roof is over 8m, 2 rows of strutting at ⅓ the span position will be necessary. This should be provided by timber strong backs in accordance with the manufacturers design.

For further information on strutting of timber joists, please refer to the ‘Upper Floors’ section.

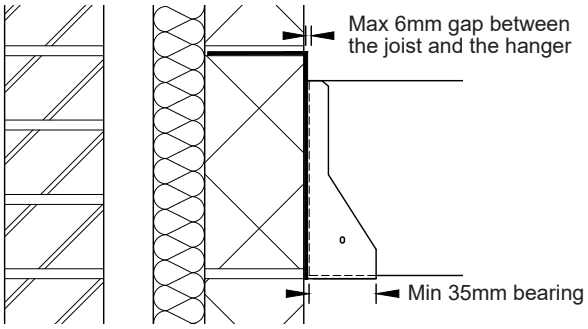
Structural support connections

Structural support connections and all fixings, such as the use of joist hangers, horizontal and holding down tension straps, and brackets for the interconnection of a flat roof structure to walls, beams, and/or columns should be:

- Specified and installed in accordance with the Engineers design.
- In accordance with BS EN 845-1 'Specification for ancillary components for masonry'.

Where the securing of roof structure involves a timber wall plate or similar, it should fully supported and capable of directing loads perpendicularly down the supporting wall. The wall plate should be suitably fixed and incorporate 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.

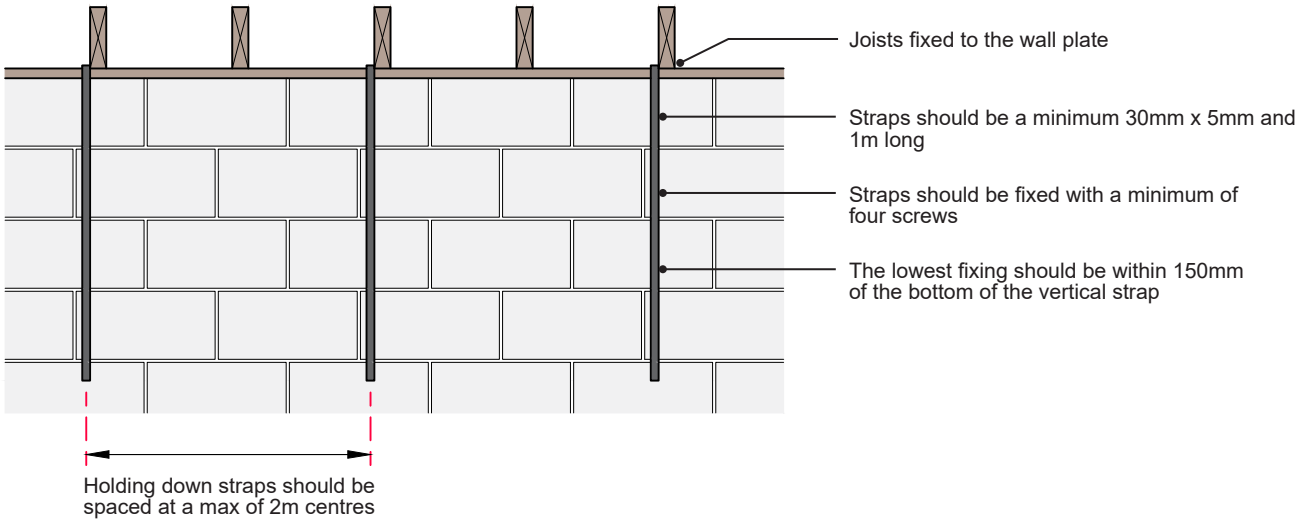
Restraint straps should be employed at 2m centres (maximum) where joists are parallel to walls.



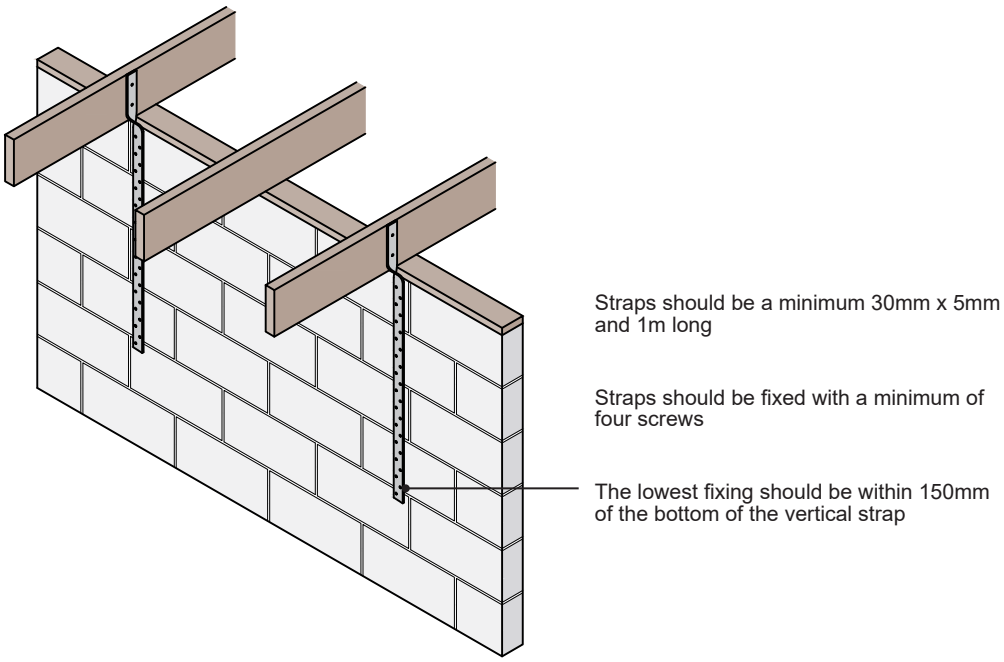
Joist hangers should be:

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

Holding down straps



Alternative strap detail



Firring sections

Where timber firring sections are required to create falls, and they are installed perpendicular to the flat roof joists (at 90° to roof joists), they should:

- Be sized to span between flat roof joists without deflection – sectional depth should not be less than 50mm at any point along their length where supports are 600mm centres. For 450mm centres, firring sections may be reduced to 38mm at any point along their length.
- Have an adequate bearing at points of support.
- Be fixed at every intersection with the flat roof joist using appropriately sized screws or fully nailed proprietary bracket fixings. Where screws are used, they should achieve an adequate penetration depth into the supporting flat roof joist - as determined by the wind uplift calculations.

Where firring sections sit directly on top of the joists, they should:

- Be secured at 300mm centres, by 3.1mm x 90mm ring shank nails, with a minimum purchase of 40mm.
- Where firring sections become too deep to achieve the minimum purchase, utilise skew nailing using two 3.1mm x 90mm ring shank nails at 300mm centres.

All timber decks

General requirements

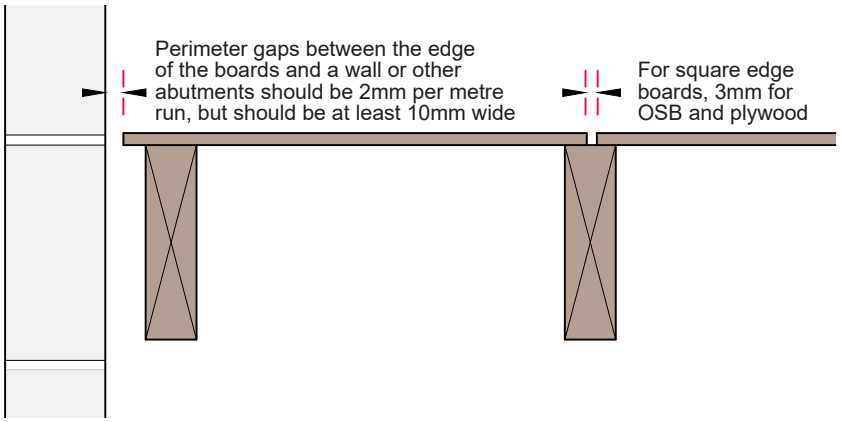
Structural decks must have a minimum recommended thickness of 18mm and boards should be laid in a staggered pattern. All square edged boards must be continuously supported on all edges. The minimum bearing onto a supporting timber is 18mm at board joints, with a full bearing for the width of the supporting timber achieved at perimeter or abutment detailing. Boards should be supported by noggins at the perimeter where they run at right angles to roof joists.

Fixings should be at centres not exceeding 150 mm along any end or edge, and not exceeding 300 mm along any intermediate support, and should be at least 8 mm from the edge of the board. Where nails are used, their heads should be punched 2 mm to 3 mm below the surface of the board. Where screws are used, they should be pre-drilled and countersunk.

All fixings should be of 'In service class 2' fixings, and should be corrosion resistant. Corrosion resistant materials include galvanized or sherardized steel, austenitic stainless steel, phosphor bronze and silicon bronze.

All structural decks should allow for the effects of expansion and include appropriate expansion gaps at all perimeter edge abutments and joints. The dimension applied to expansion gaps should be:

- Deck perimeter gaps between the edge of the boards and a wall or other abutment should be 2mm per metre run, but should be at least 10mm wide.
- Deck joints formed by square edge boards should be 3mm.
- Deck joints formed in boards with tongue and grooved edges should be aligned with manufacturers guidance.



Additional requirements for plywood decks

Plywood should be laid with the face grain perpendicular to the supports (at 90° to roof joists) and all end joints should occur over joists of at least 38 mm basic thickness or be supported by noggings. At the perimeter, boards should be supported by noggings where they run at right angles to roof joists.

All square edged boards must be continuously supported on all edges. Boards with tongue and grooved edges should be installed with the longest edge at right angles to the joists and short edges supported on a joist or nogging.

Fixing nails should be either:

- Plain wire nails at least 3.35 mm in diameter and at least 65 mm long, which penetrate at least 40 mm into the support, **or**
- Annular-ringed shank nails at least 3.35 mm in diameter and at least 50 mm long, which penetrate at least 32 mm into the support.

Additional requirements for OSB decks

All boards should be fastened firmly to the supporting timber and their directional strength demarcation (printed on the boards surface) installed perpendicular to the joists and all end joints should occur over joists of at least 38 mm basic thickness or be supported by noggings. At the perimeter, boards should be supported by noggings where they run at right angles to roof joists.

All square edged boards must be continuously supported on all edges. Boards with tongue and grooved edges should be installed with the longest edge at right angles to the joists and short edges supported on a joist or nogging.

Flat headed annular-ringed shank nails and screws have superior holding power and should be used in preference to plain shank nails.

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

Additional requirements for pre-treated T&G softwood boarding

Boards should be laid with the grain perpendicular to the supports (at 90° to roof joists), with all tongue and grooving engaged and all end joints should occur over joists of at least 38 mm basic thickness or be supported by noggings.

For boards of no more than 175 mm basic width, two nails should be used at each intersection with a supporting timber or nogging. For wider boards, a minimum of three nails should be used at each intersection.

11.4.7 Concrete flat roofs - material specification and performance

All materials used to construct a concrete flat roof structure shall be appropriately specified and approved for their intended purpose.

Concreting shall not take place during cold weather periods where working temperatures are below 2ºC.

Material specification and execution of all work related to in-situ concrete and pre-cast concrete roof construction should be in strict accordance with the designing Engineers specification and design.

Concrete for flat roof construction should use ready mixed concrete sourced from a third party accredited supplier registered to either:

- 'The Quality Scheme for Ready Mixed Concrete' (QSRMC), **or**
- BSI Kitemark Certification.

Cementitious screeds should be in accordance with BS 8204 - Screeds, bases and in-situ floorings.

Further information relating to specification of concrete and execution of concreting works can be found in 'Appendix C - Materials, Products, and Building Systems'.

Where specified, the use of horizontal and holding down tension straps, and brackets for the interconnection of a flat roof structure to walls, beams, and/or columns should be in accordance with BS EN 845-1 'Specification for ancillary components for masonry'.

In situ concrete slabs and cementitious screeds contain large volumes of water which, if not allowed to dry out, can prevent adhesion of the waterproof layer. If bonding to the slab, it is advised that an adhesion test be carried out.

11.4.8 Concrete flat roofs - strength and durability

Concrete flat roof structures shall be constructed to be durable, robust and capable of receiving the specified waterproofing system.

In-situ and pre-cast concrete flat roof construction should be designed by an Engineer to comply with the current Building Regulations, and be in accordance with the principles of relevant standards and their national annex, such as:

- BS EN 1992-1-1 - Eurocode 2 — Design of concrete structures Part 1-1: General rules and rules for buildings, bridges and civil engineering structures.

Pre-cast concrete systems should:

- Have a minimum of 90mm bearing onto supporting structure, unless justified by the design.
- Have restraint straps at 2m centres (maximum) where concrete beams are parallel to walls.
- Be grouted in accordance with the design.
- Accommodate for foreseeable differential movement.

Where the Engineer references any manufacturers information on structural performance (e.g. span capability, connective detailing, installation requirements) or system specific bracketry for the interconnection of a flat roof structure to walls, beams, and/or columns this should be clearly referenced and supplementary information provided within any structural designs and calculations.

The concrete specification and any additional cementitious screeds should be capable of resisting the anticipated loadings. Where lightweight screeds are specified, they should be overlaid with a 1:6 (cement to sand) screed topping of a minimum 10mm thickness. Further information can be found in 'Appendix C - Materials, Products, and Building Systems'.

In pre-cast panel decks, the locations of any anticipated differential movement (e.g. at perimeter or abutment interfaces or between adjacent panels that are subject to differential loading) must be identified in order that stress is not transferred to the waterproof membrane. Where unavoidable, any movement joint passing through or requiring incorporation into the waterproofing system should:

- Use materials that are durable and have a service life equivalent to the waterproofing system.
- Supported by a design and specification that is approved by the waterproofing system manufacturer.

11.4.9 Profiled metal deck structure - material specification and performance

All materials used to construct profiled metal deck structures shall be appropriately specified and approved for their intended purpose.

Material specification and execution of all work related to profiled metal deck roof construction should be in strict accordance with the designing Engineers specification and design.

Materials used should demonstrate conformity to manufacturing and the appropriate structural design characteristics detailed within:

- BS EN 1090-1 – 'Execution of steel structures and aluminium structures. Requirements for conformity assessment of structural components'.

Profiled metal sheets should:

- For galvanised steel, have a minimum recommended thickness of 0.7mm (typical gauge range is 0.7mm-1.2mm), and meet the requirements of BS EN 10346 'Continuously hot-dip coated steel flat products for cold forming — Technical delivery conditions', and used in accordance with BS EN 1993-1-3.
- For plain aluminium, have a minimum recommended thickness 0.9mm and meet the requirements of BS EN 485-2 'Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties' and BS EN 1396 'Aluminium and aluminium alloys - Coil coated sheet and strip for general applications. Specifications', and used in accordance with BS EN 1999-1-4.
- Be of suitable quality and finish before the waterproofing layer and insulation system is installed.
- Be fixed using suitable fixings which avoid bimetallic corrosion in accordance with the manufacturer's recommendations.

11.4.10 Profiled metal deck structure - strength and durability

Profiled metal deck structures shall be constructed to be durable, robust and capable of receiving the specified waterproofing system.

General

Profiled metal deck flat roof construction should be designed by an Engineer to comply with the current Building Regulations, and be in accordance with the principles of relevant standards and their national annexes, such as:

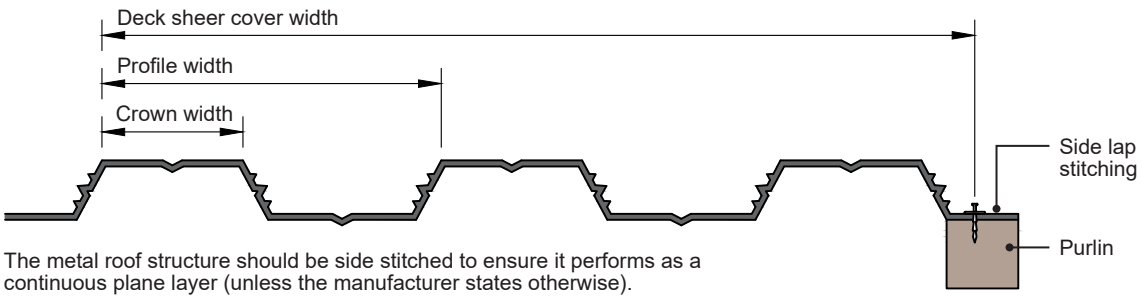
- BS EN 1993-1-3 - Eurocode 3 - Design of steel structures. Cold-formed members and sheeting.
- BS EN 1999-1-4 - Eurocode 9 - Design of aluminium structures. Cold-formed structural sheeting

Where the Engineer references any manufacturers information on structural performance (e.g. loading and span tables, and the application of appropriate factors of safety, installation requirements) or system specific bracketry for the interconnection of a flat roof structure to walls, beams, and/or columns this should be clearly referenced and supplementary information provided within any structural designs and calculations.

The installation of cold-formed structural members and sheeting made from steel or aluminium within flat roof structures should be in accordance with the principles of relevant standards, such as:

- BS EN 1090-4 - Technical requirements for cold-formed structural steel elements and cold-formed structures for roof, ceiling, floor and wall applications for steel.
- BS EN 1090-5 - Technical requirements for cold-formed structural aluminium elements and cold-formed structures for roof, ceiling, floor and wall applications.

Side lap stitching should be used to ensure the construction performs as a continuous plane layer - unless the manufacturer recommends otherwise. When considering the necessity for metal deck closures, reference should be made to the guidance of the manufacturer.



The metal roof structure should be side stitched to ensure it performs as a continuous plane layer (unless the manufacturer states otherwise).

Profiled metal decks should conform to the following standards:

- Galvanised steel: minimum recommended thickness 0.7mm to BS EN 10346 Fe E280G Z275. Typical gauge range 0.7mm-1.2mm.
- Plain aluminium: minimum recommended thickness 0.9mm to BS EN 485-2 AA3004 H34. Reference should also be made to BS EN 1396 as appropriate.

It is important that the deck has adequate provisions to resist wind uplift by being adequately anchored to the main structure.

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. The mid-span deflection of the metal deck should not exceed 1/200 of the span under uniformly distributed design loads to avoid reduced drainage performance.

Profiled metal decks should be adequately protected from the effects of temporary imposed loads e.g. avoidance of stacking and loading of construction materials.

11.4.11 Thermal performance and condensation control

Insulated flat roofs shall be designed and constructed to avoid the detrimental effects of interstitial and internal surface condensation. Factors to be included are:

- Air and vapour control layers.
- Thermal insulation requirements.
- Thermal bridging risks.
- Ventilation for cold roof systems.

For Warranty purposes, flat cold deck roofs over 3m^2 in area are not acceptable.

The risk of condensation due to the movement of water vapour into or through a roof construction should be suitably mitigated using appropriate methodology and materials, and be the subject of specialist design and specification.

Any provision required to control interstitial condensation within the roof should be determined to the calculation method defined by BS 5250, but with ambient conditions set in BS 6229. The calculated maximum accumulation of moisture within thermal insulation should not exceed 350g/m² and there should be no net accumulation in any annual cycle.

Air and vapour control layers (AVCL's)

Air and vapour control layers should be appropriate to level of risk posed by the building use and foreseeable moisture vapour loads. They should be:

- Positioned on the warm side of the insulation.
- Suitable for their position within the type of construction chosen e.g. warm roof system, cold roof system.
- Suitably attached and fixed to resist the effects of wind uplift on the completed waterproofing system.
- Continuous and fully sealed at laps, perimeters and penetrations – termination detailing should be sealed and lapped to the waterproofing layer (where compatible or extend 50mm above the insulation and sealed to the associated structure e.g. wall, pipe, rooflight, outlet.
- Compatible with any building fabric to which they are in contact with and the chosen method of attachment e.g. structural decks, insulation, bonding adhesives.

AVCL specification and selection should be determined by site specific calculations and performance requirements e.g. Condensation Risk Analysis (CRA), wind uplift calculations, the waterproofing system manufacturers requirements.

Any fixings that penetrate the AVCL e.g. those securing insulation boards to the deck, should be carefully installed to avoid pathways for water vapour to pass through.

In an inverted warm roof, the waterproofing layer is beneath the insulation and therefore acts as the AVCL. To avoid the opportunity of water transfer to this layer and any associated risks with interstitial condensation forming:

- Insulation should be butted tight at joints without gaps, **and**
- Protected by the correct installation of a water flow reducing layer laid over the insulation.

Criteria for a condensation risk analysis

Where a condensation risk analysis is required, the following boundary conditions should be used:

- 60% relative humidity.
- External temperature -2°C.
- Internal temperature 21°C.

Where external temperatures are considered to fall below -2°C due to exposure or geographical locations, lower temperatures should be used based upon climatic data within relevant standards.

Thermal insulation requirements

Insulation materials should be approved for their intended purpose and be the subject of specialist design and specification.

Insulation materials should:

- Have a relevant third party product conformity certificate confirming suitability for use in proposed situation.
- Provide the required level of thermal performance and contribute to mitigation of condensation risks.
- Be suitable for the type of construction chosen e.g. warm roof system, inverted roof system - insulation in an inverted roof should have a high resistance to water absorption and the effects of freeze/thaw cycling.
- Be suitably attached and fixed to resist the effects of wind uplift on the completed system.
- Provide a suitable surface for the application of a waterproofing system.
- Be compatible with any building fabric to which they are in contact with and the chosen method of attachment e.g. structural decks, insulation, bonding adhesives.
- Be installed to be continuous and free from any damage or distortion that may impact on required performance.
- Support loads created by the waterproofing system, and any associated surface finishes. Where required loads created by ballast, systems facilitating access to foot traffic, and placement of plant or equipment may also need to be factored in.

The attachment of the thermal insulation should be designed to resist calculated wind load by a declared margin of safety. Typically, attachment is either:

- Bonded or mechanically fixed to resist wind uplift.
- Ballasted to resist wind uplift (ballasted warm roofs and inverted warm roofs).

Where mechanically fixed, the fixings should be in accordance with the fixing specification and associated wind uplift calculations. Fixings should be thermally broken and of sufficient length to ensure adequate penetration into the supporting structure to resist pull out.

When installing in a warm roof system, the insulation should:

- Be fully supported by the receiving deck – on substrates of profiled metal, the short dimension should be parallel to the deck crowns and supported across half the crown width.
- Be laid in a broken bond pattern (except in tapered insulation schemes).
- Where two or more layers are laid, the joints in each layer should be offset.
- Insulation should be tightly butted at joints – any infilling of joints or small gaps should be to manufacturer's specification.
- Be kept dry and have appropriate controls to avoid trapping moisture during installation.

When installing in an inverted roof system, the insulation should also:

- Be protected by a water flow reducing layer (WFRL).
- Be ballasted in accordance with the specification to avoid floatation and wind uplift.

Thermal bridging risks

Design and specification of the roof system should take account of the effects of thermal bridging within the roof field areas, and at interfaces between the roof system and adjoining elements as parapet walls or abutments.

In particular, suitably designed safeguards against the effects of thermal bridging risks should be made for:

- Connections and junctions with adjoining or connected structure e.g. abutting walls, parapets, upstands.
- Fixings and fasteners used to secure insulation and/or waterproofing membranes.
- Threshold positions, formed gutters and sumps that result in a reduced thickness of insulation.
- The use of tapered insulation systems, and determination of the 'effective' performing minimum thickness.

When installing an inverted roof system, the effects of thermal bridging risks should also be considered for drainage of rainwater or snow-melt through insulation in inverted roofs – appropriate calculations to take account of the cooling effect of rainwater seeping through the insulation board joints should be carried out in accordance with in accordance with BS 6229 and ETAG 031-1.

Ventilation for cold roof systems

Cold roofs are only acceptable for roof areas less than $3m^2$.

Ventilation detailing should be the subject of an appropriate design in accordance with BS 6229 and BS 5250. Any proposals should include:

- An unobstructed minimum 50mm ventilation space above the insulation – measured from the upper surface of the insulation to the underside of the structural deck.
- Adequate cross ventilation served by openings at both ends of each joist void equivalent to a minimum 25mm gap.
- A maximum clear distance of 5m between ventilators on opposite sides of the roof.
- An effective AVCL at ceiling level.

11.4.12 Creation of falls

Flat roofs shall have a minimum finished fall of 1 in 80 to facilitate rainwater drainage.

The designer should ensure:

- Flat roofs should have a minimum finished fall of 1:80 (1.25%) on all main roof falls and intersecting falls (cross falls).
- Where two roof planes intersect at a cross fall, the line of the cross fall junction that is formed must effectively drain along its entire length. To achieve this, the adjoining roof planes should be designed to achieve a minimum installed finished fall of 1:60 or 1:40.
- Design falls should take account of any potential deflection and construction tolerances. In the absence of detailed calculations for deflection, design falls of twice the minimum finished falls (1:40 or 2.5%) should be used.

For Major Projects, the use of zero and absolute zero fall approaches may only be permitted where strictly agreed with the Major Projects Surveyor prior to commencement, and will be subject to a site specific appraisal.

Dependant upon construction type, roof falls may either be created by:

- The initial roof construction e.g. roof structure set to fall, firring sections (timber structure only).
- The addition of cementitious screed materials (concrete structure only).
- Tapered insulation systems.

Cementitious screeds should be in accordance with BS 8204 - Screeds, bases and in-situ floorings.

Lightweight screeds should be overlaid with a 1:6 (cement to sand) screed topping of a minimum 10mm thickness.

Tapered insulation systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall. However, where falls are created by tapered insulation, the design should ensure that the average U-value and maximum U-value required by the Building Regulations is achieved.

The use of these systems does not remove the need to check that deck deflection and tolerance is overcome and that a resulting fall in the waterproof membrane of a minimum of 1:80 is achieved. Allowance for deflection is particularly important in designing inverted roofs where calculation of dead loading should be based upon the ballast type and depth to be used.

11.4.13 Roof drainage

Flat roofs shall effectively drain rainwater from roof areas to a suitable drainage system.

All flat roofs should be designed to collect, direct and discharge rainwater to a suitable drainage system by a suitably experience drainage designer prior to roofing work commencing.

Information on roof plans

Flat roof designs should be supplemented by a schematic roof plan with all relevant points of the design clearly detailed. As a minimum, roof plans should include clear information on:

- Fall directions and gradients of all main roof falls.
- The position of any intersecting falls (cross falls) and the associated fall gradients.
- The position of all formed gutters, sumps, rainwater outlets (RWO's) and overflows.
- Any walkways or accessible areas.
- Any plant or equipment located on the roof.

Rainwater calculations

All relevant aspects of the drainage design should be based upon rainwater calculations, completed in accordance with BS EN 12056-3. The calculation should clearly communicate the design head of water used (taken typically 30-35mm above the outlet level) to inform gutter and outlet capacity, and overflow positioning.

Additional design considerations

The following should be factored into flat roof drainage designs:

- Roof areas with perimeter upstands or parapets that include formed gutters, should have at least two outlets serving each formed gutter. Alternatively, a combination of one outlet plus an emergency overflow may be used.
- Outlets should be positioned so that the direction of flow is not changed sharply (e.g. through 90° just before reaching it).
- The effects of additional surface finishes to facilitate access that may impede drainage. Where the roof includes paving on paving support systems, it should be designed and installed to ensure drainage is not detrimentally impeded.
- The effects of obstructions and or plant/equipment (including cabling) located on the roof. Additional rainwater outlets and/or insulation crickets should be provided to avoid ponding behind wide obstructions to the drained slope such as plant plinths or roof lights.
- Where rainwater downpipes from other higher roof areas, balconies or terraces discharge via a lower roof, an open downpipe shoe is not permitted. The downpipe should be connected directly to the downpipe serving the lower roof.

The disposal of rainwater discharge from the roof drainage system should be into an appropriate drainage system. The Performance Requirements and guidance stated by the 'Drainage – Above Ground Drainage' section should be considered applicable.

Siphonic drainage systems

The use of siphonic drainage systems will considered on a case by case basis by the Warranty provider.

They should be the subject of a full design and calculations which should be submitted for Warranty approval before construction begins on site. The Warranty provider does not consider siphonic drainage appropriate for inverted roofs.

11.4.14 Rainwater outlets

Rainwater outlets shall be appropriately sized and have the required capacity.

Rainwater outlets should:

- Be of the size and number required to deal with the expected rainfall intensity as determined by rainwater calculations completed in accordance with BS EN 12056-3.
- Be positioned to provide effective drainage to all areas of the roof - roof areas with perimeter upstands or parapets that include formed gutters, should have at least two outlets serving each formed gutter. Alternatively, a combination of one outlet plus an emergency overflow may be used.
- Interface with the waterproofing in a manner that facilitates the free flow of water, and does not check, slow or create an opportunity for ponding.
- Be accessible for maintenance.
- Be insulated to avoid surface condensation on the outlet and downpipe if passing through habitable areas.

Rainwater outlets should have their suitability assessed using information provided by the outlet manufacturer and supporting independent certification, and should include information on:

- Capacity in litres per second at a range of typical water heads.
- Compatibility with the waterproof membrane.
- The method of attachment.
- Where required, any integral insulation performance to avoid condensation where rainwater outlets constitute thermal bridges.

Rainwater outlets used in inverted roofs should be of the dual height type, designed to maximise removal of rainwater at WFRL level.

11.4.15 Overflows

Where required, overflows shall be provided and be adequately sized to avoid the risk of flooding to any roof area.

Roofs which drain to a single internal outlet or combined outlets connected into a single downpipe, should be provided with an overflow to drain and warn of outlet/downpipe blockage and so avoid the risk of flooding or structural overloading.

The capacity of the overflow should be not less than that of the outlet or combined outlets, and its discharge should be visible but directed away from the building.

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

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

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

11.4.16 Formed gutters

Formed gutters shall be appropriately sized to meet the required rainwater capacity, and all gutter beds constructed with a fall 1:80. Water collected by any formed gutter shall discharge water to a suitable drainage system via an outlet (or outlets).

Formed gutters (often referred to as boxed gutters) should be robustly constructed and gutter beds should achieve a 1:80 fall.

All relevant aspects of formed gutter(s) design should be based upon rainwater calculations, completed in accordance with BS EN 12056-3. The calculation should inform the gutter design in relation to:

- Length and size of the roof area to be drained, and any limiting factors.
- Size e.g. width, depth and length of the gutter to the outlet.
- Capacity and gutter flow rate.
- The design head of water used and overflow positioning.
- The position, size and number of outlets.
- All gutters (inclusive of their outlets) should be accessible for period maintenance and inspection.

Gutter beds and sides should use material capable of providing continuous support to any waterproofing system without deflection. Where required, insulation should be incorporated to avoid the detrimental effects of condensation and thermal bridging of the surrounding building elements. Thermal performance should be to the level required by the Building Regulations and proven by appropriate site specific condensation risk analysis.

11.4.17 Waterproofing systems

Flat roof structures shall be waterproofed so that they resist the passage of moisture due to rain and snow to the inside of the building. All waterproofing systems shall be suitable for their intended purpose.

All flat roof waterproofing systems, and all associated detailing shall be installed by a competent installer approved by the manufacturer.

General

Flat roofs should incorporate a waterproofing system and be designed and constructed to adequately resist the passage of water to the inside of the building and to materials that may be adversely affected by such moisture.

The selection of a waterproofing materials should be the subject of specialist design and specification, and be approved for their intended purpose. Selection should consider the following minimum criteria:

- Anticipated service life based on independent certification.
- Compatibility of components.
- Expected usage.
- Maintenance requirements.
- Ease of repair.

Material characteristics and independent certification

Material performance characteristics should be declared and relevant for their intended use.

Where a product has a harmonised standard, evidence of attainment of UKCA/CE marking should be provided.

Where a product does not have a harmonised standard, CE marking is still required and should be based on a European Technical Assessment (ETA) document produced in accordance with the relevant European Assessment Document (EAD).

All waterproofing systems should be used within their scope and be suitable for the intended purpose. This should be demonstrated by providing a valid third party product conformity certificate from an independent approval body which is accepted by us. For further information, please refer to ‘Appendix C’.

Statutory requirements in relation to fire

All roof coverings and associated waterproofing should achieve compliance with current Building Regulations.

Approved installers

All work execution should be strictly in accordance with the design and specification, and should be carried out by competent operatives with demonstrable experience in the area of flat roofing and the waterproofing system at hand.

This competence should be supplemented by evidence of the manufacturer’s approval of the contractor to install their products and this should be provided to the Warranty surveyor prior to works commencing.

Typically, this ‘Approved Installer’ evidence is provided in the form of an identity card, which features:

- The installer’s name.
- A passport-style photograph.
- A unique card number.
- An expiry date.
- The manufacturer’s name and logo.
- A list of the products and/or systems for which the installer has been trained.

Polymeric single ply membranes

Materials

All polymeric single ply membranes should declare compliance with the harmonised European Product Specification BS EN 13956 ‘Flexible sheets for waterproofing — Plastic and rubber sheets for roof waterproofing — Definitions and characteristics’, and provide declaration of characteristic values achieved by their product.

Installation

The installation of a single ply membrane should be:

- The subject of a site specific design and specification document which clearly details all materials and an appropriate installation methodology.
- In accordance with the ‘Single Ply Roofing Association’s Design Guide to Single Ply Roofing’, and the manufacturers installation requirements.

The site specific design and specification should include all relevant documentation e.g. a fixing schedule with supporting wind uplift calculations, Condensation Risk Analysis calculations, a roof plan, and all relevant waterproofing details.

The attachment of the single ply membrane should be designed to resist calculated wind load by a declared safety factor of two times (200%).

Where mechanical fixings are specified, the number and distribution of mechanical fasteners required to the membrane and/or preceding layers will be determined by calculation, and should relate to the geographical location of the building, topographical data and the height of the roof concerned.

Where roof systems are adhesively bonded, the adhesive should be approved by the insulation manufacturer and should be laid at the coverage rate and pattern designed to achieve a performance level to resist the effects of the calculated wind loads.

In all instances, specific restraint should be provided at the roof perimeter, at changes of slope and around details. Restraint methodology should be aligned with the manufacturers requirements and may include approaches such as:

- Individual fasteners, protected by a flashing.
- A linear bar, protected by a flashing.
- Clamping underneath a mechanically fastened, membrane-laminated trim, with the line of fixings waterproofed by a cover strip.
- Welding the field sheet to a membrane-coated metal trim secured to the deck (with thermal break fasteners where appropriate). This is not recommended for fully adhered membranes.

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

- Clamping beneath a metal rail, e.g. a parapet capping or roof light frame.
- Welding to a membrane-metal laminate trim (itself mechanically fixed).
- Mechanical fixing using individual fasteners or a mechanically fixed termination bar.

The welding of single ply membranes is a critical process. The following should be considered:

- Supply of certification for each installer indicating successful completion of the manufacturer's product specific training.
- Provision of consistent electrical power supply.
- Production and retention of test weld samples at the start of each day.
- Declared procedures for repair of weak welds or damage.

Liquid applied membranes

Materials

As there is no harmonised standard, all liquid applied membranes should have compliance declared using an ETA and EAD approach. Applicable EAD's are considered to be:

- 030350-00-0402 'Liquid Applied Roof Waterproofing Kits', **or**
- 030019-00-0402 Polysiloxane (where waterproofing on the basis of a silicone).

Installation

The installation of a liquid-applied membrane should be:

- The subject of a site specific design and specification document which clearly details all materials, material coverage rates in kg/m² or l/m², and an appropriate installation methodology.
- In accordance with the manufacturers installation requirements, and guidance documents published by the Liquid Roofing and Waterproofing Association.

The site specific design and specification should include all relevant documentation e.g. a fixing schedule for substrate/material receiving the liquid-applied system, any supporting wind uplift calculations, Condensation Risk Analysis calculations, a roof plan, and all relevant waterproofing details.

The type of insulation used for liquid applied membranes must be confirmed by the manufacturer of both the liquid applied membrane and insulation board manufacturer as being compatible.

The site installation of an OSB or plywood sheet over a proprietary rigid insulation board to facilitate application of a liquid-applied membrane should only be acceptable when supported by a site specific condensation risk analysis calculation.

Where an adhered carrier or preparation membrane is installed over an insulation board to facilitate the application of the liquid applied membrane, confirmation should be sought from the manufacturer of the insulation board regarding the compatibility of any roofing system primers or adhesives used for the attachment of the carrier material.

Where a liquid-applied membrane is required to bond onto lead pipe sleeves, flashings, steel balusters, anchoring system, etc., the preparation and any application of system specific primer should be in strict accordance with the specification and the manufacturers instructions.

The installation of a liquid-applied membrane should be the subject of a documented Quality Assurance procedure executed by the installing contractor to adequately demonstrate that a consistent material thickness and coverage rates have been achieved.

During installation, the Warranty provider may request assessment of wet film thickness by either gauge pin, 'Comb' type measurer or visual inspection.

Mastic asphalt

Materials

Within any documentation provided, mastic asphalt should demonstrate an appropriate specification for the intended purpose, and be in accordance with BS 6925 Specification for mastic asphalt for buildings and civil engineering (limestone aggregate).

Separating membranes should be laid directly under the mastic asphalt, and should be either:

- 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 included within the system should be in accordance with BS EN 13658-2 'Metal lath and beads. Definitions, requirements and test methods.'

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.

Installation

The installation of a mastic asphalt should be:

- The subject of a site specific design and specification document which clearly details all materials, the number of coats required, and an appropriate installation methodology.
- In accordance with the guidance of BS 8218 'Code of practice for Mastic asphalt roofing', and guidance documents published by The Mastic Asphalt Council.

The site specific design and specification should include all relevant documentation e.g. a fixing schedule for substrate/material receiving the liquid-applied system, any supporting wind uplift calculations, Condensation Risk Analysis calculations, a roof plan, and all relevant waterproofing details.

BS 8218 gives recommendations for the use of mastic asphalt in roofing for both flat and sloping roofs and covers a variety of applications. The number of coats should be appropriate to the waterproofing requirements and traffic conditions of the roof. Typically:

- 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.
- On sloping and vertical surfaces over 10° pitch, the mastic asphalt should be laid in three coats to a thickness of 20mm without a separating membrane.
- On sloping and vertical surfaces of timber or lightweight concrete, the mastic asphalt should be laid in three coats to a thickness of 20mm on expanded metal lathing over a separating membrane of sheathing felt.

Reinforced bitumen membranes

Materials

All reinforced bitumen membranes should declare compliance with the harmonised European Product Specification for reinforced bitumen membranes, BS EN 13707, and provide declaration of characteristic values achieved by their product.

Specifications for systems of multi-layer reinforced bitumen membranes for flat roofing should comply with BS 8747 'Reinforced bitumen membranes (RBMs) for roofing. Guide to selection and specification'.

Minimum recommended specification for reinforced bitumen membranes are provided below:

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

Notes:
[1] Insulation type: Thermoplastic foam: PIR, EPS, PF. Mineral fibre: MW.
[2] Venting layer: BS 8747 3G or proprietary equivalent with suitable certification.
[3] Under layer: as defined in BS 8747. SBS-modified products are recommended.
[4] Cap sheet: as defined in BS 8747. SBS-modified products are recommended.
[5] S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic); the higher the rating, the higher the performance.

Bitumen membranes should be protected from solar radiation 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.

Installation

The installation of reinforced bitumen membranes should be:

- The subject of a site specific design and specification document which clearly details all materials and an appropriate installation methodology.
- In accordance with the relevant guidance within BS 8217 and BS 8747, and the manufacturers installation requirements.
- In accordance with guidance documents published by the National Federation of Roofing Contractors.

The site specific design and specification should include all relevant documentation e.g. a fixing schedule with supporting wind uplift calculations, Condensation Risk Analysis calculations, a roof plan, and all relevant waterproofing details.

Where a reinforced bitumen membrane is installed over an insulation board, work should be executed strictly in accordance with the specification. This specification should include confirmation from the manufacturer of the insulation board regarding the methodology used for the attachment of the bitumen membrane e.g. torch-applied, adhesive bonding, and cover the compatibility of any roofing system primers or adhesives with the insulation boards receiving surface.

Site-applied hot melt coverings

Materials

As there is no harmonised standard, all site applied hot melt coverings should have compliance declared using an ETA and EAD approach. The applicable EAD is:

- 030065-00-0402 ‘Composite Roof Waterproofing Kits’.

Installation

The installation of hot melt coverings should be:

- The subject of a site specific design and specification document which clearly details all materials, and an appropriate installation methodology.

The site specific design and specification should include all relevant documentation e.g. a fixing schedule with supporting wind uplift calculations, Condensation Risk Analysis calculations, a roof plan, and all relevant waterproofing details.

The installation of hot melt coverings should be the subject of a documented quality assurance procedure executed by the installing contractor to adequately demonstrate that the required material thickness detailed within the specification has been achieved.

Bond tests between the covering and substrates should also be carried out prior to commencement of works to prove and demonstrate the required bond is achieved, and these should be documented within the Quality Assurance documentation on site. If bonding problems occur, advice must be sought from the manufacturer.

EPDM roof coverings

Limitations

EPDM products are only acceptable for Warranty purposes where the roof:

- Does not exceed a 100m^2 maximum roof area (Gross flat roof area of the project – not individual plots), **and**
- Is a simple open plan laid to fall roof is proposed (i.e. no parapets, changes of levels or plant installations).

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

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

Materials

Within any documentation provided, the manufacturer should declare compliance with the harmonised European Product Specification BS EN 13956 ‘Flexible sheets for waterproofing — Plastic and rubber sheets for roof waterproofing — Definitions and characteristics’, and provide declaration of characteristic values achieved by their product.

Installation

The membrane should only be acceptable for Warranty where it is installed as a fully adhered bonded only membrane to the roof deck (not mechanically fixed with ballast covering), and should be:

- The subject of a site specific design and specification document which clearly details all materials and an appropriate installation methodology.
- In accordance with the manufacturers installation requirements.

The site specific design and specification should include all relevant documentation e.g. a fixing schedule with supporting wind uplift calculations, Condensation Risk Analysis calculations, a roof plan, and all relevant waterproofing details.

11.4.18 Detailing

Flat roof waterproofing systems shall be appropriately detailed to ensure satisfactory performance against the effects of weather. Factors to be included are:

- Rain and snow.
- Wind and exposure.
- Movement – structural and thermal.

The site specific design and specification should include a roof plan which includes the type and position of all detailing.

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

- Upstands to extend 150mm above the finished roof level.
- Down stands (of separate metal or other flashings) should lap the upstand by a minimum 75mm.
- Construction should achieve independence between different elements and trades.
- Thermal and fire performance should be maintained across the detail.
- A continuous barrier to air leakage should be maintained.
- Reliance on sealant as the sole means of protection should be avoided.

The total roof zone depth should be assessed at critical points, such as the top of drainage slopes, to ensure that there is enough free upstand available to create the minimum required 150mm of waterproofing protection above finished roof level.

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

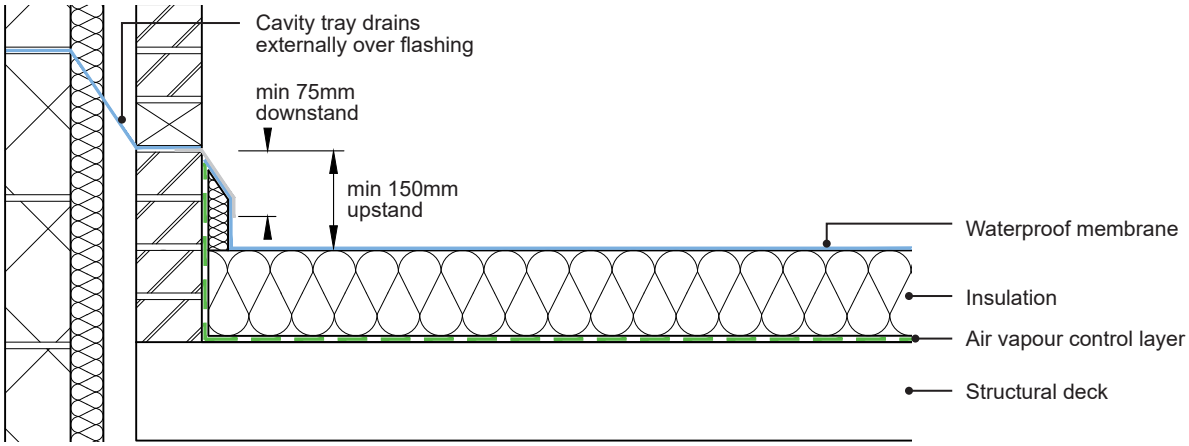
Designers should carefully consider the risks of any departure from this criterion. In the event of this being unavoidable, a written justification should be provided.

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

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

The following illustrations are intended as a guide to demonstrate the general principles of common used flat roof detailing. Further information on specific waterproofing systems may be obtained from BS 6229 and BS 8217.

Example of warm deck roof at an abutment

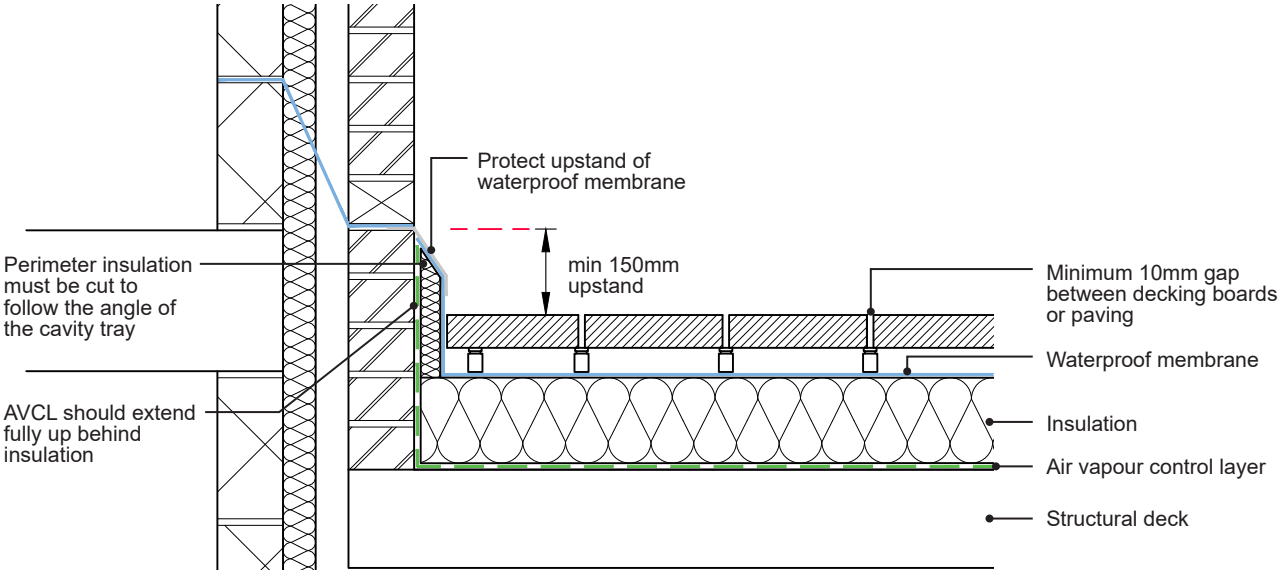


Insulation fully wrapped around by air vapour control layer and waterproof membrane.

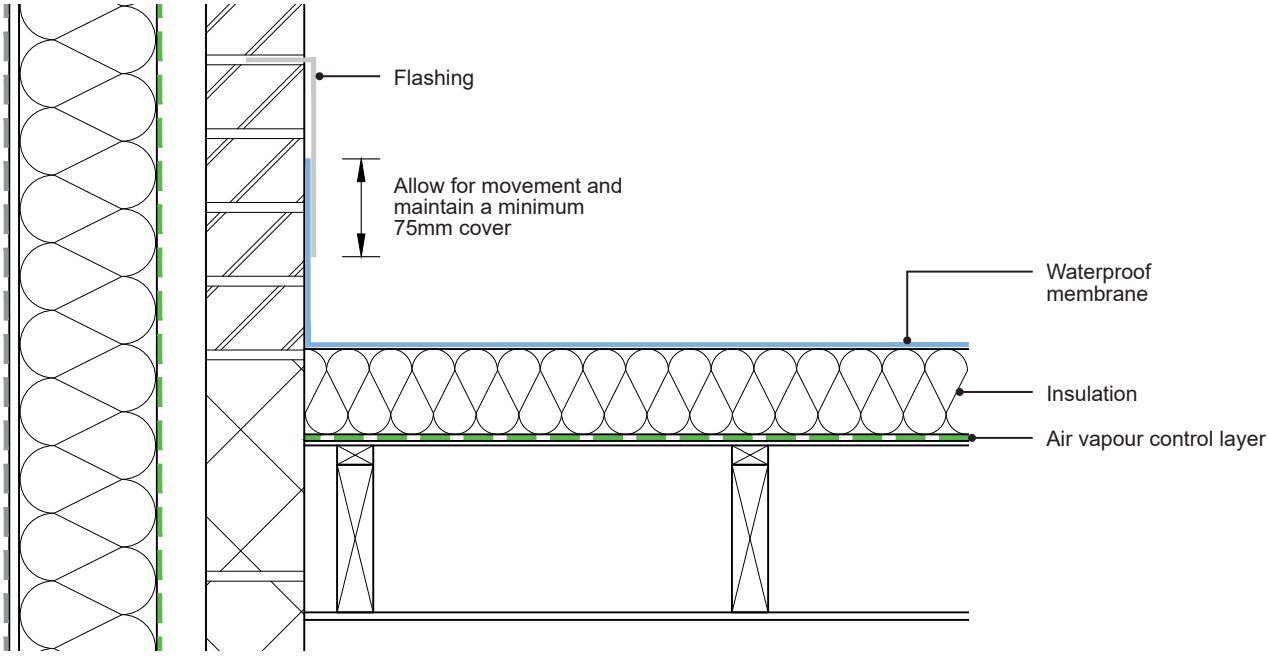
Notes:

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

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



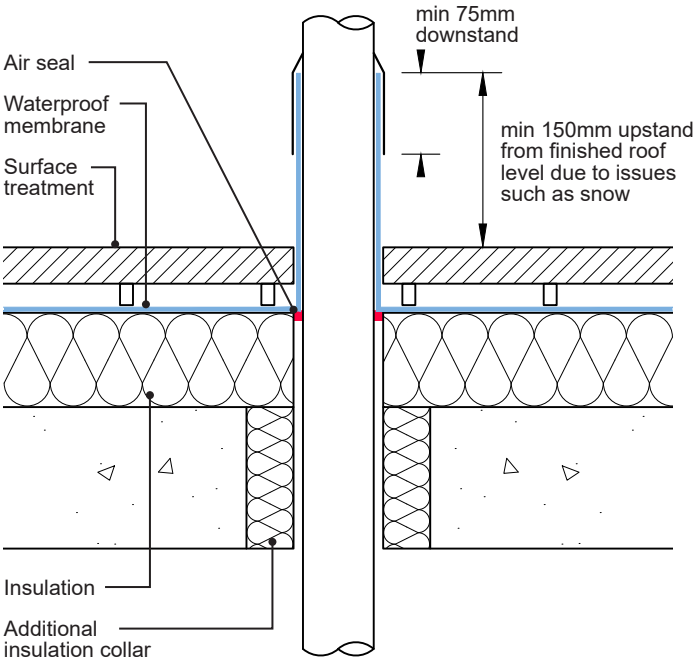
Allowance for movement where a timber frame with masonry cladding abuts a flat roof



Where a timber frame structure abuts a masonry structure, allowance should be made to accommodate movement in the timber frame and ensure the appropriate cover is maintained.

For detailing with parapet wall construction, see the ‘External Walls’ section.

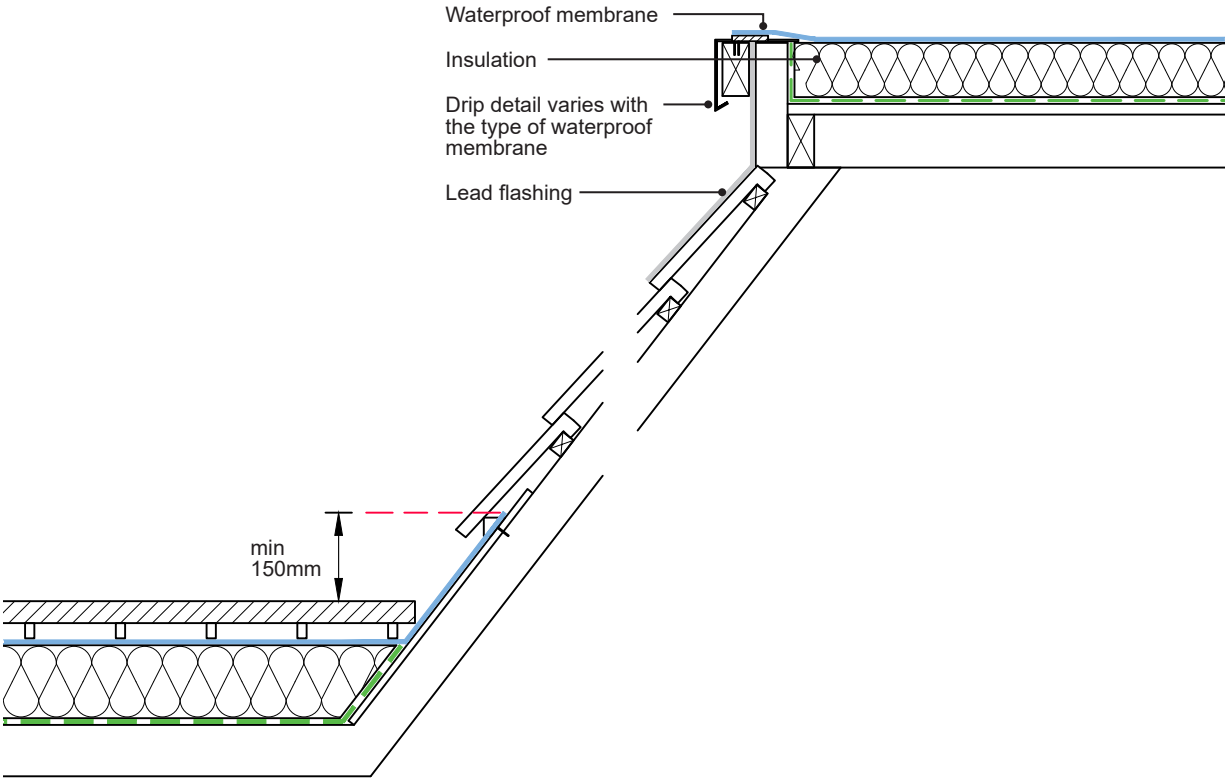
Penetration through roof system



Notes:

- Upstands to extend 150mm above the finished roof level.
- Down stands (of separate metal or other flashings) should lap the upstand by a minimum 75mm.
- A chamfered fillet is required at the base of the upstand for certain types of waterproof membrane. Roof membrane manufacturer specification should be followed.
- An effective seal is required between the air vapour control layer and pipe. It is difficult to dress a sheet material around a pipe. ‘Star cut’ approaches should be avoided where possible and proprietary “top hat” products are often most suitable. The method for doing so should be stated in the contract drawings and/or specification.

Principles: Flat roof interface to pitched roof



Special design features

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

- Minimum clearances to enable the waterproof membrane to be installed.
- Termination of the waterproof membrane at interfaces to other elements.
- Penetrations should be grouped wherever possible.
- Supports.

11.4.19 Completion testing

Waterproofing systems shall be tested where required by this section, when complete, to prove and demonstrate resistance to the passage of moisture.

Final inspection prior to test commencement

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.

Testing of flat roofs (all types of waterproofing systems)

Upon completion testing of the flat roof covering will be required to be carried out as per the following criteria.

Parameters for testing

Testing is required in the following situations:

1. On low rise housing: Detached/semi-detached/terraced housing 3 stories or less in height (including the ground storey) when:
   a. The roof areas exceed 50m², **or**
   b. Where the project consists of 10 or more properties: one test per ten houses (with a minimum of two tests per site) are required.
2. On large developments: Apartments etc. over 3 stories in height (including the ground storey), where the total combined roof areas exceed 50m². In this case, a minimum of 20% of the roof areas must be tested.
3. On developments involving our Major Projects Team, all flat roofs will require low voltage testing.
4. Where, after completion of the site risk assessment, the Warranty surveyor has identified areas of complexity in relation to the roof and its ancillary components that present a higher risk to Warranty (e.g. service penetrations, abutments with claddings, and penetrations from fixed items such as man safe systems).

These areas of complexity may be resultant of elements of:

Design, where:

1. The roof includes features beyond a typical wall abutment e.g. (but not limited to); variations of upstand constructions/penetrations/fixings/external permanent machinery/balustrading fittings etc.
2. The waterproof membrane is to be covered over (by pedestrian finishes or solar panels). Note: Inverted roofs of straightforward design and with continuous hot-applied waterproof membrane could be exempted.

Construction, where:

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

In all circumstances, testing should be carried out when the first flat roofs are completed to determine if there are any inherent issues with the design or workmanship. Where there is a failure the root cause should be determined and appropriate remedial actions should be taken. The Warranty surveyor may request an increase in the amount of testing required.

Testing of EPDM roof coverings

Where EPDM roof coverings are installed and require testing, they must be tested at completion to demonstrate waterproofing integrity. The testing provider will need to demonstrate their chosen technique is suitable for testing EPDM roof coverings as electronic leak detection techniques are not suitable.

Procurement of testing services

If testing to demonstrate waterproofing integrity is required, it should be undertaken by a suitably qualified and experienced third party who is independent of the roofing contractor.

The testing service provider should provide evidence of the following:

- Efficacy of the method proposed in the circumstances of the project.
- A detailed testing regime that includes integrity testing of detailing, specifically where the Warranty surveyor has raised these as elements of complexity within the site risk assessment.
- Experience and training of operator.
- Membership of an appropriate trade association that sets a Code of Conduct for the service.

Methods of test

Low voltage earth leakage

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

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

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

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

Flood testing
Flood testing is not recommended as a method of demonstrating the integrity of flat roofs. It may be used to test balconies.

11.4.20 Operations and Maintenance Manual

The operations and maintenance manual shall be provided to the homeowner upon completion.

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

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

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

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

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

11.4.21 Protection of completed waterproofing

Where access provision is required, the waterproofing systems shall be appropriately protected to prevent damage.

Protection of roof system

The anticipated use of the roof during service should be assessed and the associated risk of damage determined based upon factors such as:

- Type of load exerted e.g. foot traffic, equipment.
- Risk of damage posed by use.
- Frequency of access e.g. permanent foot traffic, periodic maintenance and servicing access.

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

- Polymeric single ply membranes: compatible sheets or tiles welded to the membrane.
- Load-spreading materials.
- All waterproof membrane types: paving on paving supports or protection layer.
- Polymeric single ply and reinforced bitumen membranes: galvanised steel sheet with additional covering with slip-resistant finish.

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.

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 be laid on routes where access is most likely, and should not be laid on routes where temporary ponding is likely e.g. near parapet walls in the absence of cross falls between rain water outlets.

It is recommended that concrete paving is laid on support pads, as this allows adjustment. The following should be considered:

- The height of support pads should not exceed the maximum recommended by the manufacturer.
- Paving should not be cut. If cutting (part-slabs) is unavoidable to match plan geometry then an alternative means of support may be required.
- Paving should be firmly butted up against support pad separating pegs.

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

Ancillary components installed on top of a waterproof layer

Non-access areas: stone ballast
Stone ballast for inverted warm deck roofs and ballasted warm deck roofs should be clean, rounded aggregate graded 20mm-40mm and as free from fines as practicable. Ballast should be applied over a protection layer on warm ballasted systems and over a filter layer or WFRL on inverted warm roofs.

Access areas: concrete paving slabs
Concrete paving slabs for use as walkways or as paving on terrace decks should conform to BS EN 1340 and be laid in accordance with the manufacturer's instructions.

Access areas: flexible walkway tiles
Evidence of the compatibility of the tile with the waterproof membrane is required.

Pedestals
Where pedestals are specified to support pedestrian surface finishes (such as paving slabs), they should be:

- Appropriate for the intended purpose.
- Appropriate for the site specified conditions.
- Compatible with the waterproofing system, thermal insulation and all other components within the roof terrace build-up.

Pedestals, and the loads they impose on the structure below should not exceed the expected designed loads. The compressive strength of the insulation, waterproof membrane and other materials within the flat roof build up should be considered by the designer when specifying pedestal systems.

Where dead and/or live loads are anticipated to be high, there should be consideration for the use of a cover board underneath the waterproof layer and/or a rail system.

In addition, the pedestal should not create a risk of damage to the waterproofing (e.g. sharp edges).

11.4.22 Control of work post waterproofing completion

Any additional works carried out by a third party, after the waterproofing system completion but prior to the building being signed off for Warranty shall:

- Be a part of the original design proposal.
- Appropriately managed.
- Controlled to avoid a loss of waterproofing integrity.

General

Where additional work is required to facilitate a follow-on service or function, as far as practicable, any waterproofing work should be executed by the approved installer of the waterproofing system. Where this cannot be accomplished, any work conducted by a third party should be inspected and signed off by the approved installer when complete. The Warranty surveyor at their discretion may request evidence of this for record purposes.

Relevant additional work is considered to include:

- Installation of lightning protection.
- Installation or placement of mechanical, electrical and communication services.
- Installation or placement of renewables e.g. PV panels.
- Installation of safety equipment for access.

The placement of services and or equipment is considered a foreseeable function that can be factored in at design stage, and as such the Warranty provider requires that all work is included into the site specific design and specification.

Surface attachment

Any form of attachment made to the surface of a waterproofing system (e.g. lightning protection pads or clips) must not compromise the integrity of the waterproofing system or diminish its longevity. The materials, inclusive of bonding adhesives, and methodology for attachment should be confirmed as compatible with the waterproofing system by the waterproofing manufacturer.

Service penetrations

If penetrations can be avoided and cabling and/or pipework suitably routed without penetrating the waterproofing system, then this is considered the preferred course of action. Where penetrations cannot be avoided, then they should be formed to avoid water ingress and formed using appropriate detailing and materials.

Where ductwork is located on a roof:

- A 50mm clearance should be provided to horizontal ductwork to ensure it does not rest upon the waterproof membrane or roof finish.
- Entry/exit points should be suitably weathered without loss of integrity of the waterproof membrane – this should include the formation of appropriate upstands in the waterproof membrane at risers and include separate down stand or weathering flashing to be formed in ductwork.

Equipment and plant installations

Loads from equipment, associated mounts or frames and any ballast should appropriately transfer loads to the structure without damage to the waterproofing system. The placement of equipment and/or plant, and any associated proprietary framework systems or mounts onto the waterproofing system should include all relevant protection measures to ensure that the risk of damage is avoided.

Where there is a requirement for structural fixings or mounts to penetrate through the waterproofing system and into the roof structure, installation requirements stipulated by the manufacturer of the associated equipment should be communicated to the waterproofing system manufacturer and installer to enable the design and execution of an appropriate waterproofing detail.

Penetration from structural fixings or anchor points

Where there is a requirement for structural fixings or anchor points to penetrate through the waterproofing system and into the roof structure, installation requirements stipulated by the manufacturer of the associated equipment should be communicated to the waterproofing system manufacturer and installer to enable the design and execution of an appropriate waterproofing detail.