# FUNCTIONAL REQUIREMENTS

## 7.10 ROOF COVERINGS – CONTINUOUS MEMBRANE ROOFING

### Workmanship

**i.** All workmanship must be within the tolerances defined in Chapter 1 of this Manual.
**ii.** All work is 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 that 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.** Whilst there is and can be no Policy responsibility and/ or liability for a roof covering performance life of 60 years or less, roof coverings shall be designed and constructed so they have an intended life of not less than 15 years.

### Design

**i.** The 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 regional building regulations.

### Limitations of Functional Requirements

**i.** The Functional Requirements are limited by the recommendations applied to the specific areas covered in this chapter.
**ii.** These Functional Requirements do not and will not apply to create any policy liability for any remedial works carried out by the contractor or otherwise, nor to any materials used in those remedial works.

### 7.10.1 Definitions

For the purposes of this Technical Manual, the following definitions shall apply:

**Flat roof:** a roof having a pitch no greater than 10º 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.

**Insulation cricket:** wedge of shallow- fall insulation material, designed to divert the flow of rainwater on a roof

**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) 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 system.

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

**Protection layer:** construction material (usually a geotextile all rigid board) that 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) that separates two construction materials that 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 VCL 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.

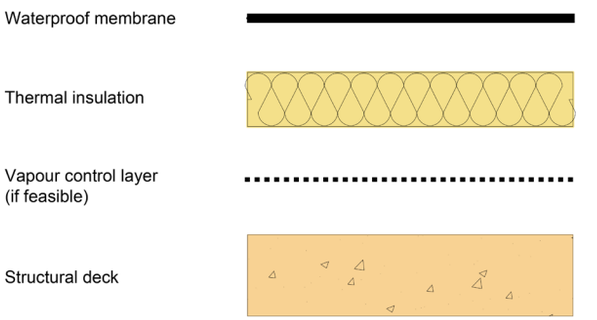


**Figure 1: Warm roof (section) above vapour control layer (if shown by calculation to be required)**

**Inverted warm deck roof**

A variant of the warm deck roof in which the principal thermal insulation is placed above the waterproof membrane, resulting in the waterproof membrane, structural deck and structural support being at a temperature close to that of the interior of the building. Generally, the principal insulation is secured by separate ballast (paving or stone).

A filter membrane or (WCM) should be provided to control mineral and organic material passing into and below the insulation joints. A WCM is recommended because it will provide improved rain water run off, which may allow for a reduced thickness of insulation and reduced loading of ballast. If a WCM is included, it is essential that the drainage design facilitates the rapid transfer of rain water across the product and to rain water outlets.

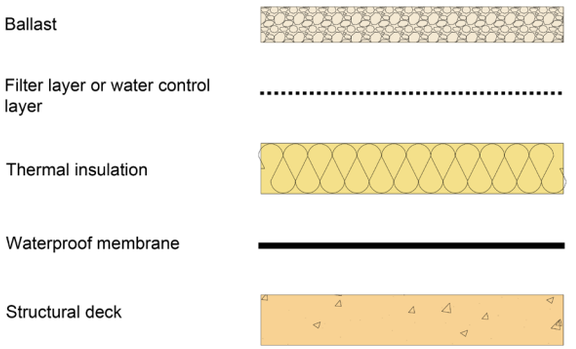


**Figure 2: Inverted warm roof (section)**

### 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, e.g. if during refurbishment, a cold deck roof is converted to a warm deck roof by placing insulation above the deck and closing off the ventilation. It is necessary to provide at least as much thermal resistance above the deck as was previously provided below the deck. A condensation risk calculation should always be carried out in such circumstances to ensure that the deck is above dew point during service.

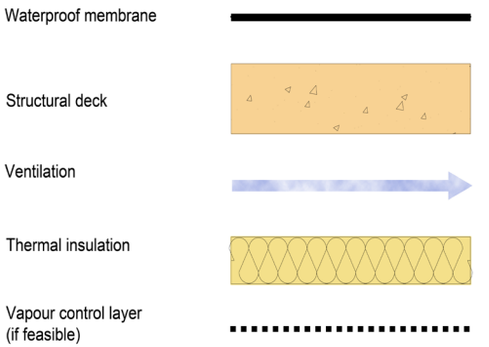


**Figure 3: Cold roof (section) 'under ventilation' (to / from external air. Minimum height of void 50mm)**

### 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 with regards loading with equipment, e.g. air handling, renewable energy capture and the intensity and frequency of foot traffic. This should inform the selection of the deck, insulation, safety guarding and protection.

### 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 calculations, this may necessitate design falls of twice the minimum finished falls (1:40 or 2.5%).

Cut-to-falls systems are often produced to a 1:60 (1.7%) fall or 1:40 (2.5%) fall. However the use of these systems does not remove the need to check that deck deflection and tolerance is overcome and that a resulting fall in the waterproof membrane of a minimum of 1:80 is achieved. Allowance for deflection is particularly important in designing inverted roofs where calculation of dead loading should be based upon the ballast type and depth to be used.

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

Consideration should also be given to;

- The available upstand height at the high end of the falls. This may be a limiting factor on the length/size of the roof area to be drained. If necessary additional rainwater outlets should be provided.
- Avoidance of ponding behind wide obstructions to the drained slope such as plant plinths or roof lights. Additional rainwater outlets and / or insulation crickets should be provided.
- Avoidance of gutters by designing with intersecting roof planes.
- Falls between rain water outlets along a perimeter.

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

Ponding on membrane roofs 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.
Water proof 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 either be created during the construction of the deck or alternatively by using tapered insulation systems.

The creation of falls in the deck should always be attempted because it has the following advantages:

- There will be a consistent thermal environment across the roof.
- The VCL will also be to a 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 to sand) screed topping of a minimum 10mm thickness.

Tapered insulation schemes, suitable for warm deck roofs only, have the following advantages:

- It is possible to create effective drainage layouts to complex plan areas.
- Mitred falls can be created easily to direct rain water to single points where outlets are to be located.

Where falls are created by tapered insulation, the design should ensure that the average U-value and maximum U-value at any point, required by SBEM or SAP calculation, is achieved.

Where the roof finish is to include paving on access routes, consideration should be given to the height difference created by the falls and spacing of rain water outlets in order that the maximum height of paving supports is not exceeded or trip hazards created.

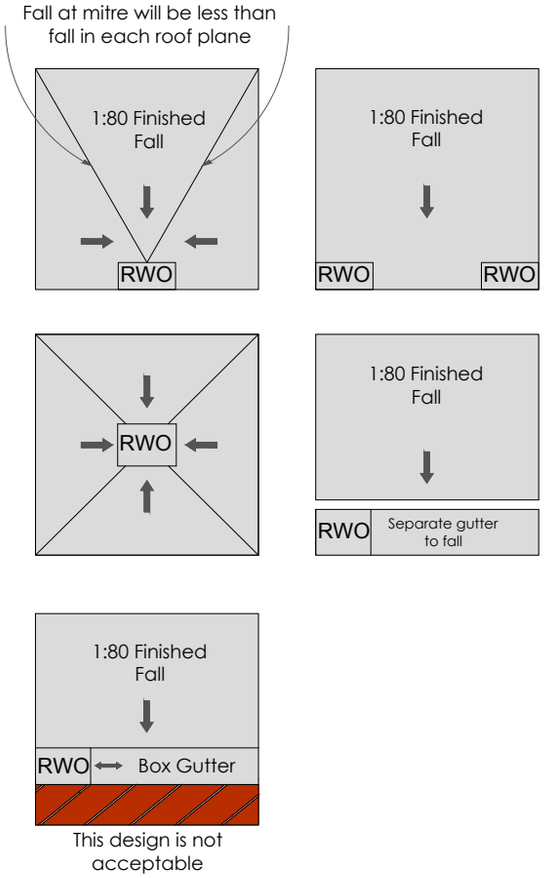


**Figure 4: Drainage layout options**

### 7.10.5 Drainage

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

It is not generally necessary to provide separate box gutters where two planes of roofing intersect, or where a single plane falls to an abutment. In the latter case, there will be no fall between outlets, so consideration should be given to creating these in the structure or insulation. Box gutters are slow, difficult to construct and introduce unnecessary complexity. The need to maintain a fall in gutters and comply with the energy requirements of the Building Regulations may be difficult to achieve.

All waterproof membranes are compatible with siphonic roof drainage systems, which for larger roofs offer many advantages:

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

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

Roof systems designed to attenuate the discharge of rainwater to surface water drainage are becoming more common. Any such designs must consider not only the effect upon loading but also the effect of hydrostatic pressure on the waterproof membrane. Where a head of water is deliberately retained on the roof, appropriate certification of the waterproof membrane product must be supplied which demonstrates fitness for purpose in this application.

### 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 rain water or snow-melt through insulation in inverted roofs. The use of WCMs beneath ballast to reduce thermal bridging is recommended.
- The locations of above-average thermal transmittance at sumps, gutters or areas of minimum thickness of tapered insulation.

Manufacturers of thermal insulation and WCMs provide certification and calculations of the effects of thermal bridging by fasteners and drainage respectively. Further advice is available in Building Research Establishment BR 262 Thermal insulation: avoiding risks, 2002 edition.

#### 7.10.6.3 Air permeability

Relevant contract drawings should define the position of the component – the air barrier – that determines resistance to air permeability. This may be achieved by an additional, purpose designed membrane or by an additional function of another component, such as the deck or waterproof membrane.

#### 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. The calculated maximum accumulation of moisture within thermal insulation should not exceed 350g/m2 and there shall be no net accumulation in any annual cycle.

### 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 roof-level pedestrian routes to equipment that 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 weather proof (incorporating an upstand/cover flashing arrangement) or waterproof (providing continuous waterproofing across the detail).

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

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

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

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

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.

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

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

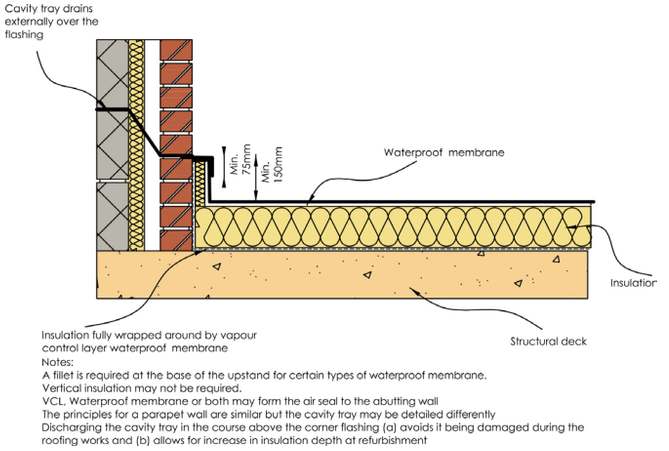


**Figure 5: Principles of detailing: an example of warm deck roof at an abutment**

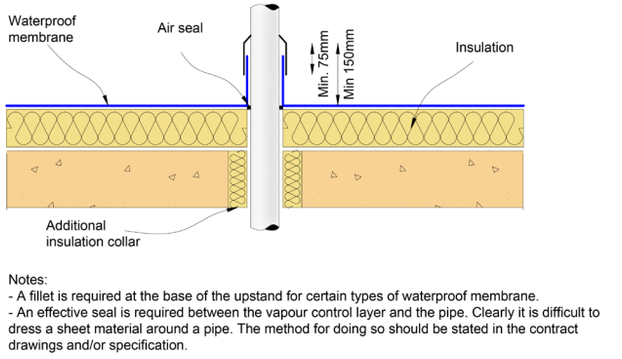


**Figure 6: Penetration through roof system**

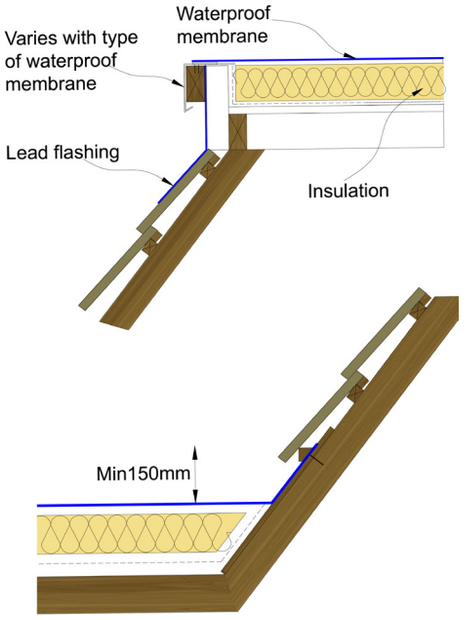


**Figure 7: Detail: principles: flat roof interface to pitched roof**

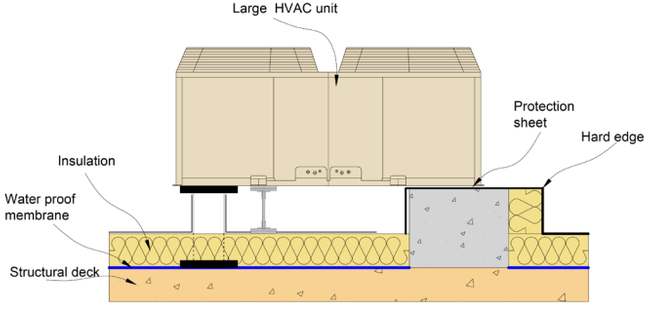


**Figure 8: Detail – principles: Options for support of plant support**

#### 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 that 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 the roof's waterproofing integrity and without the involvement of the roofing specialist. Support systems based on 'top-fixed' plate and post components should be accompanied by documentation to demonstrate their compatibility with the waterproof membrane.

#### 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 and without the involvement of the roofing specialist.
- The upstand of the waterproof membrane at risers should be arranged to enable a separate downstand or weathering flashing to be formed in ductwork.
- Cladding to insulation placed around ductwork should not be sealed to the waterproof membrane.
- Sufficient clearance should be provided to horizontal ductwork to ensure it does not rest upon the waterproof membrane or roof finish.

### 7.10.10 Materials

#### 7.10.10.1 Requirement

**General**

Materials for use in flat roofing systems are suitable only if the manufacturer has declared compliance with the relevant harmonised European Product Specification (hEN or European Technical Approval Guideline (ETAG) and has affixed the CE Mark to the product. All waterproof membrane products shall also have a certificate of fitness for purpose issued by a member of the European Union of Agrément (UEAtc). This may comprise a British Board of Agrément certificate or an equivalent certificate of another UEAtc member.

#### 7.10.10.2 Structural deck

**General**

At the earliest practical stage, the likely deflection in the deck, and the tolerance in the level of its finish, should be confirmed, because this informs the design for drainage. If the deck is intended to receive mechanical fasteners for the attachment of roof system components such as insulation, or equipment such as fall-arrest line posts, its resistance to pull-out should also be confirmed to enable design for resistance to wind load.

**Concrete**

Precast concrete construction should be designed in accordance with BS 8110. Information on span capability and the installation requirements of precast panels can be obtained from manufacturers. Information on the location of required movement joints should be obtained early in the design process as they have implications for drainage layout and detailing. Precast panels installed to a fall can provide a simple layout but without cross falls.

In-situ concrete construction should be designed in accordance with BS 8110. It is more difficult to lay to a fall, and it is more common to create falls in the insulation (warm roofs only) or by using an additional screed. Information on compressive strength, resistance to point load and drying periods of wet screeds can be obtained from suppliers and relevant trade associations.

Where structural movement joints are required in large concrete decks, a clearly defined movement joint detail should be constructed to a design and with the materials that afford durability equivalent to that of the roof system.

In precast panel decks, the locations of any anticipated differential movement (e.g. at perimeter or abutment interfaces or between adjacent panels that are subject to differential loading) must be identified in order that stress is not transferred to the waterproof membrane.

**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

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.

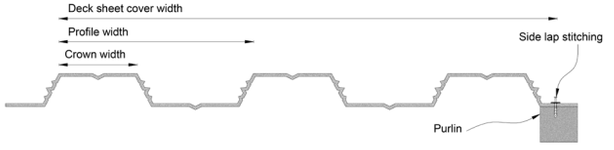


**Figure 9: Profiled metal decks: critical dimensions**

**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 Eurocode 5. Design of timber structures, and to BS EN 636 Plywood, specifications minimum service class 2 – humid conditions, or, where required, service class 3 – exterior conditions.

**Composite panels (deck/vapour control/insulation)**
The suitability of composite panels in providing a combined deck, VCL and thermal insulation in a single component should be assessed with reference to the loading and hygrothermal conditions in the application. There is no relevant hEN or British Standard. Products suitable for roofing should have current certification by one of the following:

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

**Note:** cement particle board is not suitable as a supporting deck. It may be used to clad an abutment or parapet but is not suitable for use with mechanically fastened single ply membrane.

**7.10.10.3 Vapour control layer (VCL)**
The VCL should be selected with regard to the following minimum criteria:

- Ease with which it can be sealed at laps and at abutments to other elements.
- The method of attachment.
- Condensation risk, expressed as calculated vapour pressure based on notional conditions pertaining to the project building.
- Compatibility with the waterproof membrane and thermal insulation.

The following is a minimum recommended specification. The actual specification will depend on the level of vapour resistance required, based on calculation, and the type of deck.

| 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. |

**Notes:**

(1) Reinforced bitumen membranes: minimum recommended specification based on classification in BS 8747.

(2) S and P are classifications 1-5 of Strength (tensile strength and elongation) and resistance to puncture (static and dynamic). The higher the rating, the higher the performance.

**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 VCL 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).

**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 reinforced bitumen membranes, BS EN 13707, which defines requirements for testing and declaration of characteristic values. There is no relevant British Standard.

Products suitable for roofing should have current certification by one of the following:

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

The following specifications will be acceptable as a minimum:

| Roof system type | Decks type | Insulation type | Venting layer | Underlayer | Cap sheet |
|---|---|---|---|---|---|
| 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 | Exruded 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
6. (static and dynamic); the higher the rating, the higher the performance

**Table 3: Minimum recommended specification for reinforced bitumen membranes**

In addition, specifications for systems of multi-layer reinforced bitumen membranes for flat roofing should comply with BS 8747.
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 as follows:

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

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

### 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 on warm ballasted systems and over a filter layer or WCM on inverted warm roofs.

**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 the manufacturer's instructions.

**7.10.13.3 Access areas: porous concrete tiles (for use on reinforced bitumen sheets and mastic asphalt only)**
Tiles for walkways or terrace deck paving should be designed for this application, bedded in a bonding compound compatible with the water proof membrane and fixed in accordance with the tile manufacturer's recommendations.

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

**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

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

**7.10.13.6 Fall-arrest and edge protection equipment**
The following should be confirmed by reference to the manufacturer's information or independent certification, as appropriate:

- Capacity in litres per second at a range of typical water heads
- Compatibility with the waterproof membrane
- Integral insulation to avoid condensation
- Method of attachment

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

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

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

**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 that 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.

A clear plan of type, location, sequencing and removal of temporary protection should be available before the roof system installation starts.

**Permanent protection (during service)**

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

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

- The height of support pads should not exceed the maximum recommended by the manufacturer.
- Paving should not be cut.
- 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 a broken bond pattern. Where two or more layers are laid, the joints in each layer should be offset. On substrates of profiled metal, the short dimension should be parallel to the deck crowns and supported across half the crown width.

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

**Warm roof systems with reinforced bitumen membrane waterproofing**

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

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

Where the method of attachment is outside the scope of BS 8217, the manufacturer should demonstrate that the method provides sufficient resistance to wind load.

**Warm roof systems with mastic asphalt waterproofing**

Generally, mastic asphalt on sheathing felt provides sufficient dead load to resist wind load, but this should be demonstrated by calculations in all situations.

**Warm roof systems with polymeric single ply waterproofing**

Where the insulation is mechanically fixed, the number and arrangement of fasteners required to resist wind load will be prescribed by the manufacturer, applying a safety factor of two to the design load on each fastener. This arrangement may vary across the roof according to wind load, but should be followed in all areas. Thermal break fasteners shall be used wherever feasible.

Where the insulation is adhered, the adhesive should be approved by the insulation manufacturer and should be laid at the coverage rate and pattern designed to achieve calculated wind load with a safety of factor of two times (200%). The contractor should allow for temporary loading as required to achieve a suitable adhesion and to achieve the best possible level in the upper surface of the insulation.

### 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's Design Guide to Single Ply Roofing and with the specific instructions of the membrane manufacturer.

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

Whatever the means of attachment, specific restraint is always required at the roof perimeter, at changes of slope and around details. This ensures that any tension in the membrane in the roof field or upstand is not transferred to the other as a peeling action.

Perimeter restraint is achieved by several methods, depending upon the manufacturer:

- Individual fasteners, protected by a flashing
- A linear bar, protected by a flashing
- Welding the field sheet to a membrane-coated metal trim secured to the deck (with thermal break fasteners where appropriate)

If restraint relies upon adhesive alone, the membrane manufacturer shall provide evidence of satisfactory testing for resistance to wind load using a method defined by the Single Ply Roofing Association.

If the remainder of the roof system is to be bonded, it is essential that the design resistance to wind load is also achieved for the attachment of these components.

Irrespective of the wind uplift considerations or distribution requirements for securing the membrane, the fixing of the insulation boards should always be considered separately, unless specifically sanctioned by the membrane manufacturer. The number and distribution of mechanical fasteners required to fix the insulation boards may vary with the insulation type, geographical location of the building, topographical data and the height of the roof concerned.
The upper termination of the single ply membrane at linear details such as plinths, parapets, abutments and door openings should be secured by one of the following mechanical means:

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

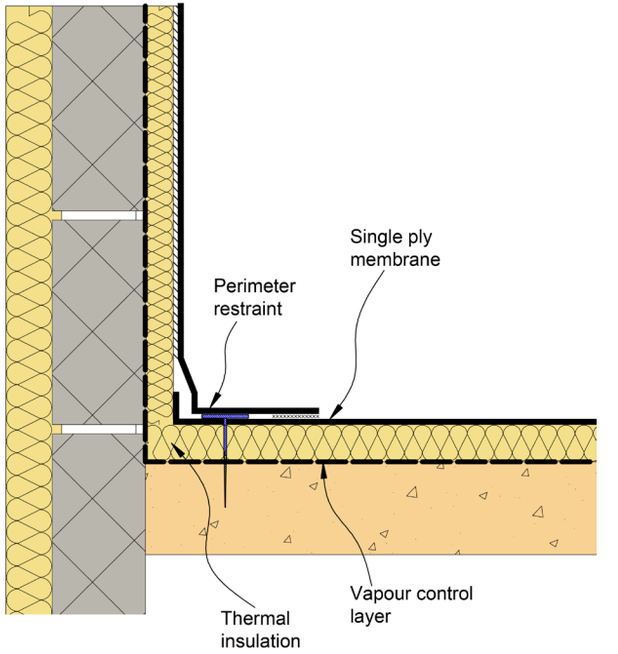


**Figure 10: Methods of restraint of single ply membrane at perimeters**

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

- Supply of a card 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.

**Reinforced bitumen membranes**
Installation should be in accordance with BS 8217. In case of doubt, or where the water proof membrane is beyond the scope of the Standard, the advice of the Flat Roofing Alliance (National Federation of Roofing Contractors) should prevail.

The safe use of gas torches, and the positioning, monitoring and transferring hot bitumen to the work face, should be adopted, all in accordance with the Health & 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.

A consistent film thickness is essential for reliable and durable liquid-applied membranes. The following should be considered:

- Supply of a card for each installer indicating successful completion of the manufacturer's product–specific training
- The coverage rate in kg/m2 must be declared before work starts
- During installation assessment of wet film thickness by one of the following methods as appropriate:
  - o gauge pin
  - o 'comb' type measurer
  - o visual inspection

**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 suitably qualified and experienced third-party who is independent of the roofing contractor.

The testing service provider should provide evidence of the following:

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

### 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).
- Rain water outlets: type, product and capacity.
- Procedure for maintenance of waterproof membrane, including (where appropriate) recommended frequency and method of application of solar reflective finish.
- Procedure for repair of waterproofmembrane.