Flat roofs with continuously supported coverings — Code of practice

ICS 91.060.20

British Standards

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/209, General building codes, to Subcommittee B/209/1, Flat roofs, upon which the following bodies were represented:

Association of Building Component Manufacturers (ABCM)

Association of British Roofing Felt Manufacturers (ABRFM)

Aluminium Federation

BRE Certification

BRE/LPC Laboratories

Building Research Establishment (BRE)

British Rigid Urethane Foam Manufacturers Association (BRUFMA)

Copper Development Association (CDA)

Cork Industry Federation

Eurisol (UK Mineral Wood Association)

European Liquid Roofing Association (ELRA)

Flat Roofing Alliance — Contractors (FRA)

Flat Roofing Alliance — Manufacturers (FRA)

Institute of Structural Engineers

Lead Sheet Association (LSA)

Local Authority Organizations

Mastic Asphalt Council Ltd. (MAC)

National Federation of Roofing Contractors (NFRC)

Royal Institute of British Architects (RIBA)

Scottish Office (Construction and Building)

Single Ply Roofing Association (SPRA)

Thermal Insulation Manufacturers and Suppliers Association (TIMSA)

Wood Panel Industries Federation (WPIF)

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Contents

Foreword

This British Standard code of practice has been prepared by Technical Committee B/209/1. It supersedes BS 6229:1982, which is withdrawn.

This code of practice deals with the overall principles of design and application of flat roofs with continuously supported roof coverings. A flat roof is defined as having a pitch not greater than 10° to the horizontal.

Where the particular use of individual materials or forms of construction is covered by other, specific codes of practice, detailed reference should additionally be made to the normative references in Clause **2**.

Since publication of the first edition of this code of practice (1982), many changes have taken place in the functional requirements for buildings, in the performance capability of many roofing materials and in some aspects of building practice. The original code of practice has, therefore, undergone a comprehensive review and updating.

Extensive guidance on the analysis of condensation risks in flat roof construction was given in the first edition of this code of practice. Guidance on the methodology of condensation risk analysis is now covered by BS 5250. Specific guidance on criteria and assumptions that are relevant to flat roof construction are retained in this revision of this code of practice.

The 1982 edition of this British Standard dealt with both design and workmanship. Workmanship is now covered by BS 8000-2.2, -3, -4, -5, and -9.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

NOTE It has been assumed in the drafting of this code of practice that the design and construction of flat roofs is entrusted to appropriately qualified and competent people. It has also been assumed that the building owner will adopt the recommendations in respect of planned inspection and maintenance of a roof during service.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Attention is drawn to the following statutory regulations relating to construction safety (see also Clause **20**): The Construction (General Provisions) Regulations 1961 [1], The Construction (Lifting Operations) Regulations 1998 [2], The Construction (Notice of Accident, etc.) Orders 1964 [3], The Construction (Working Places) Regulations 1966 [4], The Construction (Health, Safety and Welfare) Regulations 1996 [5], Health and Safety at Work etc. Act 1974 [6].

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 37 and a back cover.

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1 Scope

This code of practice gives recommendations on the design and application of flat roofs with continuously supported roof coverings. It covers weathertightness, drainage, thermal design, sound insulation, condensation control, structural support, fire precautions, maintenance and repair. The recommendations are applicable to terraces, podia, parking decks and green/garden roofs; however these particular types of roof also require consideration of additional factors, beyond the scope of this code of practice.

This code of practice is applicable to roof coverings at a pitch not greater than 10° to the horizontal.

NOTE Provided that the design conditions are similar, the recommendations given in this code may also be applied to roofs with slopes greater than 10°, but for steep roofs many of the recommendations may not apply.

This code of practice does not apply to roofs with self-supporting coverings, cold stores and high temperature enclosures, or to slated or tiled roofs.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 476-3:1958 (document withdrawn), *Fire tests on building materials and structures — Part 3: External fire exposure roof test*. See BS 5427-1:1996, *Code of practice for the use of profiled sheet for roof and wall cladding on buildings — Part 1: Design.*[1)]

BS 476-6, *Fire tests on building materials and structures — Part 6: Method of test for fire propagation for products.*

BS 476-7, *Fire tests on building materials and structures — Part 7: Method of test to determine the classification of the surface spread of flame of products.*

BS 476-21, *Fire tests on building materials and structures — Part 21: Methods for determination of the fire resistance of load-bearing elements of construction.*

BS 747, *Reinforced bitumen sheets for roofing — Specification.*

BS 882-2, *Specification for aggregates from natural sources for concrete.*

BS 1105, *Specification for wood wool cement slabs up to 125 mm thick.*

BS 2782-1, *Methods of testing plastics — Part 1: Thermal properties.*

BS 3797, *Specification for lightweight aggregates for structural concrete.*

BS 3837-1, *Expanded polystyrene boards — Part 1: Specification for boards manufactured from expandable beads.*

BS 3837-2, *Expanded polystyrene boards — Part 2: Specification for extruded polystyrene boards (XPS).*

BS 3927, *Specification for rigid phenolic foam (PF) for thermal insulation in the form of slabs and profiled sections.*

BS 3958-5, *Thermal insulating materials — Part 5: Specification for bonded man-made mineral fibre slabs.*

BS 4841-3, *Rigid polyurethane (PUR) and polyisocyanurate (PIR) foam for building applications — Part 3: Specification for roofboards.*

BS 5241-1, *Rigid polyurethane (PUR) and polyisocyanurate (PIR) foam when dispensed or sprayed on a construction site — Part 1: Specification for sprayed foam thermal insulation applied externally.*

BS 5250, *Code of practice for control of condensation in buildings.*

BS 5268-2, *Structural use of timber — Part 2: Code of practice for permissible stress design, materials and workmanship.*

BS 5268-5, *Structural use of timber — Part 5: Code of practice for the preservative treatment of structural timber.*

[1)] A review of DD ENV 1187:2002, *Test methods for external fire exposure to roofs*, will be initiated after 2 years and once completed will supersede the BS 476-3:1958 test given in BS 5427-1:1996, Annex E.

BS 5268-7.2, *Structural use of timber— Part 7: Recommendations for the calculation basis for span tables — Section 7.2: Joists for flat roofs.*

BS 5427-1:1996, *Code of practice for the use of profiled sheet for roof and wall cladding on buildings — Part 1: Design.*

BS 5588 (all parts), *Fire precautions in the design, construction and use of buildings.*

BS 5720, *Code of practice for mechanical ventilation and air conditioning in buildings.*

BS 5925, *Code of practice for design of buildings — Ventilation principles and designing for natural ventilation.*

BS 5950-6, *Structural use of steelwork in building — Part 6: Code of practice for design of light gauge profiled steel sheeting.*

BS 6100-1.3.2, *Glossary of building and civil engineering terms — Part 1: General and miscellaneous — Section 1.3: Parts of construction works — Subsection 1.3.2: Roofs and roofing.*

BS 6180, *Barriers in and about buildings — Code of practice.*

BS 6399-1, *Loading for buildings — Part 1: Code of practice for dead and imposed loads.*

BS 6399-2, *Loading for buildings — Part 2: Code of practice for wind loads.*

BS 6399-3, *Loading for buildings — Part 3: Code of practice for imposed roof loads.*

BS 6651, *Code of practice for protection of structures against lightning.*

BS 6915, *Design and construction of fully supported lead sheet roof and wall coverings — Code of practice.*

BS 6925, *Specification for mastic asphalt for building and civil engineering (limestone aggregate).*

BS 7021, *Code of practice for thermal insulation of roofs externally by means of sprayed rigid polyurethane (PUR) or polyisocyanurate (PIR) foam.*

BS 7916, *Code of practice for the selection and application of particleboard, oriented strand board (OSB), cement bonded particleboard and wood fibreboards for specific purposes.*

BS 8110 (all parts), *Structural use of concrete.*

BS 8118-1, *Structural use of aluminium — Part 1: Code of practice for design.*

BS 8118-2, *Structural use of aluminium — Part 2: Specification for materials, workmanship and protection.*

BS 8204-1, *Screeds, bases and in-situ floorings — Part 1: Concrete bases and cement sand levelling screeds to receive floorings — Code of practice.*

BS 8206-2, *Lighting for buildings — Part 2: Code of practice for daylighting.*

BS 8217, *Code of practice for built-up felt roofing.*

BS 8218, *Code of practice for mastic asphalt roofing.*

BS 8220-1, *Guide for security of buildings against crime — Part 1: Dwellings.*

BS 8220-2, *Guide for security of buildings against crime — Part 2: Offices and shops.*

BS 8220-3, *Guide for security of buildings against crime — Part 3: Warehouses and distribution units.*

BS 8233, *Sound insulation and noise reduction for buildings — Code of practice.*

BS 8290-1, *Suspended ceilings — Part 1: Code of practice for design.*

CP 143-5, *Code of practice for sheet roof and wall coverings — Part 5: Zinc.*

CP 143-12, *Code of practice for sheet roof and wall coverings — Part 12: Copper: Metric units.*

CP 143-15, *Code of practice for sheet roof and wall coverings — Part 15: Aluminium: Metric units.*

BS EN 300, *Oriented strand boards (OSB) — Definitions, classification and specifications.*

BS EN 312-5, *Particleboards — Specifications — Part 5: Requirements for load-bearing boards for use in humid conditions.*

BS EN 312-7, *Particleboards — Specifications — Part 7: Requirements for heavy-duty load-bearing boards for use in humid conditions.*

BS EN 314-2, *Plywood — Bonding quality — Part 2: Requirements.*

BS EN 336, *Structural timber — Coniferous and poplar — Sizes — Permissible deviations.*

BS EN 485 (all parts), *Aluminium and aluminium alloys — Sheet, strip and plate.*

BS EN 501, *Roofing products from metal sheet — Specifications for fully supported roofing products of zinc sheet.*

BS EN 502, *Roofing products from metal sheet — Specification for fully supported roofing products of stainless steel sheet.*

BS EN 504, *Roofing products from metal sheet — Specification for fully supported roofing products of copper sheet.*

BS EN 507, *Roofing products from metal sheet — Specification for fully supported roofing products of aluminium sheet.*

BS EN 622-4, *Fibreboards — Specifications — Part 4: Requirements for softboards.*

BS EN 634-2, *Cement-bonded particle boards — Specification — Part 2: Requirements for OPC bonded particleboards for use in dry, humid and exterior conditions.*

BS EN 636-2, *Plywood — Specifications — Part 2: Requirements for plywood for use in humid conditions.*

BS EN 636-3, *Plywood — Specifications — Part 3: Requirements for plywood for use in exterior conditions.*

BS EN 1172, *Copper and copper alloys — Sheet and strip for building purposes.*

BS EN 1313-1, *Specification for sizes of sawn and processed — Part 1: Softwood.*

BS EN 10258, *Cold-rolled stainless steel narrow strip and cut lengths — Tolerances on dimensions and shape.*

BS EN 12056-3, *Gravity drainage systems inside buildings — Part 3: Roof drainage, layout and calculation.*

BS EN 12524, *Building materials and products — Hygrothermal properties — Tabulated design values.*

BS EN 12588, *Lead and lead alloys — Rolled lead sheet for building purposes.*

BS EN 13162, *Thermal insulation products for buildings — Factory made mineral wool (MW) products — Specification.*

BS EN 13163, *Thermal insulation products for buildings — Factory made products of expanded polystyrene — Specification.*

BS EN 13164, *Thermal insulation products for buildings — Factory made products of extruded polystyrene foam (XPS) — Specification.*

BS EN 13165, *Thermal insulation products for buildings — Factory made rigid urethane foam (PUR) products — Specification.*

BS EN 13166, *Thermal insulation products for buildings — Factory made products of phenolic foam — Specification.*

BS EN 13167, *Thermal insulation products for buildings — Factory made cellular glass (CG) products — Specification.*

BS EN 13168, *Thermal insulation products for buildings — Factory made wood wool (WW) products — Specification.*

BS EN 13169, *Thermal insulation products for buildings — Factory made products of expanded perlite — Specification.*

BS EN 13170, *Thermal insulation products for buildings — Factory made products of compressed corkboard — Specification.*

BS EN ISO 140-4, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 4: Field measurements of airborne sound insulation between rooms.*

BS EN ISO 140-5, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 5: Field measurements of airborne sound insulation of facade elements and facades.*

BS EN ISO 10456, *Building materials and products — Procedures for determining declared and design thermal values.*

DD ENV 1099, *Plywood — Biological durability — Guidance for the assessment of plywood for use in different hazard classes.*

DD ENV 1992-1-1, *Eurocode 2: Design of concrete structures — Part 1: General rules for buildings (together with United Kingdom National Application Document).*

DD ENV 1993-1-1, *Eurocode 3: Design of steel structures — Part 1.1: General rules and rules for buildings (together with United Kingdom National Application Document).*

DD ENV 1995-1-1, *Eurocode 5: Design of timber structures — Part 1.1: General rules and rules for buildings (together with United Kingdom National Application Document).*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS 6100-1.3.2 and the following apply.

3.1
flat roof
roof having a pitch not greater than 10° to the horizontal

3.2
condensation
process whereby water is deposited from air containing water vapour, when its temperature drops to or below dew point

3.3
interstitial condensation
condensation occurring within or between the layers of the building envelope

3.4
surface condensation
condensation occurring on visible surfaces within the building

3.5
harmful condensation
interstitial or surface condensation which is likely to cause damage to the building fabric, or degrade its thermal performance or support mould

3.6
cricket
tapered insulation wedge, usually thin, designed to promote flow along a parapet edge or flat gutter line, or around obstacles such as a rooflight kerb, to reduce or prevent standing water (ponding)

NOTE The term "cricket" is usually used in the plural.

3.7
tapered insulation
thermal insulation boards of varying starting thickness, designed and pre-cut or pre-formed to create or augment drainage falls when laid in a prescribed pattern

3.8
thermal bridge
cold bridge
part of a roof of lower thermal resistance than its surrounding elements, which may result in localized cold surfaces on which condensation, mould growth or staining may occur

3.9
vapour control layer (VCL)
construction material (usually a membrane) that substantially reduces the transfer of water vapour through the roof

NOTE The performance of a vapour control layer is dependent upon the material, workmanship and buildability.

3.10
waterproofing system
assembly of one or more layers of roofing sheet in an applied and/or jointed form, with the purpose of preventing the entry or passage of water to the interior of the building

NOTE 1 A bituminous roofing system is formed on site by connecting and sealing one or more superimposed layers of bitumen sheets, to form a single composite waterproof layer for use over flat, pitched or vertical surfaces according to building application requirements.

NOTE 2 Where only one layer is used, this is usually referred to as a single-layer system.

4 Types of flat roof

4.1 General

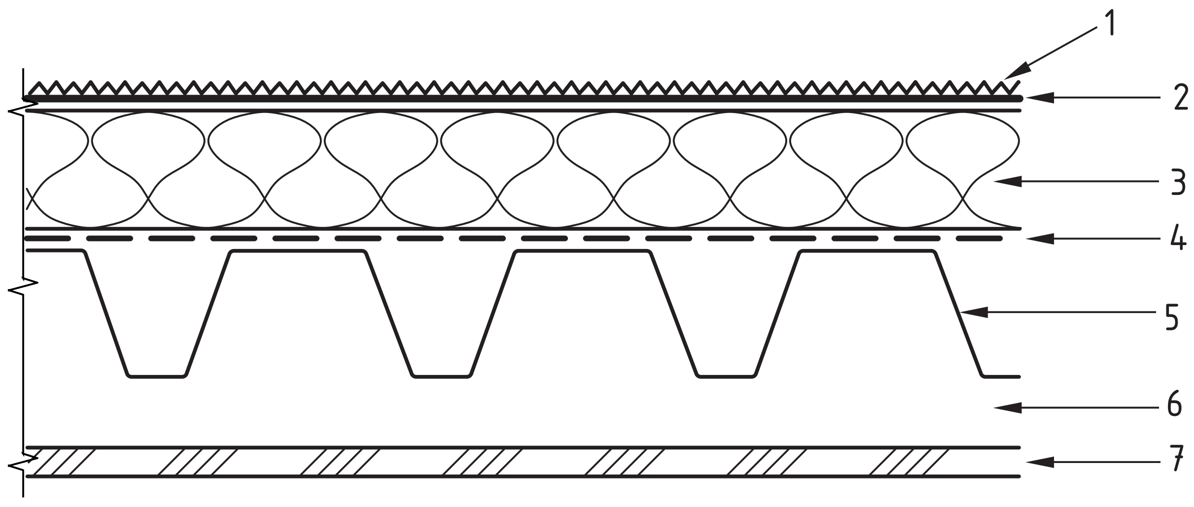
A flat roof is typically a multi-layer construction of roof covering, thermal insulation and structural deck, incorporating drainage outlets and gutters. In addition, it may incorporate vapour control layers, screeds, surface paving, surface reflective treatment, rooflights, ventilators, ceiling materials and attachments such as handrails, gantry rails and lightning conductors.

4.2 Principal types

Flat roof constructions are generally divided into the following types, according to the position in which the principal thermal insulation is placed (see Figure 1, Figure 2 and Figure 3).

a) **The warm roof**

The principal thermal insulation is placed above the deck and a vapour control layer and immediately below the roof covering, resulting in the structural deck and ceiling being at a temperature close to that of the interior of the building (see Figure 1).

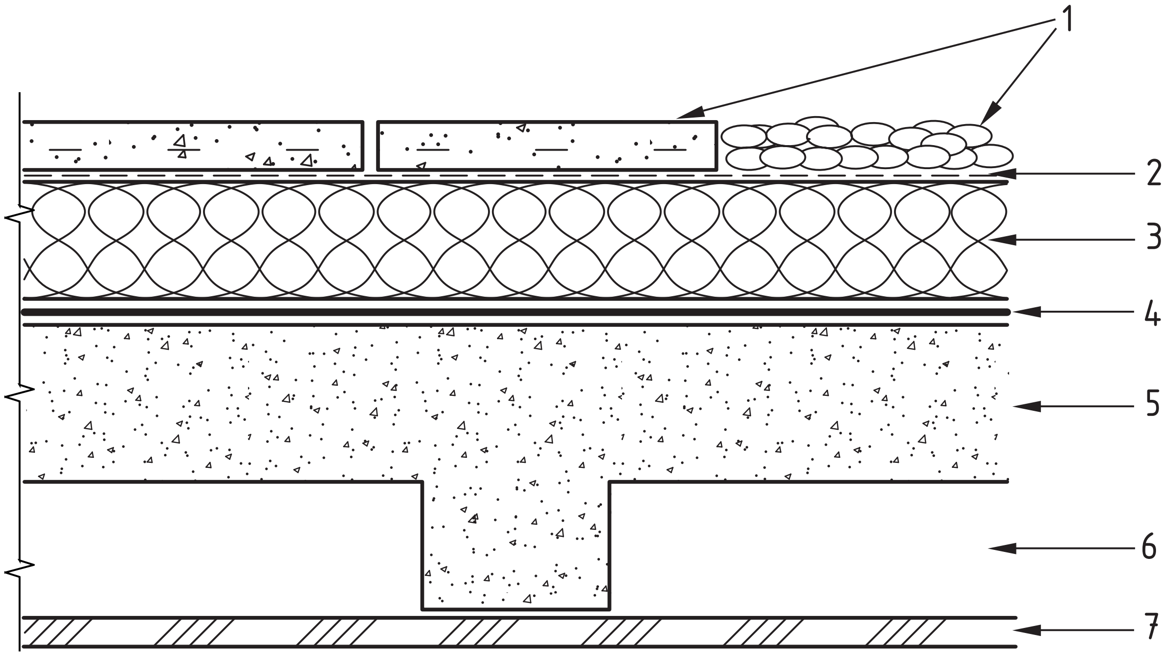


1 Surfacing
2 Roof waterproofing system
3 Insulation
4 Vapour control layer
5 Structural deck (e.g. profiled metal)
6 Ceiling void
7 Ceiling (optional)

Figure 1 — Typical warm roof construction

b) **The inverted roof**

The principal thermal insulation is placed above the roof covering, resulting in the roof covering, structural deck and ceiling being at a temperature close to that of the interior of the building. Generally the principal insulation is secured by ballast, however proprietary lightweight systems are available which do not rely on ballast (see Figure 2).

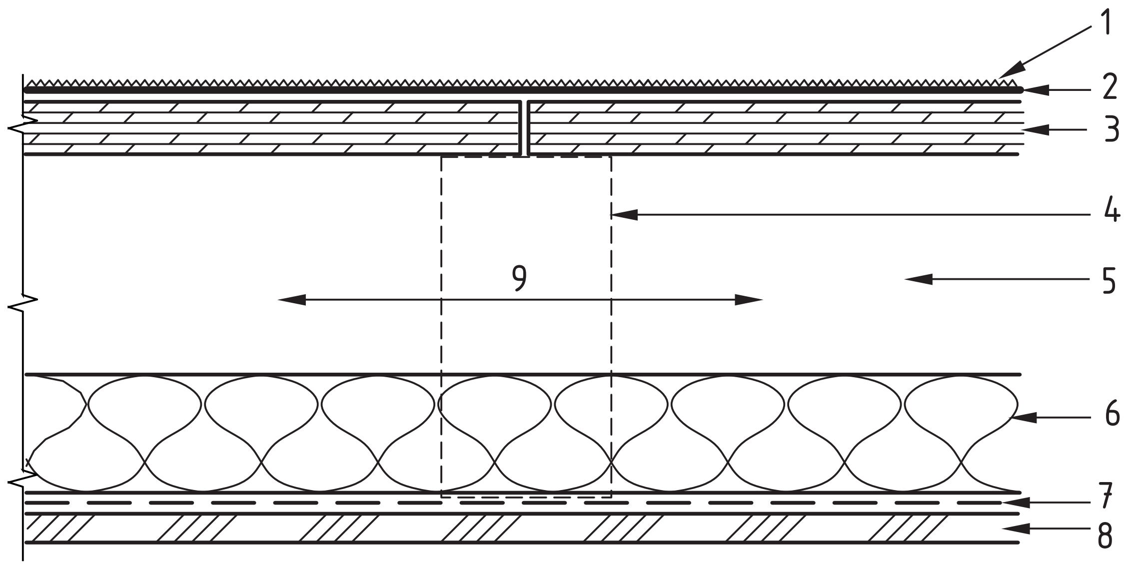


1 Surfacing/ballast (e.g. paviors or shingle)
2 Filter layer
3 XPS insulation boards (extruded polystyrene)
4 Roof waterproofing system
5 Structural deck (e.g. concrete)
6 Ceiling void
7 Ceiling (optional)

Figure 2 — Typical inverted roof

c) **The cold roof**

The principal thermal insulation is placed at or immediately above the ceiling, resulting in the roof covering and structural deck being substantially colder in winter than the interior of the building (see Figure 3).



1 Surfacing
2 Roof waterproofing system
3 Structural deck (e.g. plywood)
4 Notational roof joist
5 Roof void
6 Insulation
7 Vapour control layer
8 Ceiling
9 Cross-roof ventilation paths

Figure 3 — Typical cold roof construction

4.3 Other types

Some flat roofs combine the features of two or more of the roof types described in **4.2** a) to c). Examples include structural decks with high thermal insulating properties combined with additional insulation, existing roofs to which thermal insulation is added, and constructions in which the waterproofing layer is sandwiched between two layers of insulation. This form of construction is generally known as a duo roof.

Certain types of metal roof covering (e.g. aluminium, lead and zinc) require ventilation of the underside of the sheeting to the outside air, to reduce the risk of condensation and corrosion. This type of roof design, which is generally known as a ventilated warm roof, combines the principle of a cold roof for the metal sheet and its support layer with that of a warm roof for the main structural deck.

The material supplier should be consulted for specific requirements.

5 Materials and components

5.1 General

Materials and components for flat roofs should conform to the relevant specifications, codes of practice and other guidance documents given in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6.

NOTE For certain materials and components, guidance on performance and suitability for use in particular conditions is available from European Technical Approval bodies, such as the British Board of Agrément[2] or BRE Certification[3].

A number of proprietary products are available, such as composite structural decking including integral insulation and/or vapour control layer, and insulated rainwater outlets. These products should be assessed on an individual basis before use.

5.2 Roof coverings

Roof coverings should conform to the relevant specifications or other guidance documents, as given in Table 1, and be fitted in accordance with the recommendations given in the related codes of practice.

Table 1 — Materials for roof coverings

Material	Specification	Code of practice	Other guidance
Lead	BS EN 12588	BS 6915	LSA Handbooks [7]
Zinc	BS EN 501	CP 143-5	—
Stainless steel	BS EN 502 BS EN 10258	— [a]	—
Copper	BS EN 504 BS EN 1172	CP 143-12	CDA Handbook [8]
Aluminium	BS EN 485 BS EN 507	CP 143-15	—
Flexible bitumen sheets	BS 747	BS 8217	FRA Handbook [9]
Mastic asphalt	BS 6925	BS 8218	MAC Technical Guide [10]
Single ply membranes	— [a]	— [a]	SPRA Design Guide [11]
Liquid waterproofing systems (hot- or cold-applied)	— [a]	— [a]	ELRA Code of Practice [12]

[a] No British Standards currently exist for these materials.

[2] British Board of Agrément, P.O. Box 195, Bucknalls Lane, Garston, Watford, Herts WD25 9BA. www.bbacerts.co.uk.
[3] BRE Certification, Garston, Watford, Herts WD25 9XX. www.bre.co.uk.

5.3 Structural deck

Materials for structural decks should conform to the relevant standards, and where appropriate, to the recommendations given in the related codes of practice shown in Table 2.

Table 2 — Structural deck materials

Materials	Specification or code of practice
Aluminium (profiled)	BS 8118-1 BS 8118-2
Cement bonded particleboard	BS EN 634-2 BS 7916
Concrete	BS 8110 DD ENV 1992-1-1
Oriented strand board	BS EN 300 BS 7916
Particle boards	BS EN 312-5 BS EN 312-7 BS 7916
Plywood	BS EN 314-2 BS EN 636-2 BS EN 636-3 BS 5268-2 DD ENV 1099
Sawn and processed timber	BS EN 1313-1 BS EN 336
Steel (profiled)	BS 5950-6 DD ENV 1993-1-1 [a]
Timber	BS 5268-2 DD ENV 1995-1-1 BS 5268-5, for preservative treatments BS 5268-7.2, for spanning tables
Woodwool slabs	BS 1105

NOTE Proprietary composite decking systems are available, comprising a plywood upper layer, a rigid urethane foam or similar insulation as the core, and commonly incorporating a lower face of reinforced aluminium foil. This foil can form a rudimentary vapour check.

Generally, their installation method is the same as for plywood decking but their additional thickness entails much longer fixings. As no British Standard currently exists covering these materials, the manufacturer's advice should be followed.

[a] Some profiled metal roofing sheets may not be suitable for decking.

5.4 Screeds

Materials for screeds should conform to the relevant standards, where appropriate, and to the recommendations given in the relevant codes of practice shown in Table 3.

Table 3 — Screed materials

Material	Specification or code of practice
Sand and cement screed	BS 8204-1
No-fines concrete	BS 882-2
Lightweight aggregates	BS 3797
Foamed slag	BS 3797
Clinker aggregate	BS 3797
NOTE Dry or insulating screeds may also be available. However, no British Standard currently exists for these materials.	

5.5 Thermal insulation materials

Thermal insulation materials should conform to the relevant standards, where appropriate, and to the recommendations given in the relevant codes of practice shown in Table 4.

Table 4 — Thermal insulation materials

Material	Specification or code of practice
Resin bonded mineral fibre slabs	BS 3958-5 BS EN 13162
Expanded polystyrene board (EPS)	BS 3837-1 BS EN 13163
Extruded expanded polystyrene board (XPS)	BS 3837-2 BS EN 13164
Rigid urethane foam roofboards	BS 4841-3 BS EN 13165
Phenolic foam	BS 3927 BS EN 13166
Cellular glass	BS EN 13167
Woodwool slabs	BS EN 13168
Perlite	BS EN 13169
Cork board or slab	BS EN 13170
Sprayed rigid urethane foam	BS 5241-1 BS 7021
Fibre boards (Softboards)	BS EN 622-4 BS 7916
Composite boards (two or more layers of different insulants bonded together to form a single board)	Component materials should conform to the relevant British Standards given in this Table
NOTE Various types of quilted mineral and glass fibre and loose-fill insulation may also be suitable as thermal insulation but no British Standards currently exist for these products.	

5.6 Vapour control layers (VCLs)

NOTE Vapour control layers are provided to control or preclude condensation (see Clause **10**).

Membranes for vapour control layers should conform to the standards given in Table 5. A vapour control layer may consist of one or more layers of these materials. The in-service performance of a vapour control layer is dependent upon the material, workmanship and buildability.

Table 5 — Vapour control layers

Material	Specification
Coated flexible bitumen sheets	BS 747
Polyethylene sheet with sealed laps	— [a]
Polyethylene sheet with metal core and sealed laps	— [a]
12 mm thick one coat mastic asphalt on glass fibre tissue	BS 6925
NOTE Metal-cored flexible bitumen sheets are frequently used as vapour control layers; however no British Standard currently exists covering these materials.	
[a] No British Standard currently exists for these materials but a European Standard prEN 13984 is being developed.	

5.7 Roof surface protection

Roof surface protection should be provided against solar gain, UV degradation and damage from traffic, and should conform to Clause **13**.

5.8 Rooflights

The weathertightness, strength, light transmission, thermal insulation, fire rating and method of fixing of rooflights should conform to Clause **14**.

NOTE Prefabricated rooflights are not covered by British Standards.

5.9 Rainwater goods

The selection and design of rainwater outlets, gutters, pipes and accessories should be in accordance with BS EN 12056-3.

Pre-formed rainwater gutters, pipes and accessories should conform to the requirements and recommendations of BS EN 12056-3.

Gutters that are formed in-situ in the roof covering materials should conform to the relevant codes of practice and standards listed in Table 1.

5.10 Lightning conductors

The design and choice of materials for lightning conductors should be in accordance with the recommendations in BS 6651.

5.11 Handrails and balustrades

The design and choice of materials for handrails and balustrades should be in accordance with BS 6180.

6 General design considerations

The roof covering, including joints, parapets, abutments, gutters and outlets, should remain weathertight under the external action of rain, snow, ice, dead and imposed loads, wind loads, solar and night radiation, and the internal environment of the building.

The detailed design and application of each roof covering material should conform to the appropriate document given in Table 1.

Falls should be provided to enable the roof to drain towards outlets, gulleys or gutters of sufficient capacity (see Clause **7**). The drainage falls should take into account deflections due to the most unfavourable dead and imposed loads.

The structural deck and its connections to the building should be of adequate strength and stiffness to ensure structural integrity, and to provide adequate support to the roof covering system (see Clause **8**).

Thermal insulation should be provided in all roofs, except those in unheated buildings, for thermal comfort and energy conservation (see Clause **9**).

NOTE Thermal comfort and energy conservation is covered by Parts L1 and L2 of the Building Regulations 2001 [13], Part J of the Building Standards (Scotland) Regulations 2001 [14], and Technical Booklet F of the Building Regulations (Northern Ireland) 1994 [15].

The roof should be designed to accommodate the extremes and duration of temperature and water vapour pressure differences across the roof layers.

To avoid harmful condensation, thermal design should always include an analysis of condensation risk. Particular attention should be paid to the positioning of insulating materials, and, where necessary, vapour control layers, ventilation, the effect on the roof covering, thermal insulation, ceiling and structural supports of thermal and moisture movements, and the choice of materials resistant to the effects of condensation (see Clause **9** and Clause **10**).

In some circumstances, protective treatments against corrosion or biological attack may be required.

The satisfactory performance of a flat roof is also critically dependent on careful and competent construction, particularly in avoiding or minimizing the amount of trapped water within the roof; where necessary, measures for drying out the roof during and after construction should be taken (see **8.4**).

The design of the roof should be considered in relation to its compatibility with the building as a whole, and account taken of the significance of materials which may be included for other reasons, for example sound insulation (see Clause **11**), fire protection or fire performance (see Clause **12**).

7 Falls and drainage

7.1 General

Flat roofs should be designed to drain over the edges or towards gutters and outlets within the roof areas. Roofs which drain to internal roof outlets should also be provided with overflows, to avoid water flooding into the building. Where water is directed to an edge or corner against a parapet or upstand of adequate height, a separate internal gutter is not normally required.

Gutters and roof drainage should be designed in accordance with BS EN 12056-3. The minimum rainfall intensity should be assessed in relation to the site location, the detailed form of construction to the roof, and the acceptable risk of damage to the interior. In no case should this be less than 75 mm per hour. Higher rates may be more appropriate with discontinuous roof coverings, such as jointed metal sheets, or where the risk of damage to the building interior is to be avoided completely.

Where loose laid aggregates are used on roofing surfacing care should be taken to avoid their displacement or removal by rain and wind, and the risk of blockage of rainwater outlets.

Where an upper roof discharges rainwater onto a lower roof, the risk of corrosive action from dissolved ingredients taken from the upper roof, wall or gutter on the lower roof covering should be considered.

To avoid cold bridges and excessive condensation around internal gutters, internal rainwater outlets and downpipes, thermal insulation should be provided at these positions in the roof.

The design of drainage falls should ensure that the continuity of the waterproof covering is maintained for a vertical height of 150 mm above the finished roof level at all abutments, door openings and parapets. For inverted roofs, those with overlaid paving, or garden roofs, the finished roof surface is the upper surface of the ballast, paving slabs or growing medium. It is particularly important in refurbishment to maintain this height, because additional insulation (especially if cut-to-falls) may reduce the effective height of parapets and kerbs.

7.2 Minimum finished falls

The minimum finished falls for specific materials should conform to Table 6.

Table 6 — Minimum finished falls

Covering	Minimum finished fall at any point
Aluminium	1:60
Copper	1:60
Zinc	1:60
Lead sheet	1:80
Built-up bitumen sheet	1:80
Mastic asphalt	1:80
Single ply membranes	1:80
Liquid waterproofing systems (hot- or cold-applied) [a]	1:80
NOTE These recommendations are applicable both to the general area of the roof and to any formed internal gutters.	
[a] For certain specialist systems designed solely for buried applications, such as garden roofs, podia, and some car parks, specific reference should be made to the manufacturer's documented advice and British Board of Agrément[4] certification.	

7.3 Design falls

To ensure that the minimum finished falls listed in Table 6 are achieved, allowance should be made for deflection of the structural members and decking under dead and imposed loads and for construction tolerances. The falls assumed for design should, therefore, be steeper than the recommended finished falls.

The design falls should be determined by considering the overall and local deflections, the direction of falls and the type of roof covering. In the absence of a detailed analysis, a fall of twice the minimum finished fall should be assumed for design purposes.

The design falls are intended to draw any water from the roof, thus avoiding ponding which would encourage the build-up of silt deposits on the roof and which could lead to the growth of moss etc. Ponding in winter may also produce additional stresses in the membrane when the standing water freezes. In the event of a membrane defect in the area of the ponding, greater water entry will occur than in a well-drained roof.

Roof-mounted fixtures or services, which penetrate the roof finish (particularly fully supported metal finishes), may interfere with the flow of water. Roof falls should be designed to prevent the build-up of water behind these positions or any crickets provided.

NOTE In a roof designed to the minimum recommended falls it is almost inevitable that some ponding will occur for a short time after a rainstorm, in particular behind laps.

7.4 Direction of falls

The arrangement of falls depends on the roof area and shape, and the drainage capacity and position of gutters and outlets. Where two-directional falls intersect, the resulting fall along the line of the mitre is less than that in the main area. If the main falls are set at the minimum finished fall given in Table 1, the resulting mitre fall may produce ponding.

In order to avoid ponding, the minimum finished fall should be set along the line of the mitre, thus increasing the main falls. As this could entail an increase in the overall height at the abutment of the roof with the walls, the construction details should be designed to take this extra depth into account. Where structural considerations may require movement joints, these should be co-ordinated with falls.

[4] British Board of Agrément, P.O. Box 195, Bucknalls Lane, Garston, Watford, Herts WD25 9BA. www.bbacerts.co.uk.

7.5 Formation of falls

7.5.1 *Sloping decks*

For roof coverings with a simple one-directional fall draining to one edge or two opposite edges, the fall can be formed by sloping the upper surface of the supporting structure. Either constant depth beams or joists laid at a slope (giving a sloping soffit) or tapered beams with horizontal soffits should be used. Falls can be formed by tapered timber firrings fixed to the top of the beams. If timber firrings are used at right angles to the beams they should be of suitable structural strength to support the loading on the roof.

7.5.2 *Pre-formed insulation boards*

Pre-formed or tapered insulation boards may be used to provide falls in one direction to a gutter or level valley. They may also be used mitred to create falls in two directions to form falls and cross-falls.

Drainage crickets or saddles may be used to improve drainage between outlets where a roof is installed to straight falls to a level valley or parapet. They may also be used to displace water held behind obstructions in the roof waterproofing, such as rooflights.

7.5.3 *Concrete and screeds*

In concrete construction, falls are either formed within the structural concrete, or more generally by providing a screed laid over the concrete deck. If an un-bonded screed is provided, the minimum thickness at any point should be 65 mm. If lightweight screeds are used they may also provide some of the thermal insulation.

Owing to the risk of water absorption during construction, dry and wet screeds should not be used with timber structural decks, nor placed above a vapour control layer.

7.5.4 *Wet screeds*

Wet screeds should normally be at least 65 mm thick but no more than 200 mm thick (including the topping screed). Precautions should be taken in laying to control shrinkage cracking by laying the screed in bays with a length or width not exceeding 3 m, in accordance with BS 8204-1.

7.5.5 *Dry screeds*

Dry screeds should be of dense or lightweight aggregate, either bitumen bound or loose laid, together with a sand/cement topping screed, and be laid to falls in one or both layers.

8 Structural design

8.1 Loading

8.1.1 *Dead and imposed loads*

Dead and imposed loads should be calculated in accordance with the recommendations of BS 6399-1, and BS 6399-3.

8.1.2 *Wind loads*

Wind loads appropriate to the exposure, roof height, building shape, topography and location in the UK should be calculated in accordance with the recommendations of BS 6399-2.

The resistance to wind uplift should be calculated from the strength characteristics of the materials used to bond or fix the roof covering to the substrate and from the dead weight resistance of the covering and finishes.

If the roof covering and supporting deck are substantially airtight, the deck itself provides resistance against wind uplift. Imperforate concrete decks and sand/cement screeds should normally be regarded as sufficiently air-impermeable, but boarded constructions with square-edged or tongued joints or metal decking not otherwise sealed should be regarded as wholly air-permeable.

For air-permeable decks, the wind uplift pressure is exerted on one or more layers of the roof that are substantially air-impermeable, such as the vapour control layer or roof covering. In such cases, the wind uplift pressure (less the appropriate dead weight) should be resisted by adequate mechanical or bonded connections between the air impermeable layer and the deck.

8.2 Strength and stiffness

8.2.1 *Structural deck*

The structural deck should be designed for strength and stiffness in accordance with the recommendations of the British Standards in Table 2.

8.2.2 *Roof coverings*

The roof covering and insulation, where applicable, should have adequate strength and stiffness or be protected to resist, without failure or perforation, the dead and imposed loads, wind loads and point loads.

8.3 Movement

8.3.1 *Structural movement*

Large roofs may need to be subdivided into smaller independent areas, separated by gaps to accommodate thermal, moisture and structural movements. The maximum length between movement joints varies with the temperature range, the coefficient of thermal expansion, the flexibility of the roof covering, structural deck and walls, and the thermal response rate of the building.

Movement joints in the roof should be arranged to coincide with similar joints in the walls, or vice versa. Special provisions may be required for structures subject to significant differential settlement or mining subsidence.

The roof deck on either side of the movement joint should be adequately stiffened to avoid excessive differential deflection.

NOTE 1 The unrestrained thermal and moisture movements of certain structural deck materials are listed in Table 7.

NOTE 2 Further guidance on thermal and moisture movements and stresses is given in [16] and [17].

Table 7 — Approximate thermal and moisture movements of certain structural deck materials

Material	Coefficient of thermal expansion per °C × 10^{-6}	Reversible moisture movement %	Irreversible moisture movement %
Concrete	8 to 12	0.02 to 0.06	−0.03 to −0.08
Steel	12	N/A	N/A
Aluminium	24	N/A	N/A
Softwoods [a]	3 to 6 along the grain 20 to 70 across grain	0.6 to 2.6 tangential 0.45 to 2.0 radial	N/A N/A
Hardwoods [a]	3 to 6 along grain 20 to 60 across grain	0.8 to 4.0 tangential 0.5 to 2.5 radial.	N/A N/A
Plywoods	4 to 16	0.15 to 0.30	N/A
Oriented strand board (OSB 3)	4 to 16	0.15 to 0.30	N/A

[a] The values given for timber are indicative only and may vary significantly according to the species; more detailed information is given in [18] and [19].

8.3.2 *Differential movement between roof covering and substrate*

In addition to the recommendations in **8.3.1** for movements of the roof as a whole, differential movement between the roof covering and substrate, or any overlaid insulation in inverted roofs, or other material should be taken into account in design.

The roof covering system should be capable of resisting such frequent movement and stresses for its design life. Such differential movements are mainly thermally induced, subject to daily and seasonal fluctuations of the environment. Detailed recommendations for individual roof coverings are given in the appropriate documents listed in Table 1.

Differential movements or stresses in the roof covering are more severe in warm roofs because the range and rate of temperature change in the covering is maximized. Conversely, the range of movement in the decking is reduced.

For inverted roofs, ballasted and loose laid insulation over the roof covering should be allowed to move freely, including at abutments and penetrations. Care should be taken to avoid aggregate or debris being trapped between the insulation and the roof covering, as this can cause damage due to abrasion.

Any materials that are bonded on top of the roof covering should be carefully assessed to verify that both the roof covering and adhesive can safely sustain the differential movements and induced stresses.

8.4 Protection against trapped moisture

As failures in flat roofs are often caused by the harmful effects of moisture which is trapped during construction, it is essential that great care be taken to minimize such risks. Trapped water may be the result of the use of wet materials, water from in-situ concrete and wet screeds, or rain on unprotected construction.

Materials should be stored under cover, clear of the ground. The same protection should be given to material temporarily stored outdoors or on the roof during construction. If materials become wet, measures should be taken to dry them out, before, during and, if possible, after construction, but wetted materials that are susceptible to weakening and distortion should always be replaced. Materials that can regain normal strength and stiffness on re-drying should be dried out before being used or subjected to load.

NOTE In most types of warm roof, the deck will continue to dry out downwards for a period.

New concrete or screeded decks should be given adequate time to dry out, prior to installing the waterproof covering. At the very least, all surfaces should be touch dry, and not be subject to moisture which re-appears within a short period.

Excess water in concrete slabs and concrete decks cast in situ should be drained downwards through temporary drain holes formed in the area of maximum sag of the roof deck. Subject to checking their effect on structural strength, the holes should be not less than 25 mm diameter, positioned to avoid reinforcement bars in the concrete and spaced at the intersections of approximately a 4 m by 3 m grid. The holes should not be filled before seepage and dampness has ceased; they should be filled with a sand-cement mortar before finishing work on the ceiling commences. As pre-cast concrete roof decking units with open joints are self-draining, holes are not required. However, if the joints are to be sealed subsequently, they should be left open for as long as possible.

The risk of trapping water during construction should be reduced as much as possible by:

— laying successive roof layers with the minimum of delay;

— providing temporary weather protection during construction and interruptions; and

— in exceptional cases, installing a temporary roof with sufficient working headroom over the roof to be constructed.

If metal decking is used as permanent shuttering, drilled holes or perforations should be used as this impermeable layer does not allow the deck to dry downwards. However, as drilled holes or perforations only allow a part of the construction water contained to drain, the remainder should be dried out from above.

In this instance, as full upward drying is particularly important, a temporary roof should be erected to work under and the waterproofing system should not be installed until the decking has dried upwards fully.

Work on laying roof coverings and other moisture sensitive layers should not be allowed to proceed in severe or continuously wet conditions.

NOTE 1 Weather forecasts available from the Meteorological Office (www.metoffice.gov.uk) may assist in planning the roof construction.

NOTE 2 Roof ventilators are not reliable as the sole means of removing and drying trapped water.

9 Thermal design

9.1 General

Thermal insulating materials should conform to the recommendations in **5.5**.

NOTE 1 The most common thermal insulating materials are listed in Table 4.

NOTE 2 The minimum amount of thermal insulation to be provided in a roof (together with that provided within other elements of the building) is covered by statutory regulations, including Parts L1 and L2 of the Building Regulations 2001 [13], Part J of the Building Standards (Scotland) Regulations 2001 [14], and Technical Booklet F of the Building Regulations (Northern Ireland) 1994 [15].

Consideration should also be given to initial and running costs, thermal comfort, energy conservation, conditions of use of the building, and control of condensation.

9.2 Thermal conductivity

In selecting a suitable value of thermal conductivity (λ-value) for design, the effect of ageing and moisture uptake of the material, and the temperature at which the λ-value is measured should all be taken into account.

The λ-value should be selected in accordance with BS EN ISO 10456 and BS EN 12524.

NOTE Further guidance on suitable design values is given in *CIBSE Guide A: Environmental design — 3: Thermal properties of building structures* [20] and manufacturer's quoted values.

The λ-value varies with moisture content. However, for roofs within the range of psychrometric conditions, insulation values and condensation control covered in this code of practice, the effect of moisture on theλ-value may normally be ignored without significant error. For other circumstances, reference should be made to BS EN ISO 10456 and BS EN 12524.

When calculating the requirements for an inverted roof, where thermal insulation is placed above the roof covering, reliable figures for the λ-value specific to that use, and a proper thickness adjustment for water run-off cooling should be sought from the manufacturer. If these are not available, the standard λ-value should first be modified to take account of any moisture absorption, in accordance with BS EN ISO 10456, and then multiplied by a factor of at least 1.2, to allow for the effects of cooling due to flowing water and ice thaw.

9.3 Thermal bridges

Where the roof construction has significant discontinuities in thermal insulation, such as a series of metal beams of high thermal conductivity, or local variations in thermal resistance, the average thermal resistance of the whole roof should be modified in proportion to the thermal resistances and areas of the thermal discontinuities, and those of the remainder of the roof.

9.4 Thermal mass

A material of large mass and high specific heat properties has a large heat storage capacity and a slow rate of response to changes of temperature to which it is exposed. Such materials and constructions are said to have high thermal mass. Heavy and thick constructions of concrete or masonry generally have high thermal mass while light and thin constructions of moderate or high conductivity, such as steel structures and sheet materials, have low thermal mass.

Thermal mass effects are not revealed in U-value calculations, since a steady state condition of heat flow is assumed as the basis of the calculation. Where heating is rapidly applied to a building in which a roof of high thermal mass is initially at a much lower temperature, condensation may occur until the roof temperatures approach the steady state condition.

In principle, heating or cooling plant with operating build-up rates which are appropriate to the thermal response rate of the building, should used to minimize such undesirable effects and provide economy in running costs.

NOTE Further advice on the effect of thermal mass in buildings is given in BS 5250.

9.5 Choice of insulating materials

9.5.1 *Techncial factors*

The following list covers the principal technical factors, which should be considered when choosing insulation materials for flat roofs:

a) physical form and suitability for use with a specific type of flat roof, including resistance to all forms of anticipated loading;

b) physical and chemical compatibility with other associated roof elements and fixing requirements;

c) thermal resistance and required thickness;

d) durability in service;

e) thermal and moisture movement;

f) vapour diffusion resistance;

g) water absorption properties;

h) sound insulation;

i) effect on fire performance of the roof and effect of any requirements imposed by the insurance assessor [e.g. Factory Mutual (FM) or Loss Prevention Council (LPC)];

j) ease of handling and installation.

The relative importance of these factors is dependent upon the type of flat roof, the internal and external design conditions, and the other associated roof elements.

9.5.2 *Types of insulation*

The variety of insulating materials available can be divided into the following categories:

a) rigid slabs or boards;

b) flexible mats or quilts;

c) loose particles or pellets (loose-fill);

d) structural materials with some insulating value, e.g. woodwool slabs;

e) lightweight screeds, cement or bitumen-bound.

In warm roofs, normally only rigid slabs or boards should be used. These should be installed with the waterproof covering.

In cold roofs, the materials given in b) and c) should normally be used. It is essential that full provision is made for adequate cross-ventilation of the whole roof space (see **10.3.3**), and care should be taken to secure the insulation against displacement by the ventilation draught.

In inverted roofs, the only insulation materials that should be used are those with thermal resistance properties that are not significantly changed by wetting, but are resistant to deterioration under extremes of external temperatures, immersion in water, freezing and thawing, wetting and drying, weathering and ageing (see **13.3**).

9.6 Positioning of thermal insulation

Placing the thermal insulation in different layer positions does not change the overall thermal insulation value of a roof (except marginally where the roof becomes a cold roof with a ventilated roof space). However, different temperature and water vapour pressure distributions within the layers of the roof are developed.

The position of the thermal insulation layer should be established with regard to the control of condensation (see Clause **10**) and structural movement (see **8.3.1**) and the temperature to which each of the layers are exposed.

10 Control of condensation

10.1 General considerations

During cold weather warm moisture in the air generated by occupants of or activities in buildings develops a higher vapour pressure than the outdoor air causing water vapour to permeate upwards into the roof. As the water vapour becomes colder towards the upper surface of the roof, the temperature may fall to, or below, dew point. Interstitial condensation results when this occurs within the roof.

Conversely, in warm weather, a reversed flow of vapour may occur when the outdoor vapour pressure is greater than the indoor vapour pressure or when higher vapour pressures are generated within the layers of the roof. Surface condensation occurs when the surface is at or below the dew point of the air immediately adjacent to it.

The roof should be designed to control these effects.

10.2 Design considerations

Condensation should be controlled within safe limits, having regard to the type of roof and the indoor and outdoor climates. Control of condensation in warm and inverted roofs should conform to the recommendations in Annex A. Vapour control layers are commonly used for this purpose.

Large variations may occur in the amount of moisture generated in different compartments within buildings:

a) moisture amounts within offices, schools and similar buildings are generally small;

b) amounts of moisture generated within industrial buildings vary according to the processes taking place;

c) amounts of moisture within domestic buildings are large in relation to those amounts within many other buildings, and there may be both intermittent heating and short periods during which high amounts of moisture are generated;

d) certain high humidity buildings such as swimming pools, textile and paper mills pose a high risk.

Where high amounts of water vapour are generated in a building compartment, in addition to any vapour control layer within the build-up, adequate indoor ventilation or extraction should always be provided in order to assist in the control of condensation.

The possibility of a future change of use or occupancy of the building should be considered, as this may create conditions considerably different from those on which the original thermal design was based.

Most materials can tolerate small amounts of condensation for short periods without adverse effects, but when condensation is excessive and prolonged, serious damage can result in the following ways:

— reduced thermal insulation due to increased moisture content;

— blistering and eventual rupture of some roof coverings, due to high vapour pressures developed under the roof covering, from vaporizing of the condensate when exposed to high outdoor temperatures;

— fungal attack to non-durable and timber-based materials;

— chemical attack from leaching of aggressive chemicals when roofing materials are wetted;

— accelerated metallic or bimetallic corrosion in structural components, fixing devices and electric wiring;

— loss of strength and stability;

— staining and deterioration of the ceiling:

— health hazards, e.g. from mould growth.

10.3 Types of roofs in relation to interstitial condensation

10.3.1 *Warm roofs*

In a warm roof condensation should be controlled by using vapour control layers and insulation of appropriate vapour resistance to avoid or minimize the occurrence of interstitial condensation under the design indoor and outdoor climate conditions.

NOTE Annex A and BS 5250 provide appropriate design guidance.

Notional design standards for outdoor and indoor climates and for safe transient limits of condensate in insulation materials are given in **A.3**. These design standards are based on conservative estimates of moisture absorption and durability characteristics of the relevant roofing materials and on confirmation of roof designs known from experience to be satisfactory or unsatisfactory as regards condensation risk.

The recommendations in Annex A should be used to make systematic comparative judgements relating to condensation risk in warm roofs. However, it should be recognized that with the wide variations in indoor and outdoor climates and in the thermal and vapour properties of roofing materials, the calculations are approximate and high numerical accuracy is not meaningful.

10.3.2 *Inverted roofs*

An inverted roof should be designed to ensure that, under the worst combination of indoor and outdoor design climates, the underside of the roof covering is maintained at a temperature above dew point.

To compensate for the effect of rainwater cooling of the deck below the insulation, and for moisture absorption by the insulant, the recommended thickness of the insulation should be increased (see **9.2**).

Where the roof layers below the roof covering provide a significant amount of thermal insulation, there may be a risk of condensation occurring in these layers. In such cases, the method of calculating condensation levels for warm roofs should be applied (see **10.3.1**).

10.3.3 *Cold roofs*

A cold roof should not be exposed to continuous high levels of indoor humidity; in such cases another roof design, e.g. warm or inverted, should be used.

In all cold roofs, it is essential to ventilate the roof void, even where the indoor design vapour pressure is low. For condensation control in cold roofs, a vapour control layer should be used to reduce the water vapour intake into the roof and ventilation of the roof void should be used to remove some of the water vapour. The recommendations for ventilation in BS 5250 should be followed.

NOTE Attention is drawn to the recommendations for ventilation given in The Building Regulations (England and Wales) 2001, Approved Document F, Ventilation and condensation [21], Parts G and K of the Building Standards (Scotland) Regulations 2001 [22], Technical Booklet K of the Building Regulations (Northern Ireland) 1994 [23].

Ventilation may be provided by airways through the fascia, soffit board or wall, detailed to avoid penetration of rainwater and entry by large insects. Where insulation, fire stopping, cavity barrier or service installations prevent unobstructed ventilation between opposite sides of the roof, a cold roof will not be viable and a warm roof should be designed.

Ventilation should be arranged so that all parts of the roof void are reached, avoiding stagnant air pockets, particularly at the upper parts of the void. Every void closed by imperforate beams, joists, fire stops, cavity barriers or other obstructions should be individually ventilated. In timber construction, the spaces between joists provide ventilation paths parallel to the direction of span, whereas the use of transverse purlins can provide ventilation paths transverse to the direction of span. For ventilation purposes, the ventilation direction should be chosen according to the practicability of providing openings to the outside air at opposite ends (e.g. impractical at an abutment wall).

Natural ventilation may not be adequate as the only source of ventilation in all circumstances to achieve satisfactory control of condensation.

10.4 Condensation at thermal bridges

Thermal discontinuities may give rise to local condensation in the roof and pattern staining on the ceiling. The small cold bridges formed by metal through-fixings connecting the insulation to the structural deck in warm roofs are generally not harmful where the likely extent of interstitial condensation is within safe limits (see Annex A) provided that the metal connectors have adequate resistance to corrosion.

NOTE Further advice on avoiding harmful effects of thermal bridges is given in BS 5250, and BRE Report 262, *Thermal insulation — Avoiding risks* [24].

11 Sound insulation

11.1 General

The amount of sound insulation required in a new or refurbished roof should conform to the recommendations for the control of noise in and around buildings in BS 8233, which also suggests appropriate noise criteria and limits for different situations.

Where it is necessary to consider how much sound insulation is provided by an existing roof construction, field testing should be undertaken; the sound insulation across a roof and the sound insulation between the spaces separated by an existing roof construction are measured. Sound insulation should be measured in accordance with BS EN ISO 140-4 and -5.

11.2 Sound insulation across the roof

The roof of a building should provide insulation against the ingress and egress of sound. Sound insulation increases with mass, but may be significantly reduced by penetrations such as rooflights, ducts, pipes and imperfectly sealed roof-wall junctions. The approximate sound insulation values provided by typical roof constructions are listed in Table 8.

NOTE 1 Further information on sound insulation across the roof is given in BS 8233 and CIRIA Report 127 [25].

Table 8 — Approximate sound insulation values for typical flat roofs

Roof construction	Weighted sound reduction index R_w, in dB
Timber and boarding, without ceiling	20–30
Timber and boarding with ceiling	35–40
Metal trough deck and insulating board without ceiling	25–35
With rooflights on about 10 % of roof area	25–35
Concrete of mass of at least 200 kg/m^2	50
NOTE Incorporating some thermal insulation materials can add to these values.	

It is particularly important to consider the sound insulation provided by a roof when either:

a) a source of noise is overhead, such as when a building is sited near paths of low flying aircraft, or a roof is exposed to high levels of road or rail traffic noise; or

b) high noise levels are to be generated inside the building and the roof separates the building from nearby noise sensitive receptors.

A proportion of such noise penetrates other building elements such as walls, doors and windows, either directly or by reflection from nearby obstructions, and should be taken into account in conjunction with the roof.

For cases such as a), the approximate noise level under the roof may be obtained by deducting the weighted sound reduction index of the roof from the external noise level immediately above the roof. For some sources, such as road traffic, this method is likely to underestimate the result by up to 5 dB.

For cases such as b), the approximate noise level at a receptor is more difficult to appraise. The received noise level depends not only on the noise level inside the building and the sound reduction provided by the roof, but also on the area of the roof radiating the sound, the orientation of the roof to the receptor, and the separation distance. Other factors such as local obstructions, and ground and meteorological conditions also influence the received noise level.

NOTE 2 Advice on calculation procedures is given in BS 8233 and CIRIA Report 127 [25].

11.3 Sound insulation along the roof

Sound can propagate along a roof or through the space formed by a roof and therefore transmit between adjacent rooms or adjacent buildings having a common roof.

NOTE 1 Sound insulation between dwellings is subject to statutory regulations. For dwellings sharing a common roof, guidance on the control of noise between them is given in the following documents:

— for England and Wales, Approved Document E to the Building Regulations 2000 [26];

— for Scotland, Part H of the Technical Building Standards (Scotland) 1990 [27];

— for Northern Ireland, Technical Booklets G and G1, 1990 [28].

In general, where a wall dividing two spaces extends up through the roof construction, the roof is unlikely to be a factor affecting the transmission of sound between the two sides. Where, however, a dividing wall terminates below the roof construction, the sound insulation provided by the roof may affect the transmission of sound between the two spaces. In such cases, sound insulation barriers should be installed in the roof or roof space above the wall. In addition, joints between wall and ceiling or barrier should be sealed to avoid sound leakage through air paths.

NOTE 2 Roof cavity sound barriers may often serve as fire-stops, but in cold roof voids they may interfere with ventilation requirements.

Where the ceiling or roof void contains air conditioning or ventilation ducts that cross a dividing wall, special measures may be necessary to control the amount of noise transmitted through them from one room to another.

11.4 Sound absorption

In certain circumstances it may be advantageous to provide sound absorption material within or to the underside of a roof construction, e.g. when sound absorption material is placed within the void of a twin skinned roof construction the sound insulation performance of a roof is improved. When provided to the underside of the roof construction, the material absorbs sound in the space below tending to reduce the reverberation time within the space.

NOTE This can be useful in reducing noise in the space or improving speech intelligibility.

Guidance on the sound absorption properties of various materials and their use is given in BS 8233. Care should be taken when providing a sound absorbent ceiling to avoid inadvertently creating a risk of interstitial condensation (see **10.3** and **A.2.3**).

12 Fire precautions

12.1 General

Flat roofs should be designed in accordance with the recommendations for fire precautions given in BS 5588.

NOTE Attention is drawn to the following statutory regulations relating to fire precautions:

— Part B of the Building Regulations (for England and Wales) 2000 [29];
— Parts D and E of the Building Standards (Scotland) (Consolidation) Regulations 1990 [30];
— Part E of the Building Regulations (Northern Ireland) 1994 [31];
— constructional standards for maintained and direct grant educational buildings in England and Wales [32].

12.2 Insurance

As alternative forms of roof construction may attract different costs of insurance against loss in fire, this factor should be considered in the design of flat roofs. Guidance on designing for construction to achieve improved fire resistance and protection is given in [33].

Statutory regulations on external fire (see [29], [30], [31] and [32]) aim to limit the risk of ignition by radiation from a nearby fire, the spread of fire from the roof to nearby buildings, and the spread of fire between the compartments in a building via one part of the roof to another. To achieve this, the technical guidance supporting these regulations place limitations on the use of certain materials and forms of construction.

The category designations for the performance under external fire of roofing materials and roof construction, and the methods of test, should conform to the text of BS 476-3:1958, *External fire exposure roof tests*, given in BS 5427-1:1996,Annex E.

NOTE Details of certain roof constructions tested and classified in accordance with BS 476-3 (see BS 5427-1:1996, Annex E) are given in BRE Fire NOTE No. 4 [34].

12.3 Internal fire

12.3.1 *General*

Statutory regulations on internal fire, given in **12.1**, aim to limit the risk of:

a) spread of flame over exposed internal surfaces;

b) spread of fire through cavities in the structure;

c) structural collapse after a specified period of fire;

d) fire spreading from one building compartment to another;

e) excessive heat conducted by hot flues to the surrounding roof.

12.3.2 *Spread of flame and fire propagation*

Methods of test, for spread of flame and fire propagation, should conform to BS 476-6 and BS 476-7.

NOTE Details of certain internal surface materials, tested and classified in accordance with BS 476-6 and BS 476-7, are given in Fisher and Rogowski [35] and [36], and in Fisher [37] and [38].

Ceilings or rooflights made of plastics materials should conform to those sections of BS 2782-1 which are relevant to the actual material.

The performance under fire of ceilings should conform to BS 8290-1.

12.3.3 *Fire in cavities*

The spread of fire and products of combustion along cavities in the roof may be restricted by means of fire stops and cavity barriers respectively.

NOTE Guidance is given in Approved Document B in support of the Building Regulations 2000 [29], Parts D and E of the Building Standards (Scotland) Regulations 2001 [30], and Technical Booklet E of the Building Regulations (Northern Ireland) 1994 [31].

The recommendations for cavity barriers may conflict with the need to provide ventilation in the roof space of cold roofs. In such cases, where it is impractical to ventilate across opposite sides, other types of roof should be considered.

12.3.4 *Fire resistance*

A roof structure is by itself not normally required to have a prescribed period of fire resistance, and for this purpose it is not classified as an element of structure. However, if the roof is required to support or to stabilize the load-bearing walls or other structural parts of the building, is used as a floor, or is used as a fire escape route, the appropriate fire resistance period should be met.

Where required, the fire resistance of structural decks should be established in accordance with the appropriate part of BS 476-21.

NOTE Guidance is given in Approved Document B of the Building Regulations (England and Wales) 2000 [29] and BS 476-21, Parts D and E of the Building Standards (Scotland) Regulations 2001 [30], and Technical Booklet E of the Building Regulations (Northern Ireland) 1994 [31].

12.3.5 *Fire across compartments*

The risk of external fire spreading across a compartment wall and of internal fire crossing the compartment wall in the roof space should be controlled by one or more of the following measures:

a) continuing the compartment wall up to a specified height above the upper surface of the roof covering;

b) fire stopping the roof-wall junction;

c) using non-combustible coverings or coverings of high external fire performance rating within a certain minimum distance of the compartment wall;

d) using a non-combustible structural deck.

NOTE The application of the measures in a) to d) depends on the type and use of the building. Details are given in BS 5588 and the Building Regulations [29], [30] and [31].

12.3.6 *Hot flues*

The risk of softening, distortion, charring or ignition of the roof construction surrounding a hot chimney or flue should be controlled by insulating and isolating the flue where it penetrates through the roof.

Flues with a temperature in excess of that at which timber and timber products char should be surrounded by non-combustible materials. As plastic foams and bituminous roofing materials soften and distort at relatively low temperatures, they should always be isolated from hot flues.

13 Surface protection

13.1 Solar protection

Roof coverings of dark colour and non-reflective texture (high emissivity) absorb more solar radiant heat and develop temperatures significantly higher than the ambient temperature of the outside air, particularly in warm roof constructions. The guidance given in the relevant codes of practice in Table 1 for appropriate measures for different roof covering materials should be followed. Solar reflective treatment is particularly important in warm roofs, where the differential thermal movement between the roof covering and the substrate is high (see **8.3.2**) and where properties of the materials are adversely affected by high temperatures.

13.2 Damage from traffic

The extent and nature of the traffic to which a roof will be subjected (particularly for access to roof-mounted plant, but also including traffic for construction and roof maintenance purposes) should be established at the design stage and an appropriate wearing surface or specific walkways provided. During the construction phase, temporary protection may be required.

13.3 Inverted roofs

For inverted roofs, the insulation and roof covering should be secured against removal or displacement by the combined effects of wind uplift and floatation in water. Where the insulation is secured by ballast the minimum aggregate size should be sufficient to prevent wind scour (see BRE Digest 311 [39]).

Where concrete slabs are used as the ballast they should be raised off the insulation to provide a nominal air gap to assist the removal of water and to help reduce rocking. They may be loose laid on proprietary support pads. A 150 mm wide edge strip filled with ballast (clean rounded, nominal diameter 20 mm – 40 mm) should be provided against parapets and upstands, and around rooflights.

Proprietary systems of lightweight insulation that do not require separate ballasting may also be used, but consideration should be given to their wind uplift resistance and flotation potential (see BRE Digest 295 [40]).

Consideration should be given to the use of a water permeable filter layer between the insulation and aggregate ballast, to prevent any fines from being washed below the insulation, which may damage the waterproofing membrane or block the roof drainage system.

A separation layer may be needed between certain waterproofing membranes and the insulation, in which case the manufacturer's advice should be sought.

14 Rooflighting

14.1 General

Rooflighting may be in single or multi-layer glazing, or prefabricated units of various types of glass or plastics. It may also incorporate ventilators with natural or forced smoke ventilation, opening lights, escape hatches and security grilles.

The incorporation of rooflights should be co-ordinated with the design of the structural elements of the roof. The maximum width of a rooflight may be limited by the clear spacing between joists or beams. The structural deck, insulation and ceiling should be framed to receive and support the rooflight.

14.2 Daylighting recommendations

The provision of daylighting in buildings should be in accordance with the recommendations given in BS 8206-2.

In general, daylighting from roofs should be provided where necessary:

a) to augment daylighting provided by doors and windows;

b) to provide daylighting in buildings or rooms where wall openings are absent or inaccessible (e.g. internal bathrooms) or deep plan buildings.

14.3 Weathertightness

Rooflighting should be as weathertight as the roof covering. Edges of rooflights should incorporate upstands of at least 150 mm above the finished roof level. Allowance should be made for future increases in insulation thickness. The rooflight components and fixings should have sufficient strength to resist dead, imposed and wind loads in accordance with BS 6399-2.

14.4 Thermal insulation

The thermal transmittance, or U-value, of rooflights is usually much greater than that of the general roof construction. In normal conditions, typical U-values can range from 1–2 $W/m^2{\cdot}K$ for multi-layer glazing systems to 5–6 $W/m^2{\cdot}K$ for single glazing.

The thermal insulation of rooflight framing, upstands around the rooflight and the effect of ventilation or air leakage in rooflights with ventilators or opening panels should be taken into account.

NOTE The thermal design of a roof, including roof glazing, is covered by Parts L1 and L2, Conservation of Fuel and Power, of the Building Regulations (England and Wales) 2001 [13], Part J of the Building Standards (Scotland) Regulations 2001 [14], and Technical Booklets F and V of the Building Regulations (Northern Ireland) 1994 [15].

14.5 Condensation

Surface condensation can be expected to occur occasionally for short durations on single and double-glazing because of their relatively high U-values. Such condensation is usually acceptable if it is not excessive, i.e. if the methods of drainage are suitable, and the rooflight components, particularly the framing, fixings and finishes are resistant to wetting and contain a method of entrapment and/or drainage of condensate.

Condensation can be reduced by incorporating adjustable ventilators for natural or forced ventilation. Alternatively, where condensation risks greater than that of the roof ceiling generally are unacceptable, multi-layer glazing with air spaces or metallic coated special glass may be used to provide a U-value for the rooflight of not more than 1.0 $W/(m^2{\cdot}K)$.

Rooflight systems manufactured from multi-chamber and foamed PVC greatly reduce the risk of condensation. Some aluminium frame rooflights are thermally broken reducing the risk of condensation.

Interstitial condensation in the air spaces between multi-layer glazing should be avoided by sealing the air spaces in which the air is dry, ideally by using prefabricated sealed units.

14.6 Fire precautions

Fire precautions for rooflighting should conform to the recommendations in Clause **12**.

14.7 Sound insulation

As rooflights usually reduce the sound insulation of the roof, the recommendations given in **11.2** should be applied

14.8 Safety considerations

The selection of materials for safe use for rooflights, i.e. polycarbonates or acrylics, and other glazing materials, should be determined by the extent of access, any perimeter protection and the rooflight dimensions.

The Health and Safety Executive in HSG 33, *Health and safety in roof work* [41] differentiates between fragile and non-fragile rooflights. These can be identified by using the drop/impact test specified in the HSE test method ACR(M)000 [42].

The long-term durability of rooflight materials should be considered, as ultra violet light degradation of some plastics can have a direct influence on fragility. Rooflights may have a different lifetime to the remainder of the roof.

15 Roof plant, equipment and fixtures

Plant equipment and service units located above the roof waterproofing include air conditioning and chiller units, rooflights, ventilators, flues, service pipes, safety barriers, signs and aerials. Some of these items, or their associated cabling and ducting, require penetration of the roof waterproofing, and in some cases penetration of the deck.

Penetrations through the roof waterproofing system should be specifically designed and located to ensure continuity of the roof system, in particular waterproofing, insulation and structural integrity. At all plinths, abutments and penetrations, it is essential that the continuity of the waterproof covering is maintained for a vertical height of 150 mm above finished roof level.

Wherever possible, penetrations through the roof should be kept to a minimum.

Where plant units are mounted on the roof, or where the roof waterproofing system will be penetrated, the following recommendations should be followed.

a) Major service units, rooflights and balustrade supports should be mounted on a raised kerb or plinth or steel stub column, and should be anchored to the structural deck. Such columns should be of either circular or box section to facilitate formation of waterproof collars.

b) Suitably-designed access routes across the roof should be provided.

c) Sufficient area around and under units should be provided to enable access to the waterproofing system and for servicing and maintenance.

d) Upstands should extend not less than 150 mm above the finished roof level. Clamping devices and fixings for units should not interfere with waterproofing flashings.

e) The roof waterproofing should be dressed up the upstand and, where appropriate, over the top of the kerb or plinth.

f) The waterproofing system below the unit should be protected by a separate cover flashing or capping, that is sealed to the unit and which over-sails the waterproofing flashing details by at least 50 mm.

g) Lightweight units that do not require anchorage and are stable against wind loads, should be located on free-standing load spreaders. It is essential that the structural deck, insulation and waterproofing can accommodate the additional loads.

h) Pipes, small vents and cabling penetrations should be accommodated by a separate upstand sleeve which should be fixed to the structural deck, and provide an upstand of at least 150 mm. A cover flashing/cowl should also be provided.

i) Special precautions should be taken to avoid damage to the waterproofing by hot flues and pipes (see **12.3.6**).

j) Cold bridging should be avoided for all penetrations of the roof waterproofing or deck. Continuity of insulation should be maintained around units.

k) Consideration should be given to the effect on roof drainage of service units and steps taken to avoid water standing behind the units. Tapered crickets may need to be used to minimize standing water.

l) Lightning conductors, supports and straps should not be fixed through the waterproofing. Supports should be bonded to the waterproofing with adhesive or membrane straps, allowing free movement of the lightning conductor strip.

NOTE 1 With single ply membranes, and with some bitumen sheet systems, manufacturers recommend the use of proprietary weld-down or torch-down clips.

NOTE 2 A number of proprietary roof accessories are available, that provide free-standing support and safety devices to plant and equipment thus minimizing roof penetrations.

NOTE 3 Further guidance on the treatment of penetrations of the roof waterproofing is given in the codes of practice for materials in Table 1.

Advice from manufacturers and suppliers should also be sought for the treatment of penetrations of the roof waterproofing.

16 Security

The general guidance on security of buildings given in BS 8220-1, -2, and -3 should be followed.

The risk of illegal entry by breaking through the roof or roof openings should be considered in the design of the roof. Generally, access to and illegal entry through flat roofs should be made as difficult as possible and not achievable without noise.

Rooflights and hatches are usually the most vulnerable components of a roof to illegal entry. Precautions should be taken to provide a reasonable deterrent against illegal entry. Strong fixings that are difficult to break or unfasten (e.g. non-return clutch head screws) should be used to attach the rooflight to the roof and locking devices should be fitted on latches to opening lights and hatches. For additional security, steel anti-burglar grilles should be installed where necessary.

The ease with which the roof deck can be broken through may also require consideration. Light roof coverings on light structural decks that are readily cut, sawn or prised open (e.g. timber boarding or woodwool slabs) are more vulnerable to illegal entry than solid concrete decks. Therefore, they should not be used in buildings requiring high standards of security (e.g. banks and buildings with high value contents).

Security measures for the roof design should be considered together with general measures for the security of other elements of the building such as walls, doors, windows, locks and other complementary measures such as burglar alarms, lighting, fencing and guarding.

17 Durability of roof coverings

Although the maximum life of the roof covering should be governed by the durability of the covering material itself, experience has shown that premature failure can occur due to incorrect design and careless construction, particularly of joints, upstands, edges and the supporting deck. The roof covering should be maintained and inspected regularly to ensure maximum durability is achieved. Specific guidance is given in Clause **18** and in Annex B.

18 Maintenance and repair

18.1 Maintenance

The service life of roofing systems may be significantly extended by periodic maintenance. Periodic maintenance should be planned. A maintenance manual should be kept, containing basic information and guidance in accordance with the recommendations given in Annex B.

18.2 Repair

Repairs should only be carried out after the type and extent of any defects have been determined and their underlying cause identified. Repairs should be carried out using compatible materials (see Table 1 for relevant standards and codes of practice).

19 Refurbishment and renewal

Refurbishment, which usually involves either significant restoration of a previous system, or upgrading beyond what was originally built, should be conducted in accordance with the recommendations in Annex C.

20 Safety

Attention is drawn to the following statutory regulations relating to construction safety:

— The Construction (General Provisions) Regulations 1961 [1];
— The Construction (Lifting Operations) Regulations 1998 [2];
— The Construction (Notice of Accident, etc.) Orders 1964 [3];
— The Construction (Working Places) Regulations 1966 [4];
— The Construction (Health, Safety and Welfare) Regulations 1996 [5];
— The Health and Safety at Work etc. Act 1974 [6]; and
— Construction (Design and Management) CDM Regulations 1994 [43].

Guidance on safety and on CDM Regulations is given in Annex D and the following: HSE *Approved code of practice* (ACOP) [44] and Health and Safety Executive HSG 33, *Health and safety in roof work* [41].

Annex A (informative) Control of condensation in warm and inverted roofs

A.1 Design objective

To control condensation in warm and inverted roofs, the design objective should be to choose and combine materials for the indoor and outdoor conditions of use that will preclude surface or interstitial condensation or keep such condensation within limits which are not harmful (see **A.2.3**).

The recommendations in BS 5250 for the control of the causes and effects of condensation in buildings should be followed. The methods in BS 5250 should also be used to determine the occurrence and assess the effects of:

a) surface condensation;

b) interstitial condensation.

A.2 Design procedure

A.2.1 *General*

The calculation of condensation risk in steady state conditions should be carried out in accordance with the procedure given in BS 5250 and the additional recommendations given in **A.2.2** to **A.2.3**.

A.2.2 *Determine the appropriate indoor and outdoor climate conditions to be adopted for design*

An appropriate winter outdoor climate should be determined, defining temperature and relative humidity. Where suitable outdoor climate data are not available, the conditions given in Table A.1 should be used.

An internal climate appropriate to the type and use of the building and to the standards of heating, cooling and ventilation in use, should be determined for the analysis of condensation. In principle, the internal temperature and humidity may be determined from the thermal characteristics of the building, the heat generated by the occupants and their activities and the operation of equipment, together with the effects of natural or mechanical ventilation in accordance with BS 5250, BS 5720 and BS 5925. Short peaks of moisture emission are usually not harmful, and may be averaged over periods of 12 h or 24 h. The amount of natural room ventilation cannot be closely estimated as it may fluctuate widely because of its dependence on outdoor wind movement and large inaccuracies usually involved in assessing the air flow rate through leaks and small gaps. Where such a detailed assessment is impractical, the conditions given in Table A.2 may be used.

A.2.3 *Control the risk of interstitial condensation*

An initial analysis of the temperature and dewpoint distributions (or actual and saturated vapour pressure distributions) across the roof should be carried out, based on the relevant winter design assumptions and the thermal and vapour resistance properties of the roof. If the temperature is maintained above dewpoint (or vapour pressure less than the saturated vapour pressure) throughout the roof, the analysis indicates that interstitial condensation will not occur.

However, if at any point the temperature is at or below dewpoint (or the vapour pressure is equal to or apparently greater than the saturated vapour pressure), the analysis indicates interstitial condensation. In this case a further analysis should be carried out to determine whether the amount of winter condensate and its removal in summer are within the limits recommended in **A.3.3**. If the risk of condensation is unacceptable, the roof design should be modified, typically by adjusting its thermal and/or vapour resistance properties.

A.3 Design standards

A.3.1 *Outdoor climate*

Unless detailed data are available to predict the appropriate outdoor conditions for the location of the roof, the notional conditions given in Table A.1 should be taken to apply anywhere in the UK.

Table A.1 — Outdoor notional psychrometric conditions for flat roof design

Notional season	Temperature °C	Relative humidity %	Vapour pressure kPa	Duration days
Winter	–5	90	0.36	60
Summer	18	65	1.34	60

The values given in Table A.1 include allowances for daily temperature variations, solar and night sky radiation effects and safety margins. More extreme conditions may occur occasionally for short durations but it is assumed that the incidence is low and that roofs constructed in accordance with the recommendations in this code of practice can tolerate such occurrences without damage.

A.3.2 *Indoor climate*

In the absence of specific data, for normal conditions of occupancy and arrangements of windows and ventilation, the indoor conditions given in Table A.2 should be adopted for the purpose of condensation analysis.

Table A.2 — Notional indoor psychrometric conditions for flat roof design

Type of building	Temperature °C	Relative humidity %	Dew point °C	Vapour pressure kPa
Houses and flats	20	55	10.7	1.28
Offices	20	40	6.0	0.93
Schools	20	50	9.3	1.17
Factories and heated warehouses	15	35	–0.3	0.60
Textile factories	20	70	14.4	1.63
Swimming pool halls (ventilated)	30	60	21.4	2.54

Higher humidities are generated in kitchens, bathrooms and laundries, where different conditions may apply unless additional ventilation is provided. Further guidance on psychrometric conditions is given in BS 5250. Possible changes of use should also be considered in design. Guidance on ventilation is given in BS 5720 and BS 5925.

Where adjacent compartments under a common roof have different indoor climates, the design of the roof as regards condensation control should be based on the more severe condition.

A.3.3 *Condensate retention*

The calculated amount of winter interstitial condensate for a warm roof, based on the climates given in Table A.1 and Table A.2, should not exceed 0.35 kg/m^2 for insulation materials, provided that no accumulation of condensate from one year to the next has been calculated.

NOTE This advice is not applicable to fibreboard (softboard) insulation, which may be permanently damaged.

A.4 Vapour resistance

Unsealed joints or penetrations reduce the vapour resistance of the material in which they occur, the reduction being particularly significant for materials with high vapour resistance. For example, the theoretical very high value for profiled metal decking would be greatly reduced by un-stitched or unsealed laps or perimeters.

Roof layers that contain joints or perforations, e.g. foil-faced insulation boards, should have their vapour resistance modified to take these into account for calculation purposes.

A ceiling layer that contains open joints or perforations should be assumed to have zero vapour resistance over its area.

Annex B (normative) Maintenance

B.1 Maintenance manual

Inspection of the roof should be carried out both externally and internally, and should follow a specific written routine. A maintenance manual should be prepared, preferably at the time of initial construction, which includes the following basic information and guidance on the maintenance items and scheduling:

— a set of "as built drawings" including any subsequent changes;

— a set of specifications, calculations and dates of controlling documents used, including information on the proposed use of the building and any special features such as internal psychrometric conditions, any areas subjected to high loads and fragile roof materials;

— copy records of any surveys or tests carried out on the roofing system whether before handover or after occupation;

— a list of designers, contractors, subcontractors and suppliers involved;

— copies of warranties, guarantees etc., including any schedule of requirements and conditions;

— basic pro-formas to assist the collating of maintenance records including check lists, maintenance tasks, frequency and type of survey, and provision for photographic records.

B.2 Inspection

A flat roof should be routinely inspected every spring and autumn. The spring inspection may detect winter related roof damage. The autumn inspection should ensure that the roof is clear of leaves, debris and dirt before the approach of winter.

Roofs in high-risk locations, those in areas subjected to high dust or pollution, or in close proximity to trees, should be inspected more frequently.

A special inspection should also be carried out if one or more of the following situations has occurred:

— recent construction on or adjacent to the roof;

— new equipment installed on the roof;

— unusual weather conditions, such as very high winds or unusually heavy snow;

— following fire, vandalism or other known damage to an adjacent roof area.

B.3 Inspection procedure

Inspections should include building interiors, external details, components and rainwater goods.

The starting point of an inspection should be the interior of the building. Internal walls and ceilings should be checked for leaks, and signs of water staining. A floor plan, relating to the roof plan, should be developed to identify roof level problems.

The exterior walls, rainwater goods, eaves and soffits should also be included in the inspection routine, and signs of movement and cracks should be noted.

The roof should then be inspected, by checking the following roof components:

— cap flashings: metal or other rigid or semi-rigid coverings of membrane terminations, including counter flashings, expansion joint covers and copings;

— edge details: metal or other rigid or semi-rigid components used to terminate, waterproof and provide wind uplift protection at the perimeter of the roofing system;

— membrane flashings: roof membrane termination at walls, waterchecks, kerbs and gutters;

— penetrations and protrusions: pipes, drains, rooflights and all other items that penetrate the roofing membranes;

— main waterproofing: the main membrane roofing system.

In addition, the observations of the occupants of the building should be recorded.

NOTE Other than visual inspection, several other specific, electronic methods of leak detection and/or monitoring are available.

B.4 Maintenance guidelines for inspection

The following maintenance advice for the inspection should be included in the manual.

— Remove debris such as nails, bottles, cans, balls, boards and bricks.

— Clear and remove from the roof leaves, paper, dirt etc., which may collect at roof drains, gutters and gullies.

— Cut back tree limbs that overhang the roof to give a 1 m clearance outside the roof edge. This will significantly reduce leaves continually blocking drainage ways.

— Remove or repair roof mounted equipment that has fallen into disuse or become redundant. It may have the potential to cause damage to the roof membranes.

— Ensure chippings and other materials designed to protect the roof membranes from UV degradation are in place and evenly spread. Redistribute any surfacing that has been displaced by the action of wind or water flow.

— Ensure flashings to all supporting plinths and cradles of ductwork are checked and maintained in good condition. They should not be penetrating the membranes or restricting drainage.

— Surface coatings will generally require periodic re-application during the life of the waterproofing system, to maintain effectiveness against UV degradation. Re-coating is an integral part of the maintenance schedule of any roof system that employs a surface coating material.

— Ensure sealants and/or mastics at counter flashings, termination strips and other locations are in good condition and effective.

— Check and ensure that the pointing to chases at the top of skirtings is sound, i.e. not loose, missing or badly cracked.

Ventilation of the roof spaces, if any, and of the building or rooms under the roof should be checked. Corrective measures should be taken to improve ventilation or the roof construction in cases of excessive condensation.

Access to the roof should be limited and controlled to avoid as far as possible the risk of abuse and damage to the roofing system.

B.5 Recommendations — Summary

In order to properly care for the roof, the following measures should be implemented:

— maintain historical records;

— control roof access;

— conduct six monthly inspections, and special inspections (see **B.2**);

— report leaks or roof damage immediately;

— ensure routine maintenance is carried out;

— use only competent persons (i.e. specifically trained and experienced in the type of covering involved) for major maintenance, emergency repairs and permanent repairs (see Foreword).

Annex C (normative) Refurbishment and renewal

C.1 Refurbishment

C.1.1 *General*

The following factors should be taken into consideration when refurbishing an existing flat roofing system.

— It is not always possible to leave the existing roofing system in place.

— The existing membrane can sometimes be used or repaired and used as a vapour control layer for a new waterproofing system. Upstands should generally be replaced.

— If the existing roof configuration is to be changed, e.g. from a cold deck roof to a warm deck roof, the thermal performance and condensation risk should be re-assessed.

The following points should be taken into account when upgrading a roof, particularly with additional insulation:

a) overloading of the structure by additional weight;

b) overloading of the structure by snow retained longer, due to the performance of the additional insulation;

c) interrupting the drainage of the roof;

d) retaining minimum height of waterproofing at upstands at parapets, junctions, details;

e) retaining height of existing damp-proof courses and cavity trays;

f) entrapping moisture within the existing system causing blistering under the new membranes.

It may be possible to use tapered insulation in order to reduce existing ponding.

In each case, the consequences of retaining or changing a particular roof system should be examined, especially if there is an intended change of use for the building.

C.1.2 *Refurbishment — Overlays*

When an overlay specification is chosen as the means of refurbishing a flat roof, the following basic criteria should apply:

— the old roof system should be generally sound, dry and free from water damage;

— the roof surface should be clean, dry, sound, and suitable to take an overlay system;

— if using additional insulation, upstand heights should not be compromised;

— overlay materials should be compatible with existing materials.

C.2 Renewals

Design procedures for renewals should be the same as for a new roof (see Clause **6**, Clause **7**, Clause **8** and Clause **9**), but the reason why the original roof system failed should be investigated and rectified, particularly for inadequately-ventilated cold roof systems where construction timber has failed because of condensation. In this case, either the ventilation should be significantly improved, or the roof should be re-designed to a warm roof construction.

Replacement of the existing roof should also be considered if either the existing insulation is saturated or degraded, or the roof deck has deteriorated or is inadequate.

NOTE As some old roof coverings may contain asbestos, reference should be made to HSE documents HSG 210 [45] and HSG 213 [46].

Annex D (informative)
Construction (Design and Management) (CDM) Regulations 1994

D.1 General

The CDM Regulations [43] aim to reduce the incidence of accidents and occupational ill-health arising from construction work and maintenance. This is achieved by introducing procedures to improve the planning and management of health and safety on construction projects of all types, throughout every phase and involving all duty holders in the management of risk.

The CDM Regulations place specific duties on each duty holder, along with a general duty to co-operate and communicate.

The CDM Regulations do not apply to smaller scale, short-duration roofing work, or to most individual domestic projects. However, even where the Regulations are not in force, their underlying principles of effective health and safety management can still be applied. Following the CDM Regulations will help clients to comply with their wide-ranging general duties under the Health and Safety at Work etc. Act 1974 [6] to exercise reasonably practicable care for the health and safety of themselves, their employees and others such as contractors and members of the public.

D.2 Clients

People who occupy or have responsibility for buildings have an important role to play when arranging for roof work to be carried out. This includes considering the design and specification of the roof, provision of adequate resources in terms of time and money so that the work can be carried out safely, and appointing suitably trained and experienced designers and contractors (see Foreword).

Unrealistic building or refurbishment programmes can lead to undue pressure on those carrying out the work. This can make it harder for contractors to plan for safe working, to prepare safety method statements and to review and amend systems of work. Clients have an important role to play, as they should avoid placing unreasonable programming demands on the project.

For projects of sufficient size or duration for the CDM Regulations 1994 to apply, clients should:

— appoint a planning supervisor, designers(s) and principal contractor and check that they are suitably trained and experienced, and adequately resourced;

— provide relevant information to allow the work to be done safely (e.g. identify any access problems or fragile materials);

— ensure that an adequate construction phase health and safety plan has been prepared;

— if they provide design details, e.g. material specification, these should conform to the duties placed on designers.

D.3 Designers

Designers can eliminate hazards and make risks easier to manage, by using their professional skills and judgement. This helps contractors to provide a safer place of work on the roof. Designers need to consider both the initial construction work and the future maintenance and cleaning requirements.

Under the CDM Regulations, designers need to take into account the health and safety implications of their decisions, because they have a duty to ensure that their designs give adequate regard to health and safety. They can often eliminate foreseeable risks by designing them out at source. Where this is not possible, designers should control risks by giving priority to general protection rather than individual protection, for example:

— eliminating fragile materials;

— facilitating inspection and ease of maintenance requirements for the completed roof;

— identifying and designing in safe access and safe place of work for maintenance and cleaning.

D.4 The planning supervisor

Planning supervision aims to improve the flow of information throughout the project. The duties of the planning supervisor include the following:

— preparation of the pre-tender health and safety plan; any fragile roofing materials or specific major hazards relating to roof access etc., should be identified within the plan;

— advising the client and other duty holders of the competence and resources of designers and contractors.

D.5 The principal contractor

Principal contractors are key players in setting practical on-site standards and ensuring that they are followed. They should:

— ensure the programme provides sufficient time for work to be conducted safely by the roofing contractor, taking into account weather conditions;

— allow time to consider method statements;

— devise a work programme reflecting the need to control access to areas below roof work where there is a danger of falling materials;

— specify at tender stage the resources allocated to control and manage risks such as falls from height;

— ensure that relevant information is passed to the roofing contractor.

The principal contractor should ensure that the construction phase health and safety plan is in place, and that it sets out explicitly how the roof work is to be conducted in practice and the precautionary measures that need to be taken. The principal contractor should also monitor the plan to ensure compliance on site and take positive action to remedy matters if a risk is not sufficiently controlled.

D.6 Roofing contractors

Roofing contractors should:

— prepare a safety method statement that is relevant to the work being completed;

— ensure that they and their employees are suitably trained and experienced to carry out the work;

— co-operate with the principal contractor in implementing the construction phase health and safety plan.

In addition, contractors should verify that the system of access and edge protection is appropriate, including checking that work platforms, etc., have adequate strength.

D.7 Specific risks associated with roofing work

Roofing is potentially a hazardous operation. Effective steps should be taken to eliminate, reduce or control commonly-encountered risks on the following list:

— working at a height, risk of falling (applicable both to initial construction and to subsequent maintenance, requiring safe access and protection of the place of work);

— handling and craneage of materials, also risk of items falling from height onto ground;

— elimination or control of fragile materials (for example, rooflights);

— hot working, which is inherent in many types of roof construction;

NOTE Hot working includes use of hot, molten bitumen and/or gas torches for felting, gas torches or electron arc methods for welding seams of metal roofs, or any similar use of flame or arcs. Such processes should only be carried out by fully trained and competent personnel.

— use of materials containing solvents;

— relationship of the roofing work to building services, for example ventilation and electrical;

— in refurbishment work, additional risks from hazardous materials which may no longer be found in new construction, e.g. asbestos.

The general approach advised by the *Approved code of practice* (ACOP) [44], is wherever possible to identify and eliminate all hazards. Where it is not feasible to eliminate a hazard, steps should be taken to reduce the risk and to provide information necessary for remaining risks to be safely managed.

Access equipment and edge protection should be appropriate to the proposed works.

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