Standard specifications, layouts and dimensions

5 FIVE

Roof coverings in schools

department for
children, schools and families

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Contents

Introduction

This guidance is one of a series of Standard Specifications, Layouts and Dimensions (SSLD) notes produced to inform the Building Schools for the Future (BSF) programme.

Who this guidance is for

- Teachers and governors acting as clients for school capital projects.
- Local authority officers responsible for procuring school capital projects.
- Diocesan building officers.
- Local authority and private sector school designers and specifiers.
- Manufacturers and suppliers.
- Contractors.

How the guidance should be used

This guidance sets out the standards of performance for roof coverings in the Building Schools for the Future (BSF) programme and shows through some examples how they might be delivered. It is one of a number of publications on various building elements within the SSLD series. The aim is to disseminate best practice and avoid 'reinventing the wheel' every time a school building is designed, so that consistently high quality environments can be delivered, offering best whole-life value for money.

School building clients, their professional advisers, contractors and their supply chains should use this guidance to inform their decisions on roof coverings at the early stages of a project's development – whether new build, extension or refurbishment – at RIBA Stages A-F.

To help encourage the take up of these performance specifications, this guidance will become the standard in BSF programme documentation and the Government will expect it to be adopted in the majority of situations where it is reasonable and appropriate to do so.

While we would expect projects to comply with the standards, other solutions – possibly based on new products or technologies, or reflecting local factors – may equally comply with the performance specification and could be used. We do not want to stifle innovation by being too prescriptive.

It will be for users to exercise their own skill and expertise in deciding whether a standard or example shown in this document is reasonable and appropriate for their own circumstances. This guidance does not affect obligations and liabilities under the law relating to construction and building.

Though principally aimed at secondary school building projects delivered through the BSF programme, the specifications and examples may also apply to other educational buildings.

We will keep this guidance under review and update it as necessary to reflect the development of new products, processes and regulations. There is a web-based version at: www.teachernet.gov.uk/schoolbuildings

Background to Standard Specifications, Layouts and Dimensions (SSLD)

The BSF programme offers a unique opportunity over the next 10-15 years to transform our secondary schools, providing innovative learning environments that will inspire pupils to achieve more. High quality, modern school buildings will help to raise standards and play a crucial part in the Government's programme of educational reform.

With the huge increases in funding associated with this programme, there is considerable scope for using standardised specifications, layouts and dimensions to speed up design and construction, reduce whole-life costs and deliver consistently high quality and better value school buildings. Standardisation will support the use of more off-site fabrication and modern methods of construction, which should help to improve health and safety performance, reduce waste and deliver more sustainable solutions. For the supply industry, being involved in standardisation will help to demonstrate market leadership – and help firms reduce risk and increase sales, profitability, and market size.

The examples in this document and the others in the SSLD series have been developed based on extensive consultation under the auspices of the SSLD Forum. Set up by the Department for Children Schools and Families (DCSF), this forum represents key stakeholders in the building design, research, contracting, and supply industry communities, as well as local authority construction client bodies.

Aims and scope of this guidance

This document provides standard performance specifications and some examples to help with the choice of roof coverings in BSF secondary schools.

Specifically it:

- Sets out minimum standards of performance and quality expected by the DCSF.
- Provides design guidance for project designers formulating technical specifications.
- Standardises roof covering types so that efficiencies and economies of scale can be generated within the supply chain.
- Enables caretakers and facilities managers to manage roofs.

It is structured as follows:

Section 2

The generic performance characteristics of roof coverings in secondary schools.

Section 3

A summary of the minimum performance requirements for roof coverings, together with some design examples and advice.

Section 4

References to relevant European, British Standards, DCSF and other design guidance.

This document is not a roofing design guide. Its purpose is to make clear the client requirements, the minimum standards to be reached or exceeded and what is expected to provide the best roof coverings for BSF and other school projects.

The document has been produced to inform rather than replace detailed project specifications. Descriptions are given in generic terms and are not intended to promote the products of specific manufacturers. Contractors and specifiers should consult with relevant manufacturers to establish which products are appropriate and compliant.

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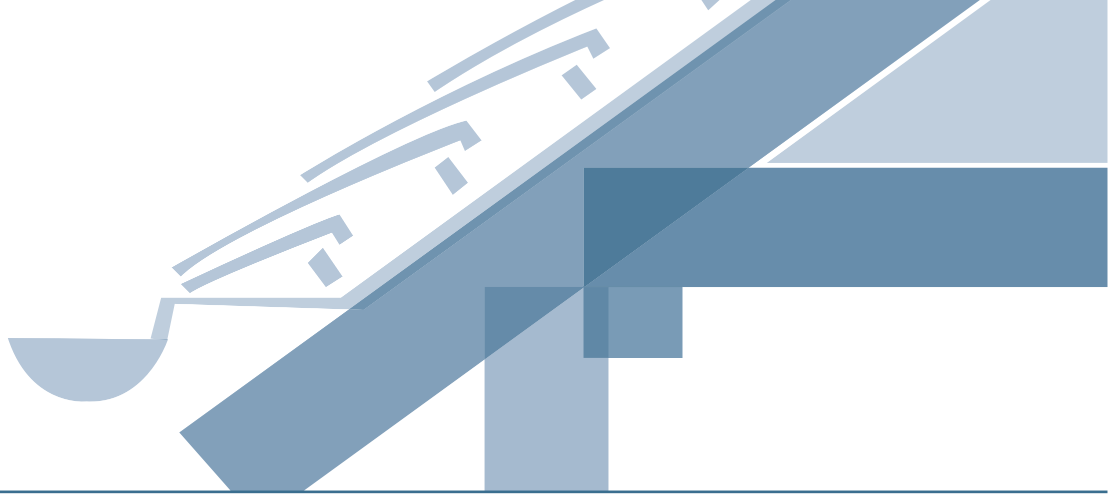


Key performance requirements

The following generic key performance requirements set the minimum standards that DCSF would expect to be adopted in BSF schools wherever it is reasonable and appropriate. Section 3 summarises the minimum performance requirements for roof coverings and provides some examples that address them.

The primary function of the roof is to provide protection from the weather and give adequate provision for thermal insulation, fire performance and sound insulation. Roof finishes must be considered by all parties at an early design stage to ensure the work is carried out safely and cost effectively; and that all details and potential conflicts are anticipated and properly provided for.

Materials

Coverings

The types of roof coverings can be grouped into two main categories defined by their support systems.

1. Continuously supported roof coverings:

Roof coverings with no structural properties fully supported on a roof deck.

- Reinforced bitumen membranes.
- Polymeric single ply membranes.
- Mastic asphalt.
- Liquid waterproofing systems.
- Malleable sheet metal roofing.

2. Discontinuously supported roof coverings:

Roof coverings with structural properties supported on rafters or purlins.

- Slating/tiling.
- Profiled sheeting.
- Insulated panels.

▲ **Above** continuously supported roof covering

▲ **Above** discontinuously supported roof covering

Roof deck – continuously supported roof coverings

Roof decks are generally either: concrete, profiled metal (steel or aluminium) or timber sheeting. The following factors must apply:

- The deck must have a minimum of 60 years' life.
- The roof covering manufacturers' recommendations for the roof deck must be followed, including but not limited to: profiled metal deck suitable for applied load and any requirements for timber sheathing, surface finish, minimum timber sheet thickness and grade, fixing locations, requirements for isolation layers and vapour control layers.
- Fasteners must be corrosion resistant and designed to withstand site wind loads to BS 6399-2 and be to manufacturers' recommendations.
- Expansion requirements must be obtained from the roof deck manufacturer.
- The construction of the roof deck must be considered with regard to safety in construction. See 'Health and safety' section, page 34.
- The roof deck must resist dead, live and wind loads.
- Metal decks must comply with BS 5950-6, BS EN 10147 (galvanised steel) and BS EN 485-2 (aluminium).

- Wood-based panels used as roof decking must as a minimum be either OSB/3 to BS EN 300, type P5 particleboard to BS EN 312, or plywood (Technical Class Humid) to BS EN 636. All wood-based panels used as decking must comply with the performance characteristics and marking requirements for wood-based panels used as structural roof decking, as specified in BS EN 13986.

Roof deck – discontinuously supported roof coverings

Roof decks/sarking are generally: timber trusses, battens or timber sheeting for slates/tiles, and metal purlins for metal clad roof systems. The following factors must apply:

Generally:

- The deck must have a minimum of 60 years' life.
- Expansion requirements must be obtained from the roof deck manufacturer.

Additionally for slates and tiles:

- Timber sarking may be required above timber roof trusses if the school is located in areas of severe wind or rain. Roof covering manufacturers' recommendations should be sought.
- Timber battens on tiled or slate roofs must not be less than those stated in BS 5534, Table 1.
- Counter battens on tiled or slate roofs should be sufficient to provide a ventilation gap as recommended in BS 5250 and/or to provide drainage path beneath the battens.
- The roof covering manufacturer's recommendations for the roof deck must be followed, including but not limited to rafter/battens or purlin sizes and any requirements for timber sheathing, minimum timber sheet depths and grade, fixing locations, requirements for isolation layers and vapour control layers.
- Gable details must be developed in conjunction with requirements for external wall structural support and cladding requirements.
- Fasteners must be corrosion resistant and designed to withstand site wind loads.
- The construction of the roof deck must be considered with regard to safety in construction. See 'Health and safety' on page 34.
- Wood-based panels used as roof decking must as a minimum be either OSB/3 to BS EN 300, type P5 particleboard to BS EN 312, or plywood (Technical Class Humid) to BS EN 636. All wood-based panels used as decking must comply with the performance characteristics and marking requirements for wood-based panels used as structural roof decking as specified in BS EN 13986.
- Timber and timber products for structural use must comply with BS 5268-2.

Additionally for metal roof cladding:

- Roof purlins, deflections and tolerances must be in accordance with the guidelines set out in *Best practice for the specification and installation of metal cladding and secondary steelwork* (SCI publication p346 – 2006).
- The panel manufacturer's recommendations must be followed regarding performance, to meet the specification requirements.
- The profiled roof covering manufacturer's recommendations must be followed, including any requirements for isolation layers and vapour control layers.
- Fasteners must be corrosion resistant and designed to withstand site wind loads.
- The construction of the roof deck must be considered with regard to safety in construction. See 'Health and safety' on page 34.

Vapour control layer

During cold external conditions, vapour control layers reduce the diffusion of moisture vapour from the habitable space below and into the roof construction, where it could damage components or reduce the efficiency of the insulation. Proprietary vapour control layers are available and should have a design life equivalent to the roof covering. All laps must be bonded or sealed as appropriate and penetrations effectively sealed as recommended by the vapour control layer manufacturer.

The principles for the control of condensation in buildings must be taken from BS 5250, 2002: *Control of condensation in buildings*. This states that a vapour control layer should extend over the whole of the element into which it is incorporated and must be integrated with and sealed to adjoining elements, such as masonry, up-stands and glazing systems, and to any VCL in those elements.

The risk of condensation forming within the roof construction needs to be considered and calculated. A steady state calculation is undertaken to check that no surface condensation will occur on any of the roofing components, based on an external temperature of -5°C. This allows a comparison between the actual temperature at any point in a specification and the dew point temperature of the internal condition. If the actual temperature at that point is lower than the dew point temperature, condensation will occur.

Sealants are not to be the sole line of defence against water vapour penetration.

Underlay

Additional to the vapour control layer, an underlay must be provided for discontinuously supported slate or tiled roofs, which should:

- Provide a barrier to minimise the wind uplift load on the slates or tiles.
- Provide a secondary barrier to the ingress of wind driven snow and dust.
- Transport into the roof drainage system any moisture in the batten space.
- Provide temporary (i.e. less than 3 months) weather protection, including rain impact resistance, before installation of the primary roof covering.
- Withstand tenting.
- Withstand fixing penetrations: nail holes through underlays should not be enlarged, due to shrinkage.

Insulation

Additional to the roof covering, the roof system must also include insulation. Thermal insulation, however, is rarely a factor affecting the choice of the roof type, since the normal methods of providing it are generally applicable to all forms of roofs. These methods vary and involve incorporating flexible or rigid insulating material in or under the roof cladding or structure, or the use of self-supporting insulating materials, which are strong enough to act as substructure to the covering. Due to the large selection of insulants available, manufacturers should always be consulted to ensure that the key performance requirements are met.

Eaves

Fascia and soffits must be constructed to achieve the same lifetime as the roof covering and require little or no maintenance.

Overhanging eaves can be useful in solar shading and reduce overheating. However, the position of gutters must be designed so that the eaves do not obstruct maintenance access or cause any health and safety issues for maintenance operatives accessing the gutters.

Low level eaves/roofs must be considered with regard to arson and security, as they are potentially vulnerable to being set alight externally.

In cold roof constructions, the eaves must have a proprietary continuous ventilator in accordance with Building Regulations.

If discontinuously supported roof coverings are fixed to the fascia to alleviate wind uplift, the manufacturer of the roof covering must be consulted to ensure that the fascia system is compatible.

Rooflights

Rooflights are discussed in the 'Daylight' section on page 28 as an effective way to introduce light into the building. Rooflights may be polycarbonate, glass or other plastic translucent sheeting. They should all comply with the acoustic, thermal, fire and safety requirements contained within this document.

Roof construction

Roofs may be pitched or flat, with the definition of a pitched roof being one that exceeds 10 degrees. The definition of a flat roof is one that is greater than 1:80 (the minimum finished fall allowable under BS 6229) but less than 10 degrees. The choice between flat or pitched roof is generally an aesthetic one dependant on the designers' choice of roof form and roof covering. In general, continuously supported roof coverings are flat and discontinuously supported roof coverings are pitched. Common to all roofs is the roof build up, which may be warm, cold or inverted construction, as described below.

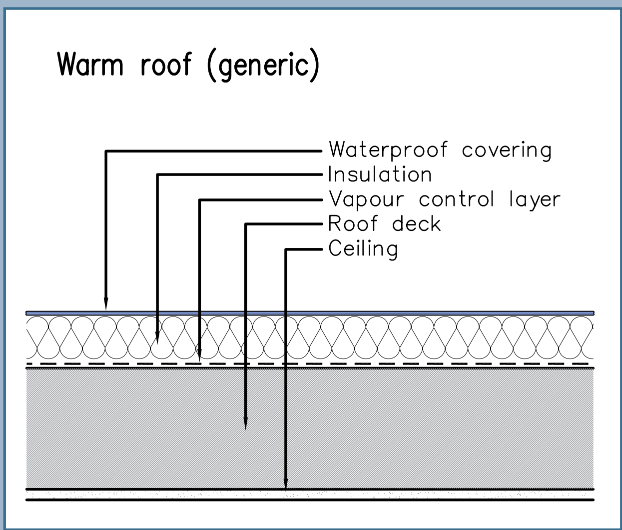
The chosen roof system must satisfy all acoustic, thermal, fire, durability and safety requirements covered in this section of the document.

Warm roof construction – continuously supported roof coverings

The insulation material is placed between the waterproof covering and the roof deck, with a vapour control layer on the warm side of the insulation. This form of roof construction may be considered for school buildings because the design should ensure that the deck is maintained at a temperature above that which could cause condensation at this level during service. A warm roof construction also offers an increased usable volume, without any corresponding increase in overall building size. Warm roofs can also incorporate a top layer of paving, ballast or green roof (as described in green roofs section on page 20) above the waterproof membrane if a protective/drainage layer is incorporated.

The following should be noted:

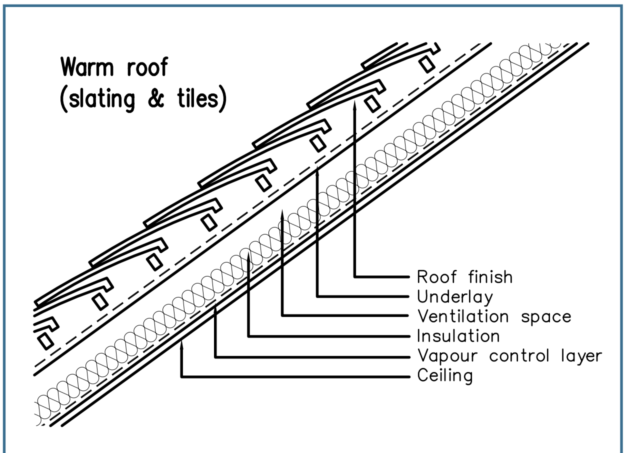
- Allow for thermal movement of insulation materials that are not dimensionally stable. This may involve the inclusion of expansion joints within the insulation layer at appropriate intervals.
- Avoid wetting the insulation during the construction phase, particularly when it is used within systems where it is enclosed between impermeable layers of vapour control layer and roof covering/underlay.
- Where frequent roof traffic (other than routine maintenance) is anticipated, the covering and insulation manufacturers should be consulted for advice on the provision of appropriate walkway design requirements.
- Roof loads will be transferred to the structure via the thermal insulation, so the appropriate choice of compressive strength is important.

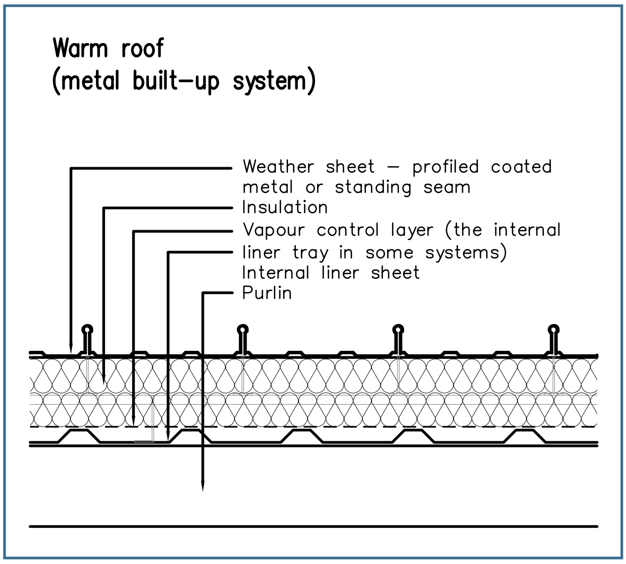


Warm roof construction – discontinuously supported roof coverings

The insulation material is placed immediately below the roof covering, with a vapour barrier on the warm side of the insulation. This form of roof construction may be considered for school buildings because of the reduced risk of condensation and more stable temperatures provided in comparison with cold roof solution. However, the following should be noted:

- Avoid wetting the insulation during the construction phase, particularly when it is used within systems where it is enclosed between impermeable layers of vapour control layer and roof covering/underlay.
- Where frequent roof traffic (other than routine maintenance) is anticipated, the covering and insulation manufacturers should be consulted for advice on the provision of appropriate walkway design requirements.
- A warm roof also has an increased usable volume, without any increase in overall building size.





Cold roof construction – continuously supported roof coverings

The insulating material is placed immediately above the ceiling within the roof deck zone. The roof deck and roof space are at or near the external air temperature. Roofs of this type require the void below the roof deck/covering to be well ventilated if condensation problems are to be avoided.

This form of roof construction for continuously supported roof coverings is not recommended for school buildings for the following reasons:

- The structural support will typically form a cold bridge between the high and low temperature zones of the roof construction.
- The mandatory requirement for external air circulation in practice is difficult to achieve, particularly where there are abutting elevations or changes in building geometry, thereby increasing the risk of condensation accumulation within the system.

- The roof deck and roof space are at or near to the external air temperature for much of the year, which is substantially below that inside the building. There is therefore considerable danger of warm humid air from inside the building penetrating and condensing within the cold roof space. This is a particular danger in schools as they tend to be humid environments.
- The ceiling will become the air barrier and vapour control layer, so it is difficult to achieve the pressure test requirements of Building Regulations Part L2 when access hatches and mechanical and electrical items are introduced into the ceiling.
- Post-construction modifications to cold roofs are difficult to achieve because they involve complex details and additional components to improve ventilation.
- Future upgrading to improve energy efficiency is difficult and can increase condensation risk.

Additionally, any form of mixed cold and inverted roof construction is not acceptable for continuously supported roof coverings.

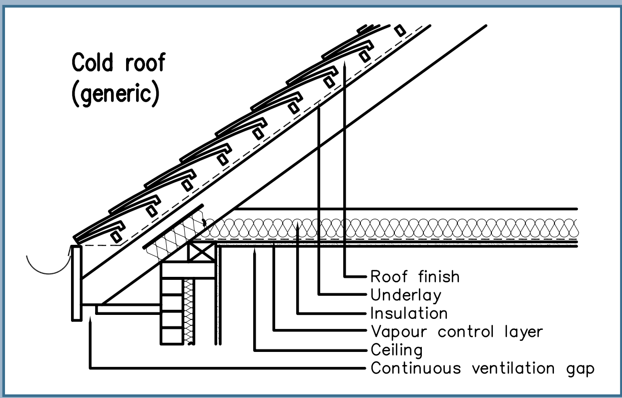
Cold roof construction – discontinuously supported roof coverings

The insulating material is placed immediately above the ceiling. The roof deck and roof space are at or near the external air temperature. Roofs of this type require the void below the roof deck/covering to be well ventilated if condensation problems are to be avoided. The advantages of this type of roof construction are as follows:

- The heated volume and the quantity of insulation material needed are minimised.
- Very high levels of insulation can be achieved because there is virtually no restriction on the thickness of insulation that can be installed.

This form of roof construction may be considered for school buildings. However, the following should be noted:

- The external roof covering and roof space are at or near the external air temperature.
- Roofs of this type require that adequate measures are taken to avoid the risk of condensation occurring on the surfaces below the roof covering. This should be either by providing adequate ventilation to the void; or by using a roofing underlay with low resistance to water vapour that has Technical Approval from an UKAS (United Kingdom Accreditation Service)-accredited technical approval bodies for use in this application. The use of a suitable, continuous vapour control layer on the warm side of the insulation or well sealed ceiling to BS 5250 is also required.
- The ceiling will become the air barrier and vapour control layer, so it is difficult to achieve the pressure test requirements of Building Regulations Part L2 when access hatches and mechanical and electrical items are introduced into the ceiling.



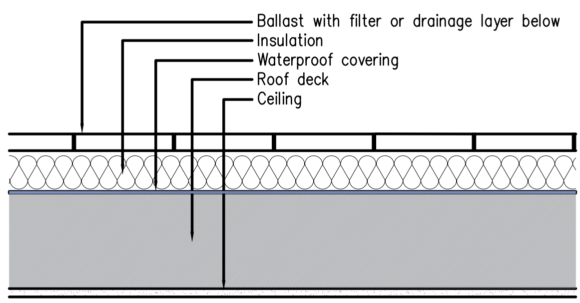
Inverted roof – continuously supported roof coverings

The insulation is placed above the waterproof roof covering and provided with some form of ballast on top, such as paving slabs, gravel or green roof (as described in the green roofing section on page 20). This form of construction is similar to a warm deck but has the additional feature of the insulation and ballast protecting the roof membrane from thermal movement and foot traffic. This form of roof construction may be considered for school buildings.
The following should be noted:

- The structural deck must be of sufficient thermal mass to avoid surface condensation on its soffit when the waterproof covering is cooled rapidly during heavy rain or snow melt.
- Sufficient insulation must be provided to ensure that the underside of the waterproof covering is warm enough at all times to prevent condensation of any water vapour passing into the roof space.
- The insulation material must be unaffected by water and capable of withstanding normal roof loads.
- The roof covering will be hidden below the insulation and ballast, so its waterproof integrity must be ensured before covering it up, as leaks will be difficult to locate after the insulation and ballast have been put in place.
- Rainwater will affect the insulation's U-value, so when calculating U-values a correction factor should be used as set out in BS EN ISO 6946 (see 'References', page 48), ignoring the effect of ballast etc. and, in the case of a 'green' roof, ignoring the effect of soil, vegetation etc.
- A drainage mat is required if the deck is fully sealed.
- For a given U-value, the inverted roof has the greatest roof zone depth of any roof type, so the design must make provision in terms of upstand heights, parapets, verges etc.
- The designer must be satisfied that the ballast chosen is adequate to resist the design wind uplift. Methods of ballasting are dealt with in BRE digest 295 and 311.

Inverted roofs are not suitable for discontinuously supported roof coverings.

Inverted roof (generic)



Roof pitch

The following generic recommendations are made for roof pitches in normal situations. Where abnormal conditions are present, such as in elevated sites, near to the coast, areas of heavy snow fall or severe exposure, the roof covering manufacturer must be consulted. In all cases, the roof covering manufacturer should be contacted to determine whether they have any additional requirements.

	Minimum roof pitch	Notes
Continuously supported roof coverings	1:40	This is the design fall, as defined in BS 6229, to achieve a minimum site finished fall of 1:80 at all points (to account for site tolerances).
Discontinuously supported roof coverings	Profiled sheeting/insulated panels: 1.5 degrees (roof with no end laps and welded openings) 4 degrees (roofing sheeting with openings, end laps etc.) **Natural Slates:** The minimum pitch for natural slates is 20 degrees, but depends on slate size and exposure. **Interlocking single lap concrete and clay tiles:** The minimum pitch for clay and concrete interlocking tiles is dependent on the design of the tile; the manufacturer should always be consulted. Some designs may be laid at 12.5 degrees. Double lapped concrete and clay plain tiles: The minimum pitch for clay and concrete plain tiles is 35 degrees. For clay tiles not meeting the dimensional and geometric requirements of BS EN 1304, e.g. handmade tiles, the minimum pitch is 40 degrees.	Profiled sheeting/insulated panels: Always consult roof covering manufacturer. Some products require greater falls. Rafter pitch and length should be as recommended by manufacturer. **Natural Slates:** The minimum pitches are recommended for normal conditions – they apply to rafter lengths not more than 9 m in driving rain, exposures of less than 56 l/m^2 per spell and 6 m in driving rain exposures of 56 l/m^2 per spell or greater. **Single lap:** Where longer rafter lengths (more than 10m) or more severe conditions are expected, the manufacturer should be consulted on the suitability of the product and appropriate precautions to be taken, which may include choosing a suitable design of tile, increasing headlaps, installing under-tile secret gutters, etc. **Double lapped:** The presence of certain roof features such as eyebrow dormers may increase the design fall required.

Building tolerances

It is advisable to note the importance of the building tolerances on the roof covering. Generally, it is the job of the roof to allow for the accumulation of design tolerances within external walls, as these will be most prevalent at the eaves.

It should be noted that a concrete frame could be +/- 30mm from plumb and still be within its acceptable tolerance zone, which could create 30mm dips in a zero fall concrete roof deck. It is imperative that no matter what structure or support is provided below the roof covering, the following are achieved:

- The eaves detail must allow for a degree of site tolerance and manufacturers' recommendations must be followed for the system being installed.
- The roof covering must achieve the minimum pitches stated in the 'Roof pitch' section on page 15, regardless of the tolerances within the roof deck. This will ensure that Building Regulations Part H is complied with, which states that: 'adequate provision shall be made for rainwater to be carried from the roof of the building.'

In the case of metal cladding roof systems, excessive tolerances in the purlins during erection or under the action of construction loads can affect the performance of the cladding system. Guidance on the selection and installation of purlins is given in *Best practice for the specification and installation of metal cladding and secondary steelwork* (SCI publication p346 – 2006).

Roof terraces

Roof spaces can be used for additional outdoor accommodation, incorporating the inverted or warm roof constructions described in roof construction section on page 11. When designing roof terraces/green roofs, particular attention needs to be given to door thresholds, especially when the threshold is level for disabled access. Drainage channels are required and attention must be given to overhangs/canopies. The roof covering manufacturer should also be consulted. It is essential that parapet heights and guard railing are designed in accordance with Building Regulations and that all details are fully discussed with the roof covering manufacturer to ensure the roof remains fully water tight.

Roof terraces/green roofs should be part of the original design and not introduced as an after thought when the school is in operation.

Care must be taken that the damp proof course is not bridged and that a minimum of 300mm is maintained between roof covering and the adjacent wall's damp proof course.

Drainage

The disposal of rainwater from roofs requires careful consideration. Part H of the Building Regulations states that: 'adequate provision shall be made for rainwater to be carried from the roof of the building'. Defects in design or construction can be costly and difficult to rectify; and maintenance is often neglected until there are serious leaks or floods. Large roofs in particular require well judged calculation, careful detailing and supervision, plus accurate coordination on site of several trades, such as structural steel, roofing membrane and plumbing.

Roof drainage, including gutter outlet and pipe dimensions, must be calculated by the specialist rainwater goods manufacturer using guidance in BS EN 12056 and BS 6367.

The design objectives should be:

- A simple layout, avoiding indirect routes to rainwater outlets.
- On flat roofs, avoidance of box gutters within the roof area.
- The shortest possible distances to rainwater outlets; an additional rainwater outlet may pay for itself in reduced roof zone depth.
- Fully accessible rainwater outlets for maintenance and replacement.
- Anti-back up design, with sealed junctions between gulley and down pipe.

Drainage design generally should ideally begin early in the design process as it will affect:

- Below ground drainage (internal layout, e.g. pipe routes, boxings and the integrity of fire-resisting constructions).
- External appearance (gutter and down-pipe size, location and relationship to doors and windows.

Rainwater down pipe design should be considered for ease of maintenance, susceptibility to vandalism and prevention of climbing. There are a number of advantages and disadvantages with both internal and external rainwater pipes:

- Internal rainwater pipes are less susceptible to abuse. However, they need to be accessible, maintainable and may require acoustic treatment. (Siphonic systems will not require access points, as they are sealed systems.) Also, if a leak occurs it will be within the building.
- External rainwater pipes keep the water outside the building and are accessible for maintenance. The disadvantage is that they are exposed and therefore open to abuse. This can be reduced by good design, for example using square pipes flush to the wall.

Bends in down pipes and horizontal runs should be minimised and all horizontal runs laid to fall. All down pipes must have rodding eyes at floor level, positioned so that a blockage between down pipe and the surface water drainage system can be cleared by rodding.

All gutters must be laid to fall and provided with overflow pipes to discharge in an obvious place to provide early warning of blocked rainwater outlets. Mechanically fixed leaf guards must be provided to all outlets and will also act as a guard against balls and foreign objects blocking the outlets. Any part of the roof must not rely on one outlet alone.

Additional requirements for tiled and slated pitched roofs:

- Sheeting used for inclined valleys, horizontal gutters, flashings, soakers and saddles should conform to BS 5534 Part 1, Table 3 and be developed in accordance with roof covering manufacturers' recommendations.
- The minimum valley gutter widths are stated in BS 5534 Part 1, Table 14 and should be developed in accordance with roof covering manufacturers' recommendations.

Movement

All roofs comprise a number of elements that expand and contract or move in relation to each other, subjecting the waterproofing element to stress. Building movement joints must be taken through the roofing system and detailed in accordance with the manufacturers' details to achieve the required structural movement. Manufacturers' advice should also be sought for any movement joints required within the deck, insulation or covering.

Particular care must be taken over flat roofs and bonding of any materials to the roof deck. A structural engineer will need to calculate the amount of movement expected in the roof structure in all three planes (up, down and sideways). With all systems, wind load should be considered and manufacturers' advice obtained for fixing all elements, based on the design wind load in accordance with BS 6399-2.

Compatibility of components

Compatibility between the various material elements of a roofing system is vital to the longevity of the system.

This rule applies both to the components in the roof and also to any elements interfacing with the waterproofing system, such as vertical cladding or rendering.

The selection of components within the roofing system should be discussed in detail with the manufacturer of the roof covering to ensure complete compatibility between components. Incorrect specification of incompatible components will lead to premature failure of the roofing system.

Lightning protection

The installation of a well-designed lightning protection system on a structure should be in accordance with BS 6651:1991, *Code of practice for protection of structures against lightning*. This requires effective integration of the roofing and electrical design at an early design stage, since lightning protection works are usually part of the electrical contract package. This may include fixing tapes from steel liner sheets to the steel frame or the inclusion of tapes/rods into foundations, which need to be considered at the beginning of the design phase.

The roof covering manufacturer must always be consulted to ensure compatibility with the lightning protection system. There must be no penetrative fixings through flat roofs, because of the risk of water ingress.

Off-site/on-site fabrication

Alongside traditional forms of on-site construction process, off-site fabrication can have numerous benefits, such as reduced programme times, improved quality control, lower costs, lower site waste and increased productivity. However, it is for the design and construction team to consider the most effective approach for their particular location/design. All the key performance requirements apply to both on-site and off-site construction. Particular care should be taken to ensure that sufficient allowance has been made for site tolerances to be overcome when producing components off-site.

Plant

All penetrations through the roof and roof level plant must be co-ordinated at an early stage in the design and must be provided in a dedicated zone to minimise roof penetrations and access required to the roof.

Where plant is required on the roof, the following must be considered:

Generally:

- Service penetrations must be provided with upstands, apron flashings or weathering cowls, all in accordance with the roof covering manufacturer's details.
- Electrical connections should be installed following manufacturers' recommendations to ensure a weather-tight seal.
- The roof substructure must be able to support the dead loads produced by the plant.
- Where kitchen extracts are provided, roof covering manufacturers should be consulted to ensure that the exhaust gases will not affect the roof covering.
- See CDM recommendations in health and safety section on page 34.
- Acoustic issues affecting any rooms below should be addressed, including vibration noise through the structure.

Additionally for continuously supported roof coverings:

- Upstands or additional structure must be provided to ensure that the plant is located adequately above the roof finish. This will enable inspection of the cover and future maintenance/replacement of the roof covering.
- Support structures that penetrate the roof covering must be designed to avoid cold bridges and maintain the waterproof covering. Any differential movement between them and the roof system must be established at the design stage.
- The roof covering must be protected from foot traffic and maintenance equipment by dedicated walkways.

Additionally for discontinuously supported roofs:

- Appropriate measures must be taken to ensure that the penetrations through the roof covering to secure the plant to the substructure are designed to be weather proof. Typically, manufacturers supply appropriate flashings for this task. In any case, the manufacturers' recommendations must always be followed.
- The plant itself must be adequately designed and mechanically fixed so as to resist the wind loads and snow loads prescribed for UK conditions in BS 6399, *Loading for buildings*, Parts 2 and 3.

Green roofs

Design

The type, size and design of each layer of a green roof will depend on the proposed landscape. As can be seen from the attached green roof pictures, there is a range of possible extensive and biodiversity type landscapes, each requiring a different support system beneath it.

A successful green roof system must basically replicate nature but within a very compressed build up. Whether it is a biodiversity (brown roof), extensive or intensive landscape, the build up should always consist of:

- A high quality waterproofing system, incorporating a root barrier to German FLL standards or equivalent.
- Moisture retention/protection layer.
- Drainage layer.
- Filter layer.
- Manufactured/recycled growing medium.
- Appropriate components – outlet inspection chambers, linear drains etc.

It is important that the client and designer clarify the performance they require from their green roof. For example, is it in response to storm water mitigation, biodiversity, or planning constraint?

The final design will be controlled by a number of fundamental factors:

- Climate dependant factors, such as rainfall, topography, periods of drought and frost.
- Structural dependant factors, such as loadings, building height, wind tunnels between buildings, roof slope.
- Plant dependant factors, such as in shade, or full sun, north, south, east or west facing, prevailing wind.

The roof covering will be hidden below the insulation and ballast/growing medium, so its waterproof integrity must be ensured before covering it up, as leaks will be difficult to locate after the insulation and ballast have been put in place.

For further detailed guidance on green roofs, see CIRIA publication C644 – *Building greener – Guidance on the use of green roofs, green walls and complementary features on buildings*.

Maintenance

Every type of green roof system will also require maintenance in some form or another, initially for a period following the installation of the plants, and subsequently for ongoing maintenance to keep the green roof flourishing.

The specifier should put into the tender documents that the contractor must price in the cost of post installation maintenance for a period of at least 12 months. This should ensure that a healthy green roof is handed over. Following this period, the responsibility for ongoing maintenance is the client's.

Maintenance and irrigation of green roofs must be considered, otherwise there is an inherent fire risk, as discussed in the fire section on page 25. The designer must also provide safe access for maintenance, as discussed in the health and safety section on page 34.

Benefits

A green roof offers excellent environmental benefits to the specifier's client:

- Storm water retention – helps to reduce ground drainage capacity requirements.
- Provides both thermal and sound insulation.
- Replaces landscape lost under the foot print of the building.
- Cools and humidifies the surrounding area – attracting wildlife and absorbing dust and traffic fumes.
- When manufactured from recycled products, the green roof components are an excellent outlet for old materials.
- Absorbs carbon dioxide and produces oxygen.

Thermal performance

The principal properties to be considered are outlined below. These will also be required by Building Control when they are checking a building's thermal design.

Design standards

Approved Document L2A of the Building Regulations 2000 (2006 edition) details the approach for compliance with energy efficiency requirements in respect of 'New buildings other than dwellings'. Minimum compliance is demonstrated by meeting the five criteria set out below:

- The Building Emission Rate (BER) as calculated using an approved tool must not exceed the Target Emission Rate (TER) by reference to a notional building. The approved calculation tools comprise the Simplified Building Energy Model (SBEM) or approved commercial software.

- The performance of the building fabric and fixed services must be no worse than set design limits:
  - The area weighted U-value for all the roof elements must be no more than 0.25 W/m^2K. This is the performance U value for use in the notional building calculation requirement of L2A (2006 edition). No one element within the roof construction should be greater than $0.35W/m^2K$.
  - The area weighted U-value for all the rooflights must be no more than 2.2 W/m^2K. This is the performance U value for use in the notional building calculation requirement of L2A (2006 edition).
- Those parts of the building that are not provided with comfort cooling systems must have appropriate passive control measures to limit the effect of solar overheating.
- The performance of the built building must be consistent with the BER.
- Necessary provisions for energy efficient operation of the building must be put in place.

The technical provisions of L2A (2006 edition) require significantly higher performance standards in comparison with previous 2002 levels. For school buildings that are naturally ventilated and heated, the minimum improvement required in terms of the reduction of the annual CO_2 rate is around 23%.

Experience has shown that, to achieve the minimum improvement levels for school buildings as determined by L2A (2006 edition), a combined improvement in fabric, heating, ventilation, lighting and air conditioning (where applicable) performance standards are required. For design U-values for roofs to reasonably contribute towards the 23% improvement, it is considered good practice to exceed the limiting insulation standards denoted by Table 4 of Approved Document L2A.

The Building Research Establishment Environmental Assessment Method for Schools (BREEAM) 2006 encourages buildings that are designed to minimise the CO_2 emissions associated with their operational energy consumption. Under BREEAM Schools 2006, 'Energy, Reduction of CO_2 emissions', credits are achieved based on the percentage improvement in the assessed design's predicted Building CO_2 Emissions Rate (BER) over the Target CO_2 Emissions Rate (TER). The number of credits achievable range from one to 15 for improvements of from 1% to 70% above the minimum requirements of L2A (2006 edition).

Due consideration should also be given to any future thermal upgrades that may be required when designing the perimeter. Particular consideration should be given to upstands, cavity trays, damp proof courses, and door and window thresholds, which should be higher than the minimum 150mm above the finished surface level, to allow for further insulation upgrades to the roof over the 60 year lifetime of the building. The minimum recommendation is 300mm. However, future thermal requirements cannot be predicted.

Building fabric

Air permeability

Buildings should be reasonably airtight to avoid unnecessary space heating and cooling demand. The design of the air permeability of the envelope (which includes the total area of the perimeter walls, roofs and ground floor area) should be no worse than $10m^3/(h.m^2)$ at an applied pressure of 50 Pascals. Better standards of air permeability are technically desirable in buildings with mechanical ventilation and air conditioning.

Once the external envelope has been completed, the building must be tested by an approved air pressure testing company to show compliance with the Building Regulations.

Guidance on appropriate design detail and construction techniques to achieve this compliance is provided by:

- *Minimising cold bridging and air tightness: Accredited Construction Details* (ACDs).
- BS 9250: *Code of practice for control of airtightness in pitched roofs.*

For metal cladding roof systems, guidance on appropriate design detail and construction techniques to achieve this compliance is provided by:

- MRCMA/EPIC Technical Paper 17 (2007) – *Design guide for metal roofing and cladding to comply with energy requirements of UK Building Regulations*, 2006.
- BRE IP 1/06 – *Assessing the effects of thermal bridging at junctions and around openings in the external elements of buildings*, BRE, 2006.
- EPIC – *Insulated panels for external roof and wall cladding – Guidance on compliance with the conservation of fuel and power Building Regulations*' 2006.

Thermal bridging

The building fabric should be constructed so that there are no reasonably avoidable thermal bridges or gaps in the insulation layers within any elements, at the joints between elements or at the edges of elements such as those around roof lights and glazing. For continuously supported warm roof systems attached via a mechanical fastener system, the use of tube washers is recommended to reduce the incidence of thermal bridging.

For traditional flat and pitched roof systems, L2A (2006 edition) refers to *Minimising cold bridging and air tightness: Accredited Construction Details (ACDs)* on the planning portal: www.planningportal.gov.uk/england/professionals/en/1115314255826.html.

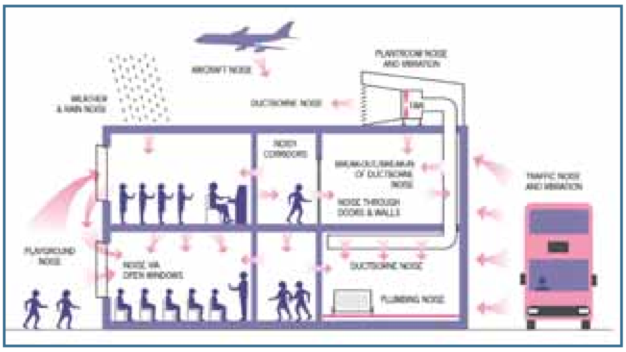
For metal cladding roofing systems, L2A (2006 edition) refers to MRCMA/EPIC Technical Paper TP17, which details how thermal bridges should be assessed. Further guidance can also be found in BRE IP 1/06 – *Assessing the effects of thermal bridging at junctions and around openings in the external elements of buildings*, BRE, 2006.

Acoustics

The external roof represents a significant portion of the building's surface area, so its acoustic performance plays a significant role in establishing an acceptable environment within the rooms below. Good acoustic standards in teaching areas are crucial for the learning process, because if pupils cannot hear properly their ability to learn is likely to be adversely affected.

Planning and layout

The control of noise pollution must be addressed from the earliest stage in the design process. For example, when schools buildings are to be located adjacent to busy roads, they will require the use of intelligent design – planning and layout. It is possible to identify noise-sensitive areas and to separate them from noisy areas using buffer zones, zoning, noise screening or by locating buildings a suitable distance apart. When considering external noise, such as from roads or aircraft, special measures are required and it may be necessary to consult an acoustic expert on the location of noise sensitive rooms such as classrooms and examination spaces. In all cases, an acoustic expert will be required to calculate the existing external noise levels so that compliance with Building Bulletin 93, *Indoor ambient noise levels* can be checked.



Indoor ambient noise levels

Once the planning and layout strategy have been optimised, the acoustic performance requirements of the roof construction should be considered. The acoustic performance of an external roof is heavily dependent on the selection of materials (especially the mass of the ceiling and roof layers, including the presence of sound absorbing material).

Consideration should also be given to the acoustic performance of other components, such as rooflights, the external wall construction and external windows and doors, which may influence internal noise levels.

A calculation of the internal noise level according to BS EN 12354-3:2000 can be used in order to estimate and confirm that a proposed construction will achieve the levels required by Table 1.1 (Performance standards for indoor ambient noise levels – upper limits for the indoor ambient noise level) of Building Bulletin 93. The objective is to provide suitable ambient noise levels for speech within study activities. Indoor ambient noise levels include noise contributions from:

- External sources outside the school premises (e.g. road, rail, air traffic).
- Building services.
- Rain noise.

Impact noise from rain on the roof can significantly increase the indoor noise level and must be considered at an early point in the roof design. It is essential that provision be made in the design of lightweight roofs and rooflights so that the noise from rain affecting internal spaces does not result in undue disturbance. To ensure that the appropriate provision is made for impact noise from rain as part of the roof design, it is required that the increase in criteria for noise intrusion from external sources during 'heavy' rainfall does not exceed the levels defined in Table 1.1 by more than 20dB in the design calculations. A credit will be awarded for meeting this requirement under BREEAM Schools 2006. See *Health and wellbeing, Acoustic performance*, HW17, p49.

An acoustic expert will be required to calculate the existing external noise levels and assess that the proposed roof construction will achieve the required ambient noise levels within the rooms below.

Wherever the required ambient noise levels cannot be achieved by the roof construction providing adequate sound insulation, it is typical to treat the ceiling. Where the ceiling is also the soffit of the roof, additional lining and sound absorption materials may be required. The solution may involve the use of an acoustic suspended ceiling or a perforated metal lining tray solution, and is specific to the room design and usage type as required by Table 1.1 of Building Bulletin 93. This should be developed with an acoustic expert.

Where internal walls abut roof soffits, flanking sound transmission must be considered and the partition sealed to the roof soffit in accordance with the partition manufacturer's recommendations, so that the partition's acoustic properties are maintained and the required movement in the roof deck achieved. Where the roof soffit is profiled, an acoustic expert should provide details to maintain the acoustic integrity between rooms.

Performance in fire

Compliance with the Building Regulations Approved Document B (ADB) and Building Bulletin 100 will help ensure that a required minimum standard of life safety will be achieved in the event of a fire. ADB requires the building to be designed and constructed so that there are appropriate provisions for warning and escape for building occupants. It provides guidance for the fire performance requirement of roofs when the fire source is either external or internal to the roof construction. For schools, the following should be adhered to:

- Internal surfaces: The 'surface spread of flame' requirements to be Class 1 to BS 476 Part 7 or European standard classification C-s3, d2.
- 'External surfaces: fire resistance' requirements – The requirement is for the fire roof exposure rating to be AA, AB or AC to BS 476 Part 3, or European standard classification $B_{ROOF(T4)}$ to ENV 1187 Part 4, as defined in EN 13501-5.

The external fire performance is expressed as a requirement for the whole roof construction, including deck and covering, characterised by penetration of fire and spread of flame.

The first letter of the designation refers to the time to penetration (A = those specimens that have not been penetrated in one hour) and the second letter is a measure of the spread of flame (A = those specimens on which there is no spread of flame, B = those specimens on which spread of flame is less than or equal to 533mm, C = those specimens on which spread of flame is greater than 533m).

ADB also requires 30 minutes' fire resistance as regards load bearing capacity, integrity and insulation to the underside of the roof in the following locations (refer to BS 476: Part 22 or European standard EN 13501-2):

- When the roof and its support structure are part of an escape route, including any opening within 3m of the escape route.
- When the roof performs the function of a floor.

Due consideration should also be given to the following additional guidance:

- Junction of compartment wall with roof details: a 3 metre wide zone centred over the compartment wall with a covering of designation AA, AB or AC on a substrate or deck of a material of 'limited combustibility' is required (B3, diagram 30(a)).
- Sprinkler systems.
- Fire rated ceilings.
- Fire stops within the building.
- Insertions of cavity barriers within the roof void where appropriate.
- Insulation in accordance with Building Regulations Approved Document B (ADB) and any insurance requirements.

Combustible thermoplastic insulation material should not be carried over the compartment wall, as a core to double-skinned roof sheeting or otherwise (paragraph 8.29 to 8.31 and diagrams 3a and 3b of Approved Document B, 2006). Its use within the roof construction or elsewhere within the building could also influence insurance terms (see 'Performance in fire' section, page 25, 'Insurance requirements') , though other insulated panel and cladding systems that have LPCB certification are accepted.

ADB Table A6 defines non-combustible materials as any that are classified as A1 in accordance with BS EN 13501-1:2002. Similarly, ADB Table A7 defines materials of limited combustibility as either any material listed in Table A6 (non combustible) or any material classified as Class A2-s3, d2 or better in accordance with BS EN 13501-1:2007.

Where the roof forms the soffit of the internal room, the internal lining must be Class 1 (Euro-equiv C-s3, d2) surface spread of flame to BS 476 Part 7 and Class O (Euro-equiv B-s3, d2) in means of escape.

Designers should also refer to Building Bulletin 100 *Design for fire safety in schools*, in particular, preventing arson by stopping access from surrounding buildings or walls to roofs, as defined in Building Bulletin 100, Section 8.8.

Rooflights' minimum 'surface spread of flame' requirements must be Class 1 to BS 476 Part 7 or European standard classification C-s3, d2. The lower surface must be classed TP(a) rigid. No rooflight must be placed closer than 6 m to the relevant boundary, unless it has a AA, AB or AC fire rating. Thermoplastic rooflights are not suitable for use in the zone of the roof 1500mm wide on either side of a compartment wall (ADB Section 14: Roof coverings, Diagram 47, Note 3).

Unless green roofs (as described in green roof section on page 20) are maintained and irrigated, they are likely to consist mainly of grasses and weeds, which often dry out in the summer months when schools are at their greatest risk of fire. The designer should also incorporate gravel margins around openings, in front of walls or other structures that rise from the roof, and around the edges of the roof to act as fire breaks.

Insurance requirements

The building insurers should always be consulted about fire performance to establish whether they have any requirements additional to Building Regulations.

For guidance, the basic principles necessary to achieve adequate levels of property and business protection are defined in the LPCB Red Book and the *Design guide for the fire protection of buildings – Essential principles* sponsored by InFiRes, the Insurers' Fire Research Strategy Funding Scheme, under the project management of the Fire Protection Association. This is one of a number of documents that make up the FPA *Design guide for the fire protection of buildings*, a development from the LPC *Design guide for the fire protection of buildings*, 2000.

The 12 basic principles in the above documents, whilst not mandatory, encourage consultation with insurers at the earliest stage of design, thereby ultimately influencing the insurance terms. One of the overriding themes is the preferred use of non-combustible materials and limitations to combustible insulation products. Principle 2 states that 'with the exception of joinery products, the building shall be constructed from materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire'. Specifically, reference is made to Euro Class A1 or A2 products (insurers may ask for a specification higher than s3, d2) and, where built up cladding or sandwich panel systems are used, LPCB (Loss Prevention Certification Board) approval to the requirements of the appropriate part and grade of LPS 1181: Part 1: Issue 1.1 Series of fire growth tests for LPCB, *Approval and listing of construction product systems*, Part 1: *Requirements and tests for built-up cladding and sandwich panel systems for use as the external envelope of buildings*. See 2.2 of the LPC *Design guide for the fire protection of buildings*.

Principle 6 of the FPA Design Guide requires that installation of certain materials should be carried out under the UKAS-approved third party accreditation scheme.

Regulatory reform (fire safety) order

Following changes to fire safety legislation introduced through the Regulatory Reform Fire Order in October 2006, designers are now required to communicate all aspects of the design that may affect the eventual fire risk assessment, including the use of combustible products used in the construction. This underlines the new fire prevention approach, which asks designers/specifiers to identify and address potential fire risks. In order to accomplish this effectively, specifiers must ensure that they have sufficient information relating to their proposed construction. The consequences of errors resulting from judgements based on the acceptance of misleading or inaccurate information could lead to criminal prosecution.

For guidance on all aspects of fire safety in educational premises, refer to the HMSO's Fire Safety Risk Assessment in Educational Premises, 2006.

Environmental

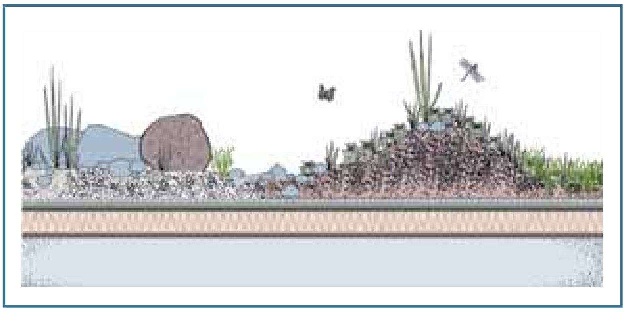
Sustainable construction

Environmental impact ranges from consumption of natural resources and energy during manufacture and installation, through to removal, recycling and disposal. Realistic durability and maintenance input estimates are an essential requisite of impact studies. These parameters feed directly into BREEAM requirements.

BREEAM Schools is the standard tool for assessing the environmental impact of a school. Within the BREEAM Schools assessment, construction elements used within the proposed roof system are rated using information from the BRE *Green guide to specification*. The ratings for components are A* to E, with A* being the most environmentally friendly. It is encouraged that the specifier chooses the most sustainable products available that meet the performance criteria. A product's environmental rating should always be checked with the manufacturer.

It is also necessary to comply with the Government's timber procurement policy, found at: www.proforest.net/cpet/uk-goverment-timber-procurement-policy/timber-guidance

For guidance on the percentage of recycled content in a new build and opportunities to increase the overall use of recycled material in the building, refer to the RC toolkit provided by the Waste and Resources Action Programming (WRAP) group. This can be found at: www.wrap.org.uk



Daylight

Rooflights have been recognised as an efficient device for introducing daylight into buildings. Modern rooflights when combined with a modern lighting system incorporating daylight sensors are effective in cutting a building's energy consumption by reducing the need for lighting during daylight hours, helping to reduce the building's carbon footprint.

Guidance on rooflight design and compliance with Part L of the Building Regulations is given in the second tier document referenced from Part L Building Regulations: 'Designing with rooflights: Supporting the guidance in AD L2A & AD L2B (2006)' (issued by the National Association of Rooflight Manufacturers) which shows that optimum reduction of carbon emissions will be achieved with rooflight area up to 15-20% floor area.

In addition BS 8206 part 2 provides information on recommended daylight factors in areas such as atriums.

The average U-value of the rooflights used must be a minimum of 2.2 W/m²K (when assessed in the vertical plane) in order to comply with Part L Building Regulations.

Care should also be taken when specifying rooflights that the following are considered and discussed with the manufacturer:

- Light transmission levels.
- The effect of increased rooflight area in reducing carbon emissions as calculated by an approved calculation tool, as required by Part L2 of Building Regulations.

- Solar overheating – the maximum internal gain allowed in Building Regulations Part L2 is 35 W/m² from all elements, including lighting, occupants, internal processes and solar gain. See NARM guidance and CIBSE guide TM37 – 'Design for improved solar shading control for guidance on solar overheating'. Externally mounted shading devices are more effective than tinted window film as they control both the heat gain and solar glare.
- Non-fragility rating as stated in health and safety section on page 34 of this specification.
- UV degradation.
- Compatibility with the proposed roof covering system.
- Loads caused by snow, ice, standing water and self weight. Guidance on loadings is available in BS 5516 and BS 6399 part 2 and 3.
- Deflection caused by wind loads.
- The performance in fire shall conform to the requirements of Building Regulations as stated on page 26.
- Where upstands are required to ensure that the rooflight is above the plane of the finished roof, it shall be suitably insulated.
- An Acoustic Expert should check that the proposed rooflight construction will achieve the required indoor ambient noise levels and intrusion of rain noise as stated in the acoustic section of this report.
- Within atria consideration shall be given to using the rooflights for ventilation and smoke control as required under BS 5588 part 7.
- Consideration shall be given to effective drainage of rainwater and condensation from the rooflight. If water is allowed to collect on surfaces close to horizontal, problems with sediment build up and long term etching may become apparent.

The most commonly used glazing materials for rooflights are glass (for skylights and panel glazing systems) and polycarbonate (for domes, continuous barrel vault rooflights, and panel glazing systems). GRP is also used for profiled in-plane rooflights in metal roofs or as stand alone canopies, and ETFE is an alternative where extremely lightweight structures are required, e.g. for some atria. Additional design guidance for each of these glazing materials is given below.

Glass

Glass is usually used in skylights or panel glazing systems. It is generally supplied as flat double glazed units (air or gas filled) designed to be installed into an aluminium support frame – either factory assembled into a complete rooflight unit, or assembled on site into glazing bars. Glass is available in a wide range of specifications, but generally offers:

- The best acoustic insulation of any glazing material.
- Outstanding durability.
- Excellent thermal insulation (although care is required to ensure the frame matches the performance of the glazing).
- High light transmission (although care is required to avoid potential solar glare problems with direct, non-diffused light).

The following should be considered when specifying glass rooflights:

- The glazing shall conform to the Centre for Window and Cladding Technology (CWCT) Technical Note 42, minimum type 2.
- Careful consideration must be given to the breakage characteristics of the specified glass. Laminated glass must be specified for the inner pane to avoid the risk of falling glass after a breakage.
- Any toughened glass specified shall be heat soaked tested.
- Guidance on loadings is available in BS 5516 and BS 6399 part 2 and 3.
- Manufacturers' advice should be sought with regard to correction factors for stated u-values of glass as they are determined in the vertical plane. Heat loss and thermal stress is higher in inclined glazing.

Polycarbonate

Polycarbonate is the most commonly used material for dome type rooflights, and is also frequently used in skylights, panel glazing systems and barrel vault rooflights. It is available as:

- Solid sheets which can be thermo formed to create individual dome rooflights or continuous barrel vault rooflights.
- Extruded flat solid or multiwall sheets which can be installed into an aluminium support frame (either factory assembled into a complete rooflight unit, or assembled on site into glazing bars),or which can be cold curved and fitted into an aluminium frame to create barrel vaults.

Polycarbonate is available in a wide range of specifications, but generally offers:

- Excellent thermal performance – when correctly specified.
- Excellent strength and non-fragility characteristics (although care is required to ensure correct design of frame/material fixing).
- Good durability (service life typically 15-25 years).
- High levels of light transmission when used as a clear material. Diffusing grades are also available.

The following should be considered when specifying polycarbonate rooflights:

- Manufacturers shall be consulted with regard to UV protection and the life expectancy of the sheet with regard to structural stability and discolouration. A manufacturers warranty shall be sought for the life expectancy and agreed as acceptable with the School/Local Authority.

- The effects of fire are important when specifying plastic rooflights, the rooflights must conform to Building Regulations as stated in the performance in fire section on page 26.
- Advice on plastics glazing is contained in BS 6262 and from the Glass and Glazing Federation.
- Plastics, unlike glass, are partially permeable to water vapour. It is recommended, therefore, that ventilation should be provided in the construction of each glazing unit.
- Adequate provision is made to allow for thermal expansion/contraction - gaskets, sealants and primers must be approved for the purpose by the manufacturer.
- When installed in glazing bars, adequate rebate depth must be provided which gives clearance to allow for thermal movement and edge cover sufficient to accommodate flexure under wind or impact loadings as recommended by manufacturer.
- The manufacturer's advice must be followed when cutting or machining plastics glazing sheet so that impact resistance is not impaired.
- Care shall be taken to assess the compatibility of polycarbonate sheets with adjacent roof materials. Some roofing sheet finishes such as plastisol coated steel can over time affect the mechanical performance of the product and an appropriate isolating system should be used.

GRP

GRP rooflights are generally profiled sheets, which form in-plane rooflights by replacing one or more profiled metal sheets within a pitched or, curved roof slope. They can also be used to create pitched canopies, and pre-curved GRP sheets can be used to form barrel vault rooflights.

GRP rooflights generally offer:

- Excellent durability (service life typically over 25 years).
- High levels of light transmission combined with high levels of diffusion for even light distribution without harsh shadows.
- Excellent thermal performance (when correctly specified).
- Excellent strength and non-fragility characteristics (when correctly specified).

The following should be considered when specifying GRP rooflights:

- Manufacturers shall be consulted with regard to UV protection and the life expectancy of the sheet with regard to structural stability and discolouration. A manufacturers warranty shall be sought for the life expectancy and agreed as acceptable with the School/Local Authority.
- GRP rooflights must be installed in accordance with manufacturers instructions.
- GRP rooflights are available in a range of fire ratings, so fire rating must be correctly specified to conform to Building Regulations as stated in the performance in fire section on page 26.

Ethylene Tetra Fluoro Ethylene (ETFE) Rooflights

ETFE rooflights are more specialised than other rooflight systems. They comprise 2 or 3 ETFE (Ethylene Tetra Flouro Ethylene) films held in an aluminium frame, inflated with a permanent pressurisation system to create pneumatic 'cushions'.

The main advantage of ETFE rooflights is their light weight (with associated low embodied energy) and ability to span large distances, which can make them suitable for some courtyard and atrium applications (although other rooflights are also often suitable for such applications). They are usually less suitable for most other rooflight application on schools.

The following should be considered when specifying ETFE roofs:

- ETFE rooflights can be relatively easily damaged or vandalised so should not be used at low level, be easily accessible or used in situations where they are likely to be subject to malicious damage.
- ETFE offers very low levels of acoustic insulation. The use of rooms below ETFE rooflights shall be considered with regard to compliance with the indoor ambient noise levels and intrusion of rain noise as discussed in the acoustic section of this report. An Acoustic expert should be consulted as rain suppressors may be required in order for the ETFE roof to be acceptable in certain areas of the School.
- In general ETFE has good durability but manufacturers should be consulted to ensure it is not affected by UV light, atmospheric pollution and other forms of environmental weathering in a particular location
- The long term performance of ETFE rooflights is dependant on reliable operation of the inflation unit. Consider the location and maintainability of the inflation unit.
- A rigorous maintenance routine must be in place for the pressurisation system.
- The design should consider the affect of power failures and requirements for back up generators – consult manufacturers for details.
- The effects of fire are important when specifying plastic rooflights, the rooflights must conform to Building Regulations as stated in the performance in fire section on page 26.
- The fire load must be low in the area covered by ETFE. The location of ETFE rooflights must not aid the spread of fire, or the products of combustion to adjacent buildings and shall not be carried over compartment walls.
- Always consult the Building Insurers at the design stage when specifying ETFE rooflights for their views on the risks presented as there may be underwriting or excess issues.
- Consult Building Control and the Building Insurers for requirements of fire detection and sprinklers where ETFE rooflights are specified.
- ETFE can be overprinted with a variety of surface patterns / treatments to reduce solar gain.

Durability

One of the key aspects of a product's environmental impact is its durability. This is expressed in terms of anticipated life until renewal. It can also be expressed as the period over which the combined initial cost and maintenance cost exceeds the effective annualised cost of a replacement system. In normal circumstances, the durability of roofs depends on design and construction, the environment, material performance and routine maintenance.

In school buildings, the roof deck and insulation must have a minimum lifetime of 60 years, with the roof covering lasting a minimum of 30 years. It should also be possible after the 30 years for the roof covering to be overlaid, overcoated, upgraded or readily replaced. Evidence must be provided by the roof covering manufacturer from an independent European accredited test authority that the above minimum lifetime can be achieved.

As discussed in 'Design standards' on page 21, consideration should be made in the perimeter detail for any upgrades to the insulation required by the current Building Regulations to achieve U-values current at the time of re-covering.

The roof should be inspected at intervals as recommended by the manufacturer of the roof covering and no longer than on an annual basis. Any accumulation of debris should be removed from roofs and cleaned/repaired if necessary as recommended by the roof covering manufacturer under the duty of care of the building owner.

All coverings will degrade when exposed to the elements, the rate depending on how severe the environment is in terms of:

- UV/solar degradation.
- Temperature stability.
- Industrial or marine pollution/resistance to acid rains, oil products.
- The presence and retention of moisture.
- The colour – lighter colours remain more stable than darker colours.

For designation of areas within the United Kingdom for wind and rain severity, consult BS 6399, Part 2.

As most durability problems can be associated with roof penetrations, robust details must be developed with the roof covering manufacturer to ensure the design life of the roof covering is not impaired around all penetrations.

All these factors must be taken into account and recommendations from manufacturers observed to achieve the design lives stated above.

Health, safety, maintenance and guarantees

Health and safety

Construction of the roof is one of the most hazardous operations because of the potential for falls or materials/components dropping onto people below.

In accordance with the Health and Safety at Work Act and the CDM Regulations (2007), a building has to be designed with safety in mind, not only for the construction period, but throughout its normal operational life. The client, designer, principal contractor, roofing sub-contractor and CDM coordinator must plan and document a safe system of work before starting construction, taking into account the fragility of the cladding systems. While fully fixed metal sheeting is generally regarded as non-fragile, many metal lining panels and roof lights must be treated with care, according to NARM Guidance Note 2003/1. Only metal lining sheets to ACR(M)001:2005 – roof fragility class B or better are acceptable.

The HSE document HSG 33, *Safety in roof work* refers specifically to fragile roof lights as an example of a potential hazard. All rooflights should be considered as fragile, as they may be non-fragile when installed but after being exposed to UV light their classification can change to fragile. The following guidance applies to rooflights; and guarding should be considered to all rooflights:

- ACR(M)001:2005 – minimum roof fragility class B for thermoplastic rooflights.
- Centre for Window and Cladding Technology (CWCT) Technical Note 42, minimum type 2 for glass rooflights.

Additional guidance relating to working at heights and with fragile materials can be obtained from ACR (Advisory Committee for Roofwork).

CDM regulations (2007) extend the responsibility of health and safety to the designer to minimise risk during construction, maintenance and repair. To ensure safety on roofs during the life of the building, the following HSE guidance should be followed in order of priority:

a) Design out the need to gain access to the roof.
   - Locate plant elsewhere.
   - Eliminate in-board rainwater gutters.
   - Provide suitable external access for MEWP for activities, such as cleaning rainwater outlets and general inspection work.
   - Provide glazing that can be cleaned from inside the building.

b) Provide guard railing or parapet to perimeter and stairs/door access (if not reasonably practicable to design out access on to the roof).
   - This is the minimum provision where maintainable plant is located at roof level.

c) Provide a travel restraint system (if not reasonably practicable to provide guard railing or parapet to perimeter and stairs/door access).
   - Travel restraint is not acceptable for access to maintainable plant.

Assessment of what is reasonably practicable must take account of the nature of maintenance operations, including frequency, duration and duty. (Refer to CIRIA Guidance C611: *Safe access for maintenance and repair*.)

On completion of the building, a health and safety file must be issued by the CDM co-ordinator to the building owner. The following must be included in the health and safety file:

- Access to the roof to be restricted to competent persons or those under their responsibility.
- Roof light specification, including its non-fragile test method and weight – see ACR Red Book for information.

Maintenance and repairs

Routine inspection of the roof should be carried out at least annually and preferably both in early spring and late autumn. The purpose of the inspection is to:

- Check for damage.
- Ensure rainwater outlets are not obstructed and serviceable.

BS 7543, 8210 and BS ISO 15686 identify that as a minimum the following maintenance regime must be undertaken:

a) Continuous regular observation by the building user.

b) Annual visual inspection by qualified personnel.

c) Full inspection by qualified personnel every five years.

They also recommend that the maintenance cycle is established when the design is being developed.

Additional inspection must be carried out if required by the roof covering manufacturer's warranty included in the O&M manuals.

Inspections should be able to be carried out safely and wherever possible from an external MEWP, eliminating the need to access the roof.

Since all green roofs require higher maintenance levels than a traditional roof finish to keep them thriving, it is advisable to include the cost of post-installation maintenance for an agreed period by appropriate contractors within the tender documents. The ongoing maintenance requirements must be obtained from the green roof system manufacturer to ensure the building owner is aware of the maintenance requirements for this type of roof.

Before any remedial/new works are undertaken to an existing roof (including the formation of new holes), the following should be ascertained:

- The original roof covering specification.
- The structure's load bearing capacity and whether it is capable of taking additional load.
- Whether any load limitations should be imposed during re-roofing.
- Kerb heights.
- Any implications for the existing guarantee or warranty of the roof.

In all cases, the original roof covering manufacturer must be consulted.

Guarantees and warranties

A guarantee or warranty for the roof covering/system must be put in place by the roofing sub-contractor directly between the client and roof covering manufacturer. This will result in the client having a single point fully comprehensible warranty for the installed product.

Over and above this, the client can obtain FSA-approved insurance protecting against insolvency of the roofing contractor.

It is for the client or financial body to decide the level of provision and length of warranty required, based on their particular circumstances, to ensure the best long-term protection.

The guarantee period should not be confused with the system durability period that is stated on certificates provided by European accredited test houses or the BRE green guide, or demonstrated by historical evidence. The durability period is the expected life of a product but does not give any guarantees that this will be achieved.

Cost Comment

Capital costs

The roof element typically comprises between 7-12% of the total building cost and often accounts for a spend running into seven figures for a large secondary school when the associated roof deck, drainage, rooflights and safety access systems are taken into account.

The elemental costs of roofs per m^2 of gross internal floor area (GIFA) vary widely from project to project, reflecting the significant differences in the planning and organisation of the floor plans they cover and the specification of the roof structure. In general, three-storey schools demonstrate better cost efficiency for roofs than more extensive two-storey or single storey plans.

At the lower end of the cost range, three-storey structures with simple specifications will cost in the region of £75-£80m^2 GIFA, while schools with more complex roof geometries, larger surface areas, steps, overhangs or similar design features will cost upwards of £100m^2, often reaching £150-160m^2 GIFA and sometimes in excess of the £200m^2 GIFA for more iconic or unusual structures.

The extent of natural daylight to be delivered into the building through the roof is also a significant cost driver. A sample of recent schemes identified that on average 6-15% of the total roof surface area in a typical secondary school is made up of some form of roof glazing.

Whole-life costs

Whole-life costs are crucial to the design, procurement, selection and maintenance of roof coverings. Whichever specification is chosen, an holistic approach to decision making will deliver maximum benefits, as opposed to roofing selected on capital cost criteria alone. Factors to be taken into account include:

- Acoustic attenuation requirements at sites with high noise pollution.
- Life span and replacement cycles of materials.
- Availability of system warranties/product guarantees.
- Susceptibility to damage and repairs (e.g. through high winds).
- Sustainability (e.g. transport, embodied energy, recycling).
- Buildability and programme sequence to weather tightness.
- Complexity of roof detailing to perimeters, penetrations, gutters, parapets, etc.

Professional advisers should take due regard of these factors and carry out option appraisals in developing project budgets. For guidance on the approach to option appraisals, see HM Treasury's Green Book *Appraisal and evaluation in central government*, at: www.hm-treasury.gov.uk/economic_data_and_tools/greenbook/data_greenbook_index.cfm

The specifications proposed in this document are assessed to be cost neutral in relation to most existing best practice solutions.

3

Performance specifications and examples

This section provides a summary of the minimum performance requirements for roof coverings together with examples of roof covering types. This does not preclude the designer from using other roof finishes to achieve particular aesthetic effects. However, the alternative proposed roof covering must conform to the key performance requirements for the area where it is intended to be used.

The DCSF considers that the examples would satisfy the standard performance specification. However, the examples are provided for guidance purposes only. Users will be expected to use their own skill and expertise in deciding what will be a reasonable and appropriate final design solution in any situation. The DCSF does not accept responsibility for any losses suffered as a result of the guidance provided in this document.

N.B. In order to achieve the minimum carbon improvement levels for school buildings as determined by Building Regulations L2A (2006 edition), a combined improvement in fabric, heating, ventilation, lighting and air conditioning (where applicable) performance standards are required. In order for design U-values for roofs to reasonably contribute towards the 23% improvement, it is considered good practice to exceed the limiting insulation standards denoted by Table 4 of Approved Document L2A.

Minimum performance requirements

Requirement	Minimum performance	Reference page
Thermal performance of roof covering	0.25 W/m^2K – weighted average (Building Regulations Part L2, 2006)	Page 21
Thermal performance of rooflights	2.2 W/m^2K – weighted average (Building Regulations Part L2, 2006)	Page 21
Air permeability	$10m^3/(h.m^2)$ at an applied pressure of 50 Pascals (Building Regulations Part L2, 2006)	Page 23
Indoor ambient noise level	As Table 1.1 BB93 and BB101	Page 24
Rain noise	The increase in criteria for noise intrusion from external sources during 'heavy' rainfall should not exceed the levels defined in Table1.1 BB93 by more than 20dB in the design calculations provided by independent acoustic consultants	Page 24
Fire internal surfaces	Class 1 to BS 476 Part 7 or EU Class C-s3, d2 or better	Page 25
Fire external surfaces	AA, AB or AC to BS 476 Part 3 or EU Class B roof (T4) to ENV 1187 Part 4	Page 25
Minimum lifetime	60 years for roof deck and insulation 30 years for roof covering, to be easily overlaid, overcoated, upgraded or replaced without effecting the insulation/deck below, when assessed by a competent technical professional. Evidence must be provided by the roof covering manufacturer from an independent European accredited test authority or historical data that the above minimum lifetime can be achieved	Page 33

Examples of roof covering solutions

Continuously supported roof coverings

TYPE 1

Reinforced bitumen membranes

Generally, two working layers are applied on site, each consisting of a reinforcing base of polyester or a polyester/glass fibre mix, saturated and coated with polymer-modified bitumen. Many substrates also require a preparatory layer – check with manufacturer. Supplied in roll form, and commonly bonded with bitumen or specialist adhesives.

Specific standards	Acceptable construction
BS 6229 BS 8217 BS 8747 BS EN 13707	Warm or inverted flat roofs (see roof pitch page 15)

Notes

Durability

The key qualities that are inherent in reinforced bitumen membrane systems and deliver proven durability are:

- The ability to withstand movement: daily thermal cycling, for example, may subject roof coverings to temperature ranges of around 100°C.
- Resistance to weathering, mechanical damage, puncturing and tearing: most roofs are suitable for light maintenance traffic; however, roof access should always be minimised. Where heavier traffic is expected, additional protection such as purpose-made walkways should be provided, for example to service roof-mounted equipment.

The Flat Roofing Alliance (FRA) recommends that both working layers of the built-up membrane should be polyester based, particularly where there is access to the roof.

Design factors that can further enhance durability include:

- Design roof falls to be twice the minimum – at least 1 in 40 – to ensure efficient drainage of water.
- For green or inverted roofs, the membrane's waterproof integrity must be ensured before covering with ballast. N.B. If a green roof or inverted roof leaks, the repair cost may be significantly higher than a traditional system, so it is prudent to undertake an electronic integrity test on the finished waterproofing system prior to burying it.

Health and safety

Hot bitumen bonding with associated health and safety risks – see Flat Roofing Alliance (FRA) information sheet 18 and HSE Guidance Note EH40.

Consideration must be given to the supporting substrate with regard to fragility and providing a safe working environment, as required by CDM regulations.

Environmental

Good – low toxicity, recyclability, high material efficiency; CEN classifies bitumen as a waste material.

Bad – non-reusable, medium/high embodied energy, non-renewable source.

Acoustics

If lightweight roof decks are used, additional acoustic treatment may be required to the roof deck soffit or ceiling within the room below. Accredited third party acoustic test data required to confirm suitability of proposed construction.

Fire

Membrane/roof covering: AA, AB or AC to BS 476 Part 3 or EU Class B roof (T4) to ENV 1187 Part 4.

Insulation: The use of combustible insulation within the roof construction or elsewhere within the building could influence insurance terms. See page 26, Insurance requirements.

Green roof: It must be stressed that the importance of good maintenance and irrigation of green roofs must be considered, otherwise there is an inherent fire risk. See page 26.

TYPE 2

Polymeric single ply membranes

A manufactured sheet product consisting of a polymer based single ply roofing membrane, which may be applied in fully adhered or bonded systems, by mechanical fastening and by loose laying with suitable ballasting.

Notes	Specific standards	Acceptable construction
See notes below	BS EN 13956 BS 6229:2003 The Single-Ply Roofing Association provides more specific advice in its single-ply roofing design guide.	Warm or inverted flat roofs (see roof pitch page 15)

Notes

Durability

Design issues that can improve the long-term performance:

- Light-coloured membranes reflect heat and help to reduce heat ageing of the membrane. They also reduce summer cooling loads.
- Ensure differential movement is not transferred to the membrane, by designing robust weatherproof or waterproof details as appropriate.
- Ensure full calculation of wind load by a competent person, irrespective of the method of attachment of the waterproof membrane. Appropriate design safety factors must be applied.
- High quality sealing of side and head laps, flashings and terminations is essential. Solvent welded seams should be tested shortly after forming and any discrepancies should be repaired immediately to prevent future failures. All personnel welding membranes (either hot air or solvent) must have passed the membrane manufacturer's approved training course.
- The waterproof membrane must be terminated at perimeters and at the base of upstands by a mechanical restraint.
- Protected walkways must be provided as appropriate for the in-service access requirement. During the construction phase the roof must be protected appropriately and contractual responsibility for it must be made clear. During service, access to the roof must be controlled by a permit system.
- Ensure the membrane manufacturer's maintenance advice (as stated in the O&M manual) is understood by all staff to avoid the use of inappropriate materials for any future repair.
- For green or inverted roofs, the membrane's waterproof integrity must be ensured before covering with ballast. N.B. If a green roof or inverted roof leaks, the repair cost may be significantly higher than a traditional system, so it is prudent to undertake an electronic integrity test on the finished waterproofing system prior to burying it.
- Roof falls must be twice the minimum (at least 1 in 40) to ensure efficient drainage of water.

Health and safety

Consideration must be given to the supporting substrate with regard to fragility and providing a safe working environment, as required by CDM regulations.

Environmental

Good – TPO, EPDM and PVC membranes are reusable, with low toxicity. PVC and FPO can be re-cycled. High material efficiency.

Bad – Derived from oil. UK recycling expected to commence only once post-consumer volumes become significant.

Acoustics

If lightweight roof decks are used, additional acoustic treatment may be required to the roof deck soffit or ceiling within the room below. Accredited third party acoustic test data are required to confirm suitability of the proposed construction.

Fire

Membrane/roof covering: AA, AB or AC to BS 476 Part 3 or EU Class B roof (T4) to ENV 1187 Part 4.

Insulation: The use of combustible insulation within the roof construction or elsewhere within the building could influence insurance terms. See page 26, Insurance requirements.

Green roof: It must be stressed that the importance of good maintenance and irrigation of green roofs must be considered, otherwise there is an inherent fire risk. See page 26.

TYPE 3

Mastic asphalt

Mastic asphalt is a type of asphalt composed of suitable graded mineral matter and asphaltic cement in such proportions as to form a cohesive, impermeable mass, solid or semi-solid under normal temperature conditions, but sufficiently fluid when brought to a suitable temperature to be spread by means of a hand float or by mechanical means without compaction.

Notes	Specific standards	Acceptable construction
Durability To ensure a durable specification, it is recommended that high performance polymer modified mastic asphalt is used, with a minimum requirement of mastic asphalt manufactured in accordance with BS 6925, 1988 type R/988/T25. Solar protection should be specified to warm roof constructions in accordance with manufacturers' recommendations. For inverted roofs, the membrane's waterproof integrity must be ensured before covering it up, as leaks will be difficult to locate after the insulation and ballast have been put in place. Roof falls must be designed to be twice the minimum – at least 1 in 40 – to ensure efficient drainage of water. **Health and safety** The main hazard in using hot melt systems is the risk of severe burns to the skin – hence PPE should be used. Refer to the Mastic Asphalt Council's Technical Guide for extensive guidance on health and safety issues. Consideration must be given to the supporting substrate with regard to fragility and producing a safe working environment, as required by CDM regulations. **Environmental** Good – Recyclable, seamless and flexible in application. Bad – Medium/high embodied energy, non renewable resource. **Acoustics** If lightweight roof decks are used, additional acoustic treatment may be required to the roof deck soffit or ceiling within the room below. Accredited third party acoustic test data are required to confirm suitability of proposed construction. **Fire** Membrane/roof covering: AA, AB or AC to BS 476 part 3 or EU Class B roof (T4) to ENV 1187 Part 4. Insulation: The use of combustible insulation within the roof construction or elsewhere within the building could influence insurance terms. See page 26, Insurance requirements. Green roof: It must be stressed that the importance of good maintenance and irrigation of green roofs must be considered, or there is an inherent fire risk. See page 26.	BS 6229 BS 8218	Warm or inverted flat roofs (see roof pitch page 15)

TYPE 4

Hot melt waterproofing systems

Hot melt bitumen membranes, hot applied by rubber bladed squeegee, consisting of primer, modified bitumen laid in two coats with polyester reinforcement interleaving. A solar protection or access sheet is applied to the top surface, depending on the end use.

Notes	Specific standards	Acceptable construction
See below	BS 6229 No specific British Standards see FRA info sheet 31.	Inverted flat roofs (see roof pitch page 15)

Notes

Durability

Key issues of durability are:

- The substrate construction and condition must be free from material that could impair the bond, or create thin spots or penetrations in the coating.
- There must be provision for moisture removal of damp substrates.
- There must be no point loads on the roof.
- The system specified must be suited to the expected traffic.
- There must be appropriate detailing at edges, verges, upstands, outlets, movement joints and day joints.
- Avoidance of air holes is essential.
- Design roof falls must be twice the minimum – at least 1 in 40 – to ensure efficient drainage of water.
- As hot melt waterproofing systems are always buried under inverted roofs, green roof or podium deck waterproof integrity must be ensured before covering it up, as leaks will be difficult to locate after the insulation and ballast have been put in place.

Health and safety

The main hazard in using hot melt systems is the risk of severe burns to the skin – hence PPE should be used.

Consideration must be given to the supporting substrate with regard to fragility and producing a safe working environment, as required by CDM regulations.

Environmental

Good – High material efficiency, recycled material in product, recyclable.

Bad – Not reusable but recyclable, medium embodied energy, non-renewable source.

Acoustics

If lightweight roof decks are used, additional acoustic treatment may be required to the roof deck soffit or ceiling within the room below. Accredited third party acoustic test data are required to confirm suitability of proposed construction.

Fire

Membrane/roof covering: AA, AB or AC to BS 476 Part 3 or
EU Class B roof (T4) to ENV 1187 Part 4.

Insulation: The use of combustible insulation within the roof construction or elsewhere within the building could influence insurance terms. See page 26, Insurance requirements.

Green roof: It must be stressed that the importance of good maintenance and irrigation of green roofs must be considered, or there is an inherent fire risk. See page 26.

TYPE 5

Malleable sheet metal roofing

Malleable sheet roofing consists of sheet metals such as copper, lead and zinc which require a substrate such as ply wood for support. The roofing requires particular attention to the junction and perimeter details, and is usually used for a particular aesthetic finish.

Notes	Specific standards	Acceptable construction
Durability Key factors are: • Failure of aluminium coverings and flashings can be caused by restraint of movement, fatigue of fixings, use of inadequate substrates, or exposure to unsuitable aggressive atmospheres. The risk of premature failure is minimised by good design and specification. Electrolytic corrosion and chemical attack can occur on cladding, flashings, fixings, gutters, etc. when exposed to other materials in moist conditions and contaminated liquid. Always consult the roof covering manufacturer to ensure compatibility, particularly with the substrate. It is essential to avoid the risk of underside condensation and corrosion by adopting forms of construction and ventilation that allow for removal of moisture. **Health and safety** Consideration must be given to the supporting substrate with regard to fragility and providing a safe working environment, as required by CDM regulations. **Environmental** Good – Recyclable, may have recycled content, high material efficiency. Bad – high embodied energy, limited source, greenhouse gases, some metals toxic in use. **Acoustics** Treatment may be required to the roof deck soffit or ceiling within the room below to meet acoustic requirements. Accredited third party acoustic test data required to confirm suitability of proposed construction. **Fire** Membrane/roof covering: AA, AB or AC to BS 476 part 3 or EU class B roof (T4) to ENV 1187 Part 4. Insulation: The use of combustible insulation within the roof construction or elsewhere within the building could additionally influence insurance terms. See page 26, Insurance requirements.	Aluminium BS EN 485, 515 and 573 Copper BS EN 504, 1172 Zinc BS EN 988 Stainless steel BS EN 502, 10088-2, 10258 and 10259	Warm & cold pitched roofs (see roof pitch page 15)

Discontinuously supported roof coverings

TYPE 6

Slating/tiling

Tiled roofing, generally consisting of clay, concrete, natural slate, resin-slate or fibre cement tiles fixed to roofing battens on timber rafters

The roof design can be either of warm or cold construction, with a roofing underlay, insulation and vapour control layer.

Notes	Specific standards	Acceptable construction
Durability Key factors include: • Good 'nesting' of slates/tiles enhances the weather tightness and reduces the risk of capillary action. • The combination of roof pitch, profile depth and size of laps is significant when considering water penetration and must always be in accordance with manufacturers' recommendations. • Fragility is the principal concern: slates/tiles are vulnerable to breakage and must be protected during roof maintenance. • Pitch and rafter lengths are critical to achieving a water tight solution; the minimum and maximums must always be checked with the roof covering manufacturer. • Long spans are achievable with profiled interlocking tiles, for which there are no rafter length restrictions. **Health and safety** Consideration must be given to a safe working environment and falls from heights through open discontinuous support structures, as required by CDM regulations. **Environmental** Good – Reusable and recyclable, may have recycled content, high material efficiency, low toxicity (except fibre cement tiles which are high), low embodied energy (except clay and slate tiles). Bad – Greenhouse gases in concrete and fibre cement tiles, high toxicity in concrete and fibre cement tiles, high embodied energy in clay and slate tiles, low UK reserves in slate tiles. **Acoustics** Treatment may be required to the roof deck soffit or ceiling within the room below to meet acoustic requirements. Accredited third party acoustic test data required to confirm suitability of proposed construction. **Fire** Membrane/roof covering: AA, AB or AC to BS 476 part 3 or EU class B roof (T4) to ENV 1187 Part 4. Insulation: The use of combustible insulation within the roof construction or elsewhere within the building could additionally influence insurance terms. See page 26, Insurance requirements.	BS 5534	Warm or cold pitched roofs (see roof pitch page 15)

TYPE 7

Profiled sheeting

Profiled roof sheeting is generally a built-up system consisting of a metal liner tray, insulation and a metal top sheet, either in natural form such as mill finished aluminium, or colour coated with a proprietary system. The system is supported on metal purlin rails and the top sheet is often a standing seam roof with no exposed fixings, which can achieve low pitches.

Notes	Specific standards	Acceptable construction
Durability Key factors are: • The risk of water penetration in profiled sheet roofs increases as the pitch is lowered; therefore, always consult the covering manufacturer for minimum pitch and suitable detailing. • Electrolytic corrosion and chemical attack can occur on cladding, flashings, fixings, gutters, rooflights etc. when exposed to other materials in moist conditions and contaminated liquid. Uncoated steel (for example, cut edges, aluminium and stainless steel) can be affected. Avoidance is by selecting suitable materials, good detailing and the use of isolating techniques. Always consult roof covering manufacturer to ensure compatibility and establish good detailing. See MCRMA Technical Paper 12 for details about the types and use of fasteners. • Some durability issues apply to all types of organic coated cladding. The amount of time the coating lasts before painting is needed is largely related to the ultraviolet light dosage and the environment it is located in – polluted or marine environments tend to reduce coating durability. **Health and safety** Consideration must be given to a safe working environment and falls from heights through open discontinuous support structures, as required by CDM regulations. Additionally, the support decks fragility must be considered. See page 34 of this document. **Environmental** Good – Recyclable, may have recycled content, high material efficiency. Bad – high embodied energy, some products from limited source. **Acoustics** The sound absorbing qualities of cladding systems can be improved by using a sound absorbing lining or a perforated metal lining backed with sound absorbing material such as mineral wool. This may be required to meet acoustic requirements. Accredited third party acoustic test data are required to confirm suitability of proposed construction. **Fire** Membrane/roof covering: AA, AB or AC to BS 476 part 3 or EU class B roof (T4) to ENV 1187 Part 4. Insulation: Combustible thermoplastic insulation material should not be carried over the compartment wall, as a core to double-skinned roof sheeting or otherwise. The use of combustible insulation within the roof construction or elsewhere within the building could additionally influence insurance terms, though insulated panel and cladding systems that have LPCB certification are accepted. See page 26, Insurance requirements.	BS 5427-1	Warm roofs on all roof pitches given that proper installation methods are used (see roof pitch page 15)

TYPE 8

Insulated panels

Insulated roofing panels are single piece factory pre-engineered metal faced panels, consisting of metal internal facing, integral insulation and a profiled metal top sheet. The panels come to site as a unit and are mechanically fixed to metal purlins. The internal and external faces are colour coated with a proprietary system. These are ideally suited to low pitches and long spans.

Notes	Specific standards	Acceptable construction
Durability Key factors are: • The risk of water penetration in insulated panel roofs increases as the pitch is lowered; therefore, always consult the covering manufacturer for minimum pitch and suitable detailing. • Electrolytic corrosion and chemical attack can occur on cladding, flashings, fixings, gutters, rooflights, etc. when exposed to other materials in moist conditions and contaminated liquid. Uncoated steel (for example cut edges, aluminium and stainless steel) can be affected. Avoidance is by selecting suitable materials, good detailing and using isolating techniques. Always consult the roof covering manufacturer to ensure compatibility and establish good detailing. See MCRMA Technical Paper 12 for details about the types and use of fasteners. • Some durability issues apply to all types of organic coated cladding. The amount of time the coating lasts before painting is needed is largely related to the ultraviolet light dosage and the environment it is located in – polluted or marine environments tend to reduce coating durability. **Health and safety** Consideration must be given to a safe working environment and falls from heights through open discontinuous support structures as required by CDM regulations. **Environmental** Good – High material efficiency. Bad – High embodied energy, some coatings contain PVCs, unrecyclable, unreusable. **Acoustics** Treatment will be required to the roof deck soffit or ceiling within the room below to meet acoustic requirements. Accredited third party acoustic test data are required to confirm suitability of proposed construction. **Fire** Membrane/roof covering: AA, AB or AC to BS 476 part 3 or EU class B roof (T4) to ENV 1187 Part 4. Insulation: Combustible thermoplastic insulation material should not be carried over the compartment wall, as a core to double-skinned roof sheeting or otherwise. The use of combustible insulation within the roof construction or elsewhere within the building could additionally influence insurance terms, though insulated panel and cladding systems that have LPCB certification are accepted. See page 26, Insurance requirements. Green roof: It must be stressed that the importance of good maintenance and irrigation of green roofs must be considered, otherwise there is an inherent fire risk. See page 26.	BS 5427-1	Warm Roofs on all roof pitches given that proper installation methods are used (see roof pitch page 15)

References

This document was published in January 2008. After this date readers should ensure they use the latest edition of all references.

Typical constructions

- British Board of Agreement certificates at www.bbacerts.co.uk
- BS 6229 *Code of practice for flat roofs with continuously supported coverings*
- BS 6915 *Design and construction of fully supported lead sheet roof and wall coverings – Code of practice*
- BS 8218: 1998 *Code of practice for mastic asphalt*
- BS 8747
- Building Bulletin 101 *Ventilation of school buildings*
- CIRIA C644 *Building greener – Guidance on the use of green roofs, green walls and complementary features on buildings*
- Flat Roof Alliance (FRA) *Roofing handbook*
- *Flat roofing: a guide to good practice*, published by Ruberoid, version 4 2007
- MRCMA Technical Paper TP9, *Composite roof and wall cladding panel design guide* (June 1995)

- National Association of Rooflight Manufacturers (NARM) *Designing with rooflights: Supporting the guidance in AD L2A & AD L2B*, 2006
- NBS Standard Guidance
- *Rolled lead sheet – The complete manual* (available from Lead Sheet Association)
- SCI Publication P346 – 2006 '*Best practice for the specification and installation of metal cladding and secondary steelwork*, Steel Construction Institute publication, prepared jointly with EPIC and MCRMA
- SPRA *Design guide to single ply roofing*, 2007
- The Mastic Asphalt Council's *Technical guide*

Thermal

- BRE IP 1/06 *Assessing the effects of thermal bridging at junctions and around openings in the envelope*
- BREEAM Schools 2006, Assessor Manual, *Energy – Reduction of CO2 emissions* Credit reference number E1
- Building Regulations Approved Document L2 *Conservation of fuel and power* (2006 edition)
- EPIC *Insulated panels for external roof and wall cladding – Guidance on compliance with the conservation of fuel and power Building Regulations*, 2006
- *Guidelines for environmental design in schools*, DfES School Buildings and Design Unit. This publication is available in the Regulatory Information Section of the DCSF School Buildings and Design Unit's website at www.teachernet.gov.uk/energy
- MRCMA/EPIC – Technical Paper TP17 (2007), for cladding systems *Design guide for metal roofing and cladding to comply with energy requirements of UK Building Regulations*, 2006
- National Association of Rooflight Manufacturers (NARM) *Designing with rooflights: Supporting the guidance in AD L2A & AD L2B*, 2006

Acoustics

- *Acoustic design of schools*, DCSF. The Stationery Office, 2003 ISBN 0 11 271105 7. This publication is available in the Regulatory Information Section of the DCSF School Buildings and Design Unit's website at www.teachernet.gov.uk/acoustics
- BREEAM Schools 2006, Assessor Manual, *Heath and wellbeing: Acoustic performance* Credit reference number HW17
- Building Bulletin 93, *Acoustic design of schools: A design guide*, DCSF
- Building Bulletin 101, *Ventilation of school buildings*, DCSF
- Building Regulations Approved Document E *Acoustics*

Fire

- BS 476: 1987 *Fire tests on building materials and structures*
- BS 476 Part 3: 2004 *Classification and method of test for external fire exposure to roofs*
- BS EN 13501: 2007 *Fire classification of construction products and building elements*
- BS EN 13501-1: 2007 *Fire classification of construction products and building elements – Part 1: Classification from reaction to fire tests*
- BS EN 13501-2: 2007 *Fire classification of construction products and building elements – Part 2: Classification from fire resistance tests*
- BS EN 13501-5: 2007 *Fire classification of construction products and building elements – Part 5: Classification from external fire exposure to roofs tests*
- Building Bulletin 100 *Design for fire safety in schools*
- Building Regulations Approved Document B – *Fire safety*
- *Design guide for the fire protection of buildings – Essential principles in fires*, published by the Fire Protection Association
- EPIC *Insulated panels for roof and wall cladding: A guide to fire safety, specification and installation*
- HMSO *Fire safety risk assessment in educational premises*, 2006
- LPC *Design guide for the fire protection of buildings*, 2000
- LPS 1181: Part 1: Issue 1.1, *Series of fire growth tests for LPCB approval and listing of construction product systems, Part 1: Requirements and tests for built-up cladding and sandwich panel systems for use as the external envelope of buildings*
- MRCMA Technical Paper TP6 *Profiled metal roofing design guide*

General requirements

- BS EN 501, 502, 504 to 508 and 1304 *Product standards for tiles and slating*
- BS 5427-1 *Product standard for profiled cladding*
- BS 5534 *Product standard for slating and tiling*
- BS 6229 *Code of practice for flat roofs continuously supported*
- BS 8000 *Workmanship on site*
- BS 8217 *Code of practice for built-up felt roofs*
- BS 8219 *Code of practice for profiled fibre cement tiles*
- Advisory Committee for Roofwork – ACR[M]001:2005 *Test for non-fragility of profiled sheeted roofing assemblies* [third edition]
- ACR [CP] 002:2005 *Guidance note for safe working on fragile roofs covering the designing, planning and carrying out of inspection, maintenance, repair and refurbishment work*
- BS 6651: 1991 *Code of practice for the protection of structures against lightning* Sixteenth edition
- CDM Regulations (2007)

- CP 143-1,5,10,12 &15 *Sheet roof and wall coverings code of practice*
- Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. (FLL) www.f-l-l.de
- *Green guide to specification*, Blackwell Science
- Health & Safety at Work Act
- HSE publication HSG33 *health and safety in roof work*
- Manufacturers' literature
- R10 General guidance NBS

Trade association links

- EPIC [Engineered Panels in Construction] www.epic.uk.com
- EURISOL (UK Mineral Wool Association) www.eurisol.com
- Flat Roofing Alliance (FRA) www.fra.org.uk
- Lead Sheet Association www.leadsheetassociation.org.uk
- Mastic Asphalt Council www.masticasphaltcouncil.co.uk
- MCRMA (Metal Roofing and Cladding Manufacturers Association) www.mcrma.co.uk
- National Association of Rooflight Manufacturers www.narm.org.uk
- Single Ply Roofing Association, www.spra.co.uk

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