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Re-covering bitumen felt flat roofs

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CONTACT DETAILS

Church Growth Trust

1 Manor Farm Barns, Baines Lane, Seaton, Oakham, Rutland, LE15 9HP

01536 201339

enquiries@churchgrowth.org.uk

www.churchgrowth.org.uk

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1.0 Introduction

Built-up bitumen felt roofs have a reputation among many building owners as being a poor choice of construction and being prone to leakage. However, the current range of materials which are now available is far superior to those typically used 30 years ago. Instead of a life expectancy of 7 to 15 years for the older traditional felts, the modern materials can come with a guaranteed life of 20 years and a much greater actual life expectancy. Some systems could achieve a service life of 50 years.

The term "roofing felt" is now commonly taken as to apply to the earlier traditional membranes. The term "Reinforced Bitumen Membrane" (RBM) now covers the newer high-performance membranes, which are now in common use, being reinforced and made with modified bitumen coatings. Although the modern reinforced bitumen membranes are now commonly used, the older, cheaper and poorer quality roofing felts continue to be available and can often be offered by some roofing contractors and builders in a bid to secure a project based on the cheapest price. Generally, it would be false economy to use traditional felts on anything other than temporary buildings or outbuildings.

The term "Built-up felt roofing", to which this document relates, refers to the formation of a waterproof system, constructed on top of the structural roof, by bonding two or more layers, typically three, commonly bedded with hot bitumen. Other forms of flat roof coverings, not covered by this paper, can include single ply membranes (one layer as opposed to several built-up layers), asphalt, liquid applied membranes and metal sheets, such as zinc, copper and lead as well as green roofs which comprise turf or planting on the upper surface. This briefing paper only considers the built-up systems using reinforced bitumen membranes.

The paper is intended for guidance to those building owners who may be considering replacing the built-up roof covering on an existing building. Flat roofing is a specialist trade involving the formation of complex junctions which are not covered in this paper. The paper is therefore intended not as a guide for work to be undertaken by inexperienced persons on a DIY basis, but as an information paper for those who are commissioning the work to be undertaken, in order that they may be better informed regarding the methods of construction and options available when considering quotations. A basic knowledge of which materials should be used and how they are laid should enable building owners to understand if the work on a roof is being carried out correctly.

2.0 Legislation

Planning permission is unlikely to be required for the re-covering of flat roofs unless the building is Listed.

Many building owners are unaware of the legal requirement under Part L of the Building Regulations to upgrade insulation when recovering roofs. In most cases these regulations will apply to church and community properties. There are some exceptions relating to places of worship, but these exceptions are limited and mainly related to historic properties. This matter is considered in more depth in Section 7.3 of this document.

Part B of the Building Regulations covers fire resistance of roofs and the spread of fire across their surface, the degree of fire resistance required being relevant to the distance of the roof from the boundary. The Regulations also cover the fire-resisting properties and spacing of roof lights. Fire resistance is considered in Section 9 of this document.

Health and safety is a major consideration when undertaking roofing work. The Health & Safety Executive report that about 20% of fatal falls in the construction industry are related to falls from or through roofs. The Work at Height Regulations 2005 (as amended) apply to roofing work, where a person could be injured falling from it. Sections of "fragile" surfaces, such as roof lights are also covered by the Regulations, as are the possibilities of items falling and causing injury. Typically scaffolding to prevent a person or items falling will be required, as well as covering-over or guarding of fragile sections of a roof, including fragile roof lights. Details of further guidance are given in Section 13.

3.0 How flat is a flat roof?

The formal definition of a flat roof is one whose surface is at 10 degrees or less to the horizontal, although in the building industry there is a tendency to call any roof with a membrane roof covering a flat roof. An angle of 10 degrees equates approximately to a fall of 1 in 5.7, which is fairly steep.

Nearly all manufacturers of roofing membranes recommend an absolute minimum fall of 1 in 80. All structural materials used to construct the roof will deflect to some degree and there will always be some tolerance or error in the physical construction. For this reason, the recommendation of the British Research Establishment, NHBC and other recognised authorities is to have a design fall of 1 in 40, to ensure that an absolute minimum fall of 1 in 80 is actually achieved.

Falls on existing flat roofs can easily be checked using a spirit level and tape measure. In a 1m horizontal run a flat roof should fall 25mm if it is at the design fall of 1 in 40, or it should fall 12.5mm if it is at the minimum fall of 1 in 80.

No roof should be so flat as to permit the ponding of water, although some ponding may be inevitable during heavy rainstorms. Falls should be towards the rainwater outlets or gutters provided. Standing water on flat roofs will trap silt and encourage vegetation. Ponding also causes local temperature differences in the waterproof layer, which accentuates stresses.

The degree of fall on a flat roof can often be underestimated. For example, for a roof 5m wide the fall should be 125mm at the design fall of 1 in 40, or 63mm at the minimum fall of 1 in 80.

The options on how the falls are formed to some degree depend upon the type of roof structure and the type of deck. These are covered in Section 6.1

If there are no falls, or there are insufficient falls, on a roof which is to be recovered, then one of the following options can be considered in order to provide or improve falls:

- If the roof deck is defective and needs to be replaced, additional firrings (strips of timber cut to a wedge shape) can be fitted to the roof structure before replacing the deck, to form or increase the fall. It is important that the firrings are installed so that they are aligned with, and are fully supported by, the roof joists and not at right angles to the joists. Firrings at right angles to the joists will inevitably be supported only at intervals of 400-600mm and may easily deflect and cause ponding in the roof deck.

- If the roof deck is sound and requires no replacement, insulation boards with a sloping upper surface can be laid on top of the deck to form a fall before replacing the roofing membrane.

4.0 Why do flat roofs fail?

In common with all parts of a building, flat roof coverings can fail prematurely if they are the subject of poor design, bad workmanship, or if incorrect or poor-quality materials are selected.

However, all flat roofs will, at some point, reach the end of their serviceable life. This is due to the surfacing materials no longer having the ability to cope with the stresses and strains to which they are subject on a regular basis.

The following are the most common causes of failure of flat roof coverings:

4.1 Movement and fatigue

All buildings constantly move under the effects of changing loads and temperatures and this will cause stress, and eventually fatigue, to any sheet material fastened or adhered to the structural elements. Typical circumstances will include:

- Thermal expansion and contraction of the sheet materials of a flat roof. These will be subject to considerable temperature differences such as cold frosty nights below freezing to hot summer afternoons with associated thermal contraction and expansion. If parts of the roof are in shade whilst others are in full sun a substantial temperature difference can occur. The continual expansion and contraction will eventually lead to fatigue.

- There can be considerable temperature difference between the top layer of a roof, which is at, or near to, the external temperature, which could be below freezing temperature during the winter, and the lower parts of the roof, which will be closer to the internal building temperature, particularly if there is little insulation. Top layers and bottom layers may be bonded together but will be subject to forces causing them to expand or contract at different rates, with consequential break down over a long period.

- Thermal expansion and contraction at the junctions of differing materials of the supporting structure, such as the junction between a timber roof deck and adjoining brickwork parapet, which would expand and contract at different rates. Any sheet material spanning such junctions will need to cope with the differential movement between the two elements, across which it spans. Movement around pipe penetrations and roof drainage outlets can also become the cause of fatigue.

- Movement of the structure due to pressures such as wind loads will also cause movement at structural joints, again affecting any sheet materials which span the junctions.

- Any roof deck, even concrete decks, will deflect slightly under load, such as extra snow loading and this is all part of the normal building design. The deflection will be more pronounced if the roof is under-designed e.g. timber joists of insufficient size being used so that they noticeably flex when the roof is walked on. When the roof deck deflects it puts strain on any sheet material which is fixed or bonded to the upper surface, as it is caused to stretch.

Differential movement, whether thermal or physical, will eventually cause bitumen sheet roof coverings to split, tear or crack. The rate at which this occurs will depend upon the properties of the materials used and their tolerance of such effects.

4.2 Degradation

When exposed to the weather, a bitumen surface is gradually attacked by ultraviolet solar radiation and by atmospheric contaminants or oxidation. The effects are significantly reduced, but not entirely removed, by the use of chippings bedded in bitumen, a mineral surfaced felt, or a solar reflective paint, all of which reflect sunlight to a greater or lesser extent.

The effects are that the membranes become increasingly brittle or crazed, leading to exposure of the bonding fibres and progressive attack of the bitumen underlying them.

In areas of high wind, or if chippings are not properly bedded in the bitumen, smaller grade chippings can be dispersed by the wind to expose the bitumen below, thus accelerating to process.

If solar reflective paints have been used, check the manufacturer's technical information. Some products only have a life-expectancy of 3 to 4 years before requiring re-coating.

4.3 Moisture Vapour

The principle of moisture vapour and condensation are quite simple: the higher the temperature of the air, the greater amount of moisture it can accommodate without condensation occurring. A heated room located below a flat roof will be able to accommodate a certain degree of moisture, due to the temperature of the room. As the air filters through the roof structure towards the outside surfaces of the roof it will cool. If it cools sufficiently it will lose the ability to retain all of the moisture and condensation occurs. The exact point at which the condensation occurs can be the subject of a complex calculation.

Often condensation will occur at the underside of a timber roof deck which, if the void is not ventilated, can eventually cause timber decay in the deck or the timber joists. In other cases, the condensation point could be somewhere between the layers of the roof construction, between the roof deck and the base membrane layer, or between the layers of the bitumen membrane finishes themselves. This is known as interstitial condensation. If condensation occurs between the base membrane and deck or between the membrane finishes it can cause loss of adhesion, in a similar manner to water penetration from above.

The method to prevent moisture vapour penetrating the roof is to either provide an effective vapour barrier or to ventilate the roof void. Most older roofs, particularly timber roofs with little or no insulation, will not include either of these measures.

The likelihood of moisture vapour being the main cause of failure of flat roof finishes sharply increases if the area below the flat roof is used for purposes with a high humidity content, such as showers, swimming pools etc. For other buildings, that would normally expect a low relative humidity such as places of worship, the failure of flat roof coverings is far more likely to be attributed to the other reasons listed in this section.

4.4 Loss of adhesion

Loss of adhesion can occur due to moisture vapour as described above but can also occur where the structure to which the membrane is bonded has been insufficiently prepared or if insufficient bitumen has been used. Typical failures include:

- Pulling away of the membrane from vertical surfaces, such as abutments with brick walls of parapets, due to poor preparation of the surface, or the surface becoming delaminated (e.g. perished brickwork).

- Pulling away from vertical surfaces due to excessive height of the surface.

- Lap joints between rolls of membrane

4.5 Physical damage

Physical damage to bitumen membranes can occur, even to newly laid and modern high-performance membranes. A visual check of flat roof membranes is recommended at least once a year and also after severe weather, such as storms.

Physical damage can typically be caused by:

- Wind uplift in storms.

- Damage from falling branches and the like.

- Damage from walking on the surface, usually arising from maintenance, window cleaning etc.

At the time of inspection, opportunity can also be taken to check the roof is free from debris and vegetation and that all rainwater outlets and gutters are unobstructed and running freely. Many proprietary flat roof outlets have a funnel shape and integrated leaf guard, both of which reduce the risk of blockage. Where these are lacking, rainwater outlets are not only more likely to become blocked by leaves but, if in an area where children may play, by tennis or other similar sized balls.

5.0 Grades of roofing felt

The older type felts were far less able to accommodate the stresses and strains summarised in the preceding section, and so failed earlier. However, the newer high-performance felts have been developed to better accommodate them and so have a greater life-expectancy.

5.1 Older grades of bitumen felt: British Standard 747

Roofing felt comprising a mat of organic or inorganic fibres impregnated and usually coated with bitumen was covered by British Standard 747: 1968 and was classified as follows:

TYPE 1: FIBRE BASE
Early felts were based wholly on organic fibres. These were very strong when new, but dimensionally unstable and could rot when moisture eventually penetrated the bitumen coating, leading to early failure.

TYPE 2: ASBESTOS BASE
Asbestos-based felts contained up to 20% organic fibre but were more stable.

TYPE 3: GLASS FIBRE BASE
Bitumen felt based on glass fibre was also introduced. This is more stable and rot-proof, but because the fibre is bonded to the felt, rather than woven, it does not provide very high strength.

None of these types of felt can be stretched more than about 2% to 5% before splitting. Their ability to cope with the constant expansion and contraction and physical movement of the building, is therefore limited. Typically, they are guaranteed for 5 years and have a life-expectancy of 10 years.

The 1994 revision of BS 747 included only two types of felt: Type 3 as above and Type 5.

TYPE 5: POLYESTER BASE
Polyester felts were originally made with oxidised bitumen coatings, but later more commonly with modified bitumen coatings. The addition of a polymer to the bitumen improves its properties as a roofing material in almost every respect; in particular the flexibility, strength and fatigue resistance. Type 5 felts would therefore have a greater life expectancy of 15 to 30 years.

In addition to the BS types listed above, the classes are further divided by a letter to denote the type of finish applied to the top surface. (e.g. Type 3B is sand finished and Type 3E is mineral finished).

British Standard 747, to which these felts were manufactured, was withdrawn in 2007. However, some of the traditional felts remain available on the market and are still offered by builders to give the lowest price possible for a job. This is a false economy and their use is not generally recommended. Reputable manufacturers who still produce the traditional felts will only recommend them for sheds, garden buildings and non-habitable buildings.

5.2 Current grades of reinforced bitumen membranes: British Standard 8747:2007

When BS747 covering bitumen felts was withdrawn in 2007 it was replaced with BS 8747:2007 Reinforced Bitumen Membranes for Roofing. This is the current standard which covers membranes with modified bitumens.

Modified bitumens have a fatigue resistance of around 20 times better than the older Type 5 polyester based felts of BS 747, giving much improved performance and durability. The most commonly used modifying additives are styrene butadiene styrene (known as SBS) and atactic polypropylene (known as APP).

In common with the older BS747 felts, a polyester reinforcement base is significantly better than a glass fibre reinforcement base. However, the use of a polymer modification, particularly SBS, improves the physical performance of the membrane when compared to the oxidised bitumen used in the BS747 felts.

APP polymer modification gives a high melting point for the bitumen, which particularly lends itself to membranes applied by the torch-on process as described below, as well as improving flexibility at low temperatures. However, SBS modified bitumen can also be used for the torch-on process, possibly with a slightly shorter life-expectancy.

Direct comparison between the modified bitumen membranes can be difficult, but it is worth comparing manufacturers' technical information for the product proposed, together with any independent test results. The major manufacturers will usually give a guarantee for the serviceable life of the product, which means the life expectancy can be considerably longer than the guaranteed period.

Typical guarantees for SBS and APP products with a polyester membrane are 10 years, with a life expectancy of 20 years. High performance SBS products using an elastomeric membrane are claimed to give a life expectancy greater than 20 years.

5.3 Methods of application

There are two principal methods of laying bitumen reinforced membranes; the pour and roll method and the torch-on method. There is a third method using self-adhesive membranes, where a sheet is peeled back to expose a self-adhesive bitumen surface, but these are generally not used by professional tradespersons and can generally be regarded as a DIY product.

Pour and roll membranes and torch-on membranes are both manufactured with a selection of base layers or membranes which affect their performance.

POUR AND ROLL MEMBRANES

The pour and roll method involves the pouring of hot bitumen in front of the membrane as it is unrolled so that the hot bitumen forms the adhesive. It is the more conventional or traditional method. The solid blocks of bitumen are melted and then transferred to a kettle, similar in characteristics to a watering can, and poured onto the roof in front of the roll to be laid. Apart from the process of heating the bitumen to a molten state, the process involves transporting hot bitumen up to the roof surface and ensuring that any surplus hot liquids do not leak or splash on areas below.

TORCH–ON MEMBRANES

Torch-on membranes use bitumen modified with SBS or APP, which restrict the melting range, previously applied as a coating to the underside of the roll. When torch-heated this provides a continuous small amount of molten bitumen on the front of the roll as it is unrolled. The process of heating and transporting hot bitumen to the roof is eliminated, but there is a greater risk of fire if the naked flame of the torch needs to work in close vicinity of combustible materials, including the building fabric or structure. The use of hot-air guns as an alternative has been developed, but these introduce the hazard of the heat source not being visible when operating.

Torch-on membranes are particularly appropriate when the section of roofing to be laid is in small quantities, or where access and site facilities are limited in accommodating space for heating the bitumen.

6.0 The roof structure and roof deck

6.1 Types of roof structure and deck

The large majority of felt roof structures for domestic properties or small community buildings will be formed with timber joists as the principal structure with a decking of timber boards, plywood, chipboard or woodwool slabs. Some small community buildings may have a flat roof formed in concrete, although this is not so common for small buildings.

Larger commercial buildings may have flat roofs formed on a steel structure or with steel profiled sheet deck, which are not covered by this document.

TIMBER DECK

This is the most common type of deck for older properties; typically formed from timber approx. 19-22mm thick, usually with tongued and grooved joints, but sometimes with plain edges butted.

PLYWOOD DECK

Plywood decks should be 15-18mm thickness, depending upon joist spacing, and be weather and boil-proof glued (WBP) grade or marine plywood.

CHIPBOARD OR FLAXBOARD DECK

Although they may have been used historically as an economy measure, chipboard or flaxboard are not desirable decks. If water or condensation penetrates, they will rapidly disintegrate and their structural capacity to support the flat roof covering will be irrecoverably lost. Rapid expansion, due to moisture will also cause roof coverings to delaminate from their surface. Chipboard or flaxboard decks are not recommended for new roof structures or repairs/replacements.

WOOD WOOL SLABS

Wood wool slabs used for flat roof decking will typically be 50-75mm thick. In their time they were commonly used as a deck which offered greater thermal resistance to heat loss than the conventional, much thinner, timber decking. They appear as a compressed straw board when viewed from the underside. The upper side may have been unfinished ready for felt coverings, but often could also include a pre-screeded version with a screed or slurry applied to the upper surface. Slabs could include steel channels at the edges which enabled them to span longer distances between joists or supports than could be achieved by timber or plywood decks. They are, however, less flexible than timber or plywood and so more susceptible to impact damage and less likely to flex under excessive load.

As for plywood, wood wool slabs can rapidly disintegrate once water penetration sets in, causing lack of support to the roof finish and a health and safety issue to persons accessing the roof for maintenance purposes.

6.2 Repairs or replacement

If water penetration has occurred from a failed roof, it is important that the structure is allowed to fully dry out before replacing roof coverings; otherwise loss of adhesion may occur due to dampness or the build-up of water vapour.

In the case of timber roof decks and timber joists, a check should be made for the effects of wet rot and dry rot and appropriate replacements undertaken. Although not associated with roof leaks, opportunity should be taken to check for timber infestation and appropriate replacements undertaken. In replacement work, the use of pre-treated timbers is highly recommended, with particular emphasis on the on-site treatment of any cut joints or exposed end grain.

If sections of deeper profile decks, such as wood wool slabs, are to be replaced, this may be a problem. Wood wool slabs are not so readily available as they were at their time of installation. One consideration could be to use a thinner deck, such as plywood, with packers below the deck, or additional insulation above the deck, to make up the total thickness to be replaced.

7.0 Thermal Insulation

7.1 Types of flat roof construction

As detailed below, there are three recognised categories of construction for flat roofs, depending upon the positioning of the waterproof layer and the insulation. Appendix A provides diagrams which illustrate the three roof types:

COLD ROOF

In a cold roof, the roof deck is positioned on the COLD SIDE of the insulation. The majority of older roofs will be of this construction. The deck is placed on top of the load-bearing structure, usually timber joists, with the waterproofing layers placed on top. The insulation, if any is installed, is positioned below the deck, usually in the form of glass fibre quilt, between the joists and over a plasterboard ceiling. In this type of roof, it is recommended that ventilation should be installed between the joists and above the insulation to reduce the risks of condensation occurring on the underside of the deck. In many older roofs no ventilation is present, but this is now a requirement under current Building Regulations. However, it is often found that the limited depth of the roof space or the presence of internal bracing or adjacent walls can make it difficult or impossible to achieve adequate cross ventilation in practice.

WARM ROOF
In a warm roof, the roof deck is positioned on the WARM SIDE of the insulation. The deck is fixed to the top of the joists, but the insulation is placed on top of the deck, rather than between the joists. The waterproofing layers are then placed on top of the insulation. As the deck is on the warm side of the insulation, condensation is unlikely to occur on the underside of the deck and so this form of construction has the distinct advantage of not requiring ventilation between the joists. The warm roof is now the most common form of constructing a flat roof

INVERTED WARM ROOF
Also known as "the upside-down roof". This has the same advantages as a warm roof, not requiring ventilation, but instead of the insulation being placed on top of the deck and then covered with the waterproof layer, the waterproof layer is first placed on top of the deck with the insulation placed on top. In order to retain the relatively light-weight insulation in place it is covered by gravel or stones, typically 40 to 50mm deep, or paving slabs. The claimed advantage is that the waterproof layer is more protected from the effects of the sun and physical damage by the gravel layer. The disadvantage is that the top layer of gravel can cause a build-up of debris and vegetation. Also, the sole means of holding down the insulation is the weight of the gravel, which can be questionable in areas subject to storms or high winds. An additional disadvantage is the extra weight of the gravel or paving slabs, which needs to be taken into account when calculating joist sizes. For this reason, inverted roofs are usually employed on concrete roofs, which may more readily accommodate the extra weight, rather than timber roofs.

7.2 Materials for insulation

There are many types of insulation which can be used in roof insulation, the most commonly known being glass fibre, ranging to the more unusual insulants such as sheep's wool or vermiculite. In order to achieve the same thermal resistance of a roof, the thickness of insulation required will vary depending upon the thermal properties of the insulation.

The actual thermal calculation for each project is complex and will depend upon the manufacturer and exact grade of insulant, joist spacing and sizes, type of roof deck etc, but the following may serve as a general indication:

In order to achieve the minimum thermal u-value of 1.8W/m2.K required under Building Regulations for the flat roof for a place of worship, glass mineral wool fitted between joist will need to be in the order of 270mm deep with at least 50mm ventilation space between the top of the insulation and the underside of the deck. Foamed plastics, such as extruded polystyrene will need to be in the order of 120mm thick, placed on top of the deck.

There are many types of foamed plastic insulants available on the market and these are being continually developed. These can include expanded polystyrene, extruded polystyrene, polyurethane, phenolic foam and others. Each type has unique thermal properties and so the thickness required will depend upon the exact type proposed.

7.3 Building Regulations requiring insulation to be upgraded

Under Part L of the Building Regulations a flat roof is classed as a thermal element and the renovation or refurbishment of a thermal element, which specifically includes replacing waterproof membranes on a flat roof, is subject to Part L of the Building Regulations.

The Regulations require that the thermal properties of the roof are improved as part of the refurbishment. In the case of a flat roof the standard required is 0.18W/m2K, which, for churches, is the same standard required for a new flat roof, which can be a substantial upgrade in insulation.
(Building Regulations Document L2B, Section 4, paragraph 4.7)

This requirement only applies if the refurbishment is more than 50% of the element, in this case the roof, or more than 25% of the whole building envelope. However, if a roof is to be recovered it is likely that the decision will be to recover the whole roof and not just part, so the regulation will apply.

There are some concessions: If it is not technically feasible to carry out the upgrade, it may not be required. If the payback period for the upgrade would exceed 15 years, the degree of upgrade can be limited to an upgrade which could be paid back within 15 years. e.g. the full upgrade to the standard stated could require 130mm of insulation, but the payback over 15 years may only require 75mm. The payback period is calculated by comparing the cost of the work compared to the energy savings that would be made over 15 years. (Building Regulations Document L2A, Section 5, paragraph 5.10) Although this sounds simple, it needs the cost of the works to be known before the design can be completed and requires comparative thermal performance of the building, both before and after the work, to be undertaken.

In cases where there is a valid concession as above, the element should be upgraded to the best performing u-value possible that is technically and functionally feasible and can achieve a simple payback not exceeding 15 years.

Section 3 of Document L2B lists some buildings which may be exempt from the requirements. Paragraph 3.5 includes "listed buildings" and "places which are used primarily or solely as places of worship" are, with some other buildings, exempt from the regulation. Paragraph 3.6 lists buildings which, although not exempt, may have special considerations. These again include "places which are used primarily or solely as places of worship" and "historic buildings".

The key matter here is the definition of "primarily or solely" when referring to places of worship. Paragraph 3.14 expands upon the definition of places of worship which is taken to mean buildings, or parts of buildings, used for formal worship, but excludes other parts of the buildings designed to be used separately, including offices, catering facilities, day centres and meeting halls. It therefore follows that a historic, very traditional, church or main chapel may be exempt or enjoy special consideration, but with the growing tendency to use church buildings for other activities, such as children's clubs, mother and toddler groups and similar community-based activities would render those sections as non-exempt. Where there is only one area, used for both worship and activity groups, some building control bodies have refused to concede exemption on the basis that the area is not solely for worship activities. In all but a few exceptions, it is likely that most modern places of worship will find themselves subject to the regulations to upgrade insulation when re-covering flat roofs.

Even if a building was to be judged exempt, or subject to the 15-year limitation, those managing the building may wish to seriously consider providing insulation voluntarily as this has the advantage of lower heating costs and renders the building less prone to condensation and mould.

Similarly, and also under Part L, improvements in thermal insulation will usually be required where the building is subject to a material change of use. e.g. from a store or warehouse to a place of worship, or where a building was previously unheated, and it is now proposed to heat it.

7.4 Typical methods of up-grading insulation

In the majority of cases where a flat roof requires refurbishment there will be little or no existing insulation. If there is any insulation it is most likely to be in the form of glass or rock fibre between the timber joists (cold roof) rather than insulation above the deck (warm roof). The following are the most common methods of upgrading the insulation. It is recommended that advice is sought from the Building Regulations body, ahead of any works remedial works to ensure that what is being proposed will align with the current Building Regulations.

INSULATION BETWEEN THE JOISTS (cold roof construction)

Upgrading any insulation between the joist will reply upon the ceiling below the joists being totally removed and replaced. This is an option is the ceiling is to be removed for other purposes, such as rewiring, but otherwise is somewhat impractical and expensive as this would also involve removing light fittings etc.

As described in the details of a cold roof, see section 7.1 above, it is necessary to maintain a void of 50mm between the insulation and the underside of the deck, so this will limit the depth of insulation which can be placed between the joists. If there is no ventilation above the insulation, then increasing the insulation will increase the risk of condensation forming underneath the deck and so cross ventilation should be introduced. Compared to the alternatives below, extra insulation between the joists is probably the option which will appeal the least.

INSULATION BELOW THE CEILING (cold roof construction)

An alternative to replacing insulation between the joists is to retain any existing insulation between the joists and provide additional insulation below the existing ceiling. This saves the work of removing the old ceiling, although light fittings etc would still need to be removed and replaced.

The most practical method is to use a plasterboard ready-laminated to a foamed plastic. These are known as laminated thermal boards and come with a selection of thicknesses of insulation typically from about 12mm to 90mm, bonded to plasterboard. Some insulants have better thermal insulating properties than others and so require less thickness to achieve the same level of insulation. The use of thermal laminate boards with, say, 75mm of insulation would be practical to fit, and they would improve the thermal properties of the roof.

However beyond around 75mm thick, it becomes impractical to nail the plasterboard through the insulation to the underside of the joist. If the target was to bring the roof up to the current building regulations standard for insulation of a flat roof (0.18W/m2 deg C) would typically need to be:

- Expanded polystyrene 200mm
- Extruded Polystyrene 150mm
- Phenolic Foam 100mm

Thermal laminate boards on their own are therefore not likely to be the solution if the target is to raise the insulation level to the current standards, rather than simply improve it.

As placing the insulation below the ceiling still produces a “cold roof” it is still necessary to consider the level of ventilation between the joists.

INSULATION ABOVE THE ROOF DECK (warm roof construction)

If the flat roof coverings are to be replaced this is likely to be the most efficient and cost-effective means of improving the insulation. With the warm roof construction there is no need to ventilate the roof structure and no need to take down internal ceilings. In addition to the costs for the labour and materials to supply and lay the roof membranes, the main additional cost is the purchase of the insulation itself plus a small amount of additional labour to lay it. However, there may be some other alterations required, especially at perimeters such as fascia boards, gutters etc, which will have to be adjusted to suit the increased depth of the roof construction where the top of the roof will rise in depth according to the depth of insulation installed. There will also be alterations required to triangular fillets at upstands and abutments and probably extra timber blocks to perimeters to match the depth of the insulation.

As for the insulation fitted below the ceiling, there are many types of insulation available with differing thermal properties, which need to be evaluated. For example: 100mm of one type of insulation may not be necessarily better than 75mm of another type. The most common types of insulation to be used above the roof deck are foamed plastics, but rock mineral insulation is also available. If the target was to bring the roof up to the current building regulations standard for insulation of a flat roof (0.18W/m2 deg C) would typically need to be:

- High performance rigid thermoset PIR foamed plastic 120mm
- Rock fibre slabs 200mm

The insulation should specifically be manufactured for use below built-up bitumen membranes, as the surface treatment or coating will need to be able to withstand the hot bitumen or torch method of application. Technical information should be checked to ensure it is suitable for the application method proposed i.e. roll and pour or torch-on method.

When placing insulation on top of a flat roof, consideration will need to be given to any equipment fitted to the top of the roof, such as air conditioning units etc, as fixing the equipment down to the top insulation layer will be impractical.

Adding insulation or thermal laminate boards to any roof structure will add weight to the roof to some degree. The additional weight of foamed plastic insulation is likely to be negligible. If thermal laminate boards are applied under an existing plasterboard ceiling then, in addition to the insulation, there will be the weight of an extra layer of plasterboard. Consideration needs to be given to the ability of the roof structure to bear the additional weight of any proposed upgrading of insulation.

The formation of an "inverted roof" system on top of an existing flat roof would result in a substantial increase in weight, due to the 50mm of gravel or paving slabs on top of the insulation. For this reason, in is likely to be impractical in most cases.

8.0 The build-up of roof coverings

Detailed instructions of how to form edge details, upstands, drips etc are not dealt with in this document, but should be familiar to all competent contractors. When laying bitumen membranes, side laps of not less than 50mm should be formed between rolls of felt and head laps of not less than 75mm, although some manufacturers of torch-on systems recommend increased laps.

In a three-layer system, the second and third layers should each be offset from the layer below by one-third of the width of a roll and head laps also offset. This avoids joints being directly on top of joints in the layer below and the associated excessive build-up in depth of material.

8.1 The vapour control layer

The problems with condensation and the need for vapour barriers is outlined in section 4.3 The position of the vapour layer, relative to the other roof components, will depend upon the type of flat roof, as described in Section 7 and in particular the position of the insulation. To serve its purpose, the vapour control layer needs to be located on the warm side of the insulation.

For cold roofs, where the insulation is at ceiling level the required position for the vapour barrier is at ceiling level by fitting this below the roof joists. It is, however, almost impossible to create a fully effective barrier here due to penetrations through the ceiling by cables, light fittings etc. Some precautions can be made by attempting to tape joints around cable penetrations etc, but prevention of condensation is largely dealt with by ventilating between the top of the insulation and the underside of the deck.

For warm roofs, where the insulation is placed on top of the deck, the vapour barrier is usually placed on top of the deck, prior to laying the insulation. This prevents moisture entering the layers of built-up membranes. It is important that, being below the insulation, the barrier is taken up at all perimeters to lap with the waterproof membrane on top of the insulation, and also that all penetrations around pipes etc, are taped or sealed to prevent moisture escaping around the side of the barrier and that the barrier is lapped horizontally at joints.

There are many different proprietary products used as vapour barriers. Some, particularly those which sandwich a metal or foil layer within them, are better at controlling moisture than others. Most reputable manufacturers of the bitumen membranes recommend particular vapour barriers or manufacture them themselves, so it best to follow the advice of the manufacturer.

For inverted warm roofs, where the insulation is on top of the waterproof membrane and covered by gravel or slabs, there is no need for a vapour control layer, as the waterproof membrane serves the same purpose.

8.2 The base layer

The base layer is the first layer down as part of the waterproofing system and will be fitted either to the deck or the insulation depending upon whether the construction is a cold roof, warm roof or inverted warm roof.

The surface to which the base layer is fitted must be clean and dry and any necessary preparation must be undertaken before commencing laying. Any projecting nails should be well punched below the surface. The membrane manufacturer's recommendation for priming surfaces, including upstands, roof outlets etc should be adhered to. Joints in the boards of decks such as plywood and wood wool slabs should have the joints taped with a recommended taping strip, prior to laying the base layer and the whole of the prepared surface primed with a recommended primer.

In a cold roof or an inverted warm roof, the base layer will be fixed to the deck and the type of deck will dictate the type of base layer used and how it is fixed.

- For tongued and grooved timber decks the traditional method of fixing is by nailing a continuous base layer with clout nails at approximately 150mm centres in both directions, rather than laying in hot bitumen. This method of fixing is particularly useful when the boards are plain edges, rather than tongued and grooved, as plain edge boards can permit hot bitumen to seep between the board joints.

- For other types of deck, including wood wool slabs, plywood or screeded concrete, fixing by nailing is not appropriate as the materials do not readily retain nail fixings. In these cases, the norm is that the first layer is perforated (Typically circular holes punched out of the membrane). The membrane is loose laid over the base, including lapping and the securing is achieved by the next layer being laid in hot bitumen which passes through the perforations and attaches to the substrate. This is known as partial bonding. The perforated base layer is usually a type 3G glass fibre-based layer, even if high performance SBS or APP bitumen modified membranes are used for the main upper layers.

In a warm roof construction, the base layer will be laid directly onto the insulation and so, again, fixing of the base layer by nailing is not practical and fixing is usually as follows:

- For laying on Rigid Urethane Foam (RUF) boards, Polyurethane (PU) boards, Polyisocyanurate (PIR) boards, and Phenolic boards, a partial bonding using a perforated membrane as described above is used.

- For compressed cork, rock fibre, glass fibre, perlite or composite products, the base layer is fully bonded in hot bitumen.

8.3 Interim layers

Interim layers are fully bonded by the pour and roll method or torch-on method.

8.4 The capping layer

The uppermost layer is again fully bonded by the pour and roll method or torch-on method. As normal bitumen sheets will degrade due to UV light, or the thermal expansion and contraction due to exposure to the sunlight, they need to be protected from the solar rays. This is usually achieved by one of the following methods:

- 12.5mm white spar chippings bedded in bitumen.

- Solar reflective paint (This can have a much shorter life-expectancy before requiring re-coating)

- Mineral surfaced felt, or other "capping layer" usually green but also available in other colours.

On vertical or other inclined exposed surfaces such as upstands against adjoining walls, kerbs to roof lights, felt dressed into eaves at gutters etc, it is not practical to attach the stone chippings and one of the other types of protection is used.

The choice between stone chippings or a capping layer/reflective paint can be affected by the fire resistance below, as outlined in the next section, or the need for access onto the roof. Regular access onto a roof covered in stone chippings can cause the chippings to become dislodged, with dislodged chipping being trodden into the upper surface of the membrane and puncturing it. If the roof is regularly to be used for access, such as for cleaning of windows, a capping sheet may be more appropriate.

9.0 Fire resistance of roofs

The requirement for fire resistance in roofs is covered by Part B of the Building Regulations in order to limit fire spread across the building boundary as well as across the roof surface. The closer the roof is to the boundary, the greater the fire resistance required.

The fire resistance of roofs has two classification letters. The first letter (A to D) relates to the resistance to fire penetration from above. The second letter (A to D) is relative to the spread of fire spread across the surface. In both cases A is the best grade and D is the worst. A roof classification AA has a resistance to fire penetration of one hour or more and no spread of flame.

Table 16 of the Regulations lists the classification of the roof and the minimum distance required to the boundary from the roof. For a roof to be within 6m of the boundary it has to be one of the better classes, AA, AB or AC, to BS476. Bitumen felt roofs are classed as having the best rating of class AA, which means there is no restriction on their proximity to the boundary if they:

- Are on a deck on 6mm plywood, 12.5mm chipboard, 16mm plain edge boards, wood wool slabs, fibre reinforced cement, steel deck, profiled aluminium deck, concrete or clay pot;

AND MUST BE COVERED IN:

- 12.5mm stone chippings, non-combustible tiles bedded in bitumen, sand and cement screed or macadam.

Most flat roofs on church buildings will be on one of the acceptable decks listed above, but not all roofs will have the stone chippings. If the stone chippings are not used, then the roof cannot be within 6m of the boundary. However, some companies have developed a cap sheet, to be used in place of stone chippings which has been tested and certified to be class AA rating.

If your roof is within 6m of the boundary, it must therefore be on one of the approved decks and have either 12.5mm stone chippings or a cap sheet which has a certificate for class AA rating.

10.0 Roof lights

Roof lights are covered by Part L of the Building Regulations regarding their thermal properties and Part B with regard to fire resistance and fire spread.

If the roof lights exist already, then neither of these issues are likely to come into play although, if upgrading the roof insulation, it may be worth considering voluntarily upgrading the roof lights to reduce heat loss.

If any existing roof lights are replaced, or if the opportunity is being taken to install extra rooflights, then they will be required to meet the thermal values laid down in the regulations which will usually involve double or triple glazing. With regard to fire spread some types of plastic roof lights are subject to regulations regarding the minimum distances between roof lights in a flat roof.

11.0 Flashings and trims

Flashings, such as lead flashings and metal/grp edge trims to roofing felt can often be reused, not needing replacement, subject to checking their condition. Ensure that any pointing over and around lead flashings is in good order.

However, flashings and trims will usually require repositioning, and possible replacement, where new insulation is placed on top of the deck, thus raising the level of the finished roof.

12.0 Asbestos in old roof coverings

Asbestos was used in buildings from about 1890 until blue/brown asbestos was banned by law in the UK in 1985 and white asbestos in 1999. They were most extensively used between about 1950 and 1980.

The older Type 2 felts under BS747 specifically were asbestos based. Those who manage buildings are required to have an asbestos management plan in place. (Please refer to the CGT Briefing Paper “Managing Asbestos in Church Buildings”). Consult your own asbestos register before commencing removal of felt roof coverings, which may require specialist action.

Professional advice should be sought in connection with any work involving materials known or suspected to contain asbestos.

13.0 Additional information

- Specification and Warranties
  Some of the major manufacturers of bitumen reinforced membranes, such as Polyglass, will offer a specification service for specific projects and give a material guarantee for their products. With some manufacturers, by using one of their approved contractors a warranty to cover workmanship can also be obtained.

  Polyglass (GB) Ltd, Unit 1, Electum Point, Ashmore Lake Way, Willenhall, West Midlands WV12 4HD. Tel: 01902 637 422 www.polyglass.com

  It is a common condition of such warranties that the completed work is to be inspected annually by the manufacturer’s representative or authorised installer and, in addition, that any attempt at repairing a defect other than by an authorised installer will invalidate the warranty. So, please read any documentation carefully and ensure that it is made available to all who may be responsible for maintenance of your premises.

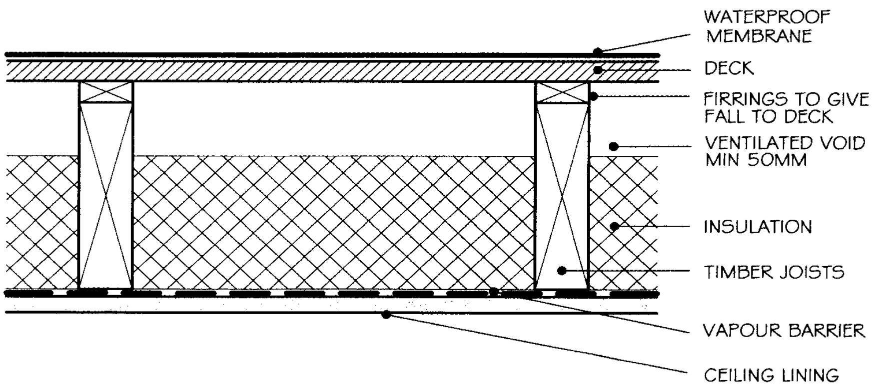
- British Standard 8747:2007 “Reinforced Bitumen Membranes for Roofing – Guide to Selection and Specification”

- BRE Digest 419 “Flat roof design: bituminous waterproof membranes” Oct 1996
  HIS BRE Press, Willoughby Rd, Bracknell, RG12 8FB. Tel: 01344 328 038 www.brebookshop.com

- Health and Safety Executive guidance document INDG401 “The Work at Height Regulations 2005 (as amended): A brief guide” www.hse.gov.uk

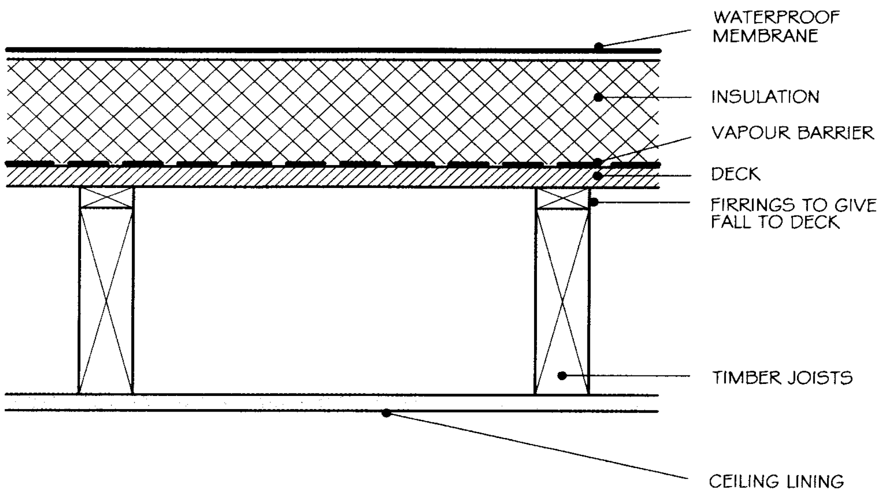
- Health and Safety Executive guidance document “Fragile Roofs: Safe working practices” www.hse.gov.uk

APPENDIX A – Types of flat roof



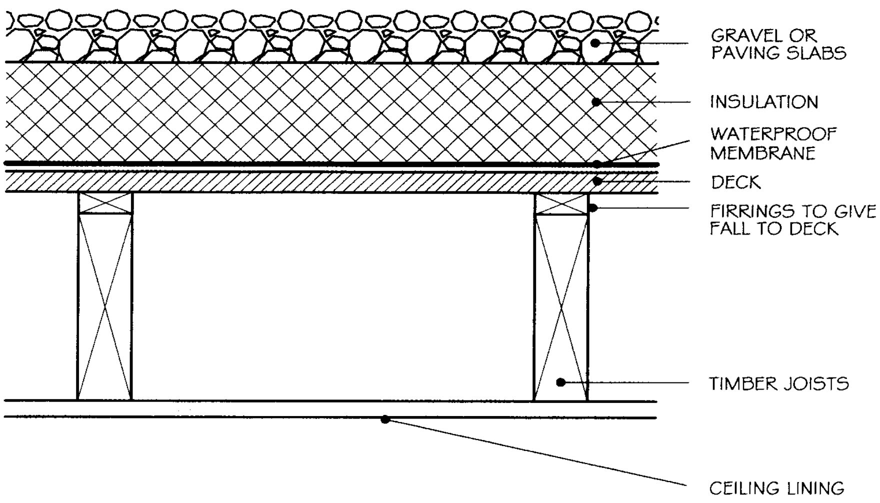
COLD ROOF

Deck on the cold side of the insulation.



WARM ROOF

Deck on the warm side of the insulation.



INVERTED WARM ROOF

Deck on the cold side of the insulation. Waterproof membrane protected by gravel or slabs above