CPD Article

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Title

Specifying a Flat Roof with PIR Insulation

Introduction

A warm flat roof represents one of the simplest forms of construction – and therefore one of the best ways of achieving the fabric first principle. A build-up of structural deck, vapour control layer, PIR (polyisocyanurate) insulation and waterproofing offers reliable performance for the lifetime of the waterproofing membrane.

Unfortunately, on site constraints, particularly in existing buildings, or confusion over what the layers in that build-up do, can lead to compromises in a roof's design and construction. These compromises can store up problems that may not be seen for several decades, but which can lead to worse-than-expected levels of thermal performance or a shortening of the roof's active life.

Nor is it uncommon for a disconnect to occur between the designer/specifier and the roofing contractor who has "built roofs like this for years". As an insulation manufacturer, Recticel Insulation is often asked to comment on the work of a contractor that has not met an architect's design or does not accord with current accepted flat roofing practice.

By offering this CPD Article, we aim to demystify some common issues surrounding flat roofs, drawing on our specialism in producing flat roof insulation and the experience of our sister company, Gradient Insulation.

Key Learning Outcomes

- Choosing PIR (polyisocyanurate) insulation boards for different waterproofing
- Requirements/products characteristics of flat roof PIR insulation
- Fixing methods for different flat roof build ups.
- Condensation risk in flat roofs.
- Understanding vapour control layers
- The dangers of hybrid roof constructions.

"Bite 1"
Specification Basics

Unless specifying a system, where the waterproofing manufacturer offers the insulation with their vapour control layer and roof finish, the choice of insulation board is dictated by the preferred waterproofing. Rigid PIR foam boards for flat roofs typically fall into two categories: foil faced and tissue faced boards.

Insulation board types
Foil faced boards are mainly used for mechanically fixed single ply membranes. They do not rely on adhesion of the waterproofing to the insulation board, and the foil facing helps the insulation to achieve the best possible thermal performance.

(Sometimes foil faced boards are used with liquid waterproofing systems, but these are tested systems with manufacturer approval).

Tissue faced boards can be divided into a further two categories. A mineral-coated glass tissue or fleece facing is usually offered for adhered single ply membranes and traditional techniques such as pour and roll, built up felt and mastic asphalt.

Bitumen fleece facings are most commonly offered for torch-on felt applications. There can be overlap with the applications of a tissue faced board, however, so you should always check with your preferred manufacturer.

Other insulation properties
Tissue faced boards are primarily used for flat roofing. Foil faced boards, by contrast, are used throughout other construction elements and often feature similar performance characteristics. It is not uncommon, for example, for them to be offered in similar dimensions and with an identical thermal performance for applications like floors and walls.

So what differentiates a foil faced board for flat roofing from other foil faced boards?

For a start, it will likely have an Agrément certificate – provided by the British Board of Agrément (BBA) or similar certifying body – to demonstrate its fitness for purpose as a flat roofing product. This will include a specific suite of tests related to flat roofing such as wind uplift, stability, and the fire performance of the roof build up.

The other principle performance criterion to look for is a compressive strength of at least 150kPa. This compares to typical performance declarations of 140kPa or 120kPa for PIR boards in other applications such as pitched roofs or cavity walls. The increased compressive strength offers greater robustness when contractors are working on the insulation to install the waterproofing over, and also gives enough loadbearing to take the weight of some roof plant.

Image1

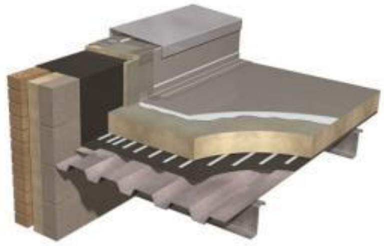

Image1 caption

Illustration of a typical warm flat roof construction, featuring tissue faced PIR insulation boards on a steel structural deck.

"Bite 2"

Fixing Flat Roof Systems

The type of insulation board is influenced by the choice of waterproofing, and to some extent so is the method of fixing the specified build-up.

Mechanical fixing

For mechanically fixed waterproofing membranes, the fixing of the insulation will also be mechanical. A minimum number of fixings are required to secure the insulation board, depending on the size of the board in question. For example, a 2400x1200mm board requires at least six fixings.

This minimum is to secure the insulation to the deck, and does not override the membrane manufacturer's requirements or the requirement calculated in accordance with national standards to resist wind uplift. The number of fixings varies subject to location, topography, and the building's height. Typically, more fixings are required at roof edges and corners.

Ideally, mechanical fixings should be 'thermally broken', comprising a plastic tube with integral washer head. The metal screw sits in the tube, penetrating only the bottom 20mm or so of the insulation layer. This eliminates the thermal bridging effect of screws fixed through the whole insulation layer, where an increased insulation thickness is likely to be necessary to achieve the same U-value.

Tissue faced boards may also be mechanically fixed, but are typically suited to adhered build ups.

Adhesive fixing

Adhesives must be compatible with the chosen insulation and waterproofing, used correctly to ensure the necessary resistance to wind uplift, and supplemented with mechanical fixings if necessary (for example, if there is any doubt about the adhesive application, or if laps in the waterproofing membrane require additional restraint).

For PIR insulation, adhesives are usually polyurethane (PU) based in order to obtain the best bond strength. Solvent based contact adhesives are generally not recommended – if they get in the board joints they can attack the foam and cause collapse. However, contact adhesive may be used in manufacturer approved, tested systems. They must be applied in strict accordance with the instructions supplied.

Other fixing types

PIR insulation boards and waterproofing may also be secured with ballast, though this is comparatively uncommon (particularly as PIR is unsuitable for inverted roof constructions). The ballast needs to be installed straight after the insulation and waterproofing have been loose laid, and requires a minimum dry weight of 80 kg/m^2, with additional weight determined by wind uplift calculation.

Some mechanical restraint may still be required, and the selected waterproofing needs to be compatible with this installation method.

Image 2

Image 2 caption

PIR insulation boards with a bitumen fleece facing, installed ready to receive adhesive and a bonded waterproofing membrane.

"Bite 3"

Flat Roof Design and Condensation Risk

This CPD article concentrates on warm roof construction, where insulation is placed above the timber, metal or concrete deck and maintains the structure at a similar temperature to the internal environment. A warm roof is the accepted ideal for a flat roof, and the reason for a shift away from traditional cold roof designs.

What is a cold roof?

In a cold roof, insulation is installed below the waterproofed deck. To ensure the performance of the roof, a ventilated airspace is required between the insulation and the waterproofed deck. In a timber construction, the insulation is friction fitted between joists and the thickness of the product is tailored to leave the necessary air gap.

Metal and concrete decks do not offer this flexibility, but retrofit projects can occasionally result in suggestions of insulation being fixed to the underside. The suggestion is made without considering ventilation, which is difficult to provide and makes fixing the insulation a tricky proposition. Even in a timber cold roof construction, the correct level of ventilation can be difficult to ensure.

Ventilation is required to carry moisture vapour out of the structure to the external air. If the ventilation is inadequate and moisture accumulates on the underside of the deck, structural defects become likely over an extended period. For this reason, cold roofs are increasingly unpopular or a last resort, and are discouraged entirely in Scotland.

Why does condensation occur?
At any given temperature, air is capable of holding a certain quantity of moisture. If the air temperature drops – for example, by coming into contact with a cold surface – the air will no longer be able to hold the same quantity of moisture and will deposit what it can no longer hold on the cold surface. This is condensation.

Particles of moisture vapour are tiny, and as a result virtually all materials allow moisture vapour to pass through them to some degree. Poor installation can also make the passage of warm air through the construction much easier than it should be, allowing moisture vapour to come into contact with the cold upper layers of the roof build up.

In a warm roof, as U-values decrease and insulation gets thicker, the temperature differential from one side of the insulation to the other increases the risk of condensation occurring in the upper layers. For this reason, the specification and installation of an appropriate vapour control layer is vital.

Image 3

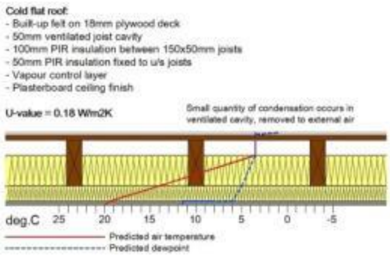

Image 3 caption
CAD detail of a typical cold flat roof construction, including an illustration of a condensation risk analysis, showing the importance of ventilation

"Bite 4"
Vapour Control Layers

Insulation must be coupled with an appropriate vapour control layer (VCL) to ensure the adequate control of vapour diffusion through a roof and limit condensation risk. Unfortunately, too many roofs are constructed without a VCL due to a lack of understanding about what the layer does.

Providing a vapour control layer
Sometimes a VCL is omitted because foil faced insulation is being used and the foil is taken as sufficient to act as VCL. While the foil on PIR insulation offers a high vapour resistance, the joints between boards always affect the continuity of the vapour resistant layer. No matter how closely butted the insulation boards are, the foil facing cannot be relied upon alone to provide the necessary vapour control.

Another misconception is that taping the joints on top of the insulation layer will provide the necessary vapour control. This is not the case, because a VCL – in any form of construction, not just flat roofs – must be positioned on the warm (i.e. internal) side of the insulation.

Polythene vapour control layers
Where insulation boards are mechanically fixed, it is sufficient to use a sheet of 1000-gauge polythene on the deck. This is loose laid and secured by the fixing of the insulation over the top. Waterproofing manufacturers may offer branded vapour control layers as part of their solutions, but these are variations on the theme.

Sometimes the question is asked as to whether a mechanical fixing penetrating the VCL compromises the VCL's performance. While the logic of this question is sound, research shows that the permeability of the VCL at fasteners is very low due to the seal achieved by the fastener.

Other vapour control layer types
In bonded build ups, the choice of VCL will largely be dependent on the choice of waterproofing. Manufacturers of torch-on felt, for example, typically offer a torch-applied VCL. And if a traditional pour and roll felt is being applied, the VCL can be provided as a layer of roofing felt bedded in bitumen.

Proprietary vapour barriers, some metal lined for increased vapour resistance, are also offered for bitumen bonded systems or build ups that use adhesive. Specified with PIR insulation, adhesives must follow the same guidelines as 'Learning Bite 2' to ensure compatibility with the chosen roof system.

Image 4

Image 4 caption

Installing the first few mechanical fixings to secure foil faced PIR insulation boards over a loose laid polythene vapour control layer – more will follow!

"Bite 5"

Hybrid Flat Roof Constructions

Flat roofs should, in theory, offer the freedom to install any thicknesses of insulation, but there are often constraints on available height. Concrete and metal decks don't have much potential for a solution in these situations, though some people may want to try fixing additional insulation on the underside.

Much easier to understand, however, is why people look at the joist cavity below a timber deck and ask if additional insulation can be accommodated there. At that point, the roof becomes a hybrid construction – and that carries with it certain risks.

Why is it a risk?

Warm air moves through the roof structure from inside to out, carrying moisture vapour through gaps between the insulation and supporting timbers. Vapour diffusion also occurs through the joists themselves.

Additional insulation between the joists lowers the temperature of the deck and the vapour control layer (VCL) on top of it. If the temperature of the VCL is too low then moisture vapour can be deposited as condensation.

The temperature of the deck/VCL interface also depends on the thickness of insulation remaining on top of the structure. If severe height constraints reduce the layer to a minimum, the chance of condensation occurring increases – a bit like a cold roof without the ventilation.

Is any hybrid solution acceptable?

If the insulation layer between joists has a lower thermal resistance than the insulation above the structure then the calculation model may well predict no condensation risk. However, the British Standard for the control of condensation – BS 5250 – does not recommend any hybrid roof construction, so nor do we at Recticel Insulation.

Can the VCL position be changed?

Since the VCL should be on the internal side of **all** the insulation in a construction, moving the vapour control layer from the structural deck to below the joists could, theoretically, solve potential issues. But here performance gap issues of 'as designed' vs 'as built' become a reality.

Positioning the VCL behind the ceiling finish sounds like a good idea, but will it be left intact? Is the ceiling likely to be modified at some point (e.g. to access wiring or install recessed lights)? Compared to being laid on the deck, will it last for the life of the building? While changing the VCL position might address a problem in the short term, being unable to guarantee its performance threatens the integrity of the roof in the long term.

Image 5

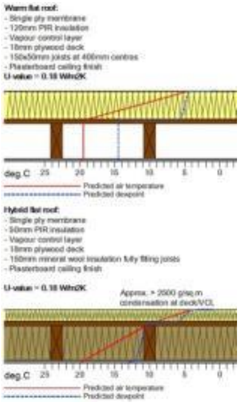

Image 5 caption

CAD details comparing a typical warm roof construction and a worst case hybrid construction, where vapour open insulation on the wrong side of the VCL results in significant condensation risk.

Date

16th December 2015