Dow Building Solutions

Making U-value calculations for inverted flat roofs: three vital considerations

By Chris Gimson, Commercial Director

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Reviewing or making a U-value calculation for an inverted flat roof? Then you should bear these three vital considerations in mind according to Chris Gimson, Commercial Manager for XENERGY™ SL insulation manufacturer, Dow Building Solutions:

1 **U-values:** Location, Location, Location.
2 Design and declared **lambda values**: know the difference.
3 Roof build up and potential **condensation effects**.

"We are all aware of the importance of U-values when it comes to the long term energy performance of well-constructed buildings. U-values can in general be calculated easily, and there is software available to make such calculations very quickly.

Anything that makes the job easier is welcome – but that doesn't mean we should overlook vital factors which can lead to misleading calculations if not addressed.
With the spotlight turning on the actual energy performance of buildings – not just the designed performance – ensuring U-value calculations are robust is a responsibility the industry must take seriously.

The **inverted flat roof** is a building element with many unique aspects, which must be tackled at the outset in order to avoid errors when making U-value calculations.
Water vapour movement as well as heat transfer should be calculated, and in addition condensation issues need to be satisfactorily addressed if a robust design solution is going to be achieved. Let's take each issue in turn.

U-values:
Location, Location, Location.

Most people understand that two identical buildings, with identical U-values, would not deliver equal energy efficiency performance if built in different locations, due to differences in local climates. But you wouldn't expect this to affect a U-value calculation itself - or would you? Inverted flat roof construction is simple in principle; just place the insulation above the waterproofing layer rather than below it, as would occur in traditional, warm roof construction.
Interchanging the position of the waterproofing and insulation layers brings numerous advantages, but also introduces an additional mechanism for heat loss: rainwater can flow beneath the insulation boards and remove heat directly from the building fabric, before finally running off the roof and down the rainwater drainage outlet.

This effect is known as Rainwater Cooling, and it must be addressed when we do a U-value calculation.
So how do we do that? First, calculate the U-value without taking it into account, and then add a correction (known as Delta U) to obtain the final U-value.

> Rainfall can vary by as much as a factor of five from the driest to the wettest locations in the UK.

Obviously, the more rain which flows under the boards, the more heat is lost. The additional heat loss due to Rainwater Cooling will therefore be dependent upon the average rainfall in the building's location and the percentage of that rainfall which reaches the waterproofing layer.

BS EN ISO 6946:2007 outlines a method which can be used to calculate how much the U-value is affected by rainwater, and by how much we need to correct it.

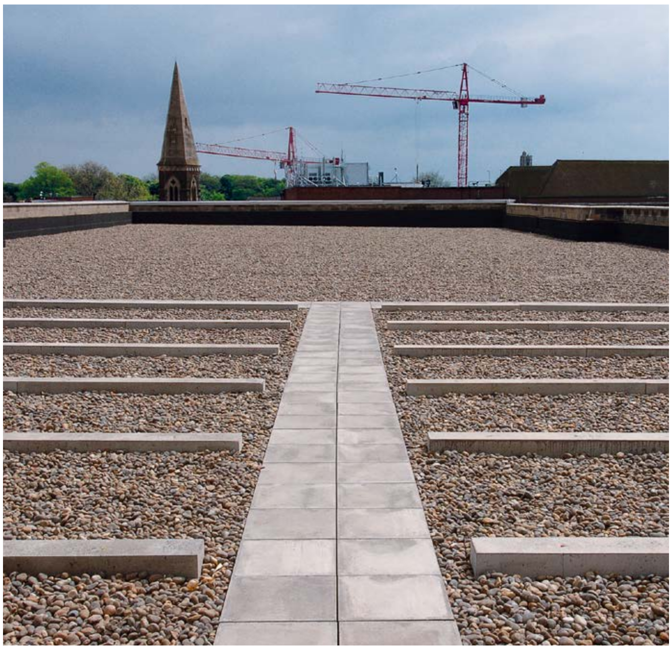
For an edge-profiled, interlocking board, a substantial proportion of rainwater can be expected to flow beneath the boards: European Technical Approval Guideline (ETAG) 031-1 stipulates that 75% can be assumed for calculation purposes.

This large percentage can be reduced by placing a water control layer (not to be confused with the waterproofing layer) over the insulation and beneath the ballast layer.

> Delta U becomes increasingly important as the U-values become smaller. It is particularly important for today's low U-values.

Tests have shown that this can reduce water flow beneath the boards to typically around 5%, making a significant reduction to the Delta U you would otherwise calculate.

Whatever the magnitude of the penalty that Rainwater Cooling brings, it needs to be correctly taken into account when making U-value calculations for inverted flat roofs.



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Design and declared lambda values: know the difference

When calculating U-values, we need to assess the individual materials which make up the construction element and know their respective thermal resistances, which can be derived from their thermal conductivity and thickness. If proprietary materials are used, a manufacturer should be able to provide relevant and - more importantly - accurate information for the calculation. In other circumstances, it may be acceptable to use generic information for the materials.

Whatever the approach, there must be no confusion about the thermal conductivity value to be used for the thermal insulation material, since the overwhelming majority of the total thermal resistance which will contribute to the final U-value is down to the thermal insulation layer.

> Approximately 90% of the thermal contribution to an inverted roof's U-value comes from the thermal insulation.

All insulation products have some degree of intrinsic variability in thermal conductivity. European Products Standards therefore take thermal test results and subject them to statistical analysis to create a level playing field. This improves the robustness of thermal conductivities used in calculations, and helps ensure that a consistent approach is used throughout the entire process. It also takes mechanisms such as aging into account.

This analysis delivers a so-called "declared" lambda value in accordance with the relevant European norm for the insulation being considered. For extruded polystyrene (XPS) such as XENERGY™ SL this norm is BS EN 13164.

This declared lambda value is sometimes referred to as the 90/90 value, i.e. 90% of production achieves the quoted conductivity value with a 90% confidence level.
Building designers have come to accept that declared (90/90) values for thermal insulation can be used as a design value as they represent a performance over a 25 year lifespan.
However in inverted flat roof applications this declared (90/90) value needs to be additionally modified, by applying correction factors based on the unique end use conditions.

ETAG 031-1 states that possible moisture absorption over time needs to be determined by examining two particular mechanisms for water absorption: by diffusion and by freeze/thaw, because the efficiency of thermal insulation is impacted by the amount of moisture it contains.
Only when the moisture levels have been determined can the relevant correction factor be applied - calculated in accordance with BS EN ISO 10456 - to the declared 90/90 lambda value, in order to derive a relevant application design lambda value.

Adding these correction factors will mean an increase in the thickness of insulation required to achieve the same U-value. **Ignoring them can lead to a significant underestimate of the amount of insulation required to achieve a target U-value.**

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Roof build up and potential condensation effects

The possibility of interstitial condensation on an inverted flat roof is further diminished, as the waterproofing layer is on the warm side of the insulation boards and thereby acts as an efficient vapour control layer.
Surface condensation will also present a low risk, as the insulation boards maintain the roof's waterproofing close to the building's internal temperature.

Nevertheless, while condensation risks are low, they are not zero, and we need to consider what other physical mechanisms may contribute. As already outlined, rainwater is able to flow beneath the insulation boards, removing heat from the roof structure. This results in a sudden drop in temperature and can lead to condensation.

> Rainwater cooling condensation is a phenomenon that can happen both in the summer and winter months.

For concrete decks - which have a significantly large thermal inertia - the duration and extent of deck cooling and therefore the consequent risk of either interstitial or surface condensation can be considered minimal.
For lightweight decks, however, rainwater cooling can pose significant risks unless steps are taken to address it.

Strictly speaking, the inverted flat roof concept involves placing all the insulation above the waterproofing layer.
However, designers from time to time may be faced with design constraints, and they may want to consider placing some insulation below the deck within the ceiling void.
Care must be taken with this approach, as increasing the thermal resistance below the waterproofing layer only increases the risk of condensation forming.

This increased risk cannot be offset by any ventilation of the insulation layer inside the building, as this would effectively provide a thermal "short circuit" and render the roof insulation ineffective altogether.

There are no hard and fast rules as to how much thermal insulation can be accommodated within a building before problems with condensation effects emerge.

However, **it is generally recognized that for an inverted flat roof design to perform effectively, the overwhelming majority of the insulation must be placed outside of the building and above the waterproofing layer.**

In summary, yes, there is more than meets the eye when calculating U-values for inverted flat roof systems and bearing issues such as condensation in mind. However, guidance is available to help ensure we all get it right – and help protect the reputation of the building industry as a whole."

For support with making or reviewing U-value calculations for inverted flat roofs and information on relevant correction factors, contact Dow Building Solutions' technical helpdesk on **FKLTECH@dow.com** or 08707 104 553.

Recommendations

XENERGY™ SL is the recommended Dow Product for inverted roof insulation.

XENERGY™ products contain a flame retardant additive to inhibit accidental ignition from a small fire source. XENERGY™ is however, combustible and if exposed to an intensive fire may burn rapidly.

During shipment, storage, installation and use XENERGY™ products should not be exposed to flames or other ignition sources.
Fire classification is based on small scale tests, which may not reflect the reaction of the products in its end use state under actual fire conditions. XENERGY™ products should, when installed, be adequately protected from direct exposure to fire.

Recommendations about the methods, use of materials and construction details are given as a service to designers and contractors. These are based on the experience of Dow with the use of XENERGY™ products. Any drawings offered by Dow are meant only to illustrate various possible applications and should not be taken as a basis for design.
Since Dow is a materials supplier and exercises no control over the installation of XENERGY™ products, no responsibility is accepted for such drawings and recommendations.

In particular, no responsibility is accepted by Dow for the systems in which XENERGY™ products are used or the method of application by which they are installed. The legal obligations of Dow in respect of any sale of XENERGY™ products shall be determined solely by the terms of the respective sales contract.

Visit **www.dowxenergy.co.uk** for further information on XENERGY™ SL insulation products as well as adhesives and sealants from Dow Building Solutions. For technical enquiries email FKLTECH@dow.com.

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