Does cold bridging matter?

Whether we call it thermal bridging, cold bridging the result is the same potential cold areas in buildings where heat leaks out easier than other better insulated areas.

If it is only localised, do we need to worry if we have the rest of the building well insulated? Unfortunately, yes, not only will the building lose heat but the bridge could lead to condensation and even mould on the inside surface. Even window reveals have shown that not insulating the reveal can have dramatic effect eg a study showed that using 140mm of insulation on the walls only and not the reveals could be compensated by only 60mm insulation in the walls with the reveals insulated.

It is not just reveals that need to addressed. As buildings become increasingly more energy efficient the smaller cold bridges are highlighted even more, we are all becoming aware of the effects of airtightness and we treat that appropriately but we need to be addressing the cold bridges to have a more holistic thermal performance. [1]

A regular question we are asked is the effect of steel beams in both walls and roofs and whether the client needs to address the potential cold bridge? The steel beams are needed in structures, but they can create a cold bridge which needs to be addressed to avoid cold coming in and heat going out. The other potential is surface condensation. The A. Proctor Group supply Spacetherm® CBS (Cold Bridge Strips) to address these issues but how can it be quantified?

The A. Proctor Group posed this question to Chris Sanders (ex BRE and Caledonian University). Drawings were sent to Chris, he then calculated the surface temperatures and U-Values of roof and wall details containing a steel beam, with various combinations of insulation inside and outside the beam. The effect of different insulation types on the risks of condensation on the steel beam were also investigated.

The results provided a good insight into cold bridging and how the effects can be mitigated in various situations.

Software and conventions followed

The calculations were done using the TRISCO software, supplied by Physibel, that complies fully with BS EN ISO 10211: 2007: *Thermal bridges in building construction. Heat flows and surface temperatures. Detailed calculations. The models were constructed in accordance with BRE Report BR 497 Conventions for calculating linear thermal transmittance and temperature factors.* Both these documents are specified in Building Regulations.

Risks of Condensation

The steel beam within the constructions analysed adds to the risks of interstitial condensation in two ways:

a. its high thermal conductivity (50 W/mK) causes a thermal bridge through the insulation, so that the internal surface of the beam will be cold,

b. the inner flange of the beam forms a completely impermeable barrier to moisture movement.

Without any additional insulation there is also a risk that the beam will lower the internal surface temperature of the wall or roof low enough to promote surface mould growth.

[1] *Iain Fairnington*

The f-value is the parameter that expresses the risk of condensation or mould occurring on the inside surface or within a detail if the inside surface is vapour open. The f-value is defined by f = (Tsi – Te) / (Ti – Te), where Tsi is the lowest surface temperature and Ti and Te the internal and external air temperature. If the f-value is less than 0.75 there is an increased risk of condensation and mould growth. Given the air temperatures of 20°C and 0°C assumed in the calculations, this means that surface temperature should be above 15°C.

For example-
If surface temperature is 16C, then f = (16-0) / (20-0) = 0.80 no condensation risk
If surface temperature is 15C, then f = (15-0) / (20-0) = 0.75 no condensation risk
If surface temperature is 14C, then f = (14-0) / 20-0) = 0.70 condensation risk

Insulation investigated-
There are two types of insulation that are available from the A. Proctor Group to reduce these problems:
Wraptherm® is made up of low thermal conductivity Spacetherm bonded to a breather membrane; its low vapour resistance means it is suitable for use outside the steel where it will allow water vapour to escape from the system.

Cold Bridge Strip (CBS) is Spacetherm encapsulated in a polythene membrane. The higher vapour resistance of this product means it is suitable for use inside the steel work.

One size does not necessarily fit all as can be seen from the work below and sometimes you need both products to mitigate condensation.

1. Roof Detail

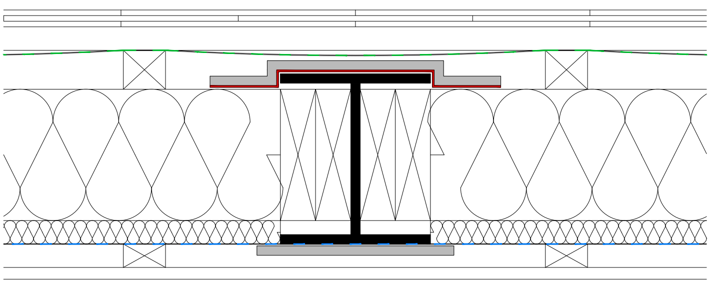

Figure 2: Sketch of roof

As specified in BS EN IS0 6946, all materials outside the ventilated cavity are not included in the model, and the outside surface heat transfer coefficient is set equal to the internal value 10 W/m²K.

Assuming the rafters are at 600mm centres, the area of the model, A, is 0.6 x 1.0 = 0.6 m². The U-Value of the roof can then be calculated from U = Q / A ·ΔT, where Q is the calculated heat loss in Watts, ΔT the imposed temperature difference = 20°C.

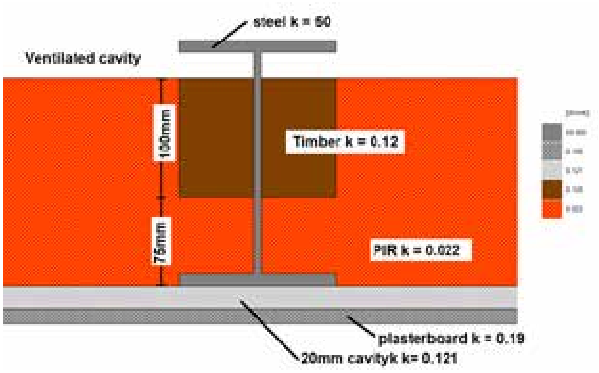

Figure 3: Trisco model of roof with no additional insulation

A) No Added Insulation

Given internal and external temperatures of 20°C and 0°C, the calculated temperature distribution through the roof is:

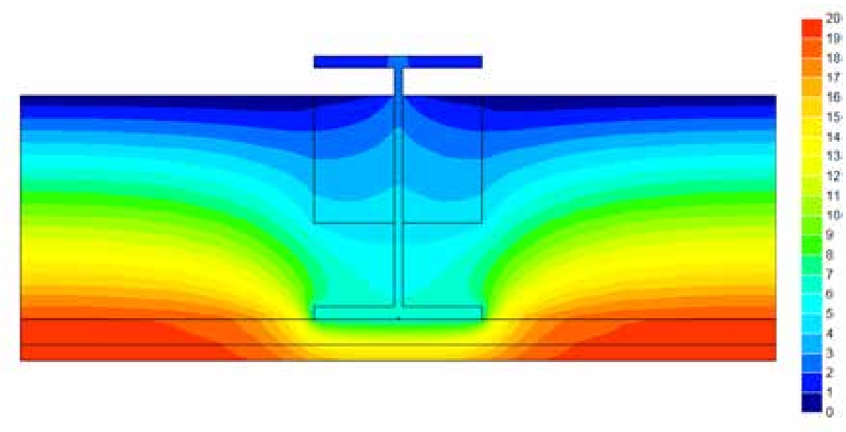

Figure 4: Calculated temperatures with no added insulation

Minimum internal surface temperature = 15.88°C f = 0.794
Minimum temperature on base of steel = 6.21°C f = 0.311 condensation risk
U-Value of roof = 0.706 W/m^{2}K

The lowest internal surface temperature is 15.9°C, which is above the 15°C below which condensation and mould growth becomes likely. However, the inner surface of the steel beam is at about 6°C, which means that, unless the internal lining is completely air and vapour tight, there will be severe condensation on the steel.

B) 100mm width of Wraptherm added outside the steel.

Covering the outside surface of the beam with 10mm of Wraptherm which extends 100mm either side of the beam (Figure 5), raises the temperature of the inner surface of the beam to 13.4°C, which still brings a risk of condensation.

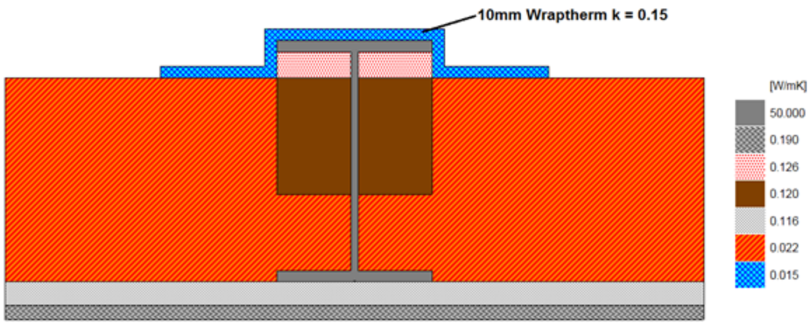

Figure 5: 10mm of Wraptherm added outside steel

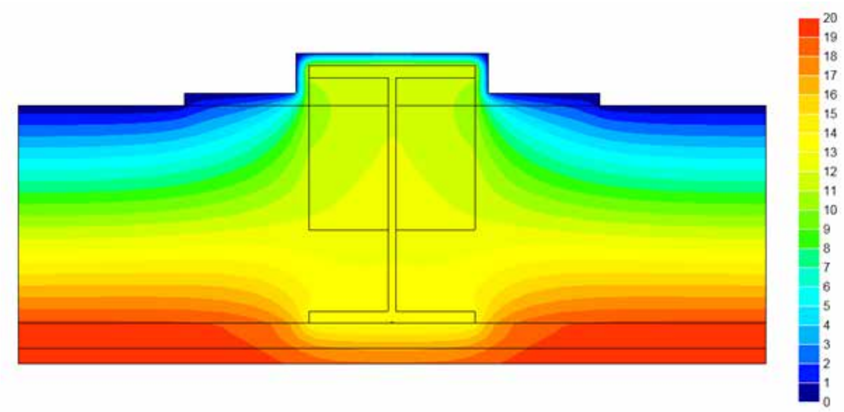

Figure 6: Calculated temperatures with 10mm added Wraptherm

Minimum internal surface temperature = 18.08°C f = 0.904
Minimum temperature on base of steel = 13.45°C f = 0.673 condensation risk
U-value of roof = 0.360 W/m^{2}K

Increasing the Wraptherm to 20mm improves the results:
Minimum internal surface temperature = 18.64°C f = 0.932
Minimum temperature on base of steel = 15.32°C f = 0.766 ok with 20mm Spacetherm
U-value of roof = 0.272 W/m^{2}K

This shows that 20mm Wraptherm can mitigate the risk of condensation.

C) 10mm CBS added inside the steel

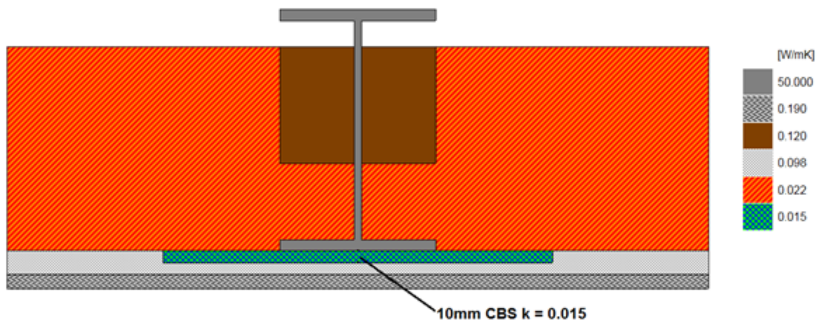

Figure 7: 10mm CBS added inside the steel

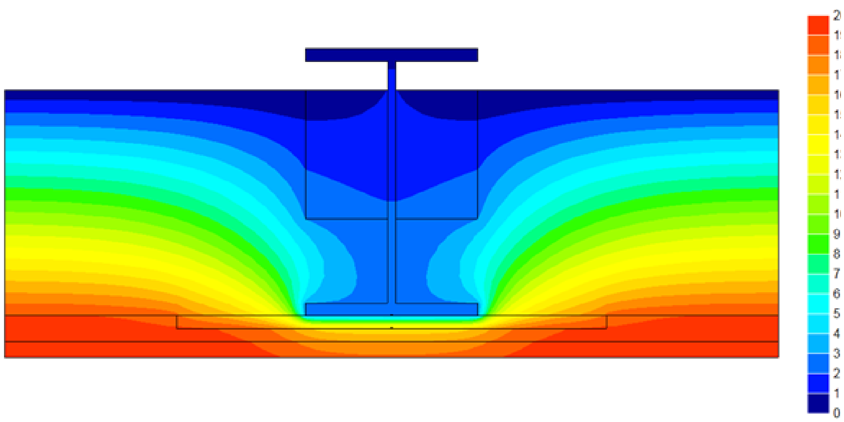

Figure 8: Calculated temperatures with 10mm of CBS added inside the steel

Minimum internal surface temperature = 18.19°C f = 0.910
Minimum temperature on base of steel =2.82°C f = 0.141 condensation risk
Minimum temperature on base of CBS =13.96°C f = 0.698 condensation risk
U-value of roof = 0.363 W/m²K

D) 10mm CBS added inside the steel

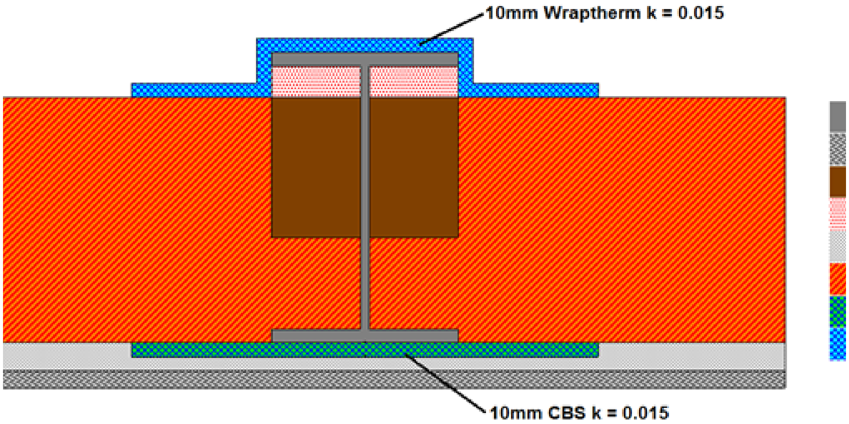

Figure 9: 10mm of Spacetherm added inside and outside the steel

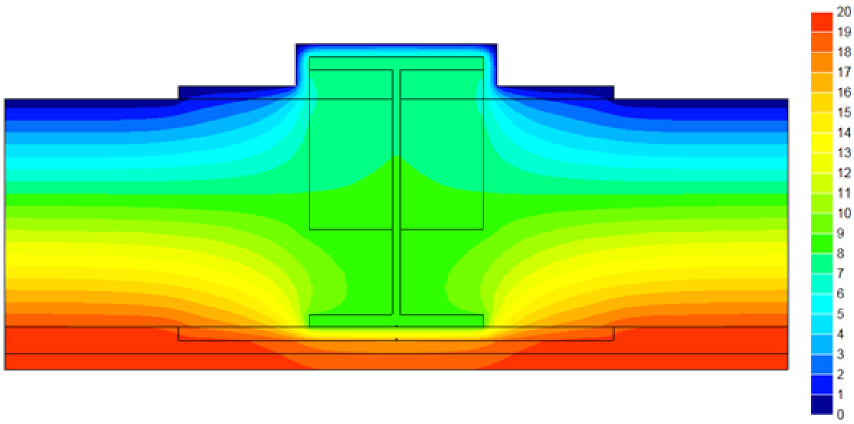

Figure 10: Calculated temperatures with 10mm of CBS added inside the steel and 10mm Wraptherm outside the steel

Minimum internal surface temperature = 18.82°C f = 0.941
Minimum temperature on base of Steel =8.80°C f = 0.440 condensation risk
Minimum temperature on base of CBS =16.06°C f = 0.803
U-value of roof = 0.257 W/m²K

Even with Wraptherm installed externally and CBS installed internally the base of the steel is too cold to avoid a condensation risk, where the 20mm Wraptherm will help avoid this.

2. Wall Detail

The Trisco model was developed from the second sketch

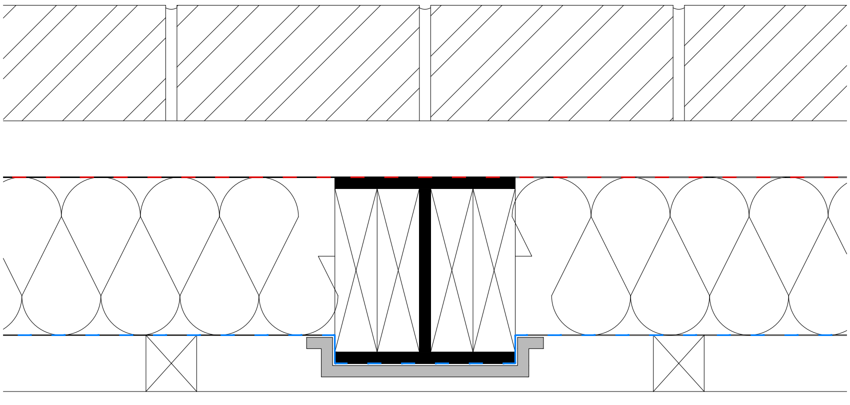

Figure 11: Sketch of wall detail

A: With no additional insulation

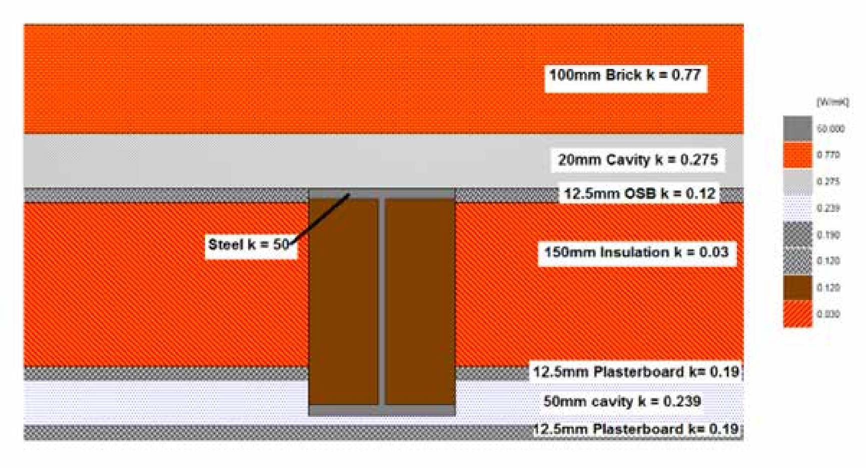

Figure 12: Trisco model of wall with no additional insulation

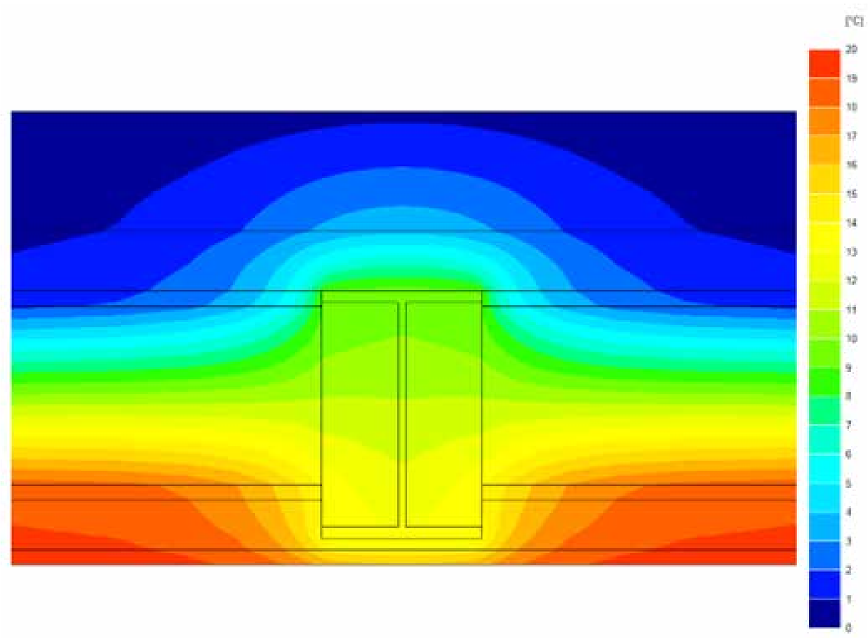

Figure 13: Calculated temperatures through wall with no additional insulation

Minimum internal surface temperature = 16.23°C f = 0.812
Minimum temperature on base of steel =12.97°C f = 0.649 condensation risk
U-value of wall= 0.632 W/m²K

B) With 10mm of Wraptherm outside the steel

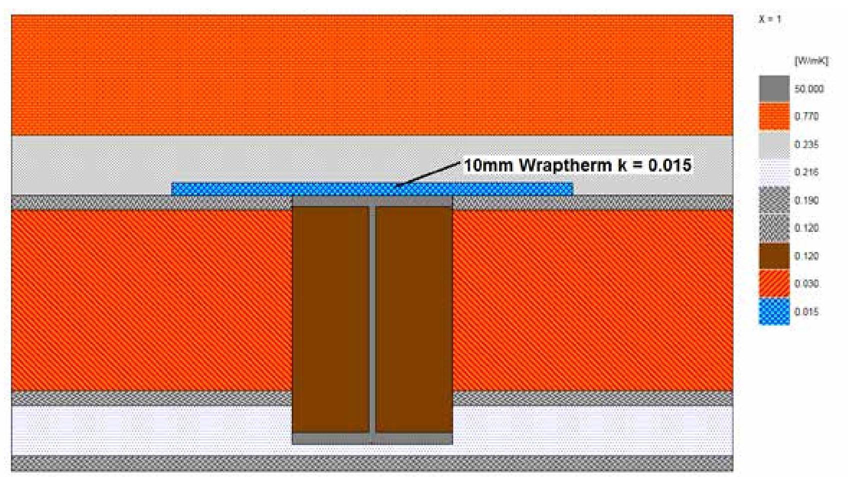

Figure 14: Trisco model with 10mm Wraptherm outside the steel

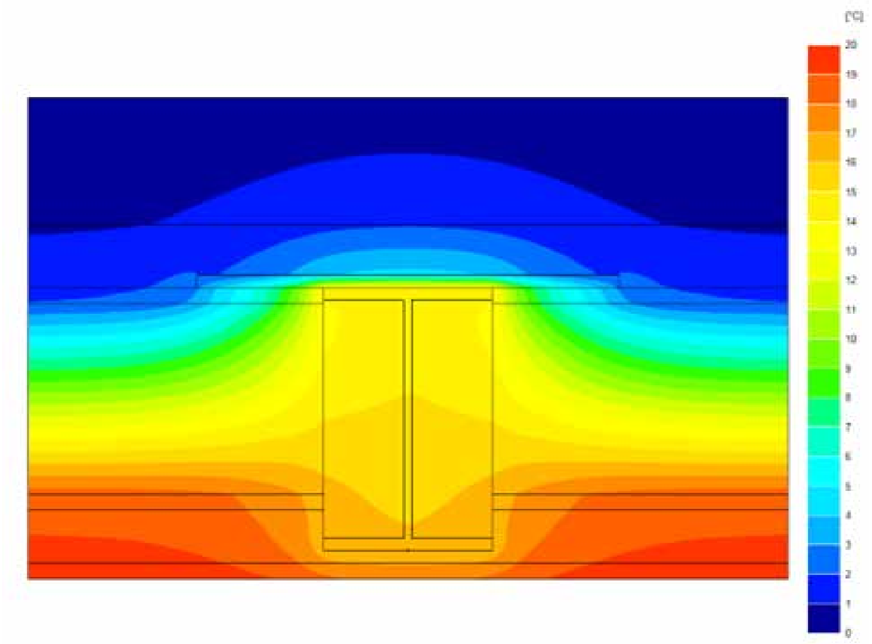

Figure 15: Calculated temperatures through wall with 10mm of Spacetherm outside the steel

Minimum internal surface temperature = 17.94°C f = 0.897
Minimum temperature on base of steel =16.13°C f = 0.808 both ok
U-value of wall= 0.378 W/m^{2}K

C) With 10mm of CBS inside the steel

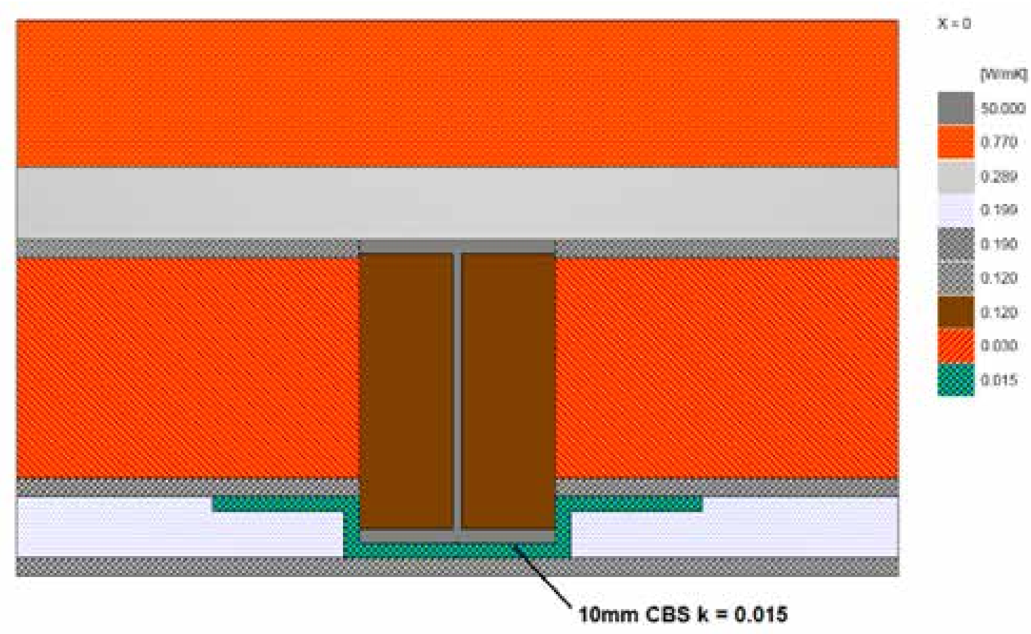

Figure 16: Trisco model with 10mm CBS inside the steel

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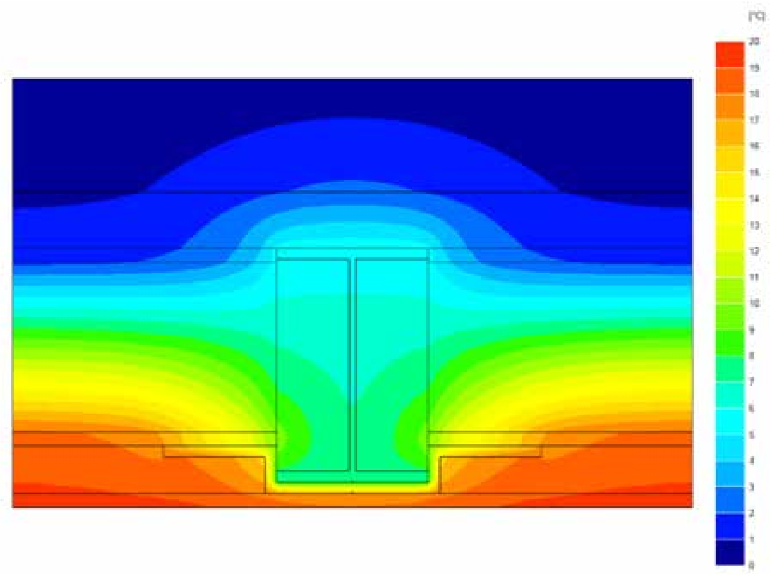

Figure 17: Calculated temperatures through wall with 10mm of CBS inside the steel

Minimum internal surface temperature = 18.15°C f = 0.908
Minimum temperature on base of CBS = 16.24°C f = 0.812
Minimum temperature on base of steel = 7.58°C f = 0.379 condensation risk
U-value of wall = 0.397 W/m²K

D) With 10mm of CBS inside and 10mm Wraptherm outside the steel

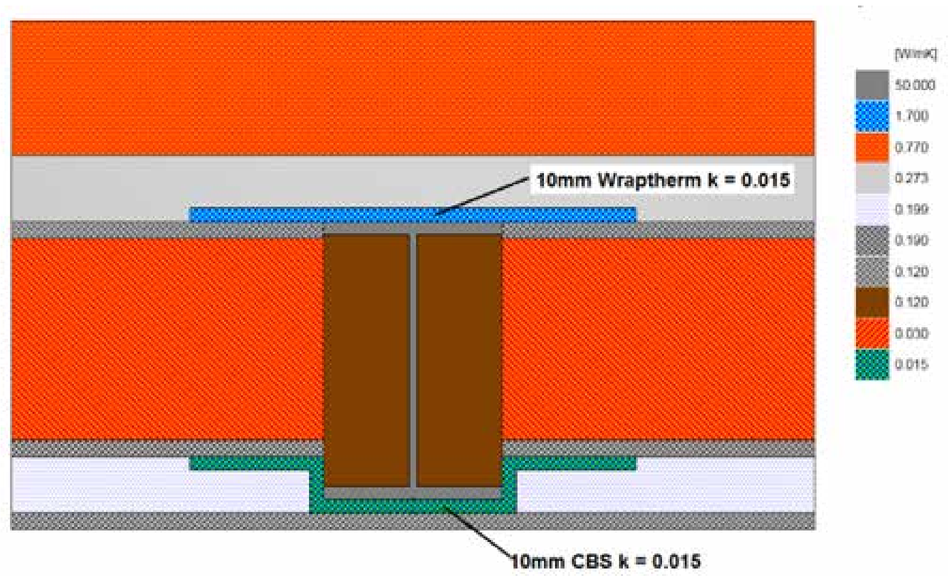

Figure 18: Trisco model with 10mm CBS inside and 10mm Wraptherm outside the steel

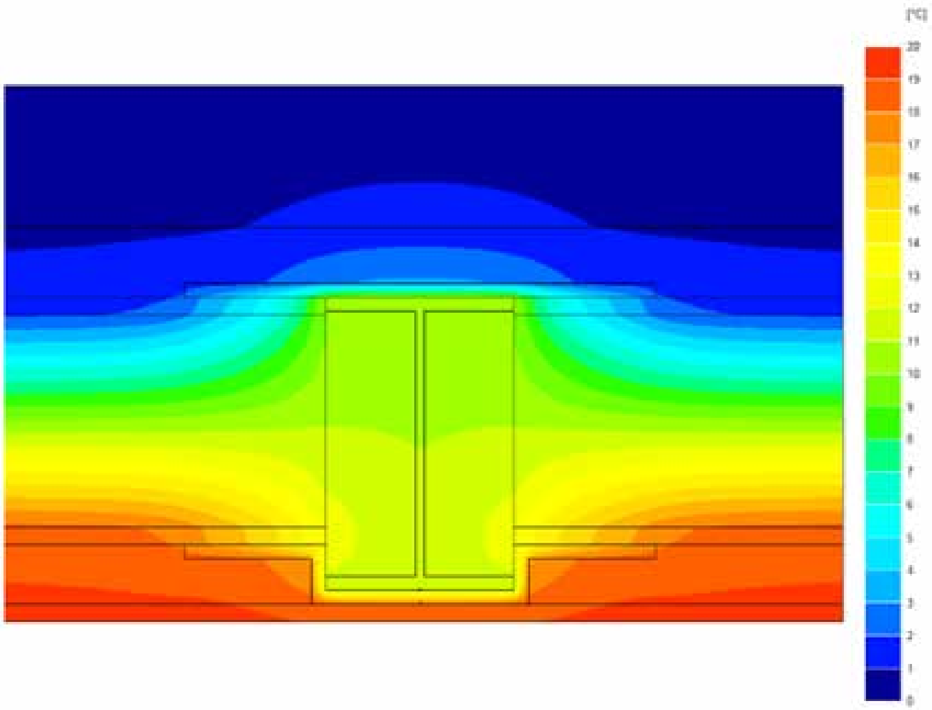

Figure 19: Calculated temperatures through wall with 10mm of Spacetherm inside and outside the steel

Minimum internal surface temperature = 18.75°C f = 0.938
Minimum temperature on base of CBS = 16.38°C f = 0.819
Minimum temperature on base of steel = 8.05°C f = 0.403 condensation risk
U-Value of wall = 0.293 W/m^{2}K

Summary

Even with no additional insulation, the internal surface temperatures in the roof and wall are not falling low enough to promote mould growth on the surface, however the U-Values are very high.

Without additional insulation the internal temperature of the steel is very low in both cases, leading to risk of severe condensation if any internal VCL is not perfect.

In the roof adding either 10mm of Wraptherm outside the steel or 10mm of CBS inside the steel does not raise the temperatures enough to avoid condensation, but it does in the wall.

In the roof it is necessary to add insulation both inside and outside the steel to avoid the risk of condensation.

Only one test from each of the wall and roof tests demonstrate no risk of condensation:

- Roof test B Fig.6: 20mm Wraptherm on outside of steel
- Wall test B Fig.15: 10mm Wraptherm on outside of steel

This work shows the effects of various insulation types and shows that 10mm of even high-performance insulation is not a solve all solution. Care needs to be taken to avoid assumptions and calculation should be carried out to provide robust solutions.

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