Thermal bridging analysis applied to window installation

The most common way that windows are installed in a wall has the frame positioned out in the wall cavity.

A window installed in the ventilation cavity

The 90mm timber frame is behind the blue wall weather resistant barrier (WRB).

The battens to hang the cladding are then spaced off the WRB to allow ventilation of this cavity to remove any moisture that moves from inside the building to outside or that directly enters the cavity from the outside.

The cladding will be fixed to the battens to be flush with the outside of the window frame. This is a common detail used in brick veneer construction as the window then bridges the cavity between the wall frame and bricks (this is standard construction).

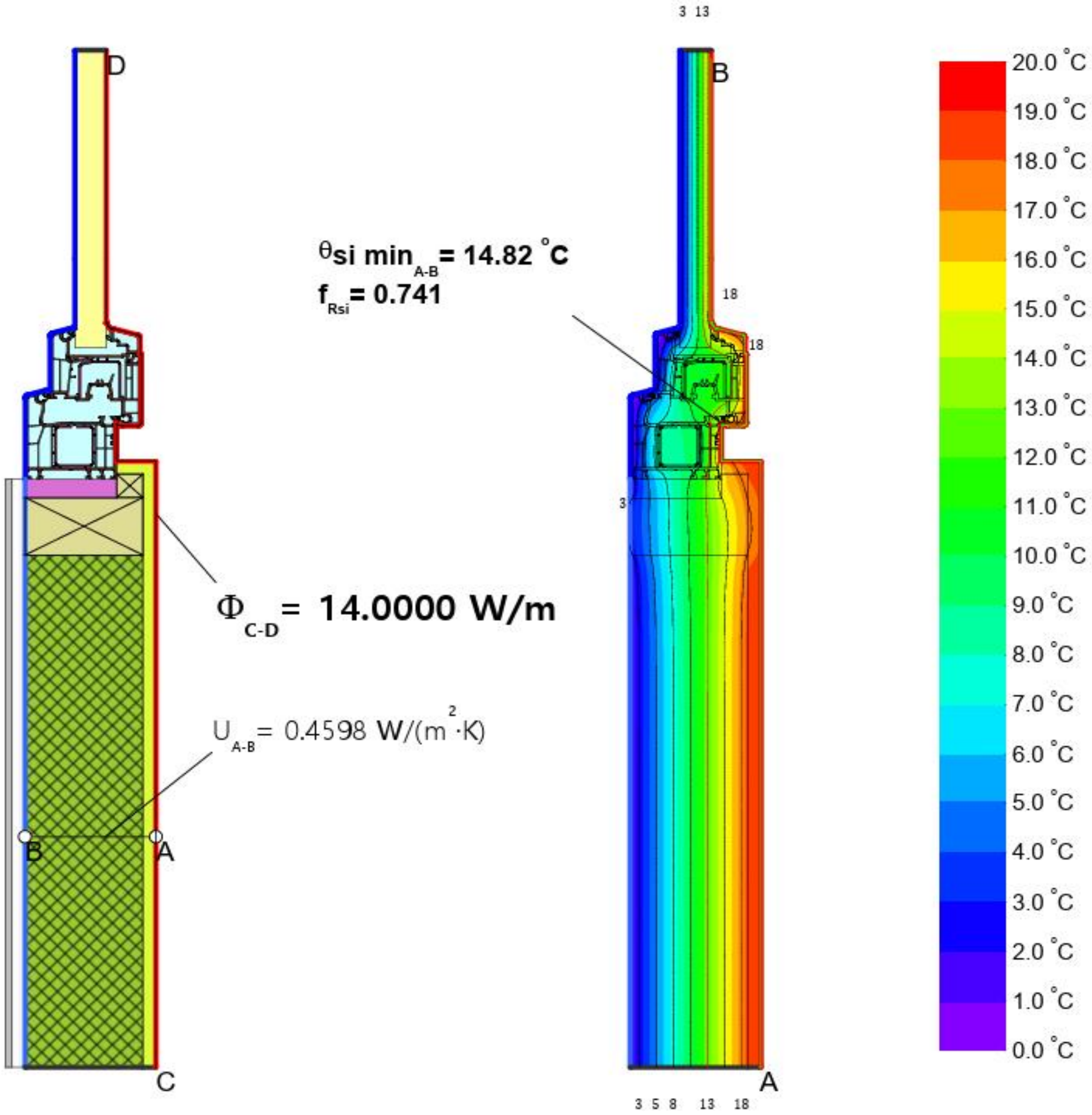
And now to the Flixo thermal bridge analysis to understand why installation of windows in the ventilation cavity is really defeating the purpose (and value) of selecting better performing windows.

This is kind of technical but actually intuitive and easy to understand with the graphical output of the analysis showing where heat is moving through the building envelope.

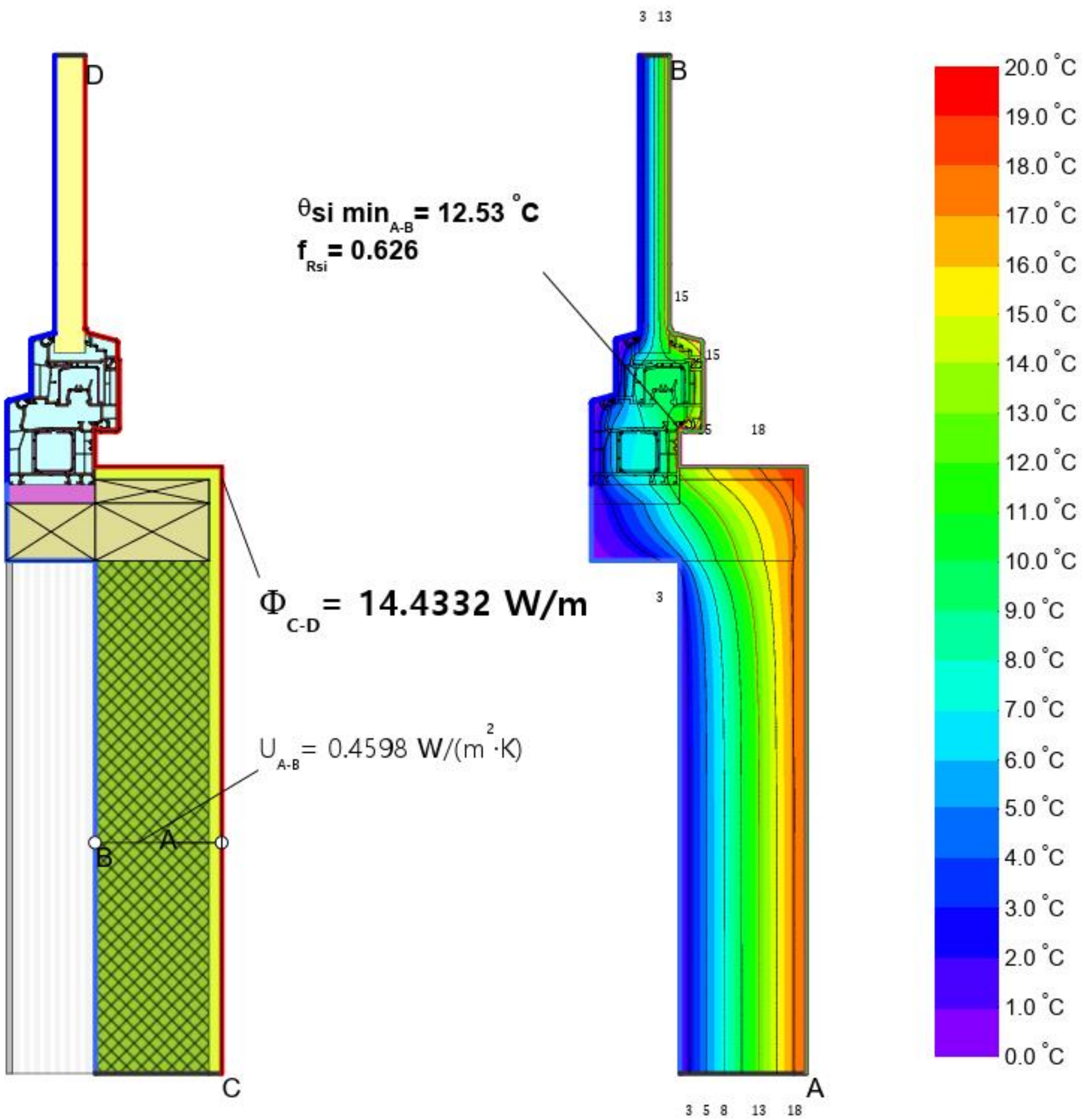
First, a quick tutorial for understanding 2D heat flow analysis. These are cross sections through frame and glass unit in a wall. These are the same uPVC frames (representing the one in the photo) in a 90mm insulated timber frame wall. The one on the left showing the materials and construction and on the right the heat flow. The temperature at each point in the frame is represented by both colour (key on the far right) as well as the black lines running from top to bottom isotherms (iso = same, therm = temperature) these are also with the temperature at each point noted.

In this model the outside is on the left and is at 0°C and the inside on the right at 20°C. Materials that are more insulative will show the isotherms running parallel, straight and closer together (see within the glass unit and wall frame). Materials that are less insulative (more conductive) will distort the lines and move them further apart. This can be seen in the uPVC where the steel reinforcing in the centre of the frame bends and spreads the lines. This is in contrast to the insulation in the insulated timber frame which being a uniform material keeps the isotherms straight and parallel.

The final information reported is the minimum internal surface temperature point indicated by the line connecting to that point. This number (f_{Rsi}) allows us to understand the risk of condensation forming on surfaces and therefore the risk of mould. uPVC window frame.



uPVC in the Cavity Instal Base Support



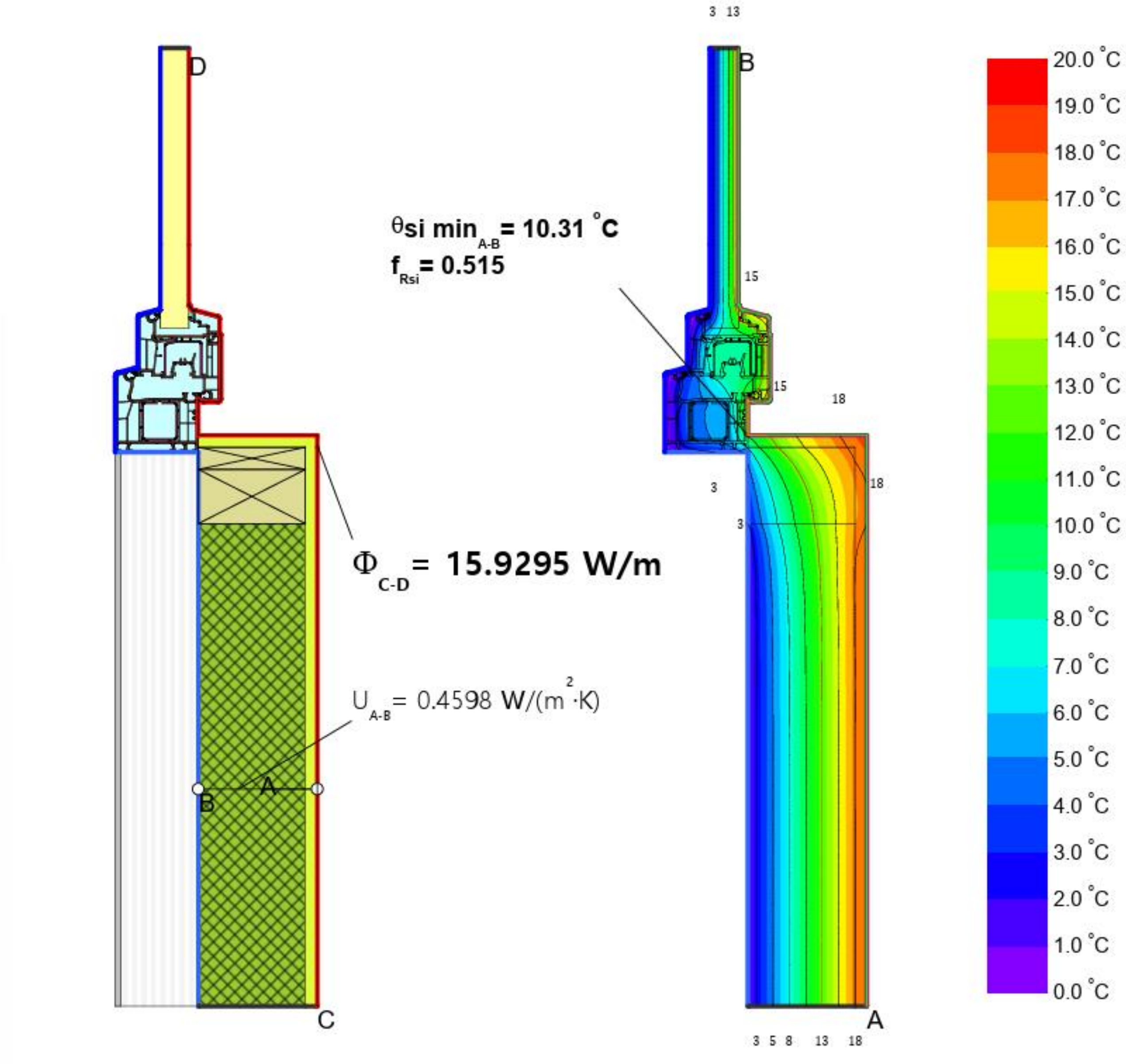
This model is showing how the bottom of the window *could* be installed in the cavity.

I have assumed that a 70x45 timber ledger was installed below to support the window and then 15mm of foam insulation between the window base and frame. The insulated 90mm timber frame shows a U value of 0.46 that is an R2.2 wall. This is representing the most common installation detail that may be used with a brick veneer cladding or ventilation/batten cavity as the example photo demonstrates.

The whole window and wall section allow 14.43W/m of heat flow. This is how much heat energy flows out of each lineal metre length of this window to wall junction.

The minimum internal temperature is 12.53°C which is just acceptable in the Canberra climate to avoid condensation.

uPVC in the Cavity Instal



This model is showing how the bottom of the window *is actually* installed in the cavity and certainly how the rest of the window sides and top are installed.

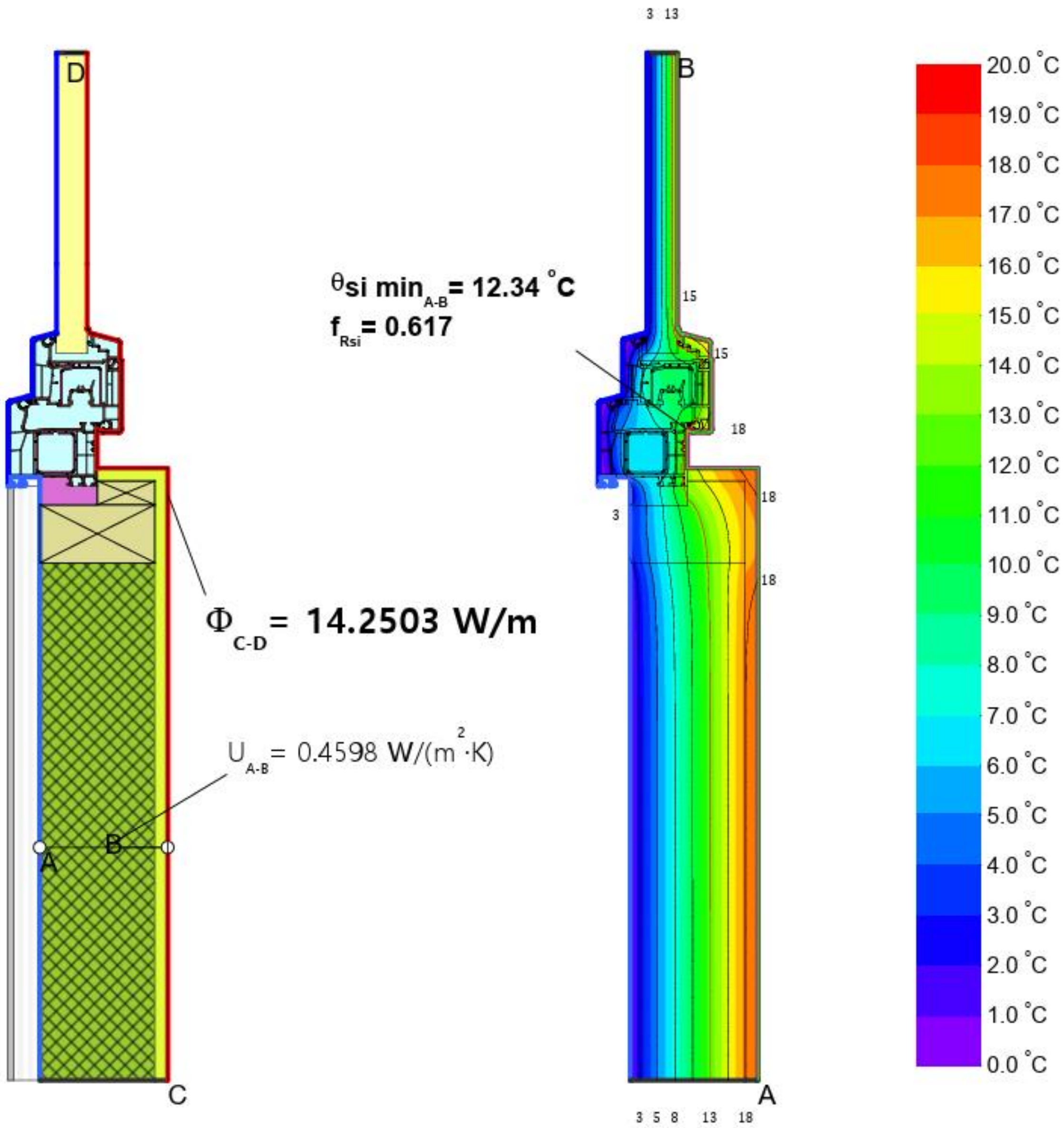
The whole window and wall section allow 15.93W/m of heat flow!

The isotherms (temperature of the materials) are significantly distorted. This is because the base of the frame is fully exposed to the ventilated cavity (outside air temperature) and it is particularly the steel reinforcing in the centre of the frame that transfers the heat so efficiently. See the blue (<6^{o}C) almost touching the inside of the window sill.

This is unfortunately defeating some of the insulative value (and economic value) of the uPVC frame and should not be installed in this way, but that is the standard installation of most windows.

The next instal shows what may also sometimes be detailed with a thinner cavity and cladding, p where it is only light-weight cladding used on the building.

uPVC Half in the Cavity Instal



This model has the frame half in the insulation of the wall and half into the cavity. This is unlikely to be an installation that is used but it is included to demonstrate the impact of the installation position on heat flow, internal surface temperatures and risk of condensation.

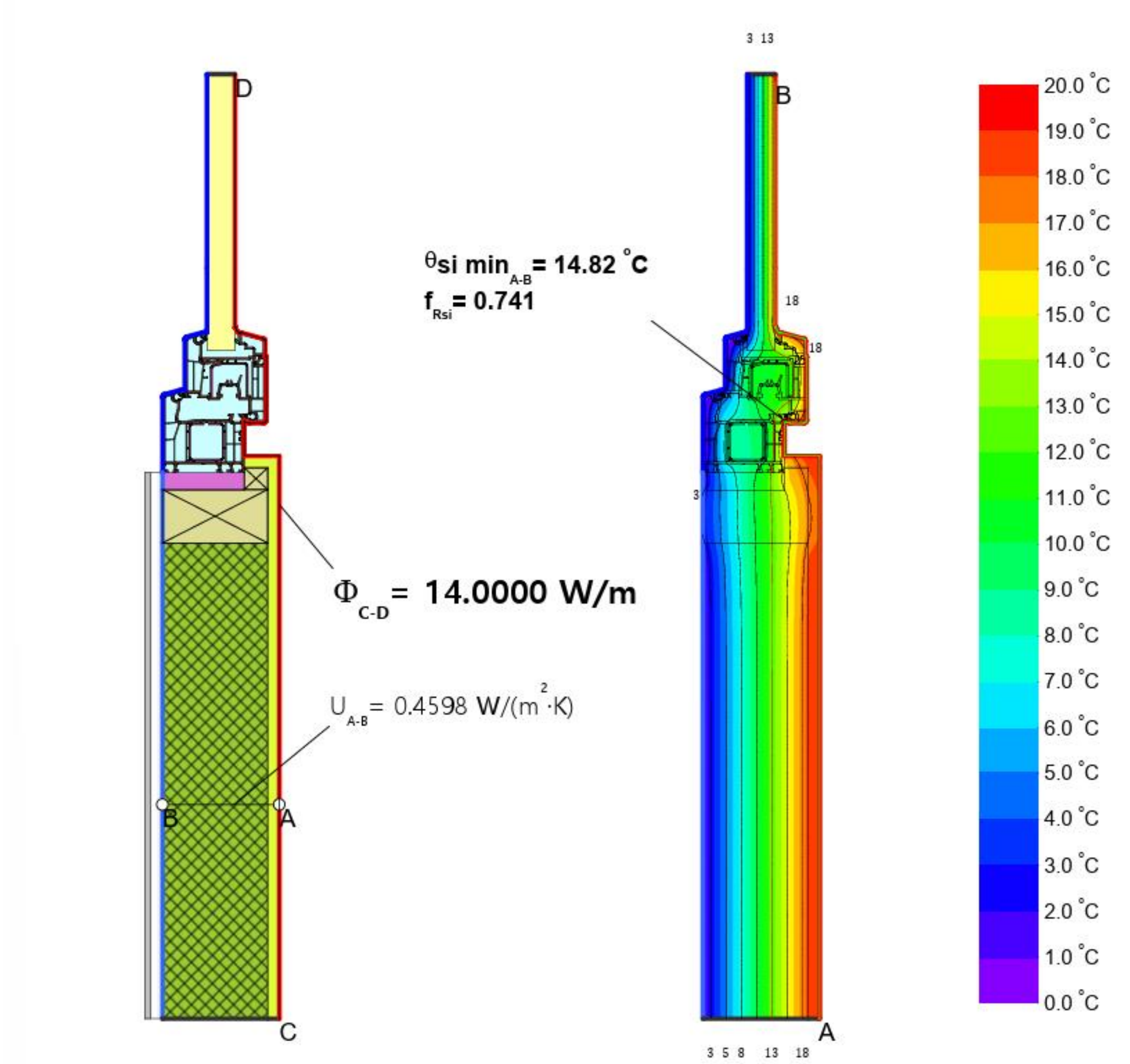
The whole window and wall section allow 14.25W/m of heat flow.

The minimum internal temperature is 12.34ºC, again this could be acceptable. This is largely the case because the steel reinforcing is all but insulated from the outside by the foam insulation added between the timber and window frames. The isotherms bend but are continuous.

If this foam was not installed (as it often isn't) then it would be just as bad as the previous cavity instal situation. This is not unreasonable to assume as it is difficult to instal foam accurately around the full perimeter of the window without taking time and care to do this well.

And finally, the ideal installation situation.

uPVC Inline with Insulation Instal



The least heat loss and highest internal surface temperature *by far*.

This installation is also the best to then dependably tape the frame onto the WRB to prevent air leakiness around the frame. This really matters as air leakiness allows far more heat energy to flow inside to out and carries the warm moist air into the structure of the wall. This is a risk for condensation and rot of structural materials.

These heat flow analyses are what is needed in Passivhaus construction as the energy loss is accounted for with every thermal bridge. There is a lot of window frame length in a building and all of this heat loss adds up.

The use of 2D heat flow analysis allows the building to be designed and detailed to both work as well as it should and manage the risk of condensation to a level that is appropriate for the building in its climate.

Only the PHPP energy modelling can account for this energy loss, not only in windows but in every building junction.