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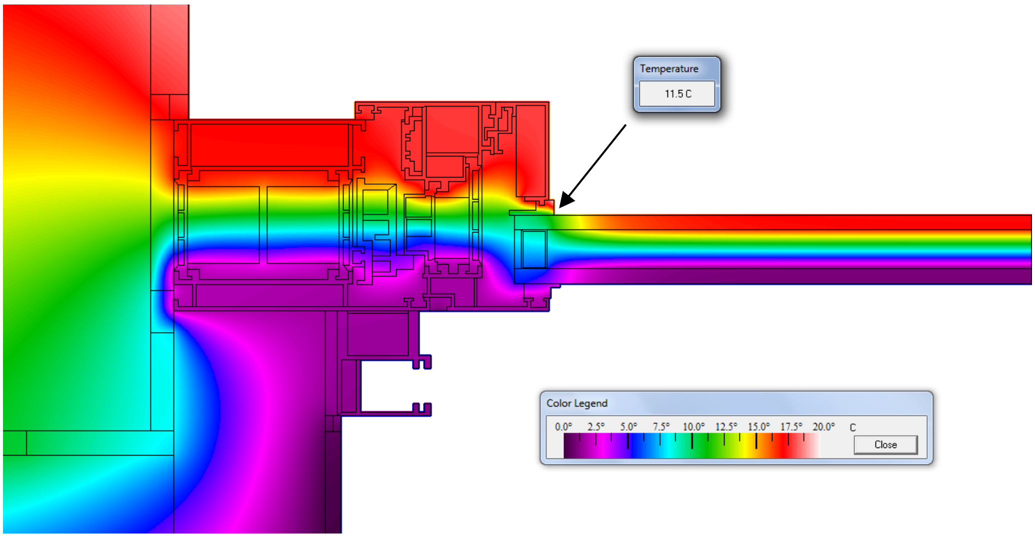
Thermal Analysis of the Building Envelope

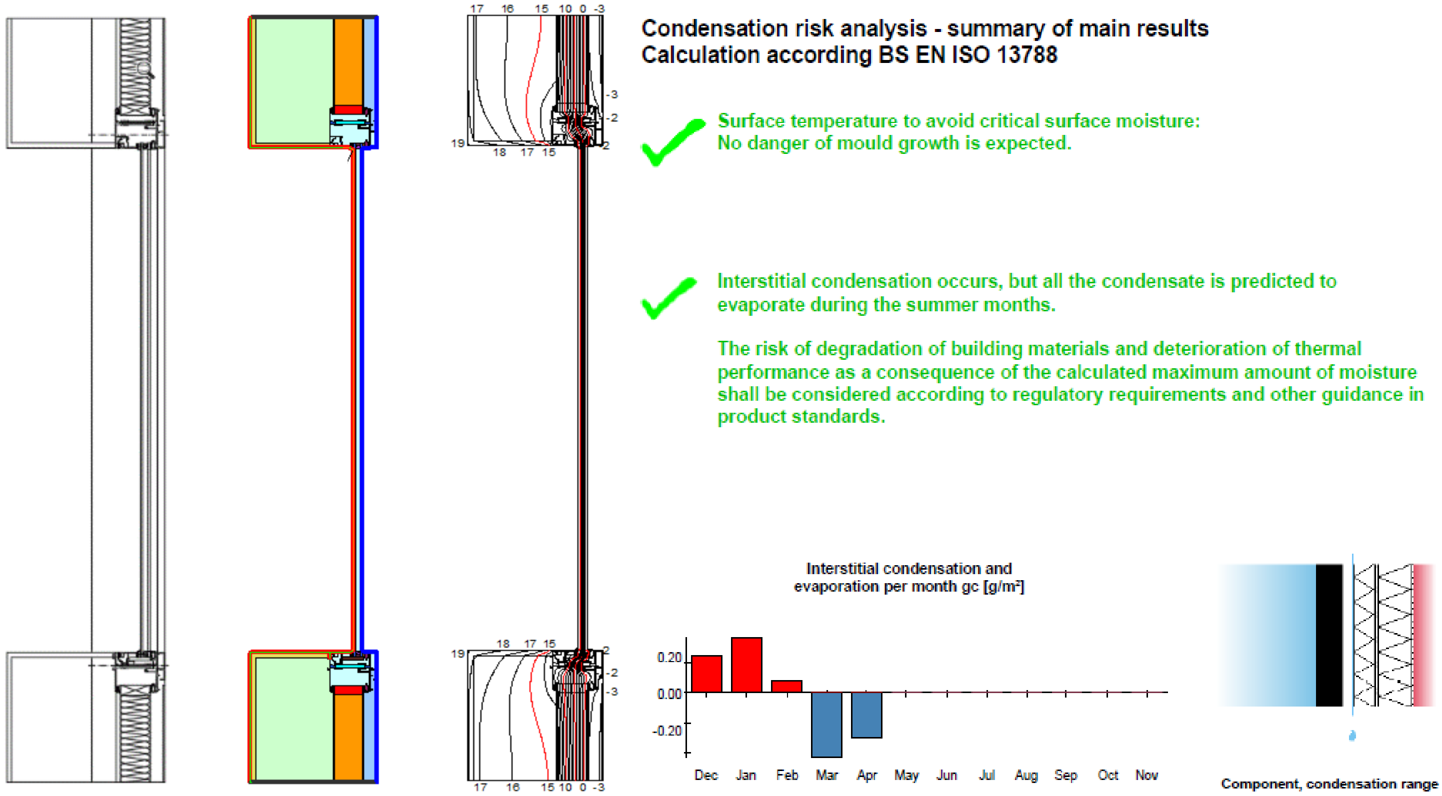
To achieve good sustainability in our buildings we need to consider heating, ventilation, solar gain, building use, choice of materials and building form, amongst others. Very good thermal separation between inside and outside is necessary to obtain the required internal conditions and optimum energy efficiency. To achieve this we must avoid thermal bridging through the wall construction.



A thermal bridge is a part of the structure of lower thermal resistance that bridges adjacent parts of higher thermal resistance and which can result in localised cold surfaces on which condensation, mould growth and/or pattern staining can occur. Not assessing the risks could lead to inappropriate construction techniques, and an inadequate protection will result in financial and energy losses over the life of the building. It could also compromise the health and safety of its occupants.

Patrick Ryan Associates have expertise in the field of thermal analysis and have been working closely with clients, architects and contractors to achieve very low thermal transmission for the building facades on our projects. In doing so we can also ensure that there is no surface condensation and minimise thermal bridging at the junctions. See example of a moderately efficient window system above with no risk of condensation.

We were recently involved in the change of use to a residential of an office building, originally built in the mid 1980’s, with refurbishment of the facades. Many of the existing fixed double glazed units were replaced with new opening windows for natural ventilation and insulated double glazed spandrel panels. Our thermal report, with calculations in accordance to British and European Standards, determined the thermal transmission through the different types of curtain wall and windows and verified that the facade U-values complied with Approved Document Part L. Some of the output from this analysis is shown below.



To calculate the thermal transmittance of a Window/Curtain Wall (U_w and U_{cw}), the following information is required:

- Thermal characteristics, U_{glass} [W/(m^{2}K)], of the centre pane of the glass unit, and it's Area [m^2];
- Thermal characteristics, U_{frame} [W/(m^{2}K)] of every frame element in the Window/Curtain Wall, and it's Area [m^2].
- Linear thermal transmittance (edge psi-values [W/(mK)]) of the junction between the different frame elements and the glass/spandrel panel. In addition, the perimeter length [m] of the junction must be known.

In the case of the mullion framing shown below, modelling has been carried out using specialist two-dimensional thermal analysis software, which calculates with the finite element method. The advantage of our software is that it is continuously updated to the most recent European standards. In this case, we have also carried out interstitial condensation analysis. The graphics below show the original AutoCAD model for the curtain wall system and its modelling for thermal analysis in our specialist software. This resulted in the correct calculation of the frame U-value, for curtain walling, in accordance with BS EN ISO 12631-2:2012, as shown on the diagram.

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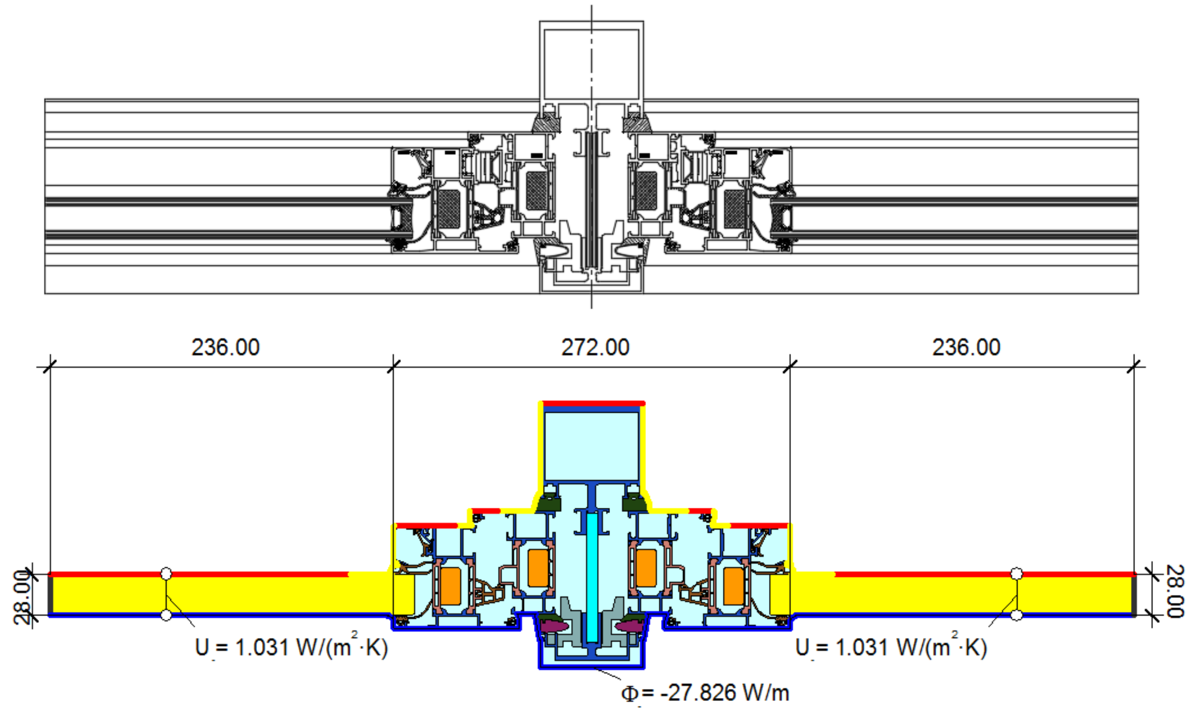

$$U_{m,w-w} = 2.47\ \frac{W}{m^2K};$$

Once the thermal characteristics of the elements of the curtain wall have been calculated, it is possible to calculate the thermal transmittance of the curtain wall. A typical example is shown in the following table:

Curtain wall transmittance	A		U		l		Ψ	
	m^2		$W/(m^2\ K)$		m		W/(m K)	
Mullion window-New spandrel	$A_{m,w-s}$	0.16	$U_{m,w-s}$	2.70	l_f	1.30	$\Psi_{m,f}$	0.11
Mullion Window-Window	$A_{m,w-w}$	0.16	$U_{m,w-w}$	2.47	l_f	1.30	$\Psi_{m,f}$	0.11
Mullion Spandrel-Spandrel	$A_{m,s-s}$	0.11	$U_{m,s-s}$	3.00				
Window Intermediate Frame	A_f	0.17	U_f	2.21				
Transom	A_t	0.39	$U_{t,w-s}$	2.70	l_f	1.30	$\Psi_{t,f}$	0.11
Glazing	A_g	1.28	U_g	1.00	l_g	7.15	Ψ_g	0.06
Spandrel Panel	A_p	2.06	U_p	0.55	l_p	5.75	Ψ_p	0.20
Curtain Walling	A_{cw}	4.32	U_{cw}	1.58				

$$U_{CW} = 1.58\ \frac{W}{m^2K};$$