Thermal bridging in steel framed buildings

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Figure 1 : Light steel infill walls in a steel framed structure

In the residential sector, satisfying the energy conservation requirements of the Building Regulations Part L1 is increasingly challenging and affects the detailed design of these buildings, particularly at interfaces between components in the façade and roof. In multi-storey residential and mixed use buildings, steel frames are often used because of their well-known benefits of speed of construction and lighter weight in comparison to concrete construction. Multi-storey frames are often combined with light steel infill walls in the façade that also support lightweight cladding, such as insulated render and rain screen systems. An example of infill walling used within a composite steel frame residential building is shown in Figure 1.

In housing, a considerable amount of work has gone into assessing the thermal bridging that occurs in typical junctions and at foundations in order to calculate their cumulative effect on the whole building energy performance. This has resulted in a range of Accredited Construction Details for all materials that cover many common design details in housing.

The parameter which is used to take account of the combined effect of all thermal bridges is known as the y-value. This has the same units as the U value of the individual walls and roof etc and effectively adds to the U value. A building with low thermal bridging has a y-value of about 0.04 W/m²K, a building with reasonable control of thermal bridging has a y-value of about 0.08 W/m²K, and the default case without special consideration of thermal bridging has a y-value of about 0.12 W/m²K. This may be compared to an overall heat loss parameter (of the walls, roof, windows etc) of about 0.5 W/m²K expressed over the whole building envelope, and so the effect of thermal bridging can add 10 to 30% to the heat loss due to conduction through the building envelope.

In the case of multi-storey residential buildings, little work has been carried out to determine the effect of thermal bridging. In the case of steel frames with infill walls, the steel edge beams and columns bridge the insulating later to some extent because the mineral wool insulation that is placed between the C section of the infill wall is not continuous at the lines of the steel beams, floor slab and columns.

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SCI together with Oxford Brookes University has recently completed an EU research project with the working title of TABASCO, which had the objective of analysing thermal bridging effects in a wide variety of steel structures and cladding systems. Examples of these analyses for two typical cases relevant to steel framed construction are presented below.

1. Steel edge beams with insulated render cladding

The heat flow through a façade of a steel framed building with insulated render cladding is shown in Figure 2 for a 300mm deep edge beam supporting a 130mm deep composite floor slab and for a 20°C temperature difference between inside and outside. The insulated layer outside the structure is taken as Expanded Polystyrene (EPS) which is often used in these cladding systems. The infill walls use 100 × 1.6mm Cs at 600mm centres with mineral wool in between. The results are expressed in terms of the linear thermal transmittance ψ in W/mK at the beam line, and an f_{RSI} parameter, which defines the 'cold spots' on the surface, as shown in Table 1 for various thicknesses of EPS insulation. An f_{RSI} value of 0.9 corresponds to a local temperature of 18°C on the room surface, and a value of 0.95 to a local temperature of 19°C. In both cases, the f_{RSI} values will not lead to local condensation and so are acceptable.

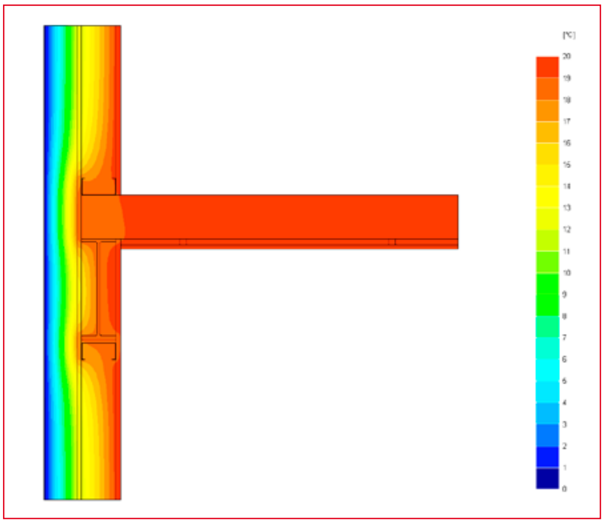

Figure 2: Thermal profile at an edge beam for a light steel infill wall with insulated render cladding

EPS thickness (mm) outside the C sections in the external wall	f_{RSI}	Linear thermal transmittance ψ W/mK
60	0.913	0.994
80	0.927	0.066
100	0.936	0.049
120	0.944	0.037

Table 1: Linear thermal bridging at an edge beam with EPS insulation externally

For 100mm of EPS externally which leads to a basic U value of 0.2 W/m²K, the ψ value at the beam line is about 0.05 W/mK. Dividing the ψ value by a floor to floor height of 3.5m leads to an increase in the effective U value of the wall of 0.014 W/m²K. This represents about a 7% additional heat loss in relation to the basic U value of the wall.

2. Steel H-section column in wall

Consider the case of a 200mm UKC column located within a light steel infill wall and with insulated render cladding using EPS insulation with a sheathing board external to the steel column. Mineral wool is contained between the C sections in the wall. The steel column is encased in a single layer of plasterboard for 30 minutes fire resistance. Two cases are considered: with or without mineral wool placed between the flanges of the steel H-section. The thermal profile for the case with mineral wool between the flanges is shown in Figure 3.

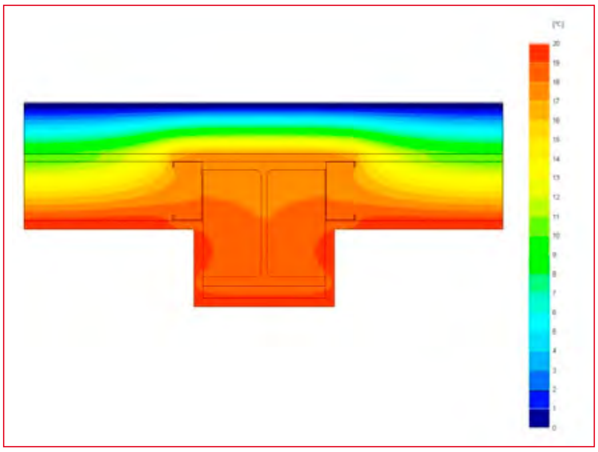

Figure 3: Thermal profile of steel column in an infill wall with mineral wool between the flanges

The linear thermal transmittance ψ is presented in Table 2 for the two cases. The linear thermal transmittance ψ is 0.055 W/mK for a column in a wall with a U value of 0.2 W/m²K, which is similar to the case of an edge beam. There is little difference between the cases with and without mineral wool infill. Dividing the ψ value by a column spacing of 6m gives an increase in the effective U value of the wall of 0.01 W/m²K, which is again relatively small and will add about 5% to the heat loss through the wall.

EPS thickness (mm) outside the C sections in the external wall	No insulation between flanges of steel section		With insulation between flanges of steel section
	f_{RSI}	Linear thermal transmittance ψ W/mK	Linear thermal transmittance ψ W/mK
60	0.932	0.103	0.098
80	0.946	0.074	0.070
100	0.954	0.055	0.053
120	0.961	0.044	0.042

Table 2: Linear thermal bridging for a 203UKC column in a wall with EPS insulation externally

The results show that thermal bridging can be determined in steel framed structures and leads to relatively low additional heat loss. Other cases examined in TABASCO were steel beams supporting brickwork by stainless steel angles and brackets, slim floor edge beams, rectangular hollow section edge beams and columns, and single point penetrations.

For more information on the results of TABASCO and capabilities in thermal modelling, contact Guillaume Vannier at SCI on 01344 636525.