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Thermal Bridging in Rainscreen Cladding

A simple rainscreen cladding support system typically consists of 'helping hand' brackets. These are the backbone of any rainscreen cladding system and are fixed to the substrate at set vertical and horizontal separations. A layer of insulation is then fixed to the substrate, and where the brackets are placed they penetrate directly through the insulation, forming what it is called a "*Point Thermal Bridge*". Aluminium 'L' and 'T' profiles are inserted into the brackets, lined, levelled and fixed. A ventilated layer behind the external façade material ensures the risk of condensation is minimised as well as dissipating solar gain in the building.

One of our recent projects included five mixed-use medium rise buildings. Commercial units occupy the lower levels, together with amenity space including outdoor landscaped podium areas and some residential units. The upper levels are residential use. The development consists of 467 residential units (planning use class C3); including a proportion of discount market rent units and circa 2000m^2 of flexible commercial/community space (use classes A1/A3) in new buildings ranging from 2 to 17 storey's in height.

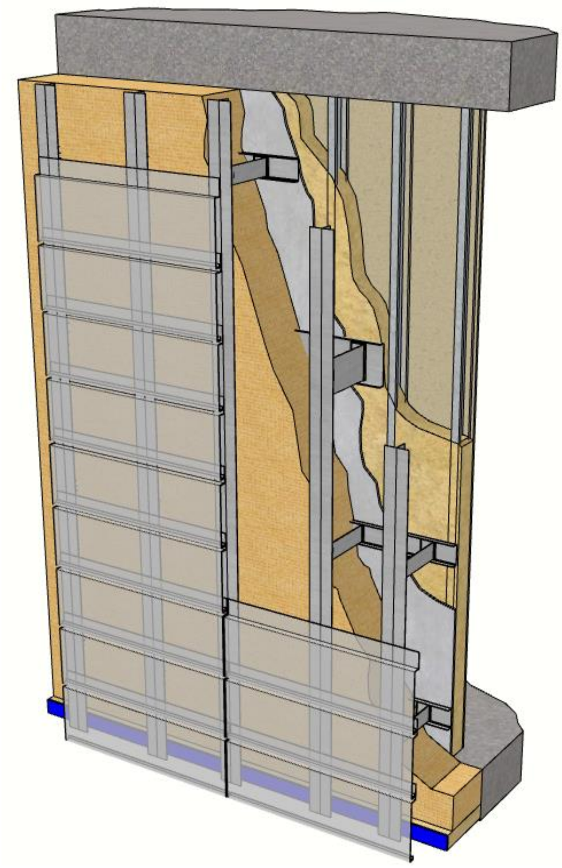

Figure 1 - Rainscreen cladding

Due to the Climate Change Act 2008 (CCA), the government introduced a policy for all new homes to be constructed to meet a zero carbon standard from 2016 onwards. This means that the average U-value for new construction elements nowadays is 0.13 - 0.18 W/(m^2*K). Our limiting value for this project is 0.15W/(m^2*K), which can be quite challenging for a rainscreen cladding.

If thermal bridging (see my Blog no. 1 for definition) weren't to be considered the overall U value for the rainscreen cladding, shown above, would be U = 0,11 W/(m^2*K). However, that would be incorrect.

The correction (ΔU) for thermal bridging must be applied to this value according to additional elements composing the rainscreen cladding:

- Mechanical Fasteners fixing the Rockwool Duo slab;
- Air gaps;
- Studs within SFS wall cavity (whether that is composed of air cavity or filled with insulation);
- Additional aluminium channels penetrating through the insulation;
- Aluminium Brackets (Point Thermal Bridge);

Thermal bridging tends to be especially significant in well-insulated buildings. Different studies carried out, have measured that thermal bridge heat loss generally represents around 30% of the primary energy consumption of a low-energy building. This is so significant that it can easily overcome the demand of solar hot water. The percentage of energy consumption increases further if we consider the cold bridging in rainscreen cladding systems. Discussions with one manufacturer of mineral fibre insulation have shown that in some cases the point thermal bridges represent up to 50% - 60% of the total energy consumption of the building.

A **Point Thermal Bridge** happens where there is a point penetration of the insulation layer, such as a fixing or a steel post or beam. Unlike linear thermal bridge [psi-value (ψ)], these need to be calculated three-dimensionally. A three-dimensional calculation (conforming to EN 10211 and BR 497) allows us to determine the additional heat loss at the point thermal bridge measured by the point thermal transmittance [Chi-value (χ)].

For the residential project mentioned above (Figure 1), the wall comprises of an SFS solution, an external wall infill that forms a secondary, lightweight structure, fixed onto the primary super-structure. To be more precise, our solution is a hybrid light steel-frame construction, where some insulation is fixed between the steel studs and further insulation is placed on the outside of the studs to reduce thermal bridging through the steel. The insulation chosen between the SFS is a typical Rockwool Flexi slab and outside of this, Rockwool Duo Slab has been chosen. More details about the building materials composing the rainscreen cladding can be found in the following table:

Table 1 – Building materials composing a typical rainscreen cladding

	Manufacturer	Name	Thickness [m]	Lambda [W/[m*K)]	R [m²*K/W]
	R_{se}				0.1300
1	BS EN 12524	Aluminium alloys	0.0030	160.000	~~0.0000~~
2	BS EN ISO 6946	Well ventlated air layer	0.0500	0.000	-
3	Rockwool Ltd	Rainscreen Duo-Slab (100-150mm)	0.2000	0.035	5.7143
	Fixings	Plastic insulation anchors No./m2. equivalent diameter: 0.01m	2.5/m^2	0.500	-
	Air gaps	Level 1: dU'=0.01 W/(m^{2}K)			
4	Inhomogeneous material layer	consisting of:		Ø 0.674	0.0742
4a	Rockwool Ltd	Rainscreen Duo-Slab (50-75mm)	99.60%	0.034	-
	Fixings	Plastic insulation anchors No./m2. equivalent diameter: 0.01m	2.5/m^2	0.500	-
	Air gaps	Level 1: dU'=0.01 W/(m^{2}K)			
4b	BS EN 12524	Aluminium alloys	0.40%	160.000	-
5	BS EN 12524	Cement-bonded particleboard	0.0120	0.230	0.0522
6	Light steel-frame	consisting of:	0.1000	Ø 0.138	0.7250
6a	Rockwool Ltd	Flexi (50-120mm) 600mm wide	99.80%	0.038	-
	Air gaps	Level 1: dU'=0.01 W/(m^{2}K)			
6b	BS EN 12524	Steel	0.20%	50.000	-
7	BS EN 12524	Polyethylene 0.15mm	0.0002	0.170	0.0009
8	BS EN 12524	Gypsum plasterboard	0.0250	0.250	0.1000
	R_{si}		.		0.1300

The BRE Digest 465 gives an approved simplified method to assess the U-values of a light steel-frame construction. Three different types of brackets were used to analyse the point thermal bridges effects:

- Aluminium brackets;
- Aluminium brackets with chi-gaskets;
- Stainless steel brackets;
- 'Thermo' brackets;

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The below tables show how the U-value for the rainscreen cladding would vary for various number of cladding support brackets per square metre. The table shows the effect of the number of brackets on U-value for various thicknesses of insulation in front of the cement particle board (CP board).

To simplify the analysis the space between the cladding and the CP board has been kept at a constant 300mm depth. This allowed us to use the same size brackets for all cases. It must be borne in mind in mind that different cavities with different size brackets and different thicknesses of insulation will result in different point thermal bridges (chi-values) - a time-consuming exercise in 3 dimensional analysis!

Aluminium brackets

Table 2 - Thermal performance of the rainscreen cladding with aluminium brackets

Aluminium Brackets	**Thermal Transmittance [W/[m²K]] based on thickness of insulation**						
Number of Brackets/storey	**180mm**	**200mm**	**220mm**	**240mm**	**260mm**	**280mm**	**300mm**
1	0.1627	0.1500	0.1394	0.1305	0.1228	0.1160	0.1102
2	0.1787	0.1660	0.1554	0.1465	0.1388	0.1320	0.1262
3	0.1907	0.1780	0.1674	0.1585	0.1508	0.1440	0.1382
4	0.2027	0.1900	0.1794	0.1705	0.1628	0.1560	**0.1502**
5	0.2147	0.2020	0.1914	0.1825	0.1748	0.1680	0.1622

If for instance we need 4 brackets per storey, a minimum of 300mm insulation is required to satisfy the initial requirement of 0.15 W/(m^2*K). This would also increase the cavity behind the aluminium panels in order to allow an air space.

Aluminium brackets + chi-gaskets

The Chi-Gasket is a component system allowing rainscreen installations to benefit from the low thermal conductivity values associated with aerogel (synthetic amorphous silica) insulants to reduce thermal bridging within the design. It offers superior thermal performance at reduced profile thickness compared to other insulation solutions. Results from the analysis are shown below:

Table 3 - Thermal performance of the rainscreen cladding with aluminium brackets + chi-gaskets

Aluminium Brackets + chi-gaskets	**Thermal Transmittance [W/[m²K]] based on thickness of insulation**						
Number of Brackets/storey	**180mm**	**200mm**	**220mm**	**240mm**	**260mm**	**280mm**	**300mm**
1	0.1486	0.1359	0.1253	0.1164	0.1087	0.1019	0.0961
2	0.1657	0.1530	0.1424	0.1335	0.1258	0.1190	0.1132
3	0.1737	0.1610	0.1504	0.1415	0.1338	0.1270	0.1212
4	0.1817	0.1690	0.1584	**0.1495**	0.1418	0.1350	0.1292
5	0.1897	0.1770	0.1664	0.1575	0.1498	0.1430	0.1372

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Carbon steel brackets

The following table is a predictive analysis of what we could expect if we used carbon steel brackets (conductivity λ=50 W/m*K):

Table 4 - Thermal performance of the rainscreen cladding with steel brackets

Steel Brackets	Thermal Transmittance [W/[m²K)] based on thickness of insulation						
Number of Brackets/storey	**180mm**	**200mm**	**220mm**	**240mm**	**260mm**	**280mm**	**300mm**
1	0.1552	0.1425	0.1319	0.1230	0.1153	0.1085	0.1027
2	0.1632	0.1505	0.1399	0.1310	0.1233	0.1165	0.1107
3	0.1692	0.1565	0.1459	0.1370	0.1293	0.1225	0.1167
4	0.1752	0.1625	**0.1519**	0.1430	0.1353	0.1285	0.1227
5	0.1812	0.1685	0.1579	0.1490	0.1413	0.1345	0.1287

Stainless Steel brackets

The table below is a predictive analysis of what we could expect if we used stainless steel brackets (conductivity much lower at λ=15 W/m*K):

Table 5 - Thermal performance of the rainscreen cladding with stainless steel brackets

Stainless Steel Brackets	Thermal Transmittance [W/[m²K)] based on thickness of insulation						
Number of Brackets/storey	**180mm**	**200mm**	**220mm**	**240mm**	**260mm**	**280mm**	**300mm**
1	0.1527	0.1400	0.1294	0.1205	0.1128	0.1060	0.1002
2	0.1580	0.1453	0.1347	0.1258	0.1181	0.1113	0.1055
3	0.1620	0.1493	0.1387	0.1298	0.1221	0.1153	0.1095
4	0.1660	**0.1533**	0.1427	0.1338	0.1261	0.1193	0.1135
5	0.1700	0.1573	0.1467	0.1378	0.1301	0.1233	0.1175

'Thermo' brackets

To minimize point thermal bridges it is possible to use "Thermo" brackets, a cheaper solution to stainless steel brackets, which are made of a polymer composite material, an extremely strong industrial compound with low thermal conductivity and as such they fully isolate the aluminium components. The result is that they reduce even further the heat flow through the rainscreen construction and improve the overall U-value performance of the façade. However, in many circumstances they do not have an adequate fire performance. Classification of reaction of fire in accordance with EN13501-1:2007+A1:2009 — Classified 'E' (Combustible). Consequently these brackets are no longer being marketed in the UK but we will examine their benefits below, purely for interest.

The table below is a predictive analysis of what we could expect if we used thermos-brackets:

Table 6 - Thermal performance of the rainscreen cladding with thermo brackets

'Thermo' Brackets	Thermal Transmittance [W/[m²K)] based on thickness of insulation					
Number of Brackets/storey	180mm	200mm	220mm	240mm	260mm	280mm
1	0.1484	0.1357	0.1251	0.1162	0.1085	0.1017
2	0.1607	0.1480	0.1374	0.1285	0.1208	0.1140
3	0.1657	0.1530	0.1424	0.1335	0.1258	0.1190
4	0.1697	0.1570	0.1464	0.1375	0.1298	0.1230
5	0.1757	0.1630	0.1524	0.1435	0.1358	0.1290

What happens if predictive analysis is not carried out?

If predictive analysis is not carried out, an additional 0.3 W/m^2*K must be added to the default U-value. This is in accordance with document BR 443 – "*Conventions for U-value calculations*", the guidance document produced by the Building Research Establishment. This greatly increases the calculated/assumed U-value for the wall as shown in the table below.

Table 7 - Thermal performance of the rainscreen cladding without predictive analysis

DU increment 0.3 W/m^2*K	Thermal Transmittance [W/[m²K)] based on thickness of insulation						
	180mm	200mm	220mm	240mm	260mm	280mm	300mm
	0.4477	0.4350	0.4244	0.4155	0.4078	0.4010	0.3952

As you will see, without a cold bridging analysis and predictive calculations the U-value will never satisfy the Building Regulations Part L minimum requirements.

We must all be serious about conserving power, energy and reducing CO2 emissions on our projects. The drive to reduce energy consumption in buildings places a greater emphasis on the performance of the Building Envelope, including all the components in the façade system. Minimising thermal bridging is a quick, smart and cost-effective way to limit the losses of performance, without requiring additional energy saving measures elsewhere.

Lastly it is important to say that the above predictive analysis will vary depending on the various parameters assumed for these tables. It should not be used for any project specific application. We would advise that a three-dimensional analysis must be performed for each individual project.

I hope this blog has been useful - please call me if you have any problems understanding anything!