

C4CI LIMITED  
CONSULTANTS FOR CONSTRUCTION INNOVATION

# Thermal Bridge Modelling

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## The Way to Maximise SAP Scores

C4Ci Energy and Sustainability Group

*“Committed to Providing Technical Solutions that Yield Deliverable Commercial Benefits”*



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The standard default assumptions adopted in the Building Regulations Part L1 SAP procedure are often conservative and therefore costly as the building structure could in reality be performing better than the defaults suggest. A more accurate picture can be obtained through thermo graphic modelling – this document explores the commercial benefits.

## Thermographic Junction Modelling versus SAP Defaults

Leaking energy from the structure → “cost leaks” → seeking other means of meeting CSH Code level 3 or 4 → increased cost in fabric or renewables

..... BUT what if the structure you already supply is actually NOT leaking energy as the defaults suggest.

There is only one way to find out...and this document will help you understand what this is and the commercial value this understanding can unlock.

What commercial benefit will Thermographic Junction Modelling bring to my business??

- Will it lower my build cost?
- Will it avoid ongoing costly (and unnecessary) renewable?
- Will I gain a more realistic understanding of how our structure is performing?
- Will this help our company improve our build profile overall?
- Can I sell on this value in the customer handbook, thereby improving our brand reputation?
  - It is certainly a value added sales pitch to show the homeowner that their new home is proven to be thermally efficient at every junction – who else is doing this?

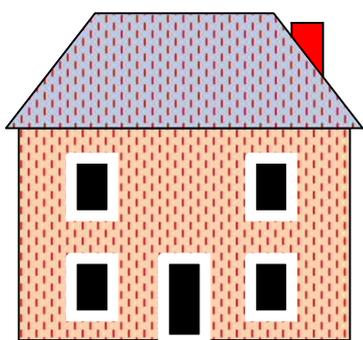
It is tempting when time is short and resources are stretched to take the well beaten default path and provide a status quo solution. It is often quicker and simpler to use default values; but the trouble with default values is that they compensate for worst case and therefore have a significant conservatism built into them. This embedded factor of safety is effectively a **“cost leak”** and will be making the structural system that you build more costly than it needs to be (view table in point 4 below). The fact is you could probably save a CSH point or two, and sometimes save the need to specify higher U-value walls or windows, or some form of costly and unnecessary renewable energy. Thermographic Modelling can now give you control over these cost items

The following sets out to clarify whether there is a value to undertaking a detailed analysis of junction details in your build structure, through Thermographic Modelling, as opposed to using the standard defaults embedded in the SAP calculation. At C4Ci we believe that there is huge potential in doing so, and by your reading of this document we believe that you will too.

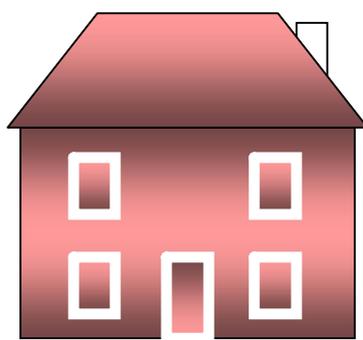
## 1) The Basics

In the SAP 2005 calculation heat loss occurs via 3 paths:

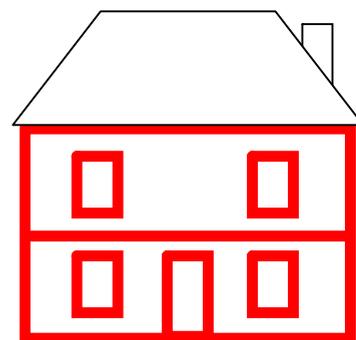
1. *Air leakage*– through open chimneys and flues, and through the ‘un-planned’ crevices and holes in the building fabric (Floors, walls, roofs, windows and doors)
2. *Thermal transmittance across the building fabric*– Heat flowing through the materials and air-gaps in the building fabric. Calculated using the traditional U-value calculation methods.
3. *Linear thermal bridging across the main element junctions*– Junctions between walls and walls, and walls and other elements tend to be denser than the elements themselves, packed with framing that often interrupts the insulation layer.



Air Leakage



Fabric losses



Thermal bridging losses

**Put very simply...**

**If you reduce heat loss → then you reduce the need for space heating → which will reduce CO<sub>2</sub> emissions**

The SAP 2005 calculation methodology now measures the amount of CO<sub>2</sub> produced from the home and Part L1 of the Building Regulations (England and Wales) requires the calculated emissions for new homes to be 20% lower than they were for a similar home constructed to the 2002 Regulations.

**The Code for Sustainable Homes requires a further 25% reduction to meet Code Level 3.**

To reduce heat loss (and therefore carbon emissions), you have 3 options:

1. Reduce air leakage losses – make the building more airtight
2. Reduce fabric losses – use building assemblies and components that offer lower U-values.
3. Reduce thermal bridging losses – the subject of this technical document

Reducing thermal bridging losses is perceived as the most difficult and cumbersome option and as such has been largely ignored. This technical document aims to redress that position and will outline a clear benefit to a more detailed approach being undertaken in this regard.

## 2) Thermal Bridging – The default approach

*Thermal bridging losses* are currently left to the SAP assessor to determine by plugging in one or the other of only two default (conservative) values:

$\gamma = 0.08$  if the junctions appear to be similar to the *Accredited Construction Details*, or;  
 $\gamma = 0.15$  if they do not.

By way of explanation the *y-value* is a sort of modified U-value that is used in the SAP calculation as follows:

**Total thermal bridging losses =  $\gamma \times$  total exposed area of the dwelling (W/k )**

ie. Thermal bridging losses equate to 8% of the exposed area of the building if accredited construction details are used, or 15% of the building area otherwise.

The  $\gamma$ -value method does not take into account the number or size of doors and windows, nor does it take into account length or type of junctions that the dwelling has. It is a very simple but very blunt instrument to satisfy the requirement.

An alternative more complicated method is to calculate thermal bridging losses by multiplying the length of each thermal bridge by its linear thermal transmittance  $\Psi$  W/m.k.

Table 3 is extracted from BRE IP 1/06. It shows the range of junction details likely to be found in a dwelling, and the default  $\Psi$  value assumed for each of these junctions if they conform to the Accredited Construction Detail. These are likely to be conservative, for example there is no provision for non-metal lintels.

If the total linear thermal losses for all the junctions in a house are calculated in this way using the  $\Psi$  values, then if this loss is divided by the total exposed area of the dwelling, then an equivalent  $\gamma$ -value for the house will have been derived. In the case of the accredited construction details, using the  $\Psi$  values opposite on typical junction lengths for houses with typical exposed areas, should provide a  $\gamma$ -value of 0.08.

**Table 3 Default values of  $\Psi$  for junctions in wall constructions in Accredited construction details<sup>[5]</sup>**

Junction detail in external wall	Default $\Psi$ -value (W/m-K)
Steel lintel with perforated steel base plate	0.50
Other lintels (including other metal lintels)	0.30
Sill	0.04
Jamb	0.05
Ground floor	0.16
Intermediate floor within a dwelling	0.07
Intermediate floor between dwellings*	0.14
Balcony within a dwelling†	0.00
Balcony between dwellings*†	0.04
Eaves: insulation at ceiling level	0.06
Eaves: insulation at rafter level	0.04
Gable: insulation at ceiling level	0.24
Gable: insulation at rafter level	0.04
Corner: normal	0.09
Corner: inverted	-0.09
Party wall between dwellings*	0.06

\*For these junctions half of the  $\Psi$ -value is applied to each dwelling.

†This is an externally supported balcony (ie the balcony slab is not a continuation of the floor slab) where the wall insulation is continuous and not bridged by the balcony slab.

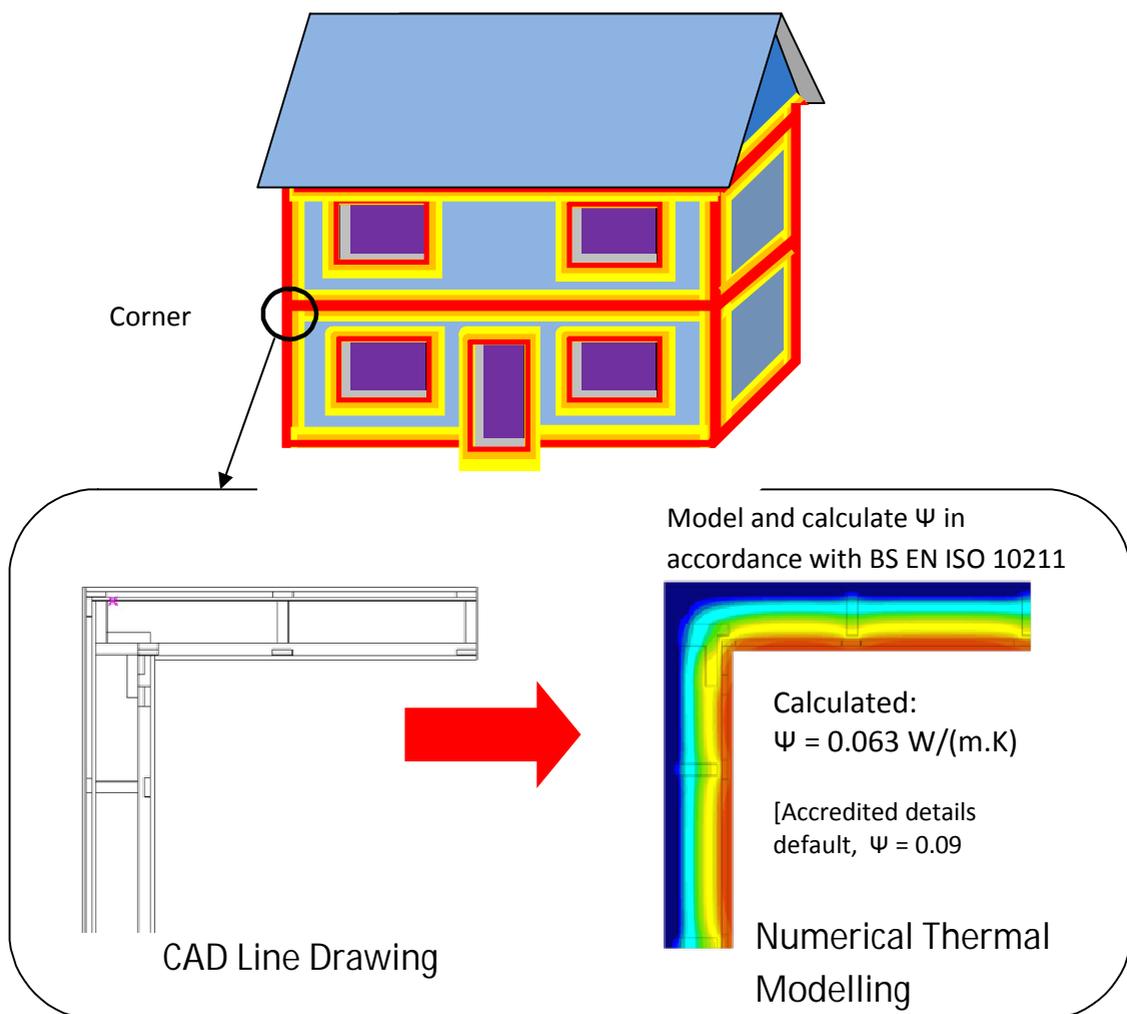
3) Is There an Alternative Method of Calculating Thermal Bridging Losses?

Appendix K of the SAP 2005 Specification states however, that as an alternative to using the default  $\Psi$  values :

Alternatively values of  $\Psi$  can be determined from the results of numerical modelling, or they can be derived from measurement.

Values of  $\Psi$  for particular cases should be calculated in accordance with BRE IP 1/06, *Assessing the effects of thermal bridging at junctions and around openings*, and BR 497, *Conventions for calculating linear thermal transmittance and temperature factors*.

The following diagram illustrates how numerical modelling can be used to calculate custom values of  $\Psi$  using tools and methods that meet the requirements of BRE IP 1/06.



#### 4) The Benefits of using Calculated $\Psi$ -values Instead of the SAP Defaults.

If your building system has struggled to meet the basic Part L1A requirement of DER < TER (Target Emission Rate), then having the junction  $\Psi$ -values calculated may unlock some untapped thermal performance within the current system specification. The system may have a  $\gamma$ -value well below the default values. For example, on a detached house, if the true  $\gamma$ -value for your construction was say 0.04, changing to this value from the Accredited Details default value of 0.08 would save 7% in the space heating requirement, and changing from the backstop value of 0.15 will save 17% on the space heating requirement.

Here are list of reasons to consider deriving specific  $\Psi$ -values for your build system junctions:

1. If the build system does not comply with the *Accredited Construction Details* it really takes a big hit with  $\gamma = 0.15 \text{ W/m}^2\cdot\text{K}$  and meeting Part L1A, DER < TER will be harder than it should be.
2. If the build system meets or exceeds the *Accredited Construction Details* the calculated  $\gamma$ -values are likely to be lower than  $0.08 \text{ W/m}^2\cdot\text{K}$ , meaning you don't have to work so hard with envelope U-values, or airtightness to meet CSH targets. For the client, less reliance on renewable and low carbon technology will often result.
3. Calculated  $\Psi$ -values for standard build system junctions may be used to identify parts of the system that can be improved at relatively small additional cost to minimise thermal bridge heat loss. The cost of calculating  $\Psi$ -values for your build system is **a one-off**.
4. Popular House Types need only to have the custom  $\gamma$ -value **calculated once**. As soon as this  $\gamma$ -value has been confirmed it can be printed on the standard drawings for the house type and applied to multiple builds on any development. The analysis cost is therefore a one-off for each house type.
5. When lower  $\gamma$ -values are used in the SAP calculation the reduction in CO<sub>2</sub> emissions that result can be used to either:
  - a. make cost savings elsewhere in the system, or:
  - b. contribute to meeting higher levels prescribed in the Code for Sustainable Homes.

The impact that the  $\gamma$ -value will have varies dependent on the type of dwelling. The influence of changing the  $\gamma$ -value will be roughly in proportion to the ratio of the volume of the dwelling to the external wall area. Therefore detached houses will benefit more than narrow fronted mid-terraces and some flats for example. Also if the main space heating fuel is electricity any reduction to the space heating load will have a greater impact on calculated CO<sub>2</sub> emissions than for other fuels such as gas.

#### 4) Continued : The Benefits of using Calculated $\Psi$ -values Instead of the SAP Defaults.

Typically, reducing the  $\gamma$ -value from 0.08 to 0.04 will reduce CO<sub>2</sub> emissions by 2% to 5%. This may not sound a lot, but to put it in context the following table quantifies the alternative measures that could be employed to achieve the same reduction. These measures will all have costs associated with them for every dwelling constructed.

Dwelling Type	Detached	Semi-detached	Mid terrace	Mid Floor Flat (gas)	Mid Floor Flat (electric)
Reducing the $\gamma$ -value from 0.08 W/m <sup>2</sup> .K to 0.04 W/m <sup>2</sup> .K is equivalent to:	Reducing all window U values by <sup>1</sup> :				
	0.42 W/m <sup>2</sup> .K	0.38 W/m <sup>2</sup> .K	0.44 W/m <sup>2</sup> .K	0.28 W/m <sup>2</sup> .K	0.28 W/m <sup>2</sup> .K
	Reducing all external wall U values by <sup>2</sup> :				
	0.09 W/m <sup>2</sup> .K	0.10 W/m <sup>2</sup> .K	0.09 W/m <sup>2</sup> .K	0.04 W/m <sup>2</sup> .K	0.04 W/m <sup>2</sup> .K
	Increasing the area of photo-voltaic panels by <sup>3</sup> :				
	2.93 m <sup>2</sup>	2.01 m <sup>2</sup>	1.10 m <sup>2</sup>	0.43 m <sup>2</sup>	0.80 m <sup>2</sup>

Notes:

1. Reducing window U-values by 0.3 – 0.4 could be the difference between double and triple glazing
2. Reducing wall U-values by 0.1 would usually require the insulation thickness to be doubled.
3. Installed PV systems cost around £ 800 /m<sup>2</sup>