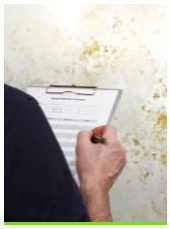
Mastering Psi-Values and Thermal Bridging in Retrofit

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1

Overview

- **What is a thermal bridge?**
  - Repeating or non-repeating, how they are dealt with
- **Standards for assessing thermal bridging**
  - EN ISO 10211: 2017 and BR497
- **IP1/06 and the importance of the temperature factor fRsi**
- **Examples of what this means in reality**
- **The impact of calculated Psi Values on energy modelling and EPCs**
- **Elmhurst's Competency Scheme and Training Options**
- **Q&A**



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2

Thermal Bridging and the Importance of Detailing

- Thermal bridge – informal term given to part of a building where there is an **increased concentration of heat flow** compared to adjacent parts.
- Creates areas of **reduced temperature at internal surfaces** as heat transfers away more readily.
  - (i.e. often called 'cold bridging' cold doesn't bridge, heat does, it should be referred to as Thermal Bridging)
- If temperatures become too low, **risk of surface condensation**, potentially leading to mould growth on adjacent surfaces.



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Thermal Bridging

- A thermal bridge is created when materials that are **poor insulators** come in contact, allowing heat to flow through the path created.
- Insulation around a bridge is of little help in preventing heat loss or gain due to thermal bridging; **the bridging has to be eliminated**.
- As insulation in buildings increases, materials which would not historically have been thermal bridges become a problem.
- To eliminate a thermal bridge, you either need to:
  - **Reduce the cross-section**
  - **Substitute materials** that have better insulating properties
  - Or **add additional insulating components**



Thermal bridging

4.36 Thermal bridges occur when an area of a building has significantly higher heat transfer than the surrounding parts. Breaks in insulation, reduced insulation or more conductive materials can contribute to thermal bridge effects. The building fabric should be constructed so that thermal bridging, including at the party wall, is reasonably limited.

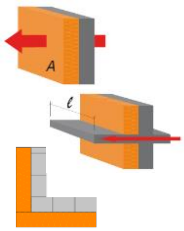
Thermal bridging in existing dwellings

4.39 When carrying out work in existing dwellings, care should be taken to reduce unwanted heat loss through thermal bridging. Thermal bridges can be limited in an existing dwelling by following the junction details from a reputable non-government database containing independently assessed thermal junction details, such as Local Authority Building Control's Construction Details library. Follow the guidance in paragraph 417 where appropriate.

4

Types of Thermal Bridge

- **Repeating thermal bridges**
  - For example, where bridges occur following a regular pattern, such that made by wall ties penetrating a cavity wall. Dealt with in the U value as well as repeating timber studs.
- **Non-repeating thermal bridges**
  - Such as the bridging of a cavity wall by a single lintel, dealt with as a length of repeating bridge.
- **Geometrical thermal bridges**
  - As at the junction of two planes, such as at the corner of a wall.

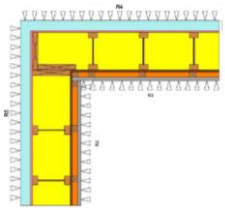


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Repeating Thermal Bridge

- Dealt with in the U value

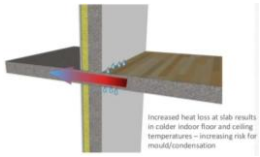


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Non-repeating Thermal Bridge

- Dealt with as a thermal bridge and the value of the thermal bridge is multiplied by its repeating length to calculate the heat loss correction if used in new build or PH and the temperature factor is used for ascertaining the fRsi value.

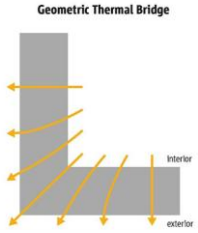


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Geometrical Thermal Bridge

- Dealt with as a thermal bridge and the value of the thermal bridge is multiplied by its repeating length to calculate the heat loss correction and temperature factor
- Depending on its relationship with other potential thermal bridges it may require 2D or 3D modelling. Refer to EN10211 for guidance on symmetry planes.



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Rules for Modelling – EN 10211



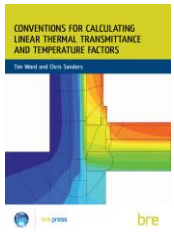
BS EN ISO 10211[7] sets outs criteria for carrying out numerical calculations, covering both three- and two-dimensional numerical modelling of building details. It provides specifications of the geometrical model and boundary conditions together with accuracy criteria for the solution technique adopted. It gives methods for the calculation of heat flows and surface temperatures and includes the method for deriving linear thermal transmittance values. Guidance on appropriate modelling techniques is in preparation[8].

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Rules for Modelling BR497 & IP1/06

- Delivers a standard methodology for assessing thermal bridging
- Ensures consistency irrespective of the software used
- Sets the fRsi for a number of building types
- Sets out the methodology for meeting the requirements of the Building Regulations



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Rules for Modelling

7.2 Rules for modelling

7.2.1 General

It is not usually feasible to model a complete building using a single geometrical model. In most cases, the building is partitioned into several parts (including the subsoil, where appropriate) by using cut-off planes. This partitioning shall be performed in such a way that all differences are avoided in the results of calculation between the partitioned building and the building when treated as a whole. This partitioning into several geometrical models is achieved by choosing suitable cut-off planes.

7.2.2 Cut-off planes for a 3-D geometrical model for calculation of total heat flow and/or surface temperatures

The geometrical model includes the central element(s), the flanking elements and, where appropriate, the subsoil. The geometrical model is delimited by cut-off planes.

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Rules for Modelling

Cut-off planes shall be positioned as follows:

— at a symmetry plane if this is less than d_{min} from the central element (see Figure 5);

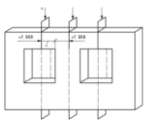
— at least d_{min} from the central element if there is no nearer symmetry plane (see Figure 6);

— in the ground, in accordance with 7.2.4

where d_{min} is the greater of 1 m and three times the thickness of the flanking element concerned.

A geometrical model can contain more than one thermal bridge. In such cases, cut-off planes need to be situated at least d_{min} from each thermal bridge, or need to be at a symmetry plane (see Figure 6).

Dimensions in millimetres



Key

* Arrows indicate the symmetry planes.

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When is it a 2D model and when is 3D needed?

Figure 1 — 3-D geometrical model with five 3-D flanking elements and one 3-D central element



Key
F1, F2, F3, F4, F5 3-D flanking elements

NOTE F2 to F5 refer to Figure 1.

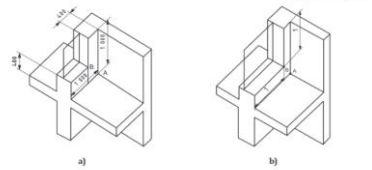
Figure 2 — Cross-sections of the 3-D flanking elements in a 3-D geometrical model treated as 2-D geometrical models

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When is it a 2D model and when is 3D needed?

Dimensions in millimetres



Key
1 1 000 mm or at a symmetry plane
A thermal bridge at the corner of the internal room
B thermal bridge around the window in the external wall

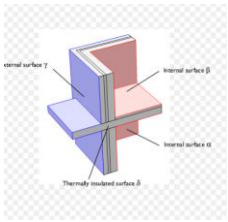
BS EN ISO 10211:2017
ISO 10211:2017(E)

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Rules for Modelling

- Simple junctions like window, head, sill and jambs then 2D is typically sufficient
- Complex junctions where multiple thermal bridges exist within a given symmetry plane or within 1000mm require a 3d model
- Hi Rise typically always require 3d modelling, given the nature of their framed construction



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fRsi – Temperature Factor

- **In simple terms, fRsi, or the surface temperature factor, tells us how warm or cold a surface in a building gets compared to the indoor air temperature.**
- The temperature factor f*Rsi (fRsi) : the difference between the interior surface temperature θsi of a component and exterior air temperature θe, divided by the difference of temperatures between interior air θi and exterior air θe. The surface temperature is to be determined with some well-defined surface resistance Rsi :
  - **Θ = f*Rsi = (θsi - θe) / (θi - θe)**
- The calculation of the interior surface temperature °C can be then be derived from following the equation:
  - **θsi = f*Rsi • (θi – θe) + θe**

Where:
θsi [°C] – interior surface temperature
θe [°C] – exterior air temperature
θi [°C] – interior air temperature

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Why is the fRsi Important?

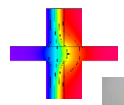
- The surface temperature factor (fRsi) is **closely linked to the possibility of condensation in buildings**. When a surface inside a building gets too cold compared to the indoor air temperature, it increases the risk of condensation forming on that surface. This happens because the colder surface can cause moisture in the air to turn into water droplets when it meets it.
- So, if the fRsi value is low, indicating that the surface temperature is significantly cooler than the indoor air temperature, there's a higher chance of condensation occurring on that surface. This can lead to issues like **mould growth, dampness, and damage to building materials over time**. fRsi factor ranges from 1 to 0. fRsi=1 means that the internal surface temperature at the thermal bridge is the same as the rest of the house. fRsi=0 means the internal surface temperature at the thermal bridge is the same as the outside temperature, this is a bad result.
- **The best result to obtain for fRsi is closest to 1. For dwellings, fRsi should be maintained above 0.75 to avoid the risk of mould growth.**

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Problems Caused by Thermal Bridges

- **Increased heat loss**
  - Simply thermal bridges have lower insulation value than the surrounding areas.
- **Condensation**
  - Because of the increased heat loss, thermal bridges produce areas on a wall with lower temperatures than those around it leading to possible condensation risk
- **Thermal Comfort**
  - Draughts
- **Pattern Staining**
  - Caused by convection



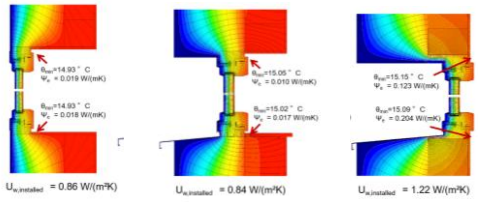




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Window Installation Position

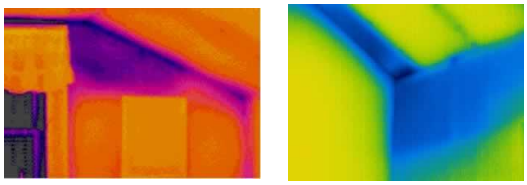


There is no point in using the best window if it is **installed badly**!

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Thermal Bridge: Insulation Issues



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How can Thermal Bridges be Minimised?



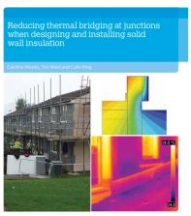
- If penetration of the insulation layer is unavoidable, then the thermal conductivity of the penetration materials should be as **low** as possible.
- Materials with a low thermal conductivity include **plastic**, **wood**, **recycled PU materials etc**.

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Thermal Bridging and the Importance of Detailing

- BRE report FB61, 'Reducing thermal bridging at junctions when designing and installing solid wall insulation', *Weeks, Ward, King, 2013*
- This guide sets out principles and methods to reduce thermal bridging at key junctions during the design and installation of solid wall insulation to:
  - Save more energy
  - Reduce condensation risk - Condensation risk at 'critical level' if f_{Rsi} <0.75

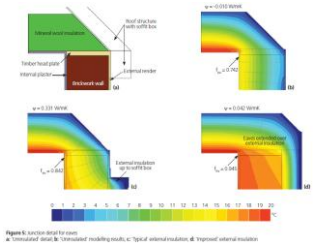


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Key Junctions: EWI at Eaves

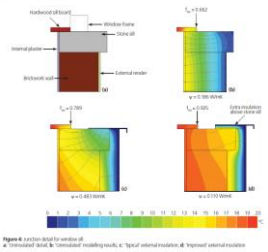
- Typically, eaves not extended to cover EWI
- 'Step out' usually remains around rainwater goods
- Thermal bridging and condensation risk reduced by extending eaves
- NB: Condensation risk would be close to critical level in (c) if slate head plate! (f_{Rsi} = 0.77)



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Key Junctions: EWI at Window Sill



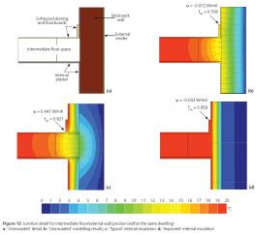
- Similar phenomena at window jamb and concrete window head
- Thermal bridging (ψ) and risk of surface condensation (f_{Rsi}) significantly reduced by extra insulation at sill
- Could be further improved if concrete sill cut back flush with wall prior to insulation

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Key Junctions: IWI at Intermediate (timber) Floor

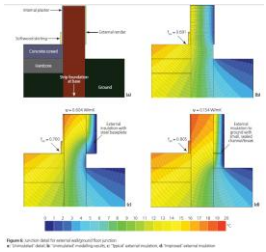
- Type of intermediate floor important:
- Bridging will be far higher with concrete intermediate floor but unavoidable
- If timber joists on hangars (as here) improved by insulating between joists (d)
- If timber embedded in solid wall, **high risk of rot/ decay to timber ends if any moisture present**
  - Is there adequate weather protection?



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Key Junctions: EWI at External Wall/Ground Floor



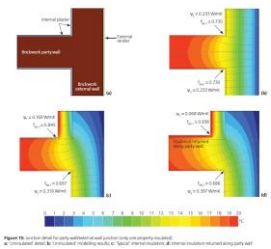
- Typically, insulation stops short of ground to allow for damp proof course and includes steel baseplate (c)
- Significant thermal bridge and temperature factor below 'risk' level of 0.75
- In (d), small channel in EWI to break capillary action of moisture behind insulation from ground to retain DPC

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Key Junctions: IWI at Party Wall with Neighbouring Dwelling

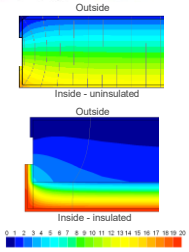
- When insulating one property internally but not its neighbour, the risk of condensation (when f_{Rsi} <0.75) may increase in neighbouring dwelling
- Returning insulation along party wall makes situation worse, so although improves bridging, may be detrimental on the whole



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Moisture Concerns with Internal Wall Insulation (IWI)

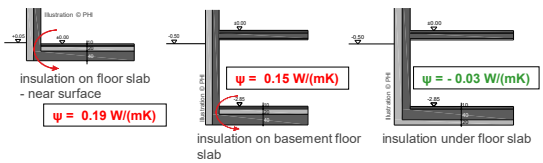


- Internally applied insulation captures heat within the room and prevents it from transferring into the wall behind
- Can see that in the insulated wall, the 'colder' colours apply to the bulk of the wall; the temperature of the wall is considerably lower than the surface temperature in the room
- If moisture can reach these cold areas, condensation can form
- No heat migration to dry this out
  - interstitial condensation behind insulation
  - potential frost damage within wall from external moisture

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Thermal Bridges: Floor Slab / Foundation

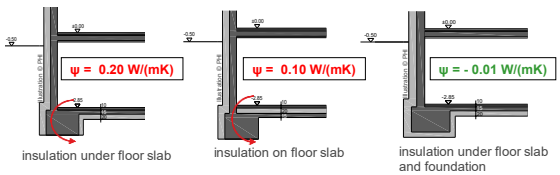


thermal bridge free: ψ = 0.01 W/(mK)

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Thermal Bridges: Floor Slab / Foundation



thermal bridge free: ψ = 0.01 W/(mK)

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A Good Example of a Window Installation When Using External Insulation



- Frame in the insulation level before the before insulation applied
- Screw attachment with metal brackets
- Adhesive tape for sealing
- Load transfer to the square-shaped timber

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IMPACT ON ENERGY MODEL

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Impact on Energy Model

- Linear thermal bridging can have a significant impact in SAP assessments.
- RdSAP does not permit assessment of linear thermal bridging but SAP does.
- SAP software allows entry of psi values and lengths to calculate heat loss from bridging.
- Useful for Retrofit to show improvements of good details.

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Impact on Energy Model

- Upgraded 1900's mid terrace.
- Solid wall insulation, replaced glazing.

Scenario	EPC Rating	Carbon Emissions (t/yr)
RdSAP default (y-0.2 Wm^2K)	68 D	2.13
Improved details (y-0.04 Wm^2K)	72 C	1.92

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ELMHURST'S PSI VALUE COMPETENCY SCHEME

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Intro to the scheme

- Scheme is aimed at:
  - Practicing accredited energy assessors and retrofit professionals
  - Construction professionals e.g. architects, developers and designers
  - Existing Psi Value modellers
- Requirements
  - Must have your own PI insurance
  - Must have completed Elmhurst's competency training course and competency assessment in either AutoPsi or TRISCO

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Benefits of the Competency Scheme

- Course fee covers entry fee
- Become part of the only UK's industry list of Psi Value modellers
- Additional credibility of your Psi Value calculations
- Added to Elmhurst's "Find an assessor" – Over 10,000 searches in 2024.
- Elmhurst are promoting the scheme and members to industry
- Elmhurst Psi Value Competency Scheme logo
- Technical support and guidance

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Benefits of the scheme



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2D Psi-Value Training (AutoPSI)

- Automates PSI value calculations using 2D modelling.
- Quick, accurate results without complex manual modelling.
- Key Features:
  - User-friendly interface
  - Faster workflow
  - Ideal for standard junctions



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2D & 3D Psi-Value Training (TRISCO)

- Advanced 3D thermal modeling for complex junctions.
- Detailed analysis for bespoke or intricate designs.
- Key Features:
  - Handles complex geometries
  - High accuracy for thermal bridges
  - Suitable for advanced projects



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THANK YOU FOR LISTENING

Any Questions?

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