An introductory guide to thermal bridging in homes
Further copies of this guide are available as a PDF download from [www.zerocarbonhub.org](http://www.zerocarbonhub.org).

Or contact us:

**Zero Carbon Hub**  
Layden House  
76-86 Turnmill Street  
London EC1M 5LG  
T: 0845 888 7620  
E: info@zerocarbonhub.org

**C4Ci Consultants**  
Expert and approachable technical consultants on building performance, thermal modelling, construction product development and accreditation.  
T: 01256 892211  
E: luke.whale@c4ci.eu

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The Zero Carbon Hub is very grateful to the following contributors/organisations for their involvement in developing this Guide.

**Author**  
Dr. Luke Whale, C4Ci Consultants

**Project Advisors**  
Rob Pannell, Tessa Hurstwyn, Ben Griggs, Zero Carbon Hub

**Graphic Design and Illustration**  
Richard Hudson, [www.richardhudson.me](http://www.richardhudson.me)

**Steering Group**  
Richard Bayliss, CITB  
Andrew Carpenter, Structural Timber Association  
Chris Carr, Federation of Master Builders/Carr & Carr Builders  
Darren Dancey, Crest Nicholson  
Tom Dollard, Pollard Thomas Edwards  
Milicia Kitson, Constructing Excellence in Wales  
Mike Leonard, Building Alliance  
Paul McGivern, Homes & Communities Agency  
Andrew Orriss, SIG Plc  
Richard Partington, Studio Partington  
Graham Perrior, NHBC  
John Slaughter, Home Builders Federation  
Barry Turner, LABC
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The Technical Annex can be found in the electronic version of this Guide available at www.zerocarbonhub.org
This document provides a simple guide to what thermal bridging is, the key construction details in new build housing where thermal bridging is particularly significant, examples of ways in which heat loss can be reduced by changes to the design and construction of these details, and the problem areas to avoid on site.

It is intended to help designers and builders focus on the key decisions that they can affect around junction detailing which will have a direct bearing on the performance of the new homes they help to deliver.

This Guide begins with a few explanatory pages describing what thermal bridges are and how their effects are quantified.

Key construction details are then illustrated for both masonry and timber frame construction showing how their thermal performance can either be improved or compromised by adopting alternative construction details, material specifications or site practices. This is the main part of the document.

The electronic version of this Guide also contains an Annex aimed at those who would like further information, covering: general principles to improve junction performance, the benefits in SAP of improved junction details, illustrated guidance to identify all relevant linear thermal bridges, how to establish the key junctions for a particular dwelling type, and a summary of the results of the PSI-value modelling work carried out for this Guide.

Please Note

⚠️ The details drawn in this Guide are for illustrative purposes only and should not be used as working drawings. For example, consideration must also be given to structure, waterproofing, airtightness, general good practice and sequencing on site.

⚠️ The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.

Various sources exist to obtain PSI-values for the building junctions of interest, as follows:

- Generic industry sponsored libraries covering the common building types e.g. LABC (http://www.labc.co.uk/registration-schemes/construction-details) or Scottish Standards (http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/publications/pubtech)

- Individual product or building system manufacturer sponsored libraries, covering specific building products/systems.

- Bespoke PSI-values calculated by ‘competent persons’ for specific developments.
UNDERSTANDING THE DETAIL PAGES

Construction detail type (with SAP Table K1 reference)

Primary responsibility: Designer Builder

Blue themes = base construction (assumed starting point)

Green themes = possible design improvements

Red themes = problem areas to be avoided and checked on site

Guide PSI-values are displayed in theme coloured circles

For indicative purposes only, black mould risk is identified where this becomes a likely consequence of problem details

Heat loss path illustrated by blue arrows

Construction type:

- Masonry
- Timber Frame
WHAT ARE THERMAL BRIDGES?

A thermal bridge (sometimes called a cold bridge) is a localised weakness or discontinuity in the thermal envelope of a building. They generally occur when the insulation layer is interrupted by a more conductive material.

The type of thermal bridges considered in this Guide are called non-repeating or linear thermal bridges. These occur at junctions between elements, such as a wall and a floor or a window and a wall. At these locations heat is more able to transfer through the construction, resulting in greater heat loss from the dwelling and localised ‘cold spots’ in the building envelope.

Improving junction details to reduce linear thermal bridging will help achieve Building Regulations compliance and is one component in achieving healthy low energy homes.

THE EFFECTS OF THERMAL BRIDGES

Increased heat loss
Thermal bridges can account for 20-30% of the heat loss in a typical new build home. As homes become better insulated thermal bridges become even more significant.

Localised ‘cold-spots’
Sometimes leading to condensation build-up or mould growth.

REPEATING AND NON-REPEATING THERMAL BRIDGES

There are two types of thermal bridges in buildings - repeating and non-repeating thermal bridges.

Examples of repeating thermal bridges are mortar joints and wall-ties in masonry construction or timber or steel studs in framed construction. Where the frequency of these is known and consistent their effects can be accounted for directly in the U-value calculation for the building element itself.

The remaining non-repeating thermal bridges are dealt with by “PSI-values” – pronounced ‘Si’ (silent p), and designated by the Greek letter ‘ψ’. Their effects on heat loss are calculated by thermal modelling software, and they are accounted for separately in SAP calculations in addition to U-values.

KEY JUNCTIONS

Although there are many junctions within a dwelling, some have extremely low PSI-values and others occur over very short lengths. The key junctions to ‘get right’ or improve are those which either have a high PSI-value or occur frequently over significant lengths. Although the particular junctions of interest will vary depending on dwelling type and design, this Guide covers the key junctions considered by the authors to be the most significant across a range of dwelling types.
The sum of the individual junction heat losses divided by the total exposed surface area of the dwelling gives the \( Y \)-value. The \( Y \)-value expresses the overall heat loss arising from all of the building junctions as an equivalent U-value for the dwelling.

- **Element Losses**
  - **U-values** (W/m\(^2\)K)
  - Quantify the heat loss from each of the external building elements such as floors, walls, windows, doors etc. The area of each element multiplied by its **U-value** gives its anticipated heat loss.

- **Thermal Bridge Losses**
  - **PSI-values** (W/mK)
  - Quantify the heat loss from each of the junctions where the building elements meet (thermal bridges). Multiplying the junction **PSI-value** by the junction length gives the junction heat loss.

- **Dwelling Y-value** (W/m\(^2\)K)
  - The sum of the individual junction heat losses divided by the total exposed surface area of the dwelling gives the **Y-value**.

In SAP fabric heat loss is quantified by a combination of **U-values** and **Y-values**.

\[
\text{TOTAL FABRIC HEAT LOSS} = \text{ELEMENT LOSSES} \times \text{ELEMENT AREAS} + \text{THERMAL BRIDGE LOSSES} \times \text{TOTAL EXPOSED SURFACE AREA}
\]

Note: Lower **U-values**, **Y-values** and **PSI-values** will result in lower fabric heat loss.
MASONRY CONSTRUCTION
## KEY DESIGN RECOMMENDATIONS

<table>
<thead>
<tr>
<th>Design recommendation</th>
<th>No. of junctions affected</th>
<th>Junction references</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use a split or thermally broken lintel</td>
<td>1</td>
<td>E2 (page 8)</td>
</tr>
<tr>
<td>2. Use light aggregate blockwork inner leaf</td>
<td>4</td>
<td>E5, P1, E12, P4 (pages 12, 14, 18, 20)</td>
</tr>
<tr>
<td>3. Use a PU/PIR cavity closer</td>
<td>3</td>
<td>E2, E3, E4 (pages 8, 10)</td>
</tr>
<tr>
<td>4. Use insulated plasterboard on the inner leaf</td>
<td>5</td>
<td>E2, E4, E10, E12, P4 (pages 8, 10, 16, 18, 20)</td>
</tr>
<tr>
<td>5. Use a window frame overlap of min. 50mm</td>
<td>3</td>
<td>E2, E3, E4 (pages 8, 10)</td>
</tr>
<tr>
<td>6. Increase eaves insulation depth</td>
<td>1</td>
<td>E10 (page 16)</td>
</tr>
</tbody>
</table>

## KEY PROBLEMS TO AVOID

<table>
<thead>
<tr>
<th>Problem / site check</th>
<th>No. of junctions affected</th>
<th>Junction references</th>
<th>Black mould risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Omitting rafter insulation at eaves</td>
<td>1</td>
<td>E10 (page 16)</td>
<td></td>
</tr>
<tr>
<td>2. Omitting insulation between truss and wall</td>
<td>2</td>
<td>E12, P4 (pages 18, 20)</td>
<td></td>
</tr>
<tr>
<td>3. Omitting soffit insulation at eaves</td>
<td>1</td>
<td>E10 (page 16)</td>
<td></td>
</tr>
<tr>
<td>4. Stopping party wall cavity insulation short of loft</td>
<td>1</td>
<td>P4 (page 20)</td>
<td></td>
</tr>
<tr>
<td>5. Swapping a split lintel with a perforated steel lintel</td>
<td>1</td>
<td>E2 (page 8)</td>
<td></td>
</tr>
<tr>
<td>6. Omitting the cavity closure</td>
<td>3</td>
<td>E2, E3, E4 (pages 8, 10)</td>
<td></td>
</tr>
<tr>
<td>7. Omitting cavity insulation below DPC</td>
<td>2</td>
<td>E5, P1 (pages 12, 14)</td>
<td></td>
</tr>
<tr>
<td>8. Omitting floor perimeter insulation</td>
<td>2</td>
<td>E5, P1 (pages 12, 14)</td>
<td></td>
</tr>
<tr>
<td>9. No window frame overlap with cavity</td>
<td>3</td>
<td>E2, E3, E4 (page 8, 10)</td>
<td></td>
</tr>
</tbody>
</table>
Use a cavity closer with a PU/PIR insulation core to improve performance for independent lintels.

Use an insulated plasterboard reveal to improve performance for perforated steel lintels.

NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
**PROBLEM TO AVOID**

Omitting the cavity closer makes heat loss significantly worse.

ψ 0.26

Cavity closer omitted

---

**PROBLEM TO AVOID**

Reducing the frame overlap to 0mm makes heat loss worse.

ψ 0.15

Window frame positioned flush with inside face of brickwork

---

**PROBLEM TO AVOID**

Reducing the frame overlap to 0mm makes heat loss worse.

ψ 0.31

Window frame positioned flush with inside face of brickwork

---

**FURTHER NOTES**

**LINTEL SELECTION**

Independent lintels have $\Psi$-values approximately $\Psi = 0.2$ lower than perforated steel lintels.

**FRAME OVERLAP**

Increasing the frame overlap from 30mm to 50mm will also reduce the $\Psi$-value of lintels, sills and jambs by approximately $\Psi = 0.02$. 
NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
Reducing the frame overlap to 0mm makes heat loss worse for sills.

Reducing the frame overlap to 0mm makes heat loss worse for jambs.

Omitting the cavity closer makes heat loss worse for sills.

Omitting the cavity closer makes heat loss worse for jambs.
Use lightweight aggregate blockwork on the inner leaf to improve ground floor performance.

**BASE DETAIL**

**IMPROVED DETAIL**

Dense aggregate blockwork
25mm perimeter insulation

Low density lightweight aggregate blockwork (density up to 900 kg/m³)

**GROUND BEARING FLOOR**

**E5 EXTERNAL WALL**

**GROUND BEARING FLOOR**

**P1 PARTY WALL**

NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations
**PROBLEM TO AVOID**

Omitting cavity insulation below DPC makes heat loss significantly worse.  

![Diagram showing cavity insulation omitted below DPC](image)

\[ \psi = 0.32 \]

**PROBLEM TO AVOID**

Omitting the floor perimeter insulation makes heat loss worse.  

![Diagram showing floor perimeter insulation strip omitted](image)

\[ \psi = 0.23 \]

**PROBLEM TO AVOID**

Omitting the floor perimeter insulation makes heat loss worse.  

![Diagram showing floor perimeter insulation strip omitted](image)

\[ \psi = 0.17 \]

**FURTHER NOTES**

Cavity insulation omission

Omitting the cavity insulation at the party wall base also makes heat loss worse.  

![Diagram showing cavity insulation at party wall base omitted](image)
Use lightweight aggregate blockwork on the inner leaf to improve ground floor performance.

Low density lightweight aggregate blockwork (density up to 900 kg/m³)

Use lightweight aggregate blockwork to improve ground floor performance.

Low density lightweight aggregate blockwork (density up to 900 kg/m³)

NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
Omitting cavity insulation below DPC makes heat loss significantly worse.

Omitting the floor perimeter insulation makes heat loss worse.

Omitting the floor perimeter insulation makes heat loss worse.

Omitting cavity insulation below DPC also makes heat loss worse.

Omitting the cavity insulation at the party wall base also makes heat loss worse.
Increase the eaves insulation depth ‘X’ to improve eaves performance.

Note – this may influence the truss design (see further notes)

Use insulated plasterboard on inner blockwork leaf to improve eaves performance.
Omitting roof insulation at eaves makes heat loss significantly worse.

Omitting soffit insulation makes heat loss significantly worse at eaves.

ADVISE TRUSS DESIGNERS OF INSULATION SPACE REQUIREMENTS

Specifying the desired roof pitch ($p^\circ$), eaves overhang (a) and eaves insulation depth (b) will enable truss designers to select the most appropriate truss heel detail to meet these requirements.
Use lightweight aggregate blockwork on the inner leaf to improve gable performance.

Use insulated plasterboard on inner blockwork leaf to improve gable performance.

NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
**PROBLEM TO AVOID**

Stopping the cavity wall insulation short makes heat loss significantly worse at gables.

**PROBLEM TO AVOID**

Omitting the roof perimeter insulation makes heat loss significantly worse at gables.
Use lightweight aggregate blockwork for the party wall leaves to improve thermal performance.

Use insulated plasterboard on party wall leaves to improve thermal performance.

NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
PROBLEM TO AVOID

Stopping the wall cavity insulation short makes heat loss significantly worse at party walls.

Cavity wall insulation curtailed

STOPPING THE WALL CAVITY INSULATION SHORT MAKES HEAT LOSS SIGNIFICANTLY WORSE AT PARTY WALLS.

ψ

0.40

FURTHER NOTES

BLACK MOULD PROBABLE

Cavity wall insulation curtailed

PROBLEM TO AVOID

Omitting the roof perimeter insulation between truss and wall makes heat loss significantly worse at party walls.

Perimeter roof insulation omitted

STOPPING THE ROOF PERIMETER INSULATION BETWEEN TRUSS AND WALL MAKES HEAT LOSS SIGNIFICANTLY WORSE AT PARTY WALLS.

ψ

0.59
TIMBER FRAME CONSTRUCTION
### TOP THERMAL BRIDGING TIPS
#### TIMBER FRAME CONSTRUCTION

**KEY DESIGN RECOMMENDATIONS**

<table>
<thead>
<tr>
<th>Design recommendation</th>
<th>No. of junctions affected</th>
<th>Junction references</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Use thermal laminate plasterboard on inside of frame</td>
<td>5</td>
<td>E2, E4, E5, E6, E10 (pages 24, 26, 28, 30, 32, 34)</td>
</tr>
<tr>
<td>2 Use beam and block ground floor instead of ground bearing slab</td>
<td>1</td>
<td>E5 (pages 28, 30)</td>
</tr>
<tr>
<td>3 Use light aggregate footing blocks</td>
<td>2</td>
<td>E5, P1 (pages 28, 30)</td>
</tr>
<tr>
<td>4 Use min. 50mm floor perimeter insulation thickness</td>
<td>2</td>
<td>E5, P1 (pages 28, 30)</td>
</tr>
<tr>
<td>5 Use a window frame overlap of min. 50mm</td>
<td>3</td>
<td>E2, E3, E4 (pages 24, 26)</td>
</tr>
<tr>
<td>6 Use min. 150mm insulation behind rimboard</td>
<td>1</td>
<td>E6 (page 32)</td>
</tr>
<tr>
<td>7 Use a PU/PIR cavity closer</td>
<td>2</td>
<td>E3, E4 (pages 26)</td>
</tr>
<tr>
<td>8 Increase eaves insulation depth</td>
<td>1</td>
<td>E10 (page 34)</td>
</tr>
<tr>
<td>9 Use PU/PIR cavity lintel insulation</td>
<td>1</td>
<td>E2 (page 24)</td>
</tr>
</tbody>
</table>

**KEY PROBLEMS TO AVOID**

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<th>Black mould risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Omitting ground floor perimeter insulation</td>
<td>2</td>
<td>E5, P1 (pages 28, 30)</td>
<td></td>
</tr>
<tr>
<td>2 Omitting rafter insulation at eaves</td>
<td>1</td>
<td>E10 (page 34)</td>
<td></td>
</tr>
<tr>
<td>3 Omitting rimboard insulation</td>
<td>1</td>
<td>E6 (page 32)</td>
<td></td>
</tr>
<tr>
<td>4 No window frame overlap with cavity</td>
<td>3</td>
<td>E2, E3, E4 (pages 24, 26)</td>
<td></td>
</tr>
<tr>
<td>5 Omitting the cavity closure</td>
<td>2</td>
<td>E3, E4 (page 26)</td>
<td></td>
</tr>
<tr>
<td>6 Omitting soffit insulation at eaves</td>
<td>1</td>
<td>E10 (page 34)</td>
<td></td>
</tr>
<tr>
<td>7 No cavity lintel insulation</td>
<td>1</td>
<td>E2 (page 24)</td>
<td></td>
</tr>
</tbody>
</table>
LINTELS
E2 TIMBER FRAME LINTEL

**BASE DETAIL**

- 50mm cavity
- Brickwork
- Mineral wool insulation
- Softwood pinch batten

**IMPROVED DETAIL**

- Use an insulated plasterboard reveal to improve performance of timber frame lintels.

- Use a thermal laminate plasterboard reveal/soffit

- 140mm insulated timber frame panel with 9mm OSB sheathing outside

- Steel external leaf lintel

- Timber lintels

Frame overlap = 30mm

LINTELS
E2 TIMBER FRAME LINTEL

**BASE DETAIL**

- 50mm cavity
- Brickwork
- Mineral wool insulation
- Softwood pinch batten

**IMPROVED DETAIL**

- Increase the window frame overlap to improve performance of timber frame lintels.

- Frame overlap increased to 50mm

- 140mm insulated timber frame panel with 9mm OSB sheathing outside

- Steel external leaf lintel

- Timber lintels

Frame overlap = 30mm

---

*NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations*
Omitting the cavity lintel insulation makes heat loss worse.

Upgrading the cavity lintel insulation to PU/PIR will reduce heat loss.

Using a thermal laminate plasterboard on the external timber frame wall will reduce heat loss.

Reducing the frame overlap to 0mm makes heat loss worse.
NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.

**WINDOW E3 SILL**

**BASE DETAIL**

- Sill nosing
- Timber cavity closer
- 50mm cavity
- Brickwork
- Frame overlap = 30mm

**IMPROVED DETAIL**

- Use a cavity closer with a PU/PIR insulation core to improve performance of sills and jambs.

**WINDOW E4 JAMB**

**BASE DETAIL**

- 140mm insulated timber frame panel with 9mm OSB sheathing
- 50mm cavity
- Brickwork
- Frame overlap = 30mm

**IMPROVED DETAIL**

- Use an insulated plasterboard reveal to improve the performance of window jambs.

- Use a thermal laminate plasterboard reveal
**Problem to Avoid**

Reduction of the frame overlap to 0mm makes heat loss worse for sills.

Reducing the frame overlap to 0mm makes heat loss worse for jambs.

Omitting the cavity closer makes heat loss worse for sills.

Omitting the cavity closer makes heat loss worse for jambs.

Window frame positioned flush with inside face of brickwork.

Cavity closer omitted.
NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.

**GROUND BEARING FLOOR**

**E5 EXTERNAL WALL**

**BASE DETAIL**

140mm insulated timber frame panel with 9mm OSB sheathing outside

**IMPROVED DETAIL**

Increase the perimeter insulation thickness to improve ground floor performance.

25mm perimeter insulation

**GROUND BEARING FLOOR**

**P1 PARTY WALL**

**BASE DETAIL**

Full fill party wall mineral wool insulation

**IMPROVED DETAIL**

Use lightweight aggregate footing blockwork to improve ground floor performance.

25mm perimeter insulation

Lightweight aggregate blockwork footing

Lean mix concrete

Dense aggregate blockwork

Concrete strip foundation

Dense aggregate blockwork

Dense aggregate blockwork

25mm perimeter insulation

140mm insulated timber frame panel with 9mm OSB sheathing outside

25mm perimeter insulation

306mm fully insulated timber frame party wall

306mm fully insulated timber frame party wall
PROBLEM TO AVOID

Omitting the floor perimeter insulation makes heat loss significantly worse.

Ψ = 0.50

Perimeter insulation omitted

FURTHER NOTES

THERMAL LAMINATE PLASTERBOARD

Using a thermal laminate plasterboard on the timber frame wall will reduce heat loss.

PROBLEM TO AVOID

Omitting the floor perimeter insulation makes heat loss worse.

Ψ = 0.16

Perimeter insulation omitted
NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
**PROBLEM TO AVOID**

Omitting the floor perimeter insulation makes heat loss significantly worse.

**PERIMETER INSULATION OMMITTED**

---

**FURTHER NOTES**

**THERMAL LAMINATE PLASTERBOARD**

Using a thermal laminate plasterboard on the timber frame wall will reduce heat loss.

---

**PROBLEM TO AVOID**

Omitting the floor perimeter insulation makes heat loss worse.

**PERIMETER INSULATION OMMITTED**

---
NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
Omitting the rimboard insulation makes heat loss significantly worse at intermediate floors.
NB: The PSI-values quoted in this Guide are for indicative purposes only and should not be used in SAP calculations.
**PROBLEM TO AVOID**

Omitting roof insulation at eaves makes heat loss significantly worse.

**PROBLEM TO AVOID**

Omitting soffit insulation makes heat loss worse at eaves.

---

**FURTHER NOTES**

**ADVISE TRUSS DESIGNERS OF INSULATION SPACE REQUIREMENTS**

Specifying the desired roof pitch \( p^\circ \), eaves overhang \( a \) and eaves insulation depth \( b \) will enable the truss designer to select the most appropriate truss heel detail to meet these requirements.