Module 5

Building Fabric 2: Continuous Insulation
Energy Efficiency for Construction
To equip the learner with the relevant knowledge and skills required to understand the importance of installing continuous insulation around the envelope and how to implement measures to prevent heat loss.
Building Fabric 2 | Objectives

1. Outline the principles of continuous insulation and thermal bridging
2. Outline the importance of creating a continuously insulated thermal envelope in order to reduce heat loss through the building fabric
3. Identify the insulation layer(s) in a range of construction drawings for the external envelope.
4. Outline the terms thermal conductivity, thermal resistance and U-value and identify the units of measurement used for them
5. Identify insulation materials that are certified and fit for purpose
6. Outline the impact of the energy efficiency of the building if the specified insulation type is substituted with an alternative type of lower thermal conductivity.
7. Outline the importance of avoiding thermal bridging in NZEB buildings
8. Investigate how to prevent thermal bridging at junctions using Best Practice details.
9. Outline the risks associated with poor workmanship relating to continuity of the insulation layer by considering reducing the number and size of service penetrations
10. Outline the Best Practice procedures regarding placement of windows, window sills, and floors in the insulation layer with special emphasis on fire safety and thermal retention.
Topic 1 – Continuous Insulation

Topic 2 – Thermal Bridging

Topic 3 – Windows and Doors

On the following slides you will see this icon:

Click and play to find out more
1. Continuous Insulation
“The “fabric first” approach to building is based on the idea that we should look at designing & constructing the building itself in a way which will retain as much heat as required before looking at installing efficient heating and cooling systems”

Irish Green Building Council

“Build Tight – Heat & Ventilate Right”
Energy and financial saving potential

For colder and temperate climates for NZEB it is recommended:
- higher level of thermal insulation
- triple glazed windows
- summer shading and
- use of passive cooling through

In warmer climates NZEB can be achieved with:
- moderate thermal insulation,
- double glazed windows
- by adding external shading devices
- it is possible to heat with fresh, supply air
- In warmer weather, opening windows at night for passive cooling can be helpful
It is possible to choose different technologies available on the market for constructing NZEBs.

- **Wood** (wood frame, CLT, TJI/FJI, …) + thermal insul.
- **Aerated autoclaved concrete** + therm. insul.
- **Steel structure** + therm. insul.
- **Masonry** + ETICS
- **Insulated concrete formwork**

Image Source: BIMzeED
Different insulation materials are possible

Types of insulation

Natural

Synthetic

Foto © PHI
Transmission Losses and Ventilation Losses - Residential

- **Walls**: 35%
- **Roofs**: 25%
- **Floors**: 15%
- **Windows**: 10%
- **MVHR losses**: 15%

**Air Leakage**
- **20°**: 15%
- **-5°**: 10%

**Data**: Department of Environment, Heritage, and Local Government, Ireland

**Image Source**: MosArt-WWETB

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Energy Efficiency for Construction: Building Fabric 2

Image Source: MosArt-WWETB

Data: Department of Environment, Heritage, and Local Government, Ireland
The greater the surface area, the greater the heat lost.
A / V Ratio = Total of all ext. envelope areas (floor, walls, windows and roof) / total volume

Image Source: Passive House Academy

Image Source: Passive House Academy

A / V Ratio = Total of all ext. envelope areas (floor, walls, windows and roof) / total volume
Continuous Insulation Principle

Poorer insulation levels = higher heat loss

Better insulation levels = lower heat loss

Traditional House  NZEB House

Image Source: MosArt-WWETB

Energy Efficiency for Construction: Building Fabric 2

Co-funded by the Erasmus+ Programme of the European Union
Critical points to maintain continuity of insulation in the envelope to keep the heat in and cold out. (Red Circles)
Case study - Acceptable Construction Details (ACD’s)

- ACDs provide general recommendations on insulation and airtightness
- Insulation shown in red, airtightness in blue
- Ensure you are familiar with the ACD’s for the construction type you are working on
- Help maintain continuity of insulation and airtightness
Be Aware of the ACD’s

- Guidelines for detailing but can be improved upon

- Provide multiple options for **key construction types** (including cavity wall and timber frame)

- Suggest positioning of **insulation** and **air permeability** measures

- Can be improved upon significantly

Source: Department of Housing, Planning and Local Government Ireland
Case Study - Cavity Wall – Insulation Above Slab - ACD

Energy Efficiency for Construction: Building Fabric 2
Source: Department of Housing, Planning and Local Government Ireland

Insulation shown in red
Airtightness shown in blue
Case Study - Cavity Wall – Insulation Above Slab & AAC - ACD

Energy Efficiency for Construction: Building Fabric 2

Source: Department of Housing, Planning and Local Government Ireland

Department of Housing, Planning and Local Government Ireland

TUS Technology University of the Shannon: Midlanders Midwestern

Co-funded by the Erasmus+ Programme of the European Union
Case Study - Cavity Wall – Insulation Below Slab - ACD

Image Source: Department of Housing, Planning and Local Government Ireland
Case Study - Cavity Wall – Insulation Below Slab - AAC

- Ensure partial fill insulation is secured firmly against inner leaf of cavity wall.
- Install perimeter insulation with a min. R-value of 1.0 m²K/W.
- Floor insulation to tightly abut blockwork wall.
- Ensure wall insulation is installed at least 225 mm below top of floor.
- Ensure block with a maximum Thermal Conductivity of 0.2 W/mK in the direction of heat flow is used and that block is suitable for use in foundations.
- Seal between wall and floor air barrier with a flexible sealant OR seal gap between skirting board and floor with a flexible sealant.
- Seal all penetrations through air barrier using a flexible sealant.

Image Source: Department of Housing, Planning and Local Government Ireland
Case Study - Cavity Wall – Suspended Timber Floor - ACD

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department of Housing, Planning and Local Government Ireland

Co-funded by the Erasmus+ Programme of the European Union
### Maximum Area-weighted average U-values (W/m²K)

<table>
<thead>
<tr>
<th>Building Fabric Element</th>
<th>Pitched Roof (Insulation at ceiling)</th>
<th>Pitched Roof (Insulation on slope)</th>
<th>Flat Roof</th>
<th>Walls</th>
<th>Floors (ground and other exposed floors)</th>
<th>External Doors and Windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>0.16</td>
<td>0.20</td>
<td>0.22</td>
<td>0.27</td>
<td>0.25</td>
<td>2.20</td>
</tr>
<tr>
<td>2005</td>
<td>0.16</td>
<td>0.20</td>
<td>0.22</td>
<td>0.27</td>
<td>0.25</td>
<td>2.20</td>
</tr>
<tr>
<td>2007</td>
<td>0.16</td>
<td>0.20</td>
<td>0.22</td>
<td>0.27</td>
<td>0.25</td>
<td>2.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15 (UF)</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0.16</td>
<td>0.16</td>
<td>0.20</td>
<td>0.21</td>
<td>0.21</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15 (UF)</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>0.16</td>
<td>0.16</td>
<td>0.20</td>
<td>0.18</td>
<td>0.18</td>
<td><strong>1.40</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.15 (UF)</td>
<td></td>
</tr>
</tbody>
</table>

U-values have been steadily improving since 2002

Remember: These are the maximum allowed – in practice much better U-values are typically required to comply with TGD Part L

Note: 'UF' above denotes under floor heating.
## NZEB: Maximum Area-weighted average U-values (W/m²K)

<table>
<thead>
<tr>
<th>Building Fabric Element</th>
<th>Pitched Roof (Insulation at ceiling)</th>
<th>Pitched Roof (Insulation on slope)</th>
<th>Flat Roof</th>
<th>Walls</th>
<th>Floors (ground and other exposed floors)</th>
<th>External Doors and Windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backstop NZEB</td>
<td>0.16</td>
<td>0.16</td>
<td>0.20</td>
<td>0.18</td>
<td>0.18</td>
<td>1.40</td>
</tr>
<tr>
<td>Reality NZEB Required</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.13</td>
<td>0.14</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Note: ‘UF’ above denotes under floor heating.
# Table E1.1 Example A: Semi-detached dwelling with gas boiler for space heating and continuous mechanical extract ventilation

<table>
<thead>
<tr>
<th>Element or system</th>
<th>Specifications</th>
</tr>
</thead>
</table>
| Dwelling size and shape         | Semi-detached house, two-storey  
Overall internal dimensions: 7 m wide x 9 m deep x 5.1 m high  
Total floor area 126 m²  
Rectangular shape with no irregularities |
| Opening areas (windows and doors)| 25% of total floor area  
The above includes one opaque door of area 1.85 m², any other doors are fully glazed |
| Walls                           | $U = 0.13\,\text{W/m}^2\text{K}$  
e.g. 150 mm cavity wall with 100 mm cavity insulation of thermal conductivity 0.022 W/mK and 60 mm internal insulation of conductivity 0.022 W/mK |
| Roof                            | $U = 0.11\,\text{W/m}^2\text{K}$  
e.g. 360 mm insulation of conductivity 0.04 W/mK, between and over ceiling joists |
| Floor                           | $U = 0.14\,\text{W/m}^2\text{K}$  
e.g. Slab-on-ground floor with 120 mm insulation of conductivity 0.023 W/mK |
| Opaque door                     | $U = 1.5\,\text{W/m}^2\text{K}$ |
| Windows and glazed doors        | Double/Triple glazed, low E (En = 0.05, soft coat) 20 mm gap, argon filled, PVC frames  
(U = 4.3 0.9 W/m²K, solar transmittance = 0.6) |
Traditional Cavity Wall

- Wide cavity required to meet low U-values
- Leads to wider foundation
- Blow-in insulation bead?
- Could combine with internal or external insulation (**BUT - doubling up of effort**)
Cavity Wall Insulation – Installation and Precautions

- Insulation should be tight against the inner leaf
- Excess mortar should be cleaned off before fixing insulation
- The insulation layer should be continuous and without gaps
- Insulation batts & boards should butt tightly against each other
- Batt & boards should be cut and trimmed to fit tightly around openings, cavity trays, lintels, sleeved vents and other components bridging the cavity, and should be adequately supported in position
- Critical locations where care should be taken to limit thermal bridging include lintels, jambs, sills, roof/wall junctions and wall/floor junctions
- The method of cavity closure used should not cause thermal bridging at the roof/wall junction
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• The method of cavity closure used should not cause thermal bridging at the roof/wall junction (see Acceptable Construction Details, section 1 details)

BRE “Good Building Guide 68 Part 2 Installing thermal insulation: Good site practice”
Cavity Wall Width – NZEB Compliance

### Diagram A1

Masonry cavity wall

(Par. A2.1)

- 19 mm external render
- 100 mm dense concrete block outer leaf
- Cavity (min. 40 mm residual cavity)
- 100 mm thermal insulation (thermal conductivity 0.021 W/mK)
- 100 mm dense concrete block inner leaf
- 13 mm lightweight plaster

**Layer/Surface** | **Thickness (m)** | **Conductivity (w/mK)** | **Resistance (m²K/W)**
--- | --- | --- | ---
External surface | - | - | 0.040
External render | 0.019 | 1.00 | 0.019
Concrete block | 0.100 | 1.33 | 0.075
Low-E Air cavity | 0.050 | - | 0.440
Polyisocyanurate (PIR) Insulation | 0.100 | 0.021 | 4.760
Concrete block (lightweight) | 0.100 | 1.33 | 0.075
Plaster (lightweight) | 0.013 | 0.18 | 0.072
Internal surface | - | - | 0.130

Total Resistance | - | - | 5.611

U-value of construction = 1 / 5.611 = 0.18 W/m²K

Image Source: Department of Housing, Planning and Local Government
NZEB Requires Wider Walls & Wider Foundations

Note: In no case should the width of the foundation be less than the total width of the wall plus 75 mm on each side.

Diagram 11  Foundation dimensions
(Par. 1.1.5.2)

The minimum thickness of the foundation (T) should either be P or 200mm, whichever is greater.

W = Wall thickness

Note: Backfill material should be in accordance with Technical Guidance Document C (Site Preparation and Resistance to Moisture)

Foundation width should not be less than the appropriate dimension in Table 7

Strip Foundation

Image Source: Department of Housing, Planning and Local Government, Part A of the Building Regulations
Full-Fill Cavity Wall Insulation

Ensure continuous insulation with no mortar snots

Image Source: MosArt
Cavity Wall Width – NZEB Compliance – Better Than Backstop

CavityTherm (Inner block 100)

<table>
<thead>
<tr>
<th>Block Type</th>
<th>100mm</th>
<th>125mm</th>
<th>150mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>0.17</td>
<td>0.14</td>
<td>0.12</td>
</tr>
<tr>
<td>Med</td>
<td>0.19</td>
<td>0.15</td>
<td>0.13</td>
</tr>
<tr>
<td>Dense</td>
<td>0.19</td>
<td>0.16</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Plaster Finish

Image Source: Xtratherm

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Image Source: Xtratherm
Energy Efficiency for Construction: Building Fabric 2

Full-Fill Cavity Wall Insulation

- 150mm of PIR insulation (0.022 W/mK). For this project
- Additional layer of insulated plasterboard was added to the inside
- The U-value of this wall would be significantly better than the NZEB backstop
Avoid gaps like this – increases heat loss
Better to Mitre Insulation at Corners

Small gap at top of insulation board

No gaps with mitred joint
The number of wall ties required in a cavity wall is generally accepted as follows:

The minimum quantity of ties provided should be:

- 2.5 wall ties per square metre for cavity widths between 50mm and 75mm
- 3 wall ties per square metre for cavity widths between 75mm and 100mm, and
- 4.9 wall ties per square metre for cavity widths between 100mm and 150mm

Extra wall ties are required at the jambs of openings and movement joints.

Image Source: Department of Housing, Planning and Local Government, Ireland
The number of wall ties required in a cavity wall is outlined in Part A – Structure.

The minimum quantity of ties provided should be:

• 2.5 wall ties per square metre for cavity widths between 50mm and 75mm

• 3 wall ties per square metre for cavity widths between 75mm and 100mm, and

• 4.9 wall ties per square metre for cavity widths between 100mm and 150mm

Extra wall ties are required at the jambs of openings and movement joints (for use of ties in other cavity widths, see S.R. 325).
<table>
<thead>
<tr>
<th>Material</th>
<th>Density (kg/m³)</th>
<th>Thermal Conductivity (W/mK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Building Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay brickwork (outer leaf)</td>
<td>1,700</td>
<td>0.77</td>
</tr>
<tr>
<td>Clay brickwork (inner leaf)</td>
<td>1,700</td>
<td>0.56</td>
</tr>
<tr>
<td>Concrete block (heavyweight)</td>
<td>2,000</td>
<td>1.33</td>
</tr>
<tr>
<td>Concrete block (medium weight)</td>
<td>1,400</td>
<td>0.57</td>
</tr>
<tr>
<td>Concrete block (autoclaved aerated)</td>
<td>700</td>
<td>0.20</td>
</tr>
<tr>
<td>Concrete block (autoclaved aerated)</td>
<td>500</td>
<td>0.15</td>
</tr>
<tr>
<td>Concrete block (hollow)</td>
<td>1800</td>
<td>0.835</td>
</tr>
<tr>
<td>Cast concrete, high density</td>
<td>2,400</td>
<td>2.00</td>
</tr>
<tr>
<td>Cast concrete, medium density</td>
<td>1,800</td>
<td>1.15</td>
</tr>
<tr>
<td>Aerated concrete slab</td>
<td>500</td>
<td>0.16</td>
</tr>
<tr>
<td>Concrete screed</td>
<td>1,200</td>
<td>0.41</td>
</tr>
<tr>
<td>Reinforced concrete (1 % steel)</td>
<td>2,300</td>
<td>2.30</td>
</tr>
<tr>
<td>Reinforced concrete (2 % steel)</td>
<td>2,400</td>
<td>2.50</td>
</tr>
<tr>
<td>Wall ties, stainless steel</td>
<td>7,900</td>
<td>17.00</td>
</tr>
<tr>
<td>Wall ties, galvanised steel</td>
<td>7,800</td>
<td>50.00</td>
</tr>
<tr>
<td>Mortar (protected)</td>
<td>1,750</td>
<td>0.88</td>
</tr>
<tr>
<td>Mortar (exposed)</td>
<td>1,750</td>
<td>0.94</td>
</tr>
<tr>
<td>External rendering (cement sand)</td>
<td>1,800</td>
<td>1.00</td>
</tr>
<tr>
<td>Plaster (gypsum lightweight)</td>
<td>600</td>
<td>0.18</td>
</tr>
<tr>
<td>Plaster (gypsum)</td>
<td>1,200</td>
<td>0.43</td>
</tr>
<tr>
<td>Plasterboard</td>
<td>900</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Source: Department of Housing, Planning and Local Government, Ireland
The Ancon ties are manufactured from basalt fibres set in a resin matrix.

These ties have a thermal conductivity of just 0.7 W/mK.
Cavity Barriers – Why Are they Needed?

• Hidden voids in the construction of a building provide a ready route for smoke and flame spread.

• As the spread is concealed, it presents a greater danger than a more obvious weakness in the fabric of the building.

• Provisions are made to restrict this by interrupting cavities which could form a pathway around fire barriers, and sub-dividing extensive cavities.
3.6.2 Provision of Cavity Barriers

Cavity barriers should be provided in accordance with the following:

(a) At the top of an external cavity wall (masonry or framed construction) including any gable wall.

(b) Vertically at the junction of separating wall and any such wall with an external cavity wall (see Diagram 12).

(c) Above the enclosures to a protected stairway (see Diagram 11).

(d) Around all openings (windows, doors, vents, service boxes etc.) in framed construction.

Source: Department of Housing, Planning and Local Government, Ireland
3.6.3 Construction and Fixings for Cavity Barriers

Every cavity barrier should be constructed to provide at least 30 minutes fire resistance.

Notes: Any cavity barrier required in framed construction may however be formed of –

(i) steel at least 0.5 mm thick, or
(ii) timber at least 38 mm thick, or
(iii) polythene sleeved mineral wool, or mineral wool slab, in either case under compression when installed in the cavity.

Cavity barriers should be tightly fitted to rigid construction and mechanically fixed in position wherever possible. Where this is not possible (for example, in the case of a junction with slates, tiles, corrugated sheeting or similar materials) the junction should be fire-stopped.

Cavity barriers should also be fixed so that their performance is unlikely to be made ineffective by:

(a) movement of the building due to subsidence, shrinkage or thermal change and movement of the external envelope due to wind;
(b) collapse in a fire of any services penetrating them;
(c) failure in a fire of their fixings; or failure in a fire of any material or construction which they abut.
Thermal Cavity Closers & Fire Stop

**ALTICLOSER FR**
- Provides an effective solution when closing cavities within openings in masonry walls, offering 30min fire resistance performance within cavities up to a maximum width of 100mm. (FR+ 60 min)
- UPVC outer which acts as a damp proof barrier, while the polythene enclosed rock mineral fibre core prevents thermal bridging issues and is a key feature of the products fire resistance capabilities

**ANTICLOSER XPS**
- The thermal cavity closer incorporates a UPVC outer which acts as a damp proof barrier, while the insulated XPS core prevents thermal bridging problems.
SIDERISE EW – Cavity Barriers and Fire Stops for Masonry External Walls

- Fire resistance: up to 2 hours
- Sound reduction: up to 25dB (Rw)
- Integral smoke barrier
- Resilient to accommodate site tolerances without cutting
- Certified 3rd Party Approval
ROCKWOOL® Mineral Wool Fire Barrier Slab

- Manufactured from non-combustible stone wool
- High density stone wool core
- Foil-faced on both sides
- Prevent the spread of flames
- Inhibits heat and smoke through concealed spaces in buildings
- Improves sound reduction

Cavity walls should always have a fire stop closure at the top of the cavity and around openings.
Single Leaf Masonry with Exterior Insulation

Energy Efficiency for Construction: Building Fabric 2

Image Source: Left – Sto Therm / Right - MosArt
Cavity Wall with Exterior Insulation – Retrofit

Image Source: MosArt
# XPS vs EPS

<table>
<thead>
<tr>
<th>Extruded polystyrene (XPS)</th>
<th>Expanded polystyrene (EPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufactured by liquefying polystyrene pellets then injecting a blowing agent under pressure.</td>
<td>Manufactured using a mould to contain small foam beads</td>
</tr>
<tr>
<td>The liquid formed is then continuously extruded through a die and expands during the cooling process</td>
<td>Heat or steam is then applied to the mould, which causes the small beads to expand and fuse together</td>
</tr>
<tr>
<td>Closed cell rigid insulation</td>
<td>Non closed cell rigid insulation</td>
</tr>
<tr>
<td>No water penetration</td>
<td>Allows water to penetrate</td>
</tr>
<tr>
<td>Lower Conductivity</td>
<td>Higher Conductivity</td>
</tr>
<tr>
<td>Good compressive strength</td>
<td>Weaker strength than XPS</td>
</tr>
</tbody>
</table>
The EWI Starter Track is a Potential Thermal Bridge

Preferable to use plastic, rather than metal

Image Source: MosArt
Exterior Insulation Options on Timber Frame

Wood fibre board

1. Made of Recycled Wood-Chips
2. T&G all sides mean no need to align to framing (roof or wall)
3. Water-resistant (WRB), Insulated sheathing + help Windproofing in 1 step
4. Vapour Open

Rockwool

1. Made from fibres which are spun from molten rock
2. Good fire resistant properties
3. Provides good noise insulation
4. Vapour open

Image Source: Left – Gutex, Right - Purchased by MosArt – (AdobeStock_203865964)
Avoiding cracking

L-shaped insulation block should be used at all window corners – high stress point – prone to cracking

Avoid joints between boards at window corners
EWI Boards to be Laid in Brick Pattern
Can your Eaves accommodate external wall insulation?
Case study - External Insulation, Insulation Above Slab

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department of Housing, Planning and Local Government Ireland
Case Study - External Insulation, Insulated Below Slab GF Insulation

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department of Housing, Planning and Local Government Ireland
Case study - External Insulation, Solid Masonry, Insulation Above Slab

Floor insulation to tightly abut blockwork wall

Ensure wall insulation is installed at least 430 mm below ground level R-value 4.0 m²K/W

Seal between wall and floor air barrier with a flexible sealant OR seal gap between skirtings boards and floor with a flexible sealant

Seal all penetrations through air barrier using a flexible sealant

430 mm

Image Source: Department of Housing, Planning and Local Government
Case Study - External Insulation, Below Slab GF Insulation- ACD

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department of Housing, Planning and Local Government

Co-funded by the Erasmus+ Programme of the European Union
Case study - External Insulation, Suspended Timber Floor- ACD

(1) WOOD FRAME WALLS
HEAVY BRICKWORK/WALLS
[Diagram of wall insulation and details]

THERMAL PERFORMANCE
- Pack gap between floor joist and blockwork wall with compressible insulation if over 25 mm; otherwise inject insulating expanding foam. Min. R-value of 0.63 m²K/W.
- Continue external insulation at least 750 mm below top of floor insulation.
- Ensure insulation is in contact with underside of timber flooring.

AIR BARRIER - CONTINUITY
- Seal between wall and floor air barrier with a flexible sealant OR seal gap between skirting board and floor with a flexible sealant.
- Seal all penetrations through air barrier using a flexible sealant.
- Seal joints in timber floor with suitable glue. Fully support and fix any square edge joints in the decking to the joists.
- Provide similar air seals at all internal partitions.

Image Source: Department of Housing, Planning and Local Government
Case Study - Internal Wall Insulation – Without Service Void

Figure 60 - Thermal laminated board fixed to internal face of wall

Figure 62 - Thermal laminate board over insulation between battens

Energy Efficiency for Construction:
Building Fabric 2

Continuity of vapour control layer!!

— to ensure vapour and air tightness, all edges of insulation boards should be continuously sealed at floors, ceilings and jambs. Care should be taken to ensure insulation boards are continued to the floor level. All board joints should be taped and all service entry points sealed to ensure the continuity of the vapour control layer;
Case study - Internal Wall Insulation – With Service Void

Timber studs

Metal studs

Figure 63 - Service void formed by timber batten

Figure 64 - Insulation board fixed to wall with cavity formed by Metal Furring (MF)

Figure 65 - Internal insulation and Metal Furring channels

Continuity of vapour control layer!!
Exterior Insulation is Safest – Interior Insulation Should have Vapour Control Layer

Existing Wall

Initial state

Long-term experience

External Insulation

Brick wall warmer

\[ \text{EPS } \lambda = 0.035 \text{ W/mK, 150mm} \]

Internal Insulation

Brick wall colder

\[ \text{clay bricks } \lambda = 0.25 \text{ W/mK 200mm} \]

Brick wall colder

\[ \text{Vapour control layer } s_d = 30 \text{ m} \]

\[ \text{drier, still humid} \]

\[ \text{wet} \]

Potential Condensation!

\[ \text{drier} \]

\[ \text{Data Source: MosArt-WWETB} \]

Energy Efficiency for Construction: Building Fabric 2
Case Study - Cavity Wall, Internal Insulation, Above Slab - ACD

Note the Vapour Control Layer. This is crucial when using internal insulation!

Data Source: Department Housing, Planning and Local Government Ireland
Case Study - Cavity Wall, Internal Insulation, Below Slab - ACD

Note the Vapour Control Layer. This is crucial when using internal insulation!

Data Source: Department Housing, Planning and Local Government Ireland
Case Study - Hollow Block Wall Width – Compliance

- Hollow concrete block wall, rendered externally, internal insulation lining with plasterboard finish
- The insulation is installed on the inner face of the masonry walls
- It may be installed between preservative-treated timber studs fixed to the wall
- Or in the form of insulated plasterboards
- Or as a combination of these
- Take note of the vapour control layer, which is installed on the warm side of the insulation

Image Source: Department Housing, Planning and Local Government, Part L of the Building Regulations
Hollow Block Wall, Internal Insulation, Above Slab - ACD

Image Source: Department Housing, Planning and Local Government Ireland
Insulating Timber Frame Walls

Insulation between and across studs

- Insulation can be installed to the full depth between the studs.
- Where the chosen stud depth is not sufficient to accommodate the required thickness of insulation, additional insulation may be provided by internally insulating.
- The VCL should be on the warm side of the insulation.
- If different types of insulation are used between and inside the studs, the vapour resistance of the material between the studs should not exceed that of the internal insulation.
- Air gaps in the insulation layer, and between it and the vapour barrier, should be avoided.

Data Source: Department Housing, Planning and Local Government
Cellulose Insulation

1. Made of recycled paper
2. Less health associated risks
3. Flows almost like liquid, meaning there are no gaps after installation

Image Source: Upper left – Ecocel, Upper right - purchased by MosArt (AdobeStock_28294685), Lower – purchased by MosArt (AdobeStock_330572761)
Blown-In Cellulose Insulation

Hole made in airtight membrane – later sealed with airtight tape
Pumping commenced after service cavity battens have been put in place – prevents damage from ‘bulging’ insulation

Image Source: MosArt
Blown-In Cellulose Attic Insulation

OSB retainer used to prevent loose insulation from falling into walkway

Image Source: Purchased by MosArt (iStock-183779679)
Case Study - Timber Frame, Insulation Above Slab - ACD

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department Housing, Planning and Local Government Ireland
Case study - Timber Frame, Insulation Below Slab- ACD

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department Housing, Planning and Local Government Ireland
Case study - Timber Frame, Suspended Timber Ground Floor - ACD

Ensure insulation is in contact with underside of timber flooring.

- Seal between wall and floor air barrier. OR seal gap between skirting board and floor with a flexible sealant.
- Seal joints in timber floor with suitable glue. Fully support and fix any square edge joints in the decking to the joists.
- Seal all penetrations through air barrier using a flexible sealant or tape.

Complying with checklist will help achieve design air permeability.

Image Source: Department Housing, Planning and Local Government
## Timber Frame Wall Width

**Image Source:** Rockwool

<table>
<thead>
<tr>
<th>U-Value (W/m²K)</th>
<th>TF034 Slab (mm)</th>
<th>Stud Depth</th>
<th>High Performance Partial Fill</th>
<th>VCL</th>
<th>Breather Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.23</td>
<td>90</td>
<td>89</td>
<td>50</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>0.21</td>
<td>90</td>
<td>89</td>
<td>50</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>0.21</td>
<td>90</td>
<td>89</td>
<td>50</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>0.19</td>
<td>140</td>
<td>140</td>
<td>50</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>0.17</td>
<td>140</td>
<td>140</td>
<td>50</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>0.17</td>
<td>140</td>
<td>140</td>
<td>50</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

- Timber studs with 25mm service void
- Vapour control layer
- Timber Frame Slab Insulation
- OSB
- Breather membrane
- High Performance Partial Fill
- 50mm clear cavity

Energy Efficiency for Construction: Building Fabric 2
Structural Insulated Panels (SIPs)

- SIP’s are made of a large EPS boards sandwiched between two OSB boards
- The entire house consists of a small number of panels, which are constructed off-site
- Usually achieve excellent airtightness results due to the requirement only to seal between panels with airtight tape
- Lightweight, making them easy to handle on site
- Not everybody is comfortable using EPS insulation, with many preferring ‘natural’ insulation like cellulose

Image Source: Purchased by MosArt-WWETB (iStock-1184822992)


However: “Where the source of space heating is underfloor heating, the maximum floor U-value should be 0.15 W/m²K”
NZEB Compliance – Floor Insulation – TF70 -Thermal Conductivity 0.022 W/m.K

**Insulation Below the Floor Slab**

- **Concrete slab**
- **Kingspan Thermafloor® TF70**
- **Kingspan Kooltherm® K106 or K108 Cavity Board**
- **Hardcore Separation layer (see ‘Sitework’)**

**Image Source:** Kingspan.

**U-values (W/m²K) for Various Thicknesses of Kingspan Thermafloor® TF70 and Floor Perimeter / Area Ratios**

<table>
<thead>
<tr>
<th>Insulant Thickness (mm)</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
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<tbody>
<tr>
<td>30</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>40</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>0.23</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>0.19</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>80</td>
<td>0.19</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>0.15</td>
<td>0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>0.14</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>110</td>
<td>0.13</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>0.12</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>0.12</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>130</td>
<td>0.11</td>
<td>0.13</td>
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<tr>
<td>140</td>
<td>0.11</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>150</td>
<td>0.10</td>
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<tr>
<td>160</td>
<td>0.10</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>0.10</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>0.10</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>0.10</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>0.10</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- Insulation overlap min. 150/225 mm from bottom of wall insulation to top of insulation upstand.
NZEB Compliance – Optim R (VIP) -Thermal Conductivity 0.007 W/m.K

Insulation Below the Floor Screed

Image Source: Kingspan

Energy Efficiency for Construction:
Building Fabric 2

Image Source: Kingspan

U-values (W/m²-K) for Various Thicknesses of the Kingspan Optim-R Flooring System and Floor Perimeter / Area Ratios

<table>
<thead>
<tr>
<th>Insulant Thickness (mm)</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.19</td>
<td>0.22</td>
<td>0.24</td>
<td>0.26</td>
<td>0.27</td>
<td>0.28</td>
</tr>
<tr>
<td>25</td>
<td>0.17</td>
<td>0.20</td>
<td>0.22</td>
<td>0.23</td>
<td>0.24</td>
<td>0.25</td>
</tr>
<tr>
<td>30</td>
<td>0.15</td>
<td>0.18</td>
<td>0.19</td>
<td>0.21</td>
<td>0.21</td>
<td>0.22</td>
</tr>
<tr>
<td>40</td>
<td>0.13</td>
<td>0.15</td>
<td>0.16</td>
<td>0.17</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>50</td>
<td>0.12</td>
<td>0.13</td>
<td>0.14</td>
<td>0.14</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>60</td>
<td>0.10</td>
<td>0.11</td>
<td>0.12</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>30 + 40***</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>40 + 40</td>
<td>0.08</td>
<td>0.09</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Important to overlap joints in insulation to minimise risk of thermal looping and thermal bridging.

Cut boards accurately to avoid gaps.
Foundation Types – Strip Foundation with Rising Wall

184mm Cellulose T.C. 0.037
20mm Ext render
184x38mm External stud
9mm OSB3 Plywood
Solitex WA Membrane all joints taped
200mm QuinnLite B5 block
Full fill joint
Standard block
Standard blockwork

200mm QuinnLite blocks to be painted with Bitumen paint to all six sides prior to laying

Concrete slab to Engineers design
70mm per insulation (T.C.0.022) if required
2x100mm Extruded Polystyrene (T.C. 0.022)
Radon barrier
Well compacted hardcore
Foundation Type – Insulated Raft Foundation

KORE

- Can meets and exceed building regulations
- Eliminates the critical wall to floor thermal bridge - Risk of condensation and mould growth behind the skirting board is greatly reduced
- Reduces the quantity of concrete for foundation by approximately 50%
- Suitable for all ground conditions
- The thermal capacity of KORE EPS will not diminish over time and is unaffected by water
- Exceptional compressive strength makes the product suitable for use in domestic and commercial applications
- Suitable with underfloor heating systems
## Table A1: Thermal conductivity of some common building materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (kg/m³)</th>
<th>Thermal Conductivity (W/mK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Building Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay brickwork (outer leaf)</td>
<td>1,700</td>
<td>0.77</td>
</tr>
<tr>
<td>Clay brickwork (inner leaf)</td>
<td>1,700</td>
<td>0.56</td>
</tr>
<tr>
<td>Concrete block (heavyweight)</td>
<td>2,000</td>
<td>1.33</td>
</tr>
<tr>
<td>Concrete block (medium weight)</td>
<td>1,400</td>
<td>0.57</td>
</tr>
<tr>
<td>Concrete block (autoclaved aerated)</td>
<td>700</td>
<td>0.20</td>
</tr>
<tr>
<td>Concrete block (autoclaved aerated)</td>
<td>500</td>
<td>0.15</td>
</tr>
<tr>
<td>Concrete block (hollow)</td>
<td>1800</td>
<td>0.838</td>
</tr>
<tr>
<td>Cast concrete, high density</td>
<td>2,400</td>
<td>2.00</td>
</tr>
<tr>
<td>Cast concrete, medium density</td>
<td>1,800</td>
<td>1.15</td>
</tr>
<tr>
<td>Aerated concrete slab</td>
<td>500</td>
<td>0.16</td>
</tr>
<tr>
<td>Concrete screed</td>
<td>1,200</td>
<td>0.41</td>
</tr>
<tr>
<td>Reinforced concrete (1 % steel)</td>
<td>2,300</td>
<td>2.30</td>
</tr>
<tr>
<td>Reinforced concrete (2 % steel)</td>
<td>2,400</td>
<td>2.50</td>
</tr>
<tr>
<td>Wall ties, stainless steel</td>
<td>7,900</td>
<td>17.00</td>
</tr>
<tr>
<td>Wall ties, galvanised steel</td>
<td>7,800</td>
<td>50.00</td>
</tr>
<tr>
<td>Mortar (protected)</td>
<td>1,750</td>
<td>0.88</td>
</tr>
<tr>
<td>Mortar (exposed)</td>
<td>1,750</td>
<td>0.88</td>
</tr>
<tr>
<td>External rendering (cement sand)</td>
<td>1,800</td>
<td>1.00</td>
</tr>
<tr>
<td>Plaster (gypsum)</td>
<td>600</td>
<td>0.43</td>
</tr>
<tr>
<td>Plaster (gypsum lightweight)</td>
<td>1,200</td>
<td>0.25</td>
</tr>
<tr>
<td>Plasterboard</td>
<td>900</td>
<td></td>
</tr>
</tbody>
</table>

The values in this table are indicative only. Certified values, should be used in preference, if available.
<table>
<thead>
<tr>
<th>Standard Block 215x450x100</th>
<th>Concrete Blocks</th>
<th>Lightweight Concrete Blocks</th>
<th>AAC Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong></td>
<td>Mixture of Portland Cement, Sand &amp; Gravel</td>
<td>Mixture of Cement, foamed blast-furnace slag, expanded clay or shale, furnace bottom ash (FBA), pulverised fuel ash (PFA), or the less common pumice (a volcanic material)</td>
<td>Mixture of cement, lime, sand, pulverised fuel ash (PFA), water, lime &amp; aluminium sulphate powder.</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>Grey</td>
<td>Heather/Purple</td>
<td>Light Grey</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>20-22 Kg</td>
<td>20kg</td>
<td>15.9kg</td>
</tr>
</tbody>
</table>
## Dense Concrete Blocks

<table>
<thead>
<tr>
<th><strong>Advantages</strong></th>
<th><strong>Disadvantages</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Durable</td>
<td>Use of new aggregates and sand is bad for the environment &amp; exhausts natural resources</td>
</tr>
<tr>
<td>Reusable</td>
<td>Non-renewable materials</td>
</tr>
<tr>
<td>High Thermal Mass</td>
<td>Use of cement contributes to global warming</td>
</tr>
<tr>
<td>High Strength</td>
<td>Poor insulating properties</td>
</tr>
<tr>
<td>Some Products have Recycled Aggregate</td>
<td></td>
</tr>
</tbody>
</table>

---

Energy Efficiency for Construction: Building Fabric 2
# Lightweight Concrete Blocks

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate thermal mass - higher than AAC</td>
<td>Use of virgin clay causes land degradation and resource depletion</td>
</tr>
<tr>
<td>Makes use of secondary aggregates</td>
<td>High embodied energy involved in the production of some aggregates</td>
</tr>
<tr>
<td>Good insulating properties</td>
<td>Use of cement contributes to global warming</td>
</tr>
<tr>
<td>Durable</td>
<td></td>
</tr>
<tr>
<td>Reusable with lime mortar</td>
<td></td>
</tr>
</tbody>
</table>
### Aerated Autoclaved Concrete Blocks

#### Advantages
- Moderate thermal mass
- Uses industrial waste (PFA) as a prime constituent
- Very good insulating properties
- Based on volume, aerated blocks contain around 25% less embodied energy than other concrete blocks
- Good workability
- Lighter weight saves energy in transportation
- Reasonable sound absorption properties

#### Disadvantages
- Non-renewable materials
- Prone to impact damage
- Use of aluminium adds embodied carbon
- Use of cement contributes to global warming

---

Energy Efficiency for Construction: Building Fabric 2
NZEB for Carpenters

NZEB for Bricklayers

Energy Efficiency for Construction: Building Fabric 2

Partial Fill Cavity Wall / Solid Ground Floor Slab Insulation Over Structural Slab.

Partial Fill Cavity Wall / Solid Ground Floor Slab Insulation Under Structural Slab

Partial fill cavity wall with internal insulation / Suspended timber floor insulated between joists

Image Source: Mannock
AAC Blocks – External Insulation

Ground Floor - Insulation above slab

Ground Floor - Insulation below slab

Timber Suspended Ground Floor

Image Source: Mannock
AAC Blocks – Internal Insulation

Ground floor - insulation below slab

Timber suspended ground floor

Image Source: Mannock
AAC Blocks – Timber Frame

Ground floor - insulation below slab

Timber Frame - Separating wall through ground floor

Timber Frame – Partition wall through ground floor

Image Source: Mannock
AAC Blocks – Disadvantages

- The production cost per unit for AAC Block is higher than standard blocks
- Care must be taken during manufacturing to ensure the final surface of the aerated concrete is not too smooth
- Efflorescence damage occurs through the high absorption and retention of water. Any expansion of the water retained in the AAC may cause cracking
- Strength of AAC is reduced when wet and long term exposure to moisture will cause the disintegration of the material
- Aggressive environments may be also a disadvantage to using AAC
BBA Accredited Moisture Resistant Insulation Types

**Xtratherm Cavity Therm**
- 150mm below DPC

**Xtratherm Foundation Riser**
Y-values achieved < 0.05 U-values achieved 0.11 - 0.15 W/m²K
- Suitable for multi storey buildings with a high compressive strength of 7.5N/mm² and 13N/mm²
- Complies with standard construction
- Traditional construction avoiding need for engineering assurances
- 225mm below DPC allows for the overlap between floor & wall insulation

Image Source: Xtratherm
BBA Accredited Moisture Resistant Insulation Types

KORE

- KORE External and KORE External Plinth are **water repellent**
- External Plinth board is also manufactured to a very high density, EPS200, made specifically to insulate the plinth below the damp proof course
- KORE Plinth is designed and manufactured to insulate below the damp proof course and has very low water absorption properties
Accredited Moisture Resistant Insulation Types

Kingspan GreenGuard

• High performance extruded polystyrene insulation offering thermal conductivities as low as 0.034 W/mK
• High compressive stress
• Resistant to ground moisture penetration
• Unaffected by air infiltration
Check Deliveries to Ensure You Get What You Specified

Conductivity is king!

Image Source: MosArt
Deliver The U-Value Specified
Do forget issues with wind!

• Traditionally, attic hatches have not been given enough attention with regards to air-sealing and insulation

• Think of it like the access hatch to a submarine!

• Seal it up – 100%

Image Source: MosArt
Access to Deeply Insulated Attic

Upstand to attic hatch to retain insulation in airtight ceiling with service cavity

Completed opening with insulated and airtight hatch. No ladder was provided to this project because there was no cold water tank installed.
Examples of Certified Attic Hatches:

Wellhofer Airtight Attic Hatch with Ladder

Wellhofer Airtight Attic Hatch

Image Source: Wellhofer
Airtight and Insulated Attic Hatch

Wellhöfer Passive House Attic Hatch
Passive House certified airtight attic hatch

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat transition coefficient (u-value)</td>
<td>0.48 W/m²K</td>
</tr>
<tr>
<td>Length of ceiling opening</td>
<td>1.3 m</td>
</tr>
<tr>
<td>Width of ceiling opening</td>
<td>650 mm</td>
</tr>
<tr>
<td>Depth</td>
<td>500 mm</td>
</tr>
<tr>
<td>Ceiling height compatibility</td>
<td>2.46 m to 2.579 m</td>
</tr>
<tr>
<td>Air permeability (q&lt;sub&gt;50&lt;/sub&gt;-value)</td>
<td>1 m³/mh</td>
</tr>
</tbody>
</table>

- Using pre insulated, airtight attic hatches can simplify installation and guarantee quality.
Energy Efficiency for Construction: Building Fabric 2

Assessment

QUIZ!
Module 5

Building Fabric 2: Thermal Bridging
Energy Efficiency for Construction
To equip the learner with the relevant knowledge and skills required to understand the importance of installing continuous insulation around the envelope and how to implement measures to prevent heat loss.
1. Outline the principles of **continuous insulation** and **thermal bridging**
2. Outline the importance of creating a **continuously insulated thermal envelope** in order to reduce heat loss through the building fabric.
3. Identify the insulation layer(s) in a range of **construction drawings** for the external envelope.
4. Outline the terms **thermal conductivity**, thermal resistance and U-value and identify the units of measurement used for them.
5. Identify insulation materials that are certified and **fit for purpose**.
6. Outline the **impact** of the energy efficiency of the building if the specified insulation type is substituted with an alternative type of lower thermal conductivity.
7. Outline the importance of **avoiding thermal bridging** in NZEB buildings.
8. Investigate how to prevent thermal bridging at junctions using **Best Practice details**.
9. Outline the risks associated with **poor workmanship** relating to continuity of the insulation layer by considering reducing the number and size of service penetrations.
10. Outline the **Best Practice procedures** regarding placement of windows, window skills, and floors in the insulation layer with special emphasis on fire safety and thermal retention.
Topic 1 – Continuous Insulation

Topic 2 – Thermal Bridging

Topic 3 – Windows and Doors

On the following slides you will see this icon:

Click and play to find out more
2. Thermal Bridging
Reminder!

A thermal bridge occurs at any location in a building where there is a break in the continuity of the insulation layer.

The heat loss coefficient of a linear thermal bridge is influenced by the severity of the thermal bridge, and the length of the thermal bridge:

\[ H_{TB} = L \times \Psi \]

- \( H_{TB} \) = Transmission heat loss coefficient (W/K)
- \( L \) = Length of the thermal Bridge over which \( \Psi \) applies (m)
- \( \Psi \) = Linear thermal transmittance (W/mK)
Thermographic images of Thermal Bridges

Evidence of heat loss through floor slabs and party walls in apartment blocks
“Repeating” Thermal Bridges through Studs

Image Source: Purchased by MosArt (iStock 90571524)
• Thermal bridges can be found at all junctions and penetrations

• Arises due to challenge in connecting insulation planes

• Solutions for most situations are now readily available

• Failure to minimise thermal bridge effect will most likely result in mould and poor indoor air quality
Typical Locations of Thermal Bridges

Energy Efficiency for Construction: Building Fabric 2

Image Source: Right & Bottom Left – MosArt / Top Left – Scheck North America
Steel Junctions cause Thermal Bridging

Energy Efficiency for Construction: Building Fabric 2

Image Source: Left - Purchased by MosArt (iStock 136199144) / Right - MosArt
In this project, the balcony system looks as though it counter levered, but is in fact thermally separated from the main structure.

Image Source: MosArt

'Out of the Blue'
Passive House – free-standing balcony
Steel Beam Externally Insulated by Cavity Wall Insulation
Typical Locations of Thermal Bridges

Energy Efficiency for Construction: Building Fabric 2

Image Source: MosArt
Mould Very Common at Wall to Roof Junction

Can cause both health problems for occupants and structural problems.
Mould Very Common at Wall to Roof Junction

Can cause both health problems for occupants and structural problems

Image Source: Purchased by MosArt (iStock 488872199)
Vinyl Wallpaper Hiding the Ugly Reality of Mould
1. No insulation cover on the wall plate

2. Pinched insulation at the eaves

Source: Department of Housing, Ireland
How can We Solve These Thermal Bridges?

1. Need to provide additional layer of insulation here

2. Need to thicken insulation here

Image Source: Department of housing, Ireland
How can We Solve the Wall Plate Thermal Bridge?

Adding a **insulated ‘service cavity’** on the interior will:
1. Reduce the thermal bridge
2. Improve the U-value of the wall
3. Make it easier to get a lower air permeability result
How can We Solve the Eaves Thermal Bridge?

Option 1

Adding a *insulated ‘service cavity’* to the ceiling will:
1. Reduce the thermal bridge
2. Improve the U-value of the ceiling
3. Make it easier to get a lower air permeability result

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department of housing, Ireland
Eaves Insulation – Timber Frame – Thermal Bridging – ACD’s

Eaves – Ventilated attic

Eaves – Unventilated attic

Eaves – Insulation
Between and under rafters
Unventilated rafter void - Dormer

Image Source: Department of housing, Ireland

Energy Efficiency for Construction: Building Fabric 2
Eaves Insulation – Cavity Wall – Thermal Bridging – ACD’s

Eaves – Unventilated attic

Eaves – Ventilated attic

Eaves – Insulation

Improvements to these details:

- Above insulation thickness in walls is not enough to meet NZEB
- Details would be improved with low conductivity block

Between and under rafters Unventilated rafter void - Dormer

Image Source: Department of housing, Ireland
Eaves Insulation – External Wall Insulation – Thermal Bridging – ACD’s

Improvements to these details:
- Above insulation thickness in walls is not enough to meet NZEB
- Details would be improved with low conductivity block
Eaves Insulation – Internal Wall Insulation – Thermal Bridging – ACD’s

Eaves – Unventilated attic

Eaves – Ventilated attic

Eaves – Insulation
Between and under rafters
Unventilated rafter void - Dormer

Improvements to these details:

• Above insulation thickness in walls is not enough to meet NZEB
• Details would be improved with low conductivity block

Image Source: Department of housing, Ireland
Can You Spot Two Clever Thermal Bridge Details Here?

Bob-tail roof truss to maximise insulation depth

Low conductivity blocks used at eaves and gable where roof insulation connects to wall insulation

Image Source: MosArt
Low conductivity blocks used at eaves and gable where roof insulation connects to wall insulation.
Use of Low Conductivity Blocks Exactly Where Needed

Overlapping with single story flat roof

Overlapping with a different single story flat roof

Energy Efficiency for Construction: Building Fabric 2

Image Source: MosArt
Thermal Bridge Free Eaves Detailing

Roof insulation overlaps perfectly with cavity wall insulation

Quilt insulation layer provided directly below the rafters reducing the thermal bridge effect

Image Source: MosArt
Thermal Bridge Free Attachment of Fascia

Skinny rafters fixed over main rafters to provide ventilation zone and attach fascia.
Alternative Approach to Overlapping Roof and Wall Insulation
Mould Very Common at Wall to Floor Junction

Image Source: Purchased by MosArt (iStock 482808792)
Case Study: Floor to Wall Junction in Cavity Wall

Image Source: Mannock
Aerated Concrete Blocks at Floor Connection

Blocks with reduced thermal conductivity used in the same plane as the floor insulation

Image Source: MosArt
Concrete foundations – sitting in soil with average winter temperature of 10°C

Base courses of rising wall constructed with standard concrete blocks
Low conductivity aerated concrete blocks used at the same place of floor insulation

Installation of sub-floor drainage services

Image Source: MosArt
Floor insulation installation to align with low conductivity blocks

Edge of floor slab insulation used to separate concrete floor from rising wall

Image Source: MosArt
Rising Wall Types and Components

450mm rising wall for insulated cavity and brick facade

Low Conductivity blocks to meet floor insulation

225mm rising wall for external wall insulation

Energy Efficiency for Construction: Building Fabric 2

Image Source: MosArt
Need to Thermally Separate Internal Wall Too

Low conductivity blocks help to ‘connect’ underfloor insulation in different rooms.
Floor Insulation of Individual Rooms

Insulation cut to fit neatly to each internal room

Image Source: MosArt
Base of internal wall built with low conductivity blocks and wrapped with insulation

Image Source: MosArt
Low Conductivity Blocks Under Radon Barrier

Energy Efficiency for Construction: Building Fabric 2

Image Source: MosArt

Low Conductivity Blocks Under Radon Barrier
Cavity Wall Insulation

- Edge of slab insulation
- Low conductivity blocks
- Cavity wall insulation

Image Source: MosArt
Mortar must be removed
Spot the Thermal Bridge

1. No insulation at the sole plate

Energy Efficiency for Construction: Building Fabric 2
Image Source: Department of housing, Ireland
Top - MosArt
How Can We Solve the Sole Plate Thermal Bridge?

Adding a insulated ‘service cavity’ on the interior will:
1. Reduce the thermal bridge
2. Improve the U-value of the wall
3. Make it easier to get a lower air permeability result
Case study - Cavity Wall: Concrete Forward Sill – Thermal Bridging – ACD’s

What do you think of this insulation thickness?
Way too thin!

Energy Efficiency for Construction:
Building Fabric 2

Image Source: Department of housing, Ireland
Case Study - Cavity Wall: Concrete Back Sill – Thermal Bridging – ACD’s

Need much more insulation to comply with NZEB

Image Source: Department of Housing, Ireland
Full Fill Cavity Wall Insulation – Passive Window Sills

200mm PIR cavity insulation with 250mm Passive Sill - Wall U-value – 0.11 W/m²K

- Designed to work with cavity wall construction and are installed in the same way as a traditional sill.
- Excellent insulation value
- Reduces thermal bridging
- Improves the overall performance of the window.
- 10% of the weight of a traditional sill
- 3 different finishes, sandstone, grey granite or white granite

Image Source: Passivesills
Need much more insulation to comply with NZEB.
200mm EWI with 265mm Passive Sill - Wall U-value – 0.16 W/m²K
Case Study - Internal Wall Insulation - Window Sills – Thermal Bridging – ACD’s

Energy Efficiency for Construction: Building Fabric 2

Image Source: Department of Housing, Ireland
Case Study - Internal Wall Insulation - Window Cills – Thermal Bridging – ACD’s

Need much more insulation to comply with NZEB

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<table>
<thead>
<tr>
<th>(3) WALLS: INTERNAL INSULATION</th>
<th>Ope - Concrete Forward Sill</th>
</tr>
</thead>
<tbody>
<tr>
<td>THERMAL PERFORMANCE CHECKLIST (TICK ALL)</td>
<td>AIR BARRIER - CONTINUITY CHECKLIST (TICK ALL)</td>
</tr>
<tr>
<td>Ensure insulated dry-lining tightly abuts underside of windowboard</td>
<td>Seal all penetrations through air barrier using a flexible sealant</td>
</tr>
<tr>
<td>Install proprietary cavity closer, or block of insulation, with thermal resistance path through closer having a minimum R-value as per relevant detail in section 1, 4 or 5</td>
<td>Apply flexible sealant to interface between plasterboard and windowboard, and between windowboard and frame</td>
</tr>
<tr>
<td></td>
<td>If forming air barrier to walls with blockwork inner leaf, or with scratch coat on blockwork, install a flexible sealant between cavity closer and blockwork wall</td>
</tr>
<tr>
<td></td>
<td>Ensure air barrier continuity between window, and wall plasterboard</td>
</tr>
</tbody>
</table>

Image Source: Department of housing, Ireland
Energy Efficiency for Construction: Building Fabric 2

Case Study - Timber Frame - Window Sills – Thermal Bridging – ACD’s

Need more insulation to comply with NZEB

Image Source: Department of housing, Ireland
Timber Frame - Window Cills – Passive Sills

Timber Frame Wall with 225mm Passive Sill - Wall U-value – 0.14 W/m²K

- Works with timber frame construction
- Installed in the same way as a traditional sill
- Excellent insulation value
- Reduces cold bridging at this point
- Improves the overall performance of your window.
- 10% of the weight of a traditional concrete or stone sill and reduces the risk of manual handling injuries on site
- 3 different finishes, sandstone, grey granite or white granite
Need much more insulation to comply with NZEB

Ensure partial fill insulation is secured firmly against inner leaf of cavity wall

Continue insulation to width of the cavity

Stainless Steel angle to support outer leaf

Air barrier - Continuity

- Seal all penetrations through air barrier using a flexible sealant
- Apply flexible sealant to all interfaces between internal air barrier and window / door frame members

Complying with checklist will help achieve design air permeability

Image Source: Department of housing, Ireland
Need much more insulation to comply with NZEB

Ensure partial fill insulation is secured firmly against inner leaf of cavity wall

Continue insulation to width of the cavity

Install proprietary cavity closer with path of minimum thermal resistance through the closer of not less than 4.29 m² K/W (manufacturers certified data)

Ensure all gaps around and between lintels are tightly packed with insulation

Air Barrier - Continuity

Checklist (Tick all)

- Seal all penetrations through air barrier using a flexible sealant

If forming the air barrier to the walls with a blockwork inner leaf or a scratch coat on blocks, install a flexible sealant between the cavity closer and blockwork wall

Apply flexible sealant to all interfaces between internal air barrier and window / door frame members

Complying with checklist will help achieve design air permeability
Case study - Galvanised Steel Top Hat Lintels – Thermal Bridging – ACD’s

Need much more insulation to comply with NZEB

Ensure partial fill insulation is secured firmly against inner leaf of cavity wall

Ensure thickness of lintel material is not more than 3.2mm

Ensure lintel is fully insulated and does not have a base plate

Steel top-hat crosses insulation – thermal bridge

Image Sources: Left: Department of housing, Ireland, Right: IG Lintels
Need much more insulation to comply with NZEB

Ensure partial fill insulation is secured firmly against inner leaf of cavity wall

Continue insulation to width of the cavity

Stainless steel lintel with perforated base plate. Base plate thermal conductivity not exceeding 7 W/mK. Thickness of lintel material no more than 3

Steel top-hat crosses insulation – thermal bridge
Hi-therm + Lintel = 80% improvement over the default or accredited lintel Psi-value

Image Source: KeystoneLintels
## Comparing Different Lintels – Thermal Bridging – ACD’s

<table>
<thead>
<tr>
<th>Lintel Construction</th>
<th>Thermal Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-therm+ Lintel</td>
<td>0.03 – 0.06 W/m.K</td>
</tr>
<tr>
<td>Standard Lintel</td>
<td>0.22 W/m.K</td>
</tr>
<tr>
<td>Default Non Plated Steel Lintel</td>
<td>0.33 W/m.K</td>
</tr>
<tr>
<td>Plated Steel Lintel</td>
<td>0.5 W/m.K</td>
</tr>
</tbody>
</table>

*Depending on wall construction.*

Image Source: Keystonelintels
The chart above shows how the thermal bridge factor impacts the energy performance coefficient of an NZEB dwelling.

As you can see, only the bespoke thermal bridge factor is compliant with NZEB in this case.

The dwelling used for this study is the ‘Example A’ dwelling presented by the Department of Housing, Planning and Local Government in Part L 2019.
Assessment

Energy Efficiency for Construction:
Building Fabric 2

QUIZ!
Module 5

Building Fabric 2: Windows and Doors

Energy Efficiency for Construction
To equip the learner with the relevant knowledge and skills required to understand the importance of maintaining continuous insulation around the envelope and how to implement measures to prevent heat loss.
1. Outline the principles of continuous insulation and thermal bridging
2. Outline the importance of creating a continuously insulated thermal envelope in order to reduce heat loss through the building fabric
3. Identify the insulation layer(s) in a range of construction drawings for the external envelope.
4. Outline the terms thermal conductivity, thermal resistance and U-value and identify the units of measurement used for them
5. Identify insulation materials that are certified and fit for purpose
6. Outline the impact of the energy efficiency of the building if the specified insulation type is substituted with an alternative type of lower thermal conductivity.
7. Outline the importance of avoiding thermal bridging in NZEB buildings
8. Investigate how to prevent thermal bridging at junctions using Best Practice details.
9. Outline the risks associated with poor workmanship relating to continuity of the insulation layer by considering reducing the number and size of service penetrations
10. Outline the best practice procedures regarding placement of windows, window sills, and floors in the insulation layer with special emphasis on fire safety and thermal retention.
Building Fabric 1 | Content

Topic 1 – Continuous Insulation

Topic 2 – Thermal Bridging

Topic 3 – Windows and Doors

On the following slides you will see this icon:

Click and play to find out more
3. Windows and Doors
Cost optimal windows for NZEB likely to require triple-glazing!

<table>
<thead>
<tr>
<th>Element or system</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows and glazed doors</td>
<td>Double triple glazed, low E (En = 0.05, soft coat) 20 mm gap, argon filled, PVC frames (U = 4.9 W/m²K, solar transmittance = 0.6)</td>
</tr>
</tbody>
</table>

or heat pump

Table E1.1: Example A: Semi-detached dwelling with gas boiler for space heating and continuous mechanical extract ventilation.
Energy and Comfort Related Window Functions

• Insulating element
• Solar gains
• Provide natural light
• Passive summer ventilation
• Protection from overheating (with low solar gain glass)
• Noise protection

Other:
• Means of emergency egress
• Security
High Performance Window Elements

3 layers of glass (glazing)

Insulating gas (Argon, Krypton) filled cavities

Low conductivity spacers

Partially insulated frames

Multiple gaskets for airtightness

Frame (Wood, uPVC, etc)
High Performance Window Elements

- Insulated glass is typically best performing element
- Spacer bars create a thermal bridge
- Frame is typically worst performing element

Image Source: Purchased by MosArt – WWETB (iStock 466205225)
Notice Anything Special About this Window Frame?

Insulated and thermally broken aluminium frame

Image Source: MosArt
Effect of Cold Glass

- Good quality double-glazed window:
  - $U_w = 1.13 \text{ W/(m}^2\cdot\text{K)}$
  - Radiant temperature difference: 5°C

- The surface of the glass when it's cold outside is too low.

- A radiator near the window is required to provide comfort
Effect of Warm Glass

- Good quality triple-glazed window:
  - $U_w = 0.70 \text{ W/(m}^2\text{K)}$
  - Radiant temperature difference: 3 C

- The surface of the glass is comfortable even when it's very cold outside
- A radiator adjacent to the window is not needed for comfort

Image Source: MosArt
Windows – Getting the Energy Balance Right

Windows are the weakest part of the thermal envelope, but they also provide free solar gains – plus, you need to consider overheating risk!
Mid-summer sun = 60°

- Shading can also be provided with **deciduous trees** which are bare in winter and allow solar gains into the building.

Mid-winter sun = 13°

- You can also use glass with a low g-value (solar heat gain coefficient).

**Image Source:** MosArt
Best Practice for Placement of Windows

- Windows should **sit in the same plane as the insulation** to ensure continuity of the insulation.
- Ideally in the **middle of the wall insulation**, difficult due to fixings.
- In solid masonry with external wall insulation, fit the window just in front of the exterior of the wall, **structural support necessary**.
- **Heat loss rises** if window is in masonry plane.
- More **choice of position of window in timber frame** construction, it can be on the inside or the outside.
- Setting the window deep in the **reveal will reduce solar gain**.
- The exterior of the frame should be **wrapped in insulation**.
- If the window is to the interior, the **reveal should be wrapped in insulation**.
Window Fitting Thermal Bridge

Energy Efficiency for Construction: Building Fabric 2

Image Source: MosArt
EWI – External Wall Insulation

Insulation placed externally on masonry buildings dramatically reduces thermal bridging
Structural insulation that can be bolted to masonry to support windows and doors.

Image Source: MosArt
Window first supported by Compacfoam insulation, then surrounded by external wall insulation.
Window installed in the same plane as the cavity wall insulation.

Window has yet to be taped to the surround with airtight tape.
Non-Metal Flashing: Pro Clima Extoseal

Image Source: Foursevenfive
Metal Exterior Sill Pans
Energy Efficiency for Construction: Building Fabric 2

Assessment

QUIZ!
Thank You

Special gratitude to Waterford Wexford Educational Training Board, Ireland for their contributions.