CONSTRUCTION BLUEPRINT

Module 5

Building Fabric 2: Continuous Insulation

Energy Efficiency for Construction

24 partners 12 countries

Date of Event

*Author/ **Institute***

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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

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Building Fabric 2 | Objectives

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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 2 | Content

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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

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1. Continuous Insulation

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"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"

Building Envelope

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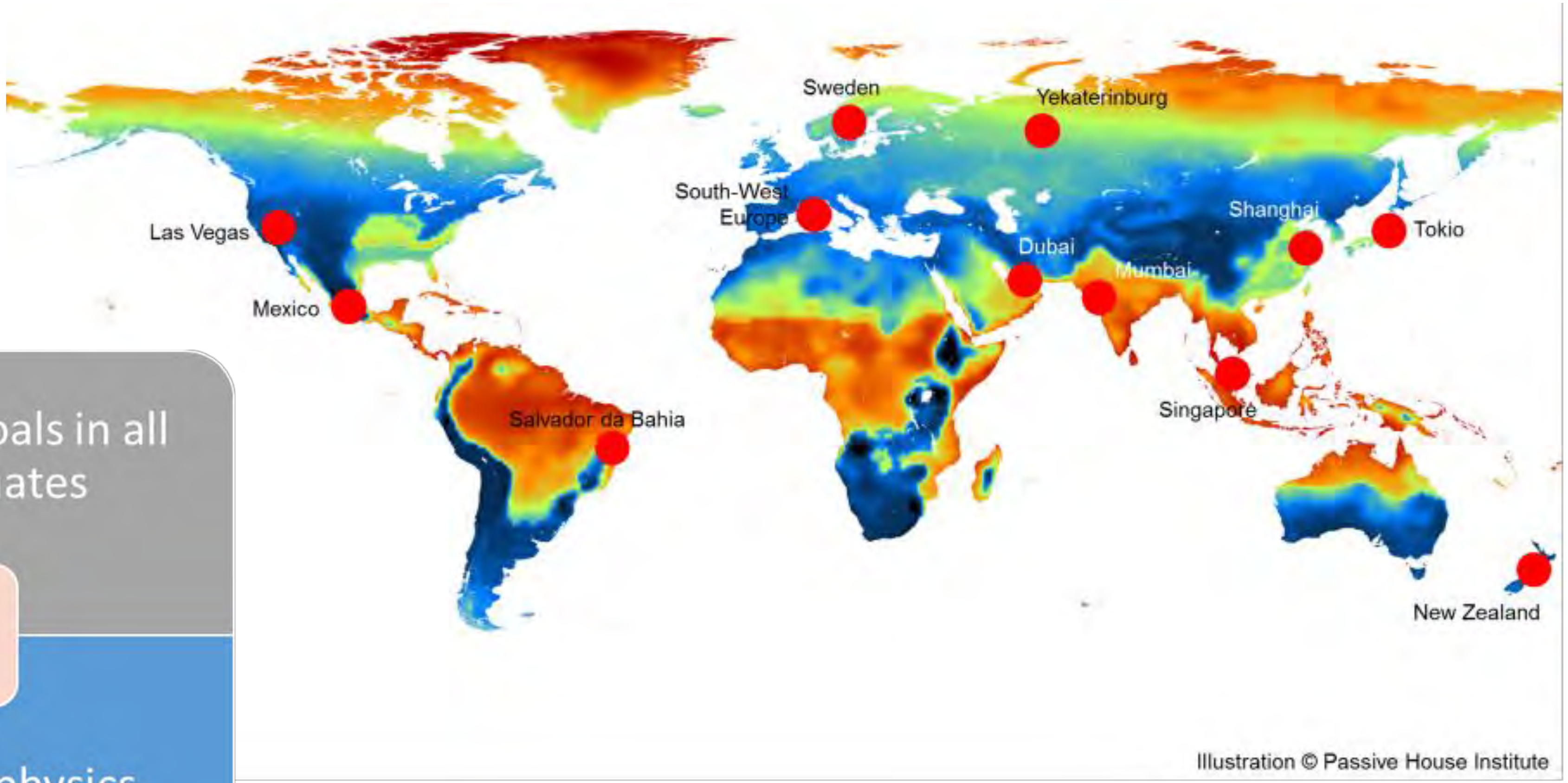
Specific building tradition in every country

Same goals in all climates

Boundary conditions vary

Climatic boundary conditions in every region

Same physics everywhere



Energy and financial saving potential

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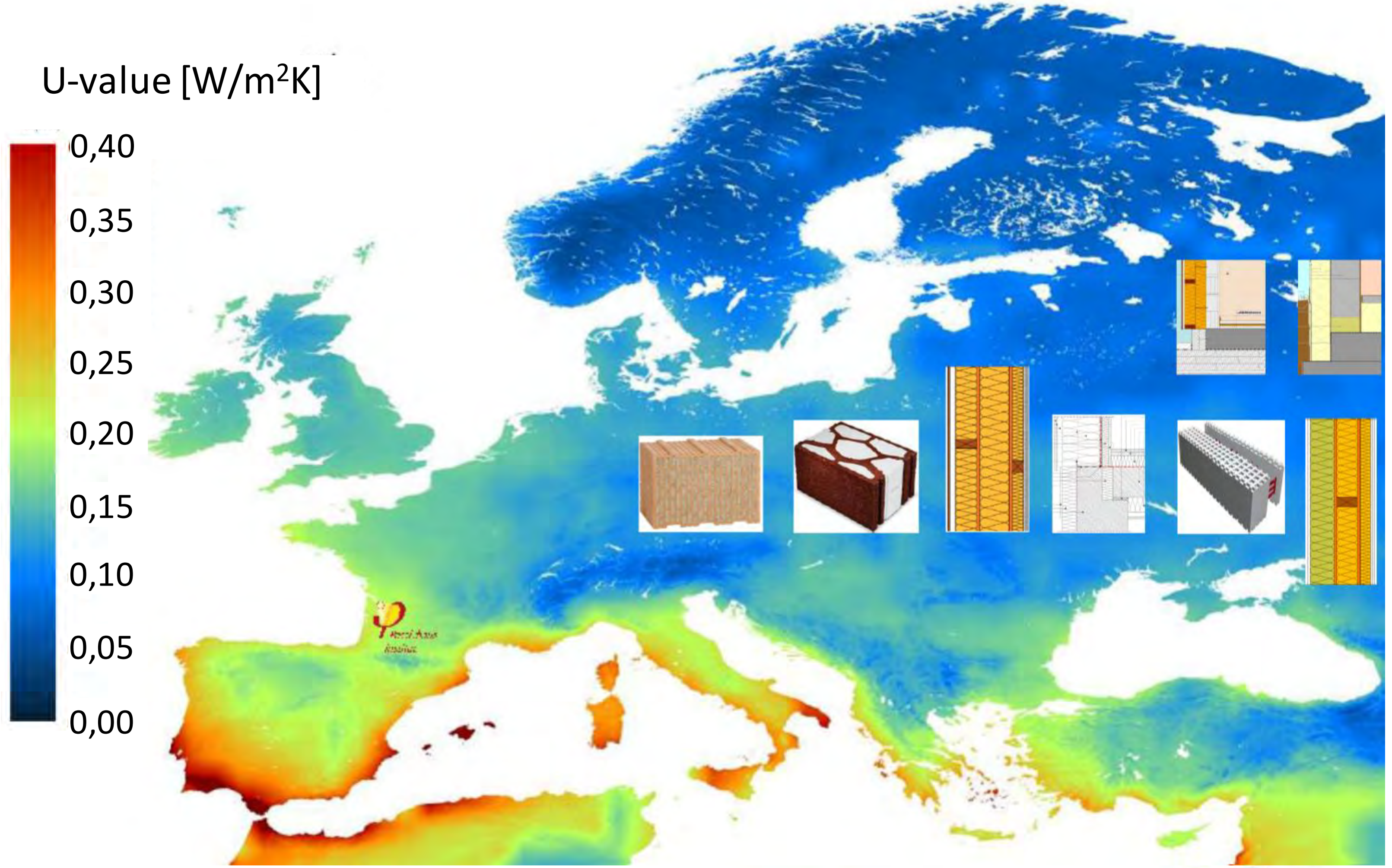
For colder and temperate climates for NZEB it is recommended:

- 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



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Insulation Systems

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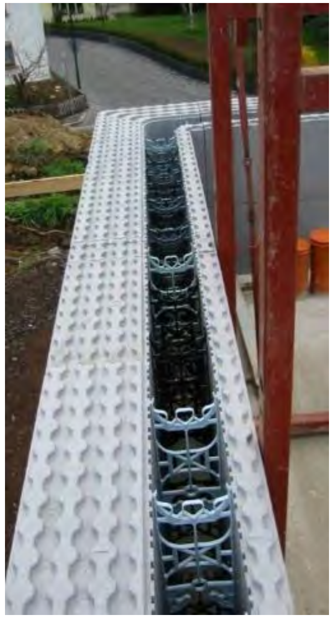
It is possible to choose different technologies available on the market for constructing NZEBs

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

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Different insulation materials are possible

Natural

Synthetic

Transmission Losses and Ventilation Losses - Residential

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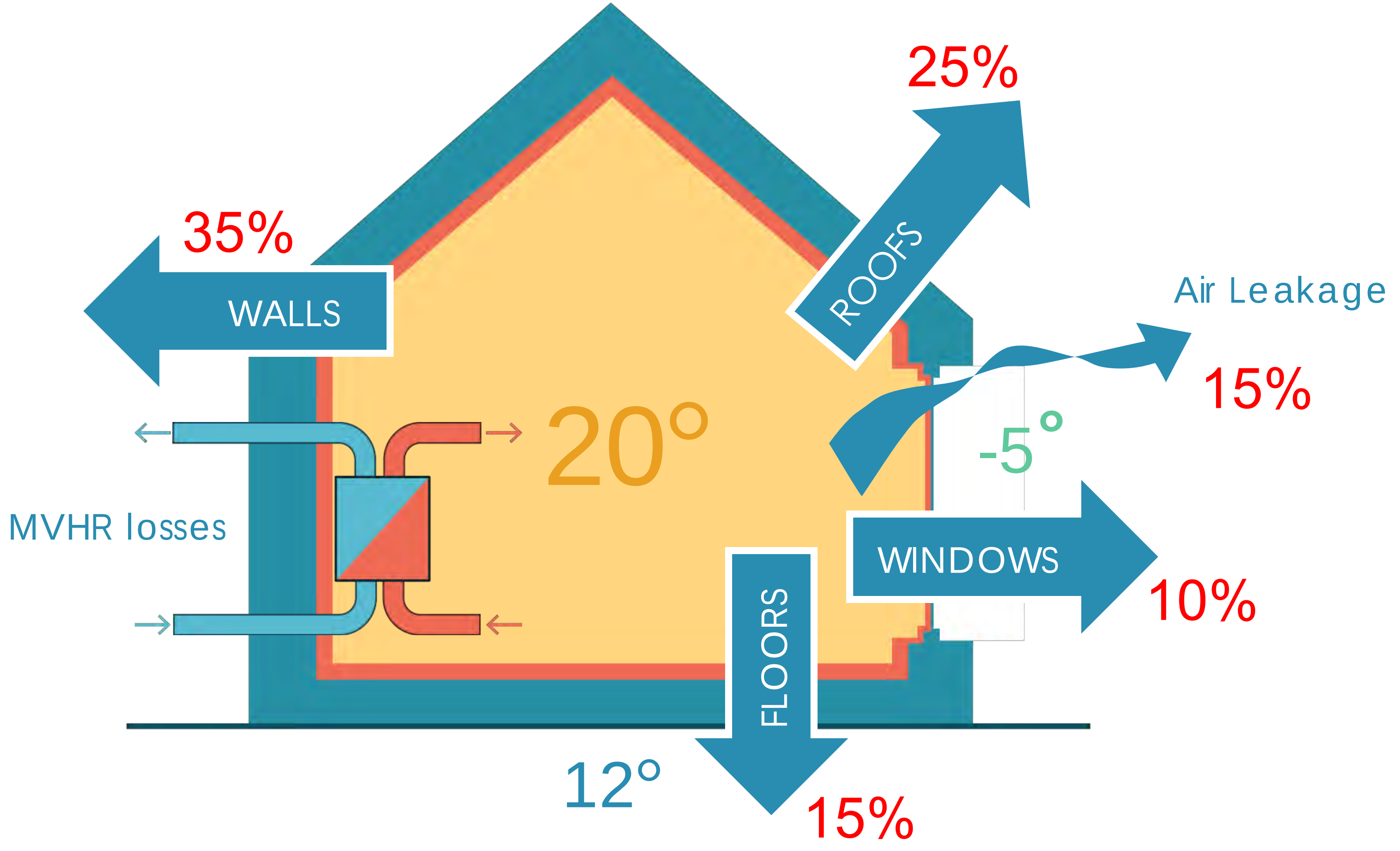

Image Source: MosArt-WWETB

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

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Building physics – The Form Factor

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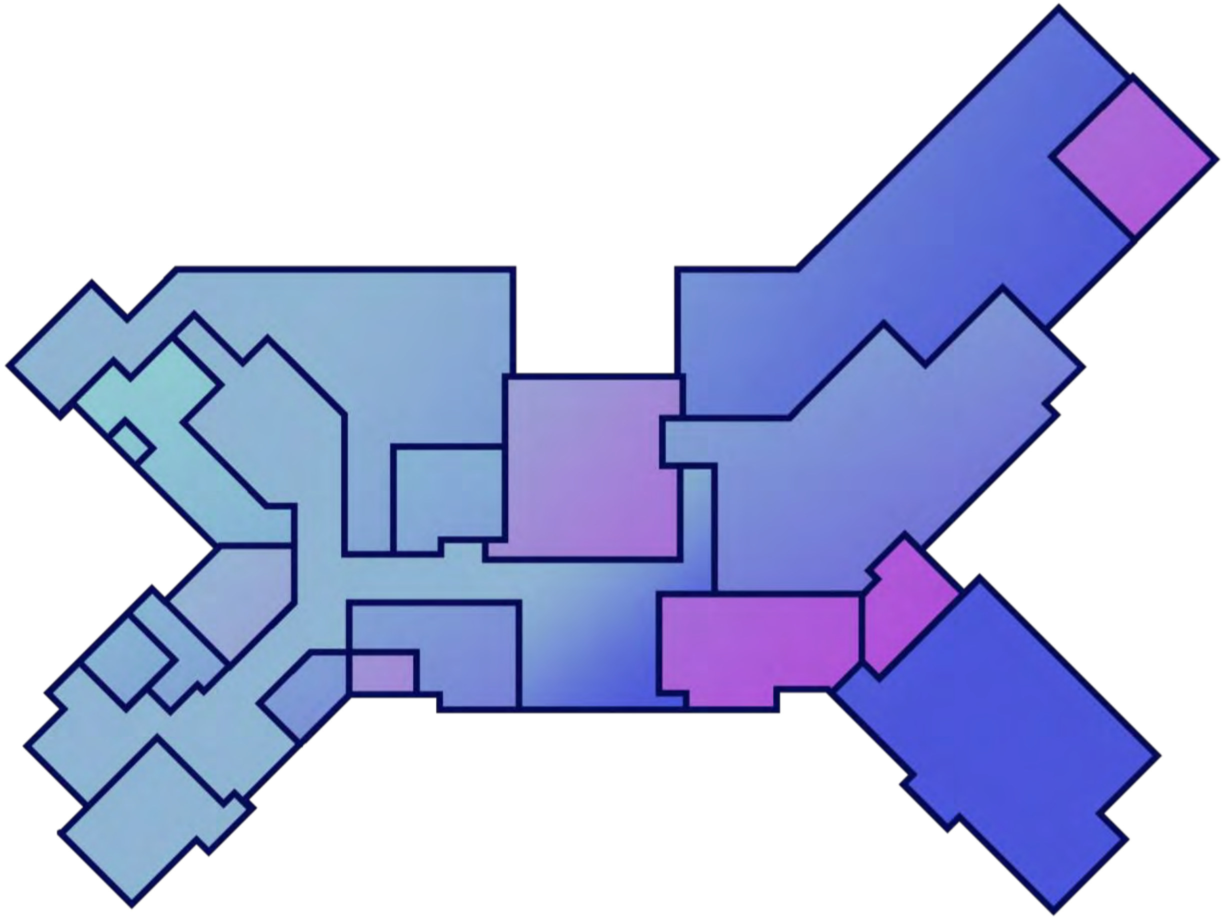

The greater the surface area, the greater the heat lost

Image Source: MosArt-WWETB

Area to Volume Ratio (A/V)

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

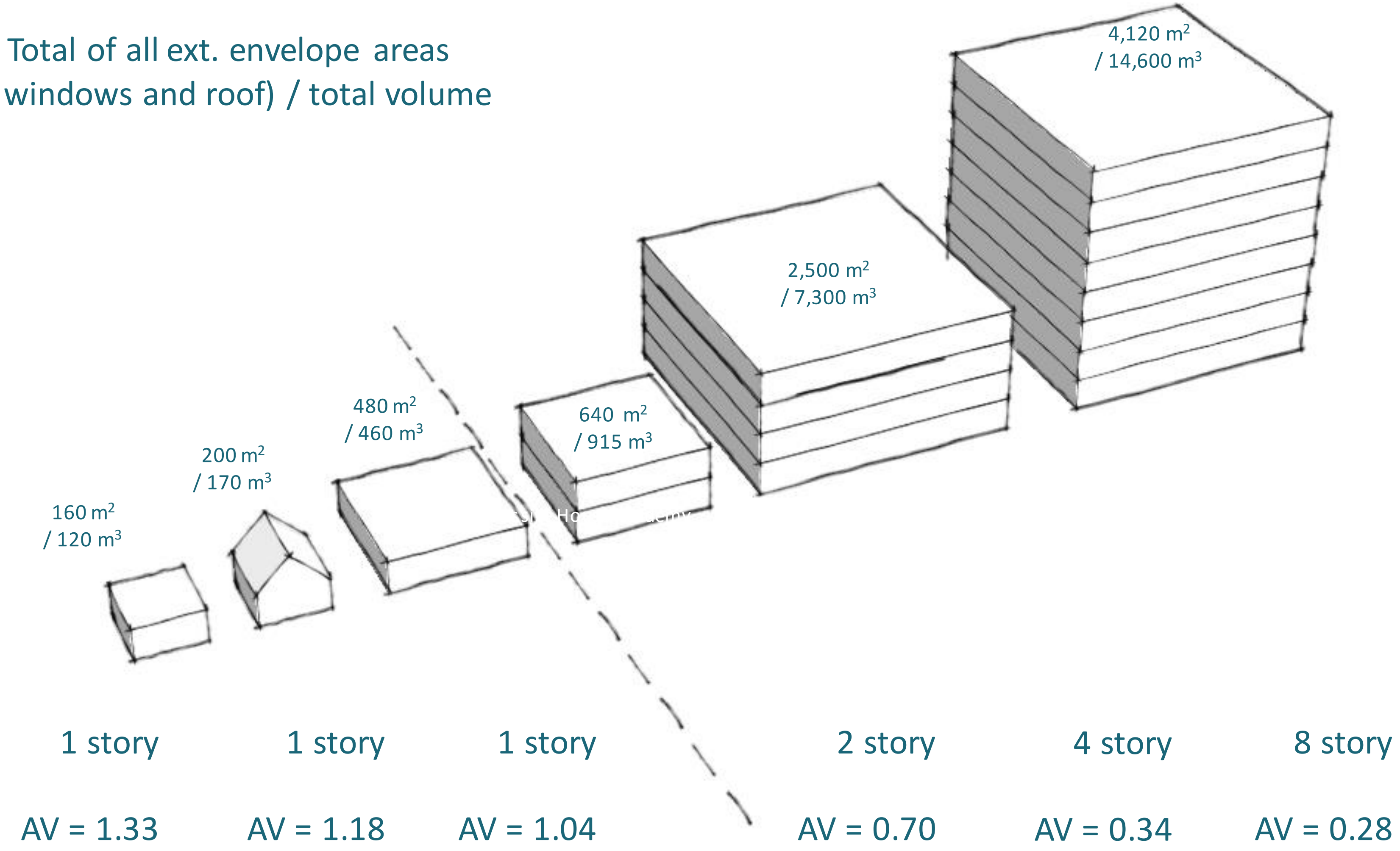

Image Source: Passive House Academy

Continuous Insulation Principle

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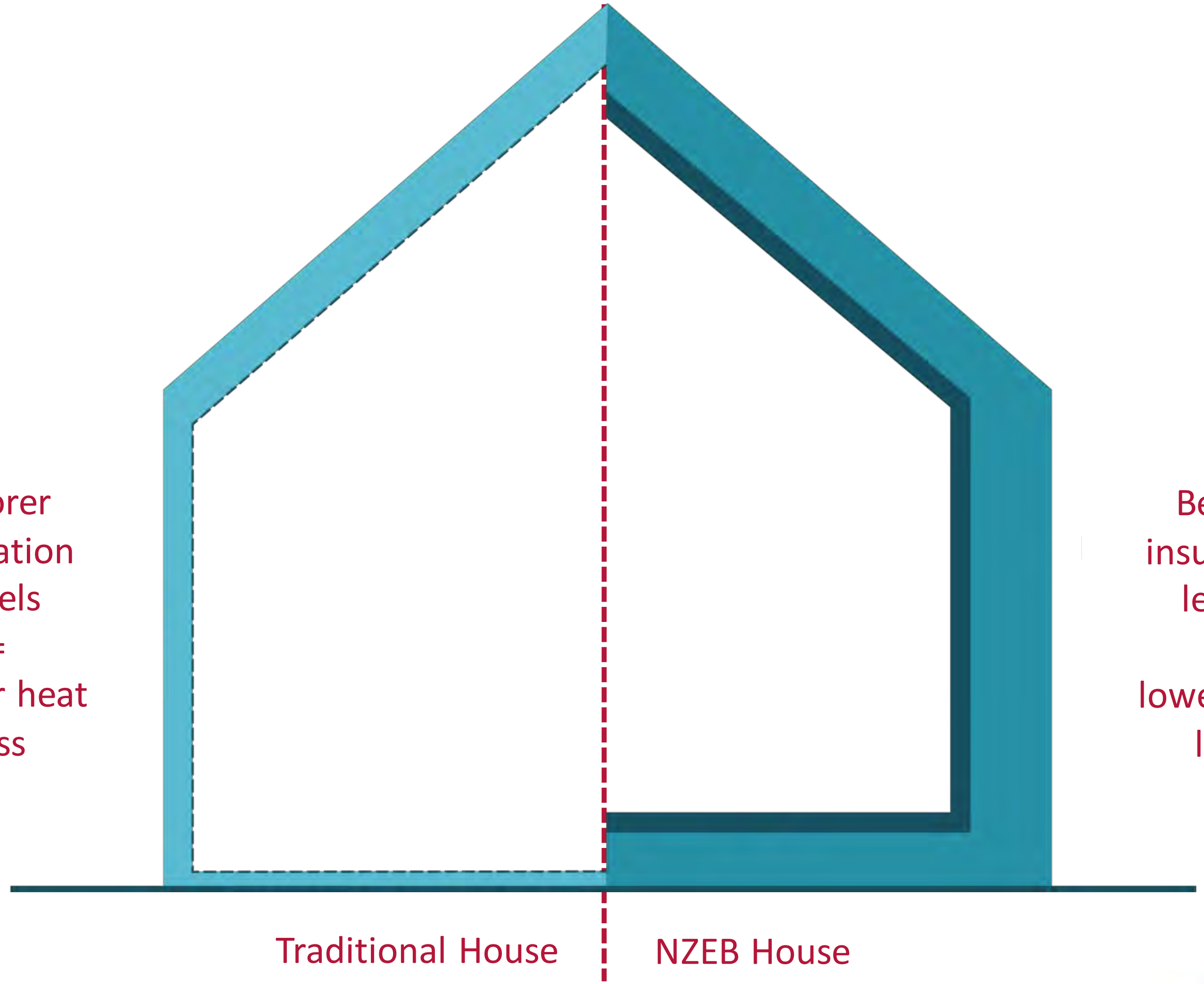
Poorer insulation levels = higher heat loss



Better insulation levels = lower heat loss

Image Source: MosArt-WWETB

Critical Insulation Continuity Locations

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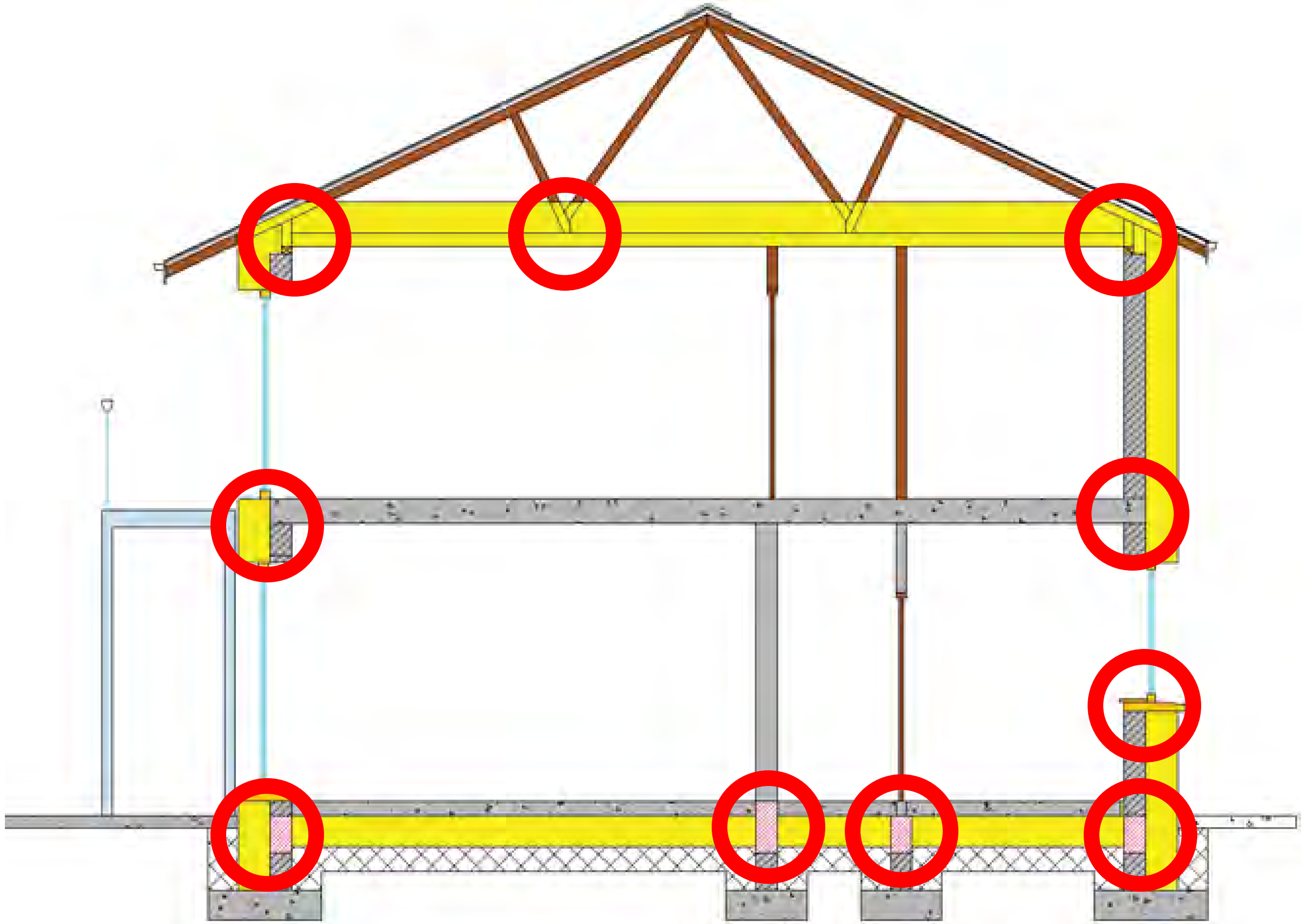
Critical points to maintain continuity of insulation in the envelope to keep the heat in and cold out. (Red Circles)



Images Source: MosArt

Case study - Acceptable Construction Details (ACD's)

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- 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

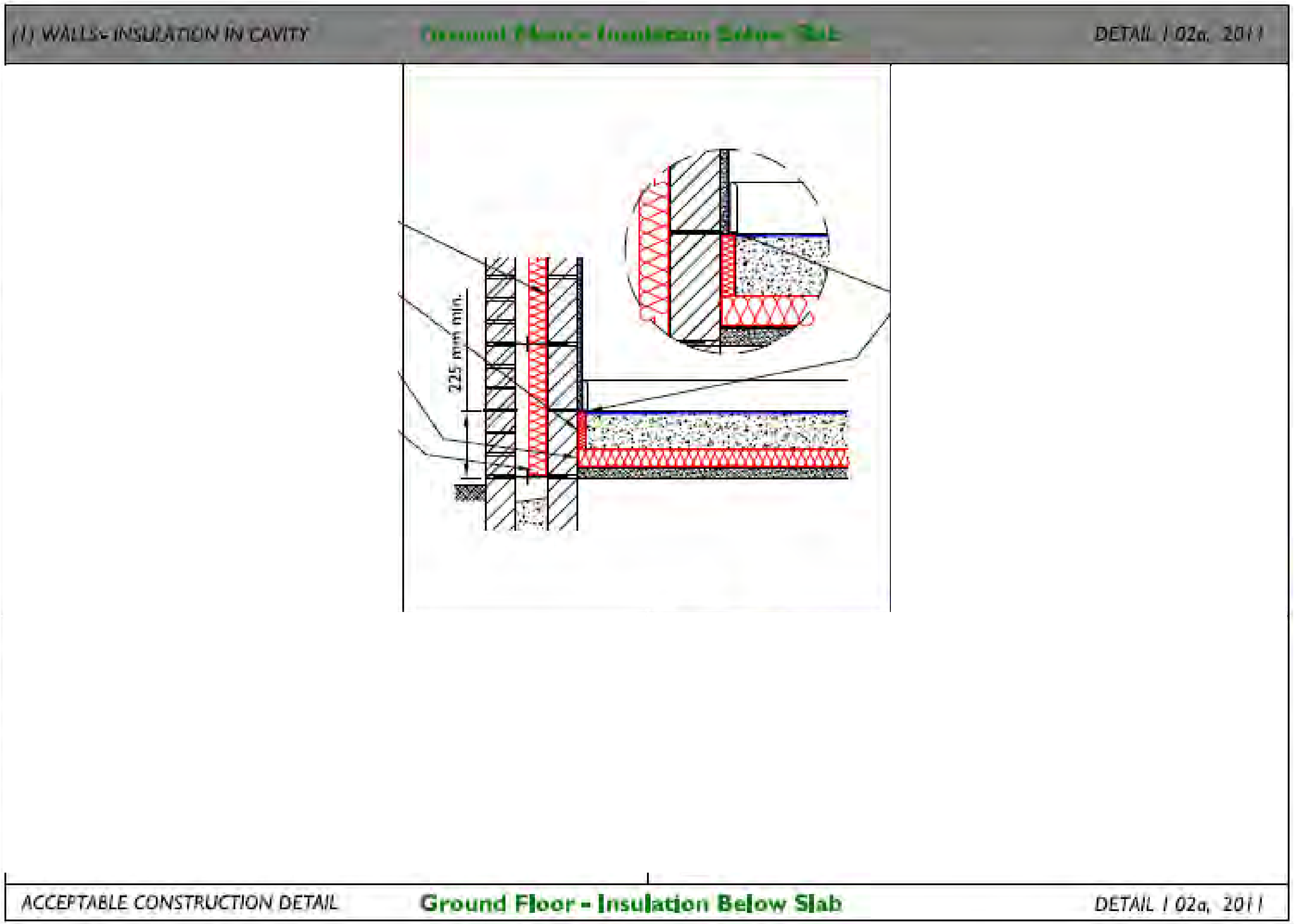

Image Source: Department of Housing, Planning and Local Government Ireland

Be Aware of the ACD's

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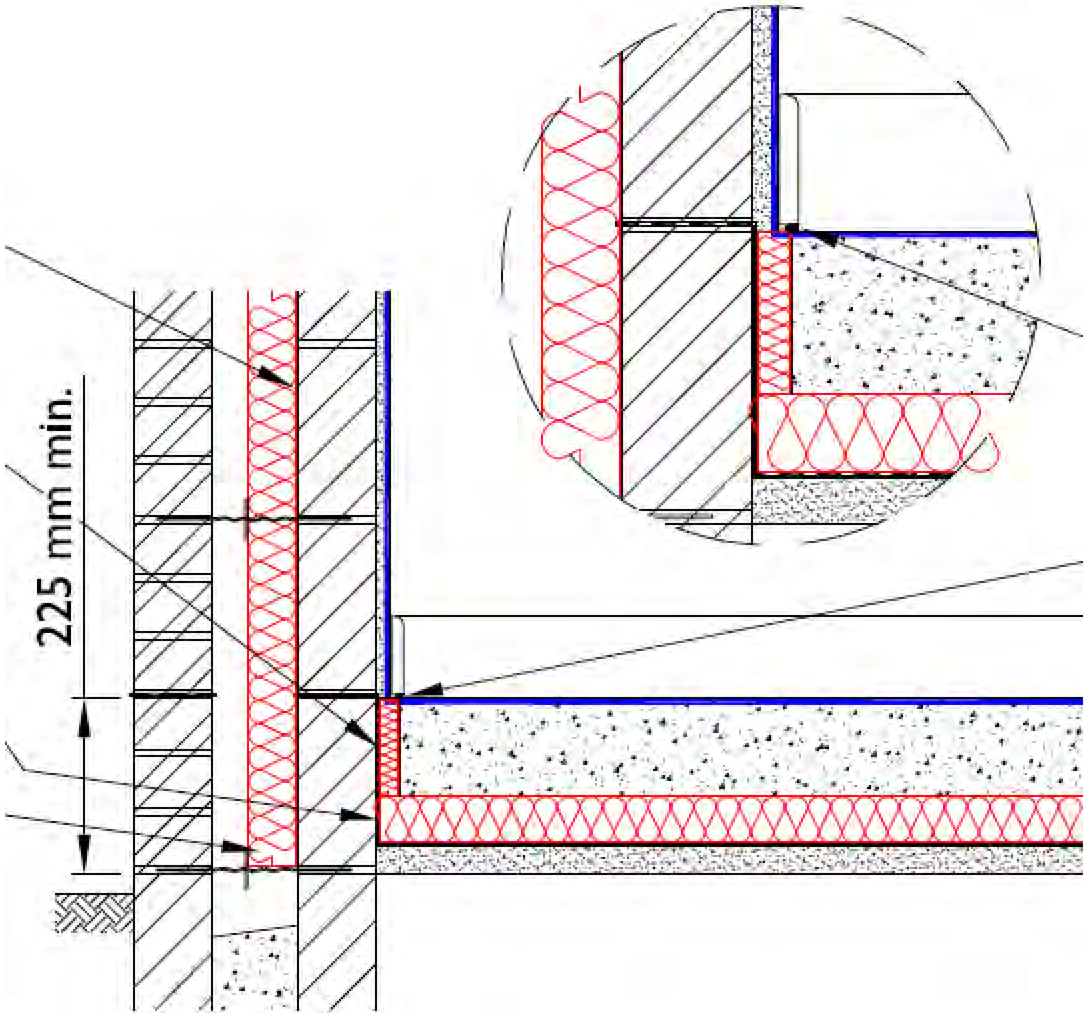

- Guidelines for detailing but can be improved upon
- Provide multiple options for **key construction types** (including cavity wall and timber frame)
- Suggest positioning of **insulation** and **air permeability** measures
- **Can be improved upon** significantly

Source: Department of Housing, Planning and Local Government Ireland

Case Study - Cavity Wall – Insulation Above Slab - ACD

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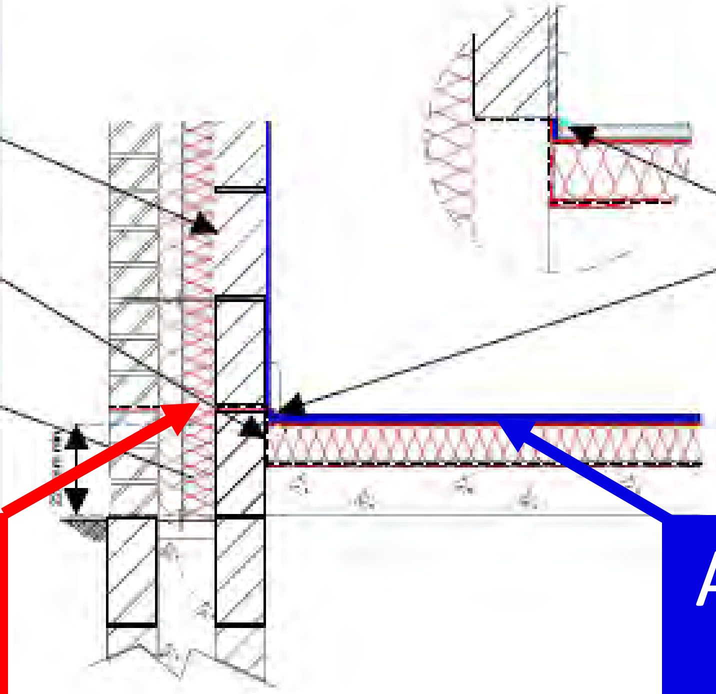
(1) WALLS:- INSULATION IN CAVITY | Ground Floor - Insulation above slab | DETAIL 1.01a, 2011

THERMAL PERFORMANCE
CHECKLIST
(TICK ALL)

- Ensure partial fill insulation is secured firmly against inner leaf of cavity wall ☐
- Floor insulation to tightly abut blockwork wall ☐
- Ensure wall insulation is installed at least 225 mm below top of floor insulation ☐



AIR BARRIER - CONTINUITY
CHECKLIST
(TICK ALL)

- ☐ 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

Insulation shown in red

Airtightness shown in blue

Source: Department of Housing, Planning and Local Government Ireland

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Case Study - Cavity Wall – Insulation Above Slab & AAC - ACD

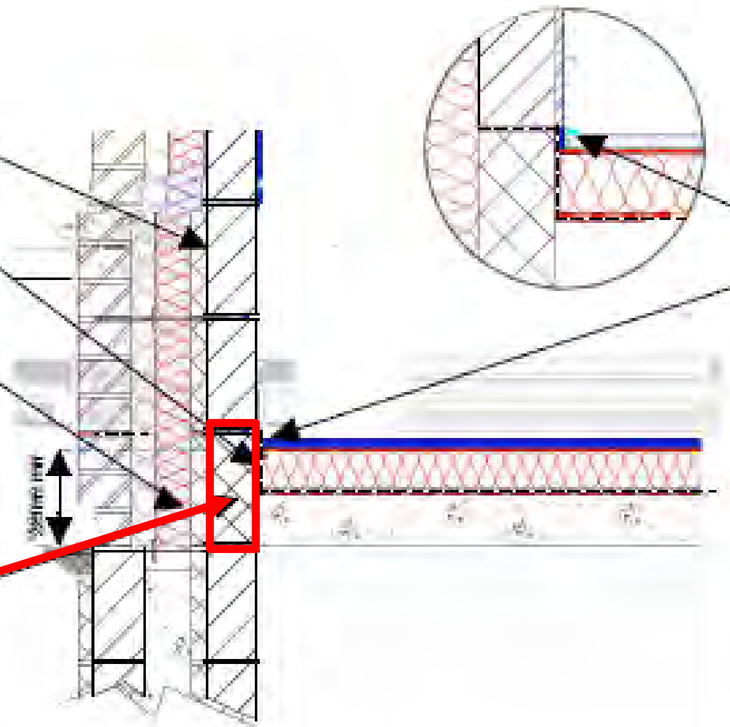
Co-funded by the Erasmus+ Programme of the European Union

(1) WALLS:- INSULATION IN CAVITY **Ground Floor - Insulation above slab plus lightweight block** *DETAIL 1.01b, 2011*

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

- Ensure partial fill insulation is secured firmly against inner leaf of cavity wall
- Floor insulation to tightly abut blockwork wall
- Ensure wall insulation is installed at least 225 mm below top of floor insulation
- Ensure block with a maximum Thermal Conductivity of .20 W/mK in the direction of heat flow is used and that block is suitable for use in foundations in all conditions. Block is to be installed so to avoid any effect of moisture on Thermal Conductivity



AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

- 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

Complying with checklist will help achieve design air permeability

Source: Department of Housing, Planning and Local Government Ireland

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Case Study - Cavity Wall – Insulation Below Slab - ACD

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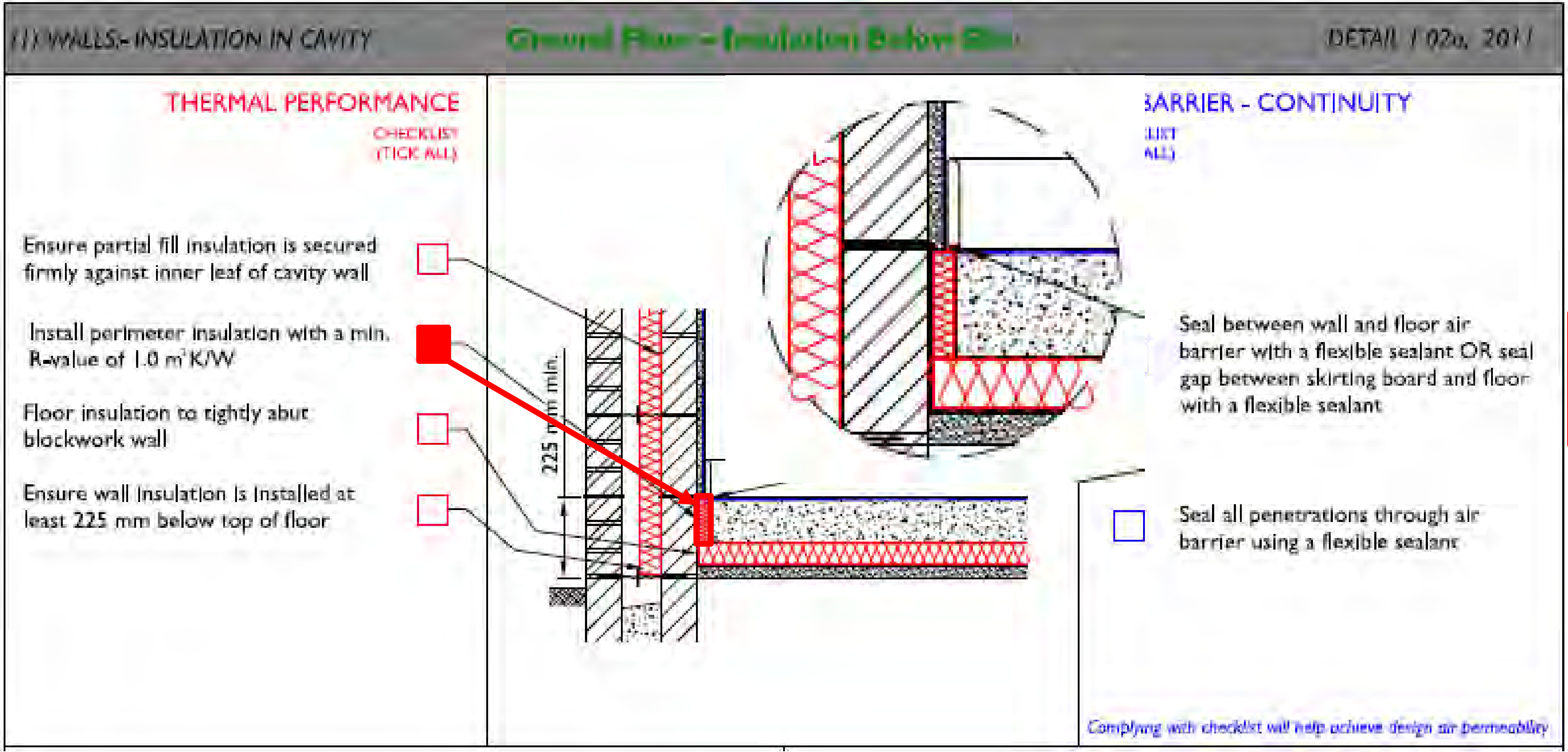

Image Source:
Department of Housing, Planning and Local Government Ireland

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Case Study - Cavity Wall – Insulation Below Slab - AAC

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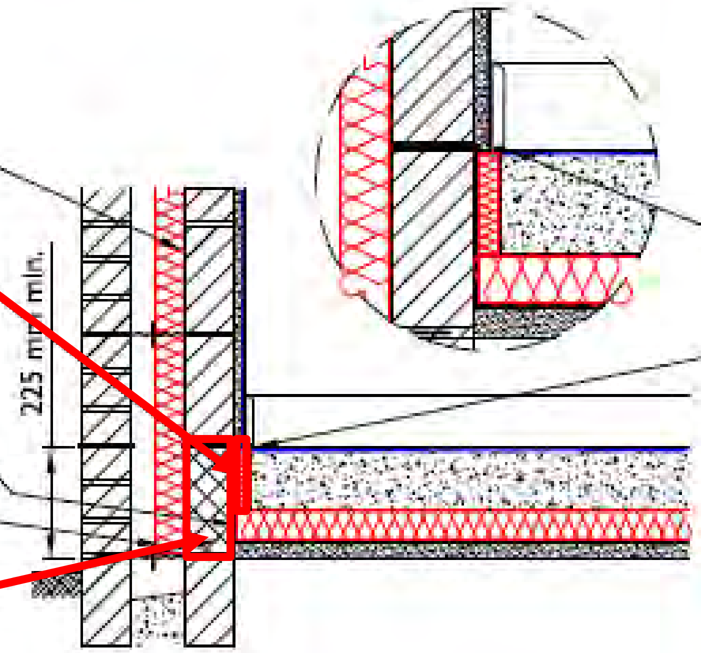
(1) WALLS- INSULATION IN CAVITY Ground Floor – Insulation Below Slab Plus Lightweight Block DETAIL 1.026, 2011

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

- 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 .20 W/mK in the direction of heat flow is used and that block is suitable for use in foundations ☐



AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

- ☐ 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

Complying with checklist will help achieve design air permeability

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

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Case Study - Cavity Wall – Suspended Timber Floor - ACD

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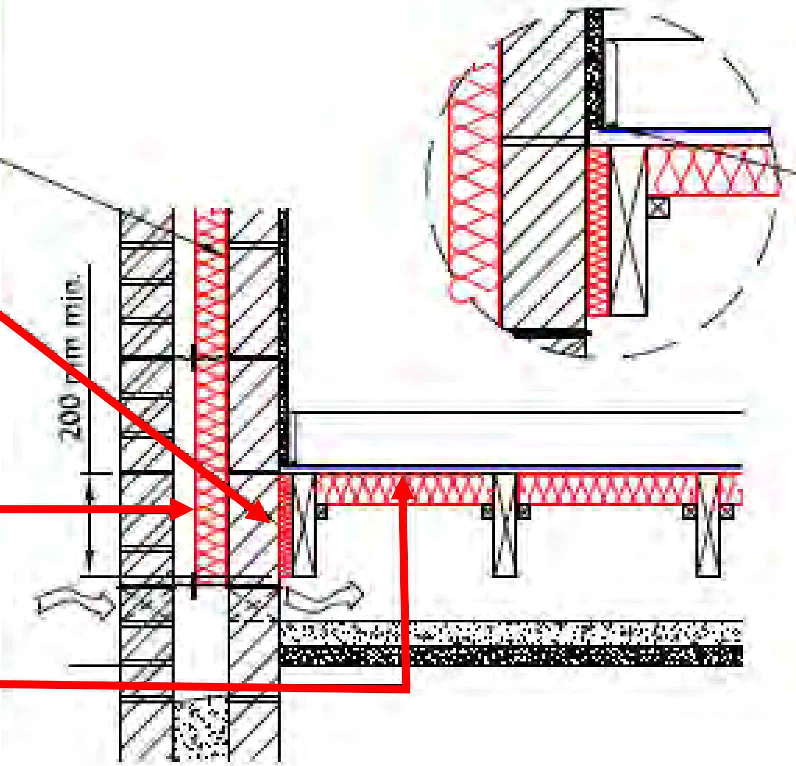
(1) WALLS:- INSULATION IN CAVITY | Timber Suspended Ground Floor | DETAIL 1.02. 2011

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

- Secure partial fill insulation firmly against inner leaf
- Pack gap between floor joist and blockwork wall with compressible insulation if over 25mm; otherwise inject approved insulating expanding foam. Min. R-value of 0.63 m²/KW
- Ensure wall insulation is installed at least 200 mm below top of floor insulation
- Ensure insulation is in contact with the underside of timber flooring



AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

- Seal between wall and floor air barrier with a flexible sealant 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
- Provide similar air seals at all internal partitions

Complying with checklist will help achieve design air permeability

Maximum Area-weighted average U-values (W/m²K)

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Building Fabric Element	Pitched Roof (Insulation at ceiling)	Pitched Roof (Insulation on slope)	Flat Roof	Walls	Floors (ground and other exposed floors)	External Doors and Windows
2002	0.16	0.20	0.22	0.27	0.25	2.20
2005	0.16	0.20	0.22	0.27	0.25	2.20
2007	0.16	0.20	0.22	0.27	0.25 0.15 (UF)	2.00
2011	0.16	0.16	0.20	0.21	0.21 0.15 (UF)	1.60
2019	0.16	0.16	0.20	0.18	0.18 0.15 (UF)	**1.40**

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/m^2K)

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Building Fabric Element	Pitched Roof (Insulation at ceiling)	Pitched Roof (Insulation on slope)	Flat Roof	Walls	Floors (ground and other exposed floors)	External Doors and Windows
Backstop NZEB	0.16	0.16	0.20	0.18	0.18 0.15 (UF)	1.40
Reality NZEB Required	0.11	0.11	0.11	0.13	0.14	0.9

Note: 'UF' above denotes under floor heating

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Reality Bites: Optimal Performance Spec for Semi-D

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

Element or system	Specifications
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 m^2 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 m^2, any other doors are fully glazed
Walls	U = 0.13 W/m^2K 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 W/m^2K e.g. 360 mm insulation of conductivity 0.04 W/mK, between and over ceiling joists
Floor	U = 0.14 W/m^2K e.g. Slab-on-ground floor with 120 mm insulation of conductivity 0.023 W/mK
Opaque door	U = 1.5W/m^2K
Windows and glazed doors	~~Double~~Triple glazed, low E (En = 0.05, soft coat) 20 mm gap, argon filled, PVC frames (U = ~~1.3~~ 0.9 W/m^2K, solar transmittance = 0.6)

Source: Department of Housing, Planning and Local Government

Traditional Cavity Wall

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- 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*)

Image Source: MosArt

Cavity Wall Insulation – Installation and Precautions

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- 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
- Batts & 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

Data Source: Department of Housing, Planning and Local Government

Cavity Wall Insulation – Installation and Precautions

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- 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 (see Acceptable Construction Details, section 1 details)

BRE "Good Building Guide 68 Part 2 Installing thermal insulation: Good site practice"

Data Source: Department of Housing, Planning and Local Government

Cavity Wall Width – NZEB Compliance

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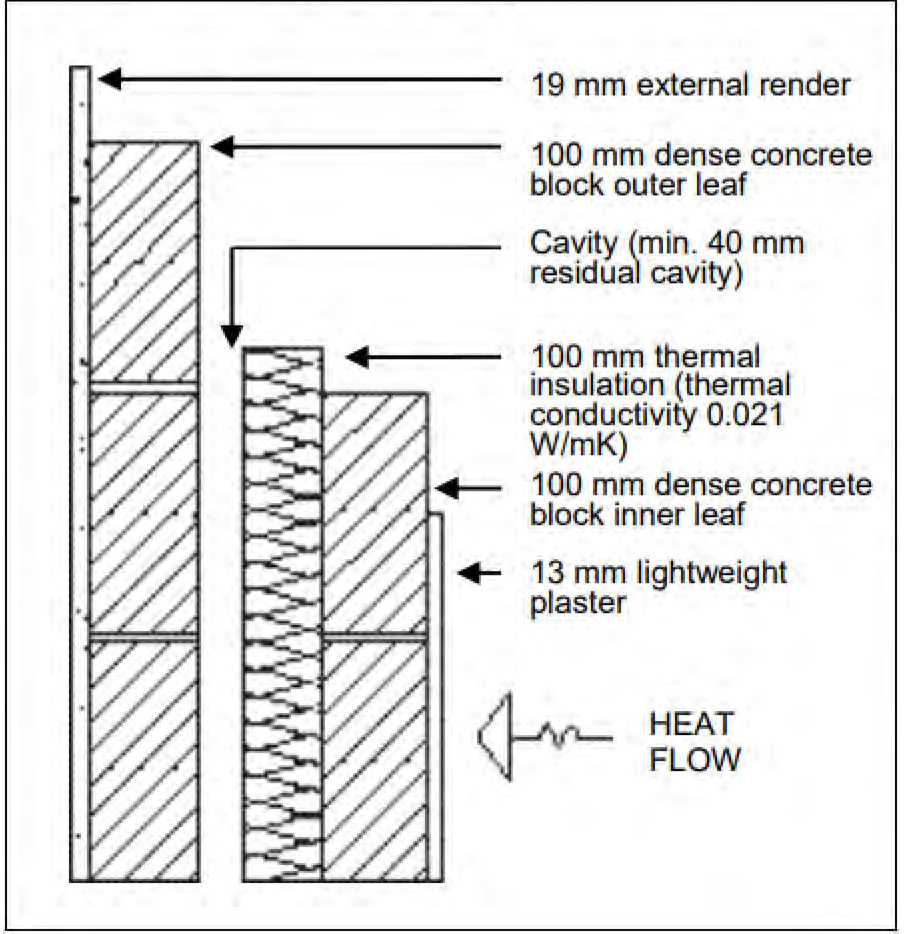
Diagram A1 Masonry cavity wall
(Par. A2.1)



Layer/ Surface	Thickness (m)	Conductivity (w/mK)	Resistance (m^2K/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	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/m^2K			

Image Source: Department of Housing, Planning and Local Government

NZEB Requires Wider Walls & Wider Foundations

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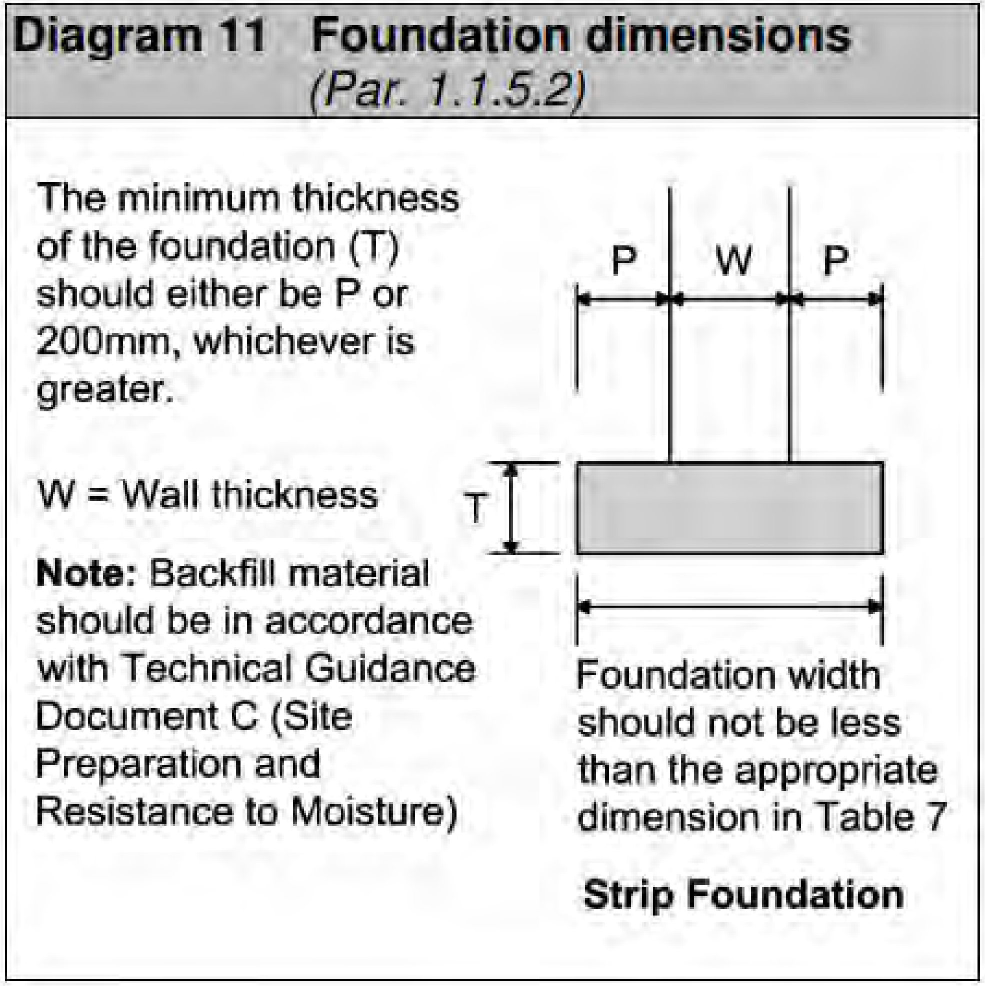

Note: In no case should the width of the foundation be less than the total width of the wall plus 75 mm on each side.

Image Source: Department of Housing, Planning and Local Government, Part A of the Building Regulations

Full-Fill Cavity Wall Insulation

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Ensure continuous insulation with no mortar snots

Image Source: MosArt

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Cavity Wall Width – NZEB Compliance – Better Than Backstop

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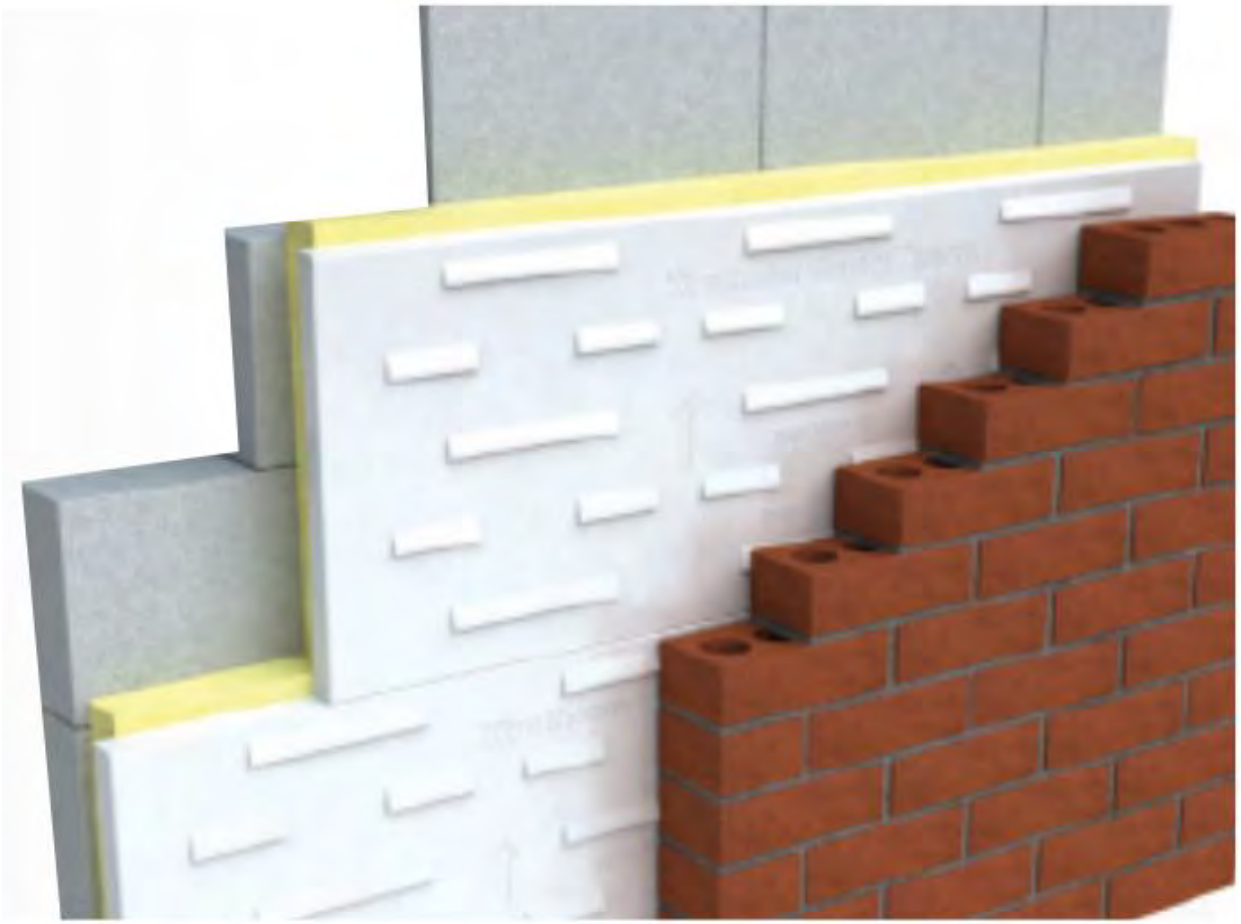

CavityTherm (Inner block 100)

Block Type	100mm	125mm	150mm
Light	0.17	0.14	0.12
Med	0.19	0.15	0.13
Dense	0.19	0.16	0.13

Plaster Finish

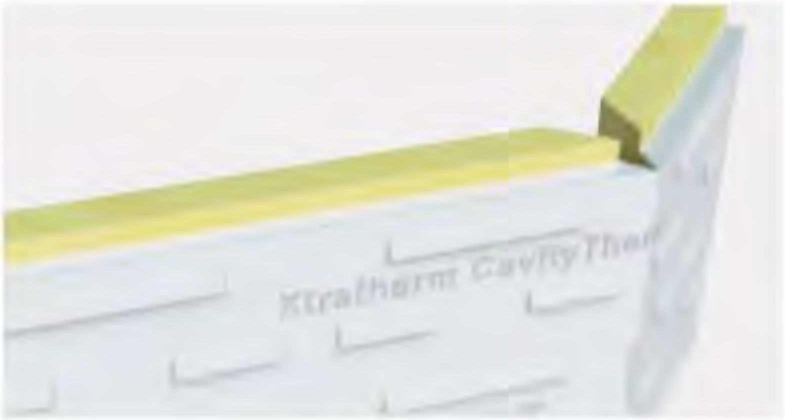

Image Source: Xtratherm

Full-Fill Cavity Wall Insulation

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- 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

Image Source: MosArt

Insulation Boards to be Tightly Butted

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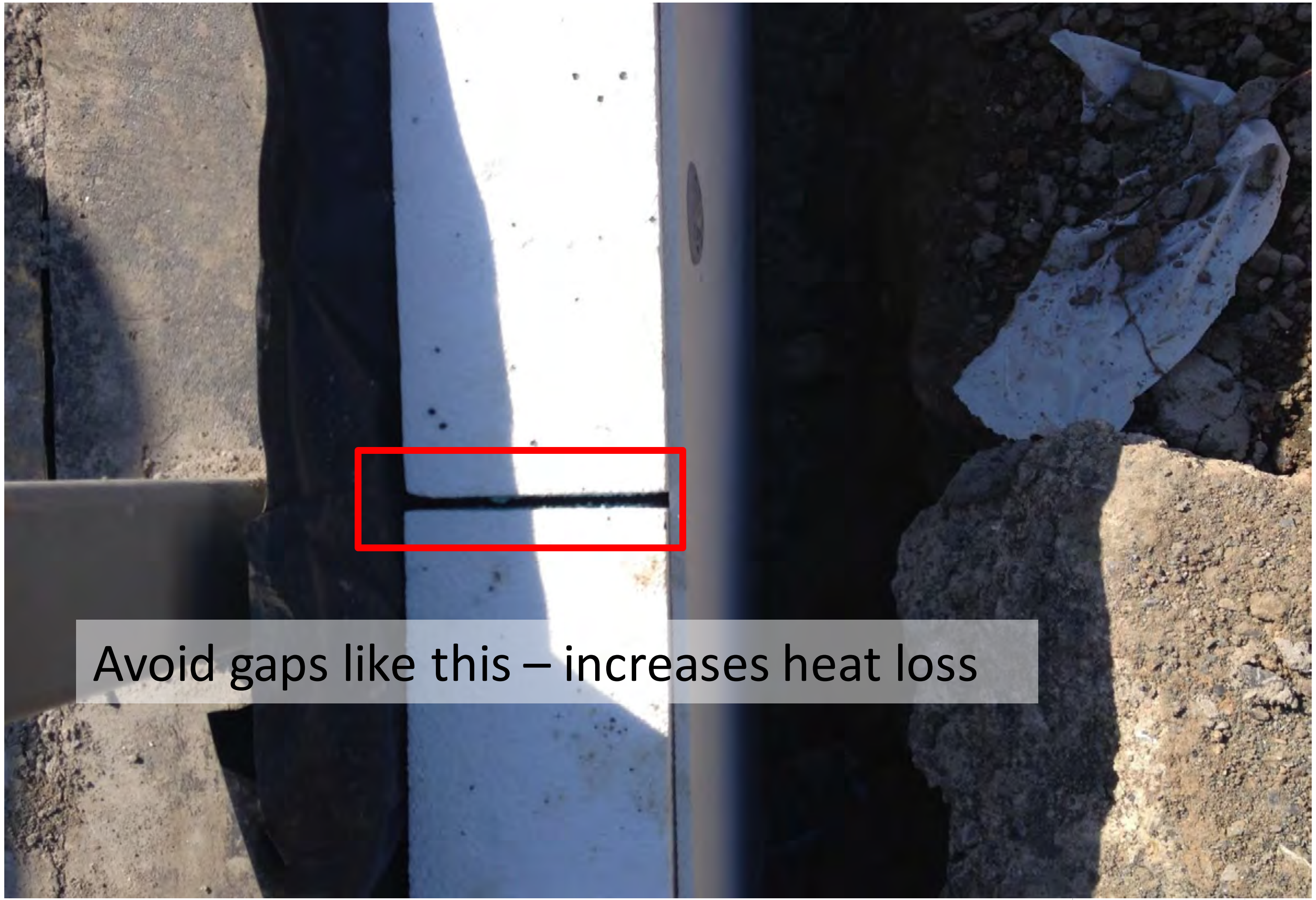

Image Source: MosArt

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Better to Mitre Insulation at Corners

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Image Source: MosArt

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Wall Ties

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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

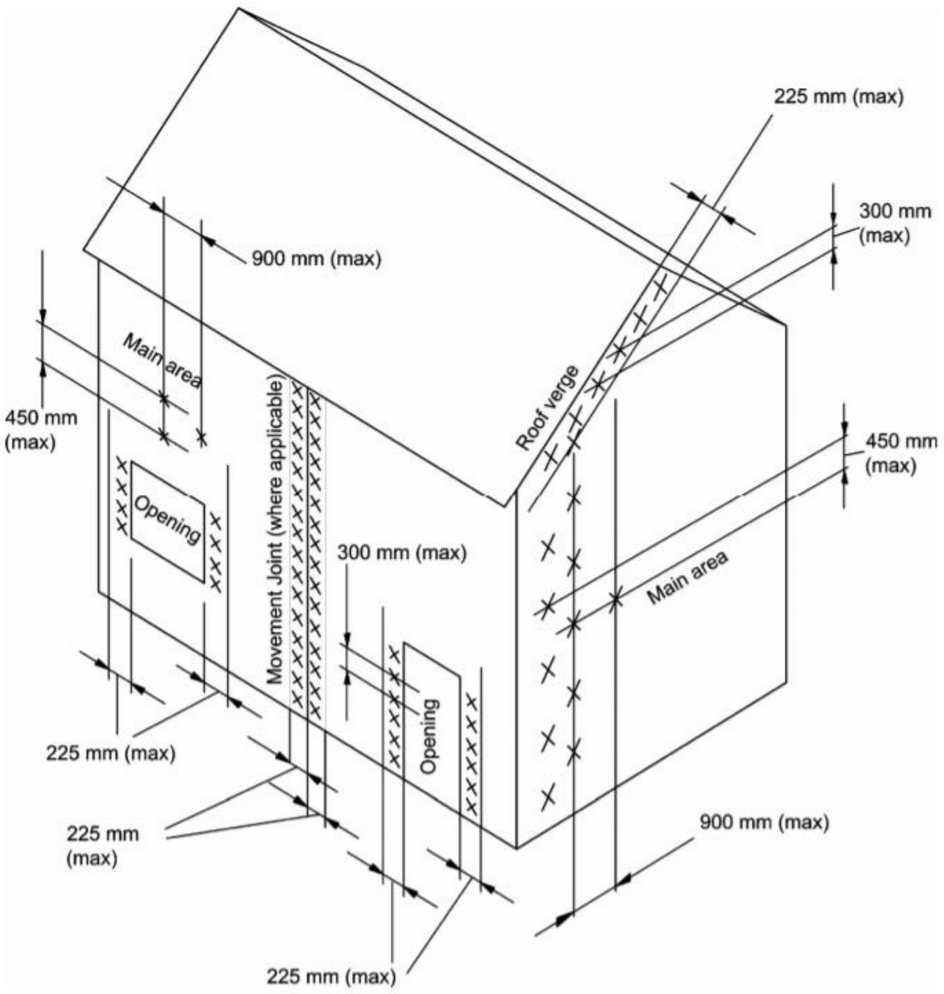

Image Source: Department of Housing, Planning and Local Government, Ireland

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Wall Ties

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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).

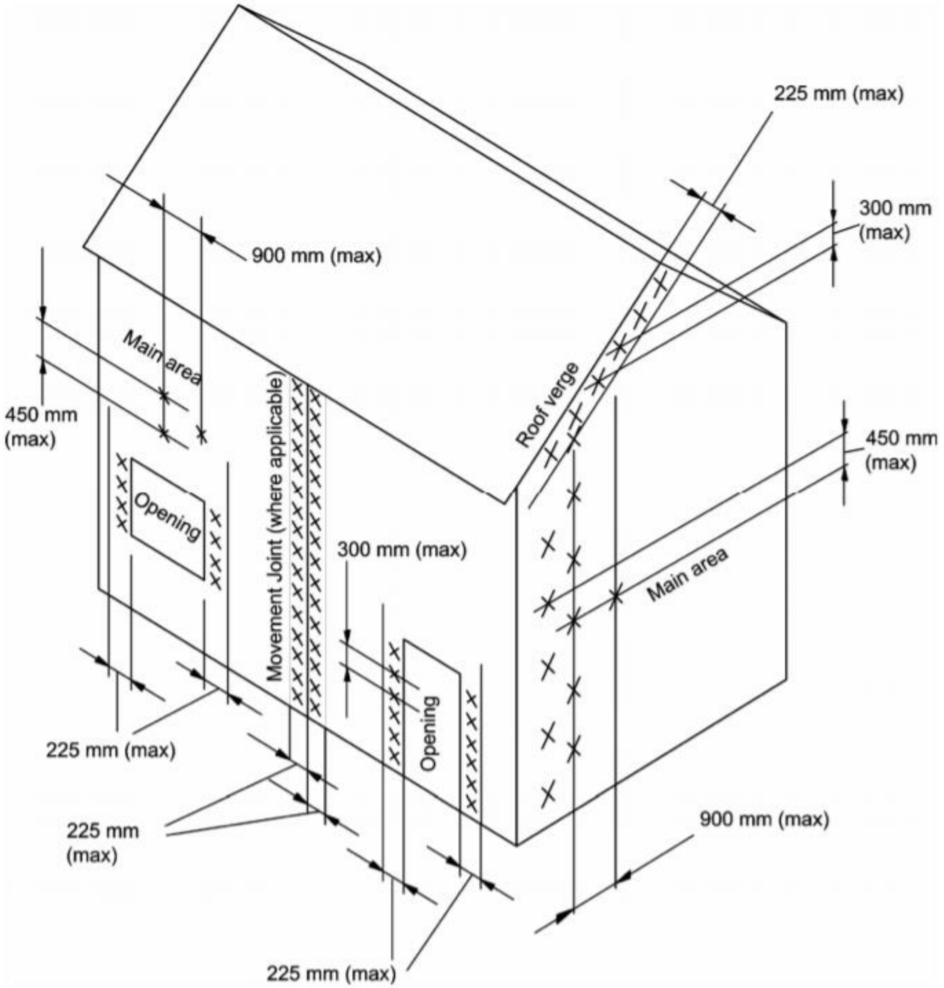

Image Source: Department of Housing, Planning and Local Government, Part A of the Building Regulations

Wall Ties & Thermal Bridging

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Table A1 Thermal conductivity of some common building materials

Material	Density (kg/m^3)	Thermal Conductivity (W/mK)
General Building Materials		
Clay brickwork (outer leaf)	1,700	0.77
Clay brickwork (inner leaf)	1,700	0.56
Concrete block (heavyweight)	2,000	1.33
Concrete block (medium weight	1,400	0.57
Concrete block (autoclaved aerated)	700	0.20
Concrete block (autoclaved aerated)	500	0.15
Concrete block (hollow)	1800	0.835
Cast concrete, high density	2,400	2.00
Cast concrete, medium density	1,800	1.15
Aerated concrete slab	500	0.16
Concrete screed	1,200	0.41
Reinforced concrete (1 % steel)	2,300	2.30
Reinforced concrete (2 % steel)	2,400	2.50
Wall ties, stainless steel	7,900	17.00
Wall ties, galvanised steel	7,800	50.00
Mortar (protected)	1,750	0.88
Mortar (exposed)	1,750	0.94
External rendering (cement sand)	1,800	1.00
Plaster (gypsum lightweight)	600	0.18
Plaster (gypsum)	1,200	0.43
Plasterboard	900	0.25

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

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CONSTRUCTION BLUEPRINT

Wall Ties & Thermal Bridging

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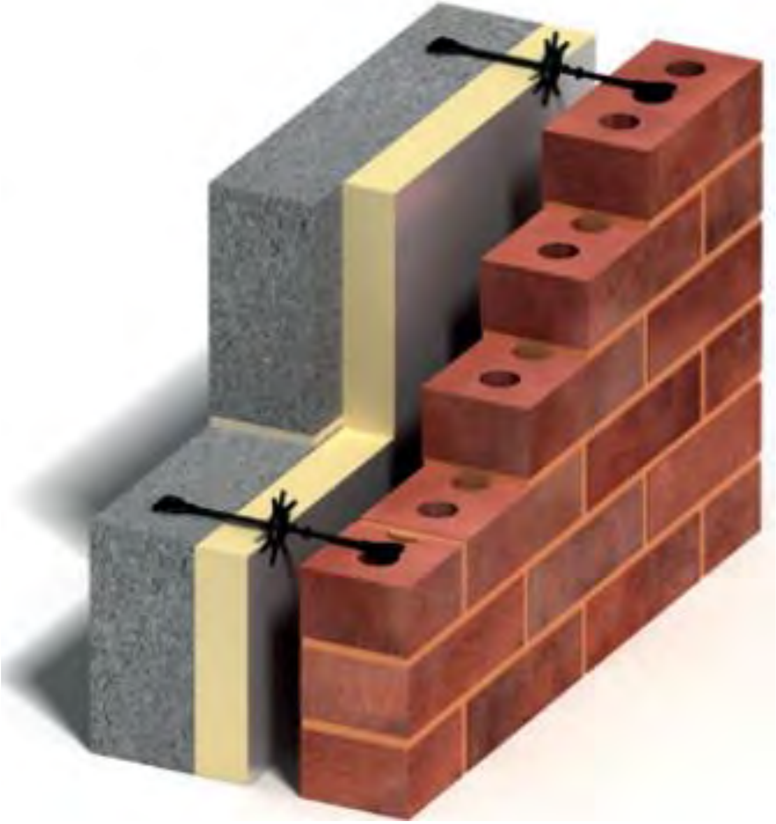


- The Ancon ties are manufactured from basalt fibres set in a resin matrix.
- These ties have a thermal conductivity of just **0.7 W/mK.**

Image Source: Ancon

Cavity Barriers – Why Are they Needed?

Co-funded by the Erasmus+ Programme of the European Union

- 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.

Cavity Barriers – Positioning

Co-funded by the Erasmus+ Programme of the European Union

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.

Diagram 11 Roofspaces over protected stairway in dwelling houses (alternative arrangements) *Par 3.6.2*

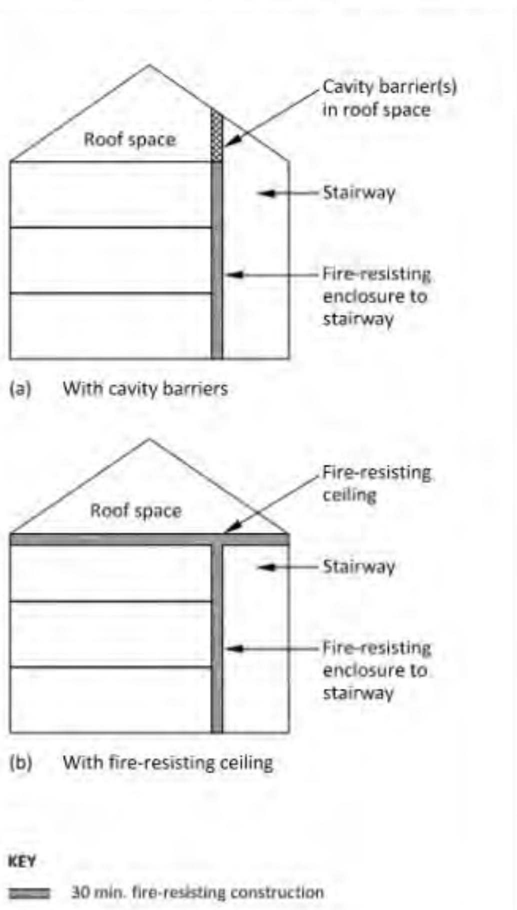
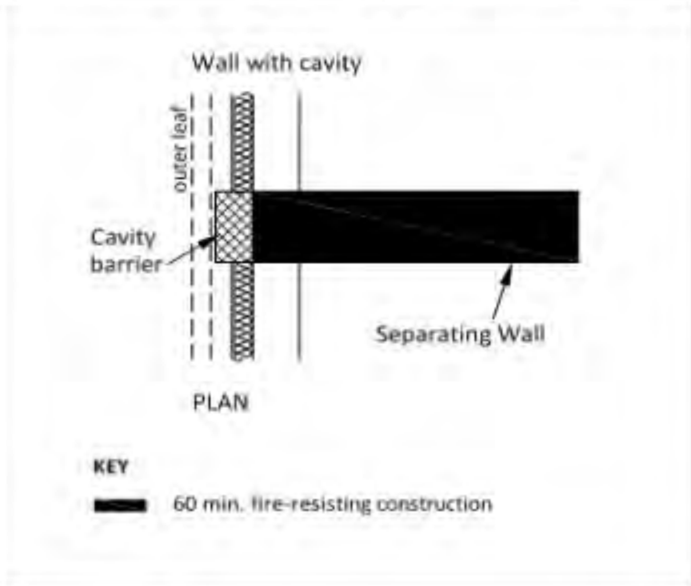


Diagram 12 Vertical cavity barrier at junction of separating wall *Par. 3.6.2.*



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

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Cavity Barriers – Construction and Fixings

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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.

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

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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

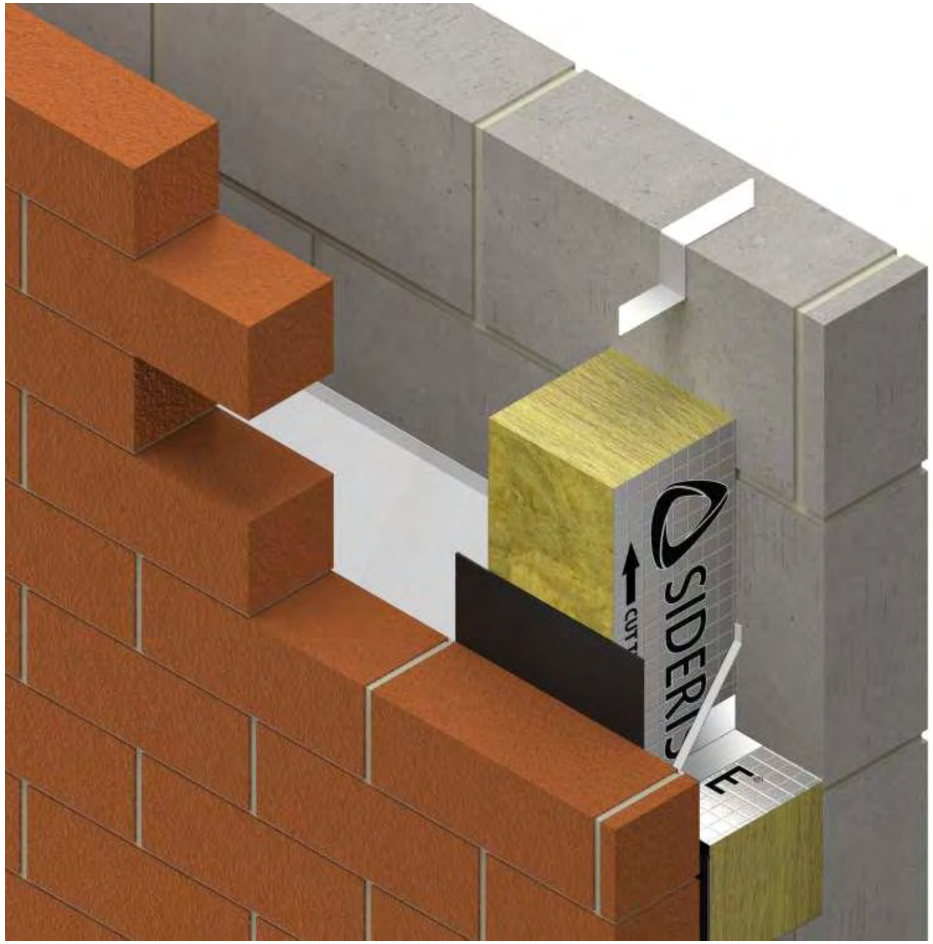
ANTICLOSER XPS

- The thermal cavity closer incorporates a UPVC outer which acts as a damp proof barrier, while the insulated XPS core prevents thermal bridging problems.

Image Source: Siginsulation

Co-funded by the Erasmus+ Programme of the European Union

SIDERISE EW – Cavity Barriers and Fire Stops for Masonry External Walls

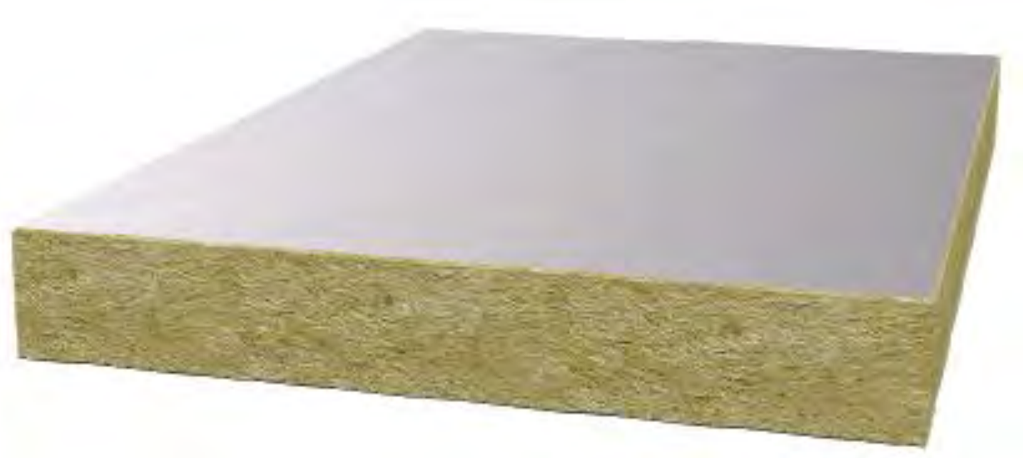


- Fire resistance: up to 2 hours
- Sound reduction: up to 25dB (Rw)
- Integral smoke barrier
- Resilient to accommodate site tolerances without cutting
- Certified 3rd Party Approval

Image Source: Siderise

Fire Stop for Partial Fill Cavity Wall Construction

Co-funded by the Erasmus+ Programme of the European Union



ROCKWOOL® Mineral Wool Fire Barrier Slab

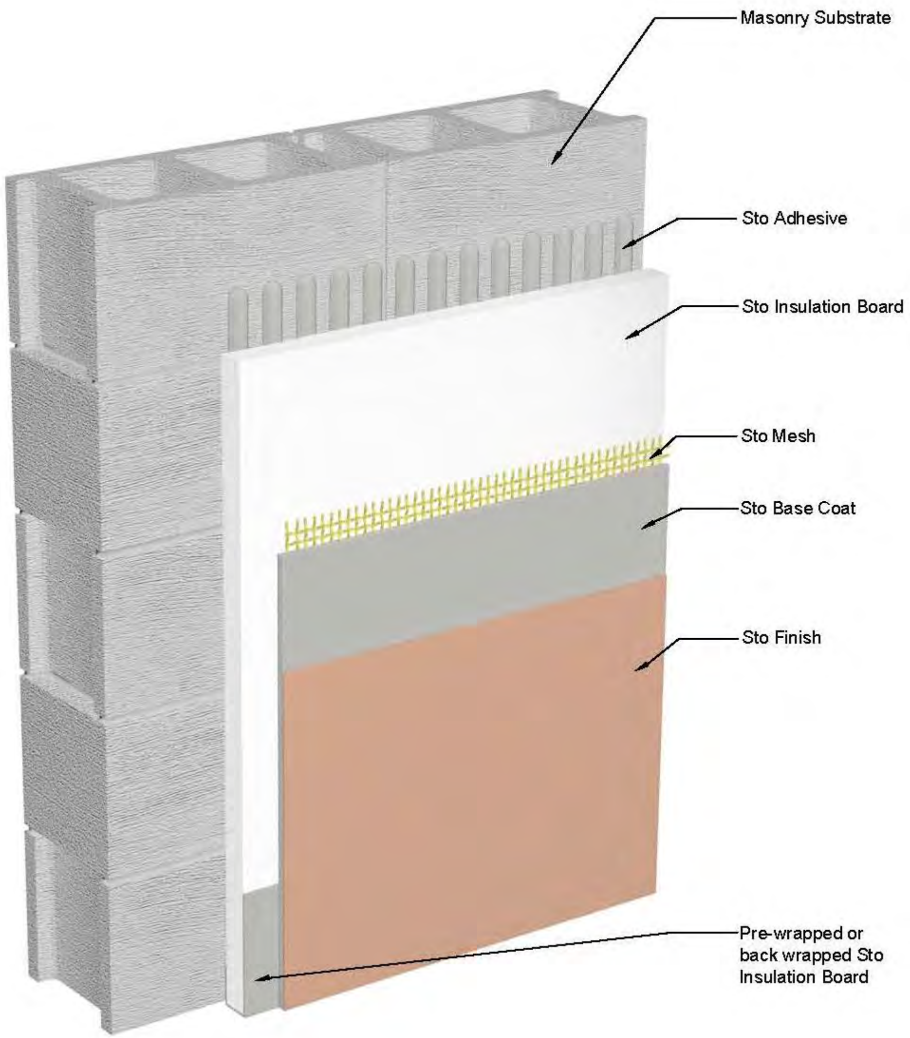
- Manufactured from non-combustible stone wool
- High density stone wool core
- Foil-faced on both sides
- Prevent the spread of flames
- Inhibits heat and smoke through concealed spaces in buildings
- Improves sound reduction

Cavity walls should always have a fire stop closure at the top of the cavity and around openings.

Image Source: Rockwool

Single Leaf Masonry with Exterior Insulation

Co-funded by the Erasmus+ Programme of the European Union



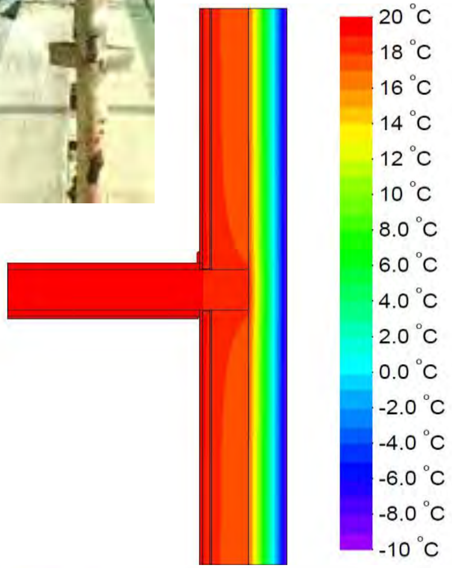


Image Source: Left – Sto Therm / Right - MosArt

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Cavity Wall with Exterior Insulation – Retrofit

Co-funded by the Erasmus+ Programme of the European Union

Image Source: MosArt

XPS vs EPS

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

The EWI Starter Track is a Potential Thermal Bridge

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Image Source: MosArt

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Exterior Insulation Options on Timber Frame

Co-funded by the Erasmus+ Programme of the European Union

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)

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Avoiding cracking

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

Avoid joints between boards at window corners

Image Source: MosArt

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EWI Boards to be Laid in Brick Pattern

Co-funded by the Erasmus+ Programme of the European Union

Image Source: MosArt

Can your Eaves accommodate external wall insulation?

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Image Source: MosArt

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CONSTRUCTION BLUEPRINT

Case study - External Insulation, Insulation Above Slab

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(2) WALLS: EXTERNAL INSULATION
SOLID MASONARY / CAVITY BLOCK WALLS

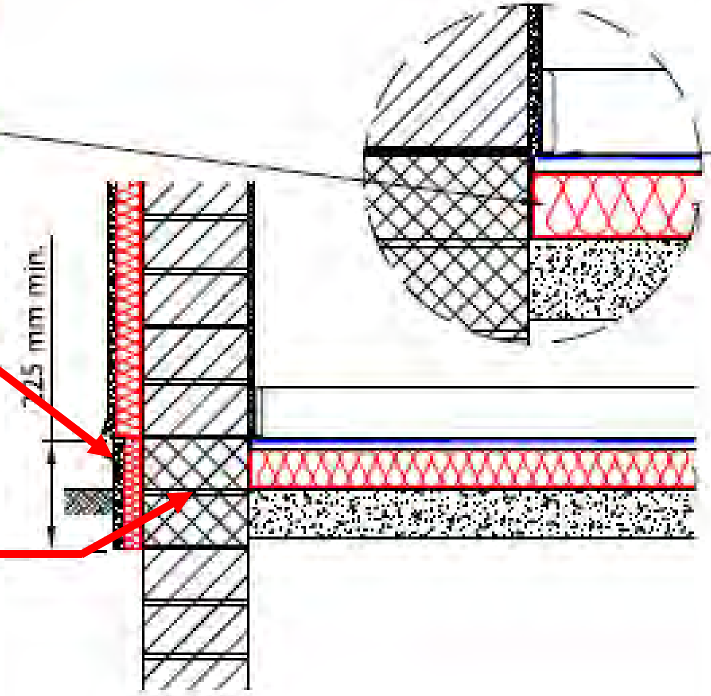
Ground Floor - Insulation Above Slab with Lightweight Block

DETAIL 2.01, 2.011

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

- [ ] Floor insulation to tightly abut blockwork wall
- [ ] Ensure wall insulation is installed at least 225 mm below top of floor insulation
- [ ] Ensure block with a maximum Thermal Conductivity of 0.20 W/mK in the direction of heat flow is used and that block is suitable for use in foundations



AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

- [ ] 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

Complying with checklist will help achieve design air permeability

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

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CONSTRUCTION BLUEPRINT

Case Study - External Insulation, Insulated Below Slab GF Insulation

Co-funded by the Erasmus+ Programme of the European Union

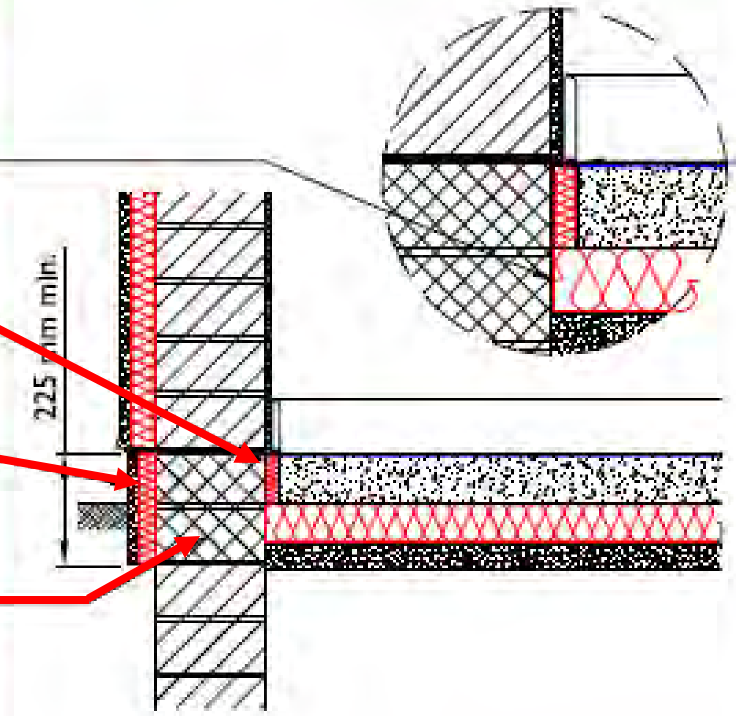
(2) WALLS- EXTERNAL INSULATION
SOLID MASONARY / CAVITY BLOCK WALLS

DETAIL 2.02, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- Floor insulation to tightly abut blockwork wall
- Install perimeter insulation with a Min. R-value of 1.1 m^2 K/W
- Ensure wall insulation is installed at least 225 mm below top of floor
- Ensure block with a maximum Thermal Conductivity of 0.20 W/mK in the direction of heat flow is used and that block is suitable for use in foundations



AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- 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

Complying with checklist will help achieve design air permeability

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

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Case study -External Insulation, Solid Masonry, Insulation Above Slab

Co-funded by the Erasmus+ Programme of the European Union

(2) WALLS- EXTERNAL INSULATION
SOLID MASONARY / CAVITY BLOCK WALLS

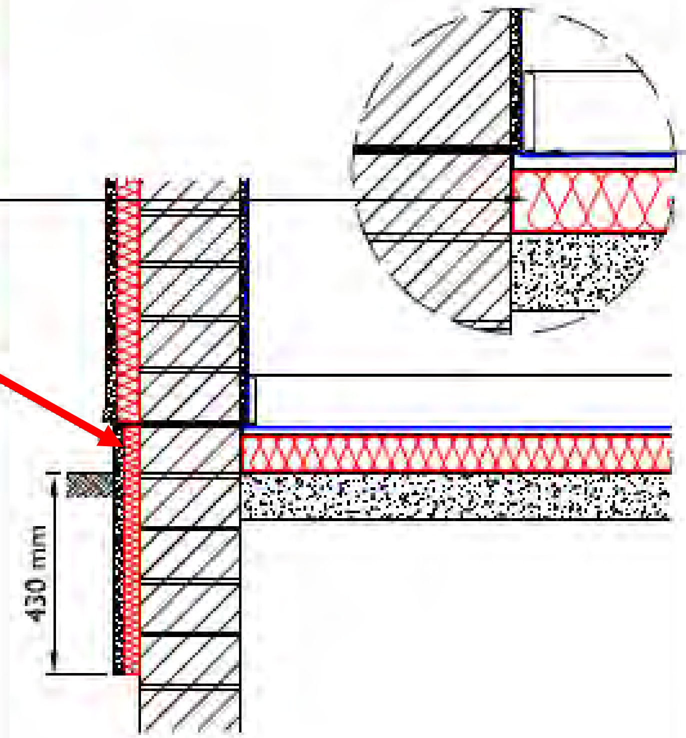
Ground Floor - Insulation Above Slab

DETAIL 2.01a, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- ☐ 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



AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- ☐ 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

Complying with checklist will help achieve design air permeability

Image Source: Department of Housing, Planning and Local Government

Case Study - External Insulation, Below Slab GF Insulation- ACD

Co-funded by the Erasmus+ Programme of the European Union

(2) WALLS - EXTERNAL INSULATION
SOLID MASONARY / CAVITY BLOCK WALLS

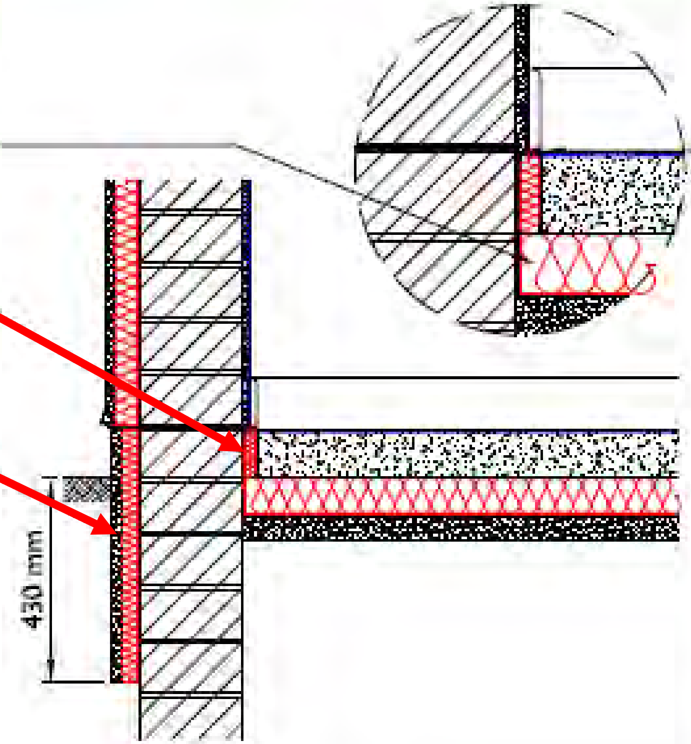
Ground Floor - Insulation Below Slab

DETAIL 2.02a, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- [ ] Floor insulation to tightly abut blockwork wall
- [x] Install perimeter insulation with a Min. R-value of 1.1 m² K/W
- [x] Ensure wall insulation is installed at least 430 mm below ground level R-value 4.0 m² K/W



AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- [ ] 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

Complying with checklist will help achieve design air permeability

Image Source: Department of Housing, Planning and Local Government

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Case study - External Insulation, Suspended Timber Floor- ACD

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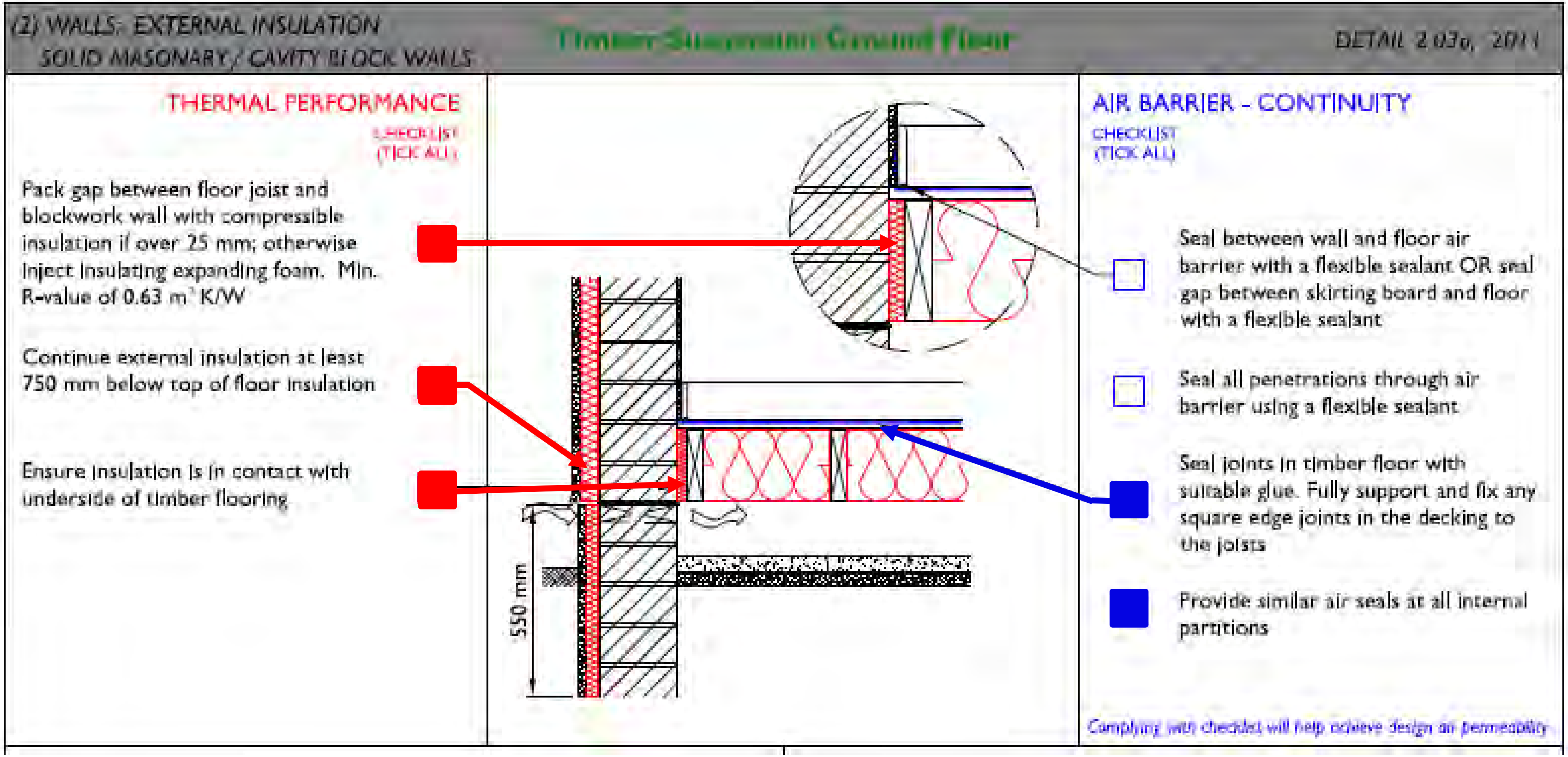

(2) WALLS: EXTERNAL INSULATION
SOLID MASONARY / CAVITY BLOCK WALLS

Timber Suspended Ground Floor

DETAIL 2.03b, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- 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 m² K/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

CHECKLIST
(TICK ALL)

- 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

Complying with checklist will help achieve design air permeability

Case Study - Internal Wall Insulation – Without Service Void

Co-funded by the Erasmus+ Programme of the European Union

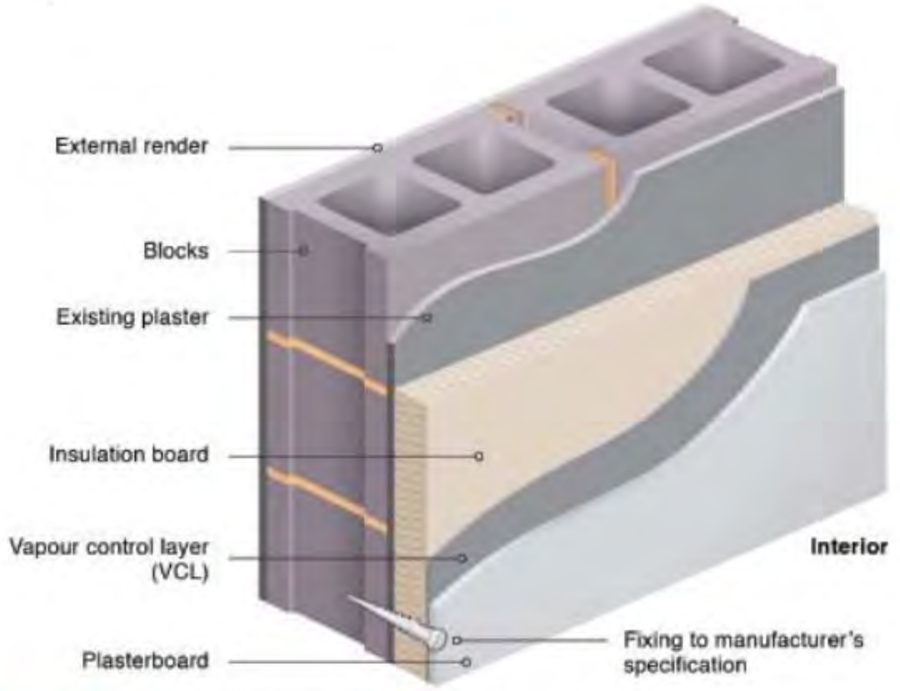

Figure 60 - Thermal laminated board fixed to internal face of wall

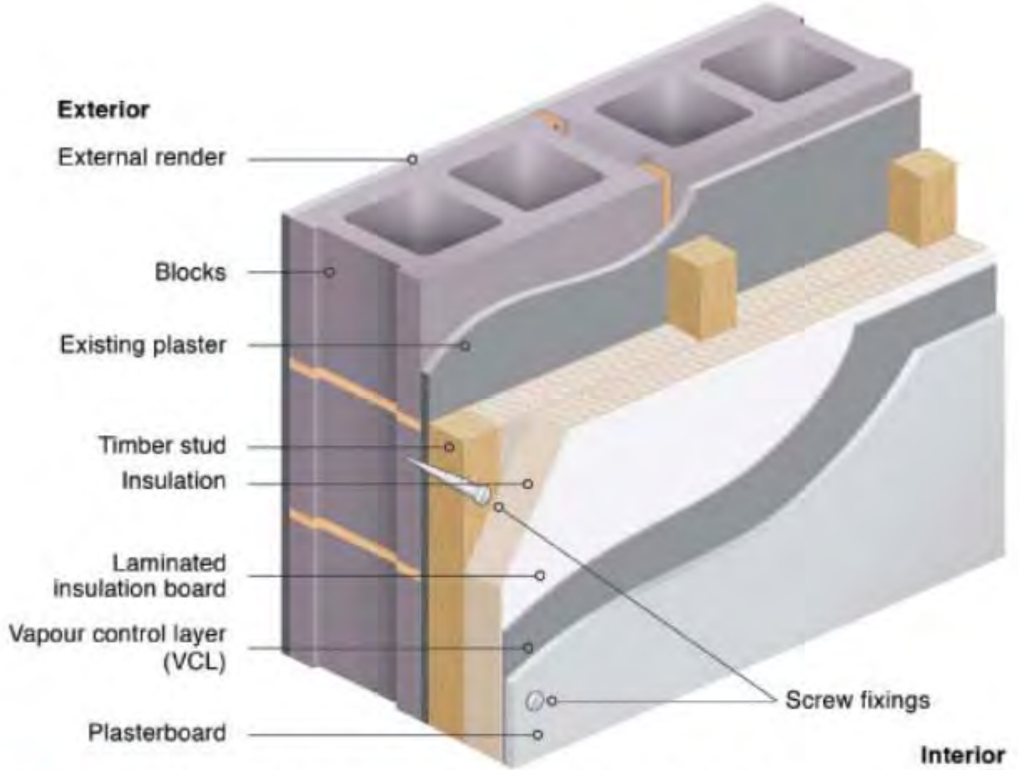

Figure 62 - Thermal laminate board over insulation between battens

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;

Image Source: S.R.54 published by NSAI

Case study - Internal Wall Insulation – With Service Void

Co-funded by the Erasmus+ Programme of the European Union

7.3.3.3.4 **Secondary layer over insulation between battens with service void fixed to single leaf walls**

Figure 63 shows the use of a timber batten to form a service void over insulation between studs (new or existing).

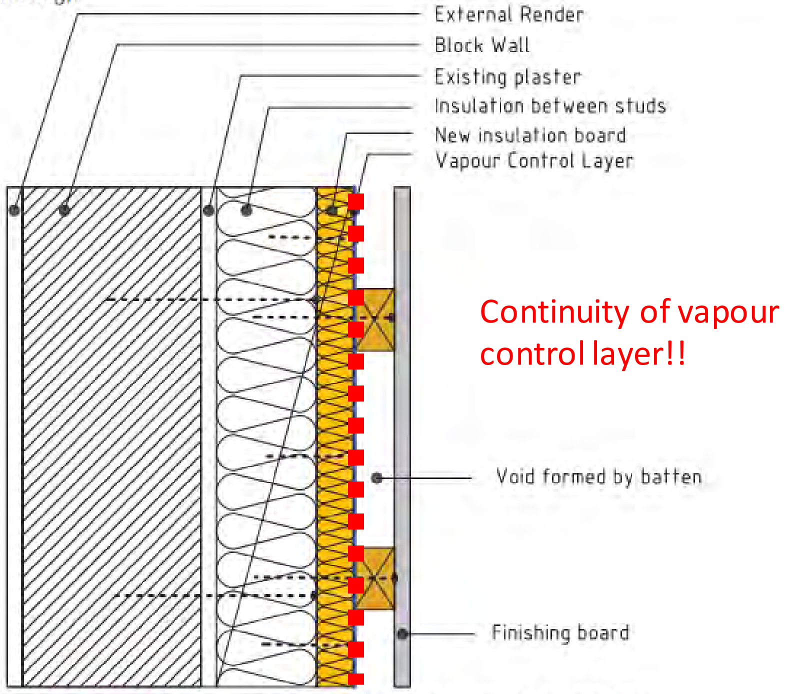

Figure 63 - Service void formed by timber batten

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

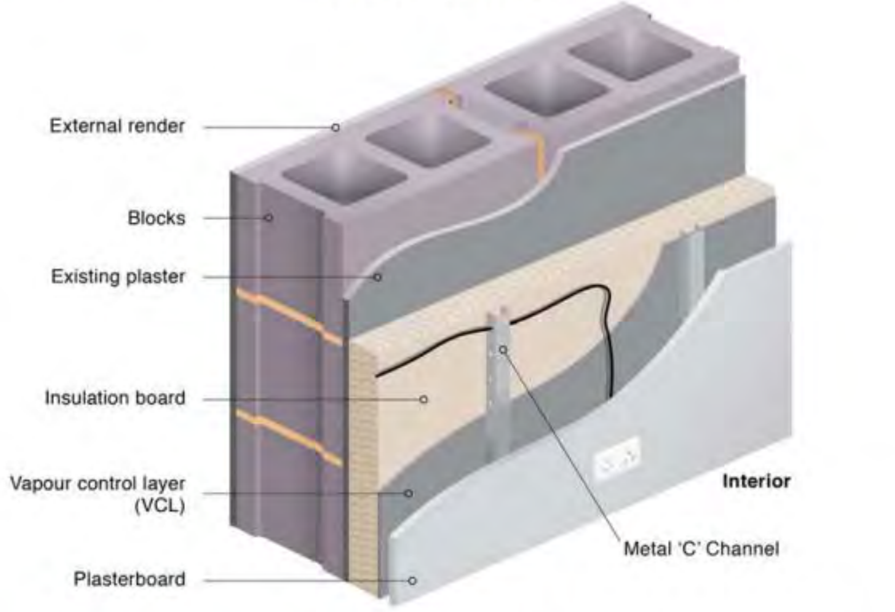

Figure 65 - Internal insulation and Metal Furrings channels

Timber studs

Metal studs

Image Source: S.R.54 published by NSAI

Exterior Insulation is Safest – Interior Insulation Should have Vapour Control Layer

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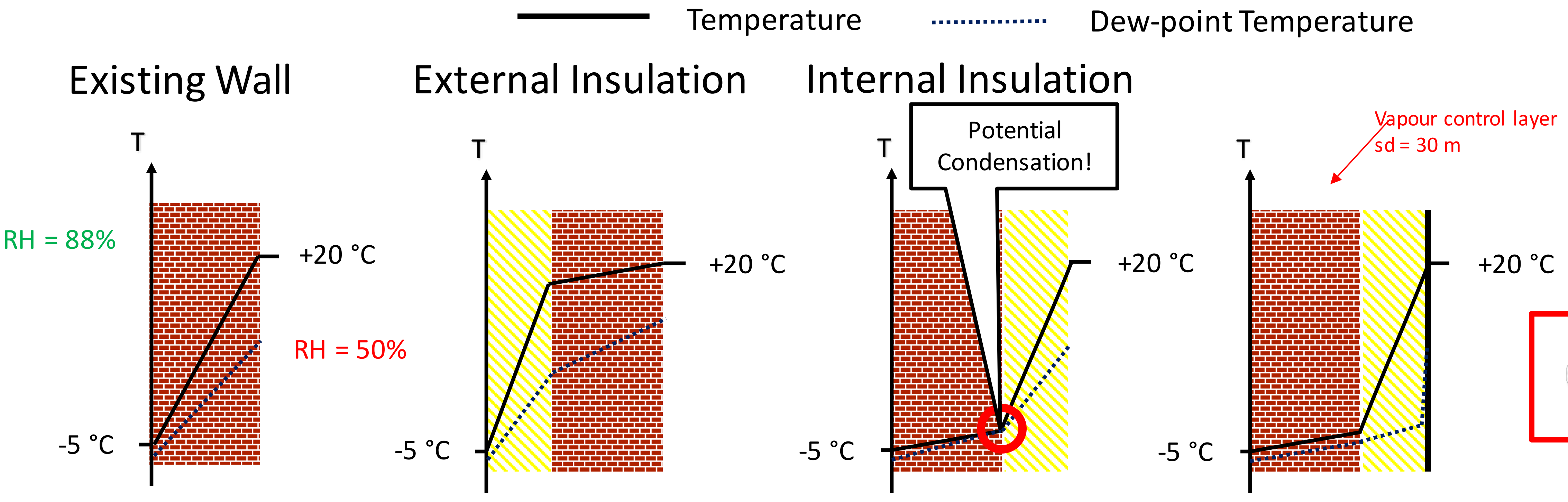

Existing Wall	External Insulation	Internal Insulation	Internal Insulation with vapour control layer
Initial state	Brick wall warmer	Brick wall colder	Brick wall colder
Long-term experience	→ dryer	→ wet	→ dryer, still humid

EPS λ = 0.035 W/mK, 150mm

clay bricks λ = 0.25 W/mK 200mm

Data Source: MosArt-WWETB

Case Study - Cavity Wall , Internal Insulation, Above Slab- ACD

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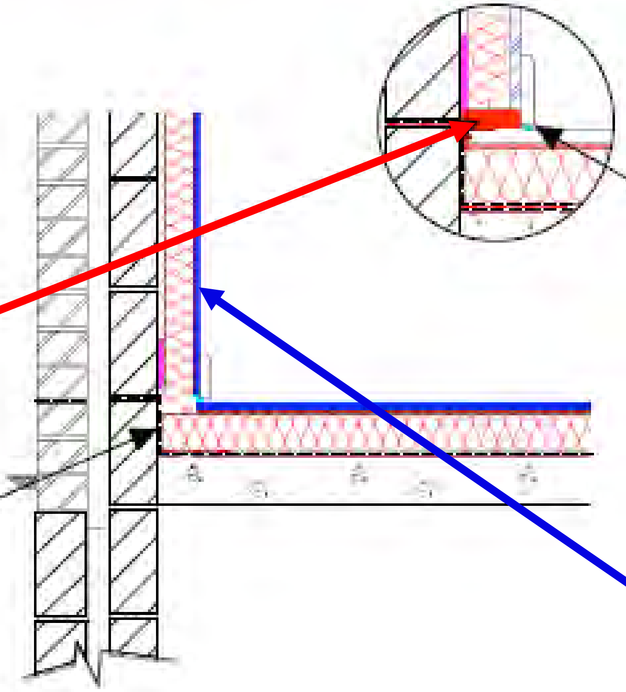
(3) WALLS:- INTERNAL INSULATION — **Ground Floor - Insulation above slab** — DETAIL 3.01, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- [ ] Inject an approved insulating expanding foam between the insulated dry-lining and the floor insulation
- [ ] Floor insulation to tightly abut blockwork wall



AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- [ ] Seal gap between skirting board and floor with a flexible sealant
- [ ] Seal all penetrations through air barrier using a flexible sealant

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

Case Study - Cavity Wall , Internal Insulation, Below Slab- ACD

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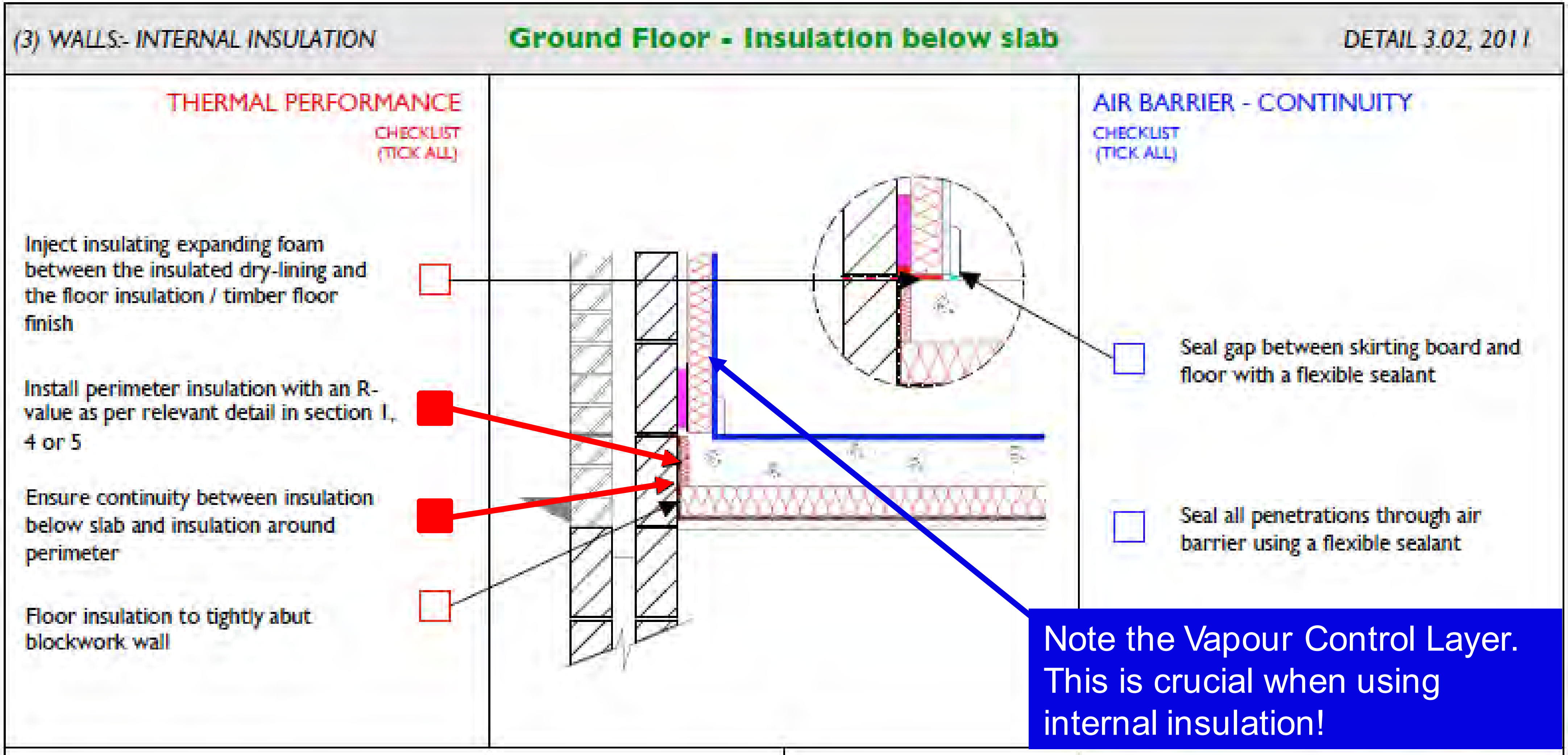

Note the Vapour Control Layer. This is crucial when using internal insulation!

Case Study -Hollow Block Wall Width –Compliance

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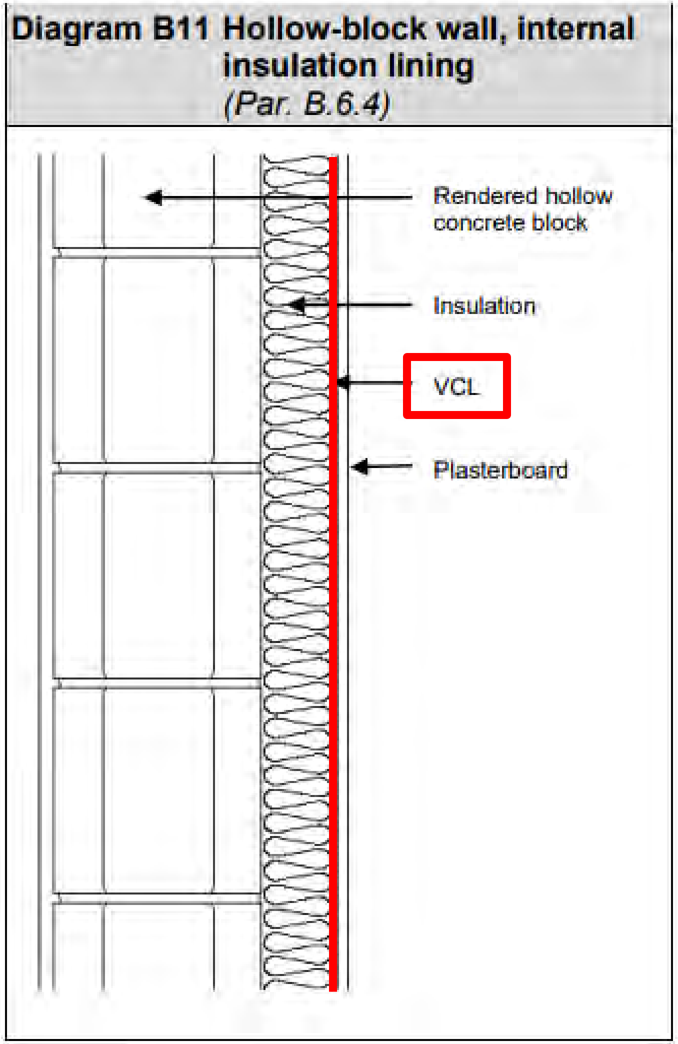

- Hollow concrete block wall, rendered externally, internal insulation lining with plasterboard finish
- The insulation is installed on the inner face of the masonry walls
- It may be installed between preservative-treated timber studs fixed to the wall
- Or in the form of insulated plasterboards
- Or 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

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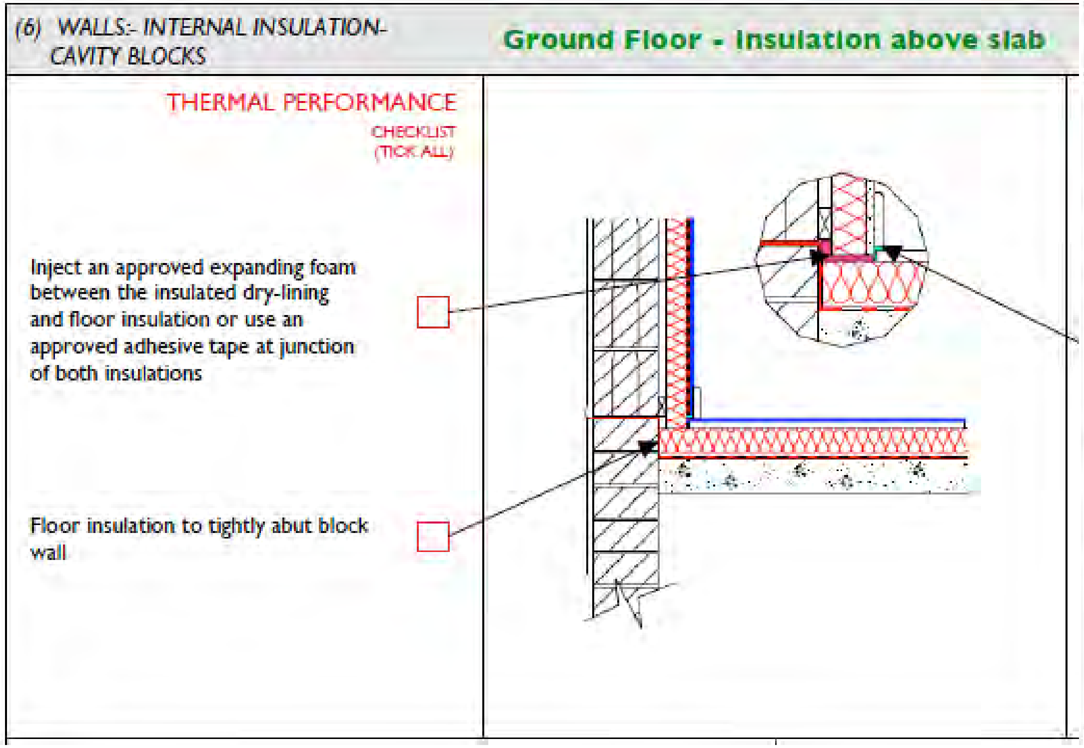


(6) WALLS:- INTERNAL INSULATION- CAVITY BLOCKS

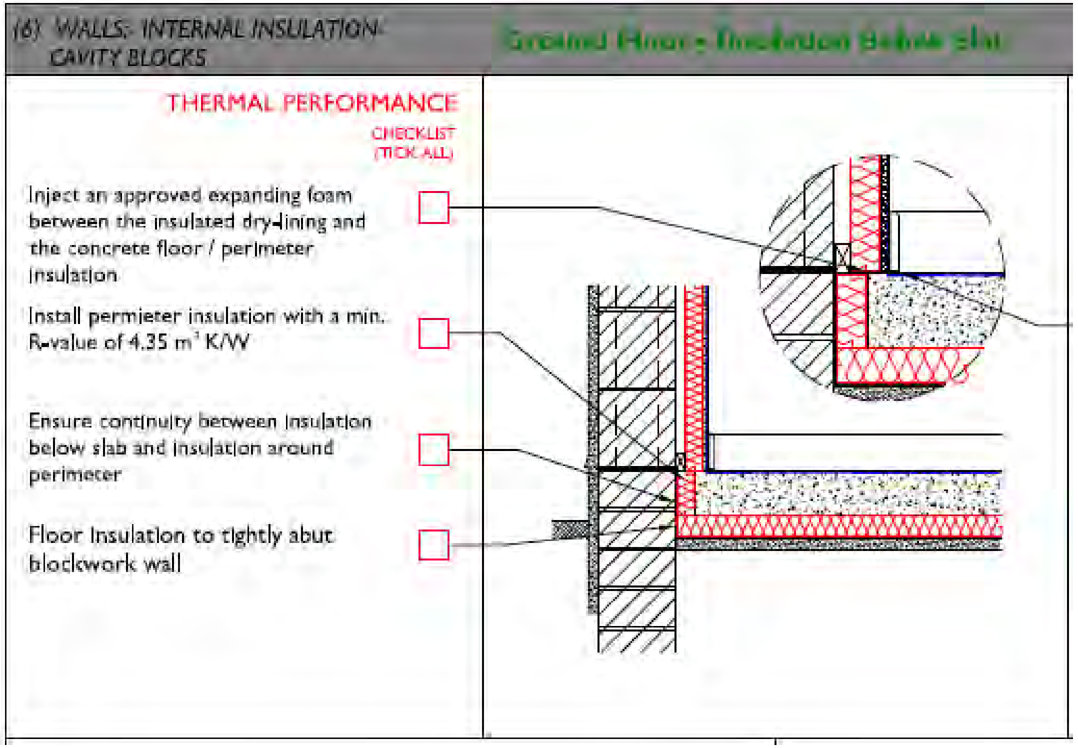
Ground Floor - Insulation above slab

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

Inject an approved expanding foam between the insulated dry-lining and floor insulation or use an approved adhesive tape at junction of both insulations ☐

Floor insulation to tightly abut block wall ☐



(6) WALLS: INTERNAL INSULATION CAVITY BLOCKS

Ground Floor - Insulation Below slab

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

Inject an approved expanding foam between the insulated dry-lining and the concrete floor / perimeter insulation ☐

Install permieter insulation with a min. R-value of 4.35 m^2 K/W ☐

Ensure continuity between insulation below slab and insulation around perimeter ☐

Floor Insulation to tightly abut blockwork wall ☐

Image Source: Department Housing, Planning and Local Government Ireland

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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

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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)

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Blown-In Cellulose Insulation

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- 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

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Blown-In Cellulose Attic Insulation

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OSB retainer used to prevent loose insulation from falling into walkway

Image Source: Purchased by MosArt (**iStock-183779679)**

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Case Study - Timber Frame, Insulation Above Slab - ACD

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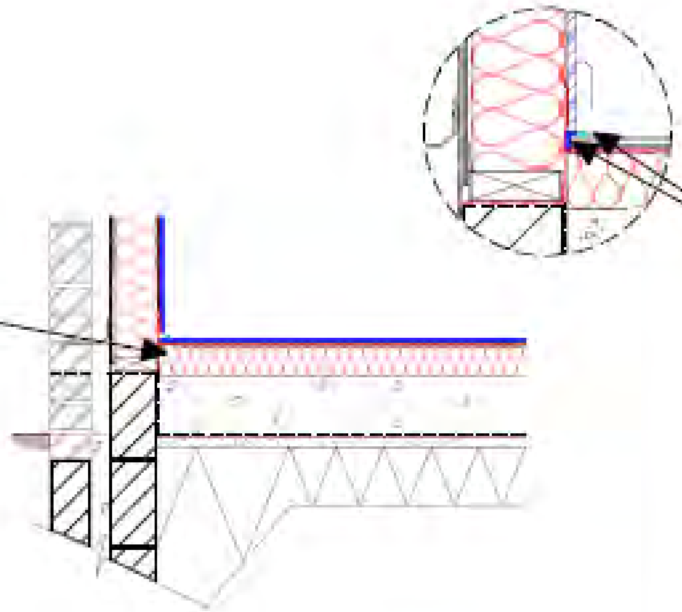
(4) TIMBER FRAME | **Ground Floor - Insulation above slab** | DETAIL 4.01, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

☐ Floor insulation must tightly abut sole plate inner face



AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

☐ Seal between wall and floor air barrier OR seal gap between skirting board and floor using a flexible sealant

☐ 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 Ireland

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CONSTRUCTION BLUEPRINT

Case study - Timber Frame, Insulation Below Slab- ACD

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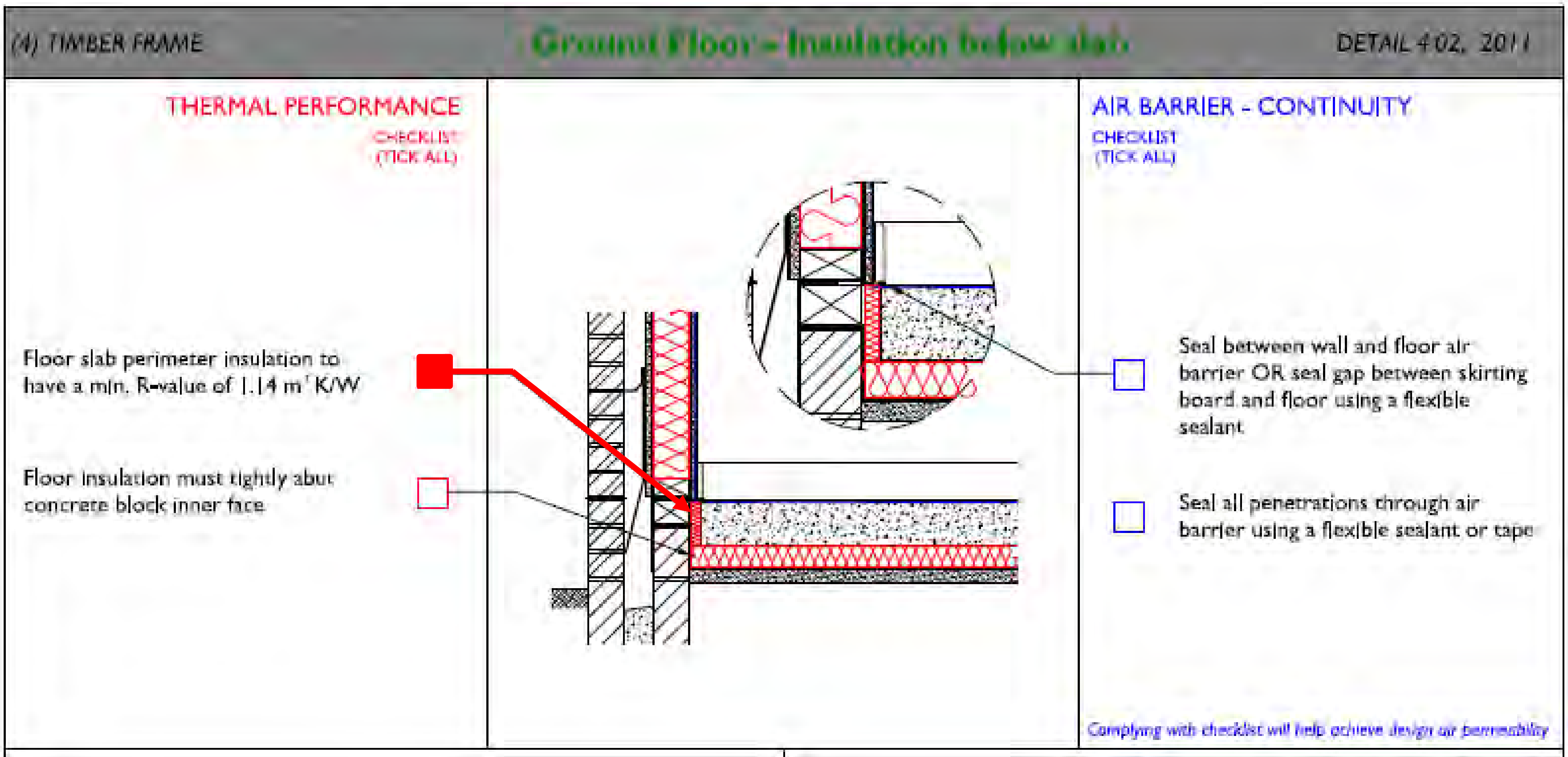

Image Source: Department Housing, Planning and Local Government Ireland

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CONSTRUCTION BLUEPRINT

Case study - Timber Frame, Suspended Timber Ground Floor - ACD

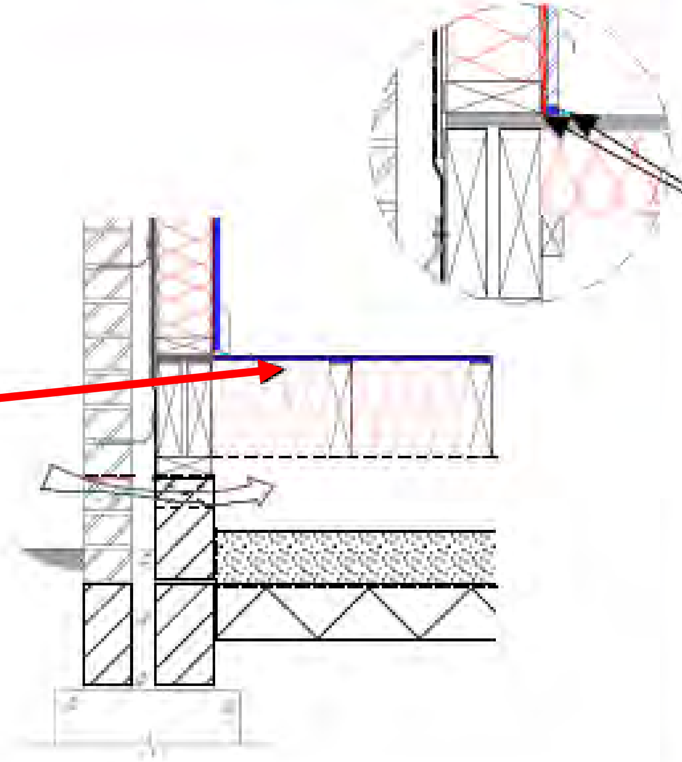
Co-funded by the Erasmus+ Programme of the European Union

(4) TIMBER FRAME | **Timber Suspended Ground Floor** | DETAIL 4.03, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

Ensure insulation is in contact with underside of timber flooring



AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- [ ] 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

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Timber Frame Wall Width

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

U-Value (W/m²K	TF034 Slab (mm)	Stud Depth	High Performance Partial Fill	VCL	Breather Membrane
0.23	90	89	50	Y	Y
0.21	90	89	50	Y	Y
0.21	90	89	50	Y	Y
0.19	140	140	50	Y	Y
0.17	140	140	50	Y	Y
0.17	140	140	50	Y	Y

Image Source: Rockwool

Structural Insulated Panels (SIPs)

Co-funded by the Erasmus+ Programme of the European Union

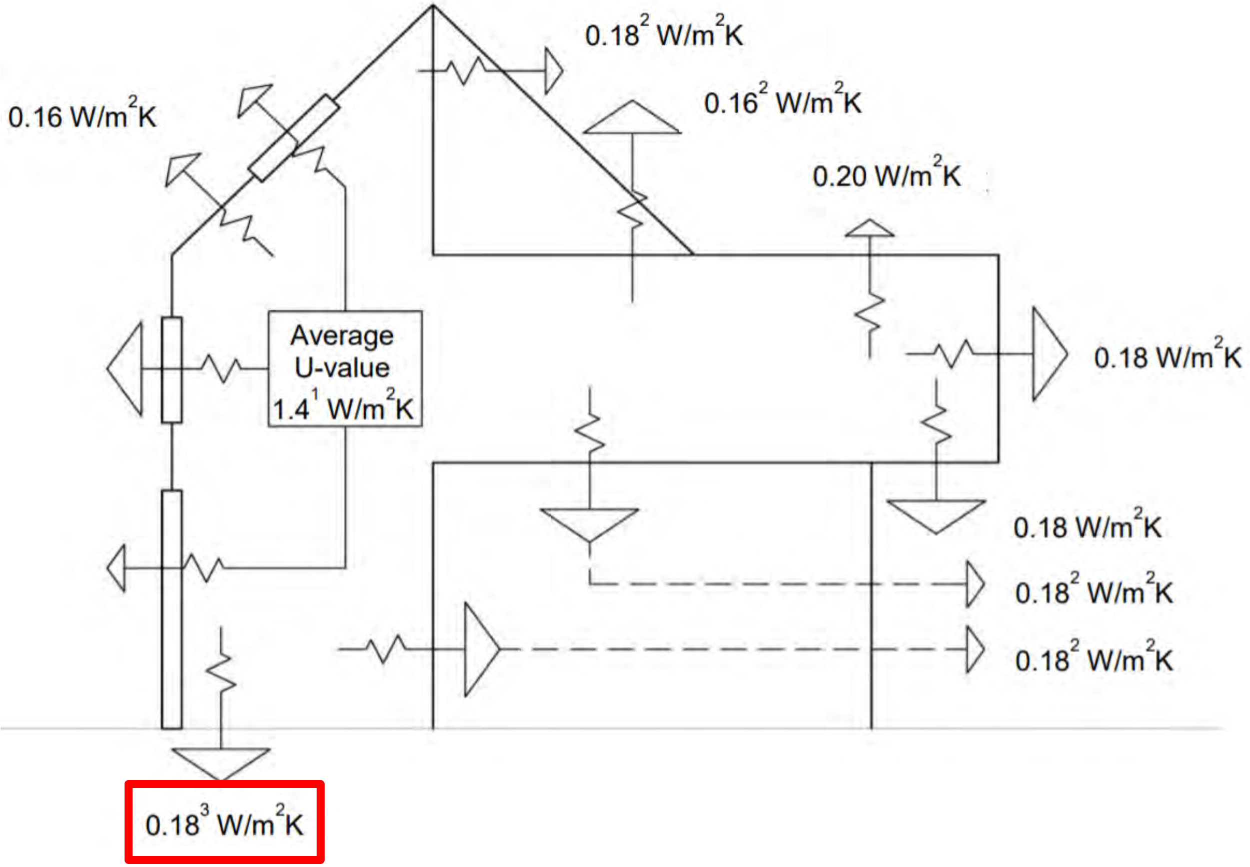
- SIP's are made of a large EPS boards sandwiched between two OSB boards
- The entire house consists of a small number of panels, which are constructed off-site
- Usually achieve excellent airtightness results due to the requirement only to seal between panels with airtight tape
- Lightweight, making 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)

Floor Insulation - NZEB Compliance

Co-funded by the Erasmus+ Programme of the European Union

Table 1	Maximum elemental U-value (W/m^2K)[1, 2]	
Column 1 Fabric Elements	Column 2 Area-weighted Average Elemental U-value (Um)	Column 3 Average Elemental U-value – individual element or section of element
Roofs		
Pitched roof - Insulation at ceiling - Insulation on slope	 0.16 0.16	0.3
Flat roof	0.20	
Walls	0.18	0.6
Ground floors[3]	0.18	0.6
Other exposed floors	0.18	0.6
External doors, windows and rooflights	1.4[4,5]	3.0



However: "Where the source of space heating is underfloor heating, the maximum floor U-value should be 0.15 W/m^2K"

Image Source: Department of Housing, Planning and Local Government, Part L of the Building Regulations

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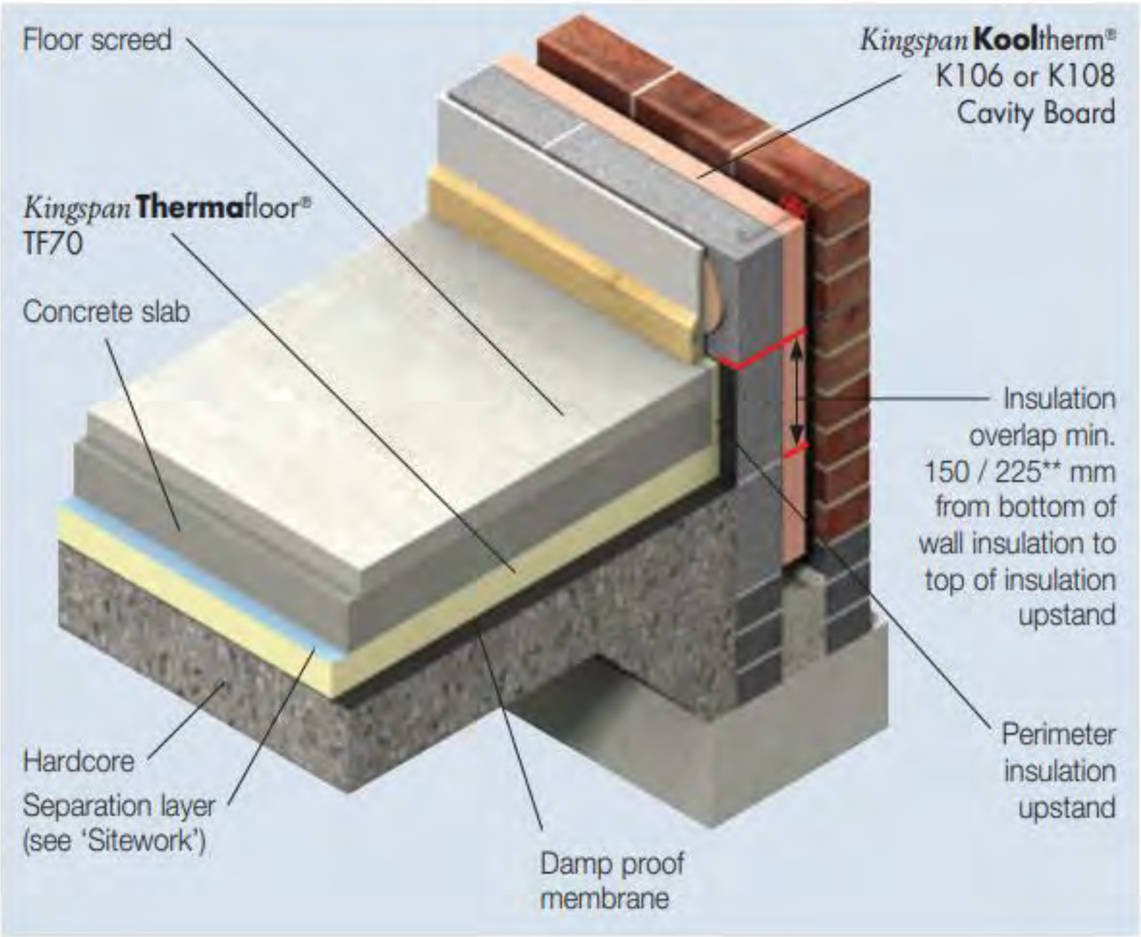
Insulation Below the Floor Slab



U–values (W/m²·K) for Various Thicknesses of Kingspan **Therma**floor® TF70 and Floor Perimeter / Area Ratios

Insulant Thickness (mm)	Perimeter / Area (m^{-1}) 0.2	0.3	0.4	0.5	0.6	0.7
30	✗	✗	✗	✗	✗	✗
40	0.23	✗	✗	✗	✗	✗
50	0.20	0.24	✗	✗	✗	✗
60	0.19	0.21	0.23	0.24	✗	✗
70	0.17	0.19	0.21	0.22	0.22	0.23
75	0.16	0.18	0.20	0.21	0.21	0.22
80	0.16	0.18	0.19	0.20	0.20	0.21
90	0.15	0.16	0.17	0.18	0.19	0.19
100	0.14	0.15	0.16	0.17	0.17	0.18
110	0.13	0.14	0.15	0.16	0.16	0.16
120	0.12	0.13	0.14	0.15	0.15	0.15
125	0.12	0.13	0.14	0.14	0.14	0.15
130	0.11	0.13	0.13	0.14	0.14	0.14
140	0.11	0.12	0.12	0.13	0.13	0.13
150	0.10	0.11	0.12	0.12	0.12	0.13
160	0.10	0.11	0.11	0.11	0.12	0.12
80 + 90*	0.09	0.10	0.11	0.11	0.11	0.11
75 + 100*	0.09	0.10	0.11	0.11	0.11	0.11
90 + 90	0.09	0.10	0.10	0.10	0.11	0.11
90 + 100*	0.09	0.09	0.10	0.10	0.10	0.10

Image Source: Kingspan.

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NZEB Compliance – Optim R (VIP) -Thermal Conductivity 0.007 W/m.K

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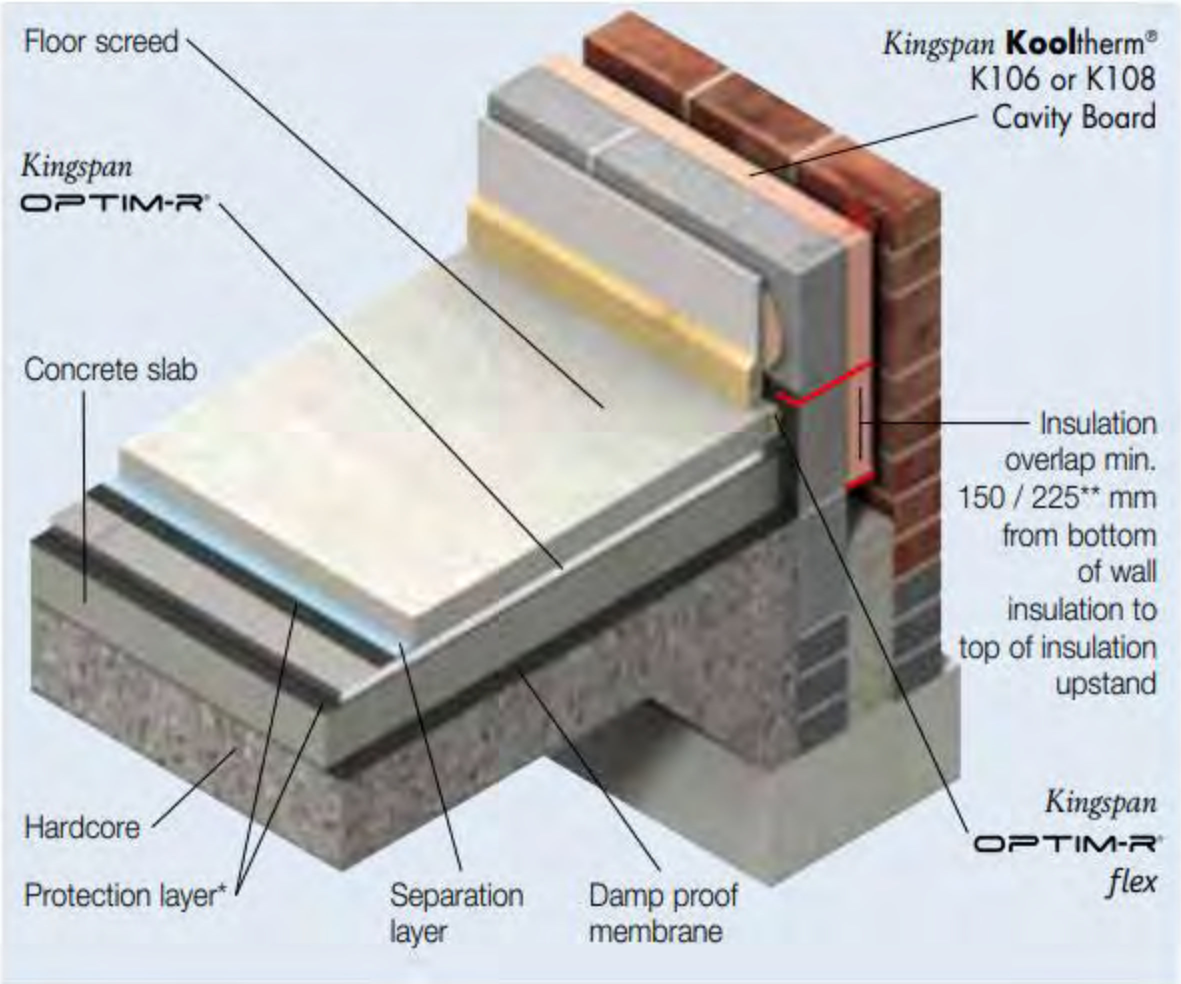
Insulation Below the Floor Screed



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

Insulant Thickness (mm)	Perimeter / Area (m-1)					
	0.2	0.3	0.4	0.5	0.6	0.7
20	0.19	0.22	0.24	0.26	0.27	0.28
25	0.17	0.20	0.22	0.23	0.24	0.25
30	0.15	0.18	0.19	0.21	0.21	0.22
40	0.13	0.15	0.16	0.17	0.18	0.18
50	0.12	0.13	0.14	0.14	0.15	0.15
60	0.10	0.11	0.12	0.13	0.13	0.13
30 + 40***	0.09	0.10	0.11	0.11	0.11	0.12
40 + 40	0.08	0.09	0.10	0.10	0.10	0.10

Image Source: Kingspan

Floor Insulation – Two Layers, with Brick Pattern

Co-funded by the Erasmus+ Programme of the European Union

Important to overlap joints in insulation to minimise risk of thermal looping and thermal bridging

Cut boards accurately to avoid gaps

Image Source: MosArt

Foundation Types – Strip Foundation with Rising Wall

Co-funded by the Erasmus+ Programme of the European Union

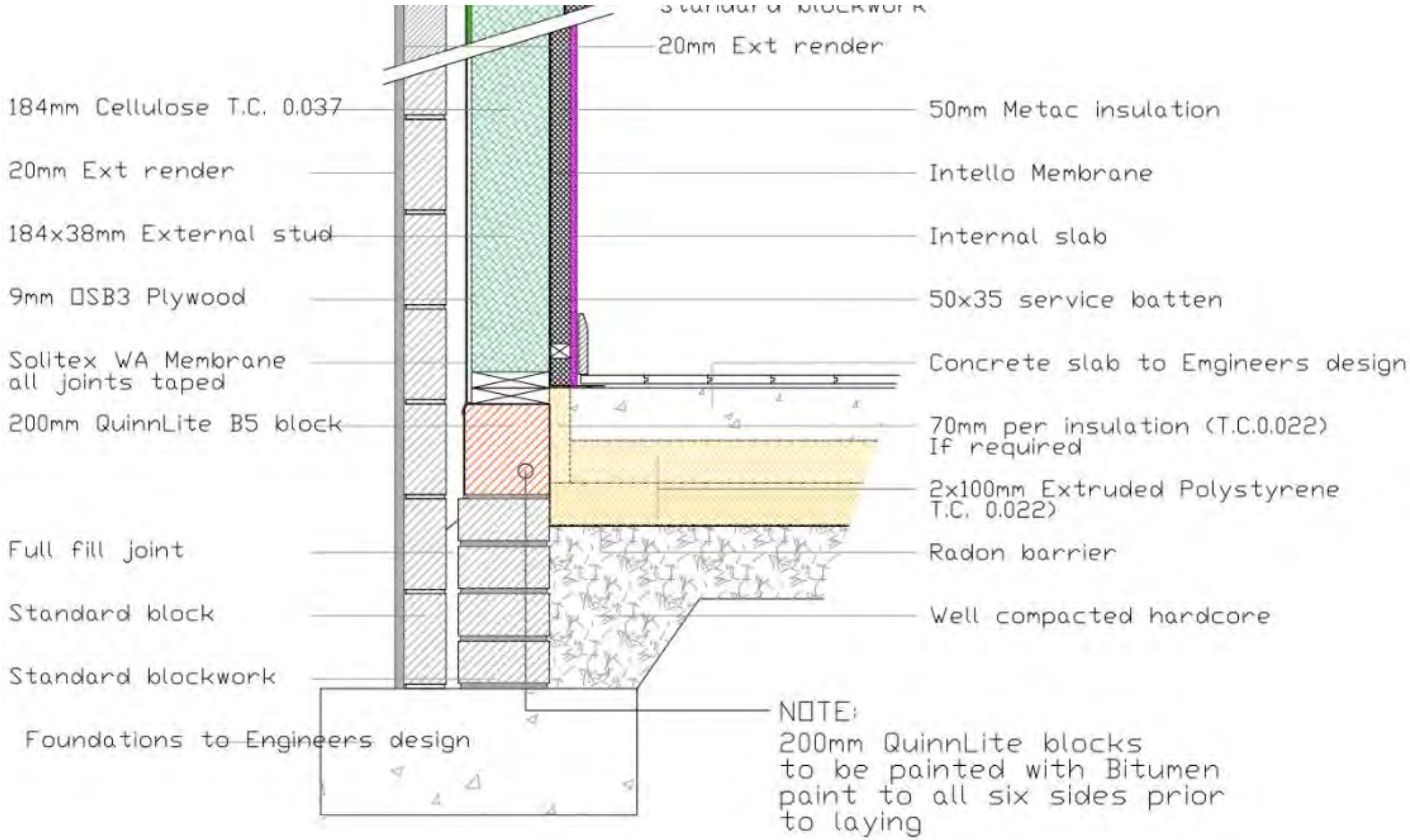
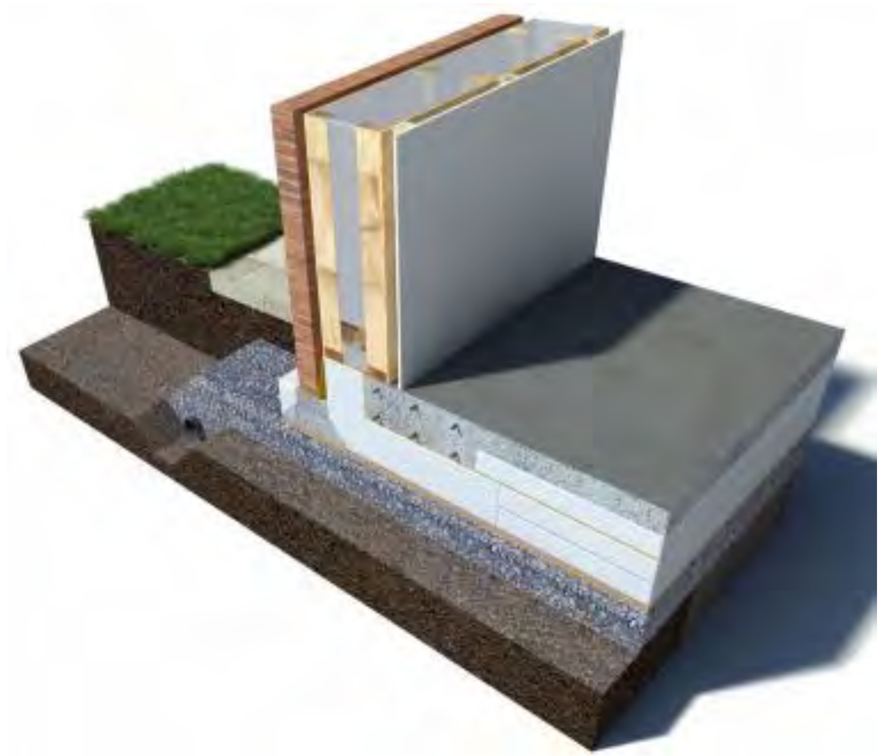


Image Source: Shoalwater and Michael Bennett & Sons Building Contractors

Foundation Type – Insulated Raft Foundation

Co-funded by the Erasmus+ Programme of the European Union



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

Image Source: Kore

Thermal Conductivity of Concrete Blocks

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Table A1 Thermal conductivity of some common building materials

Material	Density (kg/m³)	Thermal Conductivity (W/mK)
General Building Materials		
Clay brickwork (outer leaf)	1,700	0.77
Clay brickwork (inner leaf)	1,700	0.56
Concrete block (heavyweight)	2,000	1.33
Concrete block (medium weight	1,400	0.57
Concrete block (autoclaved aerated)	700	0.20
Concrete block (autoclaved aerated)	500	0.15
Concrete block (hollow)	1800	0.835
Cast concrete, high density	2,400	2.00
Cast concrete, medium density	1,800	1.15
Aerated concrete slab	500	0.16
Concrete screed	1,200	0.41
Reinforced concrete (1 % steel)	2,300	2.30
Reinforced concrete (2 % steel)	2,400	2.50
Wall ties, stainless steel	7,900	17.00
Wall ties, galvanised steel	7,800	50.00
Mortar (protected)	1,750	0.88
Mortar (exposed)	1,750	0.94
External rendering (cement sand)	1,800	1.00
Plaster (gypsum lightweight)	600	0.18
Plaster (gypsum)	1,200	0.43
Plasterboard	900	0.25

The values in this table are indicative only. Certified values, should be used in preference, if available

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Standard Block 215x450x100	Concrete Blocks	Lightweight Concrete Blocks	AAC Blocks
Composition	Mixture of Portland Cement, Sand & Gravel	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)	Mixture of cement, lime, sand, pulverised fuel ash (PFA),water. lime & aluminium sulphate powder.
Colour	Grey	Heather/Purple	Light Grey
Weight	20-22 Kg	20kg	15.9kg

Dense Concrete Blocks

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Advantages	Disadvantages
Durable	Use of new aggregates and sand is bad for the environment & exhausts natural resources
Reusable	Non-renewable materials
High Thermal Mass	Use of cement contributes to global warming
High Strength	Poor insulating properties
Some Products have Recycled Aggregate	

Lightweight Concrete Blocks

Co-funded by the Erasmus+ Programme of the European Union

	Advantages
✓	Moderate thermal mass - higher than AAC
✓	Makes use of secondary aggregates
✓	Good insulating properties
✓	Durable
✓	Reusable with lime mortar

	Disadvantages
✗	Use of virgin clay causes land degradation and resource depletion
✗	High embodied energy involved in the production of some aggregates
✗	Use of cement contributes to global warming

Aerated Autoclaved Concrete Blocks

Co-funded by the Erasmus+ Programme of the European Union

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

AAC Blocks – Cavity Wall Insulation

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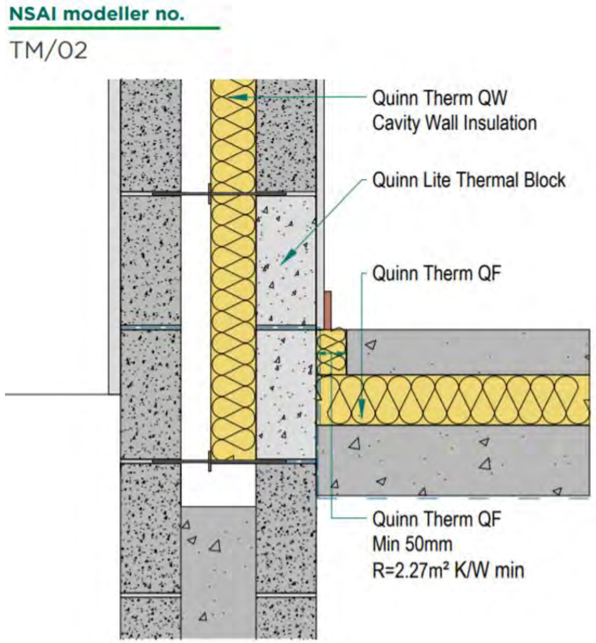
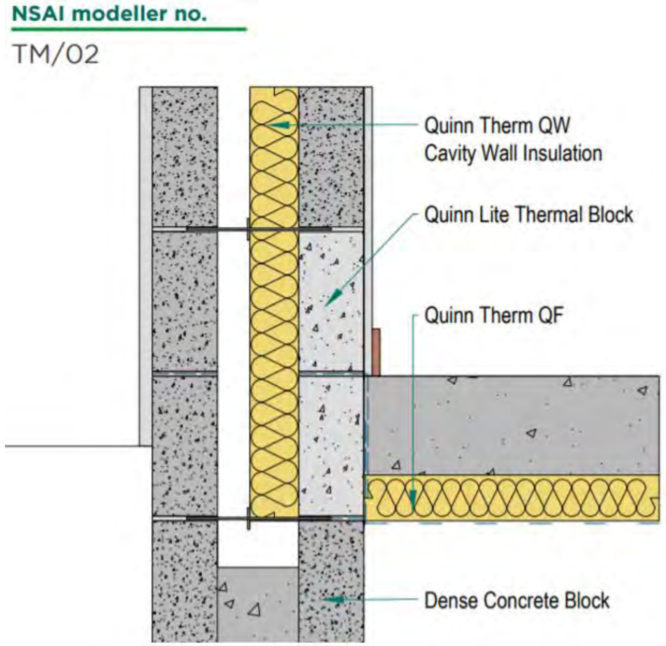
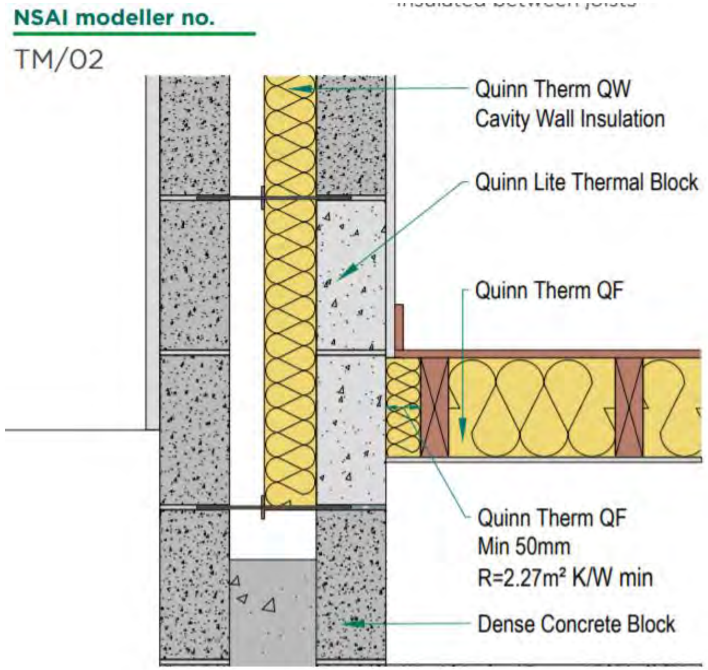


Partial Fill Cavity Wall / Solid Ground Floor Slab Insulation Over Structural Slab.



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

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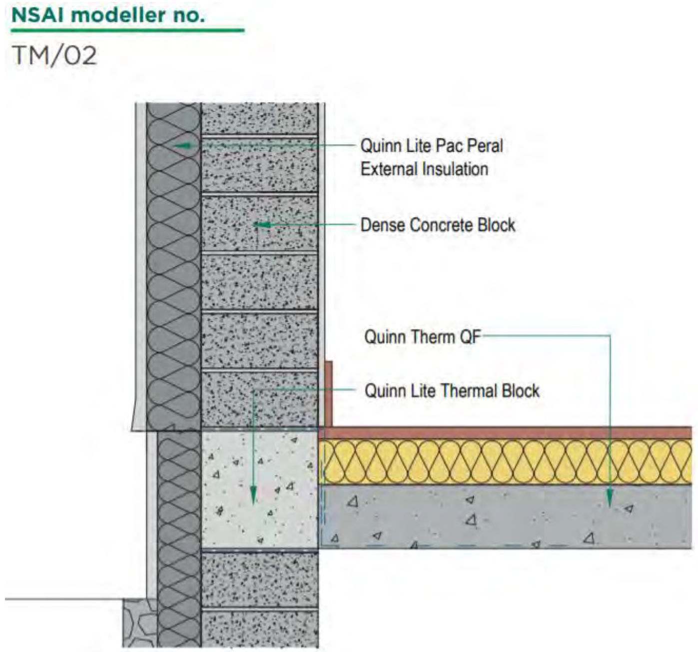
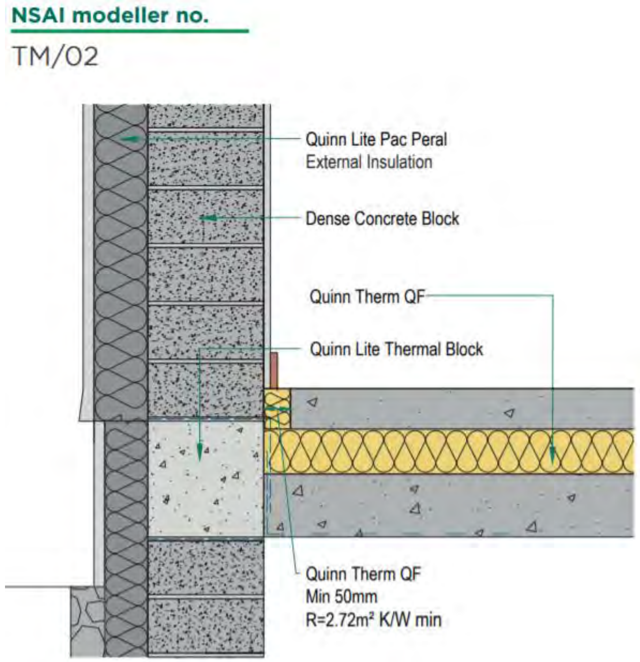
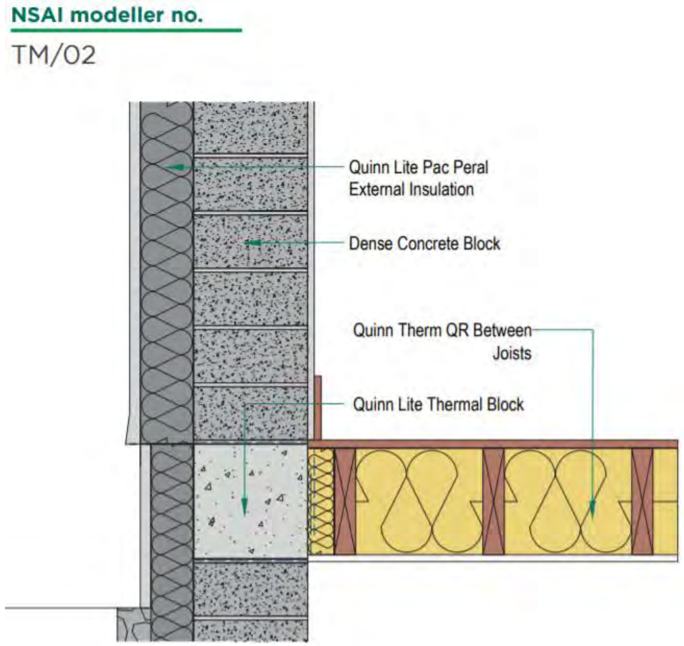


Ground Floor - Insulation above slab



Ground Floor - Insulation below slab



Timber Suspended Ground Floor

Image Source: Mannock

AAC Blocks – Internal Insulation

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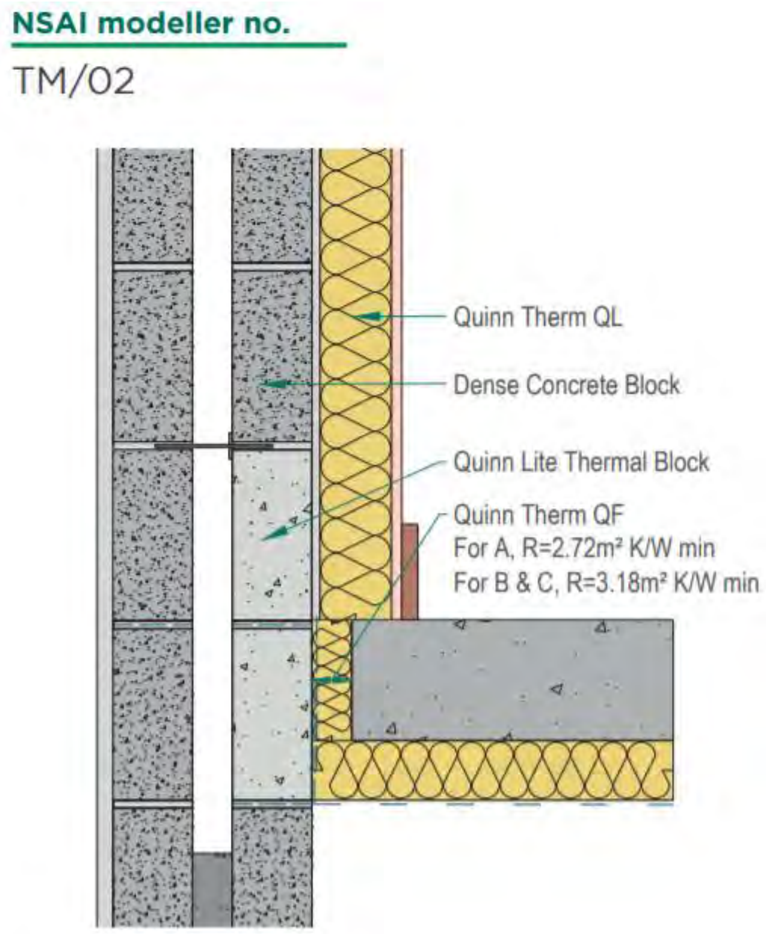
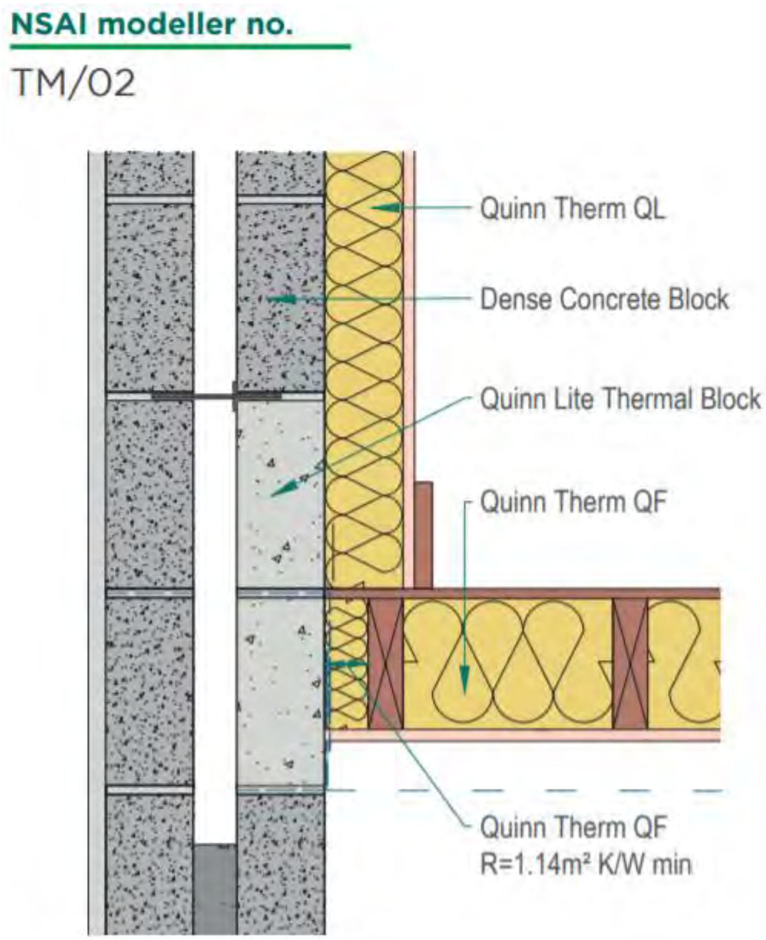


Ground floor - insulation below slab



Timber suspended ground floor

Image Source: Mannock

AAC Blocks – Timber Frame

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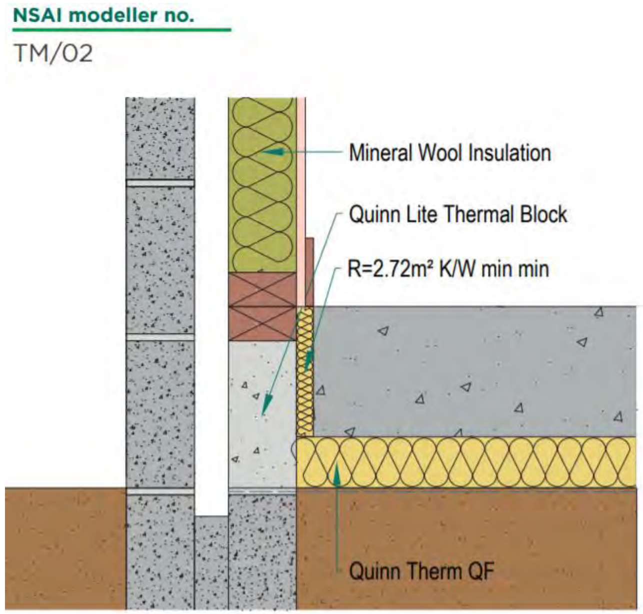
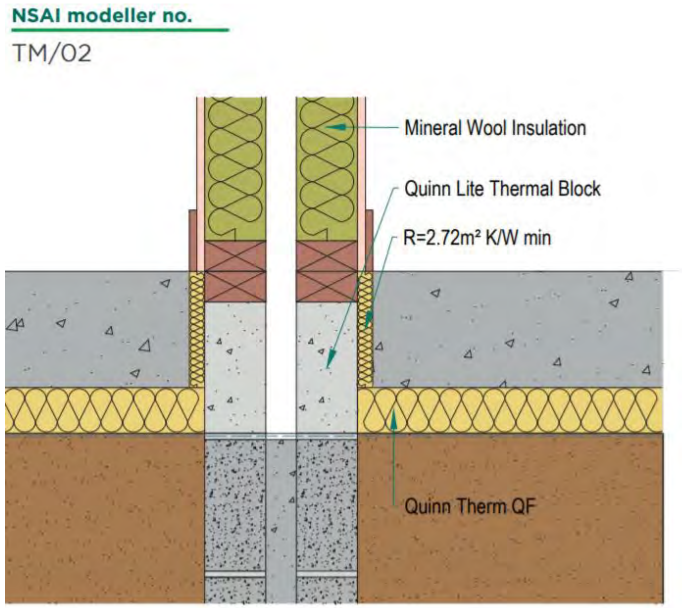
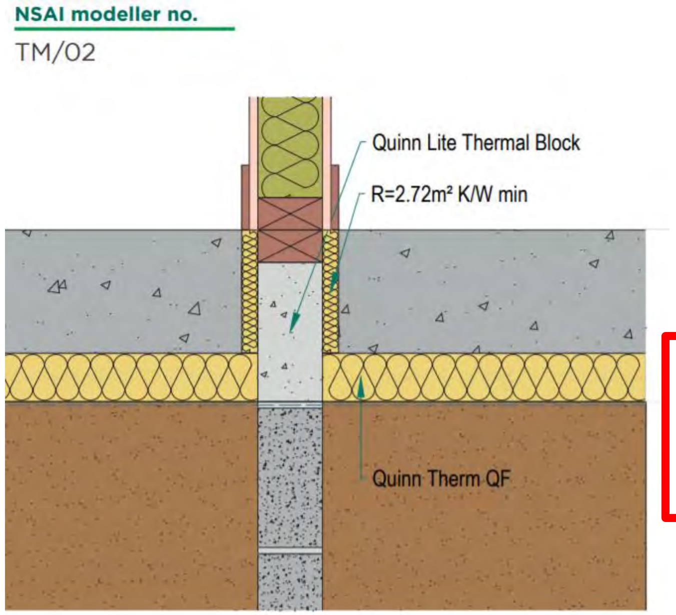


Ground floor - insulation below slab



Timber Frame - Separating wall through ground floor



Timber Frame – Partition wall through ground floor

Image Source: Mannock

AAC Blocks – Disadvantages

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- 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

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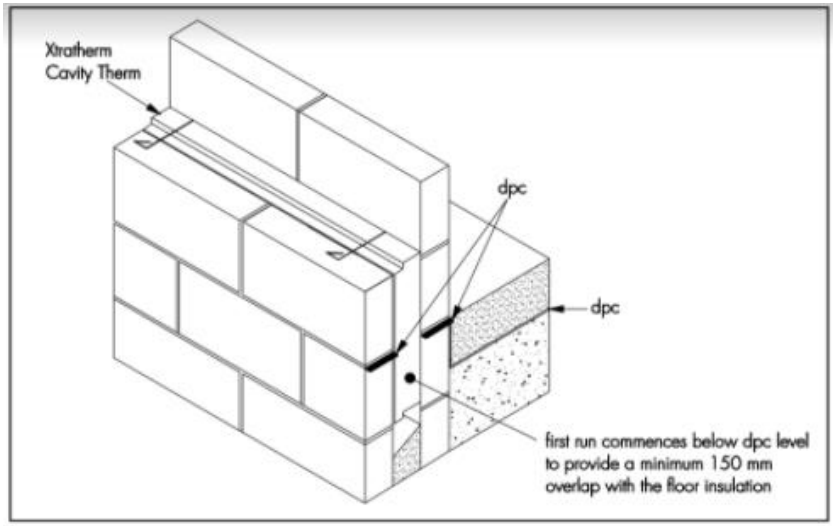

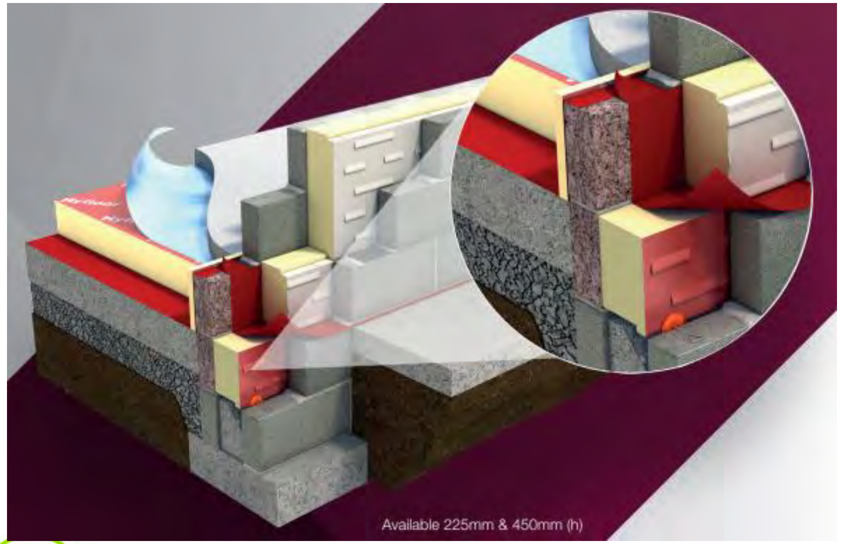

Xtratherm Cavity Therm

- 150mm below DPC

Xtratherm Foundation Riser

Y-values achieved < 0.05 U-values achieved 0.11 - 0.15 W/m^2K

- Suitable for multi storey buildings with a high compressive strength of $7.5N/mm^2$ and $13N/mm^2$
- 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

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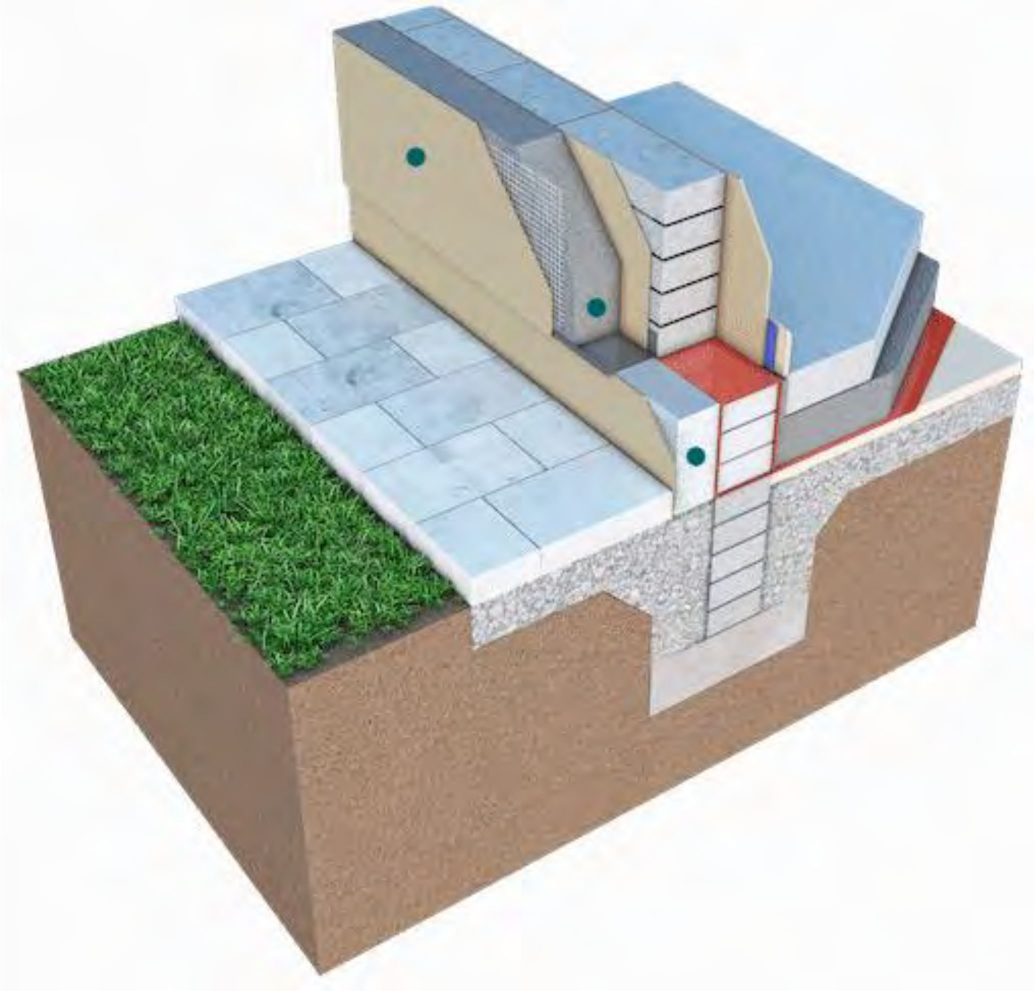

KORE

- 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

Image Source: Kore

Accredited Moisture Resistant Insulation Types

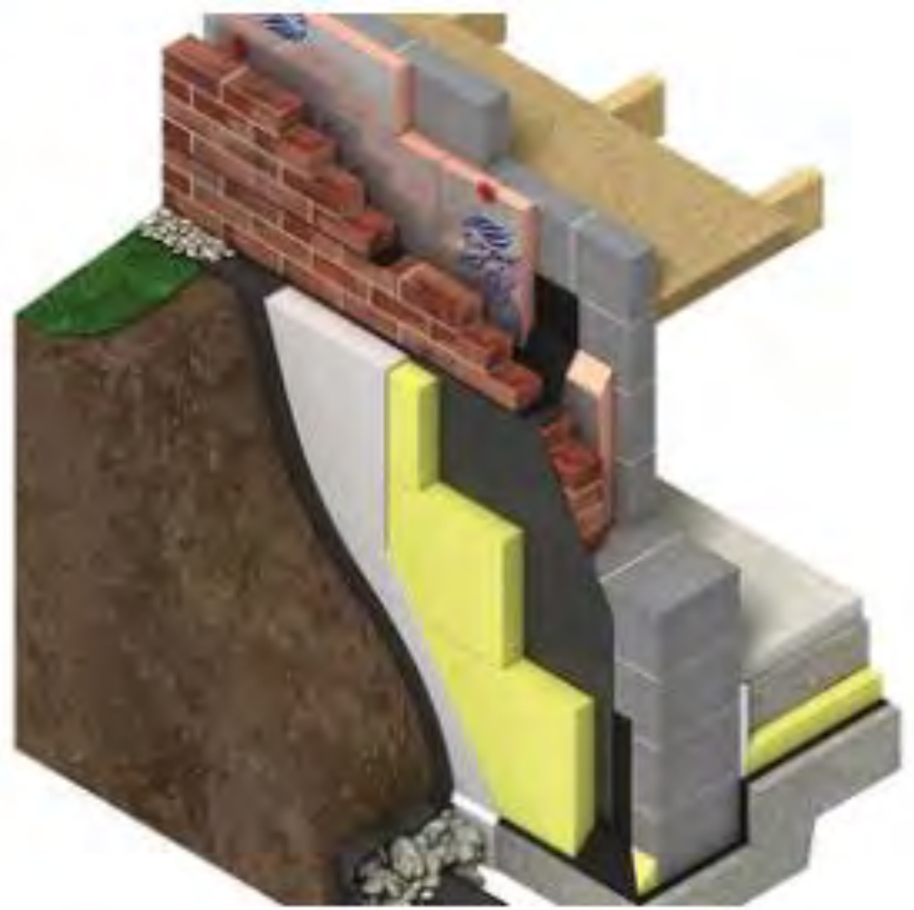

Image Source: Kingspan

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

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Conductivity is king!

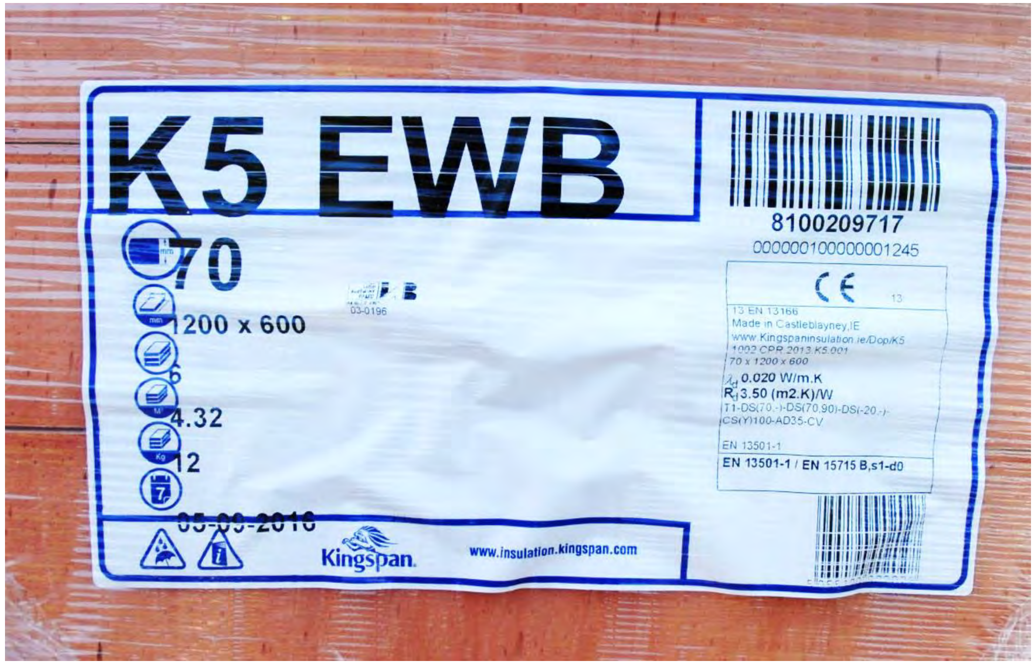

Image Source: MosArt

Insert Organiser Logo Here
For illustrative purposes only delete this shape from final presentation

Deliver The U-Value Specified

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Image Source: MosArt

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Do forget issues with wind!

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- 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

Co-funded by the Erasmus+ Programme of the European Union

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

Image Source: MosArt

Certified Airtight and Insulated Attic Hatches

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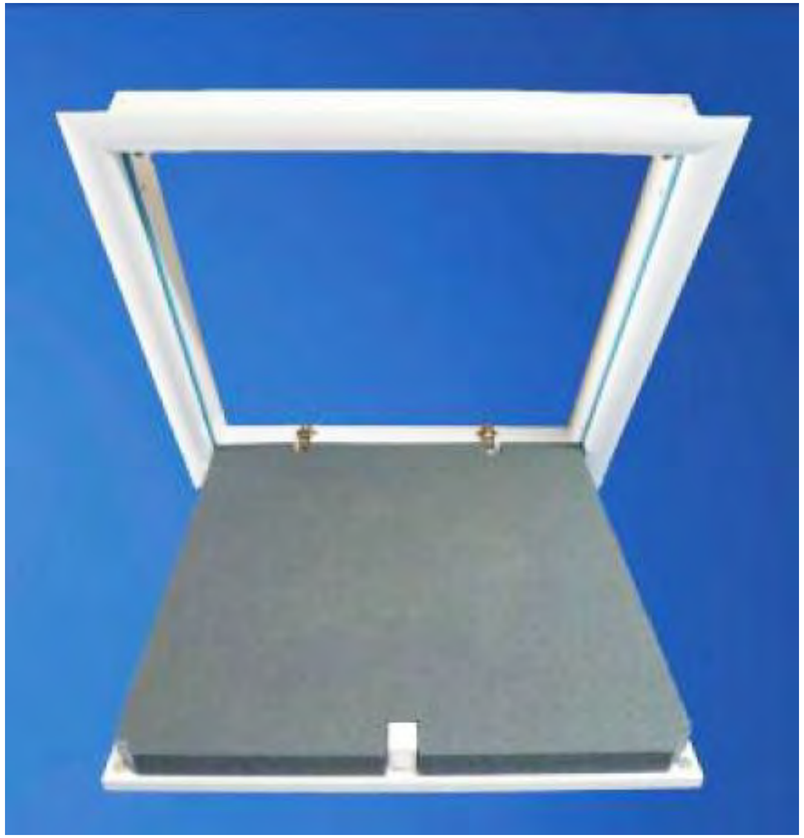
Examples of Certified Attic Hatches:

Wellhofer Airtight Attic Hatch with Ladder



Wellhofer Airtight Attic Hatch

Image Source: Wellhofer

Airtight and Insulated Attic Hatch

Co-funded by the Erasmus+ Programme of the European Union

Wellhöfer Passive House Attic Hatch

Passive House certified airtight attic hatch

Heat transition coefficient (u-value)	0.48 W/m^2K
Length of ceiling opening	1.3 m
Width of ceiling opening	650 mm
Depth	500 mm
Ceiling height compatibility	2.46 m to 2.579 m
Air permeability (q₅₀-value)	1 m^3/mh

- Using pre insulated, airtight attic hatches can simplify installation and guarantee quality.

Image Source: Ecological Building Systems

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Assessment

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QUIZ!

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CONSTRUCTION BLUEPRINT

Module 5

Building Fabric 2: Thermal Bridging

Energy Efficiency for Construction

24 partners 12 countries

Date of Event

*Author/ **Institute***

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Building Fabric 2 | Summary

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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

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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.

Building Fabric 2 | Content

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Topic 1 – Continuous Insulation

Topic 2 – Thermal Bridging

Topic 3 – Windows and Doors

On the following slides you will see this icon:

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CONSTRUCTION BLUEPRINT

2. Thermal Bridging

Definition

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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 Ψ applies (m)
Ψ = Linear thermal transmittance (W/mK)

Thermographic images of Thermal Bridges

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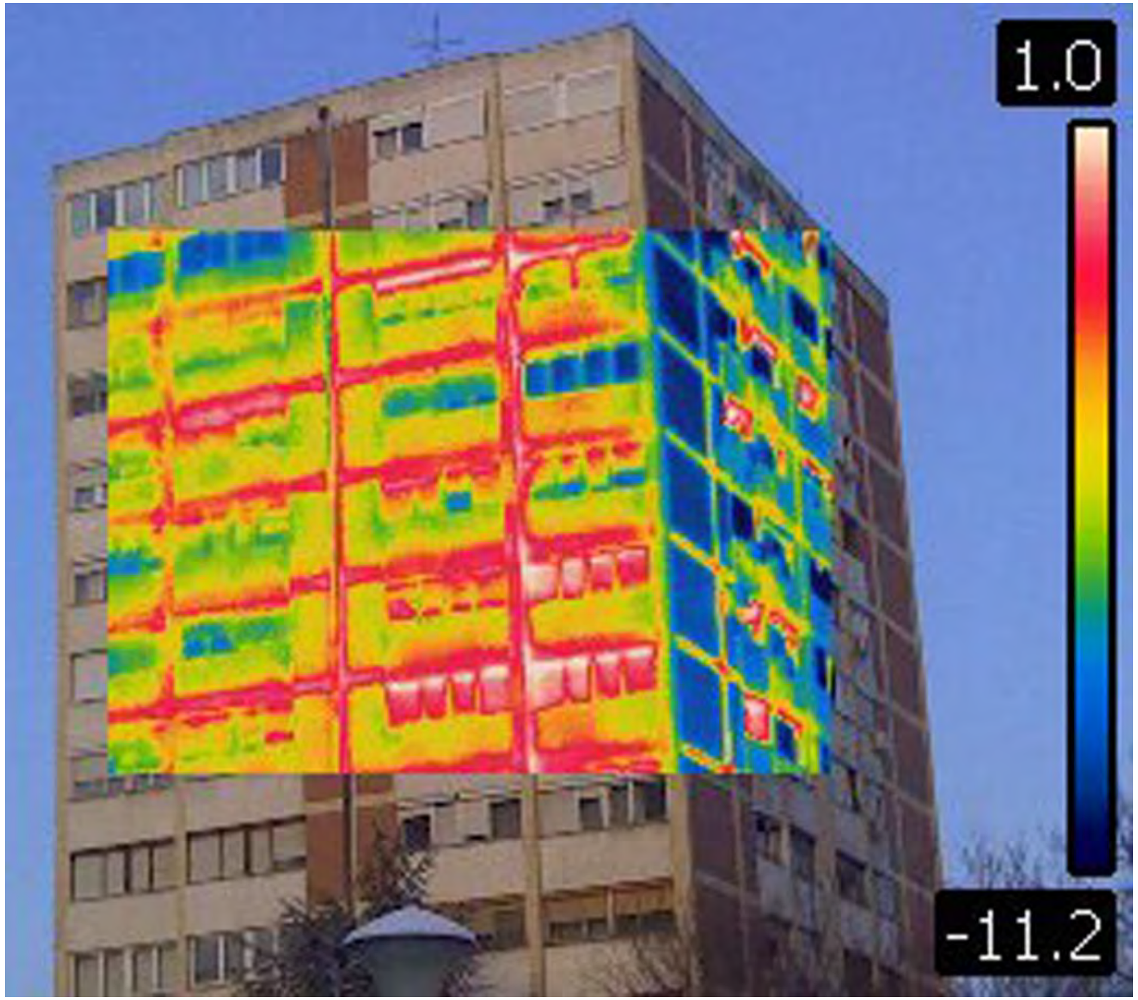

Evidence of heat loss through floor slabs and party walls in apartment blocks

Image Source: Left
purchased by MosArt (iStock 913851964)

“Repeating” Thermal Bridges through Studs

Co-funded by the Erasmus+ Programme of the European Union

Image Source: Purchased by MosArt (iStock 90571524)

Typical Locations of Thermal Bridges

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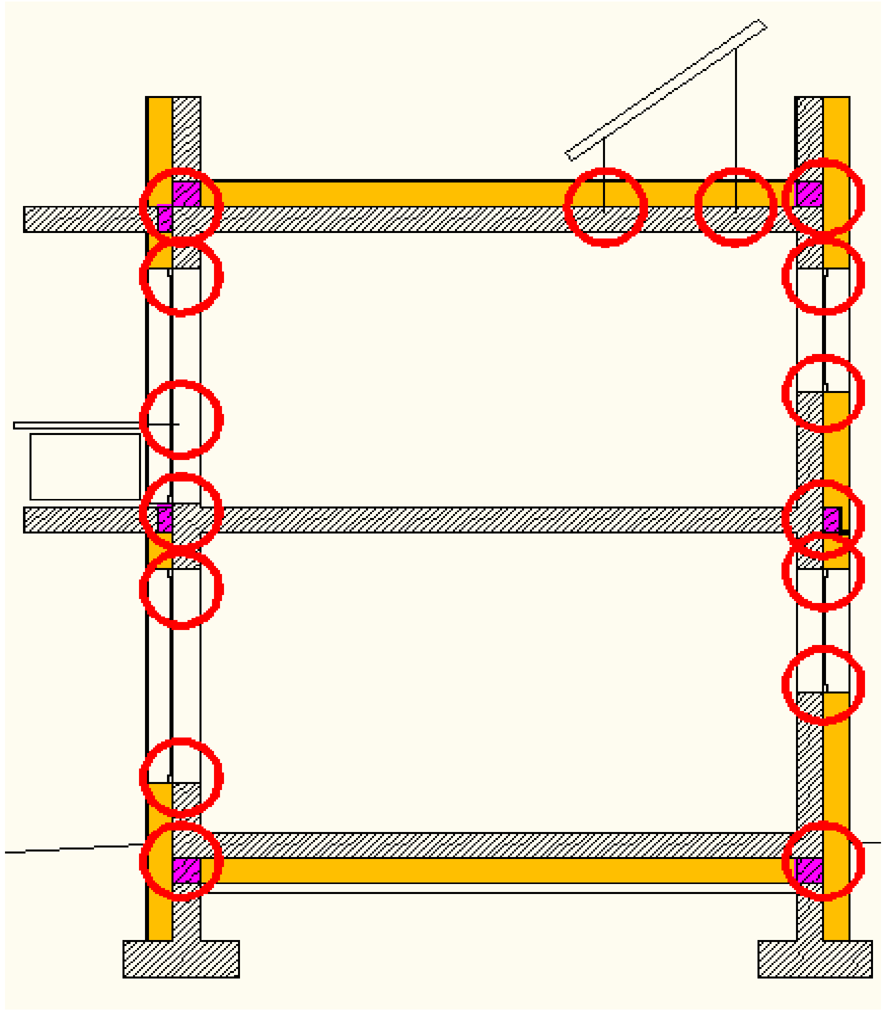
- Thermal bridges can be found at **all junctions** and **penetrations**
- Arises due to challenge in **connecting insulation planes**
- **Solutions** for most situations are now readily available
- Failure to minimise thermal bridge effect will most likely result in **mould** and poor indoor air quality



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Typical Locations of Thermal Bridges

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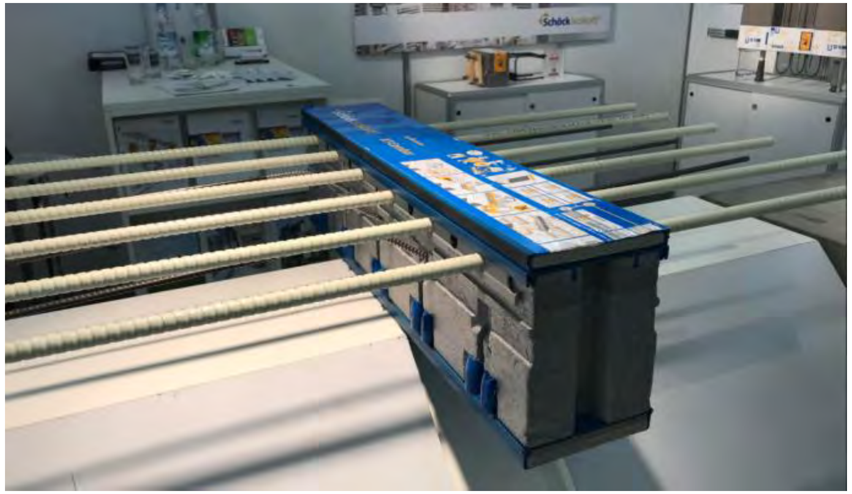

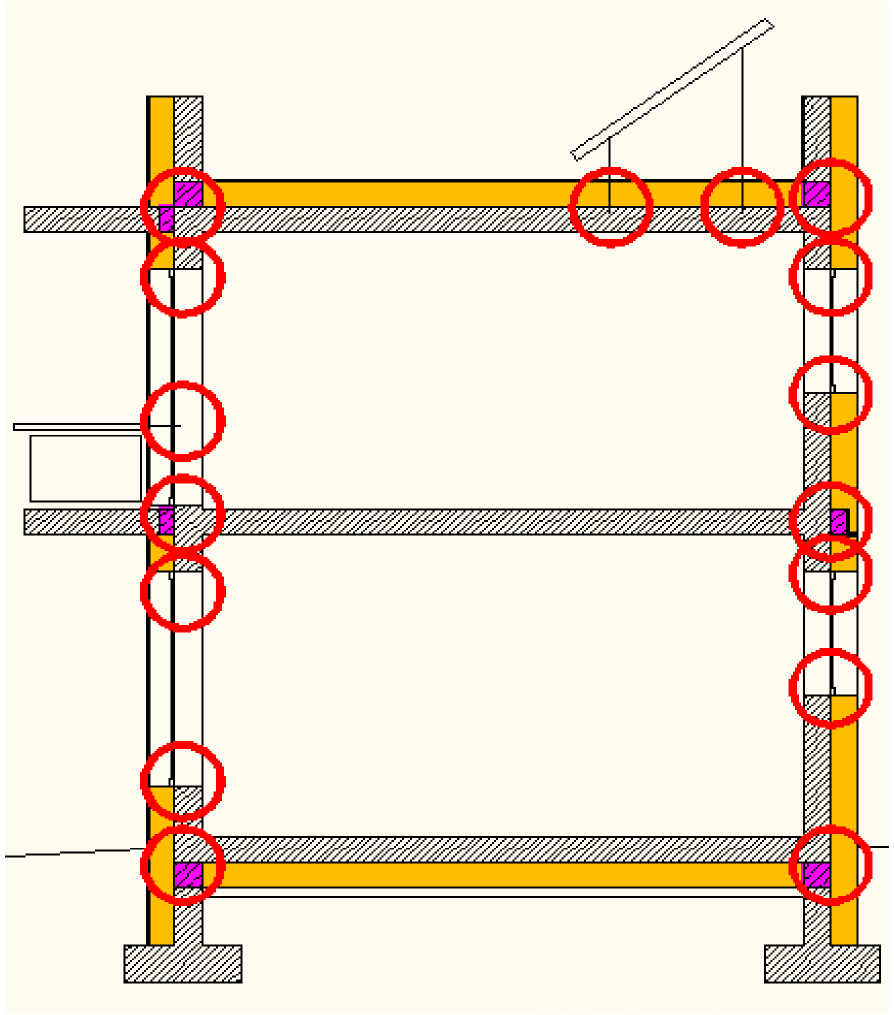

Image Source: Right & Bottom Left – MosArt / Top Left – Scheck North America

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Steel Junctions cause Thermal Bridging

Energy Efficiency for Construction:
Building Fabric 2

Image Source: Left - Purchased by MosArt (iStock 136199144) / Right - MosArt

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Standalone Balconies Reduce Thermal Bridging

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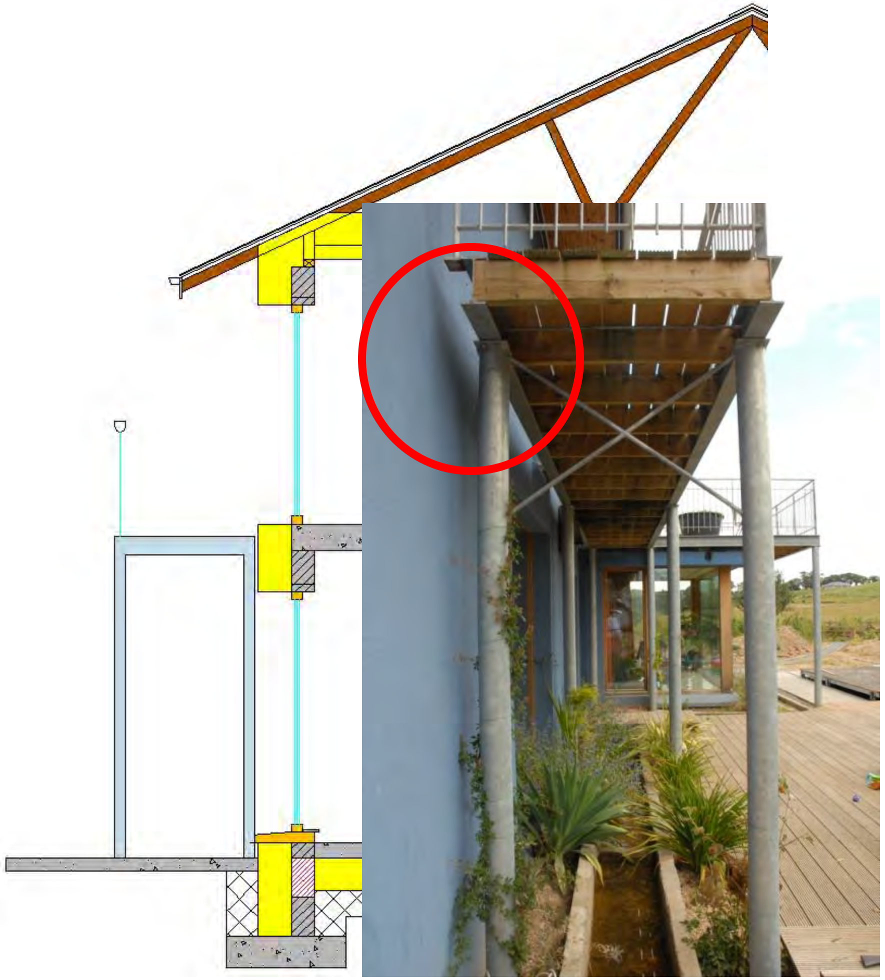

'Out of the Blue' Passive House – free-standing balcony

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

Steel Beam Externally Insulated by Cavity Wall Insulation

Co-funded by the Erasmus+ Programme of the European Union

Image Source: MosArt

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Typical Locations of Thermal Bridges

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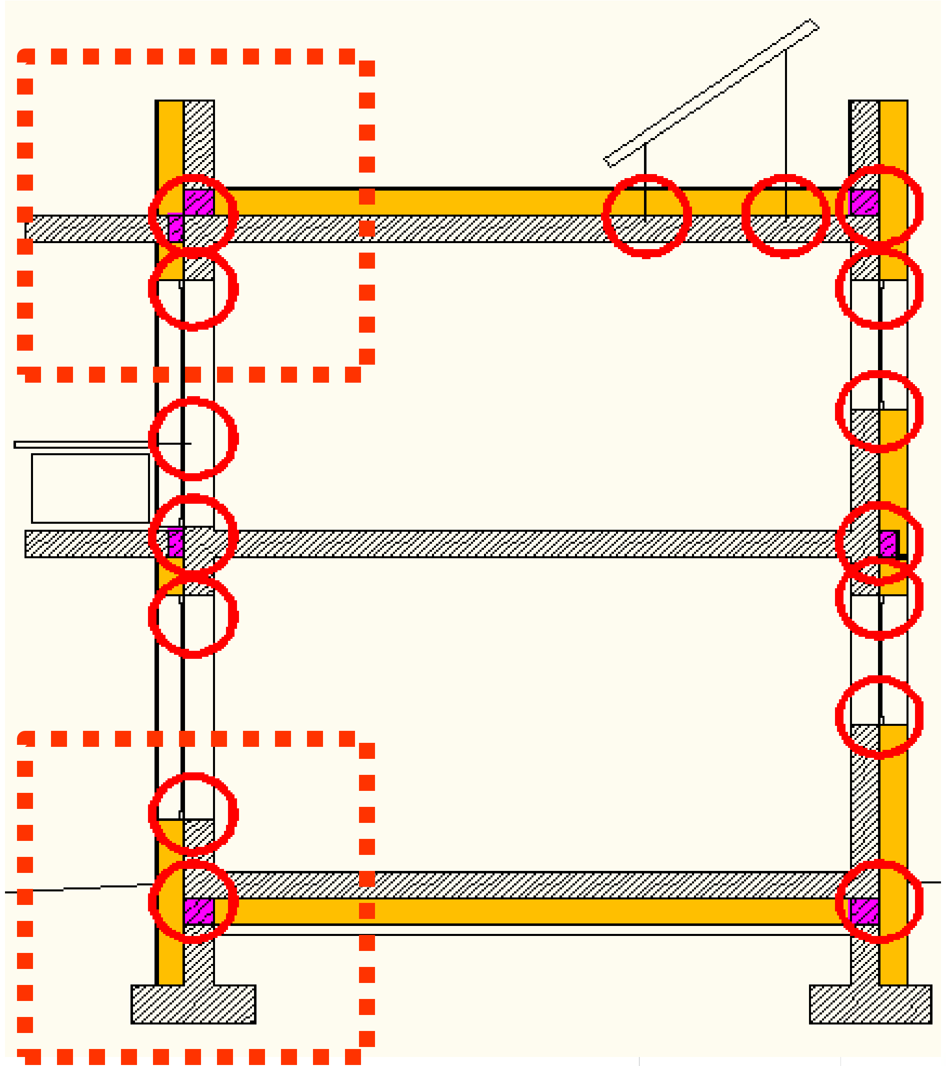

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Mould Very Common at Wall to Roof Junction

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Can cause both health problems for occupants and structural problems

Image Source: Purchased by MosArt (iStock 502417080)

Mould Very Common at Wall to Roof Junction

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Can cause both health problems for occupants and structural problems

Image Source: Purchased by MosArt (iStock 488872199)

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Vinyl Wallpaper Hiding the Ugly Reality of Mould

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Image Source: Purchased by MosArt (Adobe Stock 204673056)

Spot the Thermal Bridges

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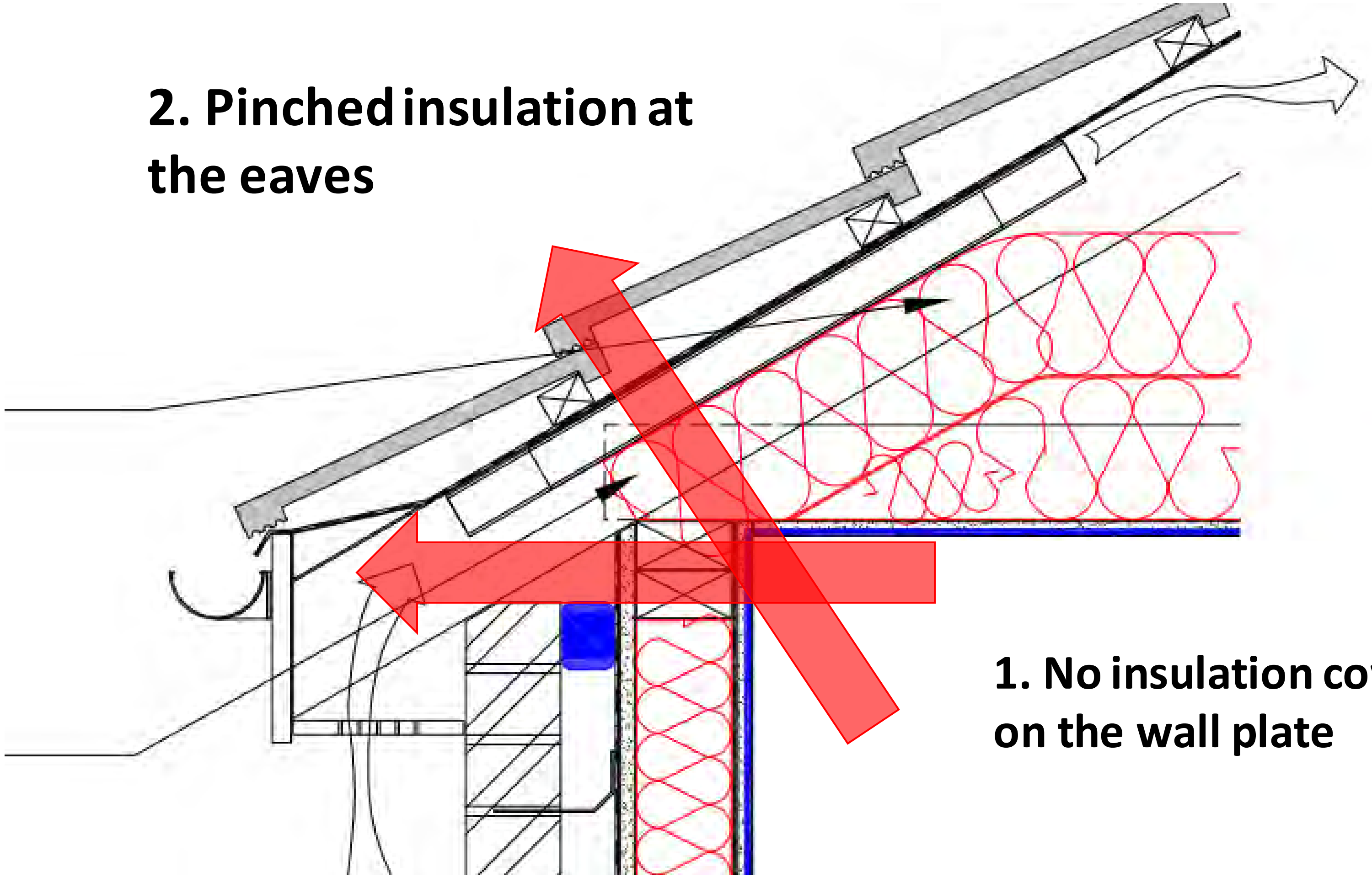


Image Source: Department of housing, Ireland

How can We Solve These Thermal Bridges?

Co-funded by the Erasmus+ Programme of the European Union

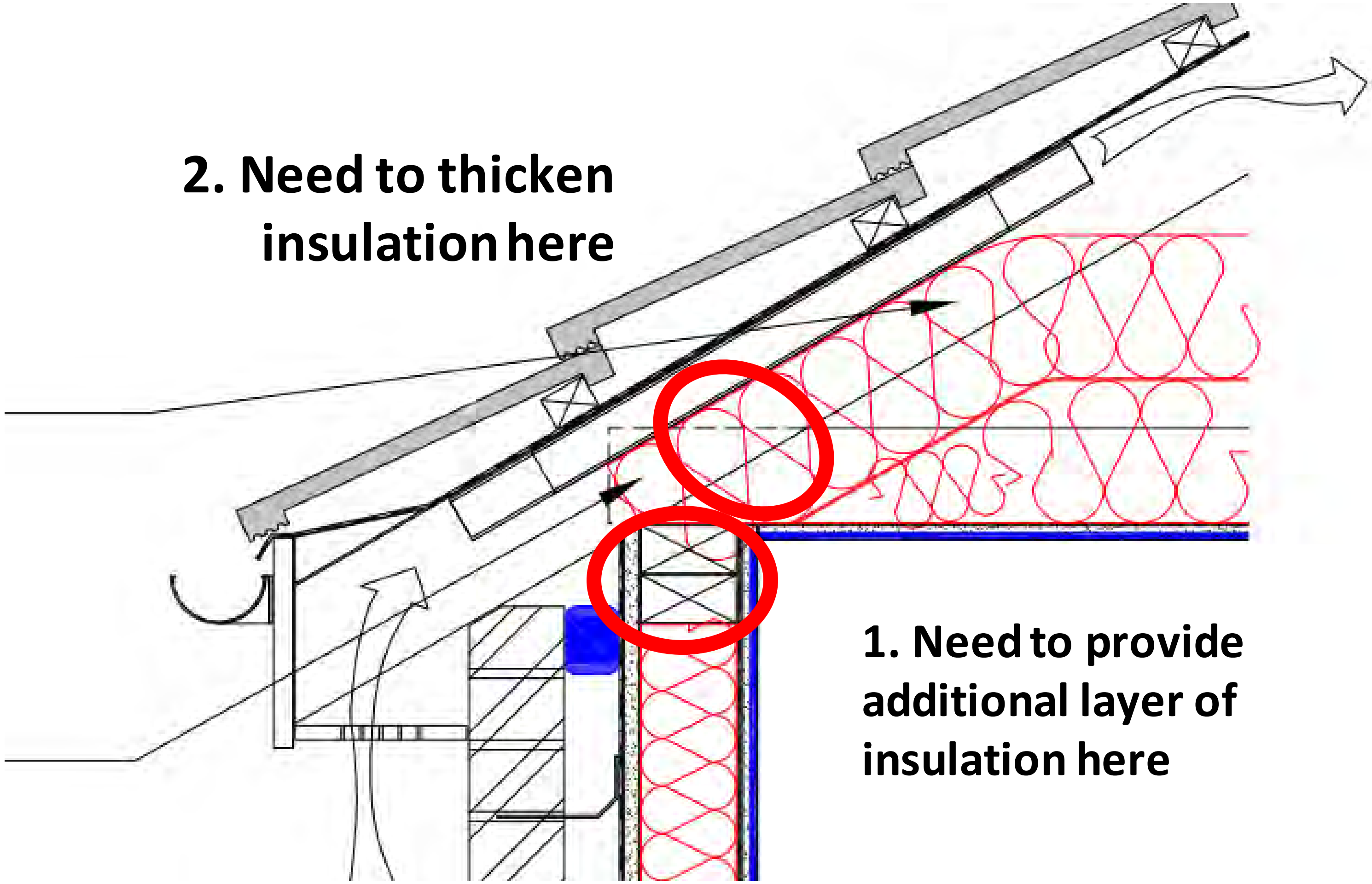
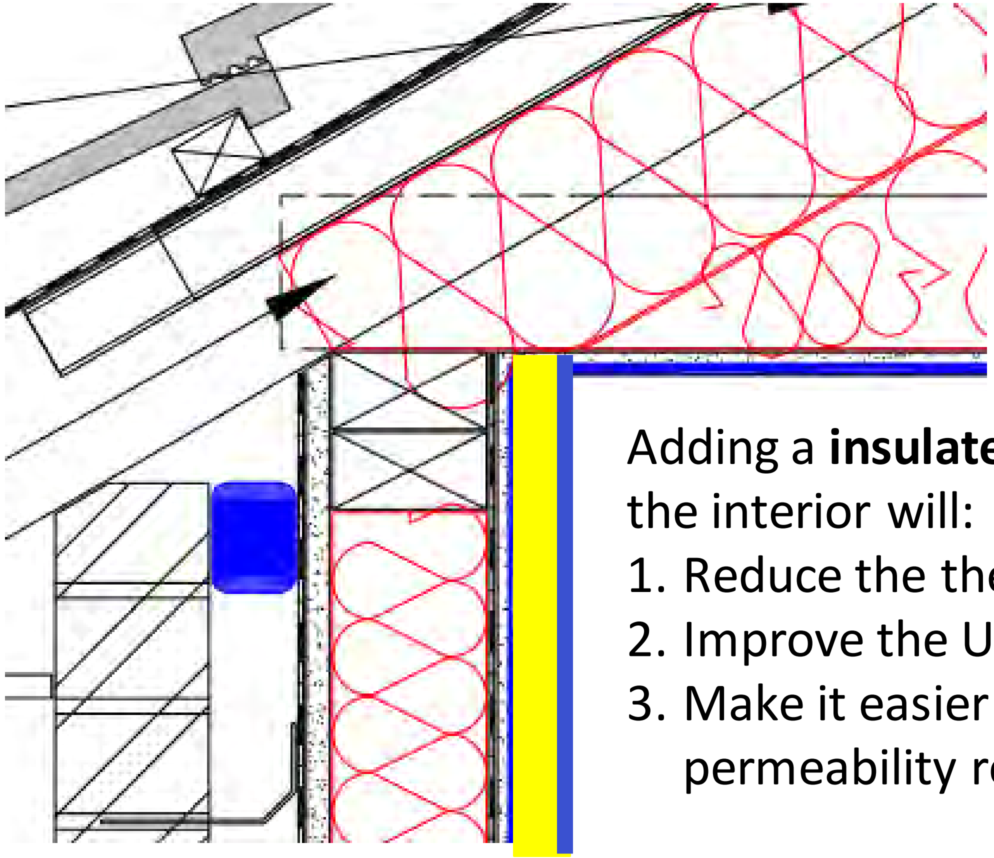


Image Source: Department of housing, Ireland

How can We Solve the Wall Plate Thermal Bridge?

Co-funded by the Erasmus+ Programme of the European Union



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

Image Source: Department of housing, Ireland

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How can We Solve the Eaves Thermal Bridge?

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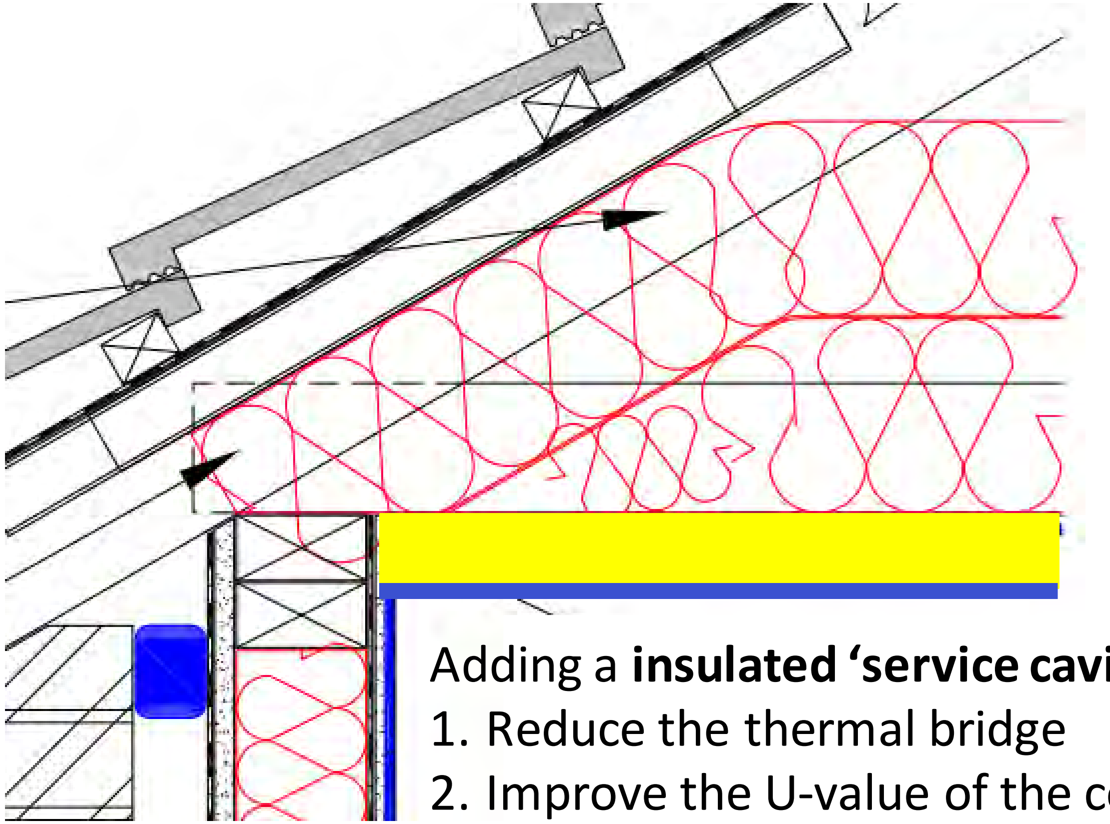


Option 1

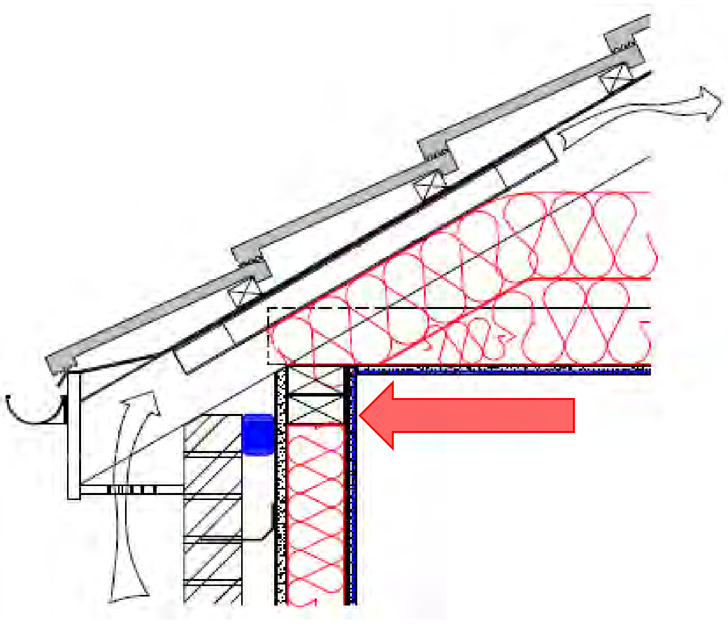
Adding a **insulated 'service cavity'** to the ceiling will:

1. Reduce the thermal bridge
2. Improve the U-value of the ceiling
3. Make it easier to get a lower air permeability result

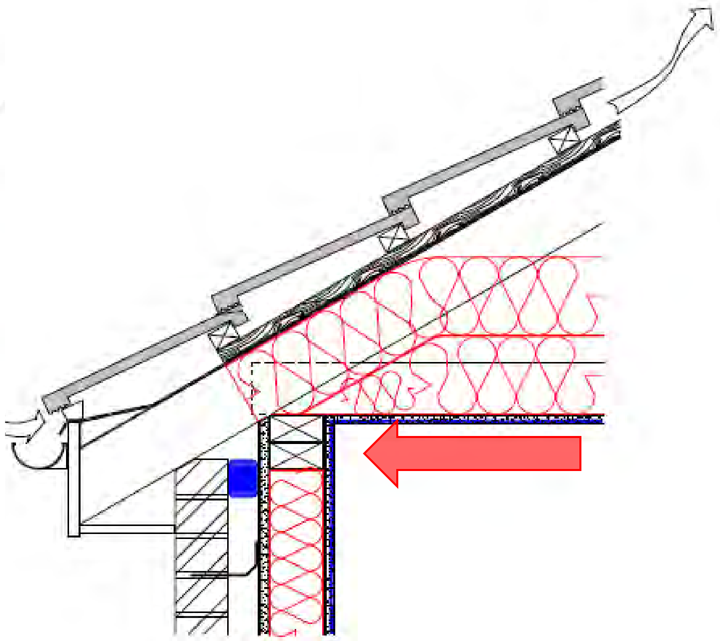
Image Source: Department of housing, Ireland

Eaves Insulation – Timber Frame – Thermal Bridging – ACD's

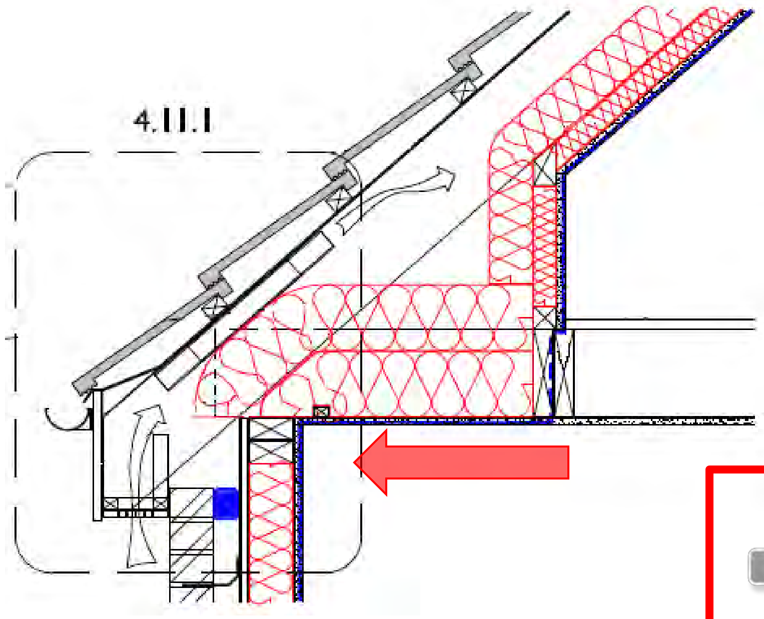
Co-funded by the Erasmus+ Programme of the European Union



Eaves – Ventilated attic



Eaves – Unventilated attic

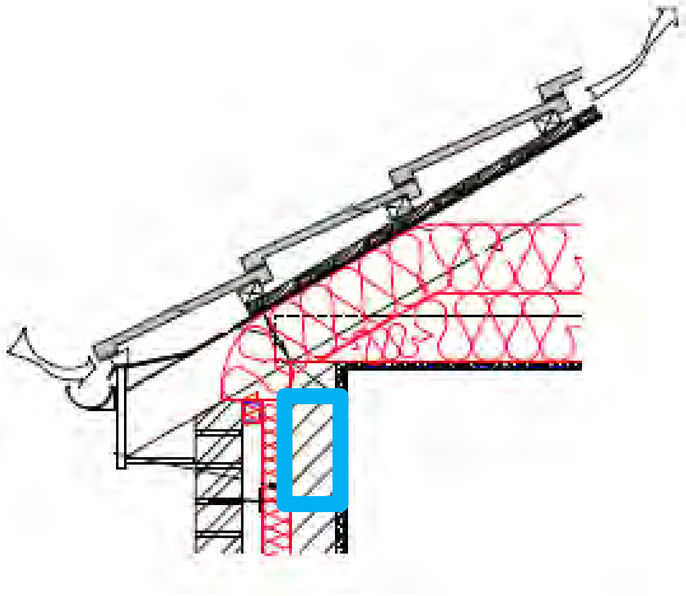


Eaves – Insulation
Between and under rafters
Unventilated rafter void - Dormer

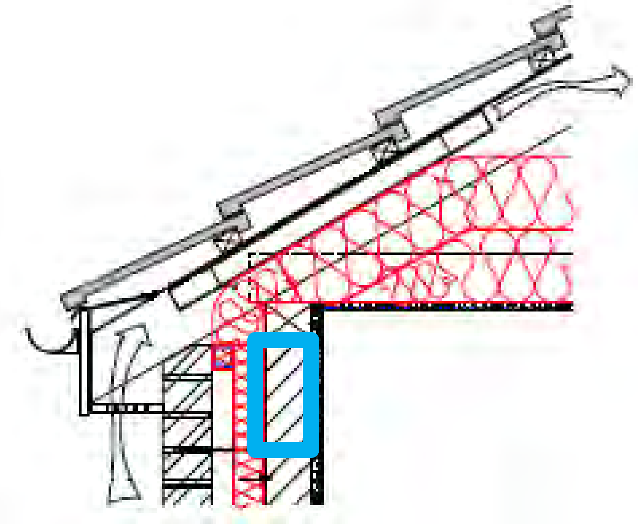
Image Source: Department of housing, Ireland

Eaves Insulation – Cavity Wall – Thermal Bridging – ACD's

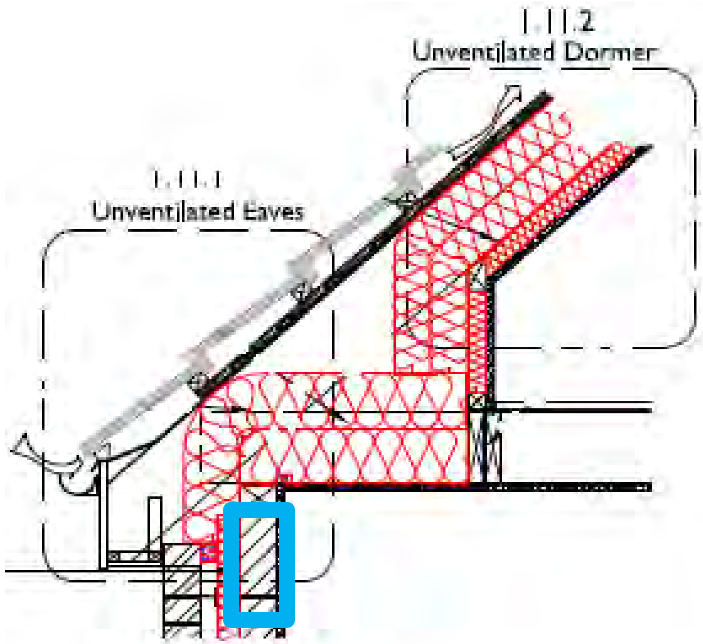
Co-funded by the Erasmus+ Programme of the European Union



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

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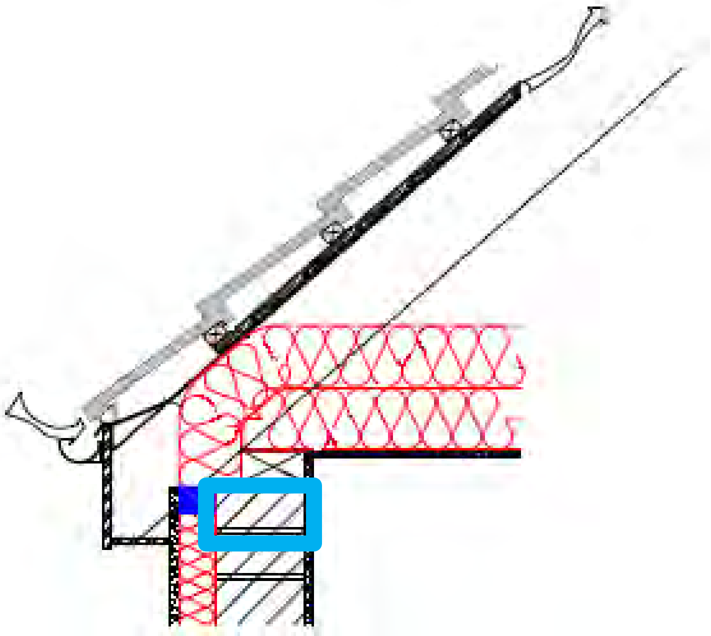

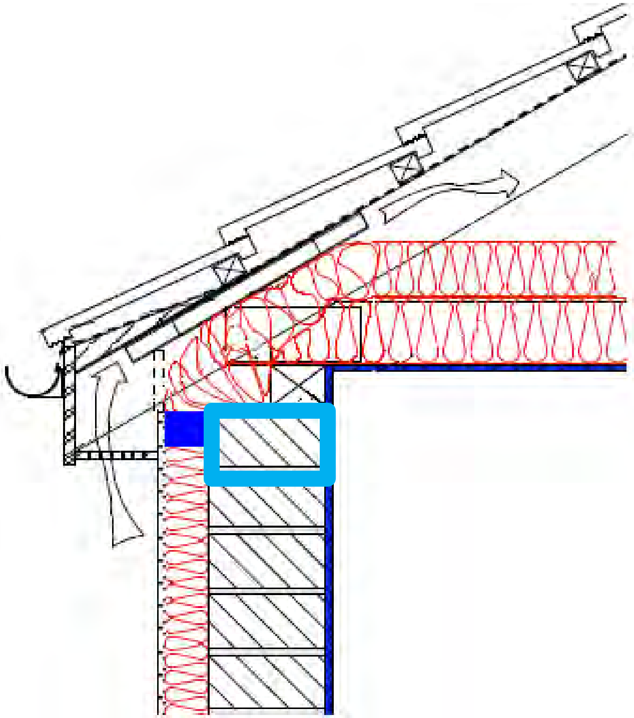

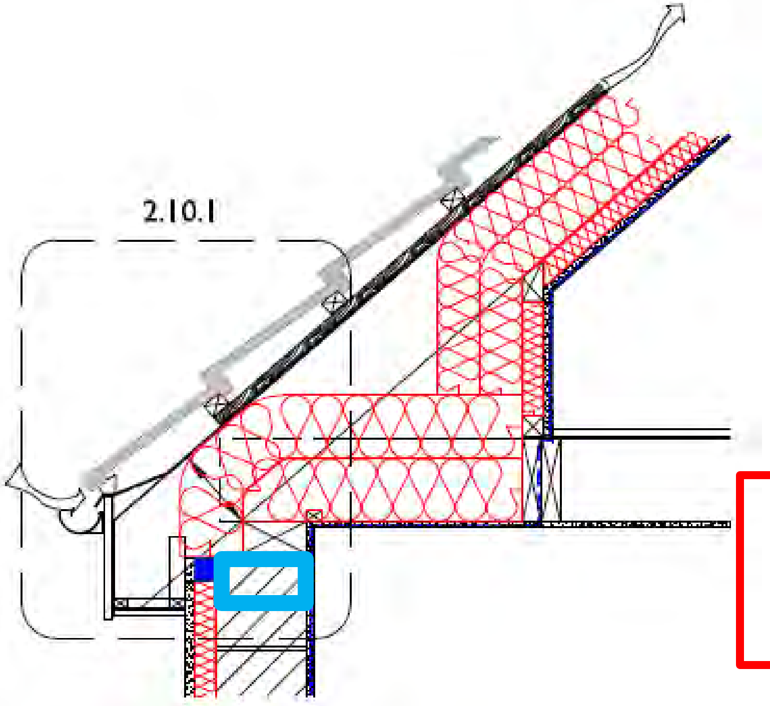

Eaves – Unventilated attic

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

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Eaves Insulation – Internal Wall Insulation – Thermal Bridging – ACD's

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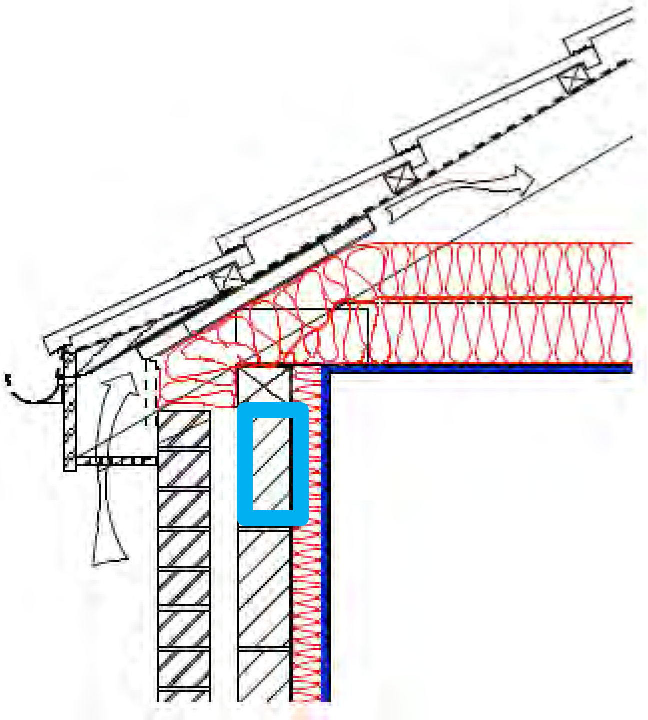
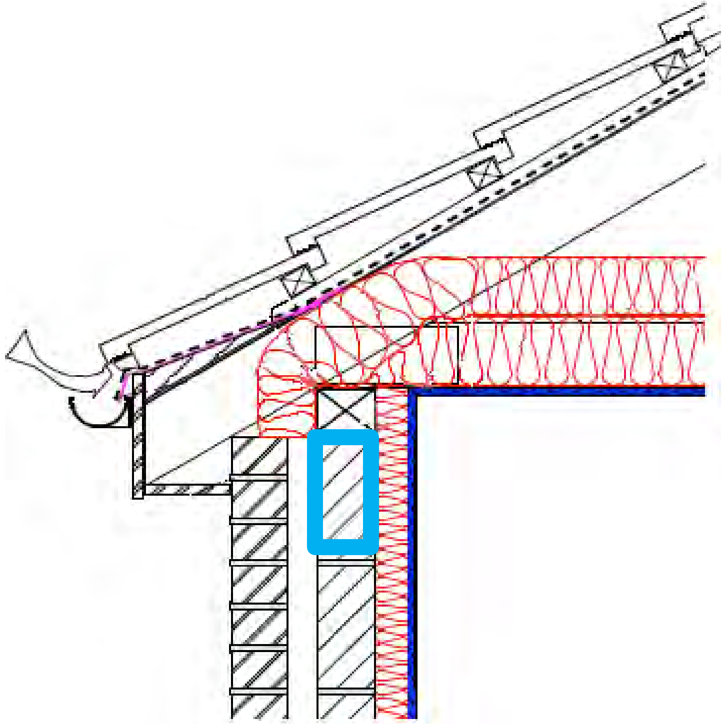
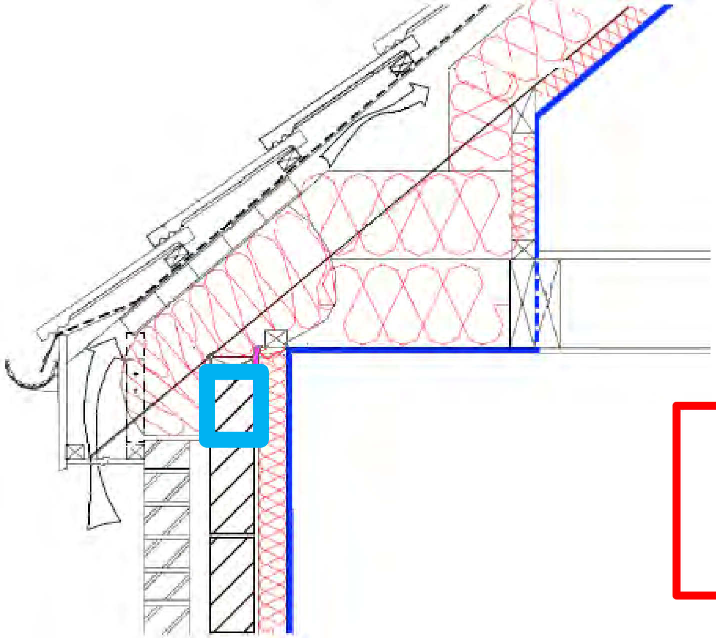


Eaves – Unventilated attic



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?

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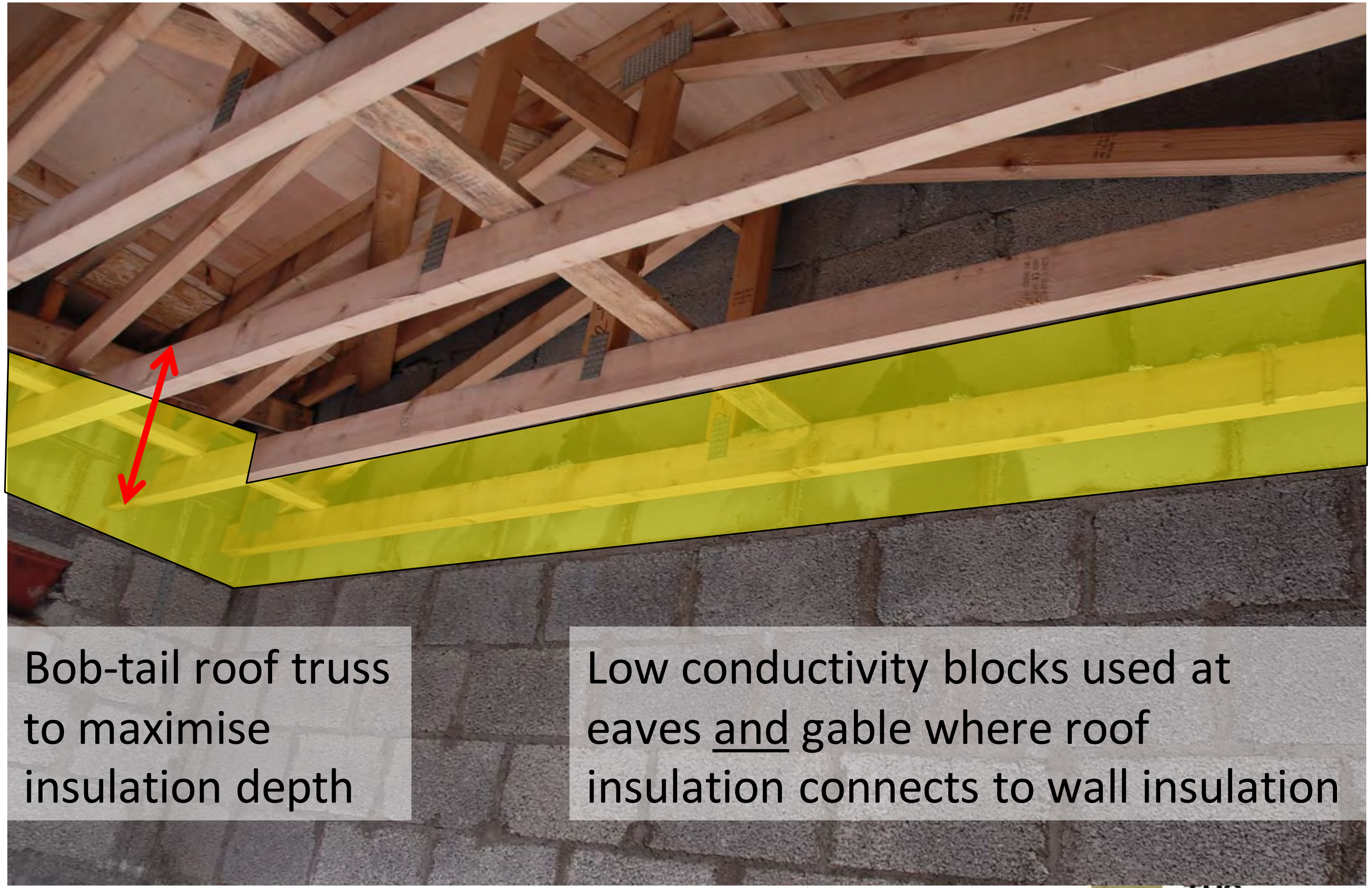

Image Source: MosArt

Aerated Blocks in Gable Wall

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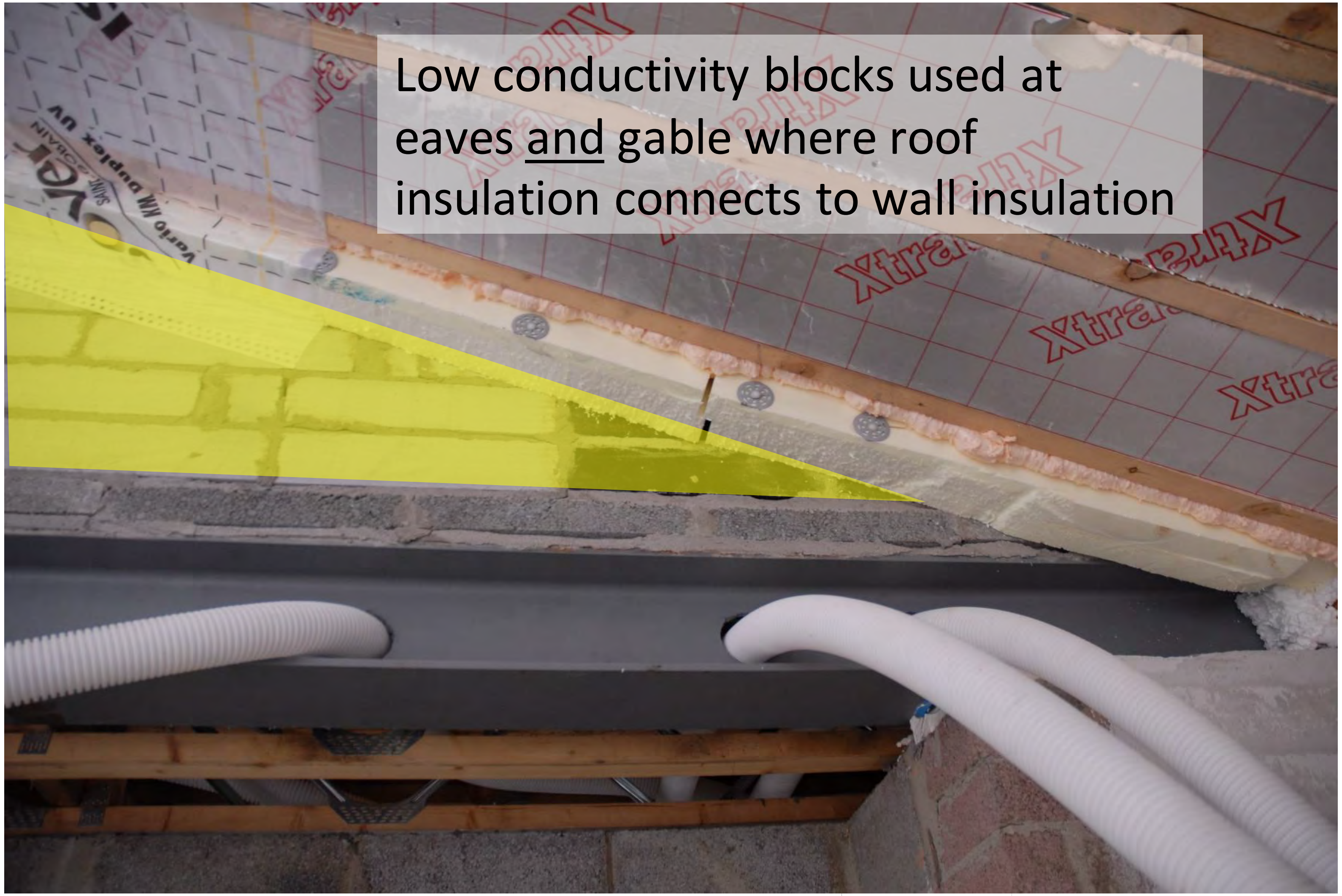

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Use of Low Conductivity Blocks Exactly Where Needed

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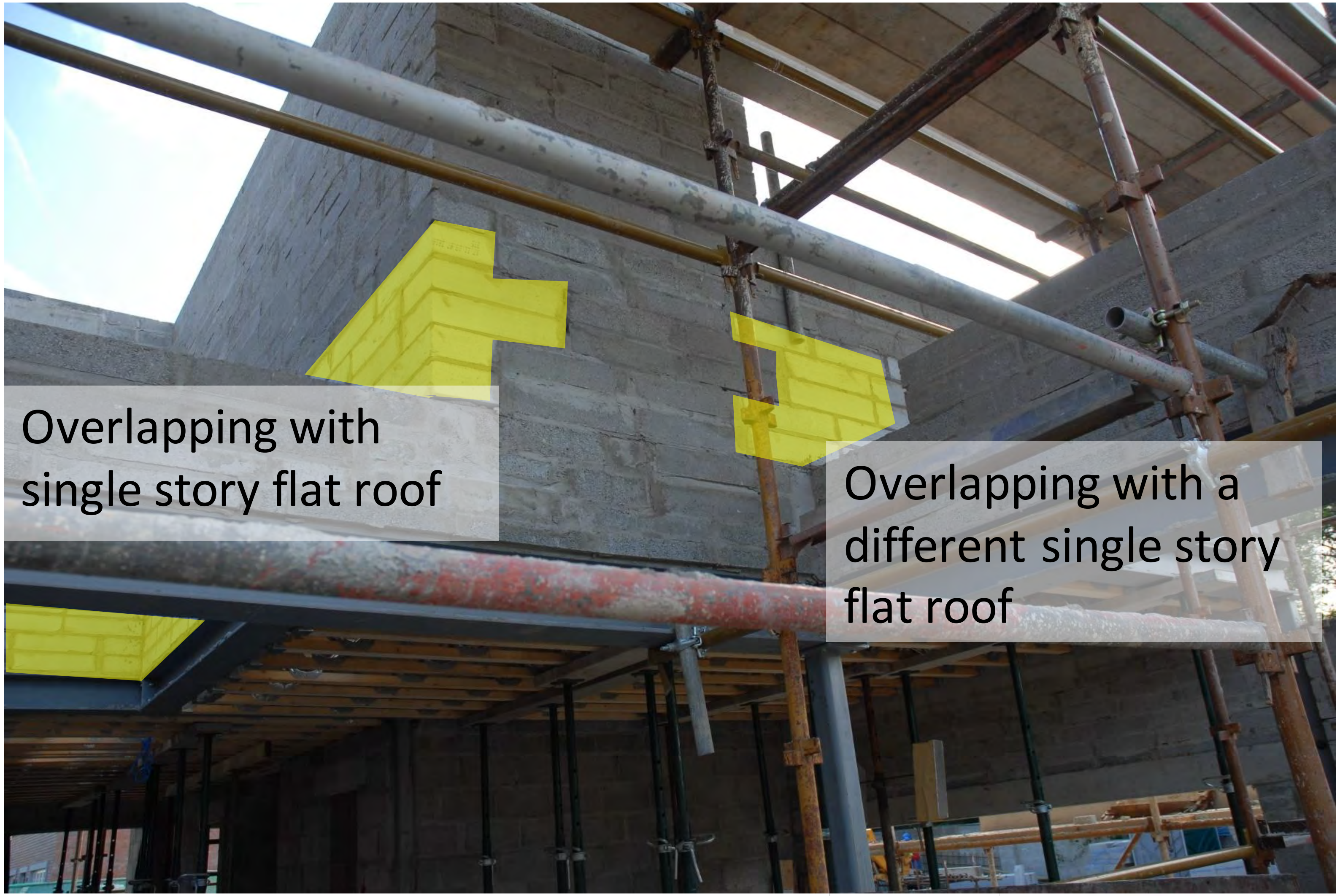

Image Source: MosArt

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Thermal Bridge Free Eaves Detailing

Co-funded by the Erasmus+ Programme of the European Union

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

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Skinny rafters fixed over main rafters to provide ventilation zone and attach fascia

Image Source: MosArt

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Alternative Approach to Overlapping Roof and Wall Insulation

Co-funded by the Erasmus+ Programme of the European Union

Image Source: MosArt

Mould Very Common at Wall to Floor Junction

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Image Source: Purchased by MosArt (iStock 482808792)

Case Study: Floor to Wall Junction in Cavity Wall

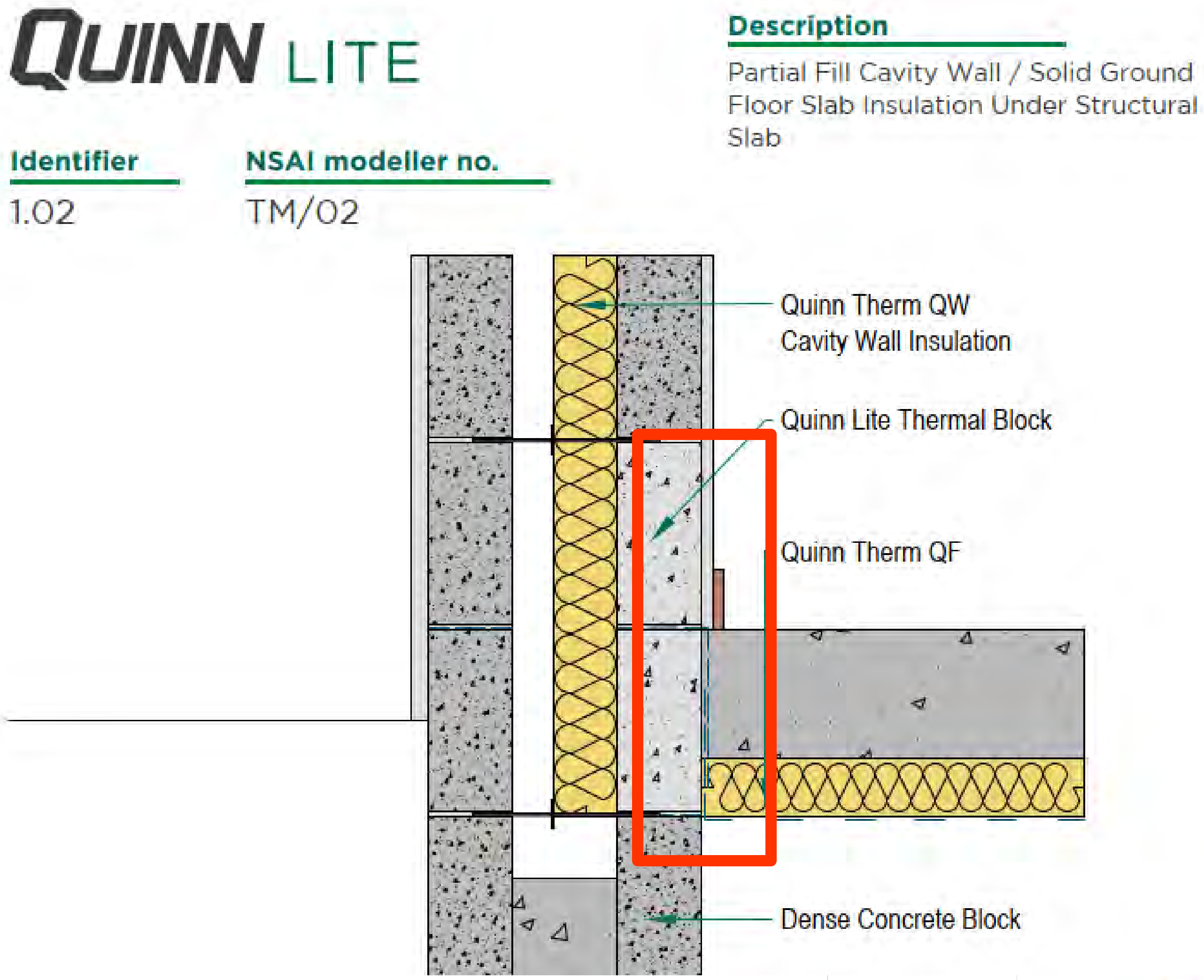

Image Source: Mannock

Aerated Concrete Blocks at Floor Connection

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

Image Source: MosArt

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Thermal Separation of Envelope and Ground (1/3)

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Image Source: MosArt

Thermal Separation of Envelope and Ground (2/3)

Co-funded by the Erasmus+ Programme of the European Union

Image Source: MosArt

Thermal Separation of Envelope and Ground (3/3)

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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

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Rising Wall Types and Components

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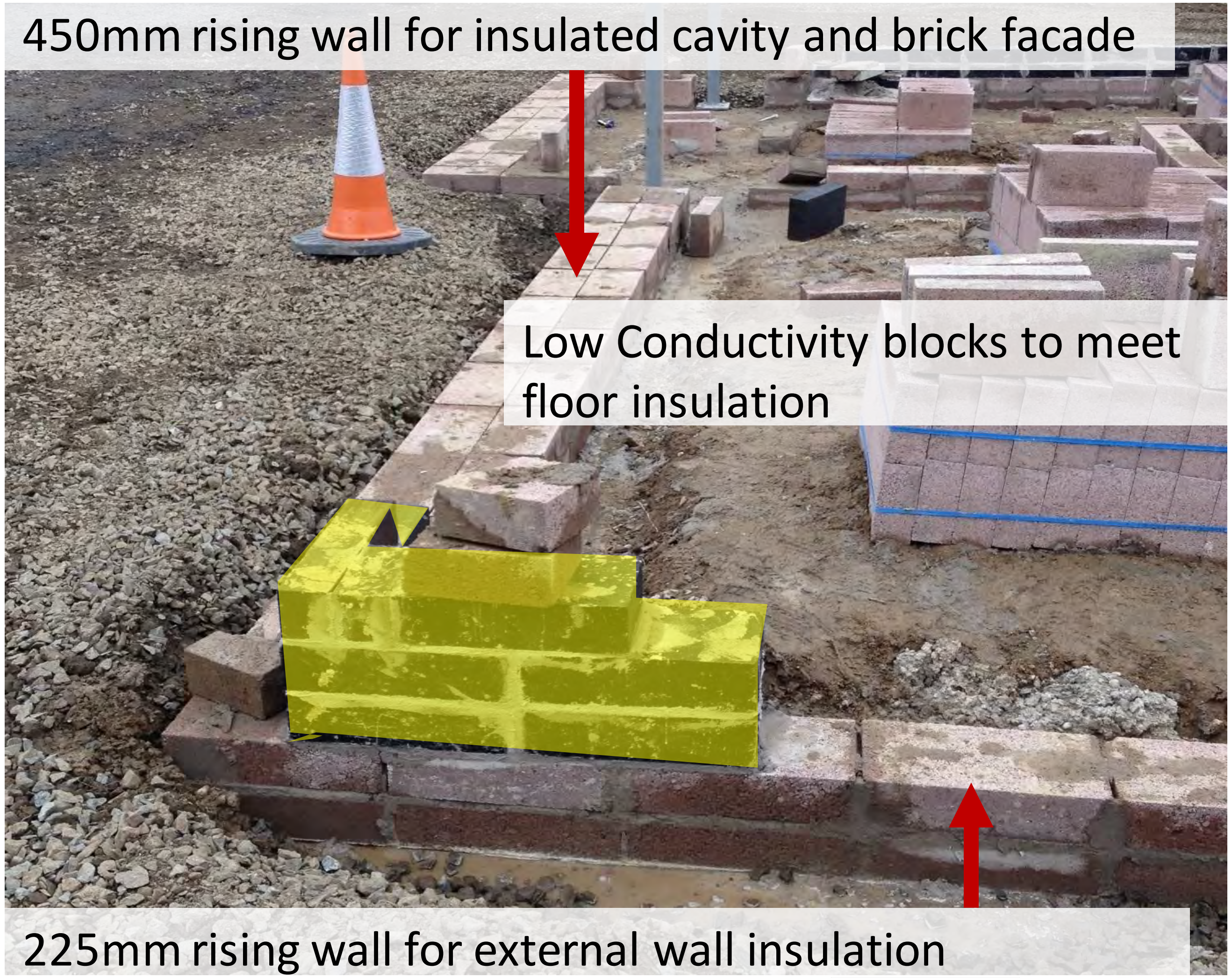

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Need to Thermally Separate Internal Wall Too

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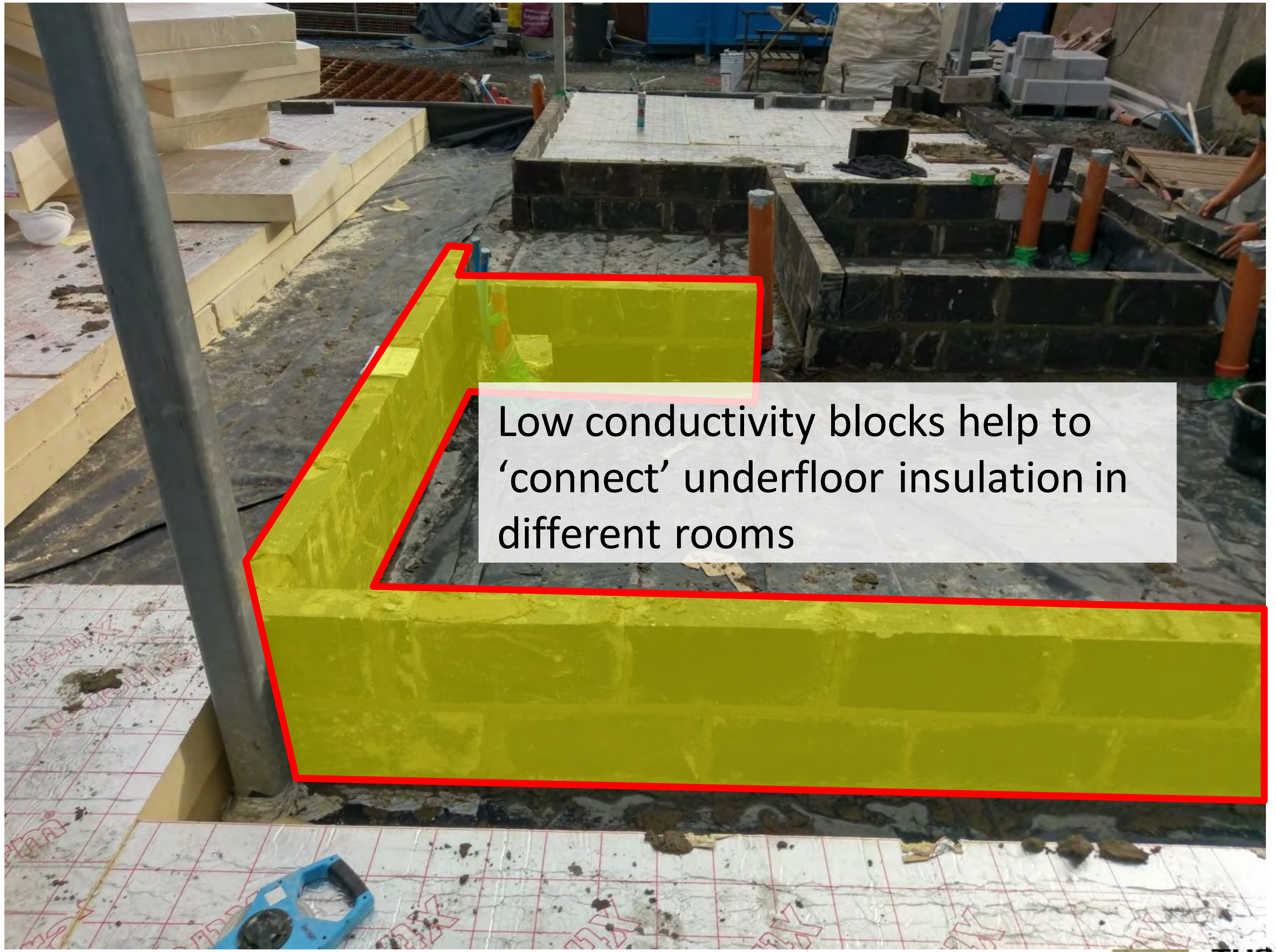

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Floor Insulation of Individual Rooms

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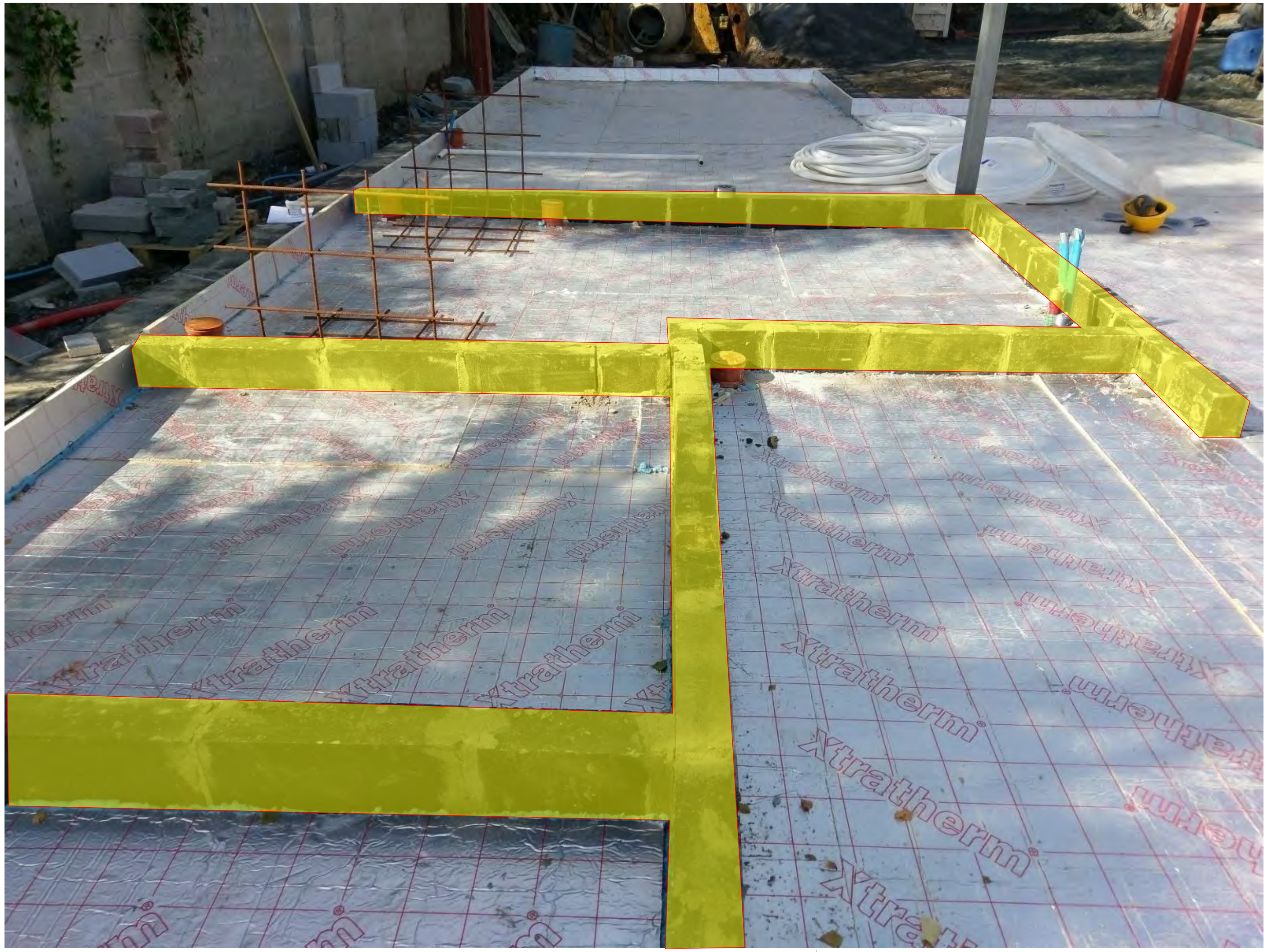
Insulation cut to fit neatly to each internal room



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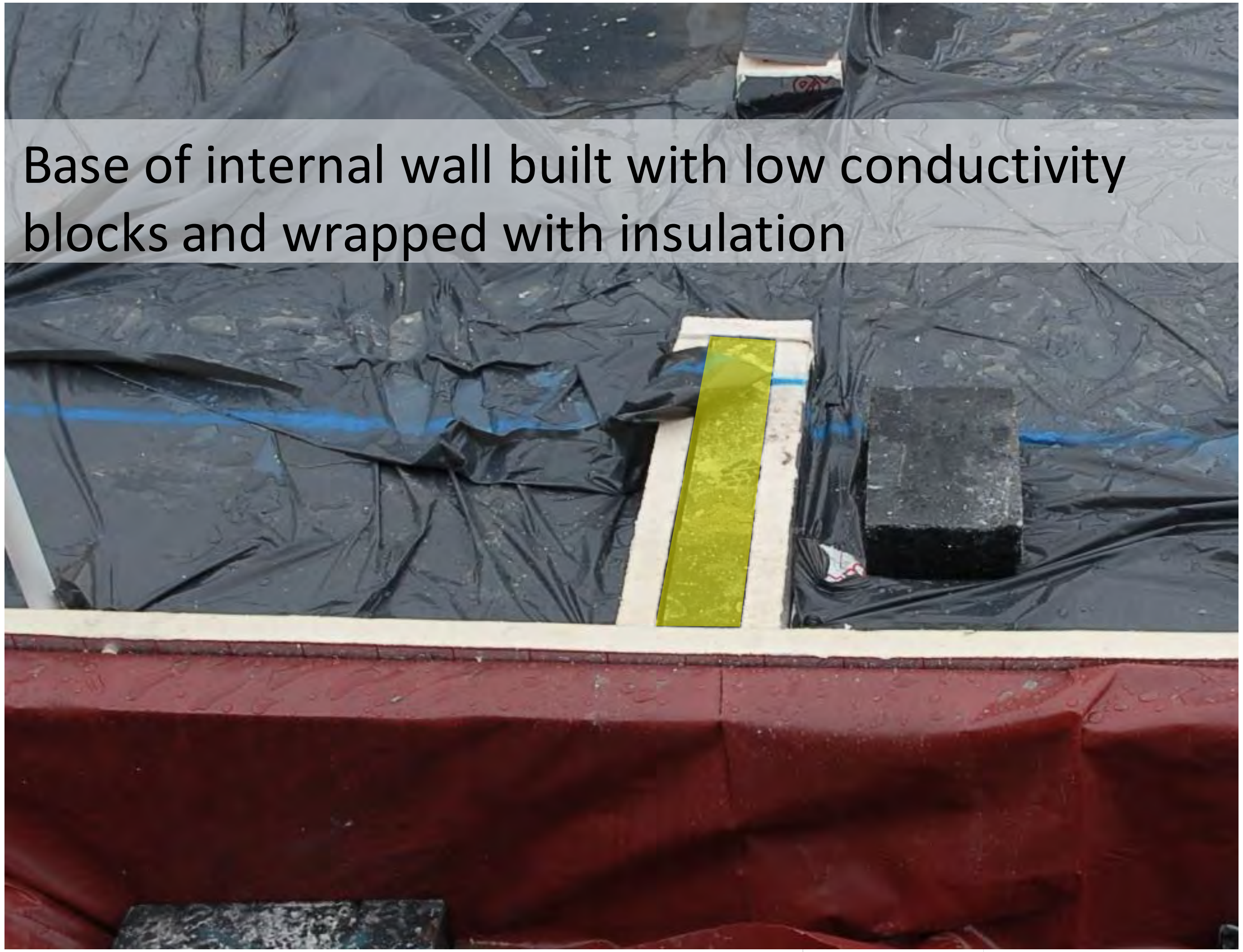

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Low Conductivity Blocks Under Radon Barrier

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Cavity Wall Insulation

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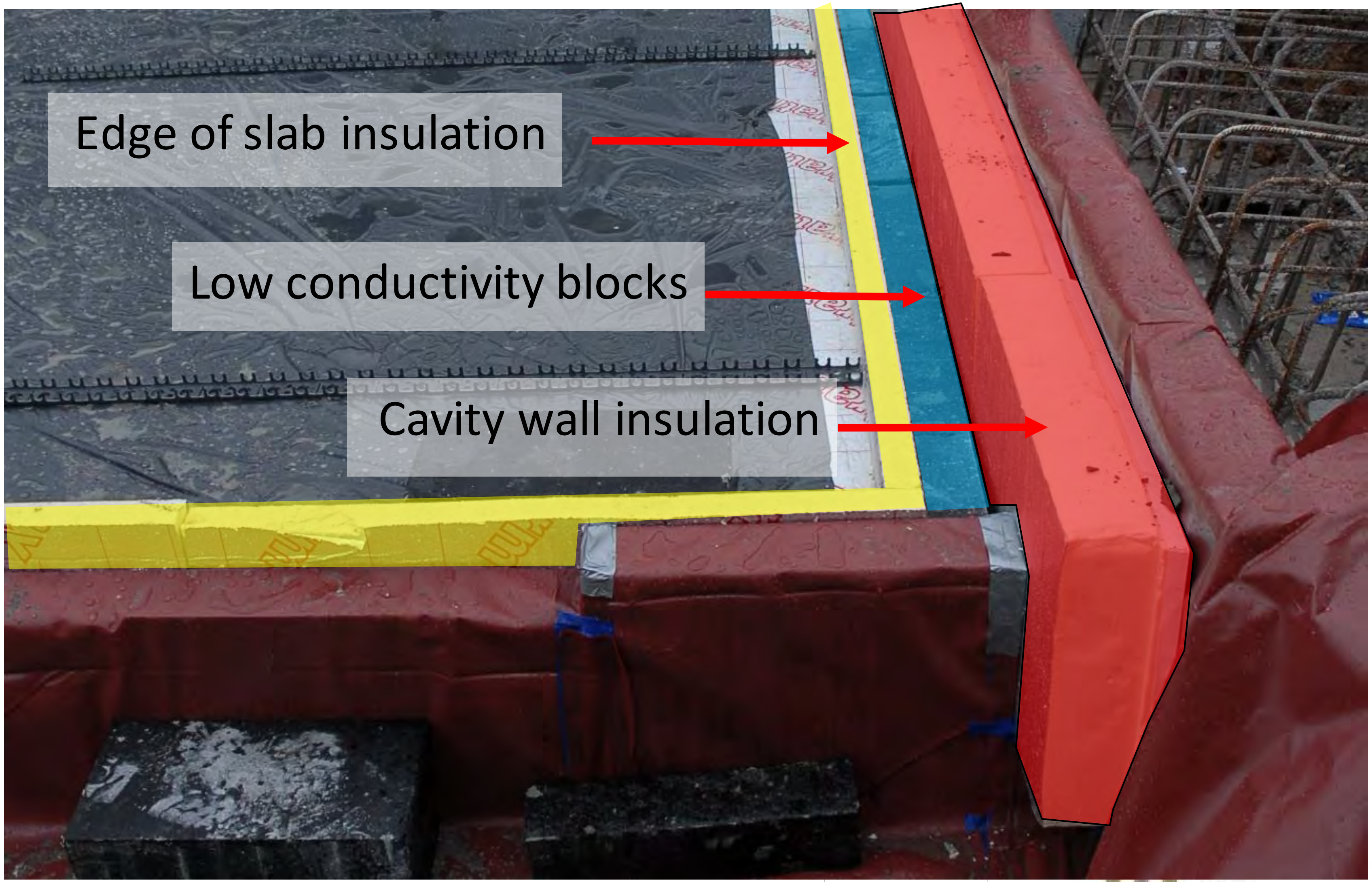

Image Source: MosArt

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Thermal Bridging Caused by Mortar Droppings

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Mortar must be removed

Image Source: MosArt

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Spot the Thermal Bridge

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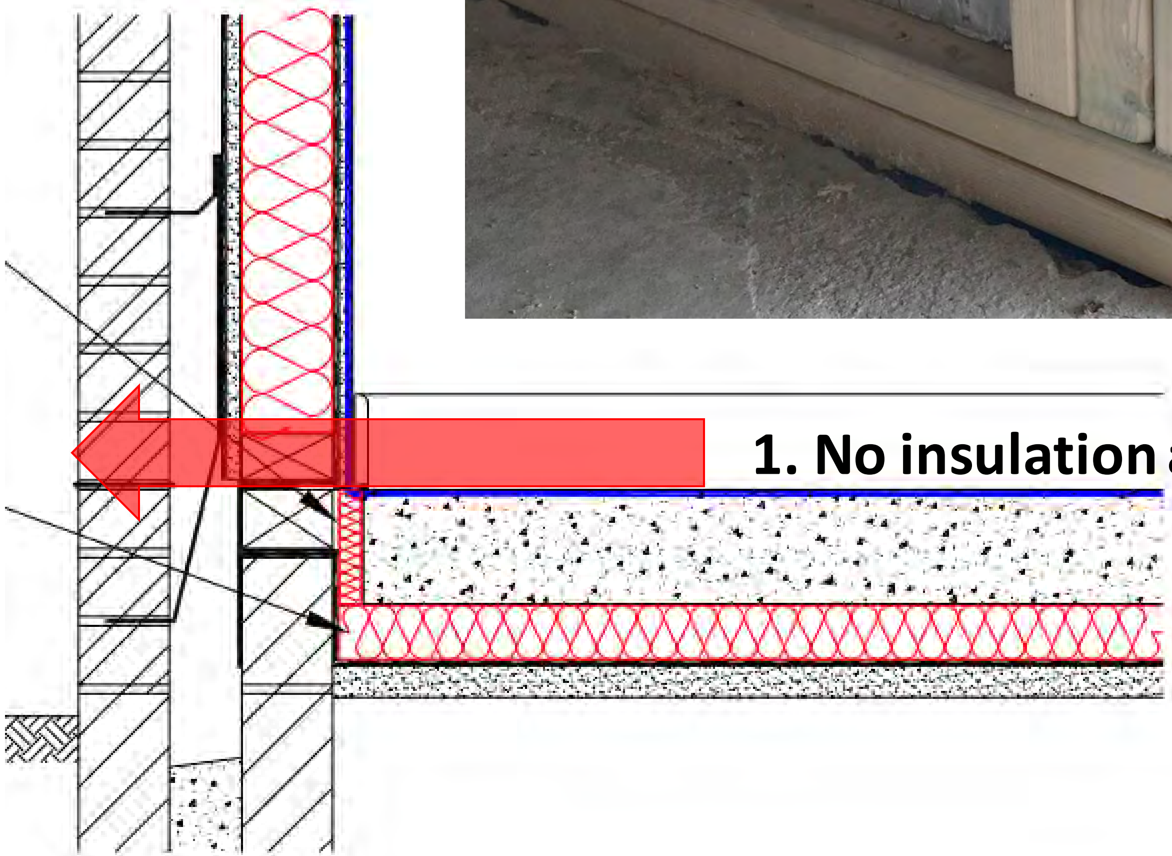


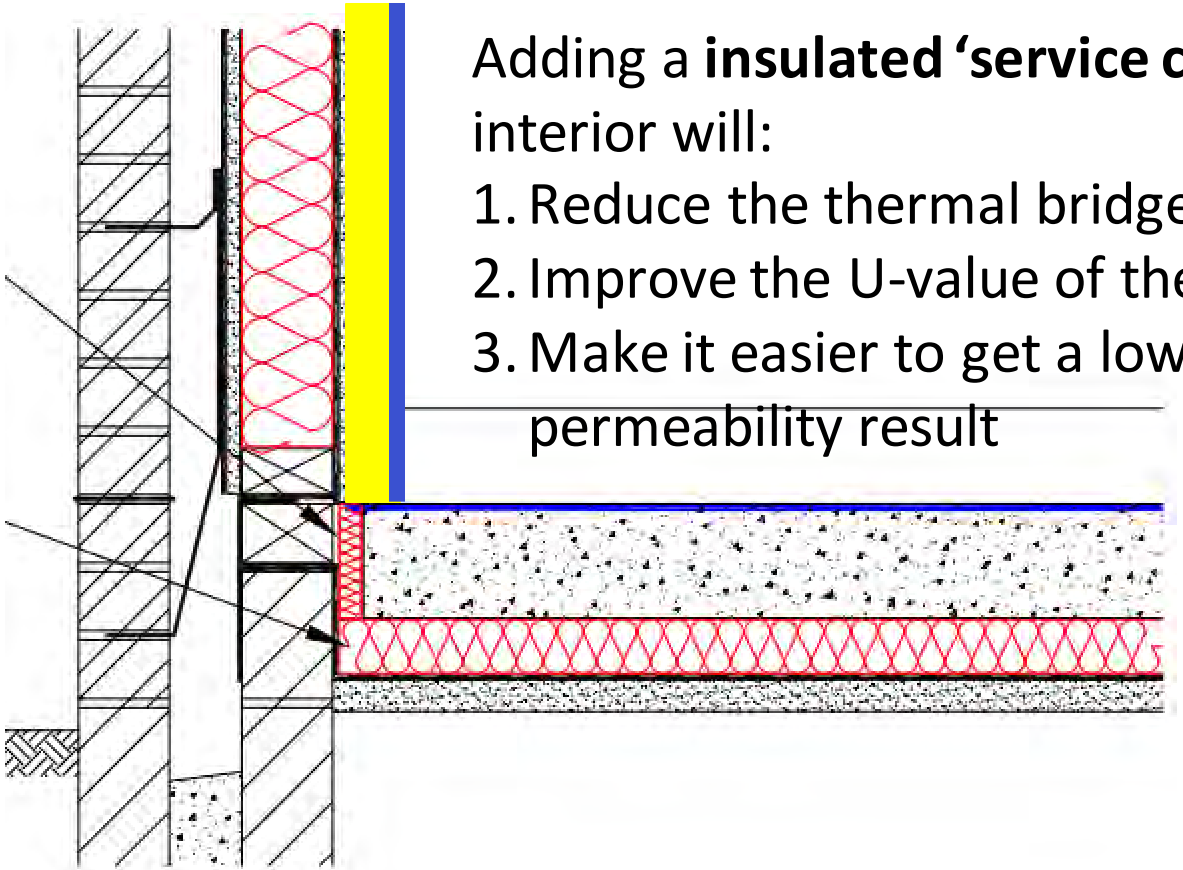
1. No insulation at the sole plate

Image Source: Department of housing, Ireland

Top - MosArt

How Can We Solve the Sole Plate Thermal Bridge?

Co-funded by the Erasmus+ Programme of the European Union



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

Image Source: Department of housing, Ireland

Case study - Cavity Wall: Concrete Forward Sill – Thermal Bridging – ACD's

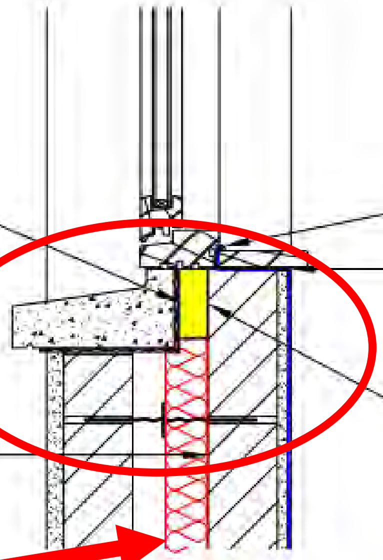
Co-funded by the Erasmus+ Programme of the European Union

(1) WALLS:- INSULATION IN CAVITY | Ope - Concrete Forward Sill | DETAIL 1.26, 2011

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

- ☐ Install proprietary cavity closer or block of insulation with path of minimum thermal resistance through the closer of not less than 2.90 m^2 K/W (manufacturers certified data)
- ☐ Ensure partial fill insulation is secured firmly against inner leaf of cavity wall



What do you think of this insulation thickness?

Way too thin!

AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

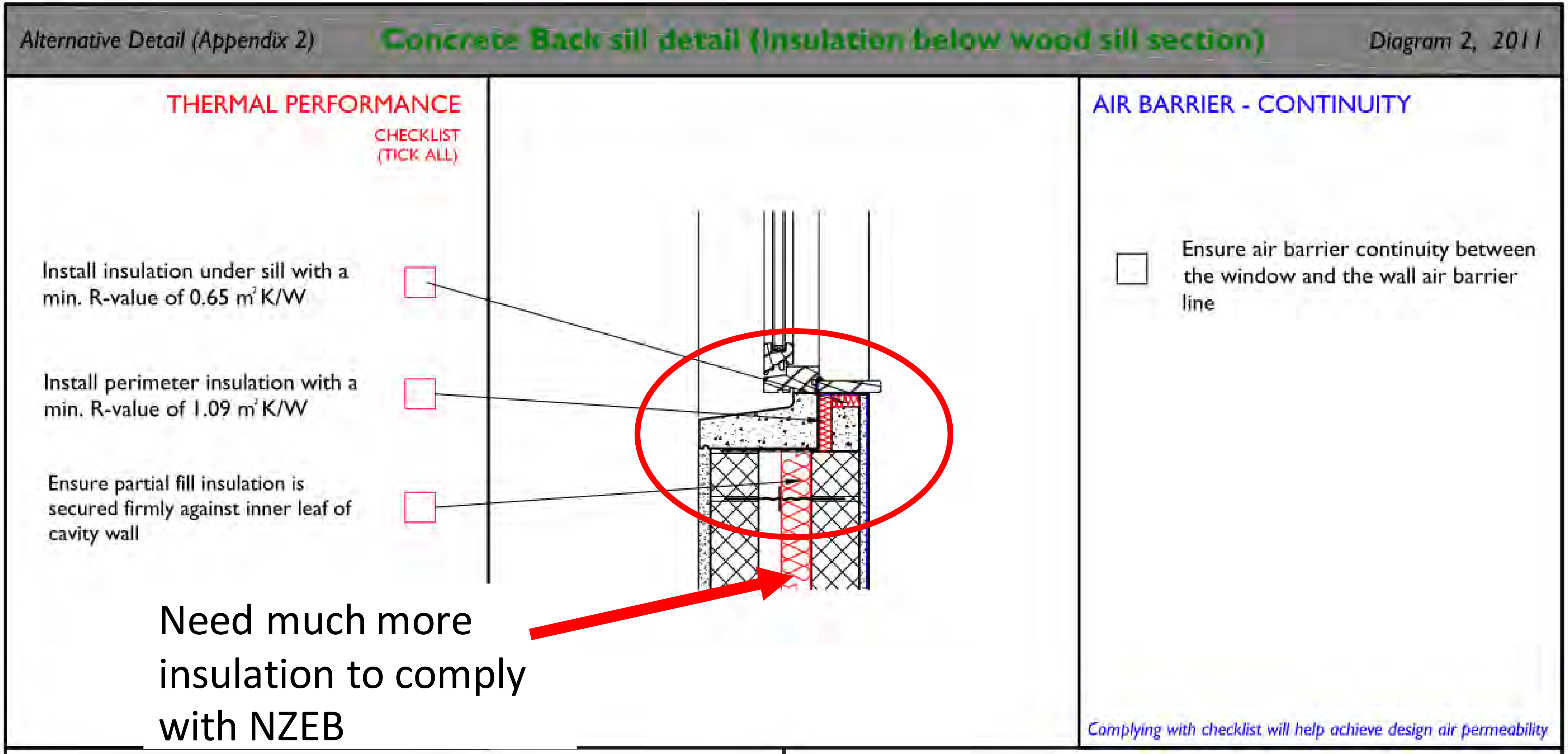
- ☐ Seal all penetrations through air barrier using a flexible sealant
- ☐ Apply flexible sealant to junctions between plaster/plasterboard and sill board, and between sill board and window frame
- ☐ Ensure air barrier continuity between the window and the wall air barrier line
- ☐ If forming the wall air barrier with a blockwork inner leaf or with scratch coat on blockwork, install a flexible sealant between the cavity closer and blockwork wall

Complying with checklist will help achieve design air permeability

Image Source: Department of housing, Ireland

Case Study - Cavity Wall: Concrete Back Sill – Thermal Bridging – ACD's

Co-funded by the Erasmus+ Programme of the European Union



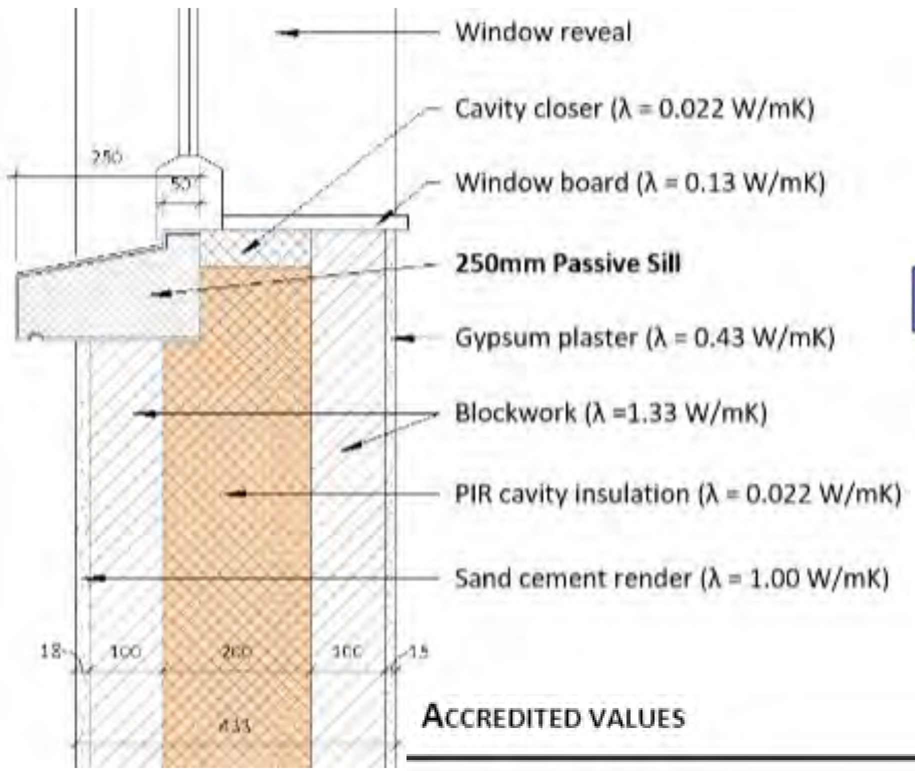
Need much more insulation to comply with NZEB

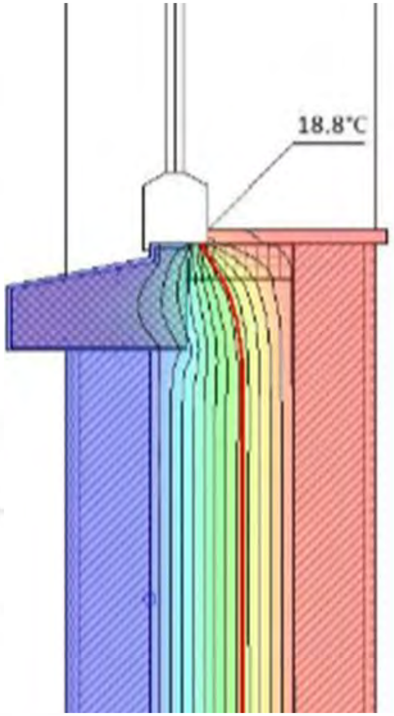
Image Source: Department of housing, Ireland

Full Fill Cavity Wall Insulation – Passive Window Sills

Co-funded by the Erasmus+ Programme of the European Union

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





ACCREDITED VALUES

	Ψ-value (W/mK)
Acceptable Construction Details	+0.019
Concrete Sill	+0.019
Passive Sills	+0.010

- 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

Case Study - External Wall Insulation - Window Sills – Thermal Bridging – ACD's

Co-funded by the Erasmus+ Programme of the European Union

(2) WALLS:- EXTERNAL INSULATION
SOLID MASONARY / CAVITY BLOCK WALLS

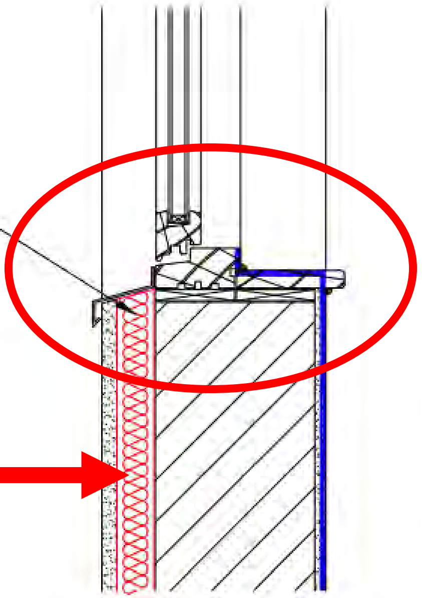
Ope - Sill

DETAIL 2.22, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- [ ] Install insulation to underside of sill



Need much more insulation to comply with NZEB

AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- [ ] Fill gap between frame / packer and blockwork with expanding foam or flexible sealant
- [ ] Seal all penetrations through air barrier using a flexible sealant
- [ ] Apply flexible sealant to junctions of frame with external render and with internal air barrier

Complying with checklist will help achieve design air permeability

Image Source: Department of housing, Ireland

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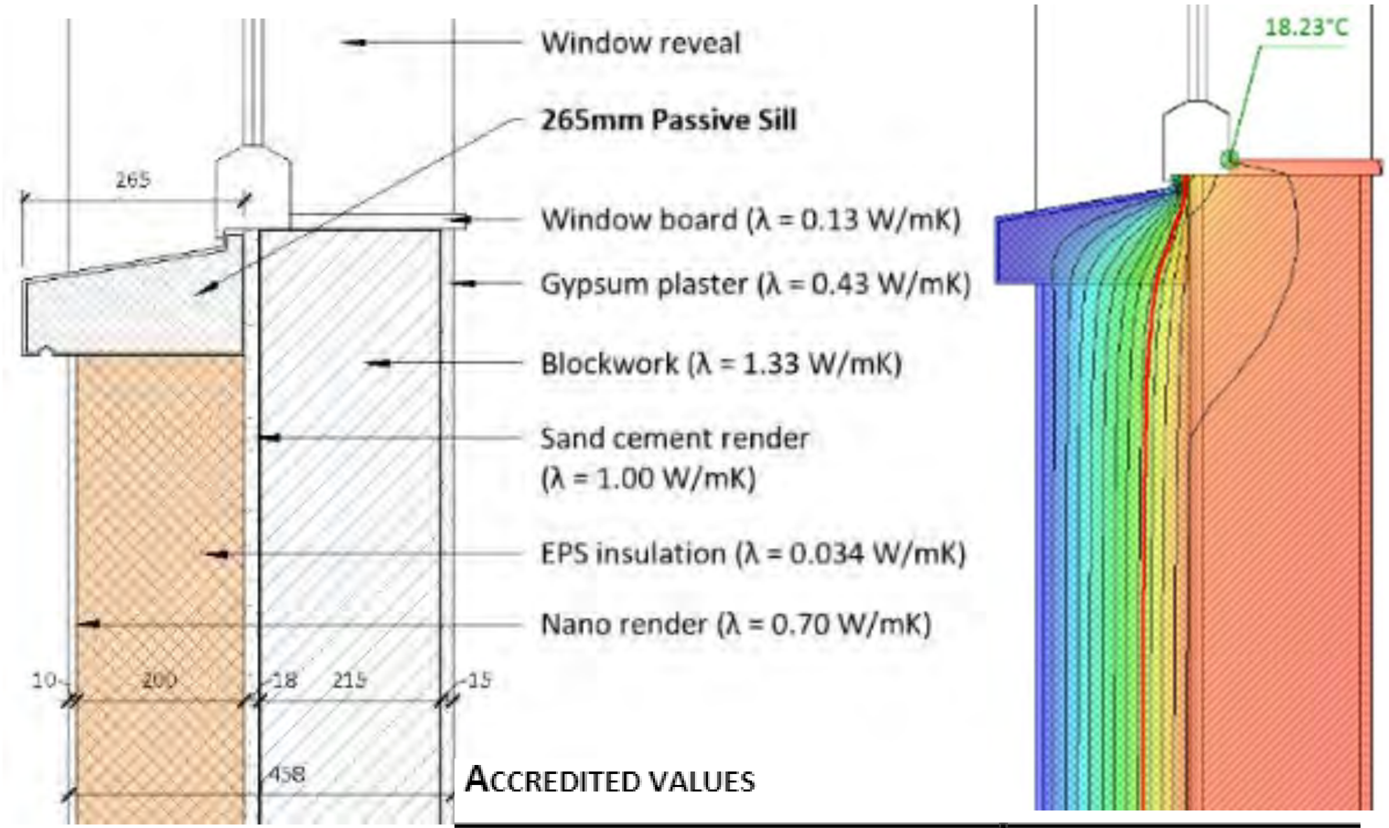
External Wall Insulation - Window Cills – Passive Sills

Co-funded by the Erasmus+ Programme of the European Union

200mm EWI with 265mm Passive Sill - Wall U-value – 0.16 W/m^2K



Accredited Values

	Ψ-value (W/mK)
Acceptable Construction Details	+0.109
Concrete Sill	-
Passive Sills	+0.110

Image Source: Passivesills

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Case Study - Internal Wall Insulation - Window Sills – Thermal Bridging – ACD's

Co-funded by the Erasmus+ Programme of the European Union

(6) WALLS:- INTERNAL INSULATION- CAVITY BLOCKS

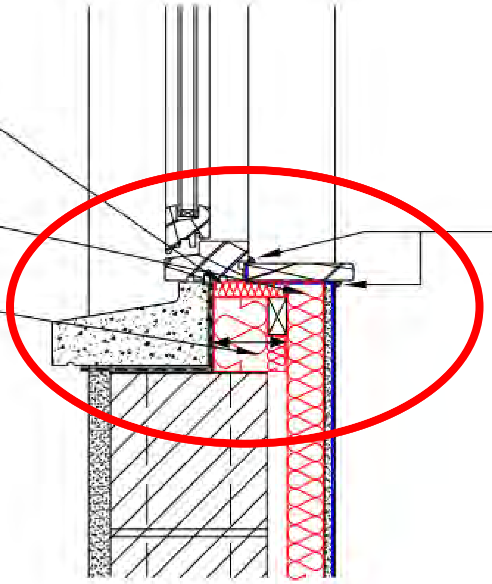
Ope - Sill

DETAIL 6.21, 2011

THERMAL PERFORMANCE

CHECKLIST (TICK ALL)

- ☐ Minimum R-value of 0.65 m^2 K/W for insulation under sill
- ☐ Ensure insulated dry-lining tightly abuts underside of windowboard
- ☐ Insulation to have a minimum R-value of 2.17 m K/W



AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

- ☐ Seal all penetrations through air barrier using approved adhesive tape or exible sealant
- ☐ Apply flexible sealent to interface between plasterboard and windowboard, and between windwboard and frame
- ☐ Form air barrier to wall with scratchcoat to blockwork
- ☐ Ensure air barrier continuity between window, and wall plasterboard

Complying with checklist will help achieve design air permeability and may effect a reduced testing regime.

Image Source: Department of housing, Ireland

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Case Study - Internal Wall Insulation - Window Cills – Thermal Bridging – ACD's

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(3) WALLS:- INTERNAL INSULATION

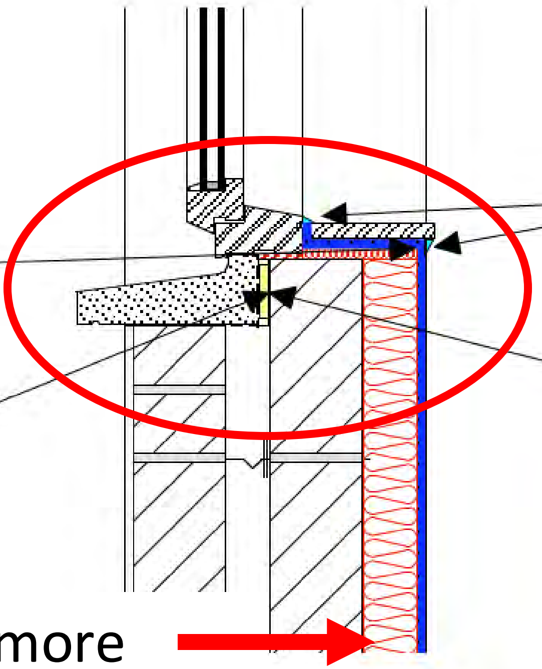
Ope - Concrete Forward Sill

DETAIL 3.24, 2011

THERMAL PERFORMANCE

CHECKLIST
(TICK ALL)

- ☐ Ensure insulated dry-lining tightly abuts underside of windowboard
- ☐ 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



Need much more insulation to comply with NZEB

AIR BARRIER - CONTINUITY

CHECKLIST
(TICK ALL)

- ☐ Seal all penetrations through air barrier using a flexible sealant
- ☐ Apply flexible sealant to interface between plasterboard and windowboard, and between windowboard and frame
- ☐ 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
- ☐ Ensure air barrier continuity between window, and wall plasterboard

Complying with checklist will help achieve design air permeability

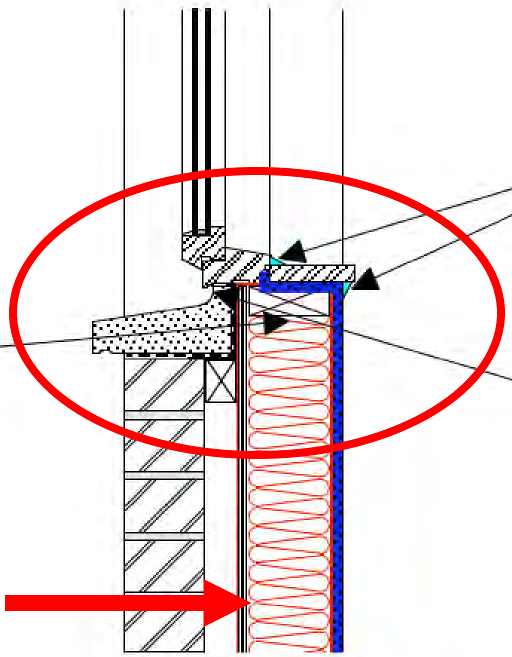
Case Study - Timber Frame - Window Sills – Thermal Bridging – ACD's

Co-funded by the Erasmus+ Programme of the European Union

(4) TIMBER FRAME | Ope - Sill | DETAIL 4.22, 2011

THERMAL PERFORMANCE
CHECKLIST
(TICK ALL)

- ☐ Ensure insulation brought tight to underside of cill plate



AIR BARRIER - CONTINUITY
CHECKLIST
(TICK ALL)

- ☐ Apply flexible sealant to junction between lining and windowboard, and between windowboard and frame
- ☐ Ensure air barrier continuity between wall linings and frame
- ☐ Apply external flexible seal around frame
- ☐ Seal all penetrations through air barrier using a flexible sealant or tape

Complying with checklist will help achieve design air permeability

Need more insulation to comply with NZEB

Image Source: Department of housing, Ireland

Timber Frame - Window Cills – Passive Sills

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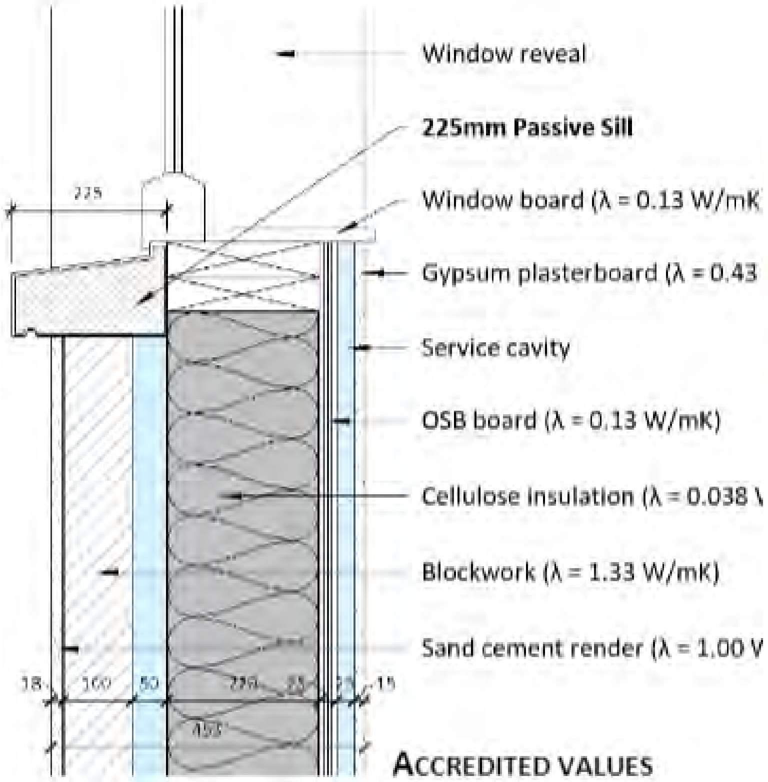
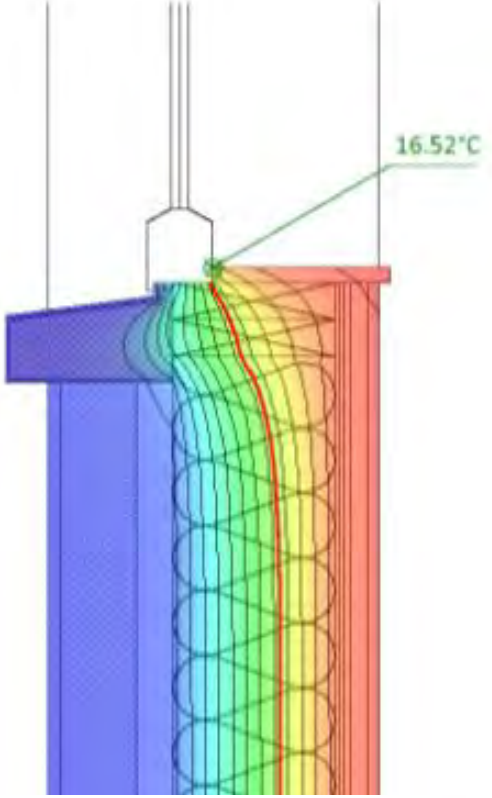
Timber Frame Wall with 225mm Passive Sill - Wall U-value – 0.14 W/m^{2}K





ACCREDITED VALUES

	Ψ-value (W/mK)
Acceptable Construction Details	+0.034
Concrete Sill	+0.078
Passive Sills	+0.051

Image Source: Passivesills

- 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

Case Study - Concrete & Steel Split Lintel – Thermal Bridging – ACD's

Co-funded by the Erasmus+ Programme of the European Union

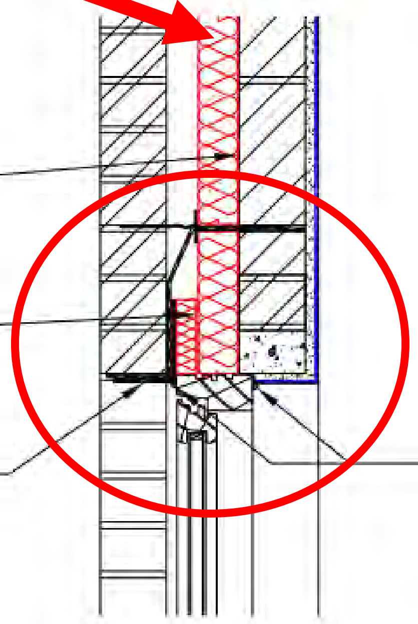
(1) WALLS:- INSULATION IN CAVITY | Ope - Split Lintels - Steel and Concrete | DETAIL 1.21, 2011

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

CHECKLIST
(TICK ALL)

☐ 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

Case study - Concrete Lintels – Thermal Bridging – ACD's

Co-funded by the Erasmus+ Programme of the European Union

(1) WALLS:- INSULATION IN CAVITY — Ope - Pre-stressed concrete lintels — DETAIL 1.23.1 + 1.23.2, 2011

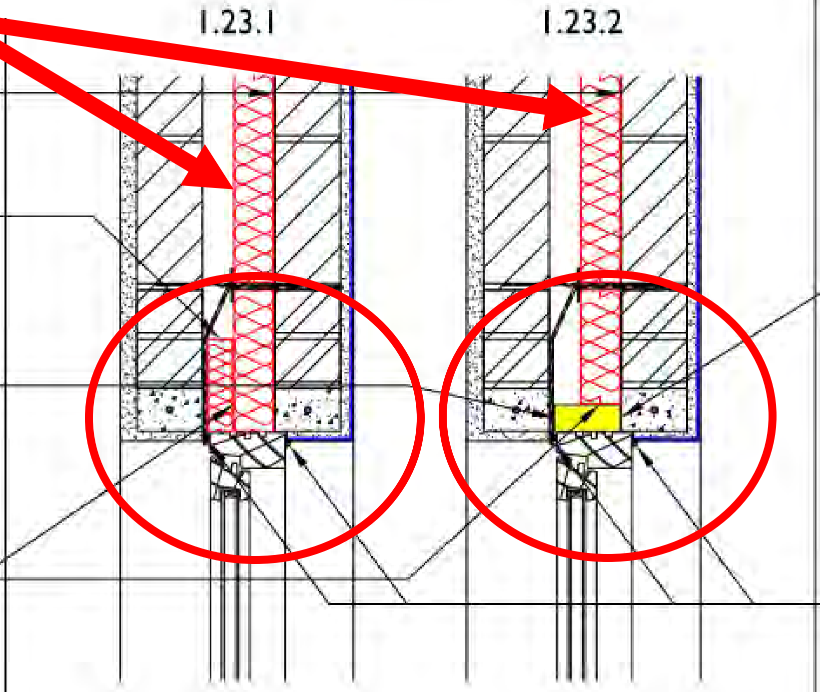
Need much more insulation to comply with NZEB

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

Image Source: Department of housing, Ireland

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Case study - Galvanised Steel Top Hat Lintels – Thermal Bridging – ACD’s

Co-funded by the Erasmus+ Programme of the European Union

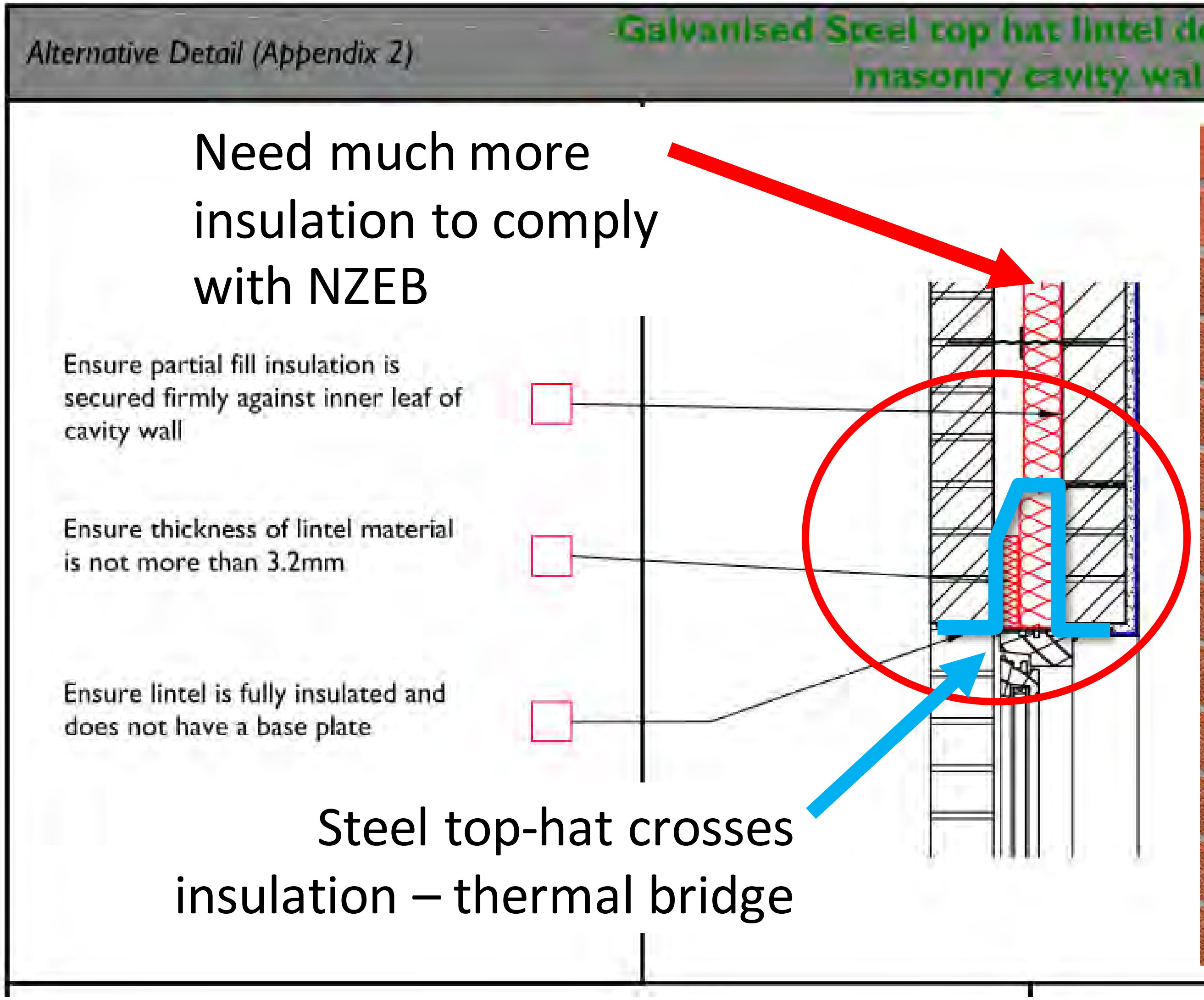


Image Sources: Left: Department of housing, Ireland, Right: IG Lintels

Case Study - Perforated Stainless Steel Lintel – Thermal Bridging – ACD's

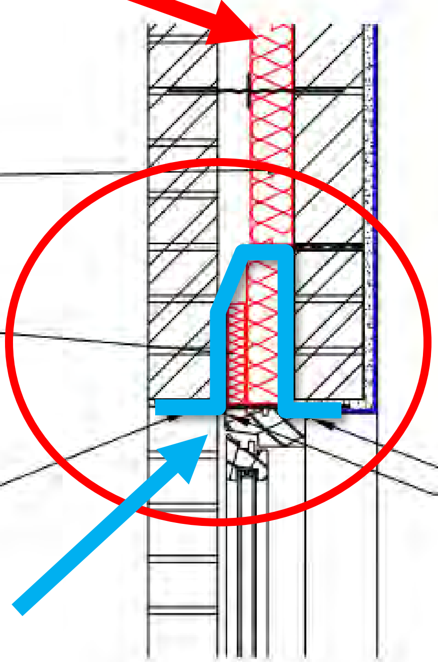
Co-funded by the Erasmus+ Programme of the European Union

(1) WALLS:- INSULATION IN CAVITY

Ope - Perforated Steel Lintel (Stainless Steel)

DETAIL 1.22, 2011

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

AIR BARRIER - CONTINUITY

CHECKLIST (TICK ALL)

☐ Seal all penetrations through air barrier using a flexible sealant

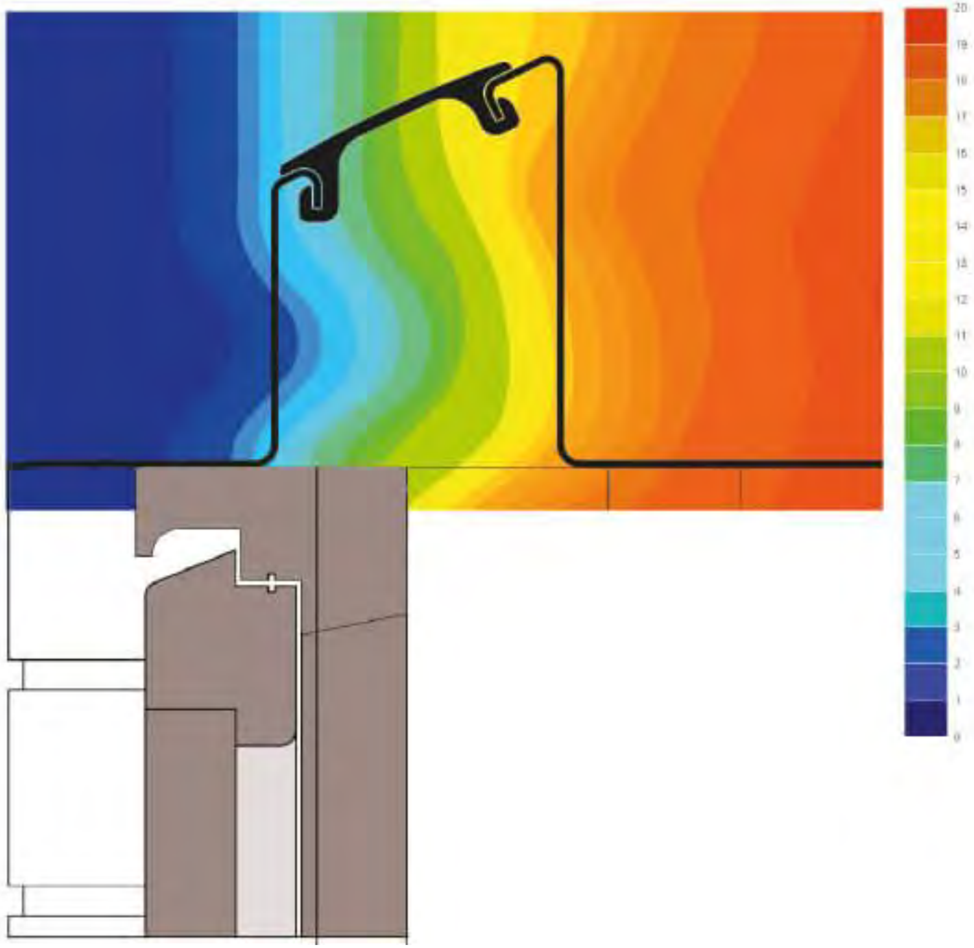
☐ Apply flexible sealant to all interfaces between internal air barrier and window / door frame members

Complying with checklist will help achieve design air permeability

Image Source: Department of housing, Ireland

GRP Hi-Therm Lintels– Thermal Bridging – ACD’s

Co-funded by the Erasmus+ Programme of the European Union



Hi-therm + Lintel = 80% improvement over the default or accredited lintel Psi-value

Image Source: Keystonelintels

Comparing Different Lintels – Thermal Bridging – ACD's

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Lintel Construction	Thermal Conductivity
Hi-therm+ Lintel	0.03 – 0.06 W/m.K
Standard Lintel	0.22 W/m.K
Default Non Plated Steel Lintel	0.33 W/m.K
Plated Steel Lintel	0.5 W/m.K

*Depending on wall construction.

Image Source: Keystonelintels

The Impact of the Thermal Bridge Factor in DEAP

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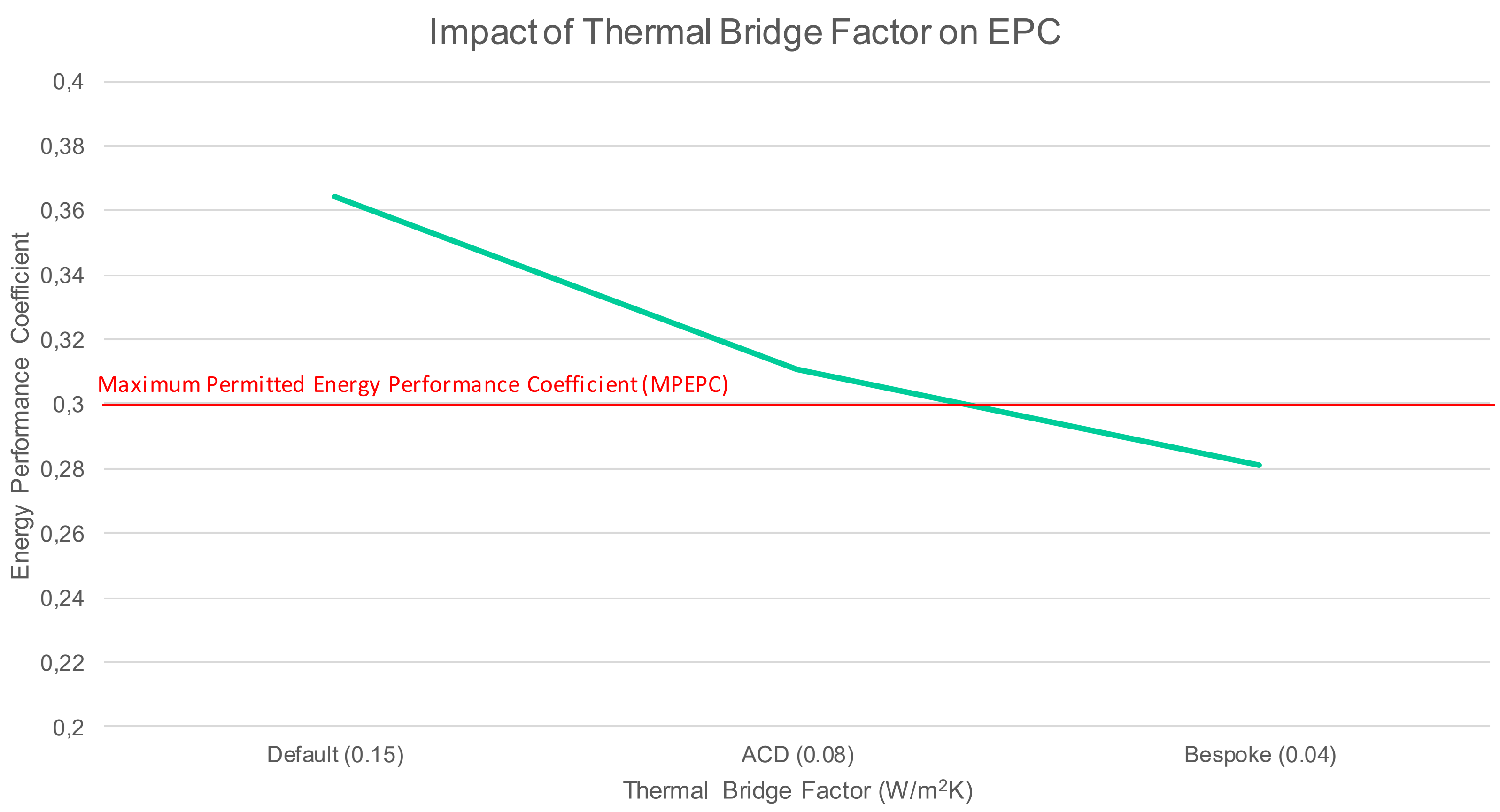

- The chart above shows how the thermal bridge factor impacts the energy performance coefficient of an NZEB dwelling.
- As you can see, only the bespoke thermal bridge factor is compliant with NZEB in this case.
- The dwelling used for this study is the 'Example A' dwelling presented by the Department of Housing, Planning and Local Govemment in Part L 2019.

Assessment

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QUIZ!

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Module 5

Building Fabric 2: Windows and Doors

Energy Efficiency for Construction

24 partners

12 countries

Date of Event

*Author/ **Institute***

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Building Fabric 2 | Summary

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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

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Building Fabric 2 | Objectives

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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.

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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

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3. Windows and Doors

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Reality Bites: Optimal Performance Spec for House

or heat pump

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

Element or system	Specifications
Windows and glazed doors	~~Double~~Triple glazed, low E (En = 0.05, soft coat) 20 mm gap, argon filled, PVC frames (U = ~~1.3~~ 0.9 W/m^2K, solar transmittance = 0.6)

Cost optimal windows for NZEB likely to require triple- glazing!

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

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Energy and Comfort Related Window Functions

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- 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

Image Source: Purchased by MosArt-WWETB (iStock 466205225)

High Performance Window Elements

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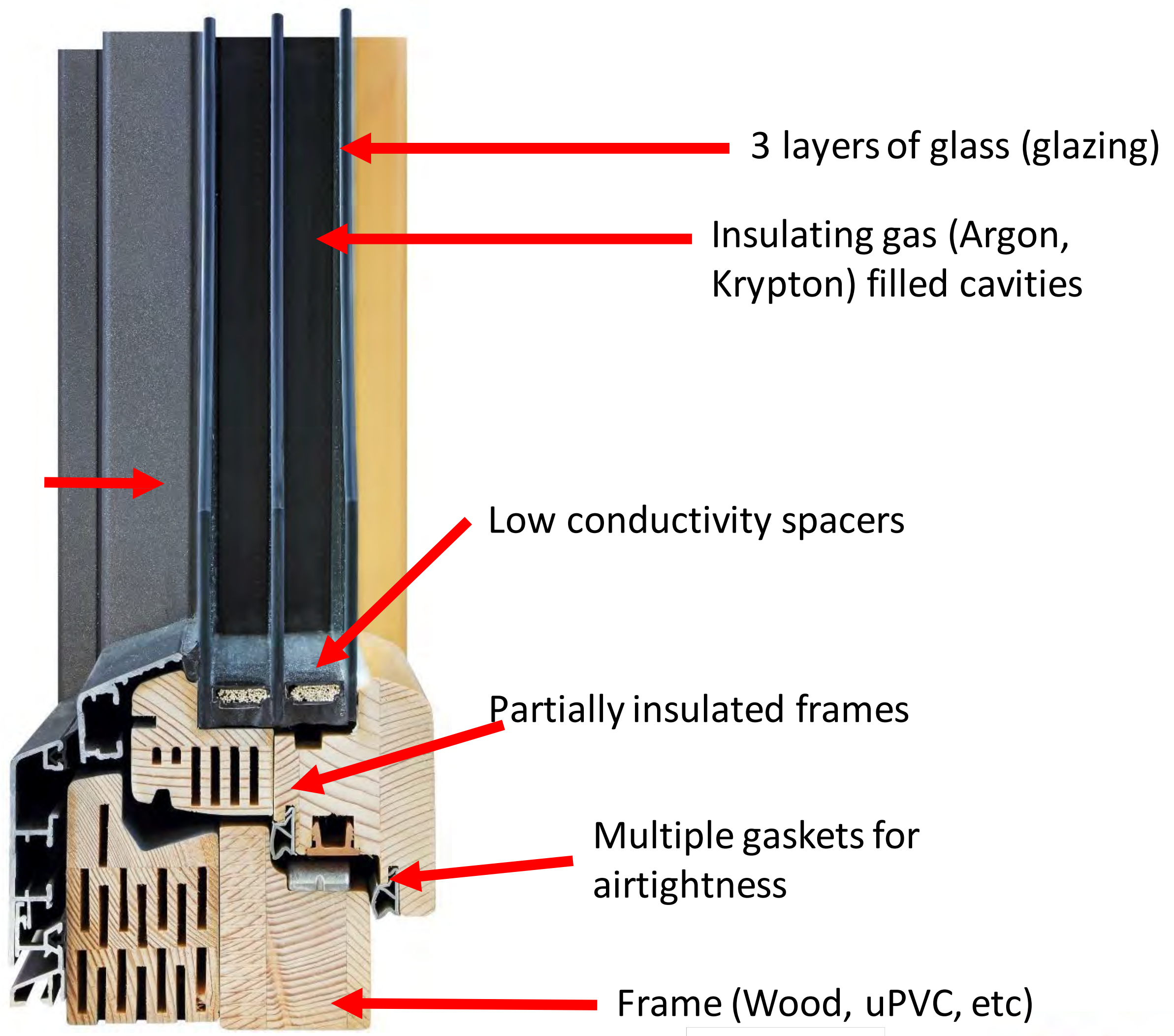

Image Source: Purchased by MosArt-WWETB (iStock 466205225)

High Performance Window Elements

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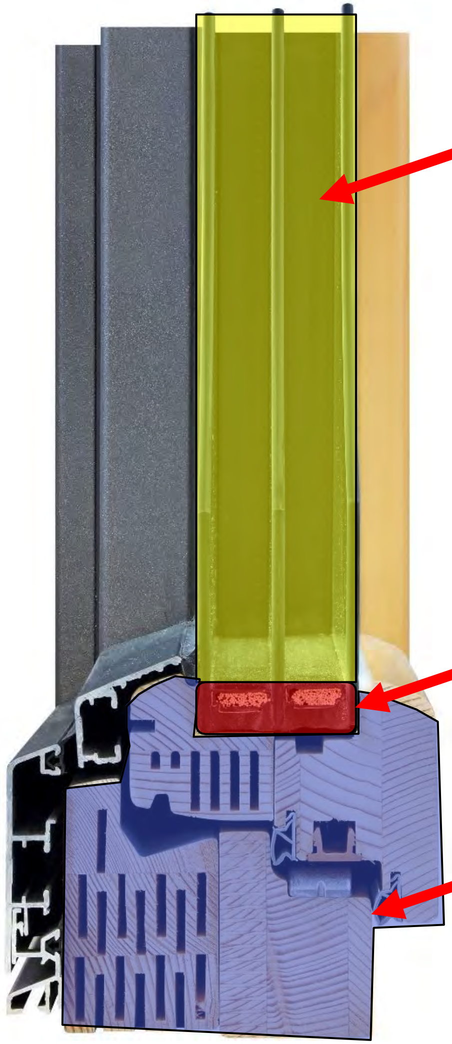

Insulated glass is typically best performing element

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?

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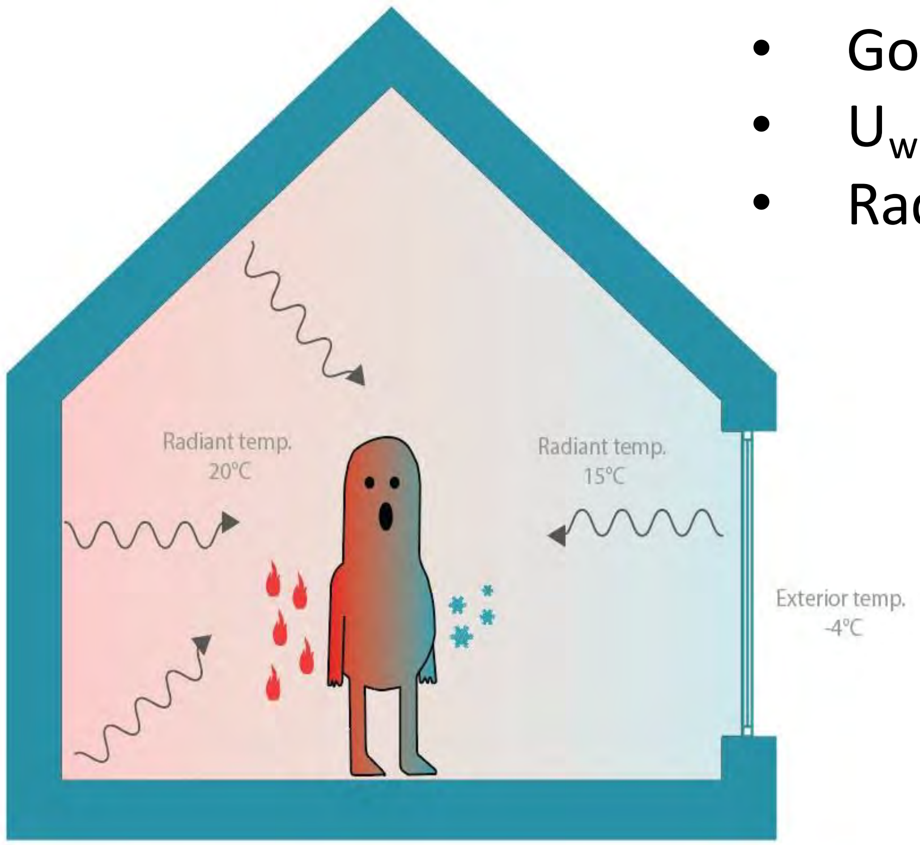
Image Source: MosArt

Effect of Cold Glass



- Good quality double-glazed window:
- U_w = 1.13 W/(m²·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

Image Source: MosArt

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Effect of Warm Glass

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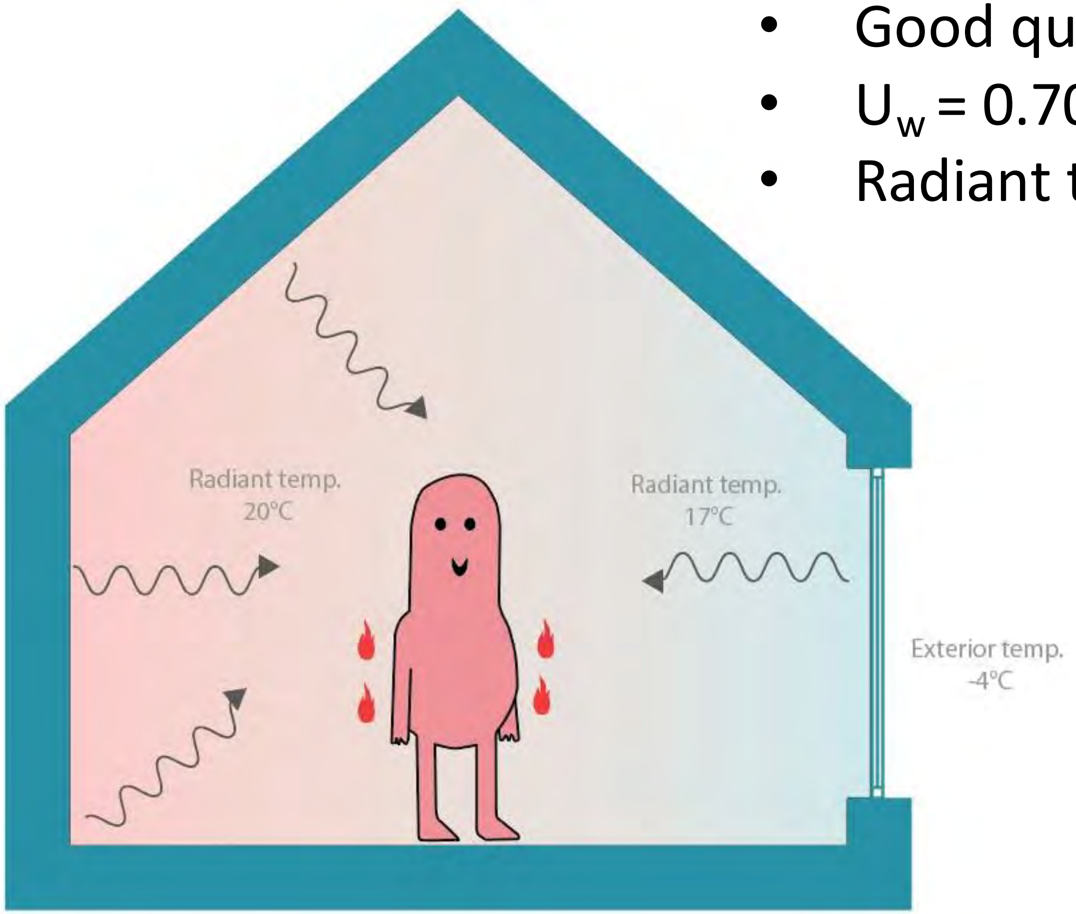

- Good quality triple-glazed window:
- U_w = 0.70 W/(m²·K)
- Radiant temperature difference: 3 C

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

Image Source: MosArt

Windows – Getting the Energy Balance Right

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Windows are the weakest part of the thermal envelope, but they also provide free solar gains – plus, you need to consider overheating risk!

Image Source: MosArt

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Solar Shading (South)

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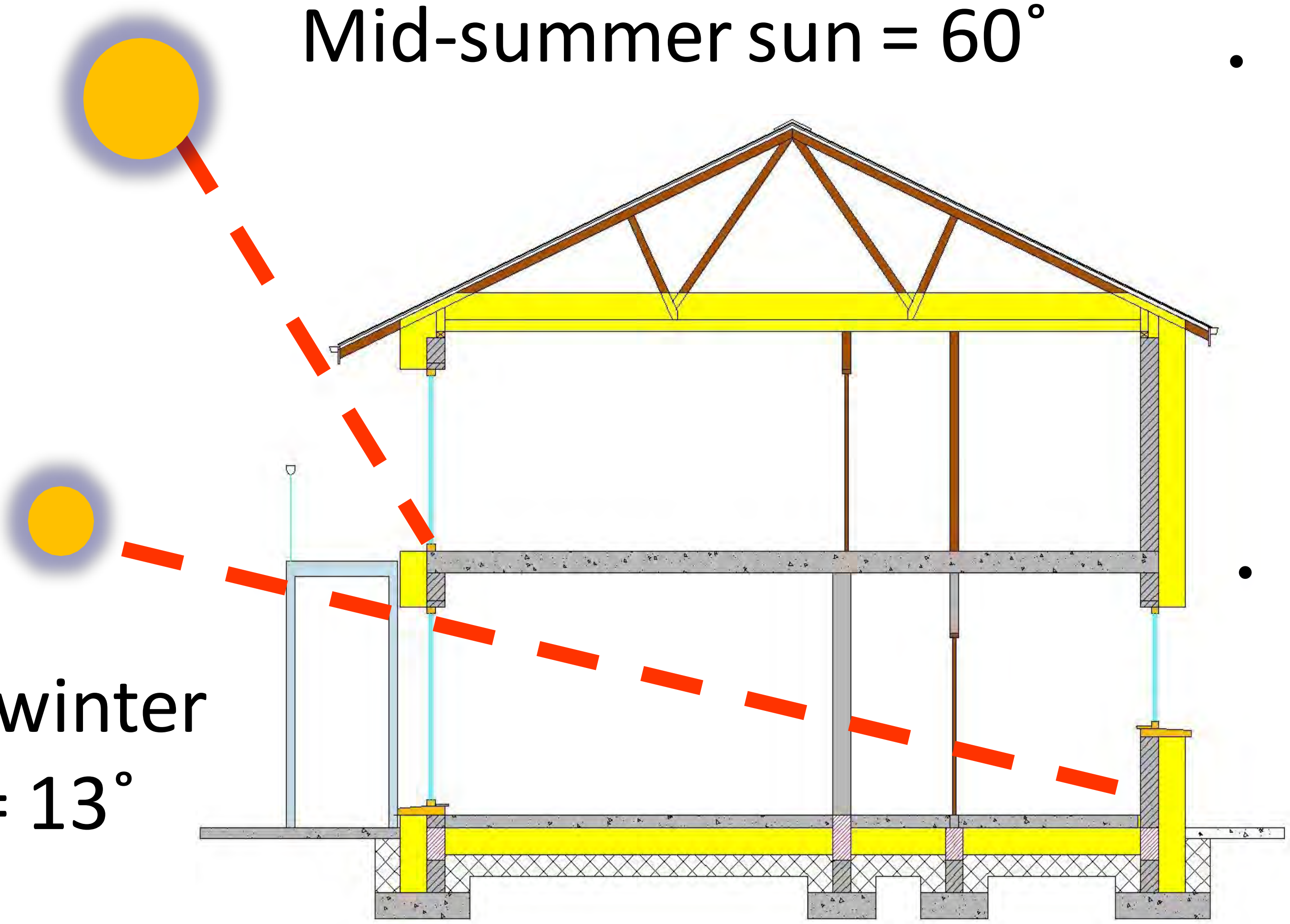

- Shading can also be provided with **deciduous trees** which are bare in winter and allow solar gains into the building

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

Image Source: MosArt

Best Practice for Placement of Windows

Co-funded by the Erasmus+ Programme of the European Union

- 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

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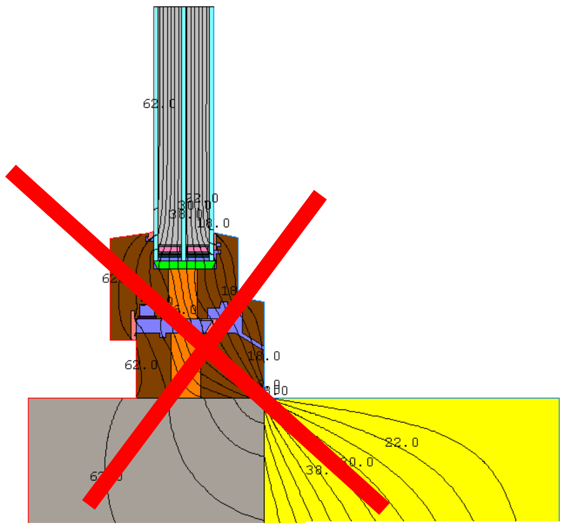
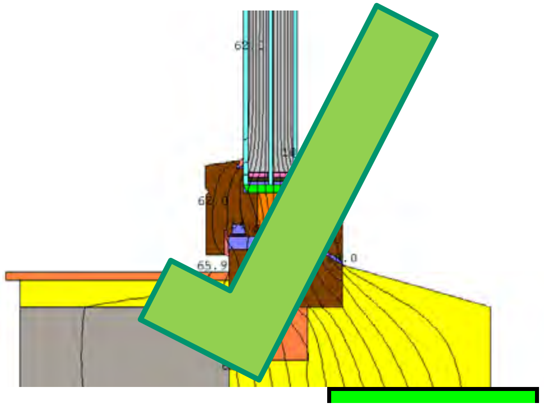
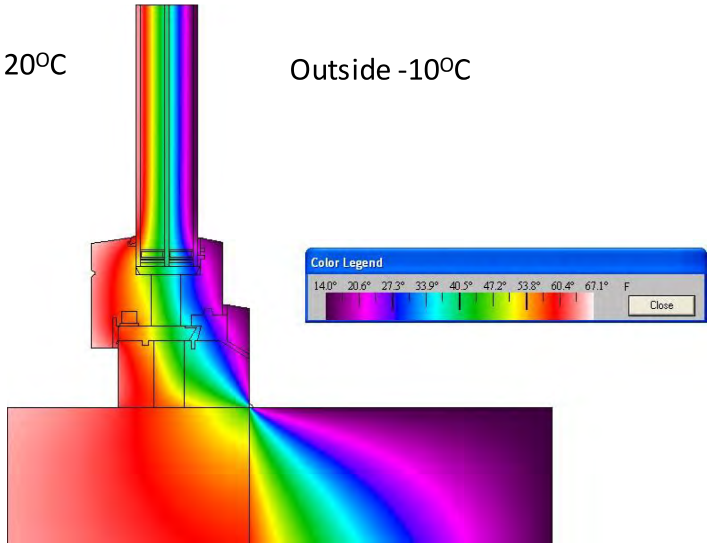


Ψ_e (for PHPP) 0.187 W/mK



Ψ_e (for PHPP) 0.01 W/mK

Inside 20ºC Outside -10ºC



Inside 20ºC Outside -10ºC

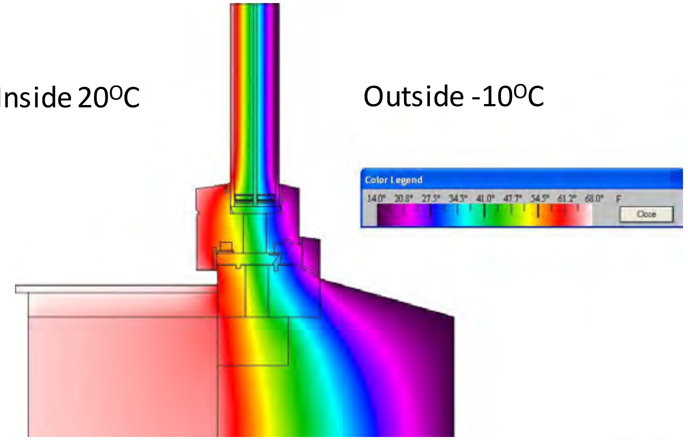


Image Source: MosArt

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EWI – External Wall Insulation

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Insulation placed externally on masonry buildings dramatically reduces thermal bridging

Image Source: MosArt

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Windows Supported in EWI by Compacfoam

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Structural insulation that can be bolted to masonry to support windows and doors

Image Source: MosArt

External Wall Insulation using PIR

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Window first supported by Compacfoam insulation, then surrounded by external wall insulation

Image Source: MosArt

Window Installation in Cavity Wall

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Image Source: MosArt

Non –Metal Flashing: Pro Clima Extoseal

Image Source: Foursevenfive

Metal Exterior Sill Pans

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Image Source: MosArt

Assessment

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Thank You

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