An investigation into the ultimate retrofit solution for a typical 1990s detached dwelling in Ireland

TU 831 BSc (Hons) Architectural Technology
TDS_T6 Part 2_ Final Presentation

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DUBLIN
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An investigation into the ultimate retrofit solution for a typical 1990s detached dwelling in Ireland

Tim Nolan
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Background

Aim

To investigate the ultimate retrofit solution for a detached dwelling in Ireland.
This is done by comparing external and internal insulation. The wall will be focused on as 35% of the heat loss is though the walls according to The Greenage.

Motivation

As sustainability becomes more of an issue in today's world, insulation retrofitting is so important to reduce energy usage in the home. According to the SEAI, "a quarter of all Ireland's energy use is directly by homes." (SEAI,2021).In this case specifically heating use is addressed by way of insulation retrofitting.

Objectives

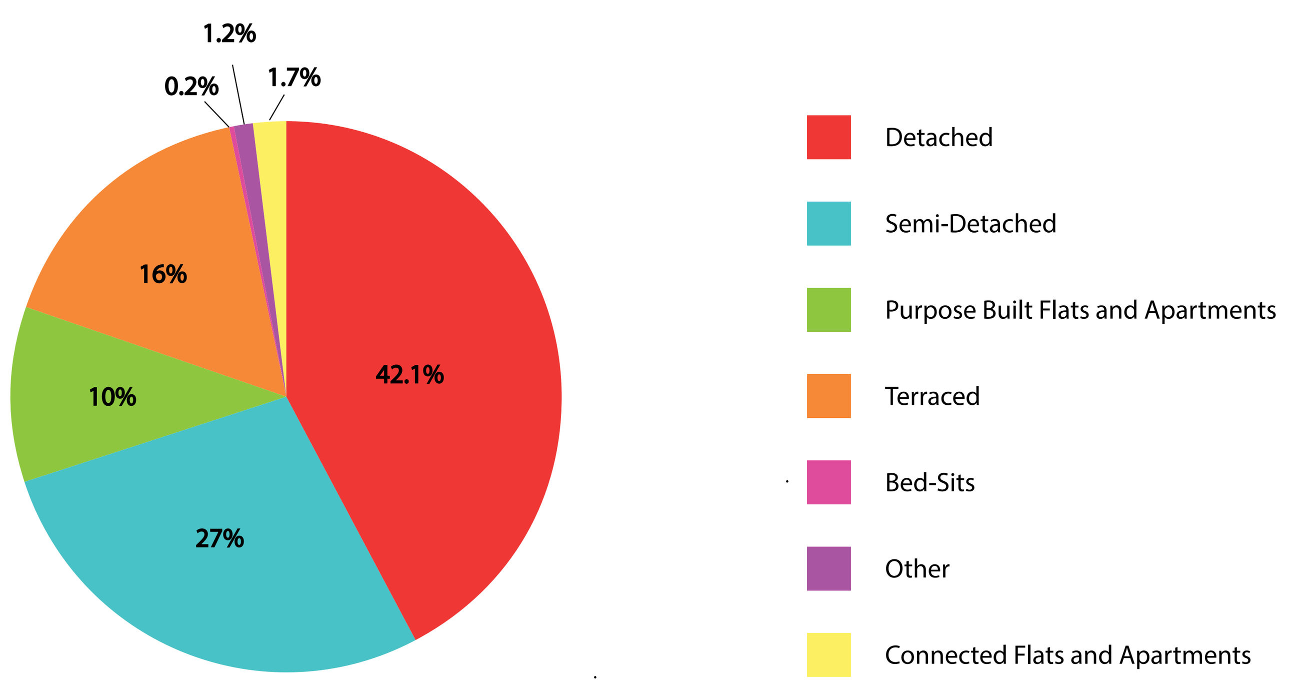
1) Understand the performance criteria that is being attempted to being achieved.
2) Examine the types of insulation.
3) Investigate the insulation systems.
4) Seek the ultimate solution.

Methodology

1) Examine the building and measure the U-Values of the walls.
2) Research and assess different insulation types and materials.
3) Research and assess different insulation systems.
4) Create details and use Trisco to identify thermally which system is better.

House Type

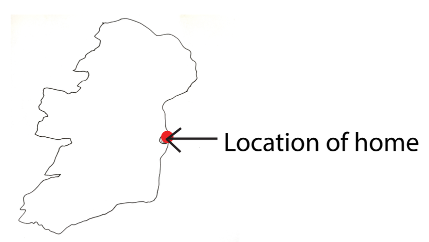
The detached home is chosen as the case study for this thesis as it is the most common house type in Ireland with 42.1% of the housing stock in Ireland being detached homes.
6.56% of all the housing stock in Ireland are detached homes built between 1991 and 2000 whilst 15.58% of all detached houses are built between 1991 and 2000.



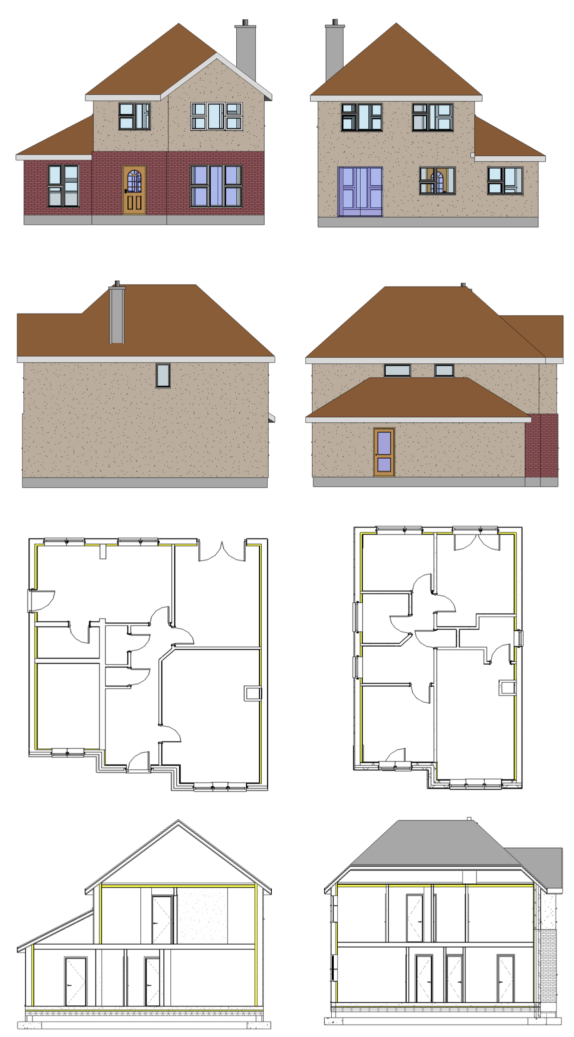
Most Common House Types in Ireland according to the 2016 CSO Census

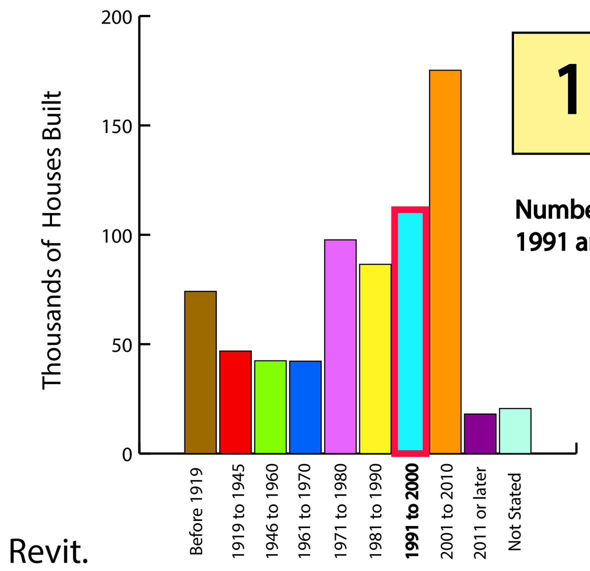
Site Location

Map of Ireland



Elevations, plans and sections of case study house in Revit.





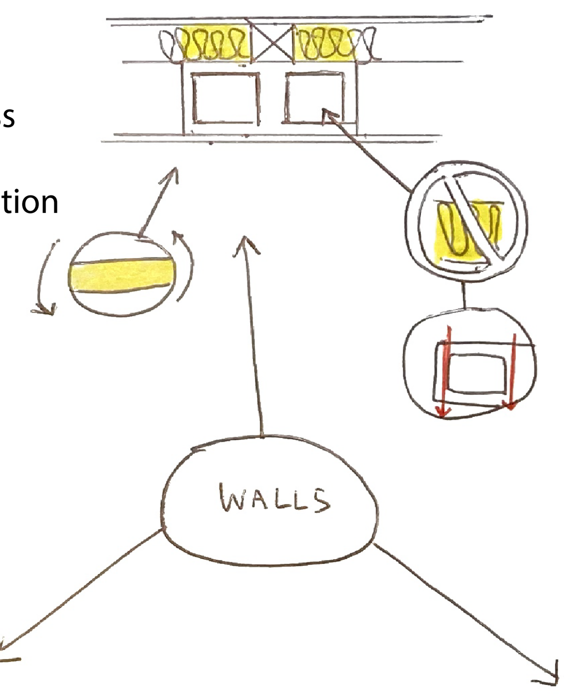
Detached Houses Built in Ireland by Period

111,455

Number of Houses Built between 1991 and 2000.

Wall Types

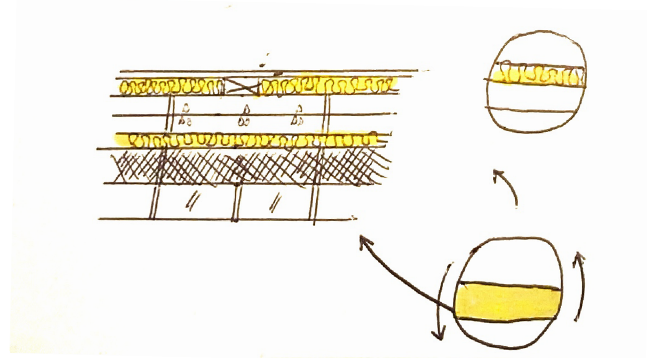
Hollow Block Dry-Lined Wall



Thermal Bypass
with
External Insulation

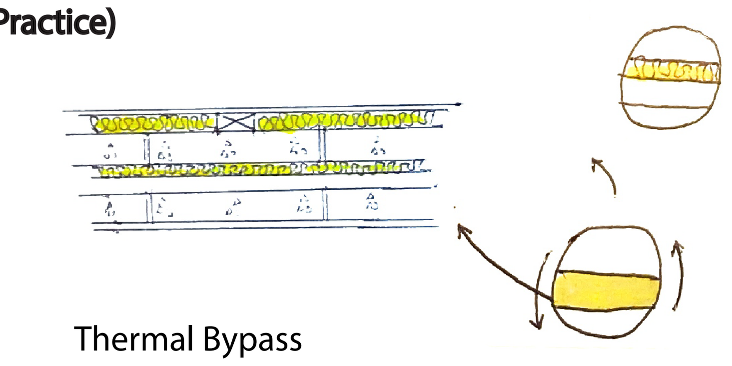
Thermal Bridging
due to
Insulating the Hollows
of the Block
Occurs at ends of block

Cavity Wall Dry-Lined with Brick - Type 3B (From S.R. 54: 2014 Code of Practice)
Type 3B - Partial Filled Cavity which can be filled using a certified system



Thermal Bypass
with
External Insulation
unless cavity
Fully-Filled

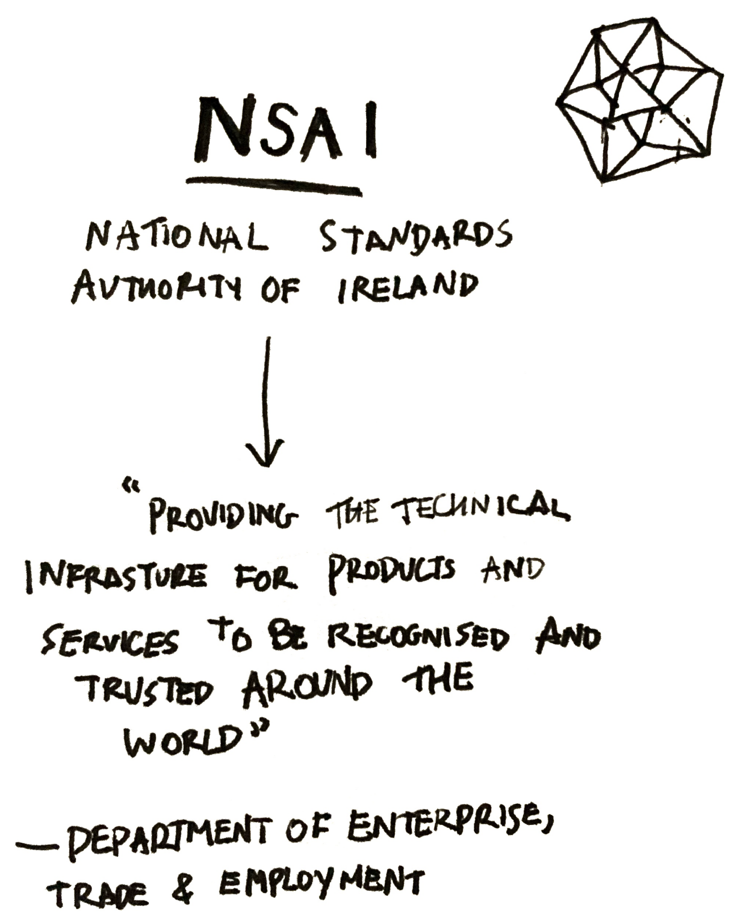
Cavity Wall Dry-lined with Render - Type 3B (From S.R. 54: 2014 Code of Practice)

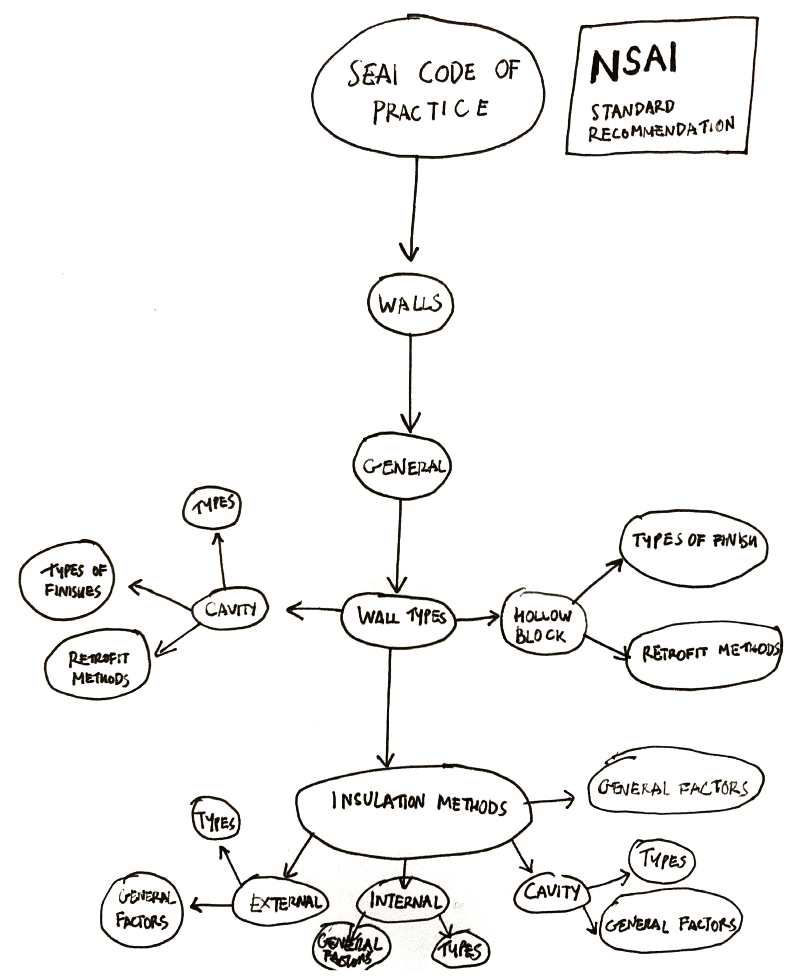


Thermal Bypass
with
External Insulation
unless cavity
Fully-Filled

S.R. 54: 2014 Code of Practice

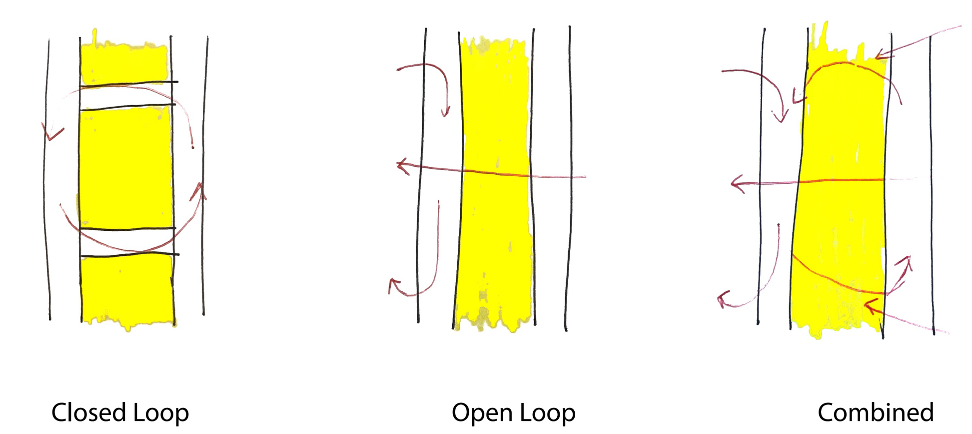
This is a code of practice for how to retrofit dwellings in Ireland from an energy efficiency point of view. The standards were brought in by the National Standards Authority Ireland (NSAI) . There are many sections in this document ranging from the building envelope to the building services. The S.R. 54 2014 Code of Practice is based on the most recent standards and regulations. These standards are supported by the Technical Guidance Documents (TGDs). Other approaches can be taken than what is described as long as the equivalent performance is met. The area that will be focused on for the thesis is the wall. The original document was published by the Sustainable Energy Authority Ireland (SEAI) in 2014 with amendments made in 2022. This document serves as the ideal to tool to help retrofit the chosen 1990s detached rish home.





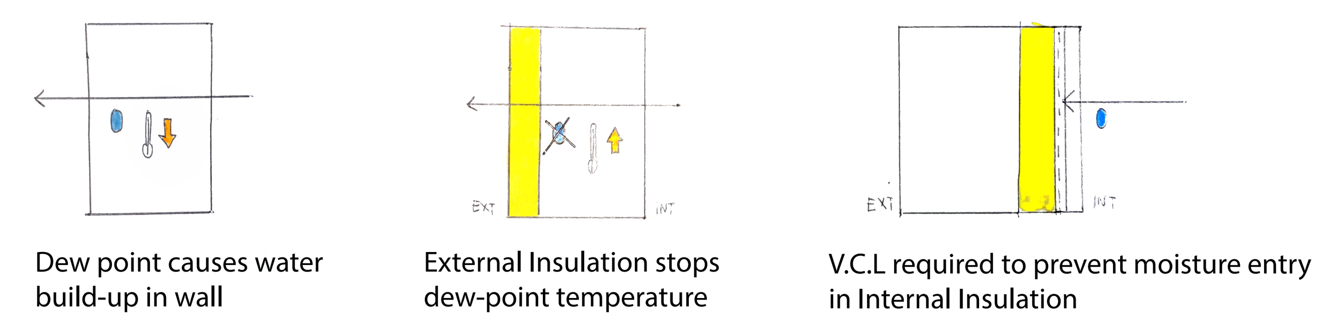
Thermal Bypassing

Thermal bypassing is air movement through or around the insulation affecting the thermal performance of the insulation. This happens because of conduction, airtightness and windwashing. Ensuring the building is airtight and wind tight is very important to prevent thermal bypassing. Failures in both design and workmanship cause these issues. Thermal bypassing can result in condensation which results in mould growth. (Greenspec, n.d) Careful and quality installation on-site is important.



Types of Thermal Bypassing

Interstitial Condensation



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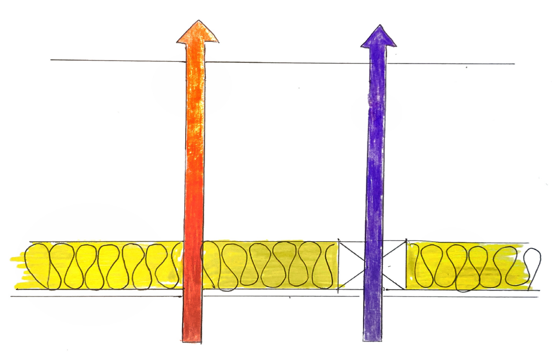
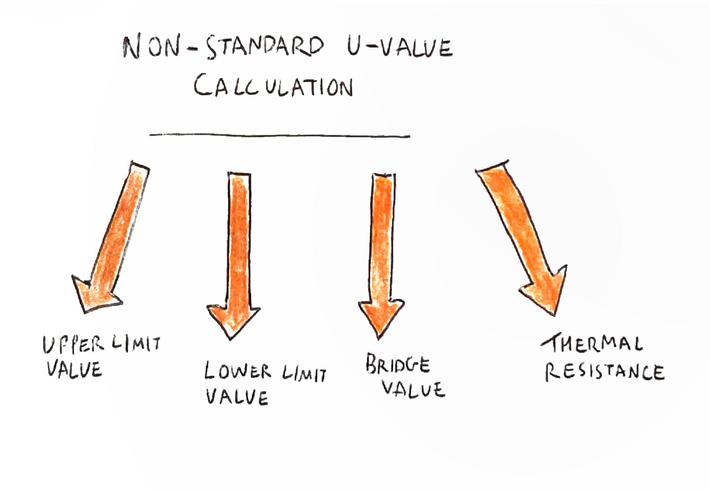
U-Value Upper and Lower Limit

When calculating U-Values, Upper and Lower Limit Calculations are used when the wall is non standard (for instance where there is a timber stud).
Using pathways, an upper and lower limit are calculated along with a bridge value and an average is found which is the U-Value of the wall.



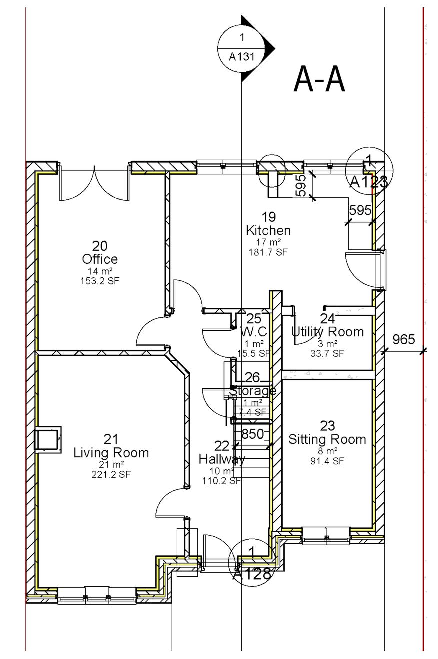


Existing U-Values

0.45W/M2k

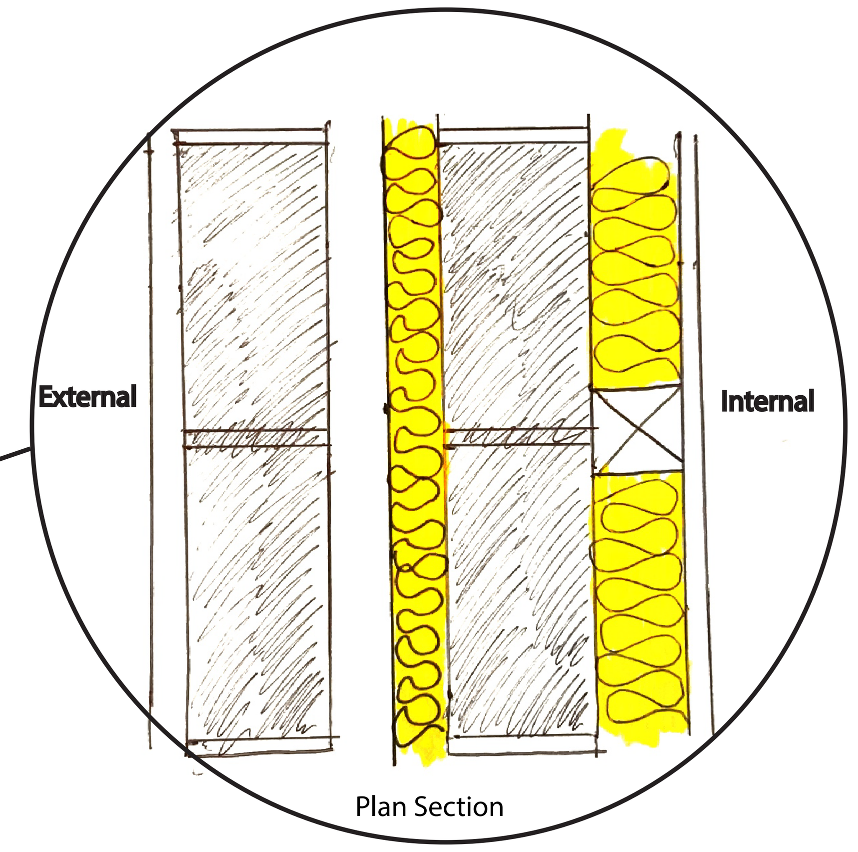
The maximum permitted U-Value in the 1991 Building Regulations.

The U-Values that apply to the 1997 home in question are from the Building Regulations from 1991. The Maximum permitted U-Value for the wall is 0.45 W/M2K.
These are the the regulatory requirements for a home built at this time.
Two sections are taken of the existing typical 1990s detached dwelling without any insulation retrofit to the walls.
There are 3 wall types of wall in this dwelling which are contained in the sections. The U-Values are taken of each.
Firstly, we must check if the 1991 Building Regulations U-Values are being complied with.



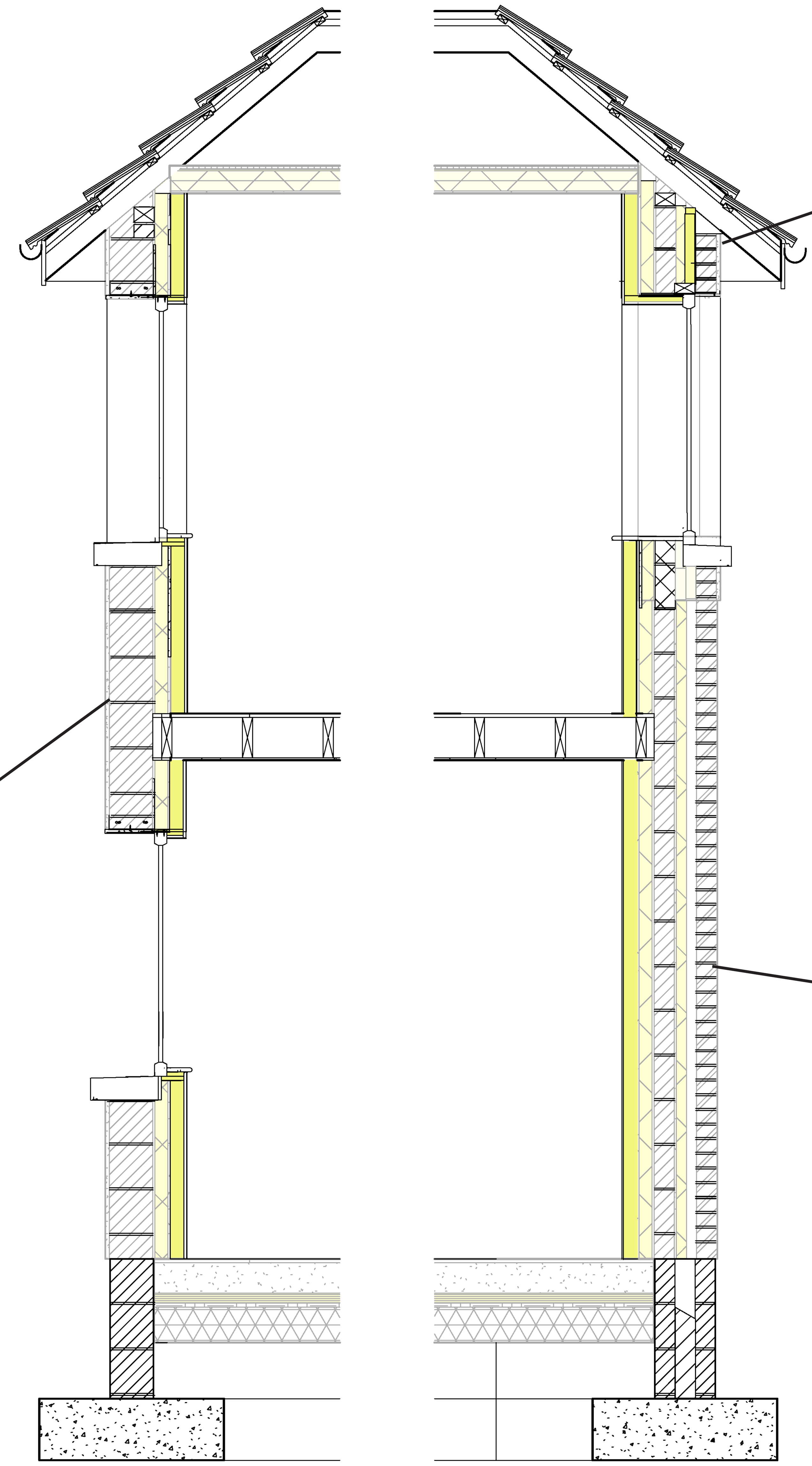
Ground Floor

Cavity Wall Dry-Lined with Render



External
20mm Render
100mm Solid Concrete Block
50mm Cavity
50mm Fibreglass Insulation
100mm Solid Concrete Block
65mm Mineral Wool Insulation with 100x65mm Timber Battens at 450mm Centres
12.5mm Plasterboard
Internal

Existing U-Value
Wall = 0.27 W/M2K
This meets the required U-Value of 1991.

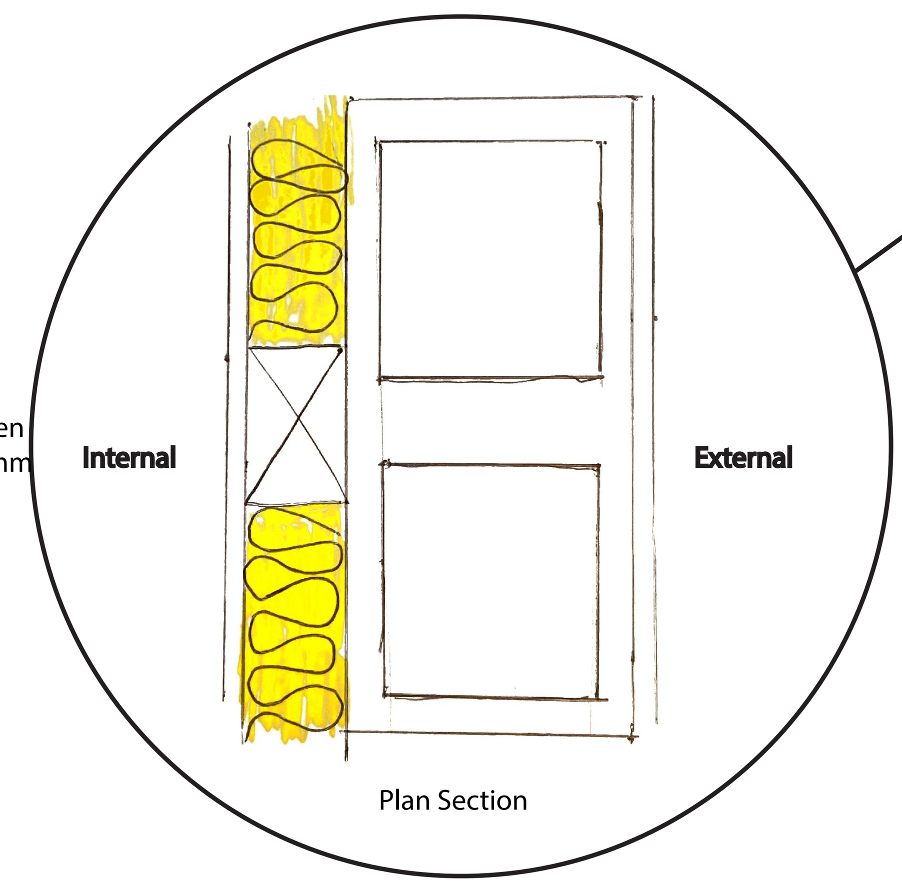


Section A-A

1:20 Detail Section Front Facade

1:20 Detail Section Rear Facade

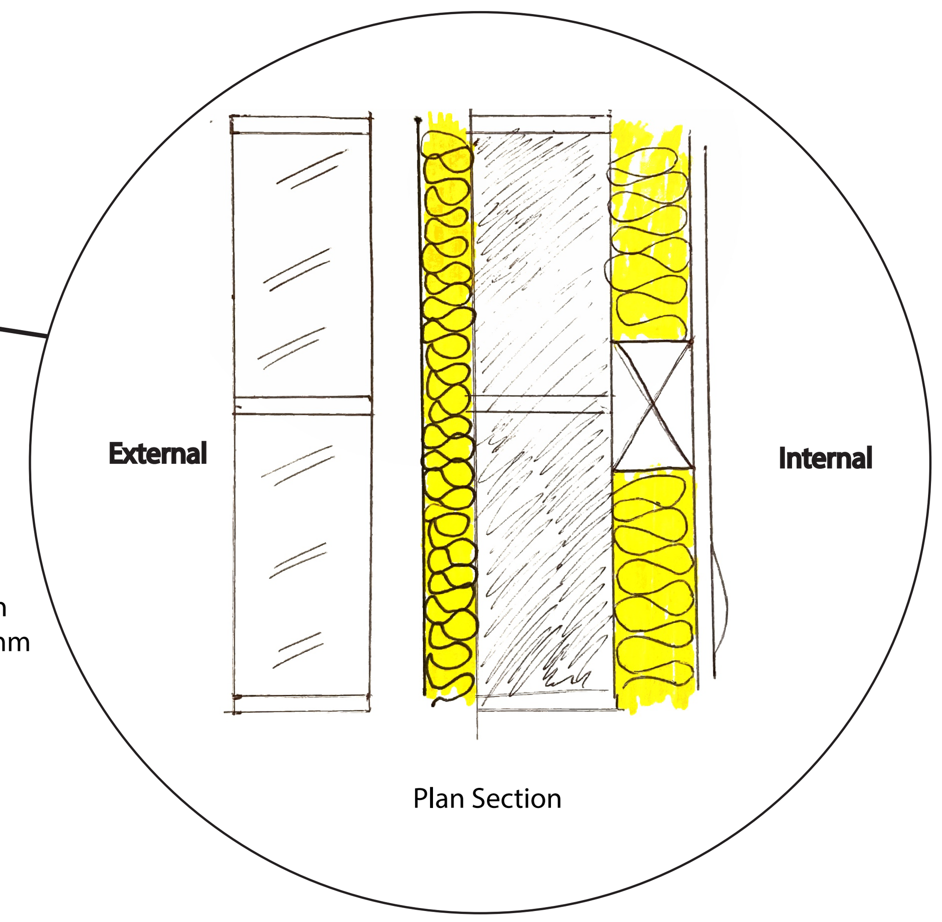
Hollow Block Dry-Lined Wall



External
20mm Render
215mm Concrete Hollow Block
65mm Fibreglass Insulation between 100x65mm Timber Battens at 500mm Centres
12.5mm Plasterboard
Internal

Existing U-Value
Wall = 0.51W/M2K
This dosen't meet the required U-Value of 1991.

Cavity Wall Dry-Lined with Brick



External
102.5mm Brick
50mm Cavity
50mm Fibreglass Insulation
100mm Solid Concrete Block
65mm Mineral Wool Insulation with 100x65mm Timber Battens at 450mm Centres
12.5mm Plasterboard
Internal

Existing U-Value
Wall = 0.28 W/M2K
This meets the required U-Value of 1991.

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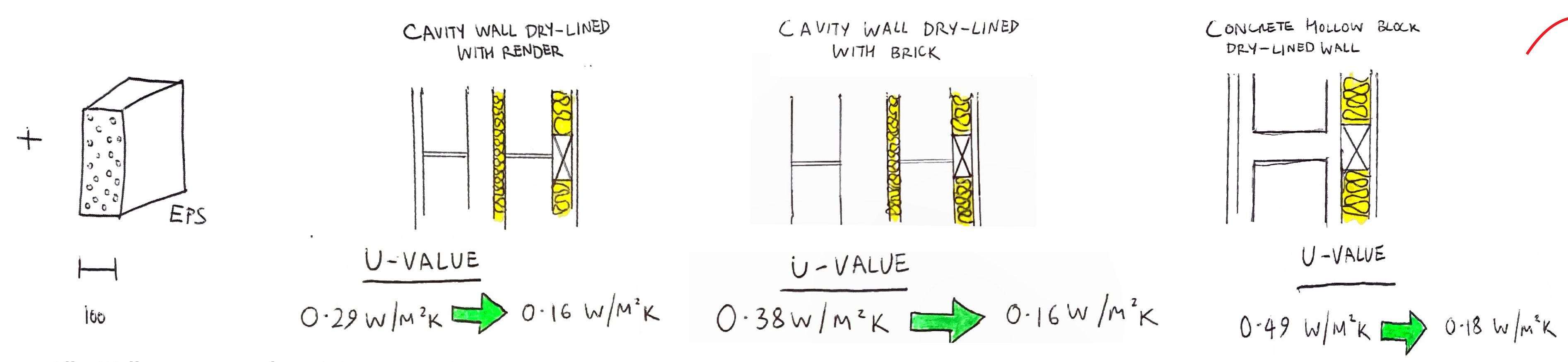
Proposed U-Values

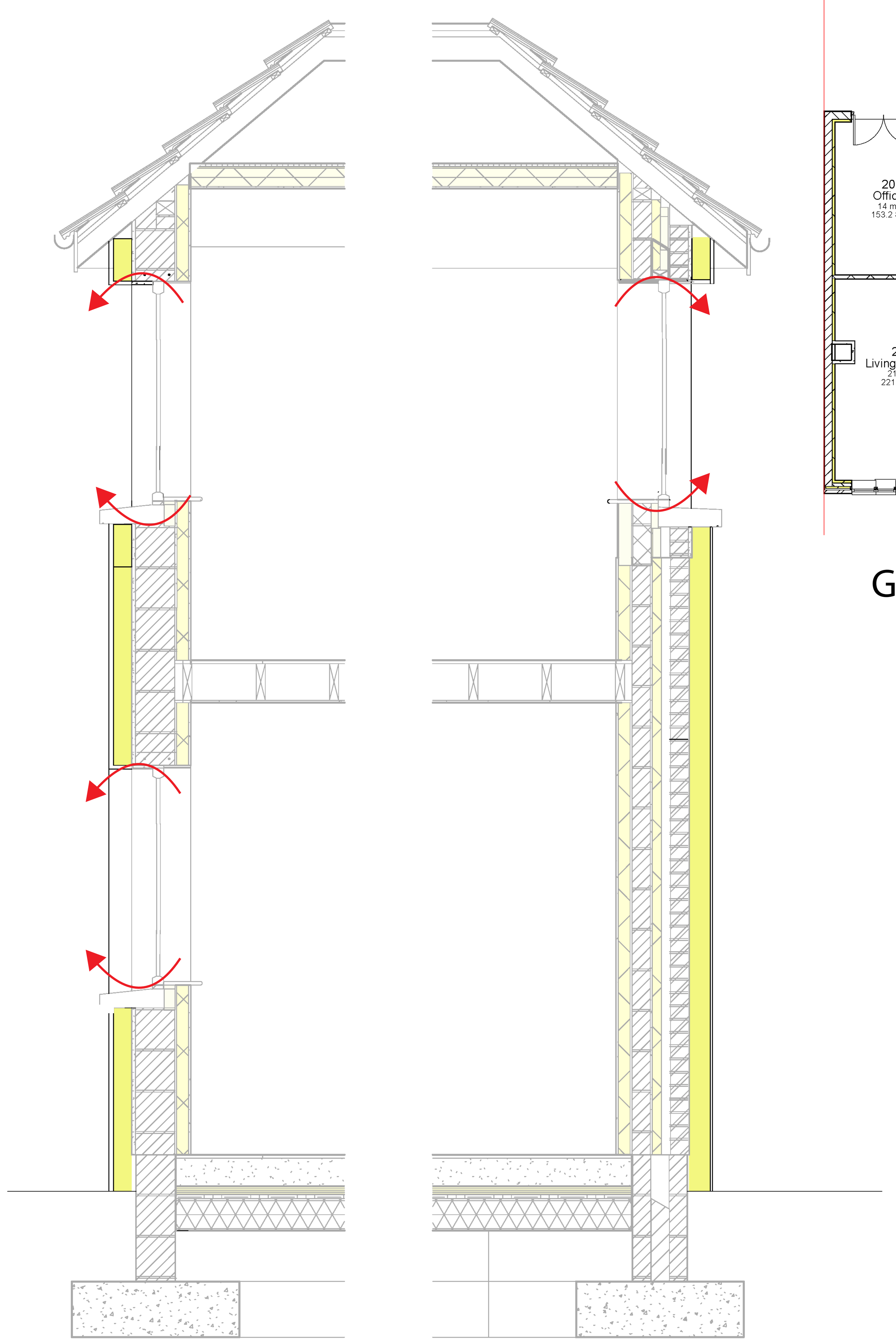
0.18W/M2k

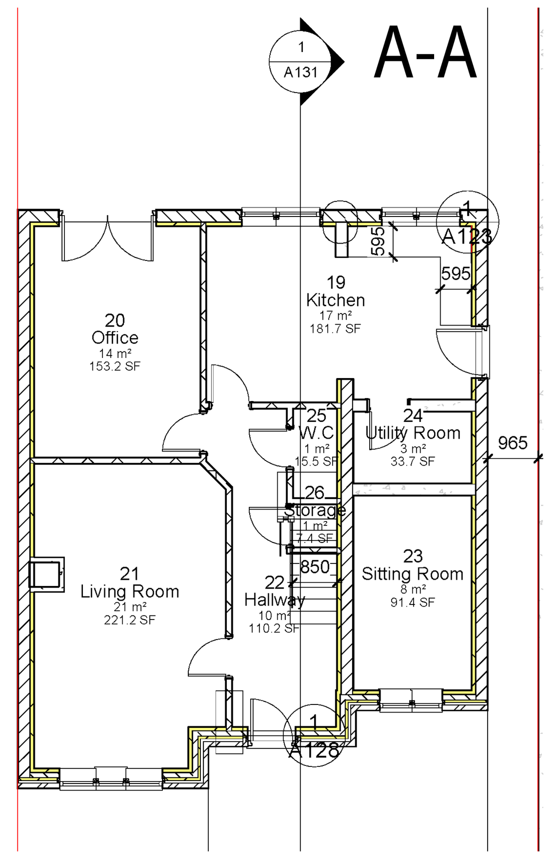
The maximum permitted U-Value in the 2022 Technical Guidance Documents.

100mm of EPS Insulation is added to each wall type
The aim is to get the wall U-Value to at least 0.18 W/M2K which is the maximum permitted U-Value.
These are the regulatory requirements for a home built in 2023.

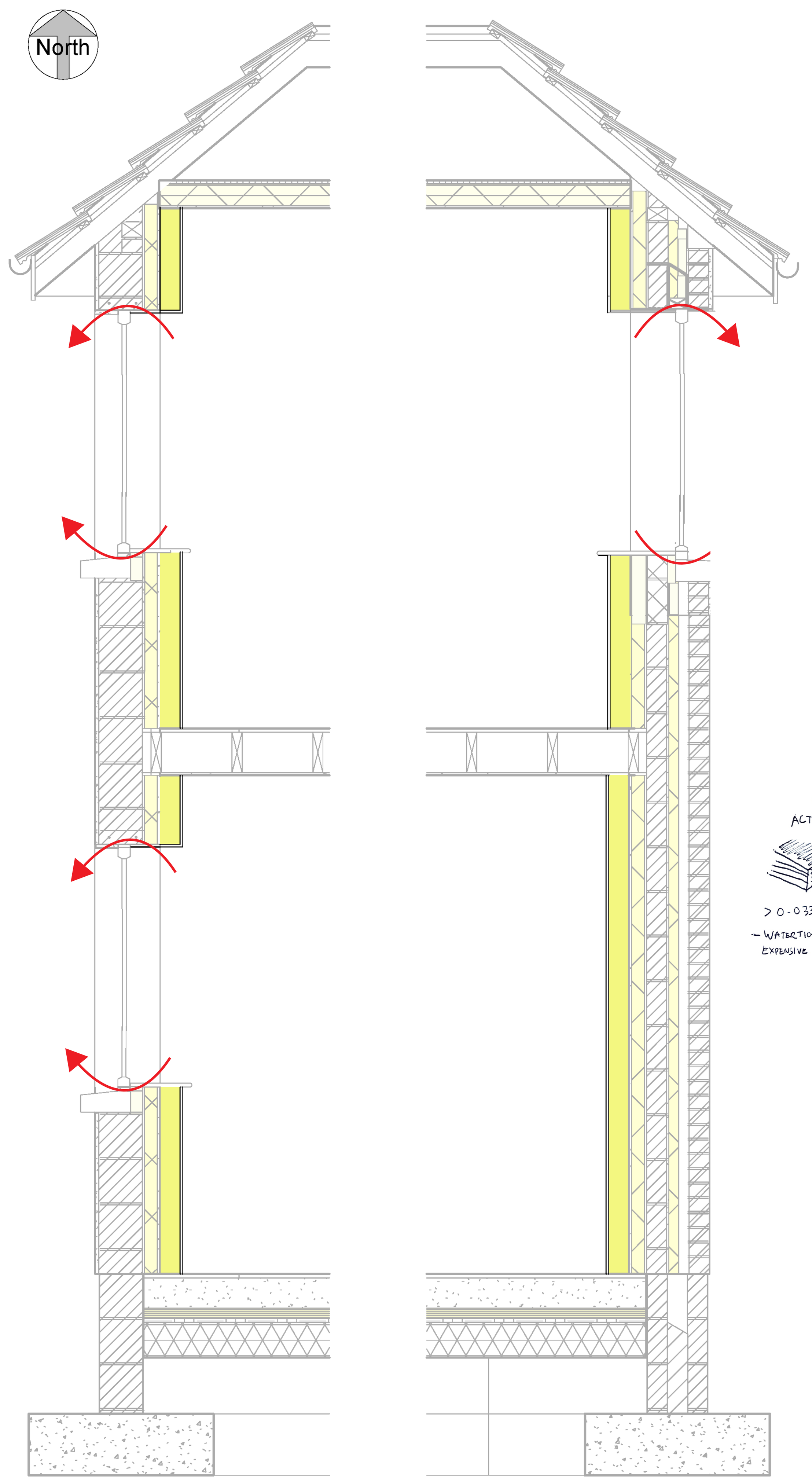


All 3 Wall types meet the minimum requirements set out.





Ground Floor



Section A-A

Front Facade

Rear Facade

External Insulation

Section A-A

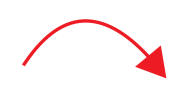
Front Facade

Rear Facade

Internal Insulation

Thermal Bridging

Thermal Bridging is the movement of heat through a building material that is more conductive than the materials around it. (Progressive Foam, n.d) This is caused by a change in building material at areas like junctions. Thermal Bridges can contribute to heat loss and lead to condensation and staining. (S.R. 54, 2014) External and Internal Insulation are applied to the front and rear sections and the areas where thermal bridging can occur are highlighted.

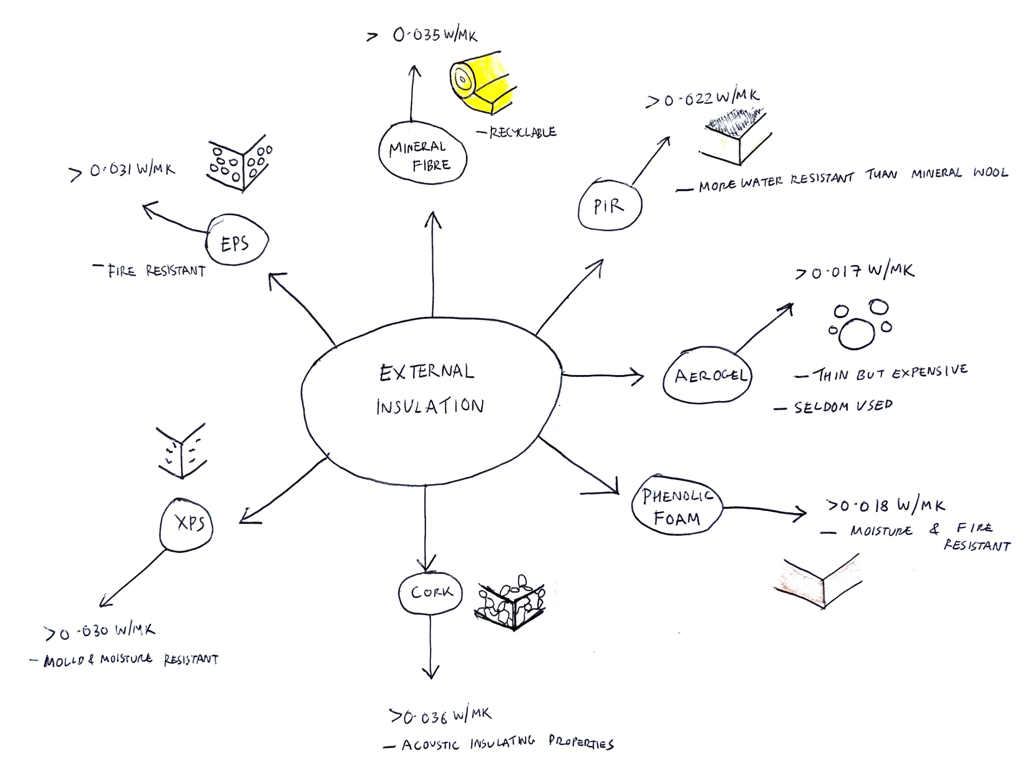


Thermal Bridging - Heat Movement from inside the building to outside the building from area of high thermal conductivity to low thermal conductivity.

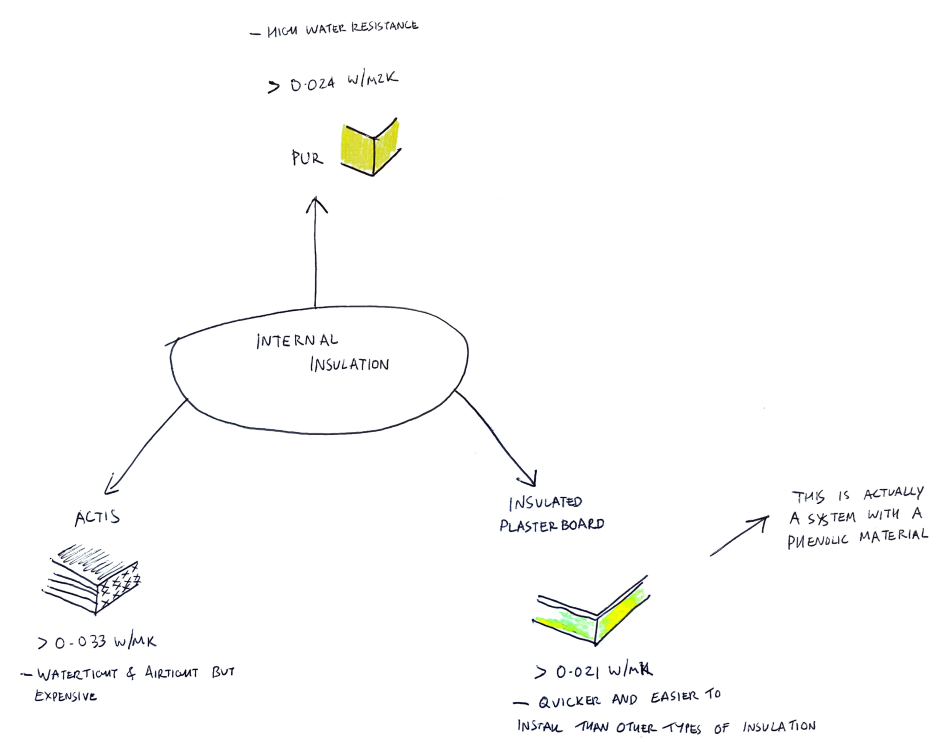
Types of Insulation

We are focusing on the two main types of insulation, those used internally and those used externally.

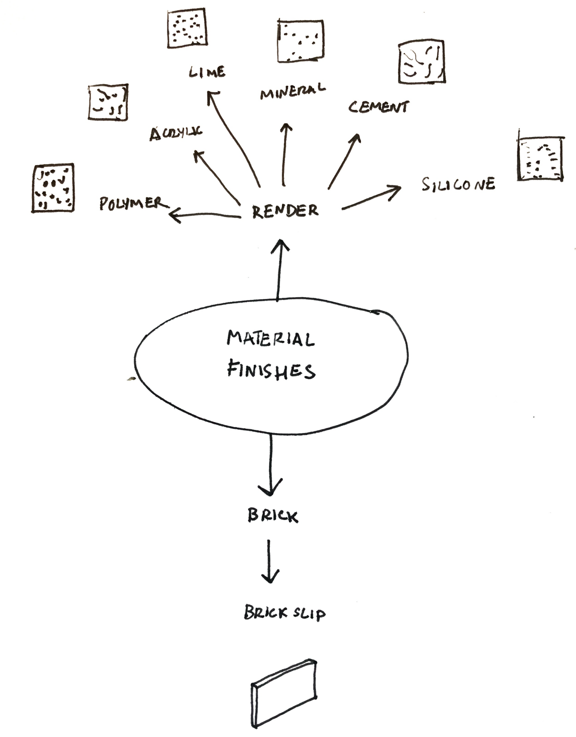
External Insulation



Internal Insulation

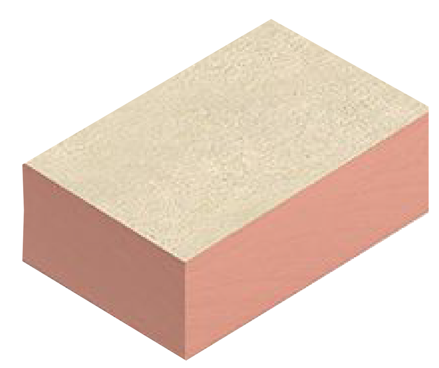


Material Finishes



Renders Compared	Pros		Cons
Cement	• Cheap		• Cracks over time
Silicone	• Pre-made • Prevents cracking over time	• Durable	• Expensive • Poor waterproofing leads to mould
Mineral	• Dries Quickly • Cheap		
Lime	• High Vapour Permeability		• Expensive
Acrylic	• Resistance to Cracking • Quick-Dry	• Flexible • Breathable	• Less eco-friendly than other renders
Polymer	• Resistance to Cracking • Stain and Water Resistant		

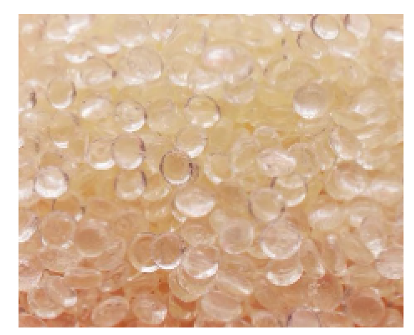
Chosen Insulation = Phenolic Insulation



- Low Thermal Conductivity = 0.018 W/MK
- Moisture and Fire Resistant according to the EFPA
- Good systems and products available on the market for both External and Internal Insulation Uses

Chosen Render = Acrylic

- More advantages than other systems
- Suitable insulation systems that allow use of finish



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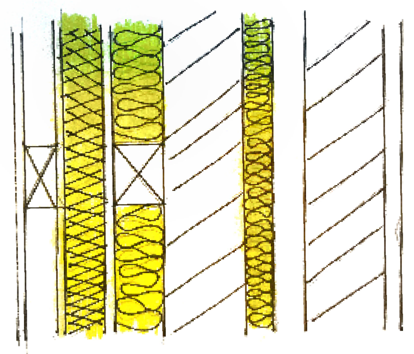
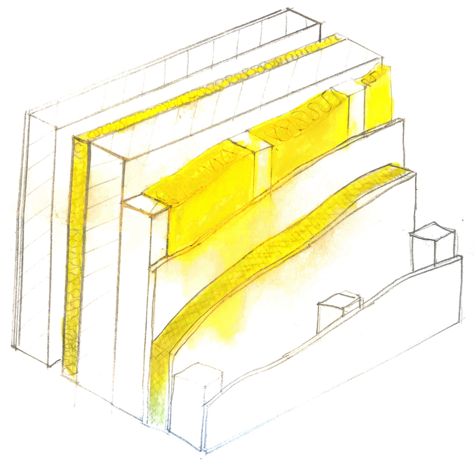
Internal Insulation

External
Existing Wall
25mm Gypsum based Drywall Adhesive Dab Bonding
52.5mm Kooltherm K17 Insulation with 3mm Skim Coat
Internal

U-Value = 0.17W/M2K

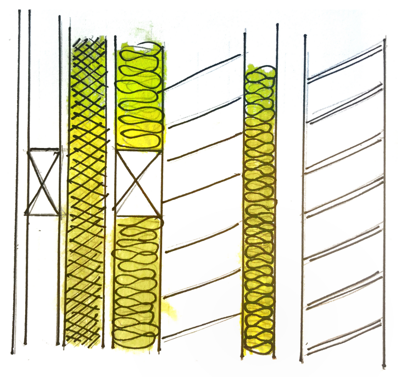
Internal  External

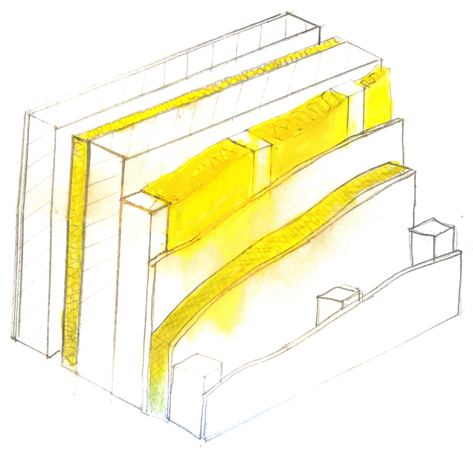


Cavity Wall Dry Lined with Render

External
Existing Wall
25mm Gypsum based Drywall Adhesive Dab Bonding
72.5mm Kooltherm K17 Insulation with 3mm Skim Coat
Internal

U-Value = 0.17W/M2K

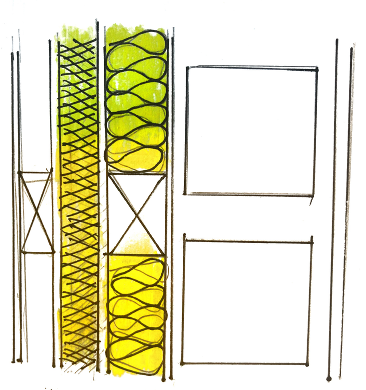
Internal  External

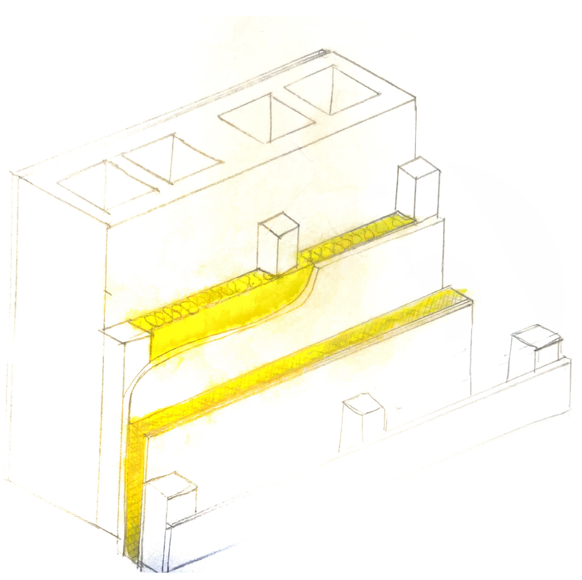


Cavity Wall Dry Lined with Brick

External
Existing Wall
25mm Gypsum based Drywall Adhesive Dab Bonding
82.5mm Kooltherm K17 Insulation with 3mm Skim Coat
Internal

U-Value = 0.17W/M2K

Internal  External

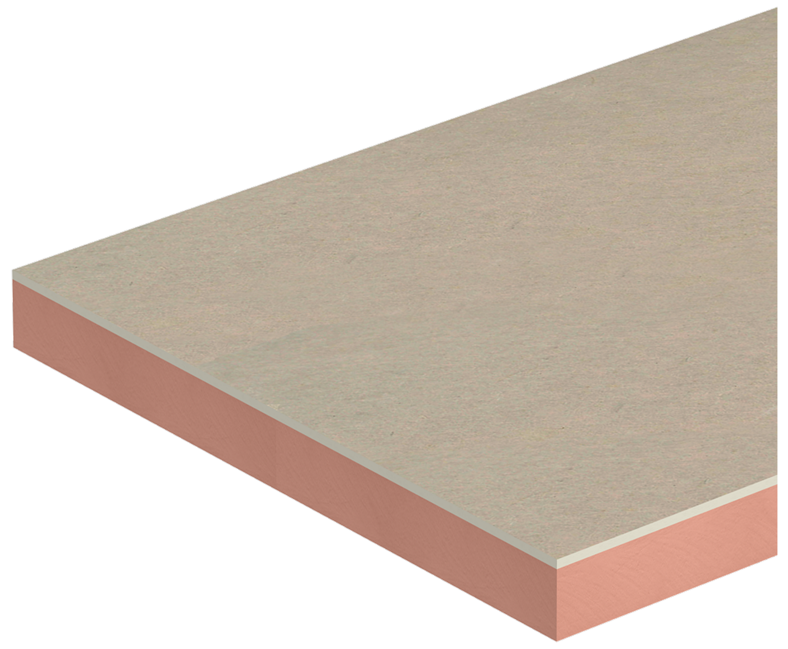


Hollow Concrete Block Dry Lined

Insulation Systems

Kooltherm K17 Insulated Plasterboard

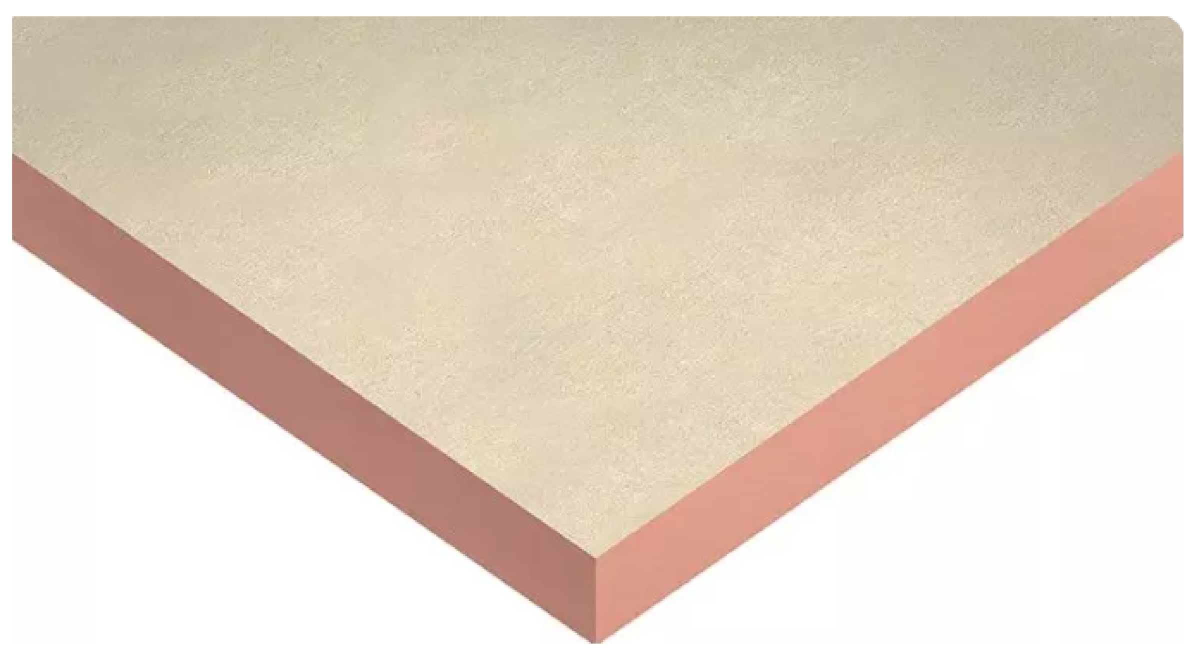
Internal Insulation



- Low Thermal Conductivity = 0.021 W/M2K
- Insulation, Dry-Lining and Vapour Control all in one
- Thermoset Phenolic Insulation

Webertherm PHS Phenolic Insulation

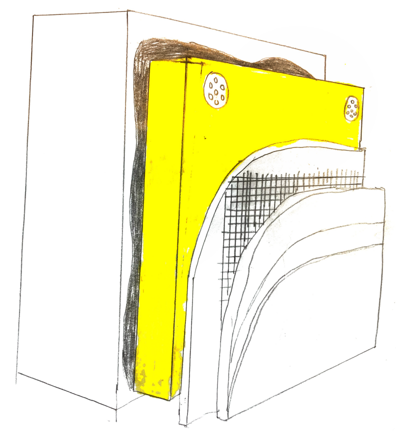
External Insulation



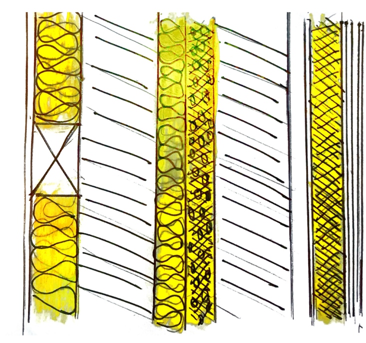
- Low Thermal Conductivity = 0.020 W/M2K
- Suitable for External Insulation System

External Insulation

External
5mm Weberplast TF Acrylic Render
0.1mm Weber PR310 Primer
6mm Weberend LAC Rapid Render Coat
3.5mm Weber Standard Meshcloth
6mm Weberend LAC Rapid Render Coat
20mm Webertherm PHS Phenolic Insulation
6mm Weberplast TF Acrylic Render Coat
Existing Wall
Internal

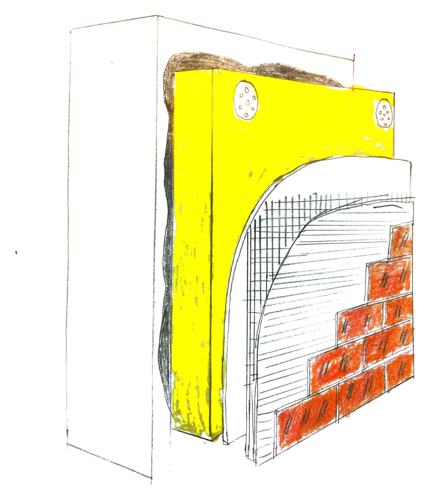


U-Value = 0.14W/M2K

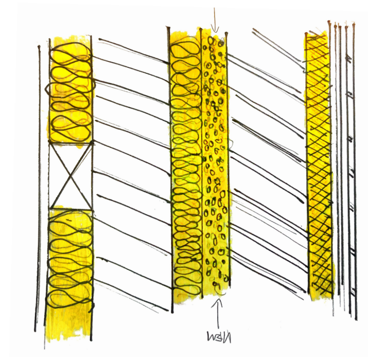
Internal  External

Cavity Wall Dry Lined with Render Webertherm XM Multi-Layer System

External
5mm Weberall Brick Slip
6mm Weberwall Brick External Adhesive
3.5mm Weber Standard Meshcloth
3mm Weberwall Brick External Adhesive
20mm Webertherm PHS Phenolic Insulation
Existing Wall
Internal

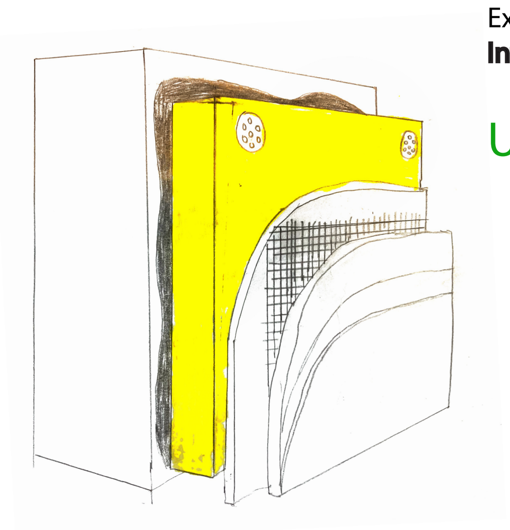


U-Value = 0.16W/M2K

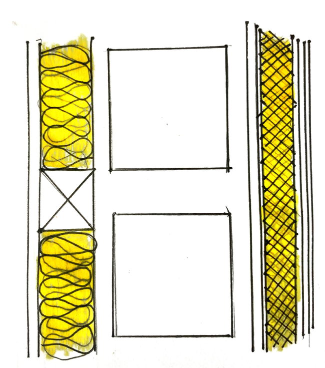
Internal  External

Cavity Wall Dry Lined with Brick Weberwall Brick External System

External
5mm Weberplast TF Acrylic Render
0.1mm Weber PR310 Primer
6mm Weberend LAC Rapid Render Coat
3.5mm Weber Standard Meshcloth
6mm Weberend LAC Rapid Render Coat
70mm Webertherm PHS Phenolic Insulation
6mm Weberend LAC Rapid Render Coat
Existing Wall
Internal



U-Value = 0.17W/M2K

Internal  External

Hollow Block Dry-Lined with Webertherm XM Multi-Layer System

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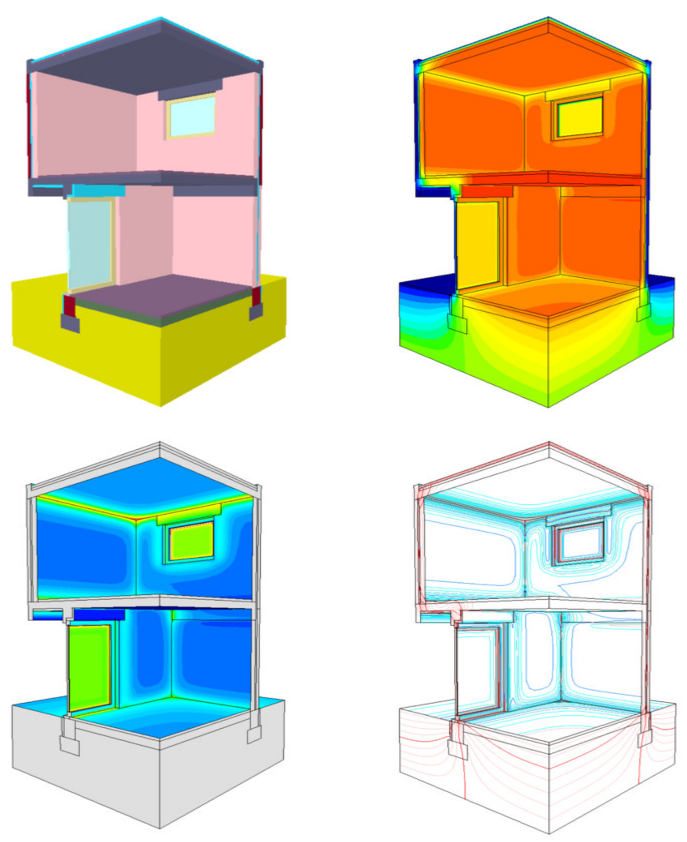
Key Junctions

There are 8 key junctions in the building
- Footing
- External to Internal Wall
- External Wall to First Floor
- Eaves
- Window Head
- Window Jamb
- Window Cill
- Lean-to Roof

The Existing Junctions were detailed firstly.

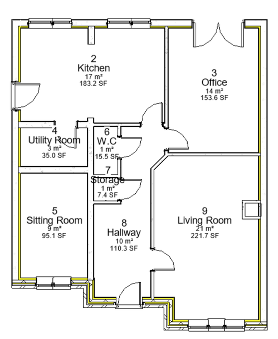
Trisco

This is a computer software that creates 3D thermal imaging of the building.
The two main methods of measuring the building in Trisco are the fRSI and Psi value.
The fRSI is the surface temperature factor (Emu, n.d) whilst the Psi Value is the measure of heat loss through a particular junction. (Kingspan, n.d)
Once the details have been completed, they will be put into Trisco and the building and the internal and external wall systems will be compared along with the existing building in terms of their Psi and fRSI Values.

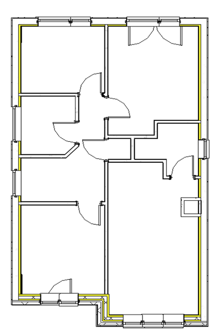


Plans

The two floor plans will be compared with the existing situation, with external and then with internal insulation.



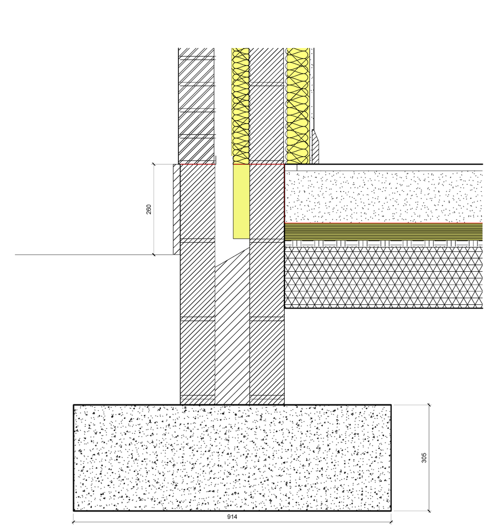
Ground Floor Plan



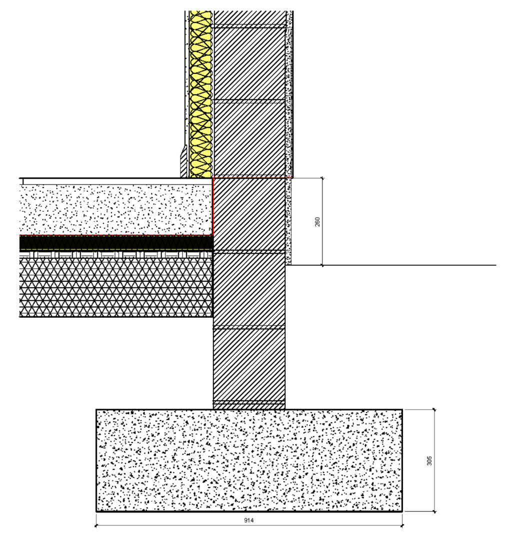
First Floor Plan

Existing Junctions

Footing

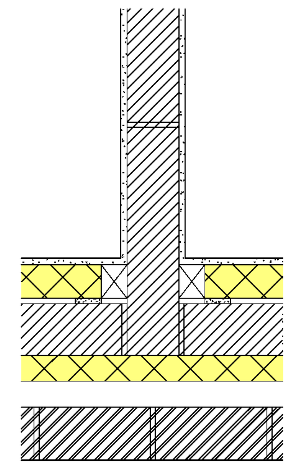


Footing Detail 1 - Cavity Brick

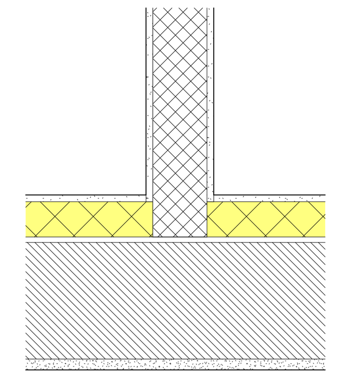


Footing Detail 2 - Hollow Block

External to Internal Wall

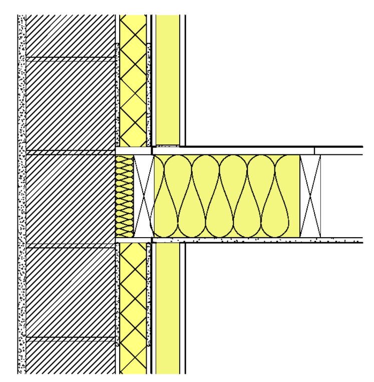


External Cavity Wall to Internal Concrete Wall

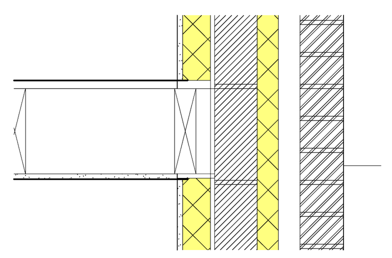


External Hollow Block Wall to Internal Concrete Wall

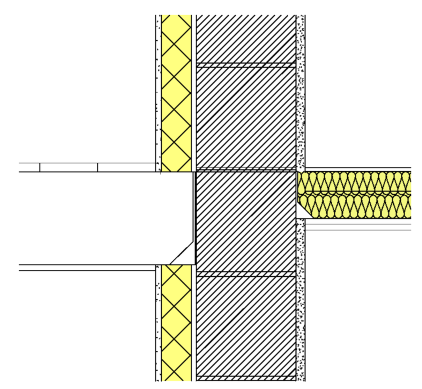
External Wall to First Floor



Hollow Block Wall to Timber First Floor Junction

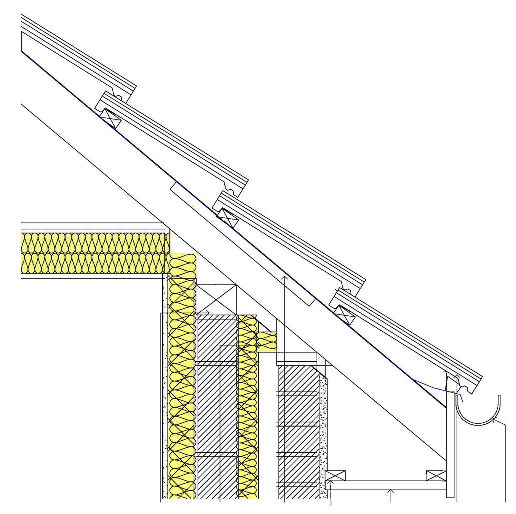


Cavity Wall to Timber First Floor Junction

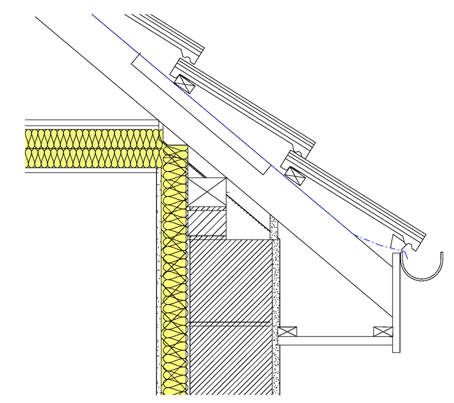


Hollow Block Wall to Timber First Floor Junction Alternative Direction including Roof Joist over Single-Storey Area

Eaves

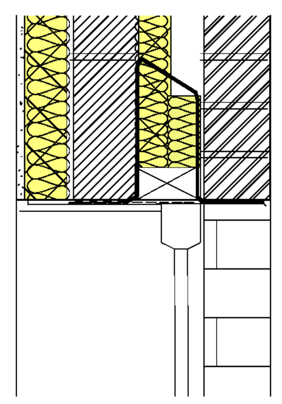


Eaves Detail 1 - Cavity Render

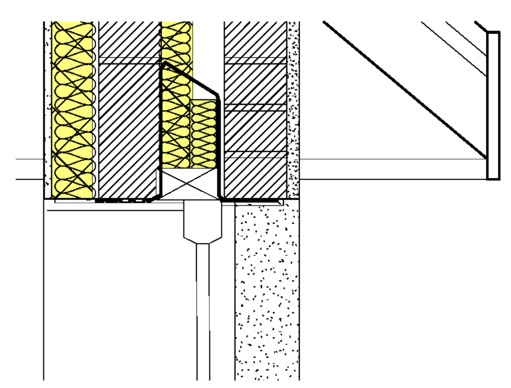


Eaves Detail 2 - Hollow Block

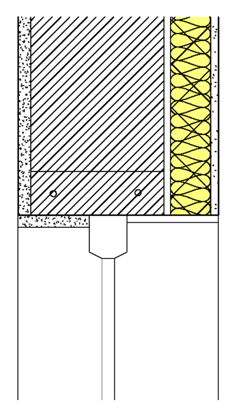
Window Head



Window Head Detail 1 - Cavity Brick

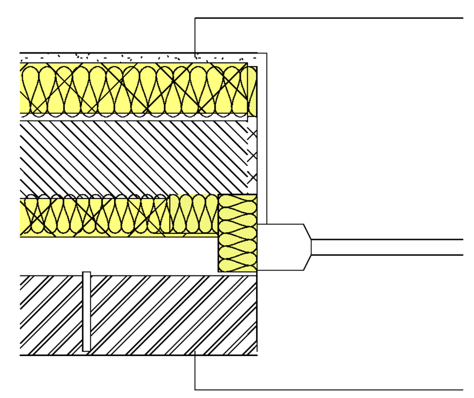


Window Head Detail 2 - Cavity Render

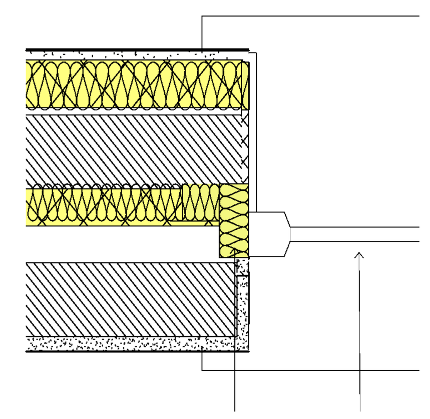


Window Head Detail 3 - Hollow Block

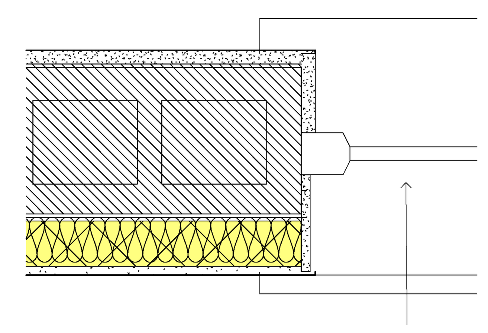
Window Jamb



Window Jamb Detail 1 - Cavity Wall Brick

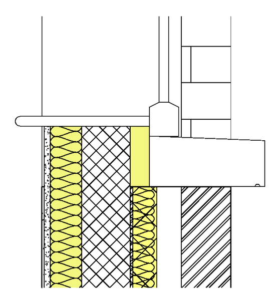


Window Jamb Detail 2 - Cavity Wall Render

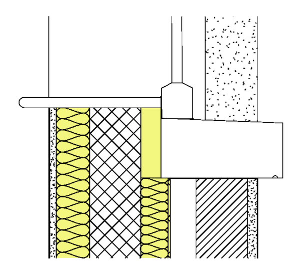


Window Jamb Detail 3 - Hollow Block

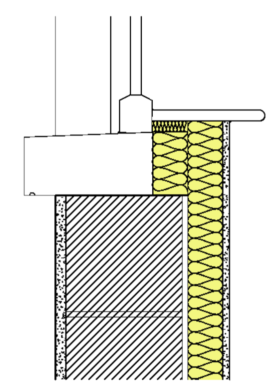
Window Cill



Window Cill Detail 1 - Cavity Brick

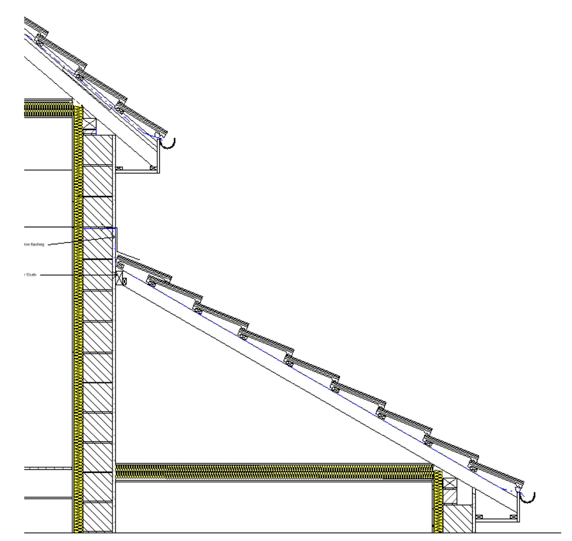


Window Cill Detail 2 - Cavity Render



Window Cill Detail 3 - Hollow Block

Lean-To Roof

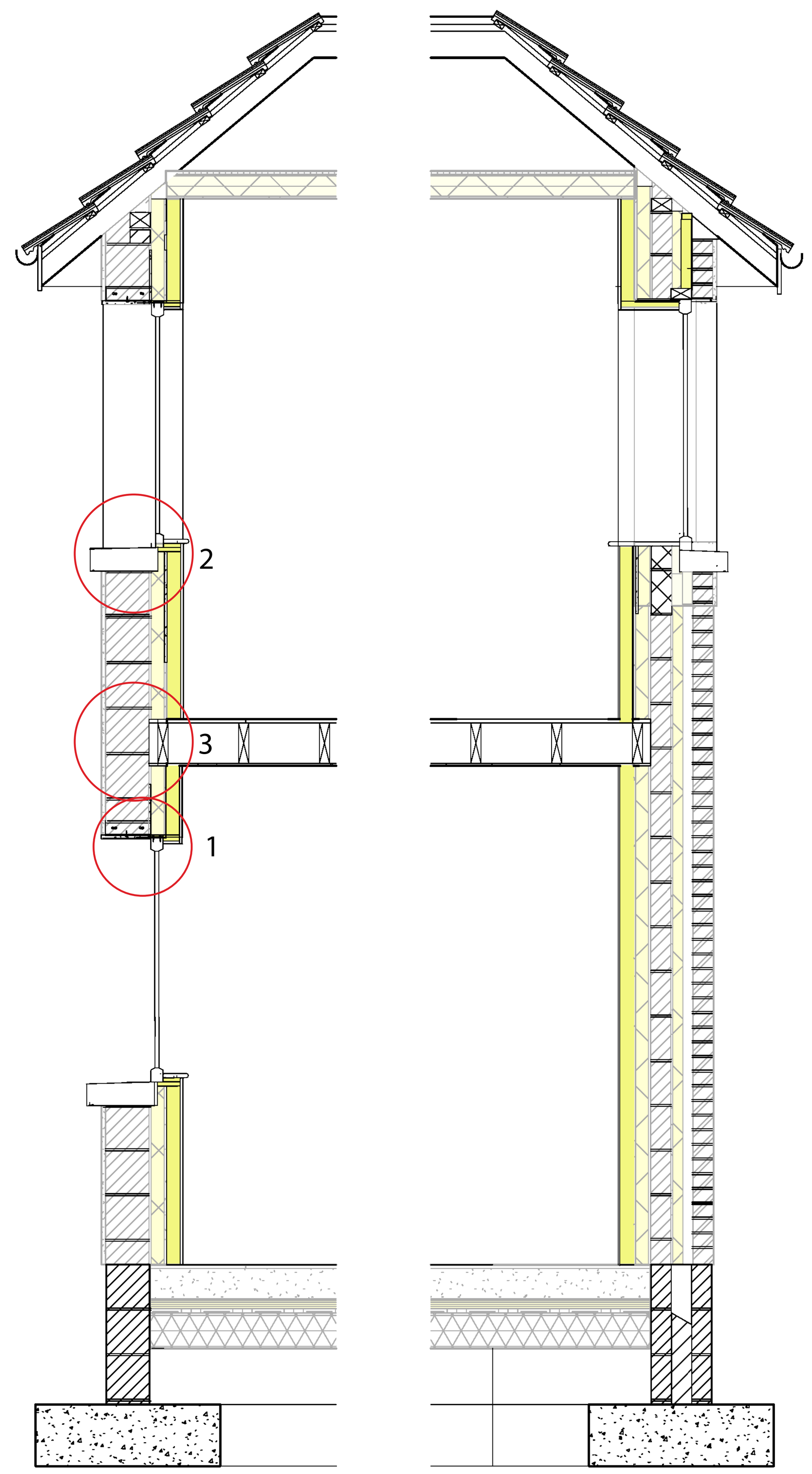


Lean-to Roof Junction Detail 1 - Hollow Block

An investigation into the ultimate retrofit solution for a typical 1990s detached dwelling in Ireland

TU Dublin
Tim Nolan
C19327403

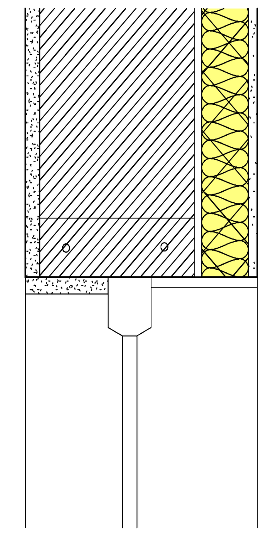
Existing Building Sections



Section A-A

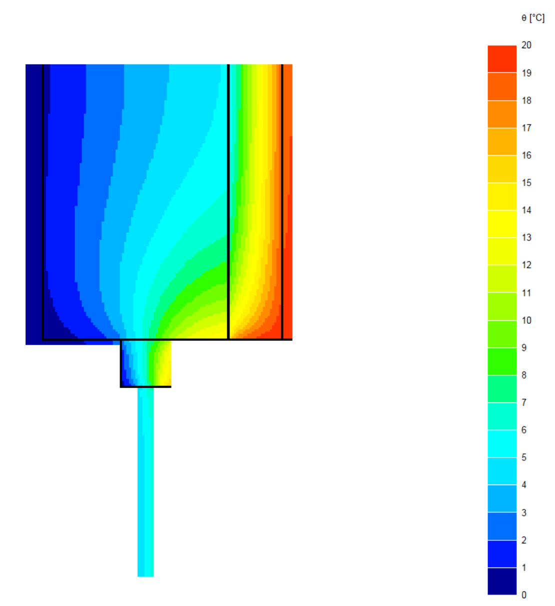
Existing Building Details

1) Hollow Block Wall Window Head



Revit

U-Value through Hollow Block Wall = 0.41W/M2K

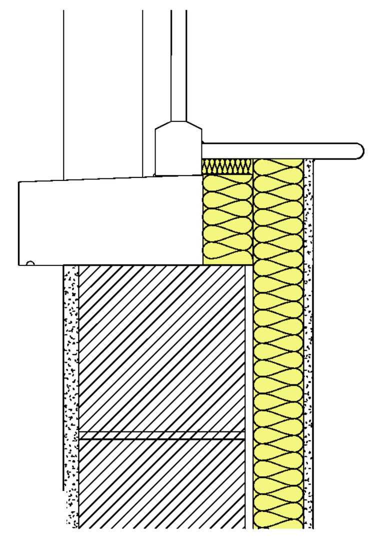


Trisco

Psi-Value=1.542 W/M2K

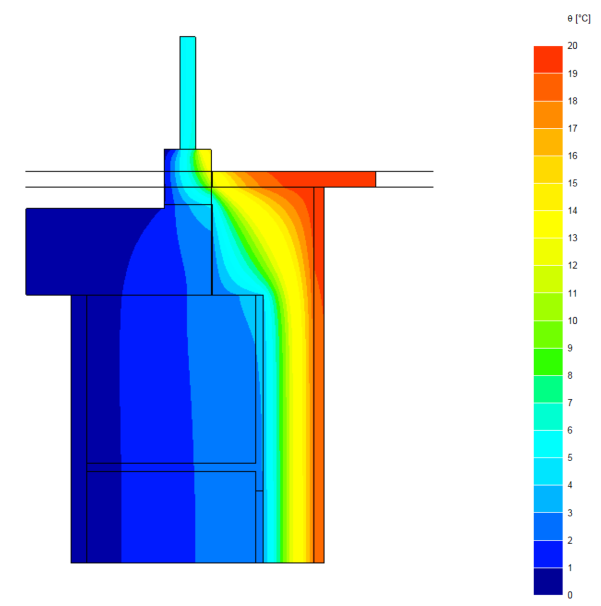
fRsi Value=0.316

2) Hollow Block Wall Window Cill



Revit

U-Value through Hollow Block Wall = 0.41W/M2K

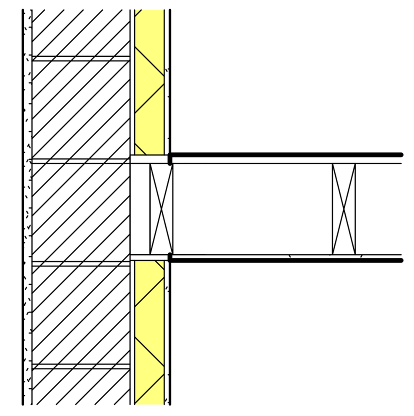


Trisco

Psi-Value=0.898 W/M2K

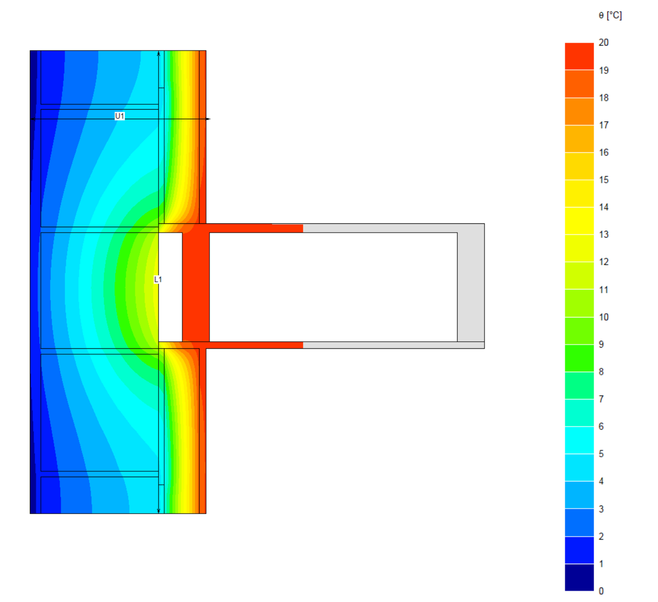
fRsi Value=0.316

3) Hollow Block Wall to Timber First Floor Junction



Revit

U-Value through Hollow Block Wall = 0.41W/M2K

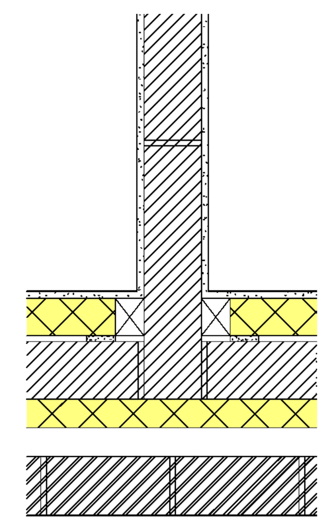


Trisco

Psi-Value=0.592 W/M2K

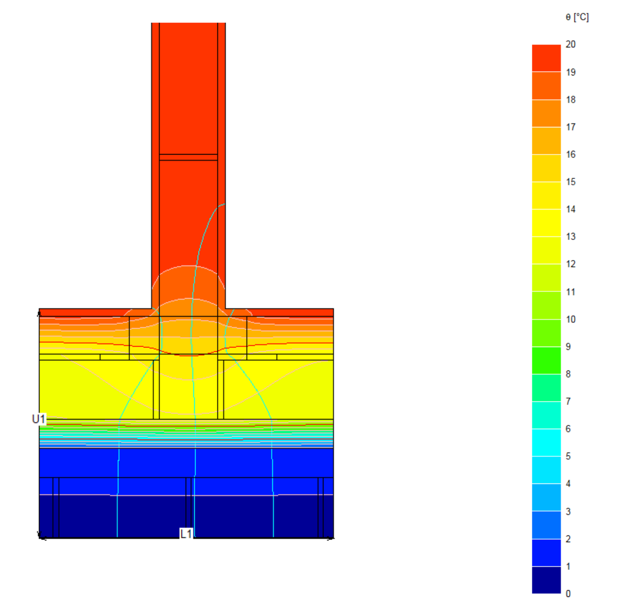
fRsi Value=0.570

4) External Cavity Wall to Internal Concrete Wall



Revit

U-Value through Cavity Wall = 0.29W/M2K

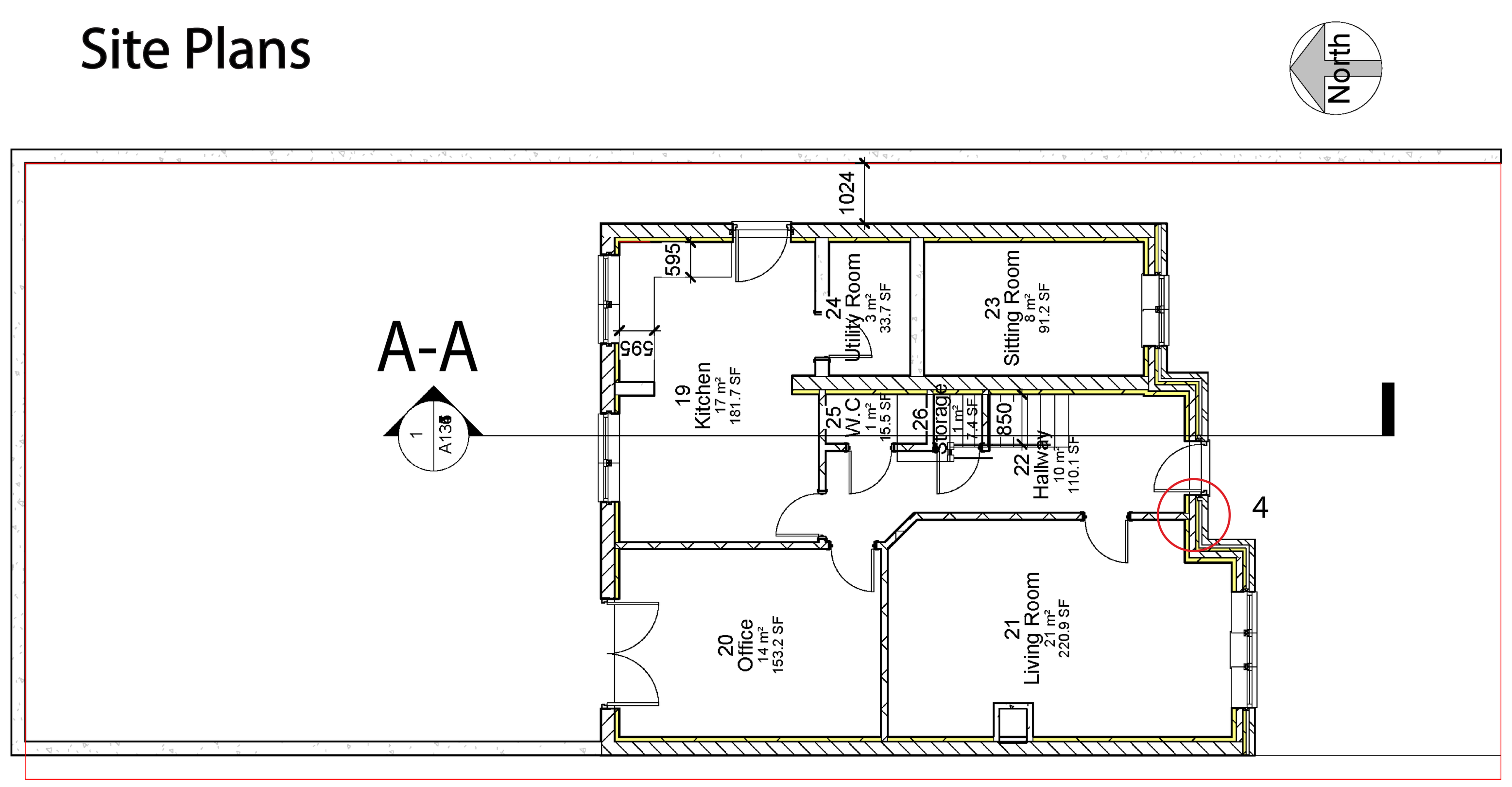


Trisco

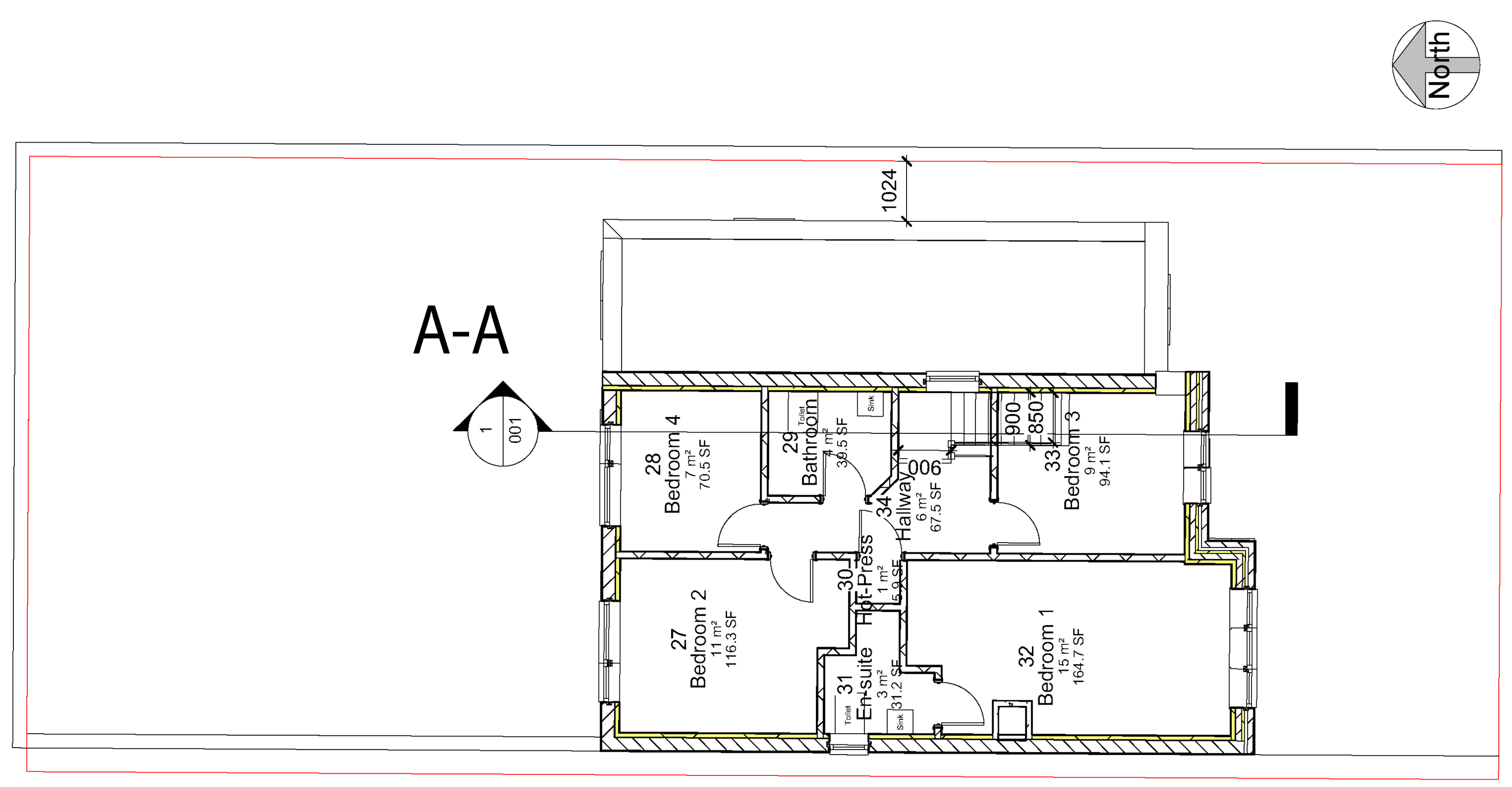
Psi-Value=0.059 W/M2K

fRsi Value=0.917

Site Plans



Ground Floor



First Floor

Site Boundary

fRsi Value (Temperature Factor) - According to the S.R. 54 document, a value of below 0.75 suggest risk for surface condensation. The closer the figure is to 1 the better.

Psi Value - This is the measure of heat loss in the building. The lower it is, the better insulated a building is.

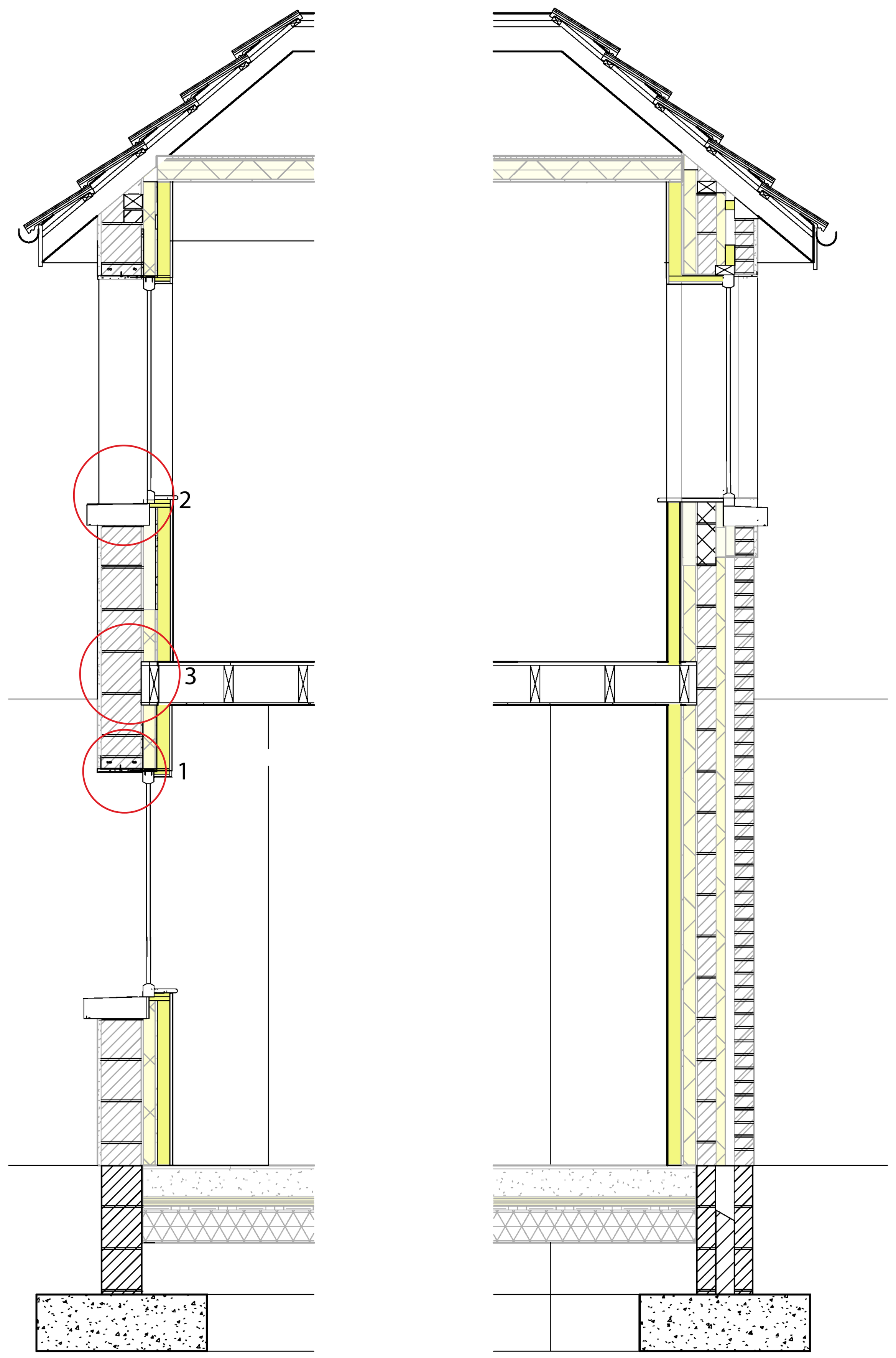
The External Cavity Wall to Internal Concrete Wall Detail is performing the best currently in terms of thermal performance. It is at a low risk for surface condensation.
The Hollow Block to Timber First Floor Junction is performing much worse and is at risk of surface condensation.
The Hollow Block Window details are performing even worse, especially the Window Head detail and both details show risk of surface condensation.

An investigation into the ultimate retrofit solution for a typical 1990s detached dwelling in Ireland

DUBLIN Technological University Dublin

Tim Nolan
C19327403

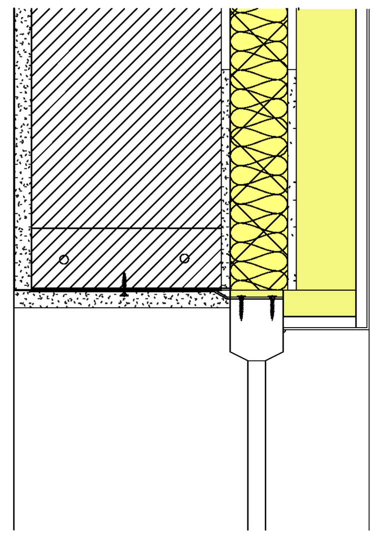
Building Sections with Internal Insulation



Section A-A

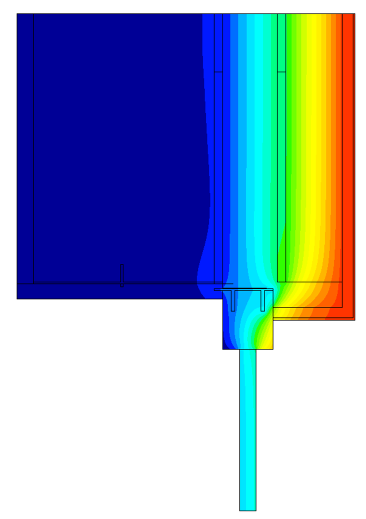
Building Details with Internal Insulation

1) Hollow Block Wall Window Head



Revit

U-Value through Hollow Block Wall = 0.17W/M2K

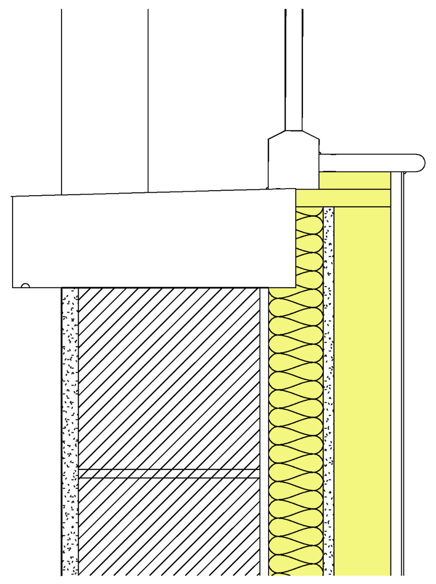


Trisco

Psi-Value=1.207W/M2K

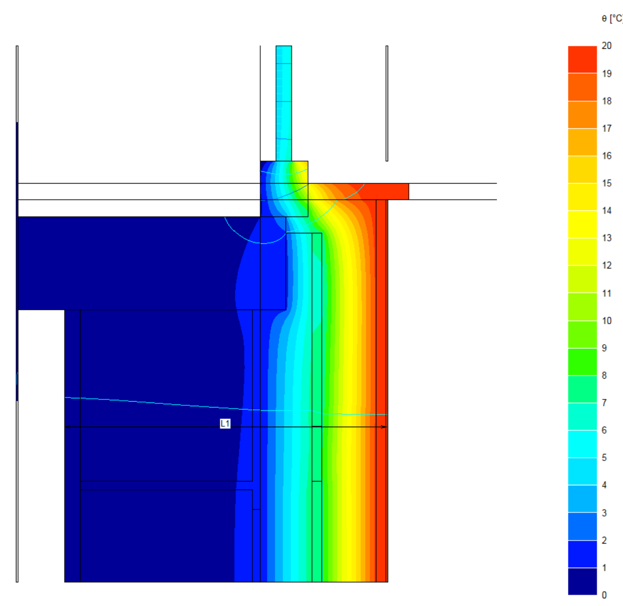
fRsi Value=0.316

2) Hollow Block Wall Window Cill



Revit

U-Value through Hollow Block Wall = 0.17W/M2K

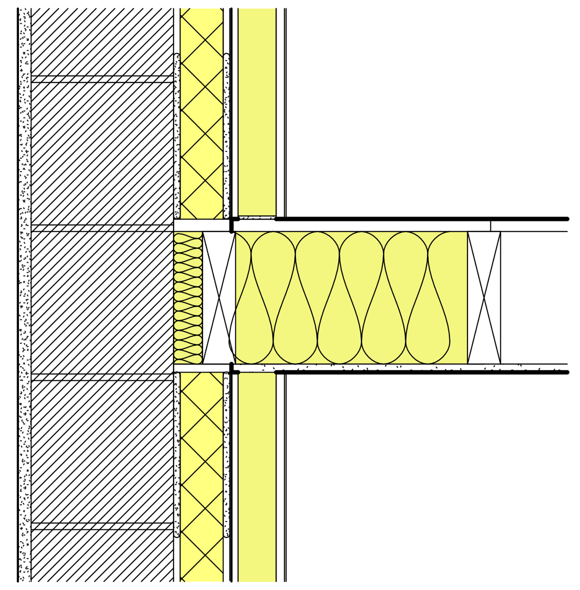


Trisco

Psi-Value=1.002W/M2K

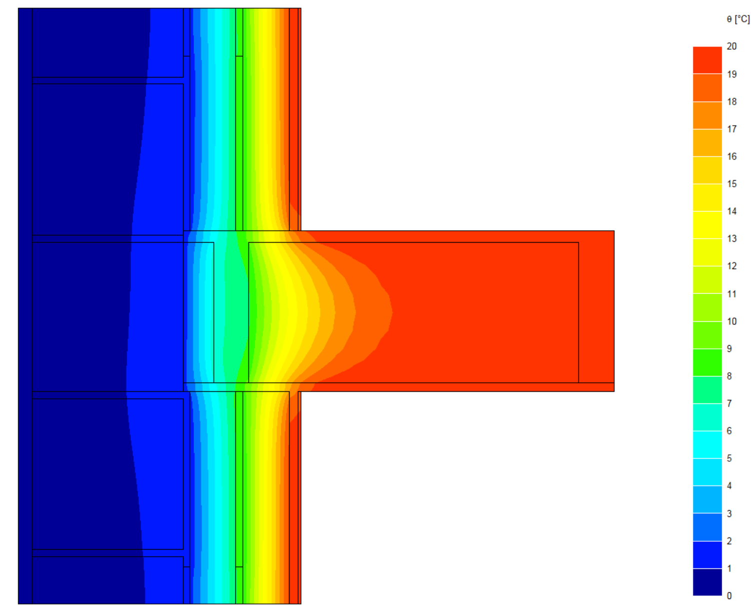
fRsi Value=0.316

3) Hollow Block Wall to Timber First Floor Junction



Revit

U-Value through Hollow Block Wall = 0.17W/M2K

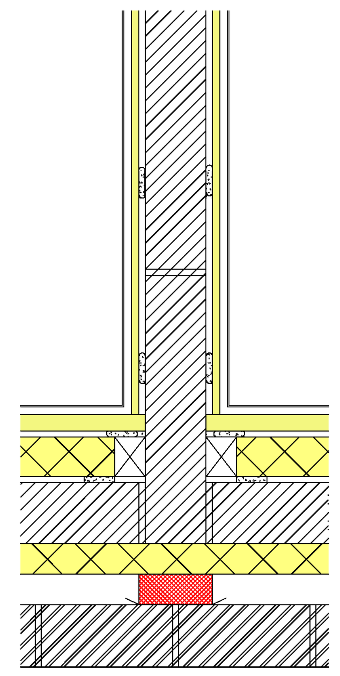


Trisco

Psi-Value=0.175 W/M2K

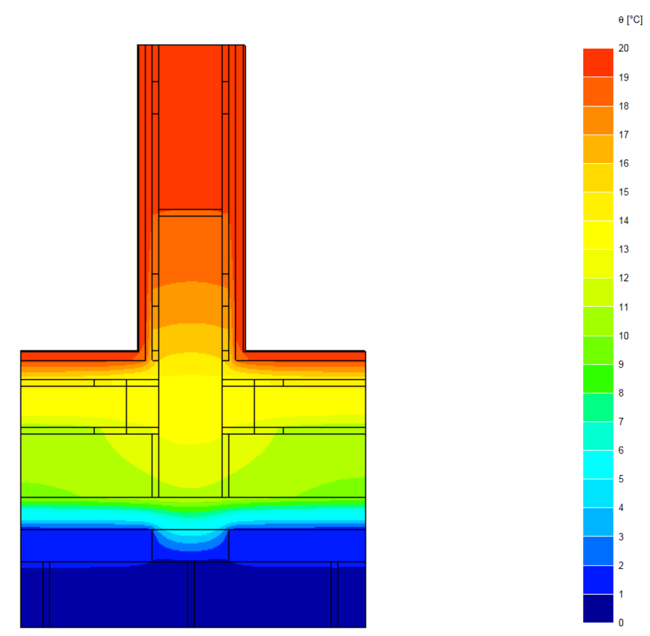
fRsi Value=0.919

4) External Cavity Wall to Internal Concrete Wall



Revit

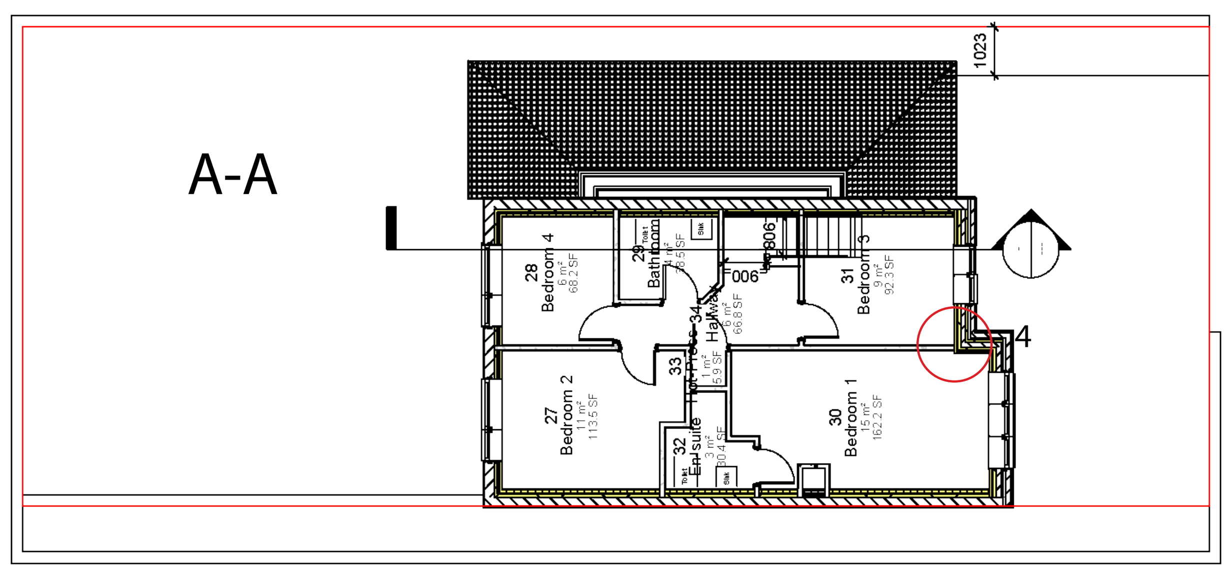
U-Value through Cavity Wall = 0.17W/M2K



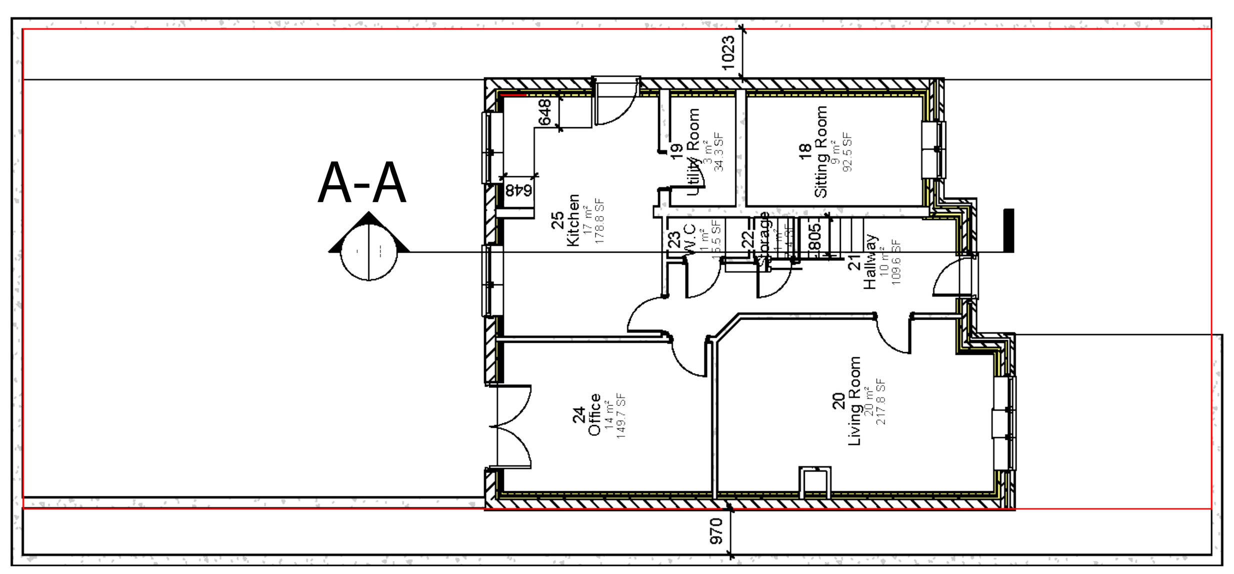
Trisco

Psi-Value=0.146 W/M2K

fRsi Value=0.956



Ground Floor Plan



First Floor Plan

Site Boundary

The External Cavity Wall to Internal Concrete Wall Detail is performing the best in terms of thermal performance with a low Psi Value and high fRsi value. It is performing similarly to the existing condition. It is at a low risk for surface condensation.
The Hollow Block to Timber First Floor Junction is performing worse in terms of Psi and fRsi value but due to the increased insulation, the junction is now no longer at risk of surface condensation.
The Hollow Block Window Cill detail is performing similarly in terms of Psi value and fRsi than without internal insulation whilst the window head is performing better in terms of Psi value and the same in terms of fRsi value as without the internal insulation.

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Tim Nolan
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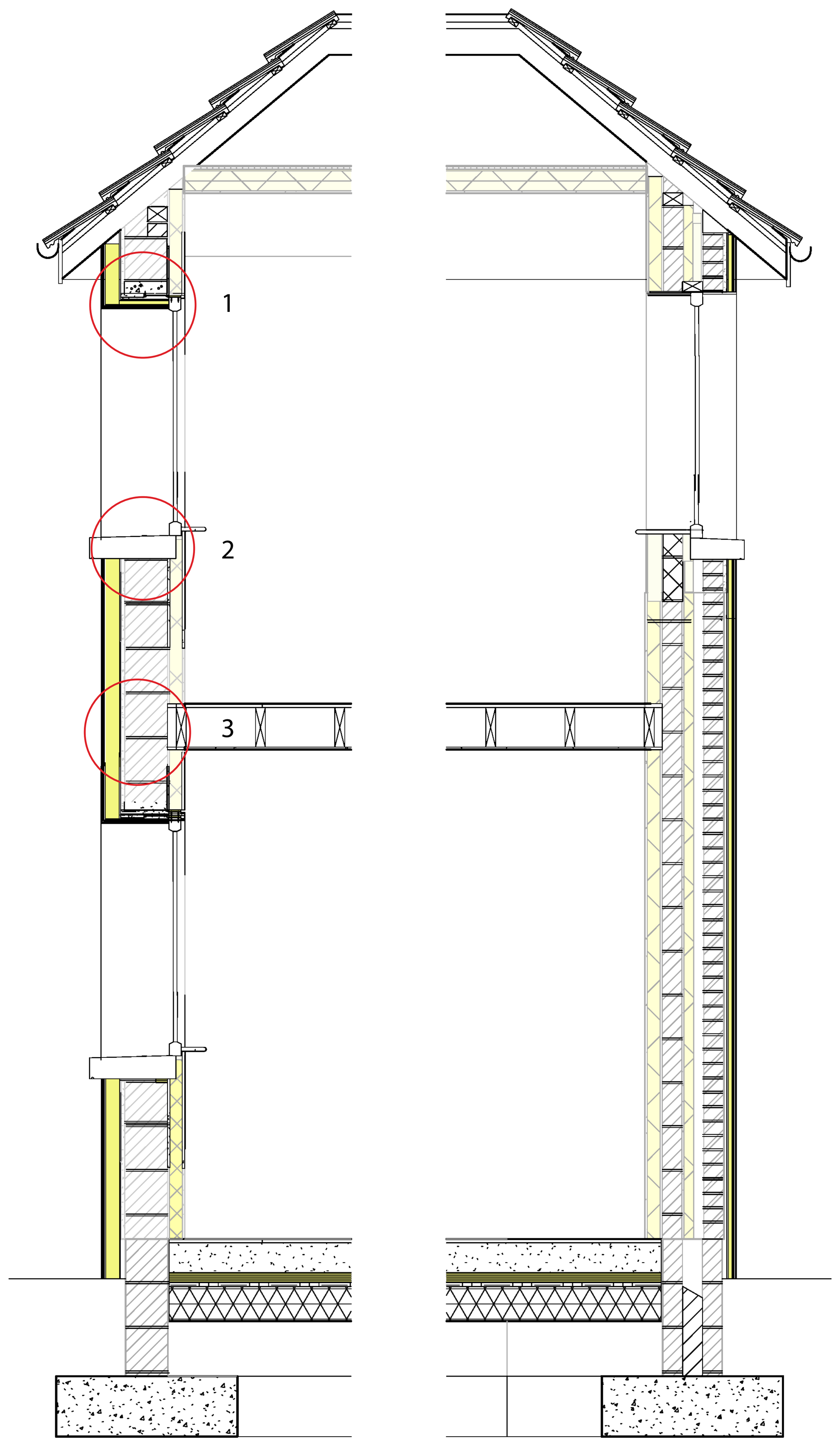
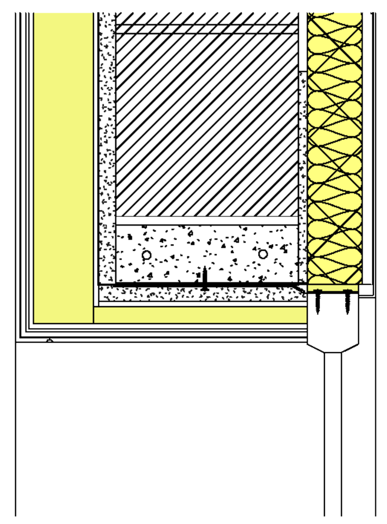
Building Sections with External Insulation



Section A-A

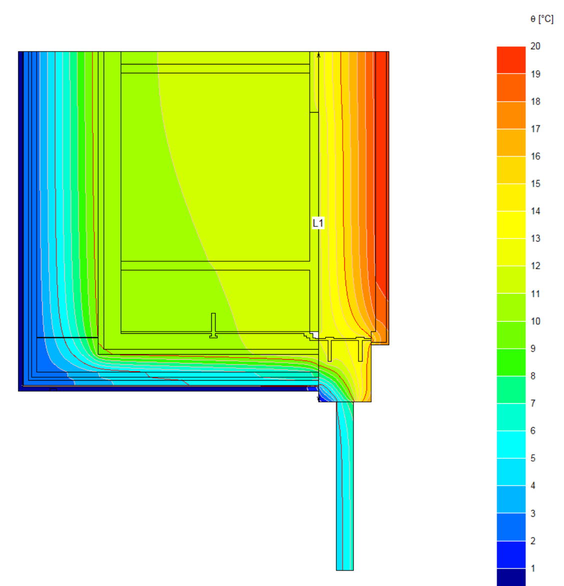
Building Details with External Insulation

1) Hollow Block Wall Window Head



Revit

U-Value through Hollow Block Wall = 0.17W/M2K

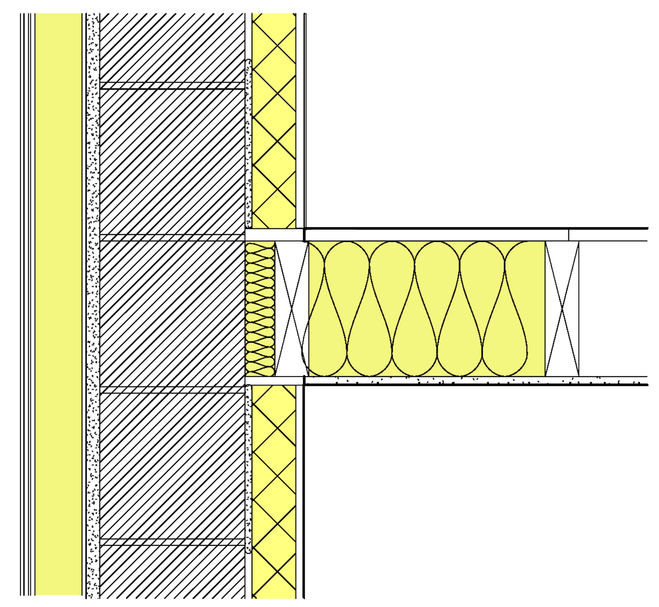


Trisco

Psi-Value= 1.243 W/M2K

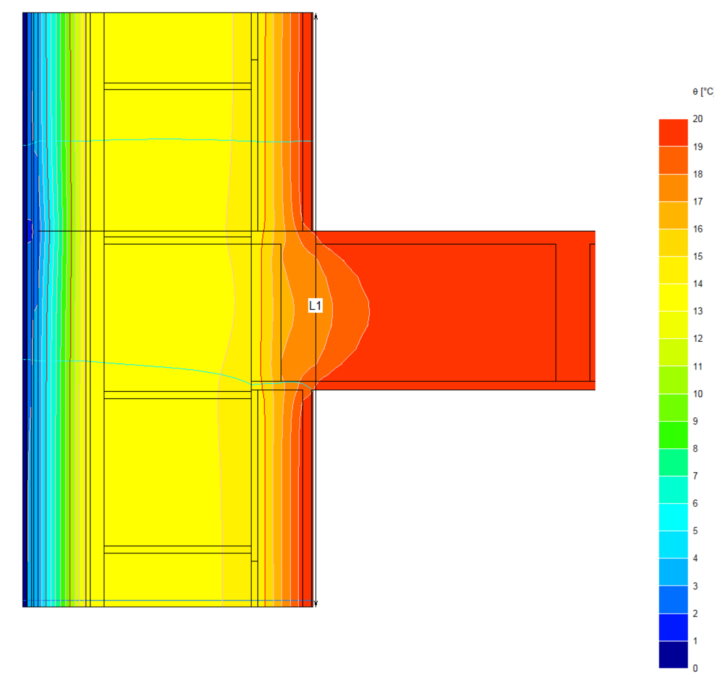
Frsi Value=0.324

3) Hollow Block Wall to Timber First Floor Junction



Revit

U-Value through Hollow Block Wall = 0.17W/M2K

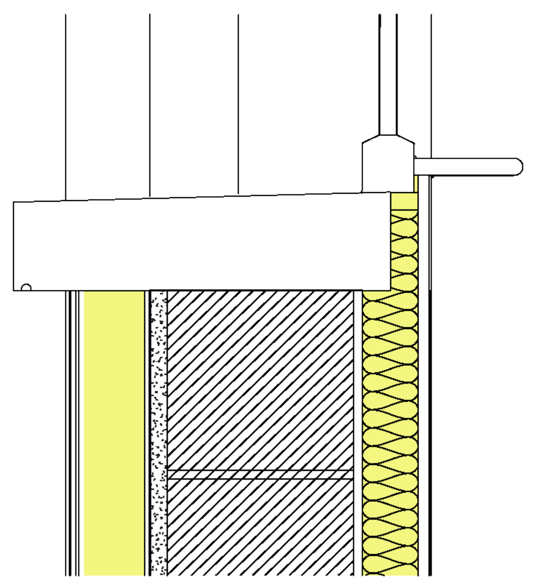


Trisco

Psi-Value=0.128 W/M2K

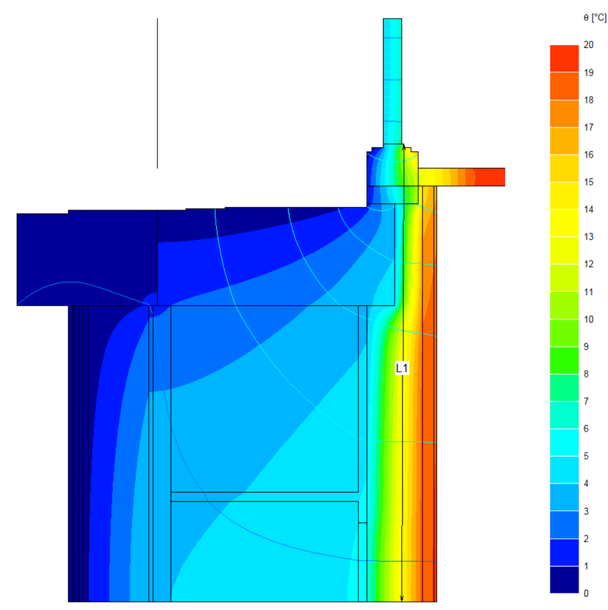
Frsi Value=0.950

2) Hollow Block Wall Window Cill



Revit

U-Value through Hollow Block Wall = 0.17W/M2K

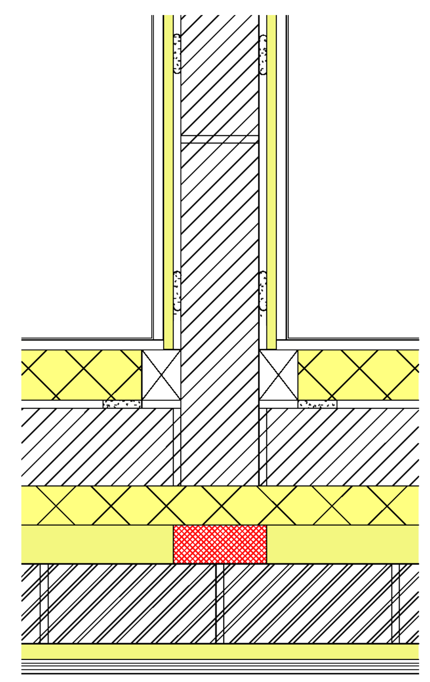


Trisco

Psi-Value=1.114 W/M2K

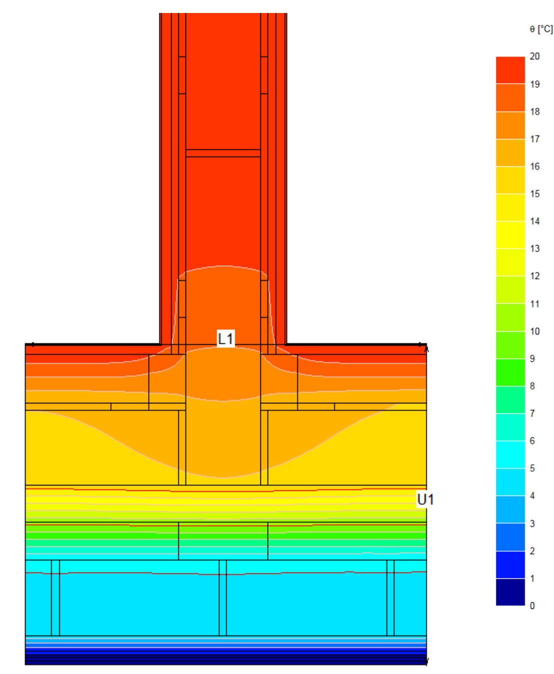
Frsi Value=0.328

4) External Cavity Wall to Internal Concrete Wall



Revit

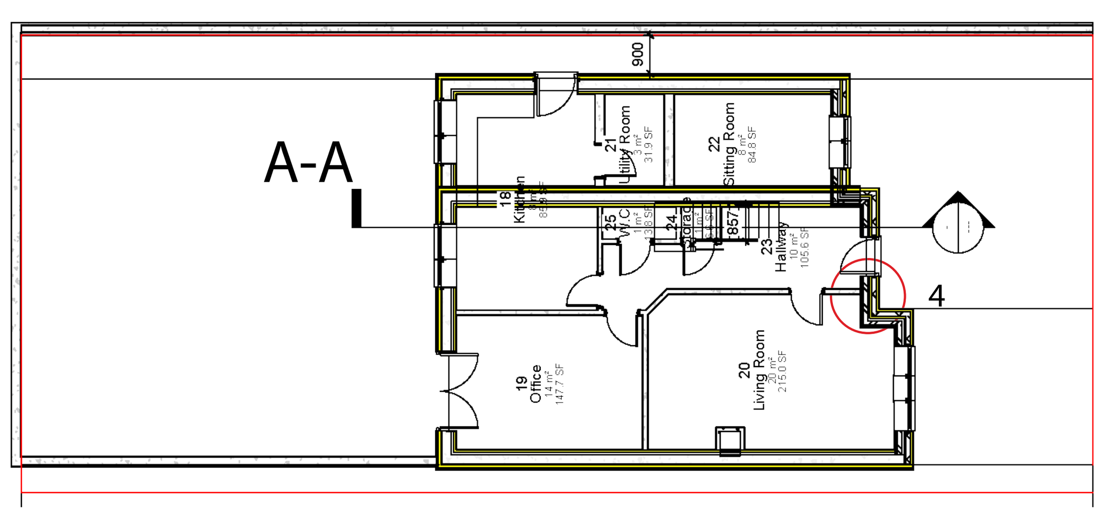
U-Value through Cavity Wall = 0.16W/M2K



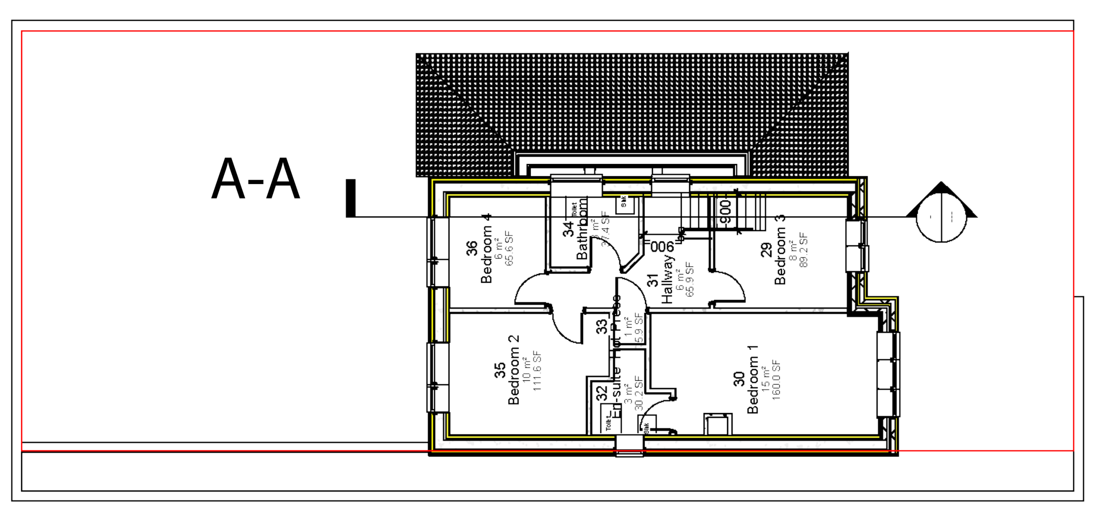
Trisco

Psi-Value=0.014 W/M2K

Frsi Value=0.963



Ground Floor Plan



First Floor Plan

Site Boundary

The External Cavity Wall to Internal Concrete Wall Detail is performing the best currently in terms of the junctions in terms of thermal performance with a low Psi Value and high fRsi value. It is at a low risk for surface condensation. The Psi Value is much better than the condition with internal insulation. The fRsi value is slightly worse. These Psi values are also slightly better than the existing condition.
The Hollow Block to Timber First Floor Junction is performing worse in terms of Psi and fRsi values than the external to internal wall but better than the condition with internal insulation. The Psi and fRsi values are better than that of the external and existing condition.
The Hollow Block Window Cill detail is performing worse than the internal condition which is performing worse than the existing condition. The Hollow Block Window Head has values that perfom similar to the internal condition and better than the existing condition.

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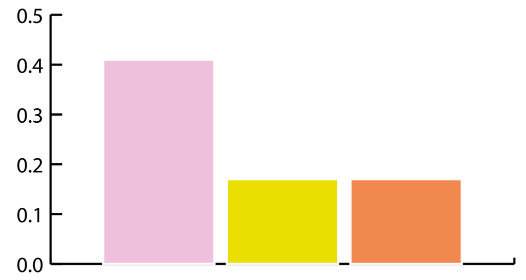
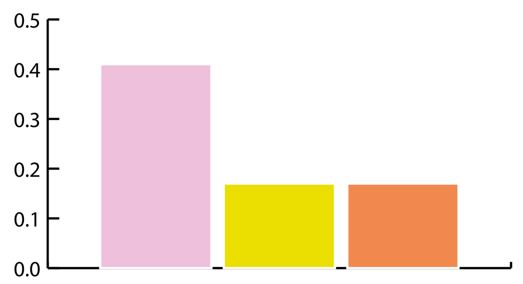
Comparing thermal Properties

Each of the thermal properties, U-Value, Psi and fRsi Values are compared between the existing junctions and then the junctions with internal and external insulation.

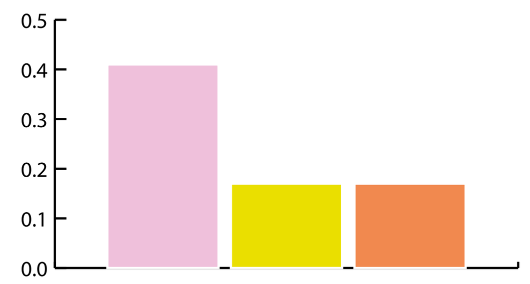
U-Values



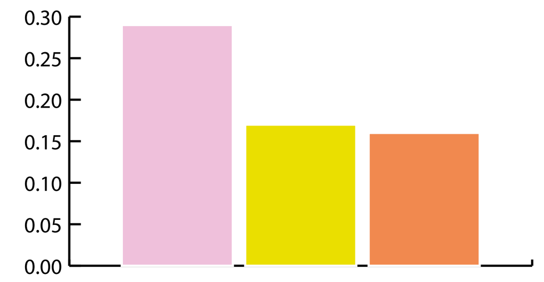
Hollow Block Window Head



Hollow Block Window Cill



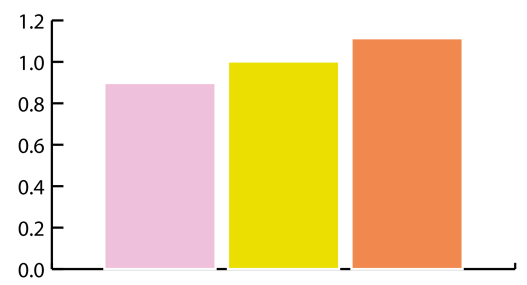
Hollow Block to Timber First Floor Junction



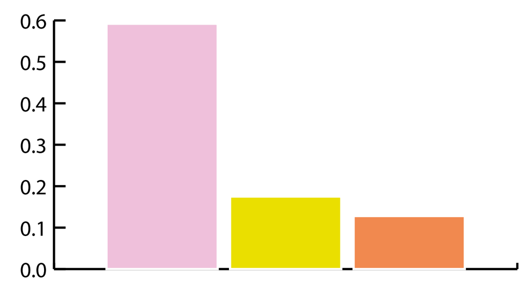
External Cavity Wall to Internal Concrete Wall

Psi Values

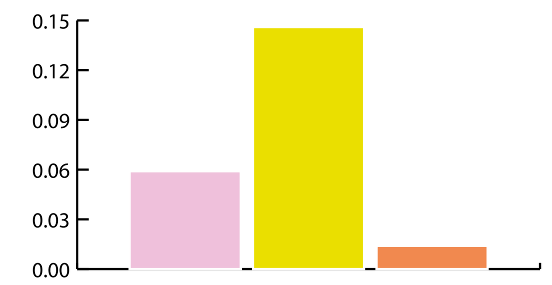
Hollow Block Window Head



Hollow Block Window Cill

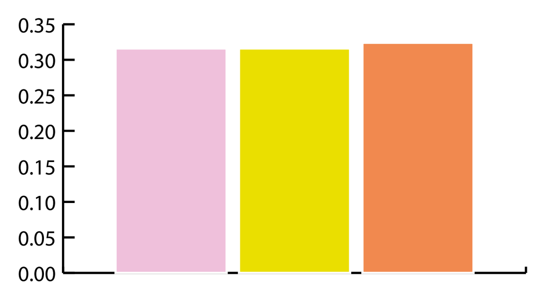


Hollow Block to Timber First Floor Junction

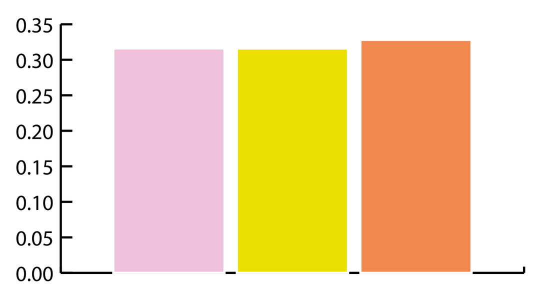


External Cavity Wall to Internal Concrete Wall

Frsi Values

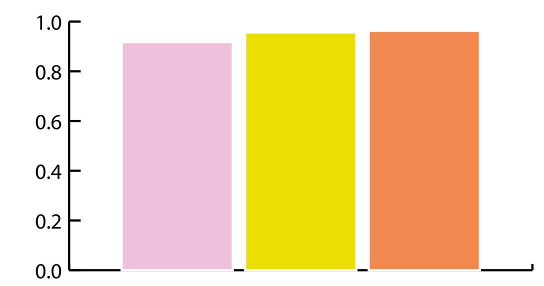


Hollow Block Window Head



Hollow Block Window Cill

Hollow Block to Timber First Floor Junction



External Cavity Wall to Internal Concrete Wall

Space Requirements

A private home must have a clear stair width of 800mm according to TGD K. The clear opening width of an access route according to TGD M is 900mm. The side passage would be considered an access route. These measurements are taken from the ground and first floor plans.

	Existing Insulation	Internal Insulation	External Insulation	Requirement
Stair Width (mm)	850	806	850	800
Side Passage Width (mm)	1024	1024	900	900

The stair and side passage width both comply with the Technical Guidance Documents.

Existing

Internal Insulation

External Insulation

Summary

0.18W/M2K

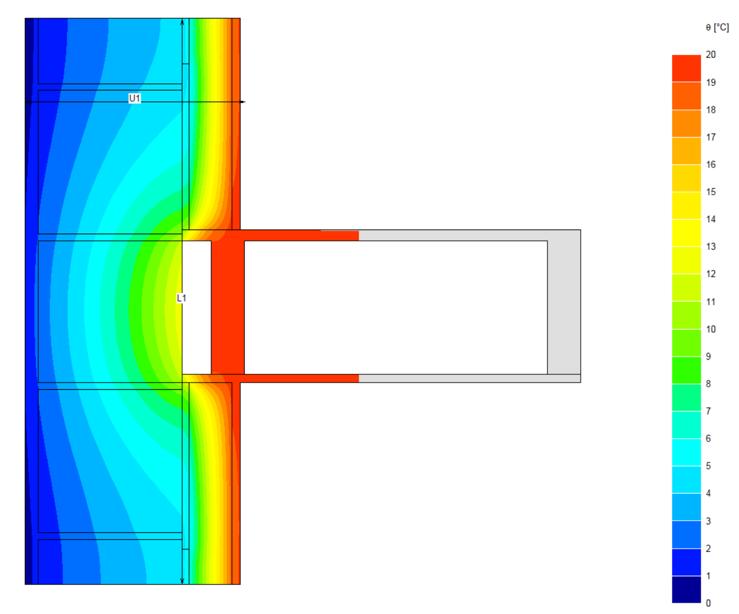
The maximum permitted U-Value in the 2022 Technical Guidance Documents.

0.75

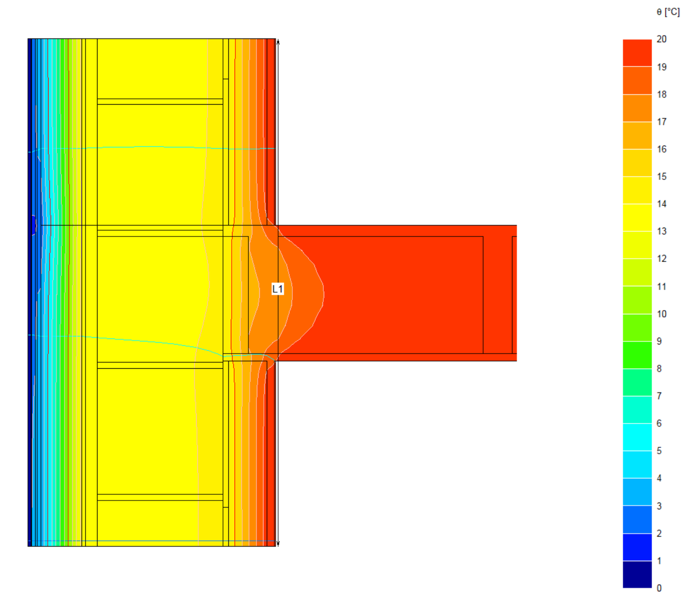
"A temperature factor lower than 0.75 suggests that surface condensation may become a risk" according to SR:54

The PSI Value depends on several factors such as the type of construction, target U-Value and junction area.

The Trisco diagrams indicates the hot and cold areas with red being the internal surface temperature at 20 degrees whist blue is the external surface temperature at 0 degrees. Between each of these the different shades are shown which all indicate different temperatures between these two different numbers. By improving the insulation in the building especially around the important junctions where the thermal bridges are present, this pushes the thermal line outwards decreasing the thermal bridge. This can be seen on the details where there are more red and yellow colours on the external and internal systems compared to the existing condition. For instance, the hollow block wall to timber first floor junction is much warmer in the external insulation condition compared to the existing condition.



Existing



External Insulation

External insulation meets the space requirements so there will be no issues with access after completing the external insulation retrofit.

Overall, I believe that the external insulation system is the best system to go with due to the superior thermal properties at key junctions compared to the internal insulation system. The risk of thermal bridging and surface condensation will be minimised in the home and more heat and energy will be retained.

S.R. 54 can be used to retrofit a typical detached home in Ireland by taking the principles of how the 4 junctions were thermally upgraded and measured and applying this to the other key junctions that were identified. Also, I believe the window cill detail needs to be redone with an aluminium cill replacing the concrete cill to reduce the thermal bridge. Also, the external cavity to internal concrete wall with internal insulation needs to be checked to see what the issue is with the Psi value being quite high.

This research can be applied to other types of homes identified in the Tabula Housing stock brochure for the Irish housing. As previously mentioned, there are multiple different house types the upgrade can apply to such as the semi-detached and terraced houses, bed-sits and flats. These building types are all different but they are all homes so the same principles of retrofitting apply. The semi-detached home is important to retrofit as it is the second most common house type according to the CSO.