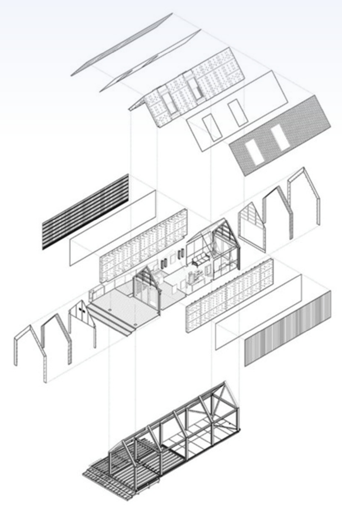
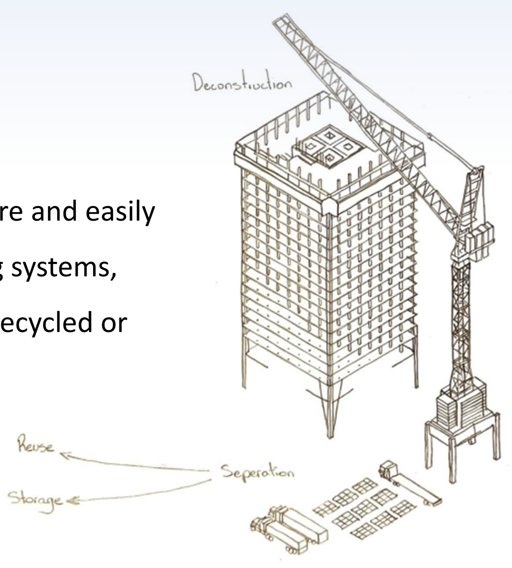
An investigation into applying Design for Disassembly Principals to an Emergency Accommodation Case Study Building in Ireland

INTRODUCTION



What is Design for Disassembly

- Design for disassembly is a comprehensive design technique, that when used correctly, can have a significant benefit in the construction of buildings. The intention of design for disassembly is to make any given product easy to disassemble into all its individual components.
- It's the process of creating structures that can be altered in the future and easily disassembled (completely or partially) for the purpose of recovering systems, components, and materials. This ensures that the structure can be recycled or reused as effectively as possible after its useful life.



AIM

The aim of this research is to carry out a detailed analysis into design for disassembly principals through a case study building to investigate its suitability for emergency accommodation

MOTIVATION

The building industry is responsible for 35% of the worlds waste.

Building industry is responsible for the use of up to 40% of the materials produced globally.

As of 19 December 2022, 67,000 refugees have arrived from Ukraine.

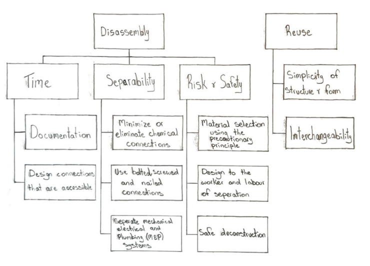
50,000 houses a year needed to match the goal of solve housing crisis in Ireland.

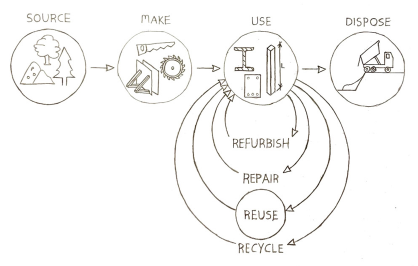
Taking architectural technology to the cutting edge of building design.

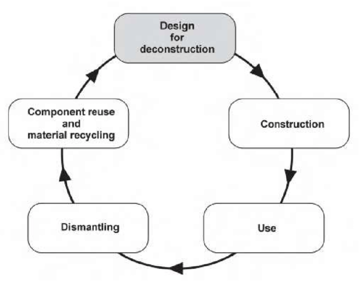
During pandemic (covid-19) extensions to hospitals took long time, fast-paced solutions needed.

OBJECTIVES

- A detailed investigation into the principles of design for disassembly and their applicability to emergency accommodation.
- Identify a suitable case study which will provide emergency accommodation. This case study will be used to test DFD principals.
- Investigate building systems, insulation types and foundation types to compare suitability for design for disassembly.
- Identify key details and measure the level of ease with which design for disassembly principles can be applied.

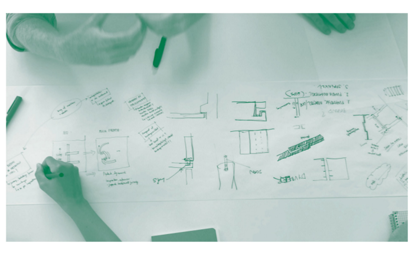






Is there a reason DFD isn't used more often?

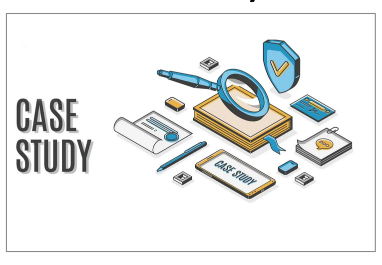
Design for disassembly requires a different way of thinking with much more planning at the design stage. As the design stage takes longer to complete, this essentially means it will also be more costly. Although the benefits afterwards totally outweigh the extra initial cost, this may be a factor in why DFD isn't a regular method of construction.



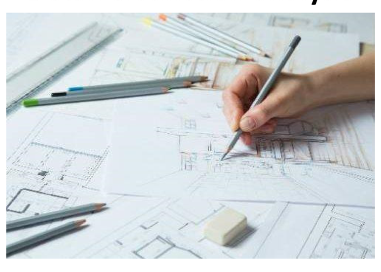
METHODOLOGY

Desktop Research

Case Study



Detail & Junction analysis



Desktop Research

Design for Disassembly analysis → Comprehensive literature review → Limitations of DFD → Analysis of DFD Principles

Case Study

- Selected suitable case study will be used to investigate and test DFD principals.
- Case study will used to carry out detailed analysis on potential construction materials and systems.
- Systems include; Foundation types, Floor types, Wall types and Roof types.

Detail & Junction analysis

- A selection of significant junctions will be selected. These junctions will be investigated through a series of sketches and then detailed to scale (1:5).
- All relevant details must be compliant with ACD's.
- U-value, thermal bridges and airtightness must be discussed.

Methodology Timeline

Data Collection → Data Reduction → Data Display → Drawing conclusion

Desktop Research → Development of Literature Question → Case Study Selection → Selection of Systems + Materials → Analysis of Details → Conclusion of Drawings

Design for Disassembly Construction Timeline

Native American Tipi
7500 BC

Mongolian yurt
424 BC

The Crystal Palace at Sydenham 1851
Joseph Paxton

Ferembal House 1948
Jean Prouvé

Better Days House 1956
Jean Prouvé

Cellophane House 2008
Kieran Timberlake

Bullitt Center 2012
Robert Hull

3XN Architects Offices 2014
Jan Ammundsen

The Future Arena 2016
LSFG Arquitetos Associados + AndArchitects

5 Principals of DFD

Materials

Choose materials with properties that ensure they can be reused

-Quality
-Healthy
-Pure

Service Lifetime

Design the building with the whole lifetime of the building in mind

-Layers
-Flexibility
-Interim

Standards

Design a simple building that fits into a larger context system

-Modularity
-Prefabrication
-Components

Connections

Choose reversible connections that tolerate repeated assembly and disassembly

-Accessible
-Mechanical
-Dissolvable

Deconstruction

As well as creating a plan for construction, design the building for deconstruction

-Strategy
-Stability
-Environment

For hundreds of years, people have extracted resources recklessly and then dumped them in landfills. Circular economy, on the other hand, focuses on reducing waste and energy consumption by allowing users to reclaim the components or materials used in the construction process. To complete the loop, various routes with varying environmental impact can be taken.

Connection Strategies

Overall approach There are a lot of different ways to make a product able to be disassembled. The main thing to remember is that when two or more components are put together, the connection must be reversible without damaging the components. This means that screws, splits, and nuts and bolts are favored over nails, as wells binders, like glue, are to be avoided.

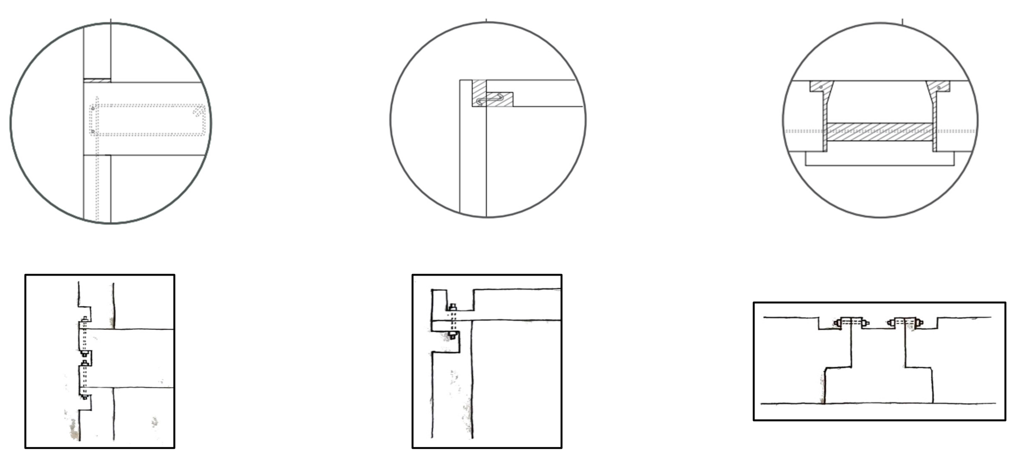
Connections

Below can be seen examples of current junction's vs design for disassembly junctions. It is important to note that all the optimal details have all joints easily accessible in order to provide easy disassembly. As well as easily accessible these joints also need to be separable without damaging any components.

Wall to Slab: | **Wall to Wall:** | **Slab to Beam:**

-Current Joints:

-Optimised Joints:



New separable joints using mechanical connections with nuts and bolts.

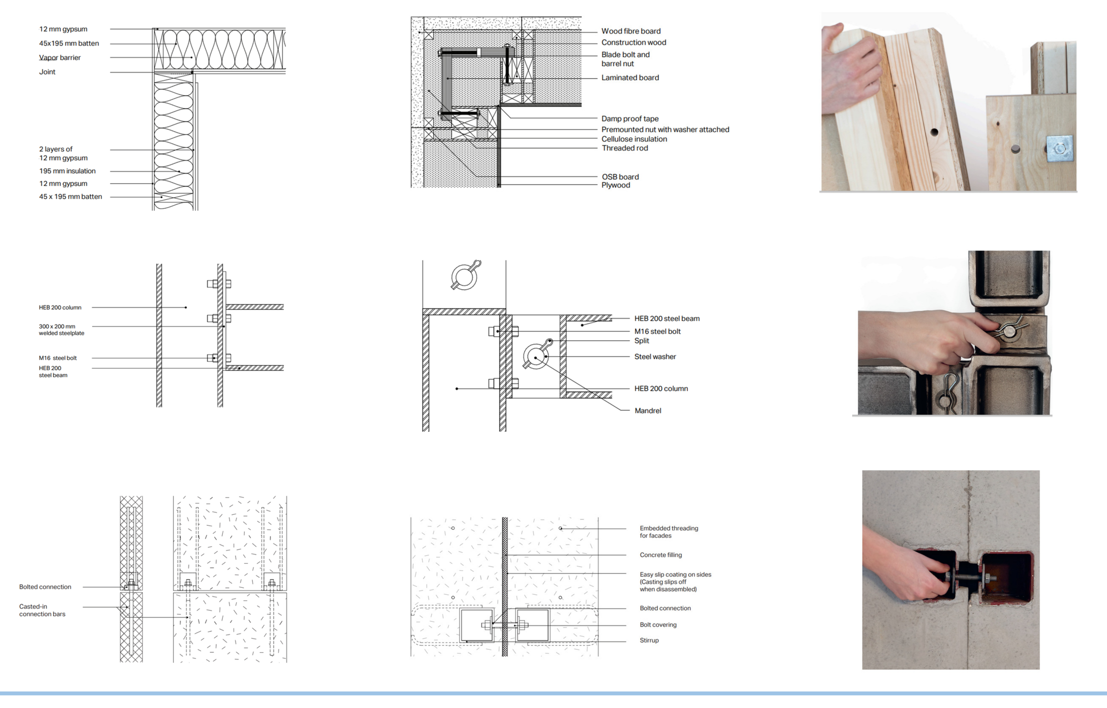
Details

Challenges: | **Solutions:**

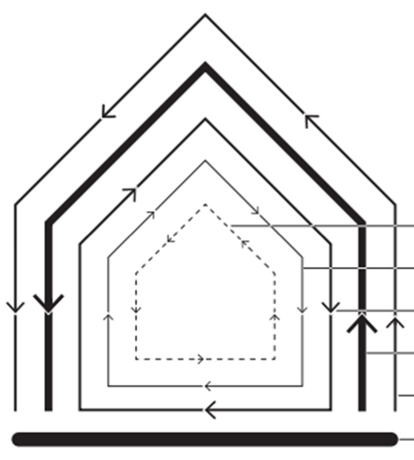
-Timber:

-Steel:

-Concrete:



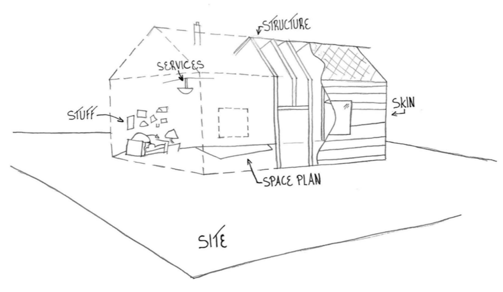
Understanding The Buildings Life



Brand's Six S's

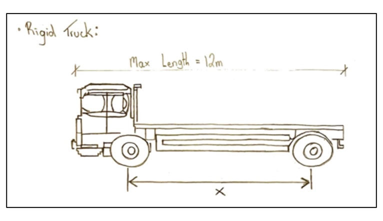
To apply the design for disassembly strategy to practice, we must first understand a buildings life. According to Stewart Brand in his book "How buildings learn", we can capture the essence of a building construction by understanding its different layers.

- Stuff (1+ Years)
- Space Plan (10+ Years)
- Services (10+ Years)
- Structure (50+ Years)
- Skin (30+ Years)
- Site (100+ Years)

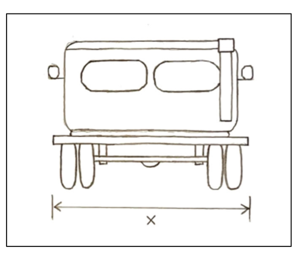


The theory of time-related building layers enables the division of a building's systems and parts into units with comparable life spans. The production of un-needed waste will be decreased as a result of effective replacements or upgrades by arranging for simple access and making materials or components with the shortest projected life cycle more accessible than longer ones

Transportation Limits

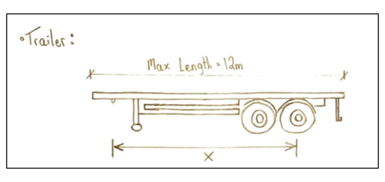


Max side overhang of 300mm each side of extreme projecting points on trailer / vehicle Overall width including load may not exceed 2.9m



Max width: 2.55m

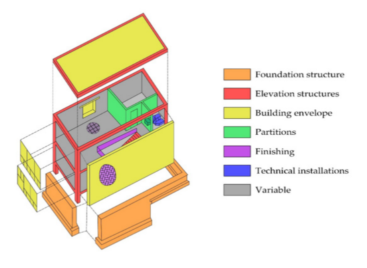
Axle Spacing (X):	Max Weight:
Less than 3m	16 Tonnes
More than 3m	18 Tonnes



Max Tonnes per meter (X):

5.5 Tonnes

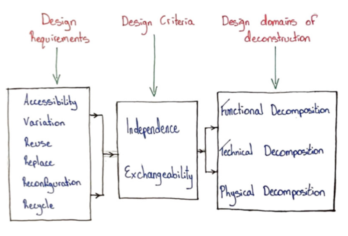
Max rear overhang of 3m. If this overhang is more than 1m, a warning device must be carried at the rear of the load.



Key Benefits of Deconstruction

- Value Creation
- Value Preservation
- Job Growth
- Material Saving
- Co2 Reduction

Key Indicators Of Reversibility



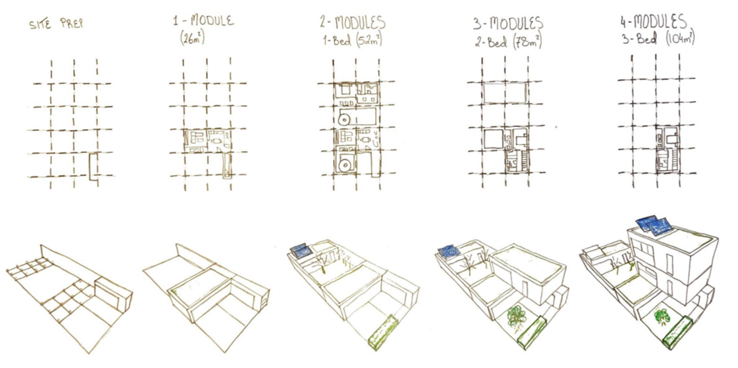
Case Study – Eco Cube

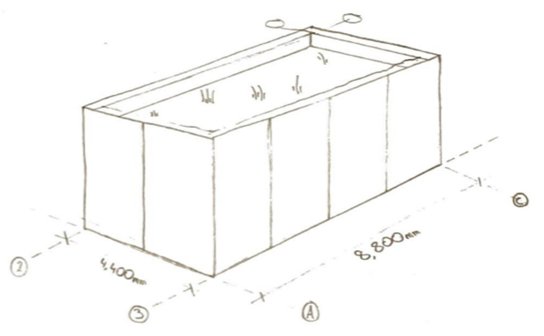
Modular homes are composed of modules that are assembled in a factory and delivered to the homesite in one or more trips.

The benefit of constructing modular home components in a factory is the controlled environment.

Volumetric Modular Assembly

Eco Cube Plans:



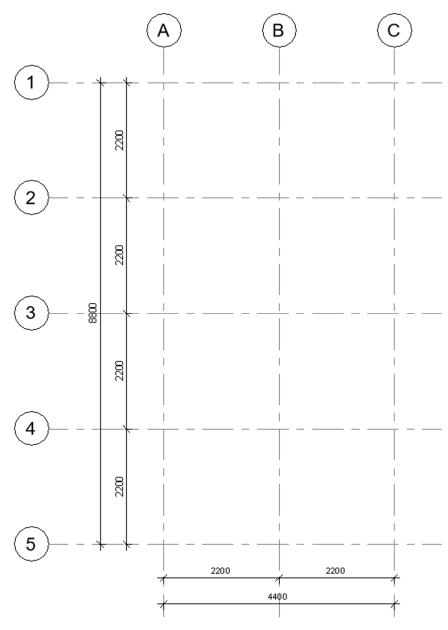


The Eco Cube is a simple rectangular modular construction which sits on an easily laid out grid of 8,800 x 4,400mm. It's a timber frame construction which is prefabricated in a factory. The Eco cube will be used as a case study to test if it can be constructed using DFD.

The grid system is essential in deploying DFD as accurate construction is necessary. The grid system is the foundation of any DFD design. The grid system also determines the organization of the buildings and an easier to work with grid systems allows for a multitude of layout possibilities.

As the Eco cube can be stacked, it can be adapted easily to the users needs, making it a perfect case study for an emergency accommodation. Each panel will be 2,200mm wide. Using this 2,200mm dimension allows for full versatility meaning any panel can be placed anywhere.

Wall = 12 Panels. Floor = 4 Panels. Roof = 4 Panels



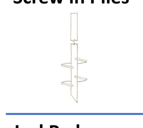
Applying DFD

DFD can be applied to any type of product in every scale with any level of complexity. Examples range from materials used in electronic devices, furniture, buildings or even complex engineering vehicles such as Formula 1 cars.

-The logistics of transporting the equipment of 10 teams to 20 races across 5 continents in a season of 9 months requires extreme fidelity and precision. These teams prove every year that the principals of DFD are possible although be it at a smaller scale then a building.

-During the design process its important to have in mind the maximum size each material can be while being transported.

Foundation Types

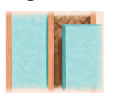
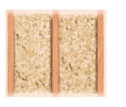
Name	Advantages	Disadvantages
Screw in Piles 	- Reversible & Reusable - Can be used in any soil type - Long lasting (75-year lifespan)	- Not usable on concrete - Torque limitation - Possibility of metal Corrosion
JackPad 	- Reversible & Reusable - Manufactured from recycled materials - Reduces installation time	- Not suited for soft soil - Possibility of uneven settlement - Susceptible to damage from earths movement
Concrete Raft 	- Shallow, less excavation - Suited to soil with low bearing capacity - Structure load distributed over larger area	- Non-reversible & reusable - Large amounts of reinforcement needed - Prone to edge corrosion

	Materials	Service Lifetime	Standards	Connections	Deconstruction	Total / 25
Steel Screw in Piles	3	5	5	5	5	23 A
Jackpads	5	5	5	3	3	21 A
Concrete Raft	1	1	1	1	1	5 D

5 = Good 3 = Average 1 = Poor

The foundation is the lowest part of a building structure that is directly in contact with the ground and safely transfers loads from the structure to the ground. Selecting the correct foundation type for this case study is the first and arguably the most important step during the design process. The foundation is the base of the structure, and it ties the building together.

Insulation Types

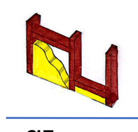
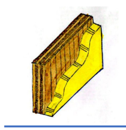
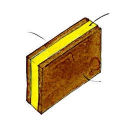
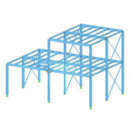
Name	Advantages	Disadvantages
Mineral Wool 	- Hydrophobic, won't absorb water - High sound proofing properties. - Fully recyclable	- Health risk during installation - Not biodegradable - Costly, extensive manufacturing process
Fiberglass 	- Flexibility (pre-cut/rolls/loose-fill) - Made from recycled materials - High sound proofing properties	- Moisture absorbent - Possibility of mould growth due to moisture - Can deteriorate, sag or settle
Rigid Foam 	- Can come moisture resistant - Durable - Lightweight	- Difficult to tight fit at edges - Taped at joints to prevent airflow - Not fire resistant
Cellulose 	- Fire resistant - Mould resistant - Great pest control	- Prone to sagging and setting - Moisture absorbent - Health risk during installation
SIP 	- Lightweight - Flexible design - Pest resistant	- Prone to moisture damage - Limited durability - Requires additional ventilation
Spray Foam 	- Expensive installation - Prevents air + moisture infiltration - Expands to all cracks/corners	- Non reusable - Too airtight - Hidden termite damage

	Materials	Service Lifetime	Standards	Connections	Deconstruction	Total / 25
Mineral Wool	5	5	5	3	3	21 A
Fiberglass	5	5	5	3	3	21 A
Rigid Foam	3	5	5	5	5	23 A
Cellulose	5	5	5	3	3	21 A
SIP	1	3	3	5	1	13 C
Spray Foam	1	1	3	1	1	7 D

5 = Good 3 = Average 1 = Poor Density High=good

Building insulation is a material used in buildings to reduce thermal energy flow. When choosing from possible insulation types, DFD requires the insulation to be durable, reusable, suitable for the building function and have a long lifespan.

Structure Types

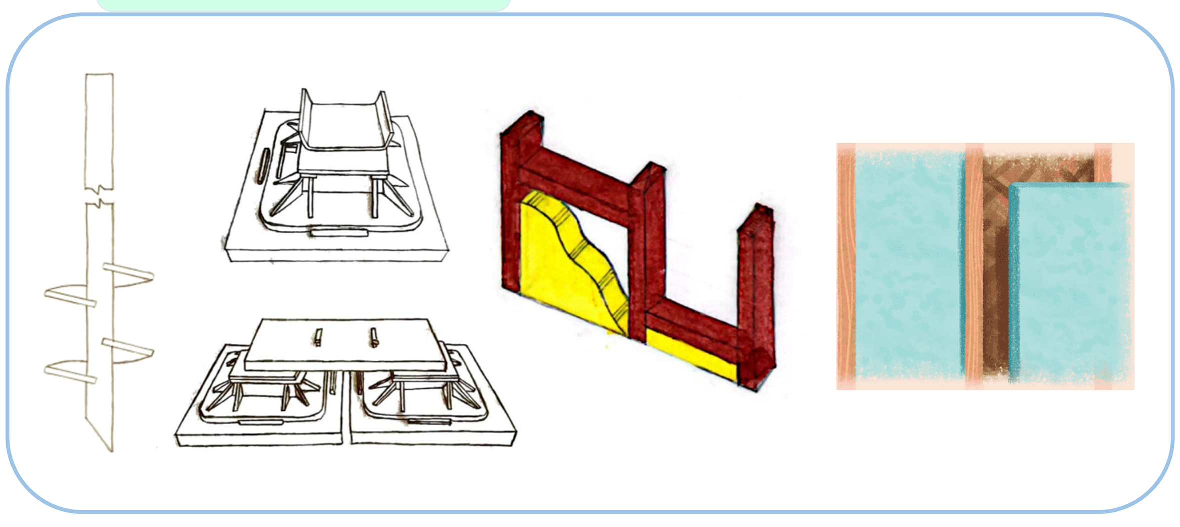
Name	Advantages	Disadvantages
Timber Stud 	- Stronger than metal stud - Low embodied carbon - Easily Recyclable & Reusable	- Potential to rot when exposed to water - Low Horizontal strength - Sound travels more easily
CLT 	- Strong lightweight material - Reusable - Light mass = good acoustic performance	- Potential moisture damage - Few CLT manufactures – High cost - Restrictions on building heights
SIP 	- Exceptional Insulation - Fast build time (easy connections) - Foam less prone to pest infection	-Reusable although non reusable -Require extra ventilation -Low lifetime
Steel 	-Flexibility & Adaptability -Lightweight & Strong -Easily Reusable	-High maintenance costs -High fireproofing costs -Low thermal conductivity
Concrete 	-Immense strength & Durability -Easily molded -Temperature resistant	-Expensive -Weak tensile strength -Low strength to weight ratio

	Materials	Service Lifetime	Standards	Connections	Deconstruction	Total / 25
Timber Stud	5	5	5	5	5	25 A
CLT	5	5	3	3	3	19 B
SIP	1	1	3	5	3	13 C
Steel	3	5	5	5	5	23 A
Concrete	1	1	3	3	1	9 D

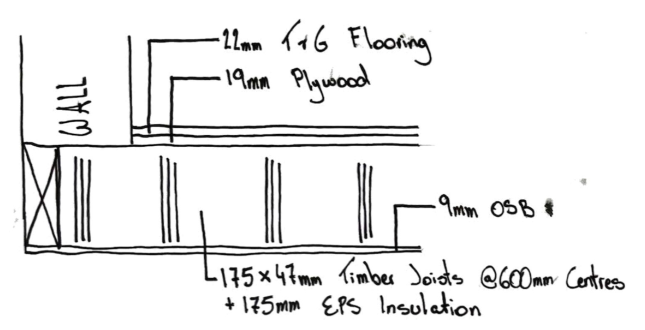
5 = Good 3 = Average 1 = Poor

A structure is a physical construction built on land for a specific purpose. It is the first and most important stage of any building construction, following the foundation. The structure is the main body of the building, it's the main construction which holds the load and feeds it to the foundation. The structure of a building must comply with DFD principles, therefore the material selected for the structure must be easily reusable, reversible and suit the purpose of the building.

Selected Materials



System 1 - Floor



Step 01: Collect all the information. Bridged layer highlighted here in pink.

		Thickness (m)	Conductivity (W/mK)	R-Value
Rsi	Internal Surface			0.170
	T&G Flooring	0.022	0.160	0.138
	Plywood	0.019	0.130	0.146
	175mm Timber Joists	0.175	0.130	1.346
	175mm EPS Insulation between Joists	0.175	0.021	8.333
	OSB	0.009	0.130	0.069
	Insulation over Joists	0.000	0.022	0.000
Rse	External Resistance			0.040

Step 02: Calulate the Upper Resistance

Resistance 1: through section containing layers of Insulation.

Internal Surface			0.170
T&G Flooring	0.022	0.160	0.138
Plywood	0.019	0.130	0.146
175mm EPS Insulation between Joists	0.175	0.021	8.333 Ris
OSB	0.009	0.130	0.069
Insulation over Joists	0.000	0.022	0.000
External Resistance			0.040
Resistance (R1)			**8.896**
Fractional Area (F1)	**0.900**		

Resistance 2: through section containing layers of timber joists

Internal Surface			0.170
T&G Flooring	0.022	0.160	0.138
Plywood	0.019	0.130	0.146
175mm Timber Joists	0.175	0.130	1.346 Rt
OSB	0.009	0.130	0.069
Insulation over Joists	0.000	0.022	0.000
External Resistance			0.040
Resistance (R2)			**1.909**
Fractional Area (F2)	**0.100**		

F1 and F2 are the fractional areas of flow paths 1 and 2. If you take 1 metre you will have two 44 joists in that space. Ratio is 88mm timber : 912mm insulation which is a ratio of 0.09 : 0.91 or 9% timber and 91% Insulation

Total Upper Resistance (Ru) = 1/(F1/R1 +F2/R2) **6.513 m2K/W**

Step 03: Calulate the Lower Resistance

Total Lower Resistance (Rl)

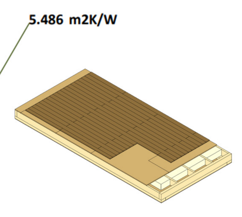
Calculate the Bridged Layer

Rb = 1/ (Fins/Ris + Ft/Rt)

Rb = 1/ (0.91/2.500 + 0.09/0.769) **5.486 m2K/W**

Substituting the bridged layer in to get the total lower resistance

Internal Surface	0.170
T&G Flooring	0.138
Plywood	0.146
Bridged Layer	5.486
OSB	0.069
Insulation over Joists	0.000
External Resistance	0.040
Total Lower Resistance	**6.049 m2K/W**



Step 04: Calulate Total Resistance and U-Value

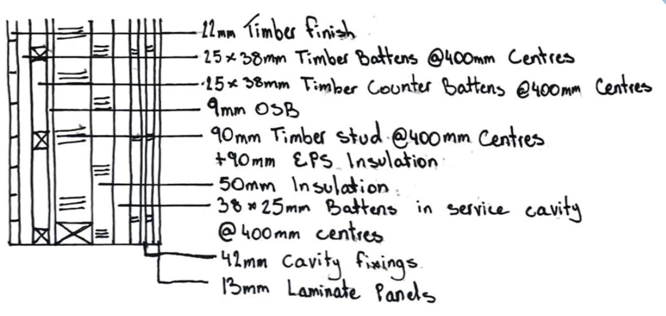
Rt = (Ru +RL) / 2 **6.281 m2K/W**

Rt = (6.438 + 6.221) / 2

U-Value 1/R

1/ 6.329 **0.16** W/m2K

System 2 – Wall



Step 01: Collect all the information. Bridged layer highlighted here in pink.

		Thickness (m)	Conductivity (W/mK)	R-Value
Rsi	Internal Surface			0.130
	13mm Laminate panel	0.013	0.130	0.100
	42mm Cavity with fixings	0.042		0.180
	service cavity	0.038		0.180
	timber in service cavity	0.038	0.130	0.292
	Timber studs	0.090	0.130	0.692
	EPS Insulation between studs	0.090	0.021	4.286
	EPS	0.050	0.021	2.381
	9mm OSB	0.009	0.130	0.069
	25mm Timber Counter Battens	0.025	0.130	0.192
	25mm Timber Battens	0.025	0.130	0.192
	22mm Timber Finish	0.022	0.130	0.169
Rse	External Resistance			0.040

Step 02: Calulate the Upper Resistance

Resistance 1: through section containing layers of Insulation and air cavity

Internal Surface	0.130
13mm Laminate panel	0.100
42mm Cavity with fixings	0.180
service cavity	0.180
EPS Insulation between Joists	4.286 Ris
EPS	2.381
9mm OSB	0.069
25mm Batten Cavity	0.180
25mm Batten Cavity	0.180
22mm Timber Finish	0.169
External Resistance	0.040
Resistance (R1)	**7.895**
Fractional Area (F1)	**0.900**

Resistance 2: through section containing layers of timber joists and battens

Internal Surface	0.130
13mm Laminate panel	0.100
42mm Cavity with fixings	0.180
batten	0.292
Timber studs	0.692 Rt
EPS	2.381
9mm OSB	0.069
25mm Timber Counter Battens	0.192
25mm Timber Battens	0.192
22mm Timber Finish	0.169
External Resistance	0.040
Resistance (R2)	**4.439**
Fractional Area (F2)	**0.100**

F1 and F2 are the fractional areas of flow paths 1 and 2. If you take 1 metre you will have two 38 studs in that space. Ratio is 88mm timber : 912mm insulation which is a ratio of 0.09 : 0.91 or 9% timber and 91% Insulation

Total Upper Resistance (Ru) = 1/(F1/R1 +F2/R2) **7.325 m2K/W**

Step 03: Calulate the Lower Resistance

Total Lower Resistance (Rl)

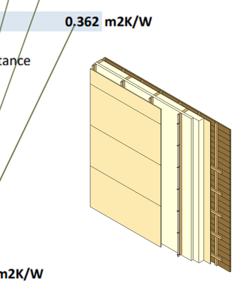
Calculate the Bridged Layer **0.187** m2K/W

Rb = 1/ (Fins/Ris + Ft/Rt) **2.821** m2K/W

Rb = 1/ (0.91/2.500 + 0.09/0.769) **0.362** m2K/W

Substituting the bridged layer in to get the total lower resistance

Internal Surface	0.130
13mm Laminate panel	0.100
Bridged Layer	0.187
Bridged Layer	2.821
EPS	2.381
9mm OSB	0.069
Bridged Layer	0.362
22mm Timber Finish	0.169
External Resistance	0.040
Total Lower Resistance	**6.260 m2K/W**



Step 04: Calulate Total Resistance and U-Value

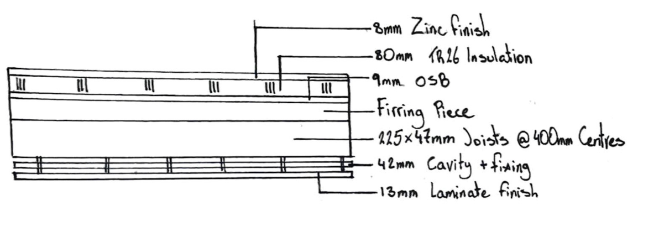
Rt = (Ru +RL) / 2 **6.792 m2K/W**

Rt = (6.438 + 6.221) / 2

U-Value 1/R

1/ Resistance **0.15** W/m2K

System 3 - Roof



Step 01: Collect all the information. Bridged layer highlighted here in pink.

		Thickness (m)	Conductivity (W/mK)	R-Value
Rsi	Internal Surface			0.170
	13mm Laminate panel	0.022	0.160	0.138
	42mm Cavity with fixings	0.042	0.130	0.323
	150mm Timber Joists	0.225	0.130	1.731
	150mm EPS Insulation between Joists	0.000	0.021	0.000
	Firring Piece	0.065	0.130	0.500
	9mm OSB	0.009	0.130	0.069
	150mm Mineral Wool Insulation over Joists	0.120	0.022	5.455
	8mm Zinc	0.008	60.000	0.000
	Roof Space			
Rse	External Resistance			0.040

Step 02: Calulate the Upper Resistance

Resistance 1: through section containing layers of Insulation.

Internal Surface			0.170
13mm Laminate panel	0.022	0.160	0.138
42mm Cavity with fixings	0.019	0.130	0.146
150mm EPS Insulation between Joists	0.000	0.021	0.180 Ris
Air Cavity between joists	0.225		0.180
Firring Piece	0.065	0.130	0.180
9mm OSB	0.009	0.130	0.069
150mm Mineral Wool Insulation over Joists	0.120	0.022	5.455
8mm Zinc	0.008	60.000	0.000
Roof Space			
External Resistance			0.040
Resistance (R1)			**6.558**
Fractional Area (F1)	**0.900**		

Resistance 2: through section containing layers of timber joists

Internal Surface			0.170
13mm Laminate panel	0.022	0.160	0.138
42mm Cavity with fixings	0.019	0.130	0.146
150mm Timber Joists	0.225	0.130	1.731 Rt
Firring Piece	0.065	0.130	0.500
9mm OSB	0.009	0.130	0.069
150mm Mineral Wool Insulation over Joists	0.120	0.022	5.455
8mm Zinc	0.008	60.000	0.000
Roof Space			
External Resistance			0.040
Resistance (R2)			**8.248**
Fractional Area (F2)	**0.100**		

F1 and F2 are the fractional areas of flow paths 1 and 2. If you take 1 metre you will have two 44 joists in that space. Ratio is 88mm timber : 912mm insulation which is a ratio of 0.09 : 0.91 or 9% timber and 91% Insulation

Total Upper Resistance (Ru) = 1/(F1/R1 +F2/R2) **6.695 m2K/W**

Step 03: Calulate the Lower Resistance

Total Lower Resistance (Rl)

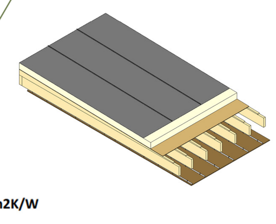
Calculate the Bridged Layer

Rb = 1/ (Fins/Ris + Ft/Rt)

Rb = 1/ (0.91/2.500 + 0.09/0.769) **0.198 m2K/W**

Substituting the bridged layer in to get the total lower resistance

Internal Surface	0.170
13mm Laminate panel	0.138
42mm Cavity with fixings	0.146
Bridged Layer	0.198
Firring Piece	0.500
9mm OSB	0.069
150mm Mineral Wool Insulation over Joists	5.455
8mm Zinc	0.000
Roof Space	0.000
External Resistance	0.040
Total Lower Resistance	**6.715 m2K/W**



Step 04: Calulate Total Resistance and U-Value

Rt = (Ru +RL) / 2 **6.705 m2K/W**

Rt = (6.438 + 6.221) / 2

U-Value 1/R

1/ 6.329 **0.15** W/m2K

TGD Part-L

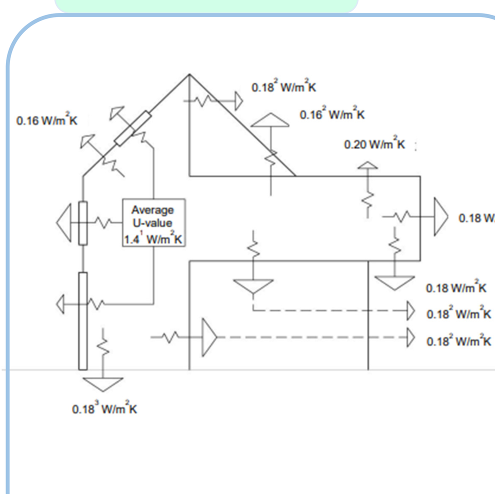


Table 1	Maximum elemental U-value (W/m^2K)[1, 2]	
Column 1 Fabric Elements	Column 2 Area-weighted Average Elemental U-value (Um)	Column 3 Average Elemental U-value – individual element or section of element
Roofs Pitched roof - Insulation at ceiling - Insulation on slope	 0.16 0.16	0.3
Flat roof	0.20	
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

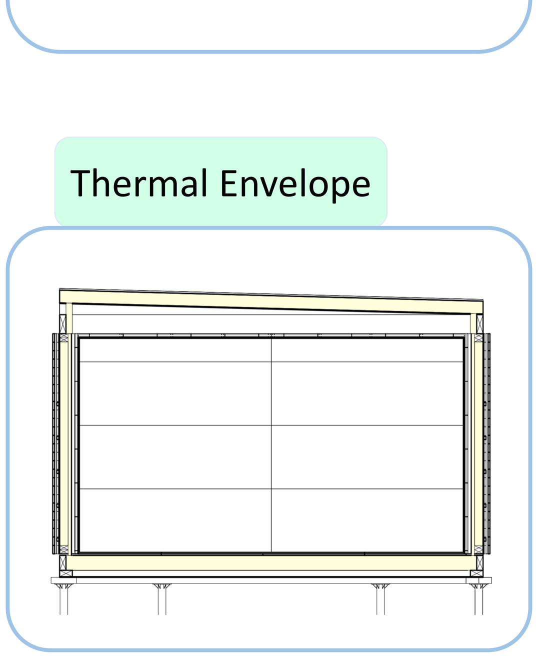
Floor U-Value: 0.16 W/m^2K

Wall U-Value : 0.15 W/m^2K

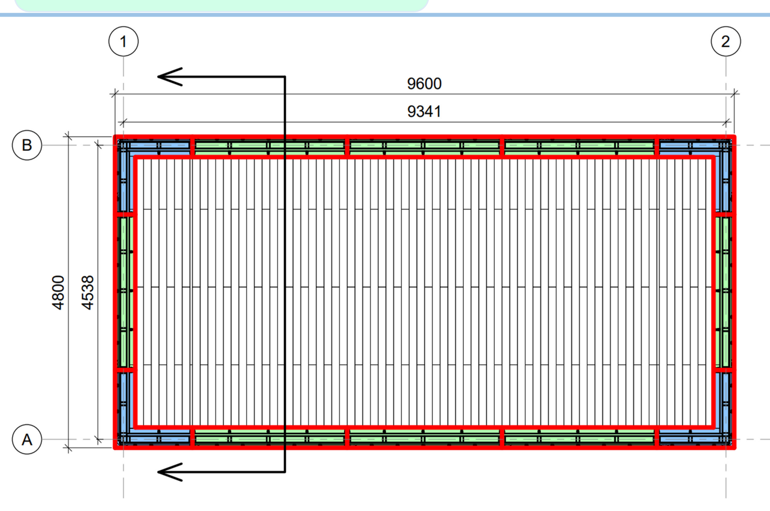
Roof U-Value: 0.15 W/m^2K

All three systems meet backstop U-Values from TGD part L

Thermal Envelope



Panel System



- Wall Panel A = 2400mm (8)
- Wall Panel B = 1200x1200mm (4)

Floor Panel A = 2400mm (3)
Floor Panel B = 1200mm (2)

Roof Panel A = 2400mm (3)
Roof Panel B = 1200mm (2)

Detail Rubric System

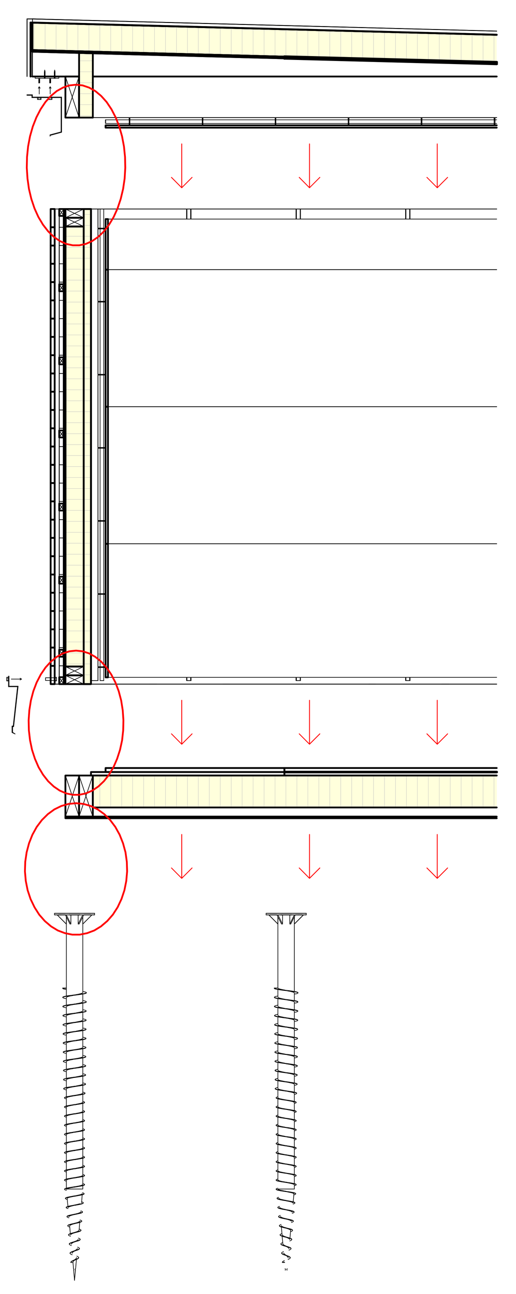
Accessibility	Reusability	Strength	Durability	Simplicity
- Access time	- Material	- Material	- Material	- Amount of parts
- Components	- Quality	- Flexibility	- Mechanical	- Prefabrication
- Ease of access	- Deconstruction	- Connection	- Reusability	- Strategy

5 = Good 3 = Average 1 = Poor Total / 25

A = 20-25
B = 15-19
C = 10-14
D = 5-9

Rubric system will allow for a deep analysis of every specific detail. Each detail to be analysed and investigated under all five headings and given a grade. Grades consist of **Good**, **Average** and **Poor**. Depending on the detail and systems used, highest graded details may not be the required or best details depending on scenario. Rubric only used as guidance to grade details under the five headings provided.

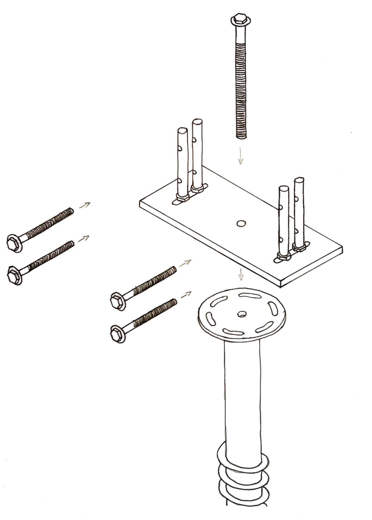
System Placement



1 1.20 Section Exploded
1 : 20

1.5 junction Details

Legend:
Breather Membrane (BM)
Vapour Control Layer (VCL)
Roofing membrane (EPDM)



Wall System:
- 22mm Timber horizontal cladding.
- 25x38mm Timber battens @400mm centres.
- 25x38mm Timber counter battens @ 400mm centres.
- 9mm OSB board.
- 90mm Timber stud @400mm centres with EPS full fill insulation.
- 50mm EPS insulation.
- 38mm Service cavity with 38x25mm timber battens @400mm centres.
- 42mm Fixing area.
- 13mm Timber laminate panels

Floor System:
- 22mm T&G Flooring.
- 19mm Plywood board.
- 225x75mm Timber joists @400mm centres with 175mm EPS insulation.
- 75x150mm Base plate at edges.
- 9mm OSB board

3mm Steel flashing fixed using bolt and nut connection

6mm Steel angle factory fitted to wall

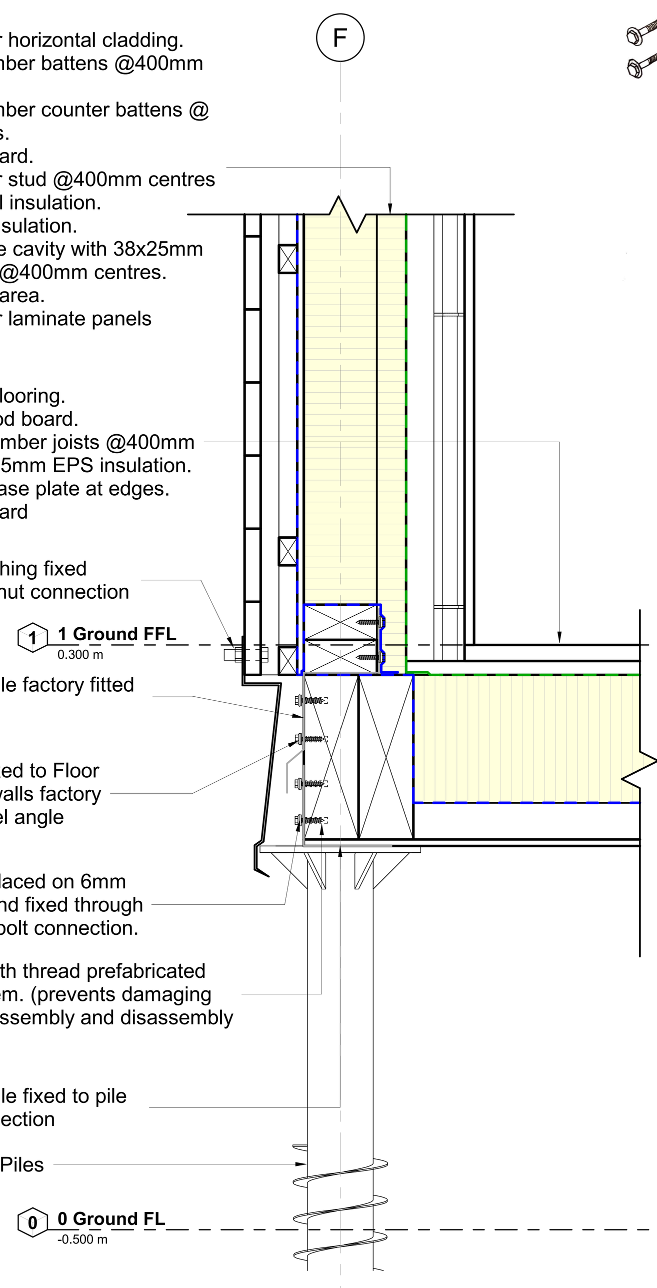
Wall system fixed to Floor system using walls factory fitted 6mm steel angle

Floor system placed on 6mm steel bracket and fixed through the side using bolt connection.

Steel sleeve with thread prefabricated into Floor system. (prevents damaging timber during assembly and disassembly

6mm Steel angle fixed to pile using bolt connection

Steel Screw in Piles



2 1.5 Wall - Floor Junction 1
1 : 5

	Accessibility	Reusability	Strength	Durability	Simplicity	Total / 25
Detail	5	3	3	3	5	19 B

5 = Good 3 = Average 1 = Poor

Steel threaded rods prefabricated in wall system. Wall + Rods fixed to Floor below using nuts.

Bolt and nut connection used to keep steel rod in place. (Factory fitted)

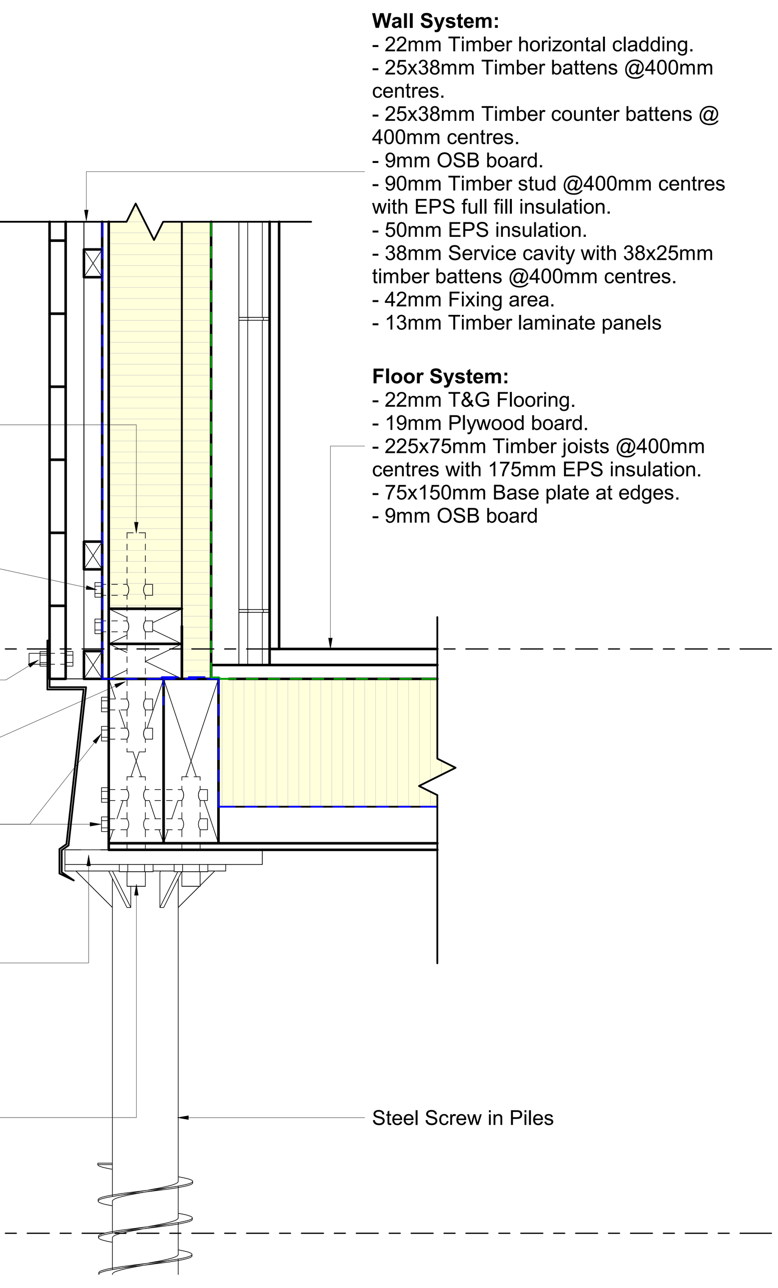
3mm Steel flashing fixed using bolt and nut connection

BM Tapped at Rod

Bolt and nut connection through steel rods used to keep Wall and Floor in place. (Accessible on site)

20mm Steel Plate fixed to pile using threaded bolt connction

Steel threaded rods Factory fitted in floor system. Floor + Rods fixed to Steel plate below using nuts



Wall System:
- 22mm Timber horizontal cladding.
- 25x38mm Timber battens @400mm centres.
- 25x38mm Timber counter battens @ 400mm centres.
- 9mm OSB board.
- 90mm Timber stud @400mm centres with EPS full fill insulation.
- 50mm EPS insulation.
- 38mm Service cavity with 38x25mm timber battens @400mm centres.
- 42mm Fixing area.
- 13mm Timber laminate panels

Floor System:
- 22mm T&G Flooring.
- 19mm Plywood board.
- 225x75mm Timber joists @400mm centres with 175mm EPS insulation.
- 75x150mm Base plate at edges.
- 9mm OSB board

Steel Screw in Piles

3 1.5 Wall - Floor Junction 2
1 : 5

	Accessibility	Reusability	Strength	Durability	Simplicity	Total / 25
Detail	5	5	5	3	5	23 A

5 = Good 3 = Average 1 = Poor

Roof System:
- 8mm Zinc finish.
- 80mm TR26 Insulation.
- 9mm OSB board.
- Timber Firring piece.
- 225x47mm Joists @400mm centers.
- 42mm Fixing area.
- 13mm Timber laminate panels

75mm Perimeter Insulation

Steel sleeve with thread prefabricated into Roof system. (prevents damaging timber during assembly and disassembly

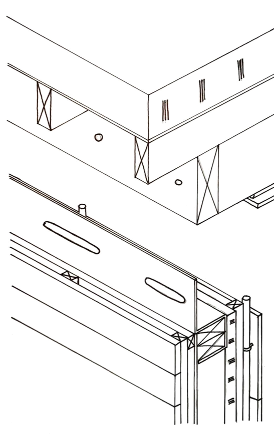
4mm Steel plate factory fixed to firring piece using screws. Steel plate prefabricated with steel bolts underneath.

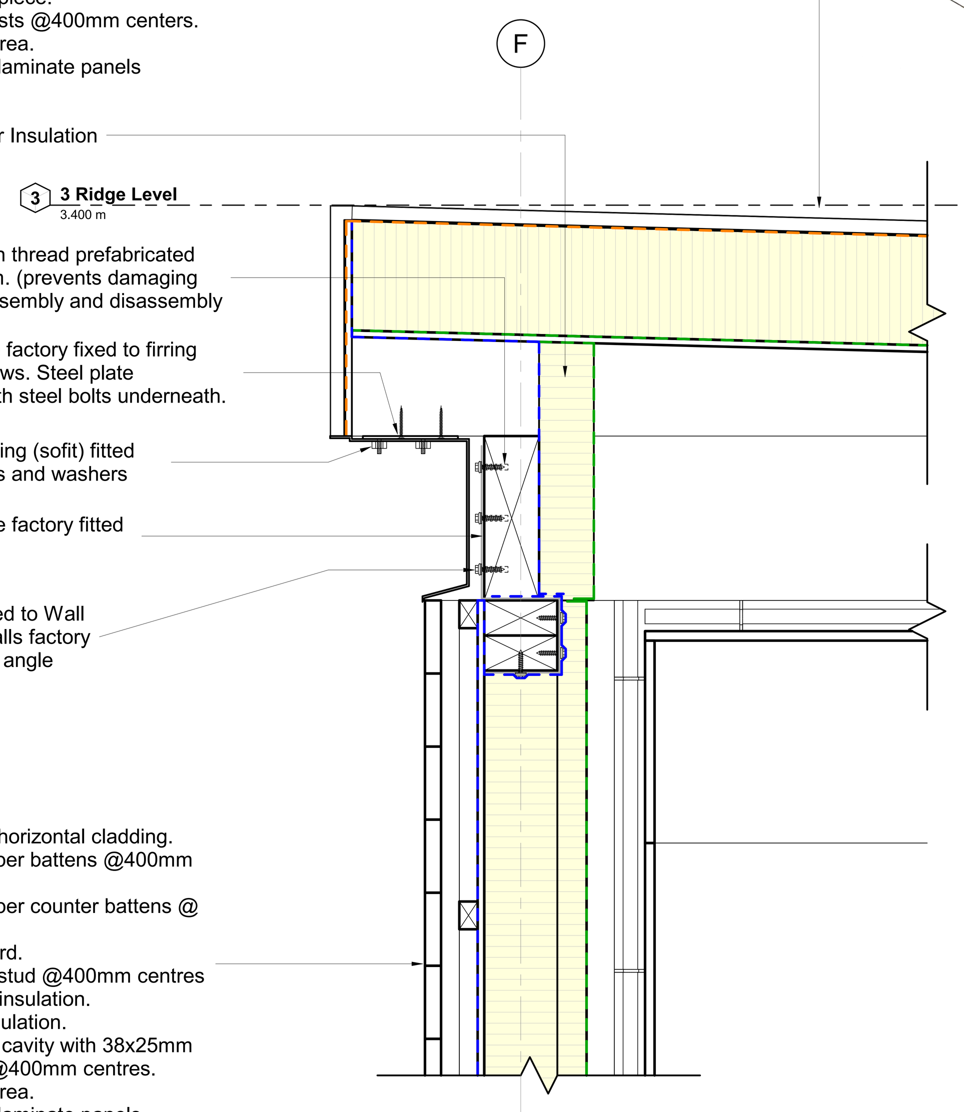
3mm Steel flashing (sofit) fitted onsite using nuts and washers

6mm Steel angle factory fitted to wall

Roof system fixed to Wall system using walls factory fitted 6mm steel angle

Wall System:
- 22mm Timber horizontal cladding.
- 25x38mm Timber battens @400mm centres.
- 25x38mm Timber counter battens @ 400mm centres.
- 9mm OSB board.
- 90mm Timber stud @400mm centres with EPS full fill insulation.
- 50mm EPS insulation.
- 38mm Service cavity with 38x25mm timber battens @400mm centres.
- 42mm Fixing area.
- 13mm Timber laminate panels





1 1.5 Wall - Roof Junction 1
1 : 5

	Accessibility	Reusability	Strength	Durability	Simplicity	Total / 25
Detail	5	3	3	3	5	19 B

5 = Good 3 = Average 1 = Poor

Roof System:
- 8mm Zinc finish.
- 80mm TR26 Insulation.
- 9mm OSB board.
- Timber Firring piece.
- 225x47mm Joists @400mm centers.
- 42mm Fixing area.
- 13mm Timber laminate panels

75mm Perimeter Insulation

Steel threaded rods prefabricated in wall system. Roof fixed to Wall + Rods fixed using nuts.

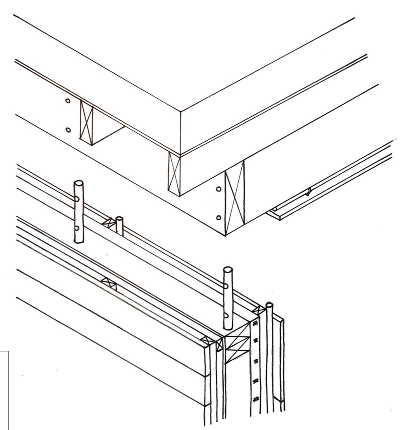
4mm Steel plate factory fixed to firring piece using screws. Steel plate prefabricated with steel bolts underneath.

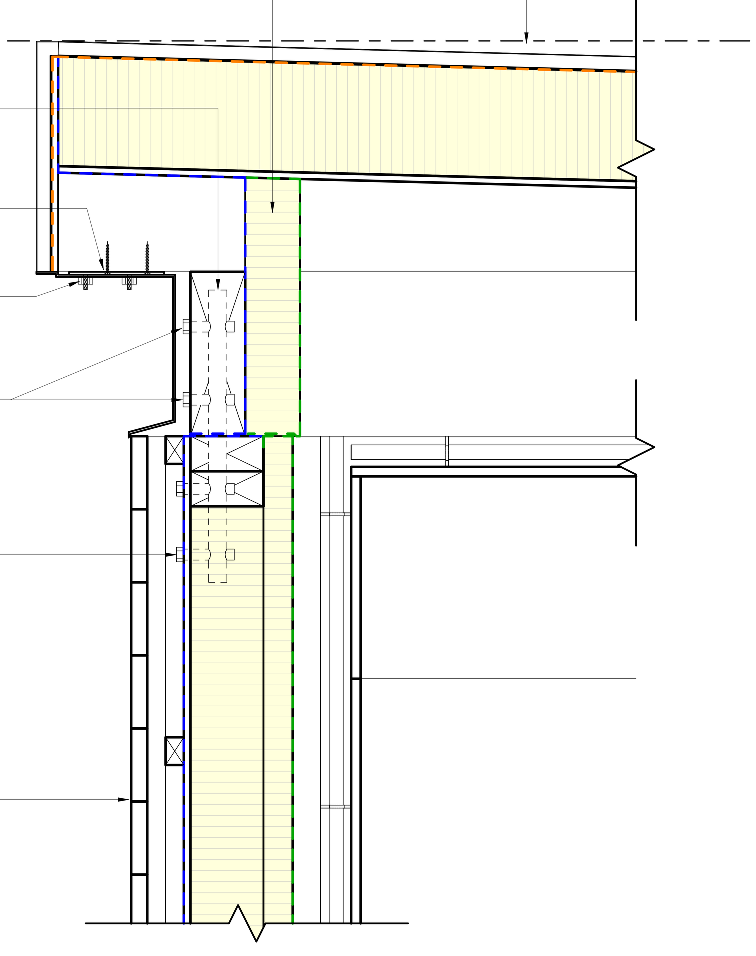
3mm Steel flashing (sofit) fitted onsite using nuts and washers

Bolt and nut connection through steel rod used to keep Roof in place. (Accessible on site)

Bolt and nut connection used to keep steel rod in place. (Factory fitted)

Wall System:
- 22mm Timber horizontal cladding.
- 25x38mm Timber battens @400mm centres.
- 25x38mm Timber counter battens @ 400mm centres.
- 9mm OSB board.
- 90mm Timber stud @400mm centres with EPS full fill insulation.
- 50mm EPS insulation.
- 38mm Service cavity with 38x25mm timber battens @400mm centres.
- 42mm Fixing area.
- 13mm Timber laminate panels

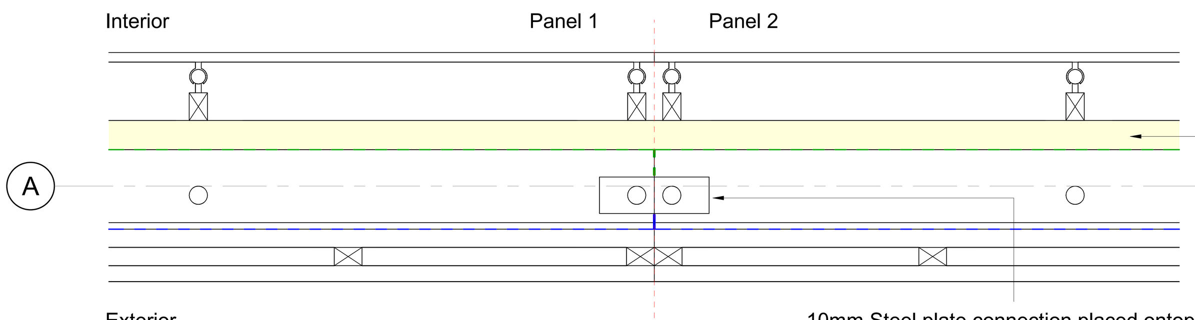




2 1.5 Wall - Roof Junction 2
1 : 5

	Accessibility	Reusability	Strength	Durability	Simplicity	Total / 25
Detail	5	5	5	3	5	23 A

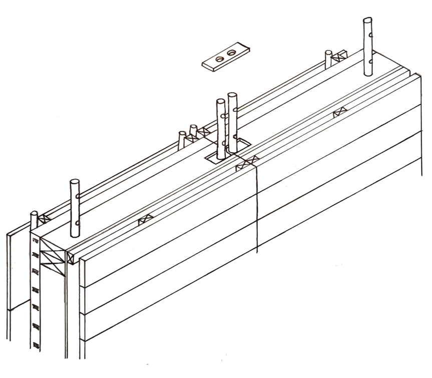
5 = Good 3 = Average 1 = Poor



10mm Steel plate connection placed ontop of rods. Extra support as walls fixed in place using Floor system + Foundation system

1 Panel to panel connection
1 : 5

Wall System:
- 22mm Timber horizontal cladding.
- 25x38mm Timber battens @400mm centres.
- 25x38mm Timber counter battens @400mm centres.
- 9mm OSB board.
- 90mm Timber stud @400mm centres with EPS full fill insulation.
- 50mm EPS insulation.
- 38mm Service cavity with 38x25mm timber battens @400mm centres.
- 42mm Fixing area.
- 13mm Timber laminate panels



	Accessibility	Reusability	Strength	Durability	Simplicity	Total / 25
Detail	1	5	3	5	5	19 B

5 = Good 3 = Average 1 = Poor

Conclusion

- In order to best select each system type, DFD principals must be investigated. These principals must be thoroughly analysed and used to compare system suitability for DFD. To best achieve this, a rubric system was created. The rubric created for the system types uses five main headings; **Materials**, **Service Lifetime**, **Standards**, **Connections** and **Deconstruction**.

- As the junctions and connections are a significant part of DFD, a second rubric system was needed to analyse DFD detail suitability. The second rubric system used different headings; **Accessibility**, **Reusability**, **Strength**, **Durability** and **Simplicity**.

- Although the rubric systems will provide a grade ranging from A to D in relation to DFD, it is also important to analyse the purpose of the given project, system or detail.

*Rubric used as guidance

Further Research

- Although the rubrics used provides guidance on suitability under each specific heading, it may be said the current rubric needs further research. Currently each rubric is measured out of twenty-five marks with each heading weighing five marks each. Although each heading is marked out of five, currently there is only three available point options; Good = 5 Average = 3 Poor = 1

In order to achieve a more decisive rubric, further research must be carried out on the principals for better definition of each. This will allow the rubric system to a bigger variety of points available such as **2** and **4**.

- Further research into system types
- Further research into connection types available

*Rubric system is graded using a comparison of materials around it, the more materials provided, the more in-depth each result will get.

Panel Size

- 2400mm Panels were the optimum size panels as 2400mm is a standard construction size. This means that little to no waste was produced during the prefabrication stage.

- 1200mm panels were also a possibility as this size is half of 2400mm, meaning all components can be cut in half with still little to no waste. Although 1200mm panels have their advantages such as being more lightweight and versatile, they also come with their own disadvantages. As they are half the size, this means there will be double the panels and as DFD is about efficient and fast assembly and disassembly, a lower amount of construction panels was the selected option.

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