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TECHNICAL REPORT

SIPs DWELLING

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1. OFFSITE CONSTRUCTION

1.1 Defining Offsite Construction

Offsite construction delivers prefabricated elements that are manufactured offsite for quick and easy assemblage on-site. This method aims to provide a cleaner and safer building site through creating elements in a controlled factory environment. Benefits include efficiency of construction, higher performance, and quality, little to no defects, and reduction in waste.

Offsite construction can be a simple manufactured timber frame, or a habitable unit such as the 'Manning Cottage' used pre-World War One as an easily assembled timber house to be delivered across the British Empire. Nowadays, there are unlimited possibilities to offsite construction, from precast concrete to modular units that can be dropped into place.

1.2 Panelised System

These are open or closed planar units which may or may not have a structural function, however for a panelised system to support heavy vertical or horizontal loads, careful consideration and planning are required to ensure that the composite item can bear the load (Lyons 2007).

An open system contains only structural elements, usually without insulation. Opposingly, a closed system offers insulated panels, lined with sheeting and a potential service zone. The closed system also provides external cladding, windows, doors, and internal lining, although this requires more detailed pre-planning than an open panel construction due to the additional build-up of elements (Lancashire and Taylor 2011). Simply, by increasing the number of elements added to the unit there must be more consideration to how these elements will marry up to their counterparts when erected on-site.

1.3 Volumetric System

A volumetric system is a 3D unit that provides internal habitable space, also known as modular construction. These units are brought to site typically furnished and ready to be placed to position. Naturally a prefabricated fully furnished unit will dramatically decrease the construction time on-site and rapidly increase the efficiency of the project, where the system will only be constraint by the available resources to transport and insert these units into place.

Volumetric systems appear as structural or non-structural elements such as a steel structural shell for a building or a bathrooms respectively. This technique is very popular when constructing student accommodation where the layout and interior design are repetitive creating an ideal opportunity to mass pre-fabricate the units.

Moreover, there are huge environmental benefits to this system such as reduction in waste and quality control in terms of airtightness to meet the required energy performances.

1.4 Sub-assemblies and Components

These are pre-manufactured elements that do not fall into any of the four categories. Typically comprising of stairs, doors, windows, steel elements, and I-joists. These elements can be seen as the smaller items of a construction project, that complete or support a structure.

1.5 Hybrid Systems

Hybrid systems comprises of numerous components and construction techniques to deliver the project needs. These can be composite items created from various materials to make bigger elements or it can be a hybrid element partly prefabricated but requires additional maintenance on-site. For example, a bathroom unit could arrive to site as a volumetric method, however the remaining house/apartment is constructed by a panelised system.

1.6 Incorporation of Offsite Construction into the Proposed House

The proposed house can take advantage of all four of these offsite construction techniques. To begin, the panelised system will be used to create the cavity walls for the house, these will be SIPs (Structurally Insulated Panels). It will be a closed system with wood-fibre blown insulation sandwiched between timber battens and OSB boards. There will be a service zone, however this will be fixed on-site through battening out plywood to create an internal cavity for services.

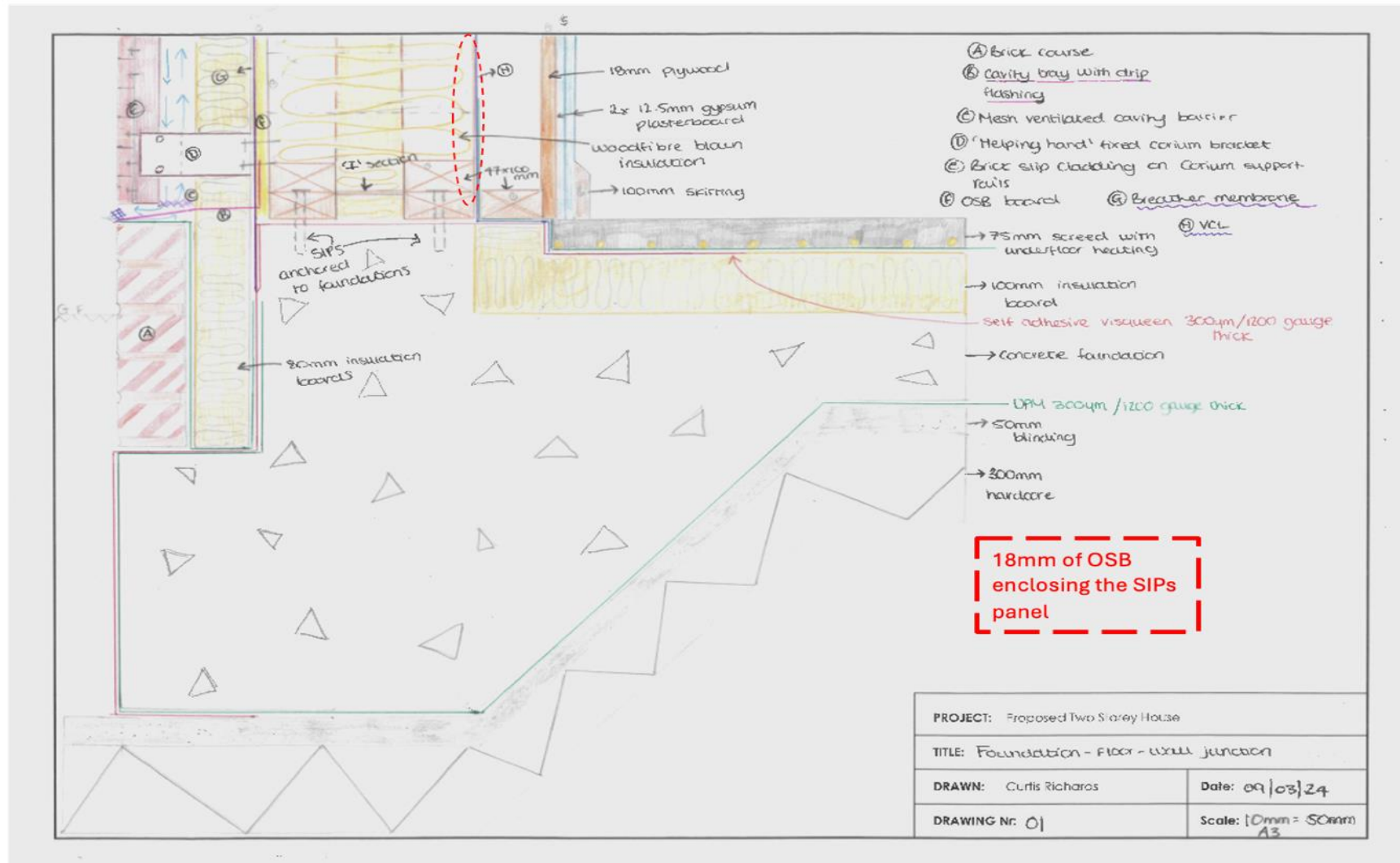
Regarding a volumetric approach, the house could incorporate this method through its habitable rooms, such as a bathroom or bedroom. The internal space could be fully, partly, or non-furnished to the clients' desires or alternatively this approach could be applied to any of the internal spaces within the house.

The stairs and intermediate floors will be constructed using the sub-assembly and component method. The intermediate floor will be an 'Easi Joist' system by Wolf System Ltd, comprising of an insulated cavity for services and acoustic performance. Please see drawing number 2.7 for further details.

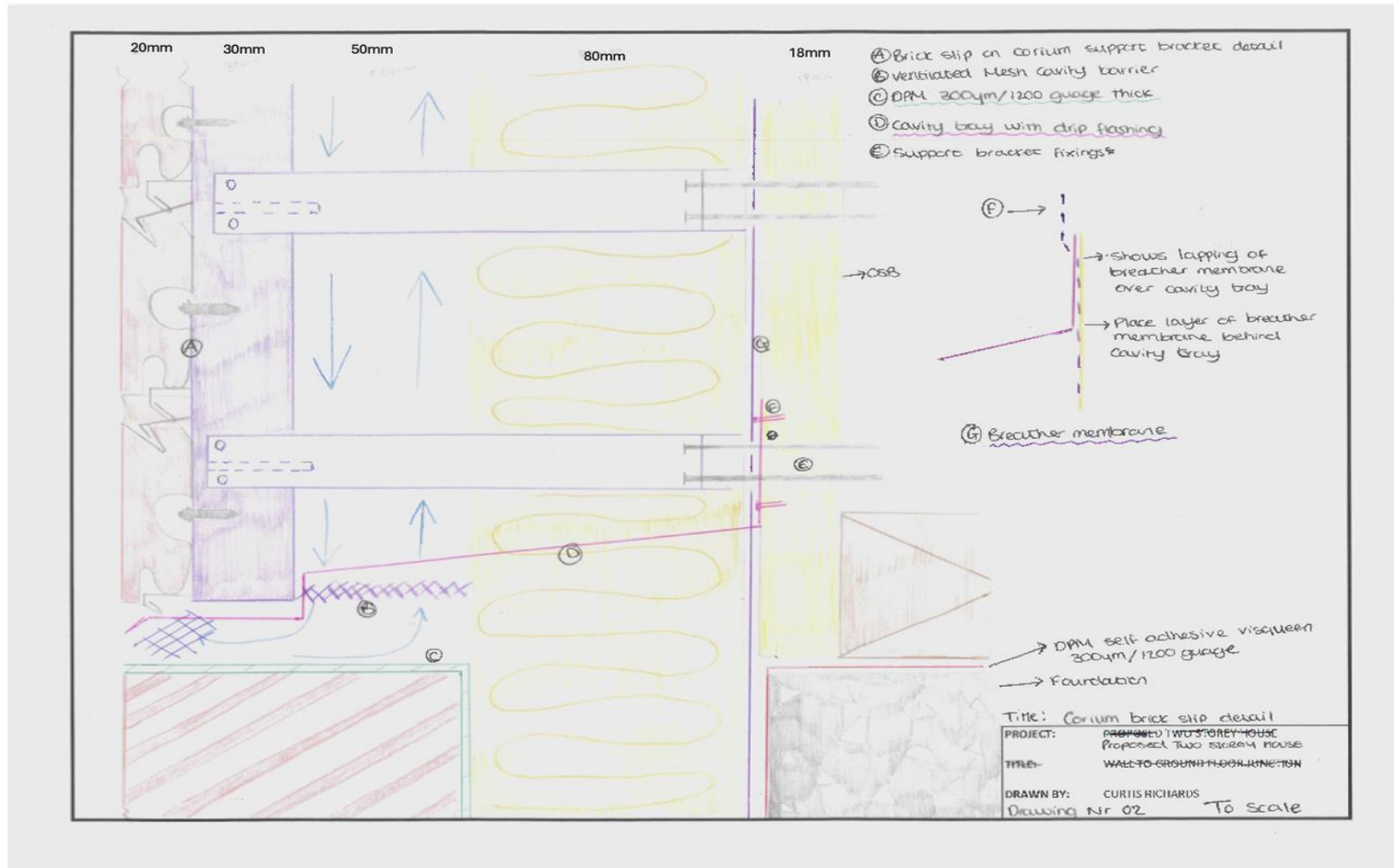
Therefore, naturally the proposed house is a hybrid system applying panelised, volumetric, and sub-assembly and component methods to various corners of the structure to promote efficient modern methods of construction to limit delay, increase quality, and secure satisfactory performance.

2. SKETCHES

Drawing 2.1: Foundation to Wall Junction



Drawing 2.2: Corium Brick Slip to Wall Detail

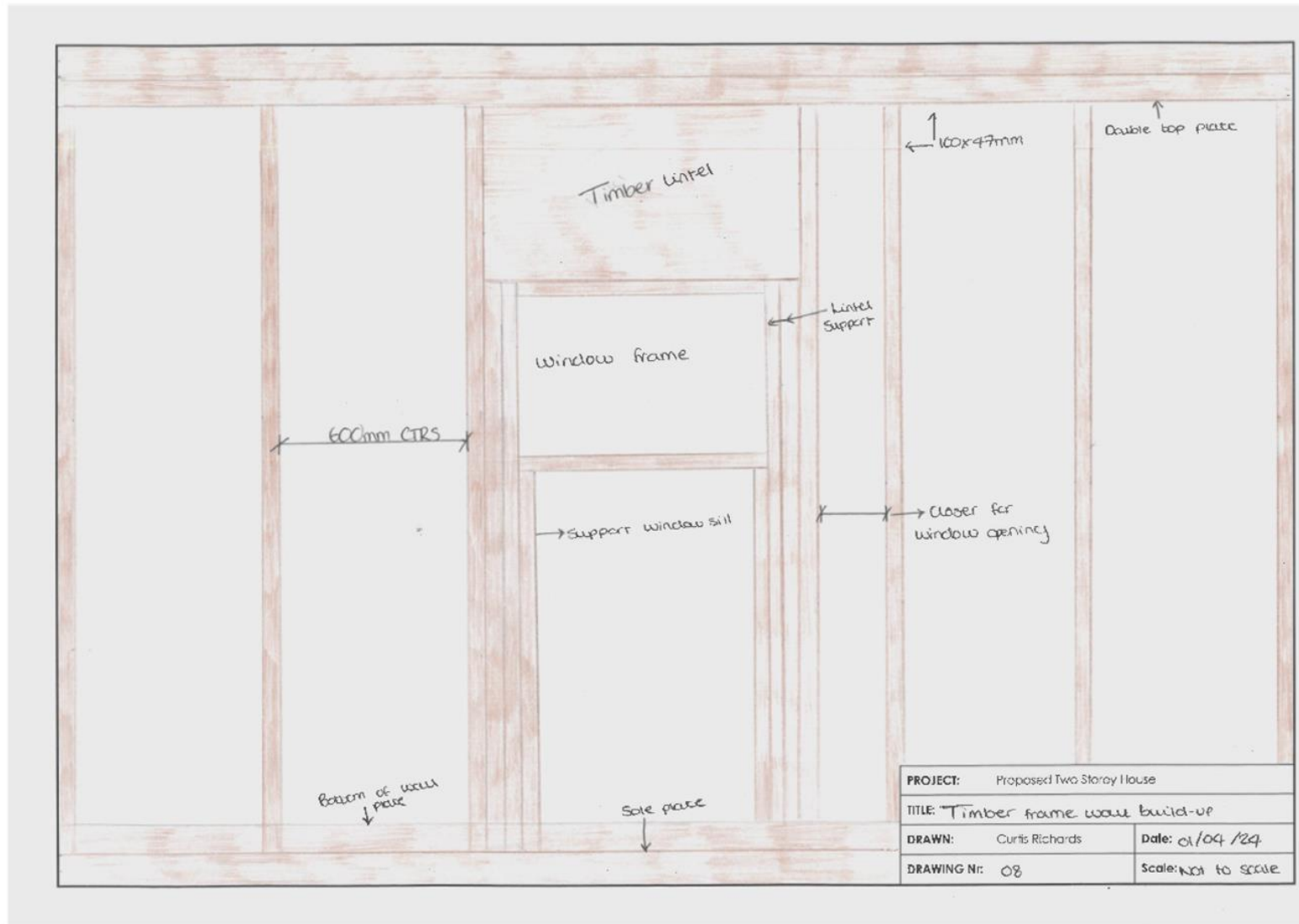


The SIPs panel is fixed to a raft foundation. Insulation boards are placed underneath the screed and abutted tightly to the raft lip to limit thermal bridging (*Approved Document 'L'*). Furthermore, a continuity of windblown fibre insulation has been provided within the SIPs to comply with maximum U-values of 0.18 (0.13 notional).

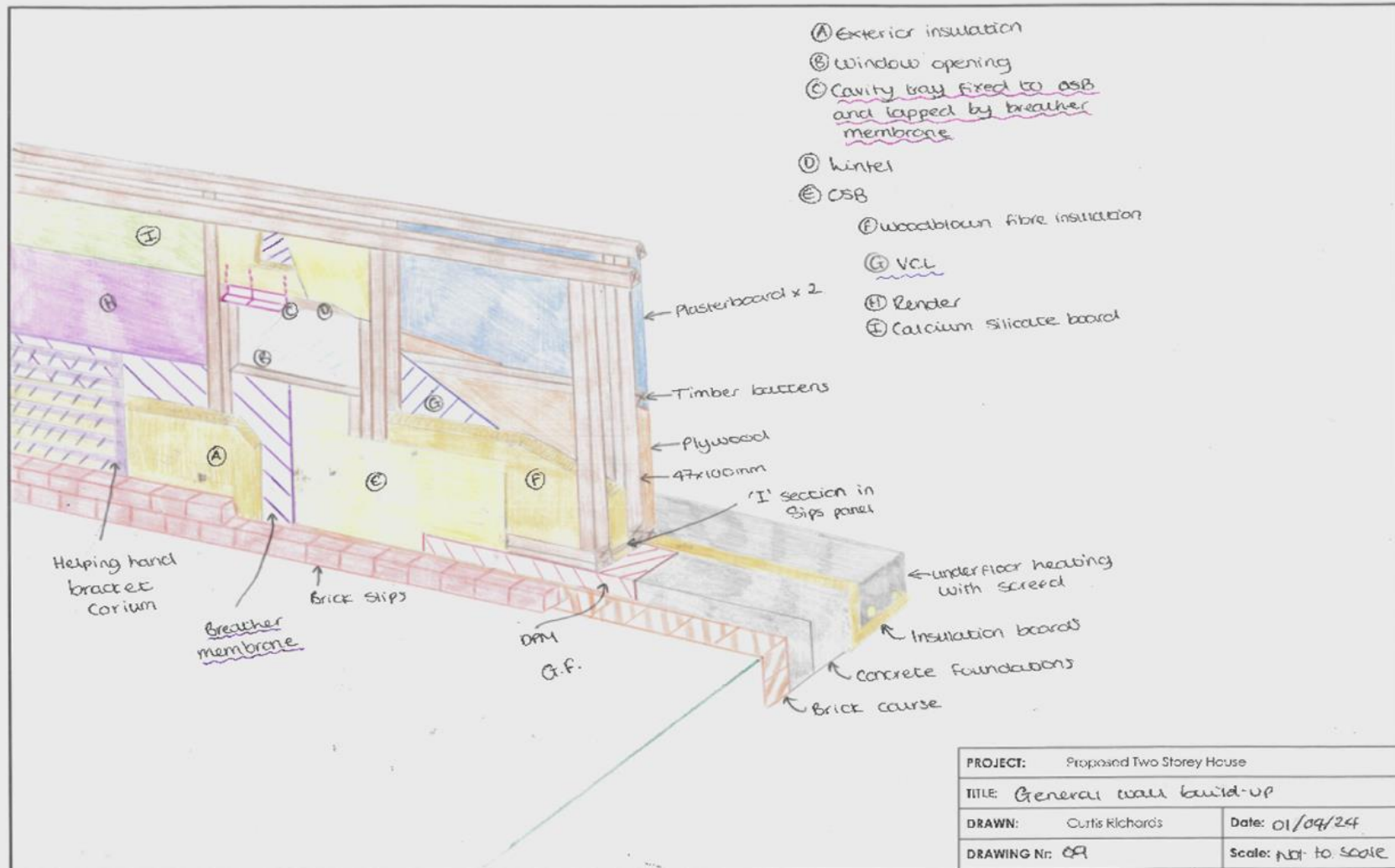
Brickwork allows the brick slip cladding fixed to a helping hand bracket to sit above DPC level (150mm) with the required lapping of DPMs to prevent any moisture ingress (*Approved Document 'C'*). The framed external cladding is separated from the insulation to create the cavity to allow ventilation and drainage, a breather membrane allows the SIPs to breathe into this cavity but can also resist the passage of moisture.

Corium requires 15mm continuous cavity, however, to exceed *Approved Document 'C'* a 50mm continuous cavity has been provided with >10mm ventilation gaps (protected with insect mesh). Moreover, the external cavity is >225mm below the lowest level of DPC, with a damp proof tray and weep holes every 900mm. A VCL is placed on the internal SIP to protect the timber from internal moisture infiltration.

Drawing 2.3: Timber Frame Construction



Drawing 2 4: General Wall Build-Up



Hand-drawn architectural section drawing of a window detail for a two-story house. The drawing shows a cross-section of the wall and window assembly. Key components include:

- Rigid insulation
- Linel (75x100mm)
- VCL (Vapor Control Layer)
- Moisture resistant MDF
- deragel insulation
- Triple glazed windows
- Plastic
- Aluminum
- Window Seal
- Breather membrane
- Air gaps
- Plastic
- Insulation board
- OSB
- Woodfibre blown insulation
- Plywood
- 2x Gypsum plasterboard
- 97x100mm
- 75x100mm
- 18mm of OSB enclosing the SIPs panel
- Damn and vertical DPC

Legend:

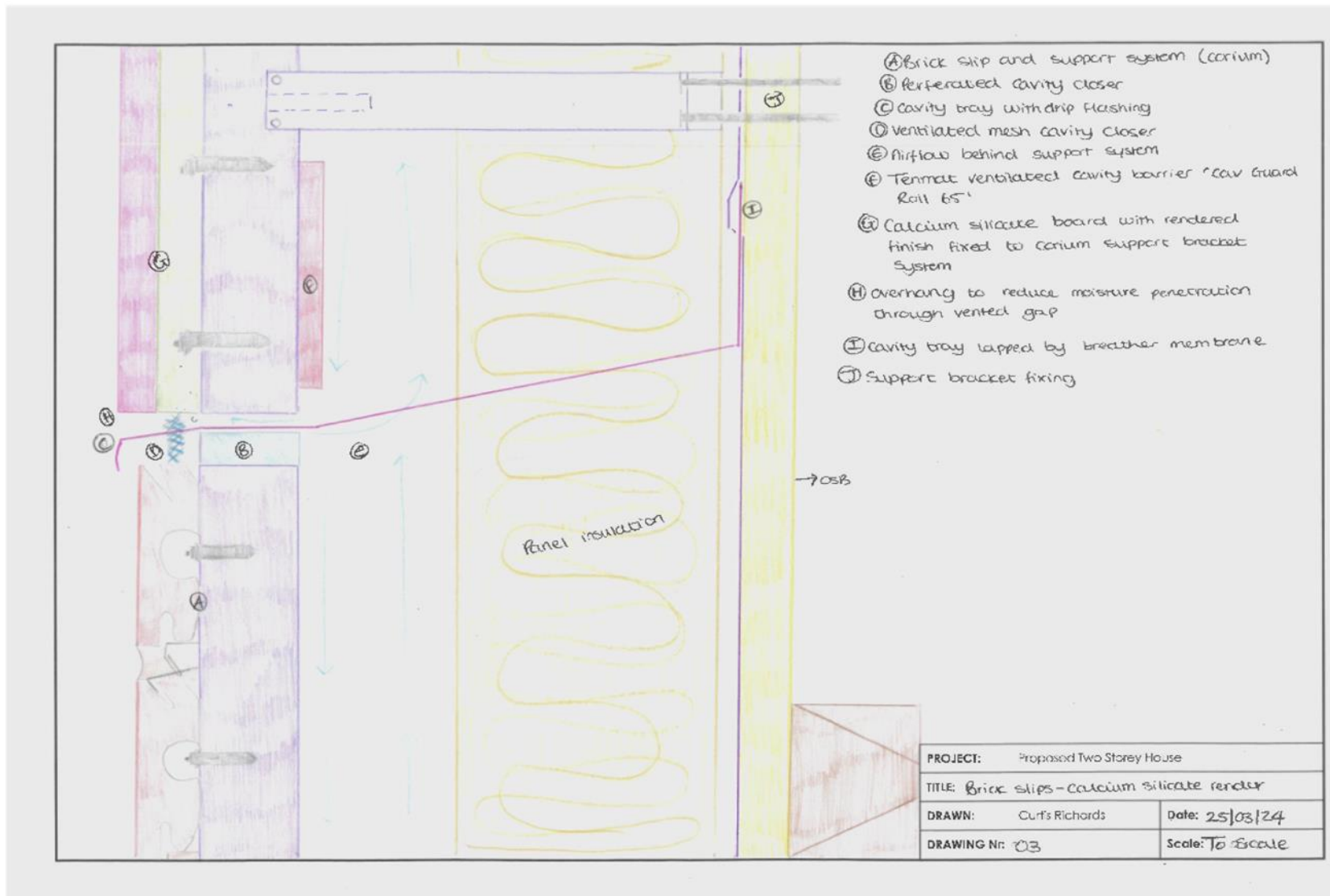
- (A) Tenmat ventilated cavity barrier 'Cav Guard Roll' 65
- (B) Corium support bracket system
- (C) Brick slips
- (D) Calcium silicate Board
- (E) Render finish

Note: Gap is less than 10mm = no mesh needed

Project Information:

- PROJECT: Proposed Two Storey House
- TITLE: Window Detail
- DRAWN: Curtis Richards
- Date: 23/03/2024
- DRAWING No: 04
- Scale: 10mm = 20mm

Drawing 2.6: Brick Slips to Calcium Silicate Board with Render Finish Detail



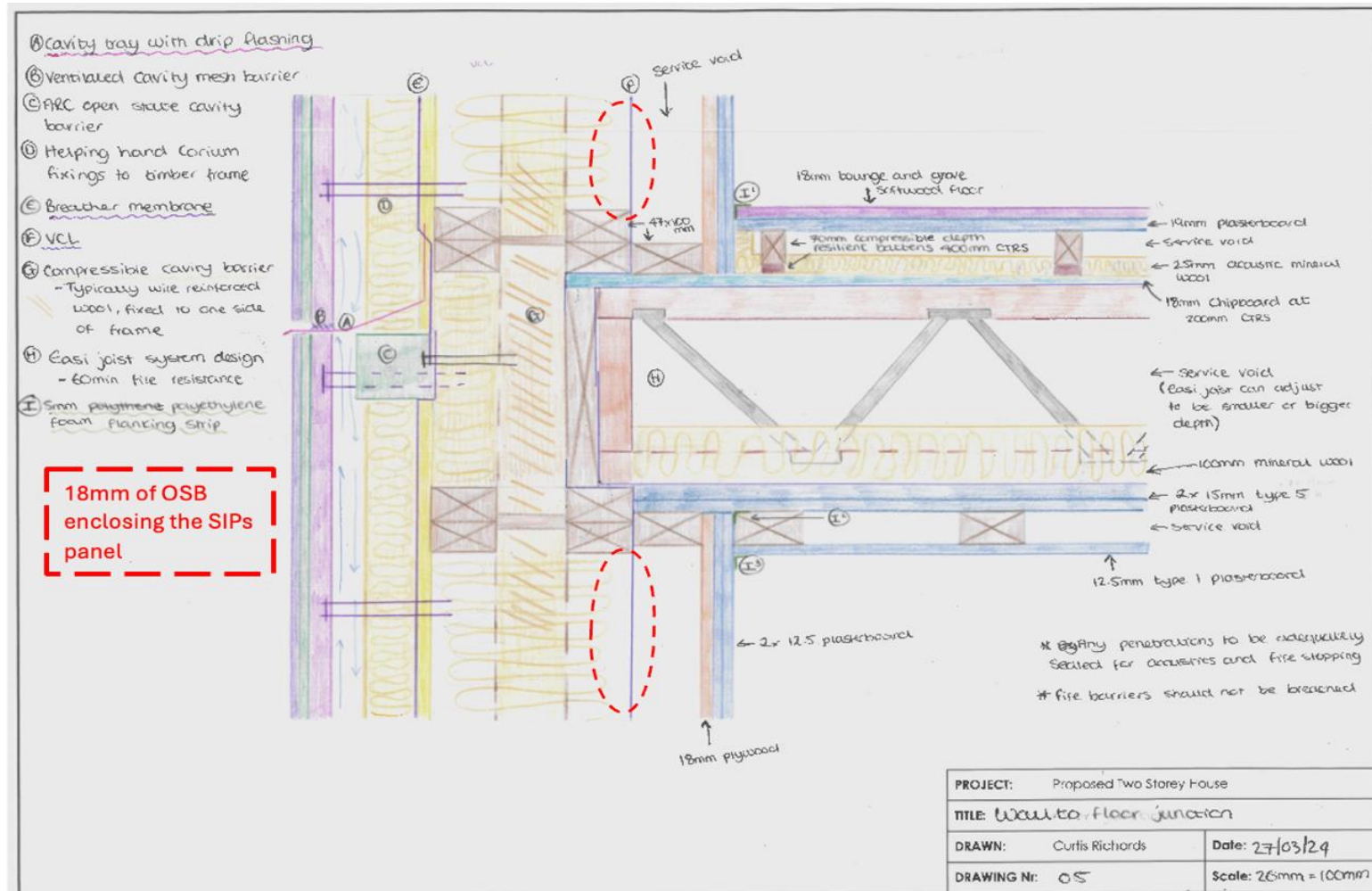
The window opening sits >800mm above floor height (*Approved Document 'N'*), framed with timber studs. All window openings are closed with fully insulated cavity closers (*Approved Document 'L'*) and lined with window tape. The window frame is a composite element of an external aluminium frame, with a timber external frame to limit thermal bridging. An aerogel insulated membrane isolates the internal MDF board to pacify any incoming cold heat.

The cavity tray is lapped by the breather membrane to ensure water is directed away from the SIPs. A dam and vertical DPM are placed around the window opening, again to protect the structure from water ingress.

The internal and external insulation on the SIPs panel also limit the passage of sound as *Approved Document 'E'* requires >25mm thickness of absorbent material. Rigid insulation supports the fixing of the window whilst aiding the limitation of thermal bridging. The Tenmat Cav Guard Roll 65 was selected as it enables a continuous cavity for ventilation, but importantly provides fire protection and halts the passage of flames through the cavity (*Approved Document B*).

The calcium silicate render is also fixed to the helping hand bracket system; however the render will overhang the brick slips to reduce any water ingress. The ventilation gap enables the passage of air (*Approved Document 'F'*), but crucially provides an opening for water to be redirected from the cavity to the external face by the cavity tray.

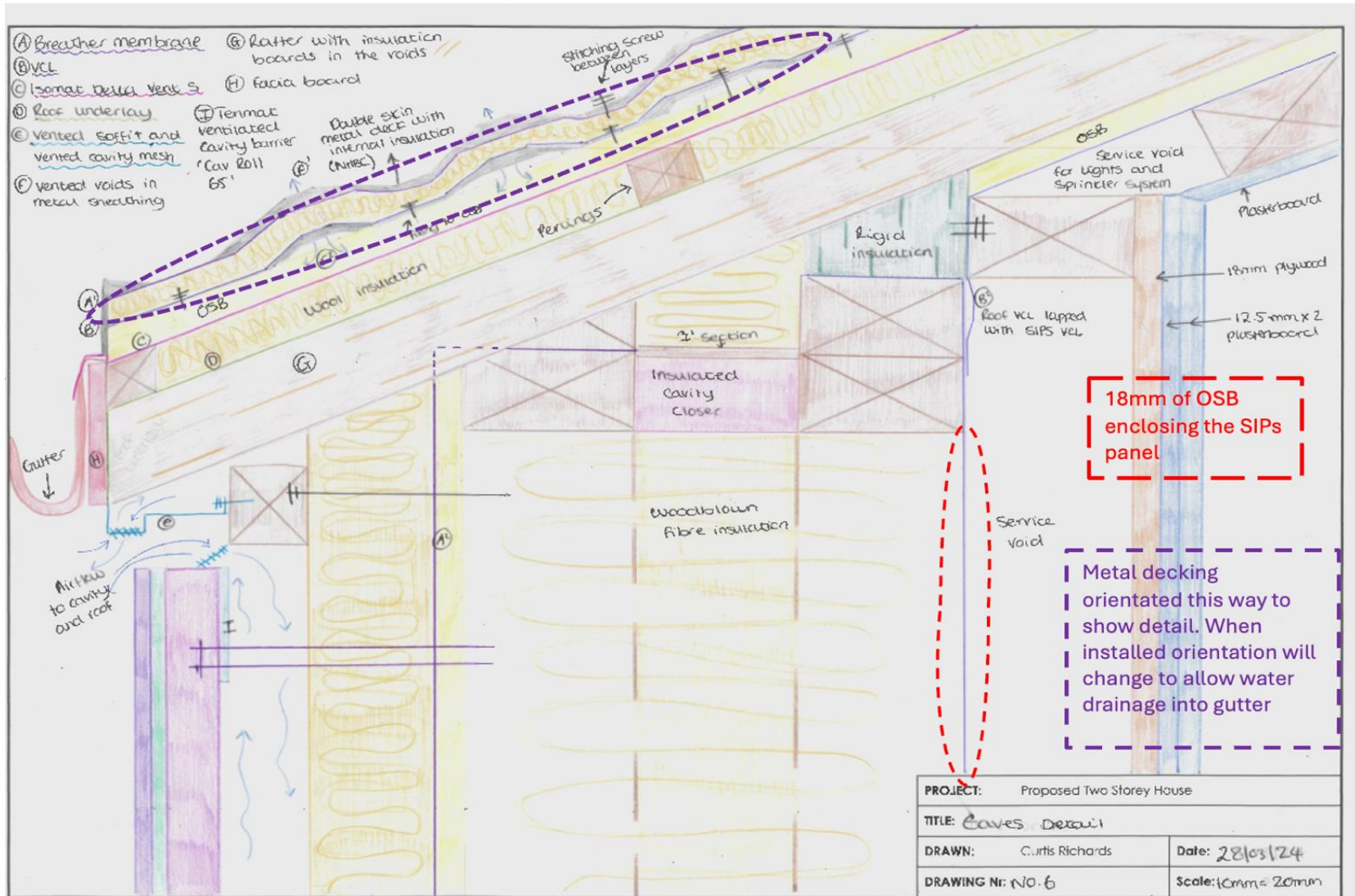
Drawing 2.7 Wall to Intermediate Floor Junction :



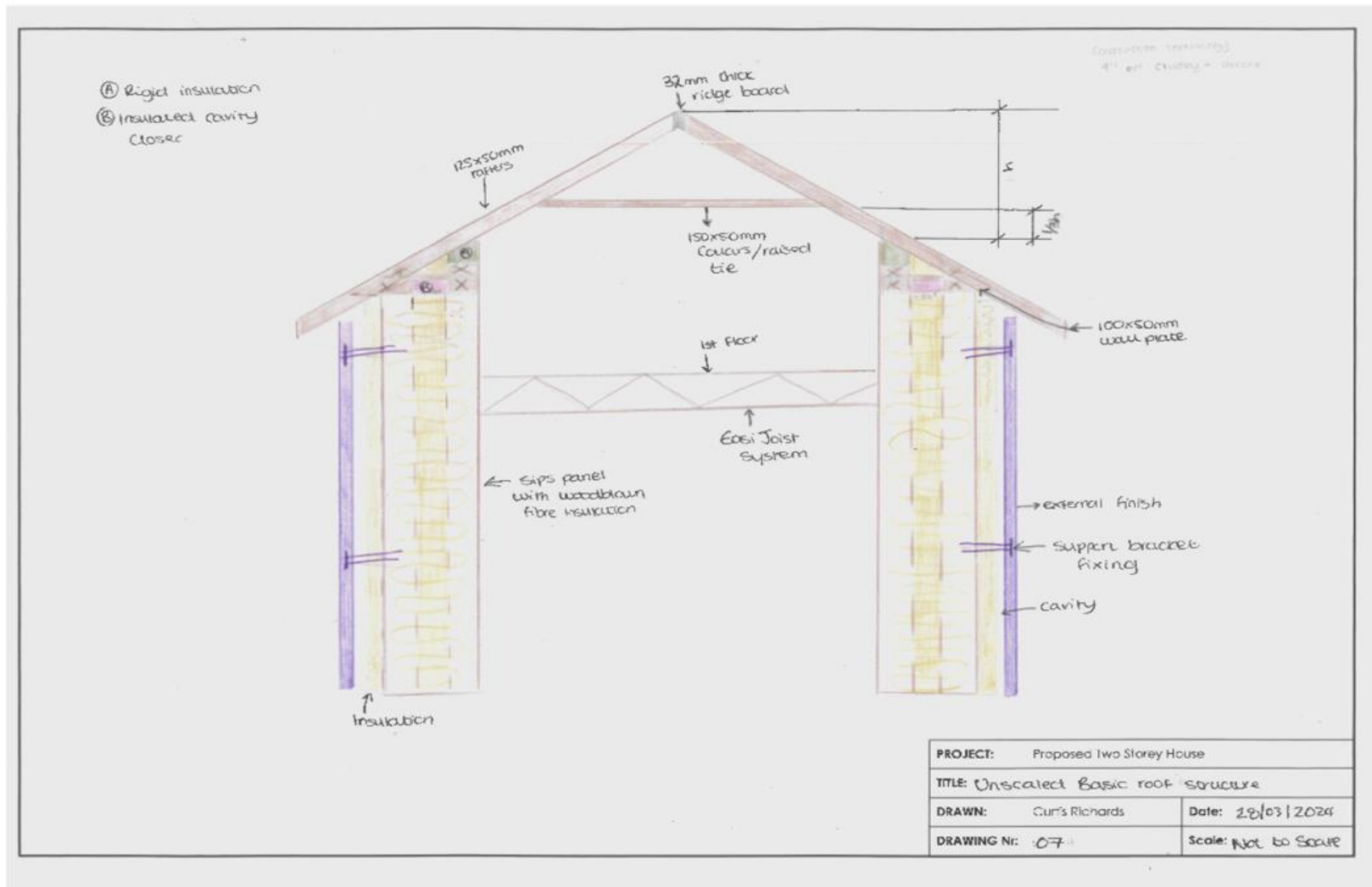
The floor system is constructed with an Easi Joist system by Wolf Systems Ltd. This design enables a service zone laid with insulation to attenuate sound from the upper floors. All joints are sealed to avoid sound leakage, and the floor finish is battened with resilient battens to attenuate sound. The Easi Joist system complies with *Approved Document 'E'* as the timber floor sits on a resilient layer of $\geq 25\text{mm}$, has a minimum of two layers of board at least 8mm thick per layer, and all junctions are taped and sealed.

A compressible cavity barrier is fixed to the frame to limit the passage of fire through the cavity, essentially sealing the cavity. An open state cavity closer by ARC is placed on the external cavity again to maintain the continuity of airflow but enable the cavity to be closed in response to a potential fire.

Drawing 2.8: Eaves Detail



Drawing 2.9: Unscaled Basic Roof Structure

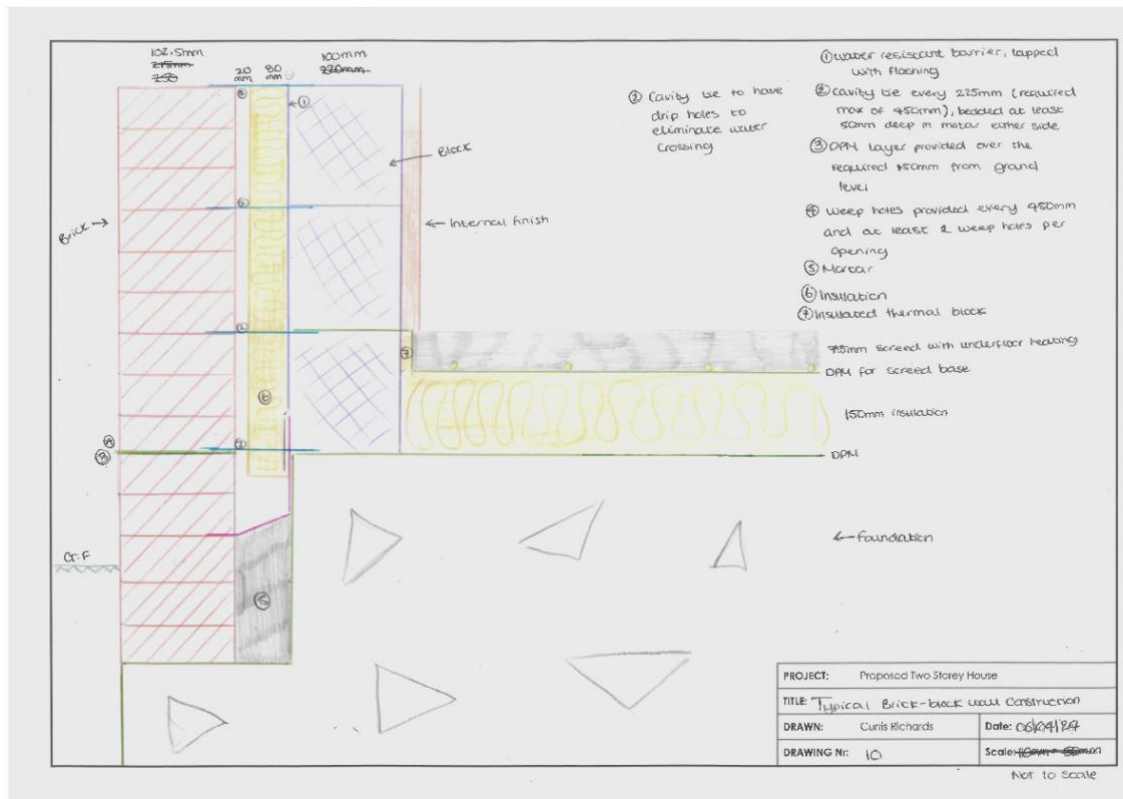


The main roof structure is of a raised tie, as the top floor of the house intrudes on the attic space above.

The roof finish is a twin-skin metal decking, sandwiched with insulation, a breather membrane, and a VCL to allow the correct ventilation but reduce any water ingress. The insulation placed in the metal decking pushes the dew point to the exterior roof reducing any build-up of condensation that might compromise the house structure. Insulation has also been laid in between the purlins, and between the roof rafters to not exceed the maximum U-values of 0.13 (0.11 notional) as stated in *Approved Document 'L'*.

The compartment wall-roof has been taken up to the underside of the roof with the necessary fire stopping. Any combustible material carried over the wall is embedded in mortar, and all roofing coverings are designated AA, AB, or AC at least 1500mm either side of the wall (*Approved Document B*). Additionally, a service zone has been maintained throughout to enable pipes from the sprinkler system to be disbursed throughout the house.

3. TIMBER v BRICK/BLOCK CONSTRUCTION



Drawing 3 1: Typical Brick/Block Wall Construction

As depicted in figure 3.1 a typical brick-block cavity wall construction appears as a similar layout to the SIPs detail, however there are numerous differences between the two methods of wall constructions.

3.1 Buildability

The proposed timber framed construction is prefabricated offsite, which will require less labour force on-site, allow for quicker installation, yield higher quality, and minimise energy consumption. Furthermore, once a few

walls have been installed additional work can be executed as the other panels are being erected (*Lancashire and Taylor 2011*).

Opposingly, brick and block work are construction methods that has not been modernised to the extent of timber. Nevertheless, there have been examples of pre-made offsite masonry units that have been craned in and bedded together with mortar joints (*de Vekey 2001*). Although, this method is rarely used, therefore brick and block work require skilled labour to build, and this is time consuming in comparison to installing SIPs.

However, this previous point could be weather dependant, especially in the UK where rain is likely, and thus it is paramount to keep the timber dry whereas brick and blocks can be laid during wetter weather. Timber must be protected by the correct membranes such as VCLs, breather membranes, and DPCs (DPCs also apply to brick and block).

3.2 Transportation

Transportation of SIPs require care, to ensure no physical damage occur that could jeopardise the quality or integrity of the product (*Lancashire and Taylor 2011*). Moreover, it is essential to protect them from any moisture, therefore the timing of delivery must be managed perfectly, or alternatively invest in adequate storage facilities.

Brick and blocks do not require coequal storage facilities to protect from moisture, although this does not mean that bricks are immune to climate

related events. In addition, bricks can still maintain mechanical damage from transportation, therefore bricks, blocks, and timber are similar in this respect and minimising mechanical and weathering processes is a priority.

Where waste is considered, SIPs outperform brick and blocks as prefabricated systems typically generate less waste (*Lancashire and Taylor 2001*), and brick and blocks tend to break in transportation, plus there is often high mortar waste (*de Vekey 2001*).

3.3 Appearance

Both systems can support various finishes. Bricks are a versatile material in this respect allowing itself to be presented in a range of bonding patterns, colours, and orientations (*Chudley and Greeno 2005*). Timber however is typically more constrained, especially as an external feature where it would quickly deteriorate through weathering processes, nevertheless it can be aesthetically pleasing on internal finishes (*Dinwoodie 2001*).

Timber construction permits thinner walls that can achieve the same or even better U-values than brick and block walls that are thicker in size. This is due to the uniform thickness of brick and blocks whereas timber is a series interconnected battens creating wider cavities.

3.4 Insulation

Following from the previous section, the wider cavities in timber framed construction enables more room for insulation, hence why SIPs can outperform brick and block for energy efficiency. To increase the thermal performance of a brick and block wall, the cavity must be increased to accommodate more insulation (*Lyons 2007*). A SIPs design could accommodate almost 300mm of insulation if the SIPs had an overall width of 300mm, whereas a brick and block wall of 300mm would probably only accommodate no more than 100mm.

3.5 Fire

Timber is a combustible material, however in comparison to steel timber can retain strength better with an increase in temperature (*Dinwoodie 2001*). Nevertheless, timber still does not perform well in preventing the spread of flames and smoke. Brick is without doubt a superior fire resisting material than timber, so much so that certain blockworks can provide upwards to 360 minutes of protection (*Lyons 2007*).

3.6 Acoustics

Regarding acoustics, again brick and block work perform better than timber if all voids are adequately sealed with mortar (*Lyons 2007*). This does not mean that acoustic levels cannot be achieved with SIPs.

3.7 Environmental

In manufacturing terms, timber is the most environmentally friendly material as it derives from trees, although the UK imports its timber across the Atlantic and Europe which creates transportation emissions. But all in all, the process of manufacturing brick and block as well as the mortar to bind the walls do generate its own environmental concerns.

3.8 Durability

Timber is very resistant to chemical attacks, although it is more vulnerable to alkaline attacks (*Dinwoodie 2001*). Furthermore, prolonged exposure to high temperatures and heavy loads will degrade the strength of timber, albeit sustained over many years. Lastly, all varieties of timbers are susceptible to insect attacks albeit very rare (especially in the UK).

Despite brick and blocks being immune to insect attack, it is prone to a series of other agents. Bricks can suffer chemical attacks (acid rain and sulphate attack), furthermore any metal fixings within the blockwork can chemically corrode if not protected correctly (*de Vekey 2001*). Also, if there are penetrations within the brick or joints any intruding water that freezes can cause fracturing of the structure through expansion and contraction of water. Lastly, the mortar that binds the bricks and blocks is susceptible to chemical attack as there are reactive binders within the mortar mix.

3.9 Cost

Timber can be a very expensive material to import (*Chudley and Greeno 2005*). Despite this, these costs can be offset by offsite construction as these methods improve efficiency of assemblage onsite and requires less labour force and less time to instal.

As this report has already alluded to, the costliest element to the brick and block wall is its construction time and labour. The material cost of a singular brick/block is minimal; however brick and block walls require continuous courses with openings only for doorways and windows. Alternatively, a SIPs panels does not require continuous battens as it is fixed at 400-600mm centres therefore even the whole material cost of the SIPs panel may outperform a brick and block system of similar scale.

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