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Fundamentals of Construction Technology

FUNDAMENTALS OF CONSTRUCTION TECHNOLOGY
(ACBA4022)

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Introduction

Miss A Client received planning permission to build a two-story detached home on a levelled, reclaimed plot that was formerly used for farming. Given site conditions require an external face of stack-bonded brickwork and a rendered blockwork finish, a raft foundation has been recommended following ground research work.

Miss A is evaluating a number of construction methods, including Timber Twin Frame, Structural Insulated Panels (SIPS), and traditional Brick and Block construction, in order to provide a new home that is both highly energy-efficient and compliant. A technical comparison of these three building systems is presented in this report, taking into account their roof eaves construction, window detailing, and ground floor interfaces.

In order assist in decision-making, the report also defines necessary construction terminology, such as "offsite construction," and concludes with a suggestion for the best approach to accomplish the project's objectives while guaranteeing adherence to the latest Building Regulations, specifically in relation to sustainability, air tightness, and thermal performance.

Offsite Construction

Off-site construction is a construction method that includes planning, designing, fabricating, transporting, and constructing prefabricated building materials quickly and with a high level of finish on the construction site. Compared to construction on-site, this level of precision is considerably better.

The four main construction methods used in off-site construction are:

- **Volumetric (Modular) Construction:** Complete 3D sections of the building are manufactured offsite (e.g., bathroom pods, whole rooms) and bolted/attached together on site.
- **Panelised Systems:** Flat panels (e.g., walls, floors, roofs) are produced offsite and assembled on-site – could include SIPS and Timber Frame systems.
- **Sub-assemblies and Components:** Smaller elements like staircases, roof trusses, or windows are prefabricated and delivered to site.
- **Pre-engineered Building Services:** Pre-assembled M&E (mechanical and electrical) systems, such as pre-plumbed wall panels for bathrooms.

All of these offsite construction methods are used on current construction sites and improve site productivity, time and efficiency during construction.

Construction methods considered

Timber Twin Frame

By using two separate, parallel timber stud frames, Timber Twin Frame Construction is a type of advanced timber framing that creates a wall cavity that is significantly wider than that of a conventional timber frame.

In order to prevent cold bridging and improve thermal efficiency, these two frames are slightly offset so that the studs are not align.

Structural Insulated Panels (SIPS)

This is a quick and cost-effective building option that can be tailored to meet the needs of each client for garden buildings, new builds and various other projects. SIPs, or structural insulated panels, are long-lasting building panels with excellent insulation and energy efficiency.

Traditional Brick and Block construction

Block & Brick comprises of an inner concrete block leaf and an exterior brick (or rendered block) leaf that has a traditional look. The insulation of your choice is then inserted into the space between the two layers.

The cavity created between the two leaves tends to measure 50 – 150mm. For insulation, the cavity can be fully or partially filled depending on the u-value requirements for that area.

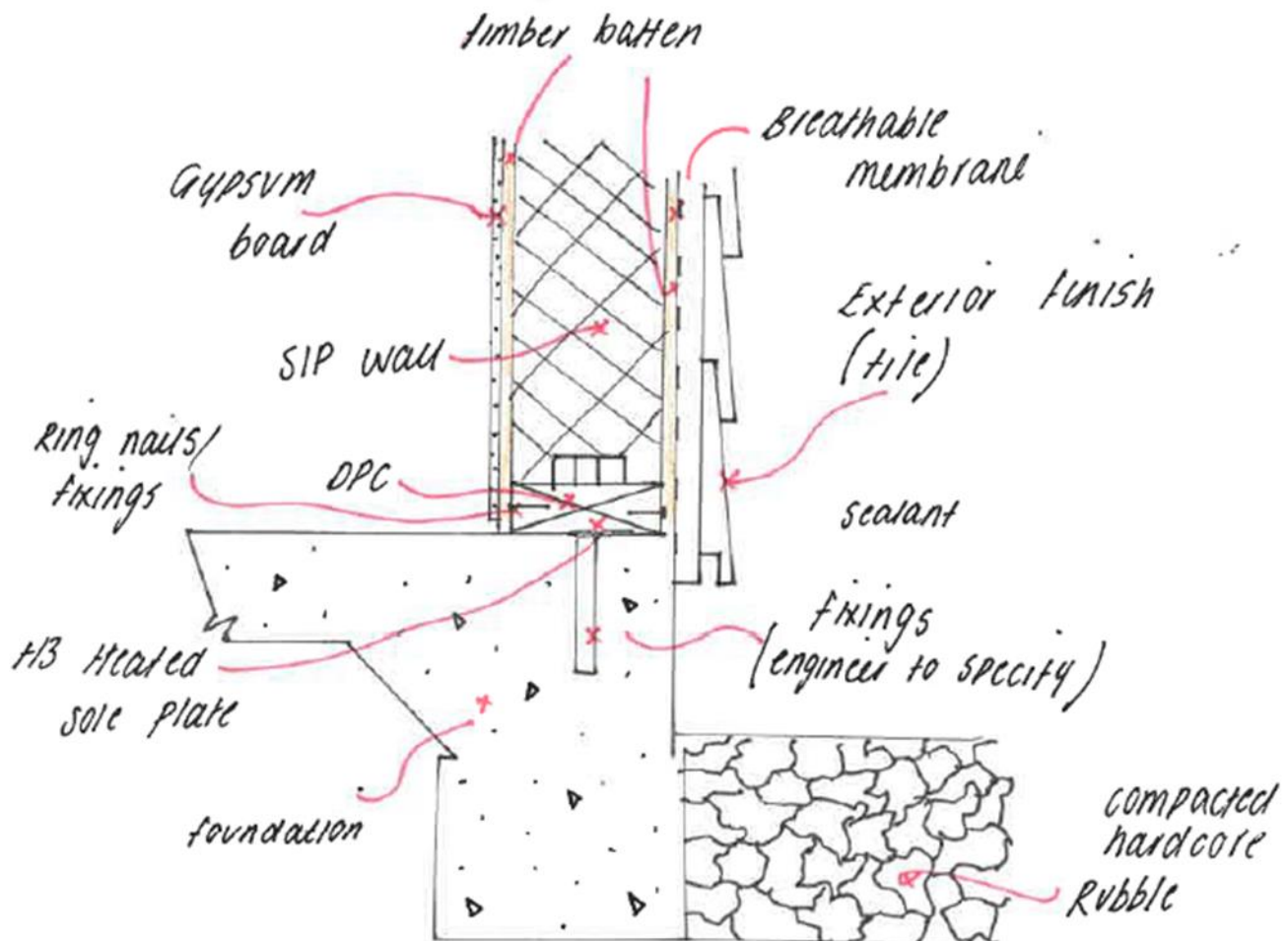
In this section of the study, I will present detailed drawings of the ground floor and its junctions with external walls, a window opening within the external wall, and the eaves detail including the roof structure. For each of these details, I will explore three different construction methods. A comparison of these methods will be provided, highlighting their respective advantages and disadvantages. Based on this analysis, I will conclude which method is most suitable for this particular build.

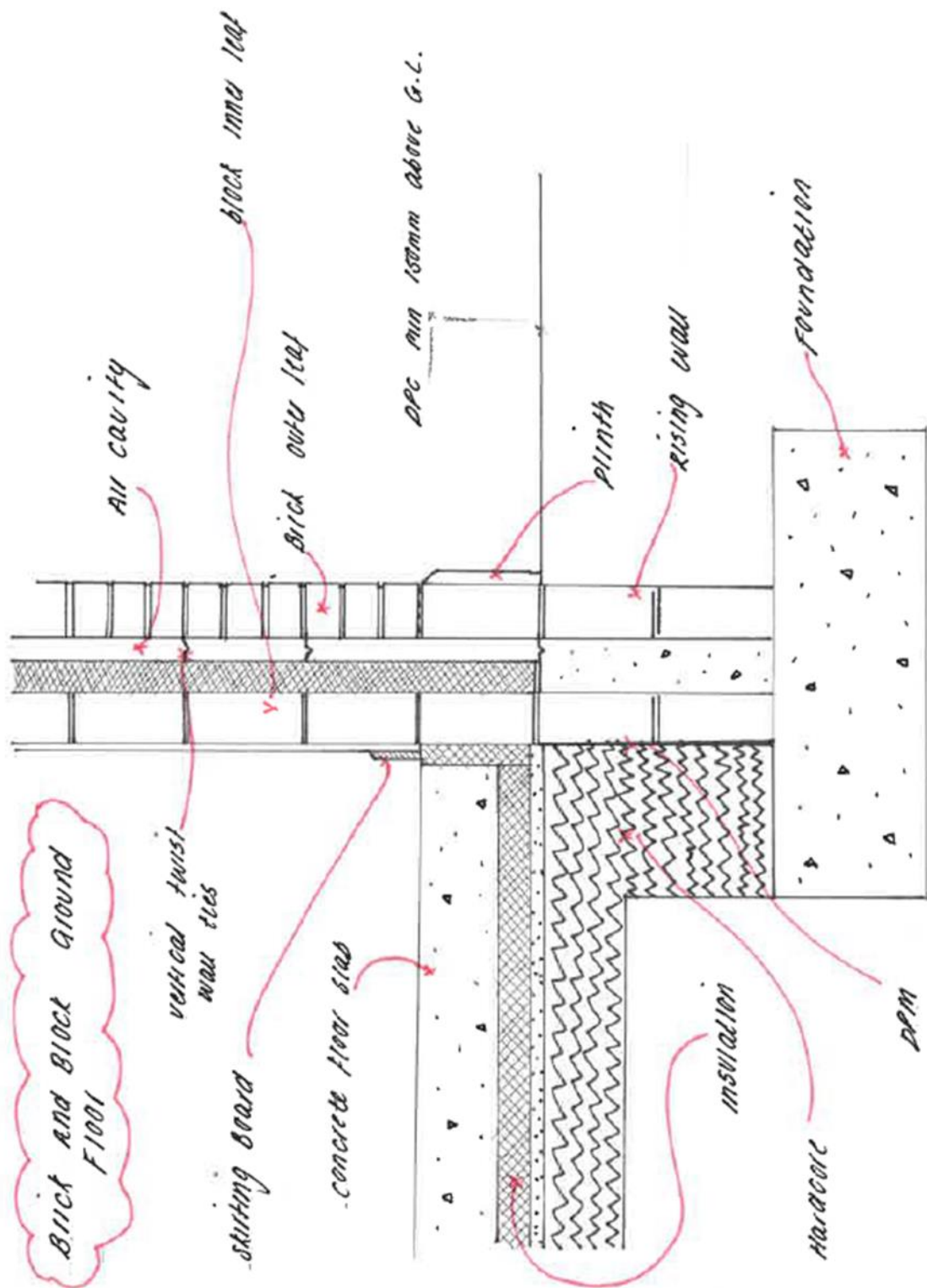
Timber frame ground floor detail

Labels in the diagram:

- Concrete ring beam
- Concrete slab
- DPM
- EPS insulation
- Sand bedding
- Compacted hard core
- service cavity
- insulation
- plasterboard
- vap airtight board
- breather membrane
- nail plate
- vent board
- EPS insulation 'L' section upstand
- Perimeter rigid beam footing installed for masonry external leaf (if required)

SIP Ground Floor
detail





Comparing ground floor Construction, detailing and junctions with external walls for each method

There is a retaining wall structure to the south of the site and the Ground Investigation report suggests a suitable raft foundation be constructed for the property. A raft foundation is a thick, heavily reinforced concrete slab that distributes the weight of a building across a wide area, making it suitable for unstable ground such as soft, waterlogged, or filled soils. The way in which the ground floor, basement floor, and external walls connect to a raft foundation differs depending on the chosen construction method. The three main construction approaches include Timber Frame Construction, Traditional brick and block, and Structural Insulated Panels (SIPs).

Timber Frame Construction uses a wooden structural system with wood-based materials to support the external walls. Some systems may also include composite materials like carbon or glass fibres used inside the building. The raft foundation forms the base, with a damp-proof membrane and insulation placed on top of the concrete slab. The timber frame is fixed to a timber sole plate, which is secured to the raft using hold-down bolts and set on a damp-proof course. Care must be taken at the external wall connections to prevent heat loss and ensure the building is airtight.

In Timber Frame Construction, external cladding—typically brick or render—is fixed to the timber frame using wall ties. The wall system is ventilated, filled with insulation, and includes a vapour barrier and internal plasterboard lining.

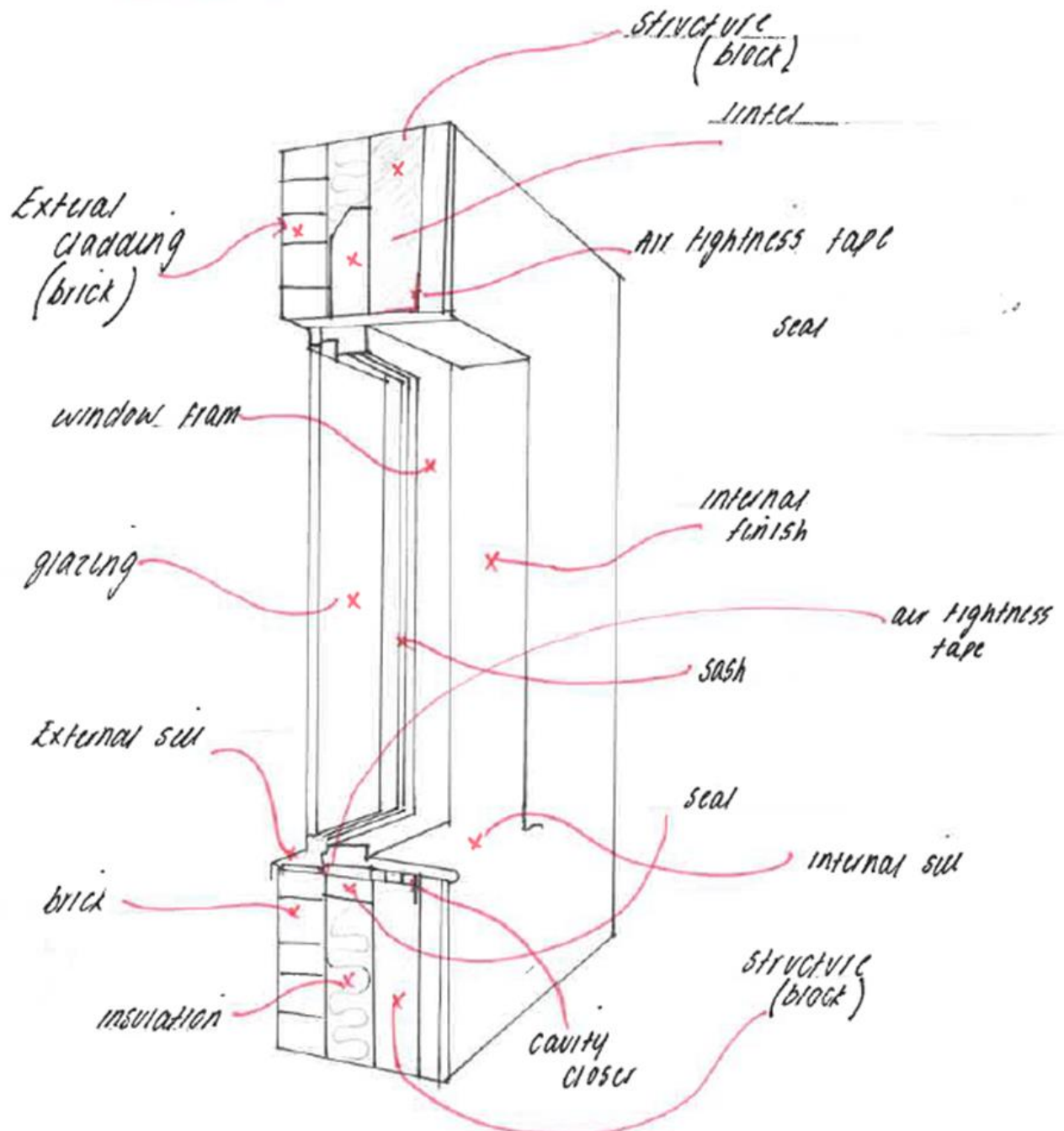
In Traditional Solid Construction, cavity walls made of brick or blockwork are used. The raft foundation supports both the structure and ground floor. Insulation is added above or below the slab before screed is applied. The wall rises directly from the raft, with a damp-proof course between the slab and first brick layer. The cavity wall includes an outer leaf, insulation in the gap, and an inner block leaf, joined with wall ties. When detailed correctly, this system offers strong, thermally efficient joints and avoids cold bridging.

Structural Insulated Panels (SIPs) consist of two boards with a rigid foam core, offering excellent thermal performance and quick assembly. SIP walls are fixed to treated timber or insulated base plates on the raft, separated by a damp-proof course. Unlike timber or masonry systems, SIPs don't require a cavity, simplifying construction and improving airtightness. Seamless junctions and continuous insulation from wall to floor are essential to maintain energy performance.

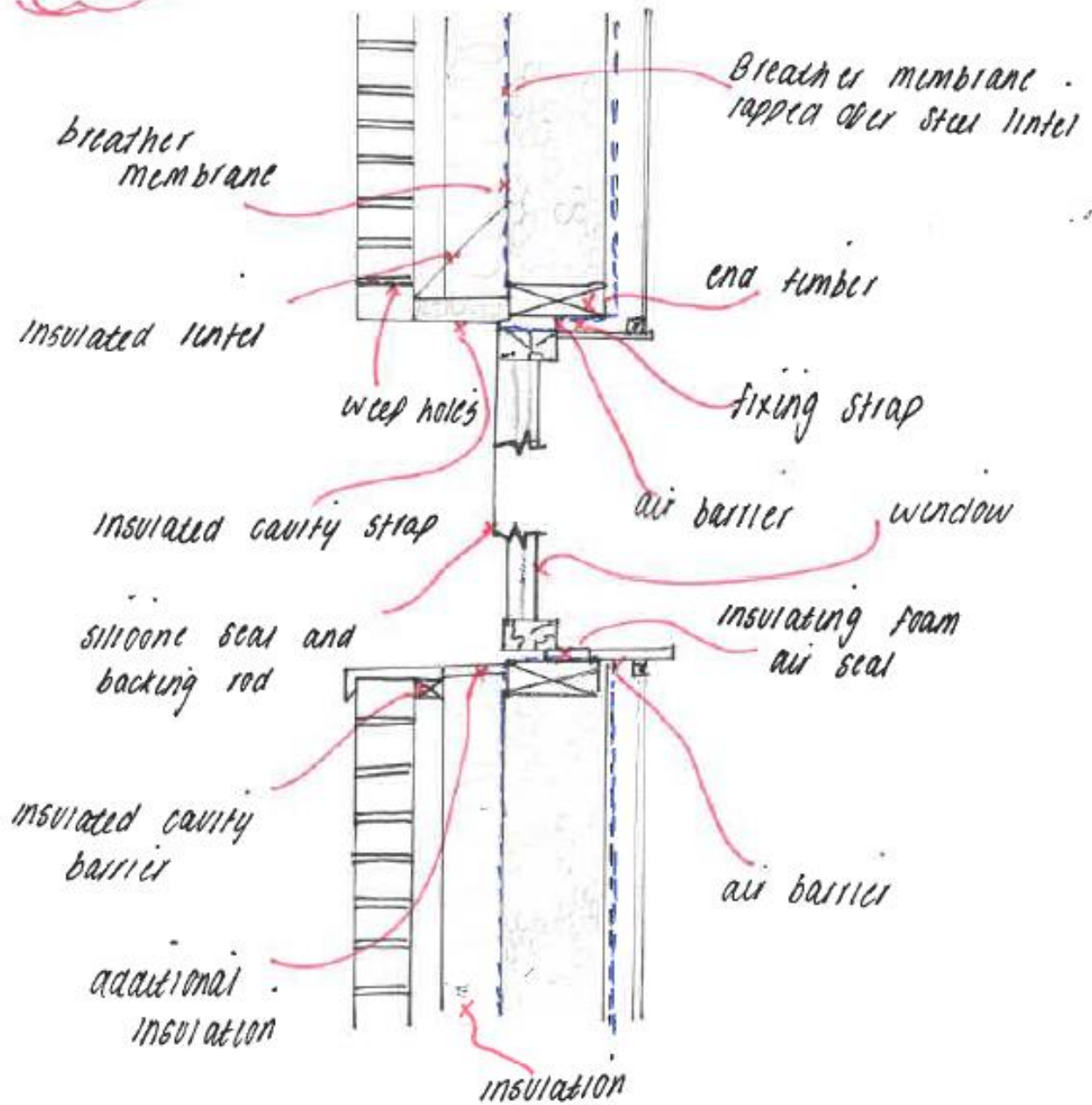
All three methods, Timber Frame, Traditional Masonry, and SIPs, can be used effectively with raft foundations, but each has specific detailing needs. Timber frames offer speed and flexibility, traditional builds are durable and well-established, while SIPs excel in energy efficiency and airtightness. Special attention is required at junctions around the raft to meet performance standards.

Window opening details for all 3 construction methods considered

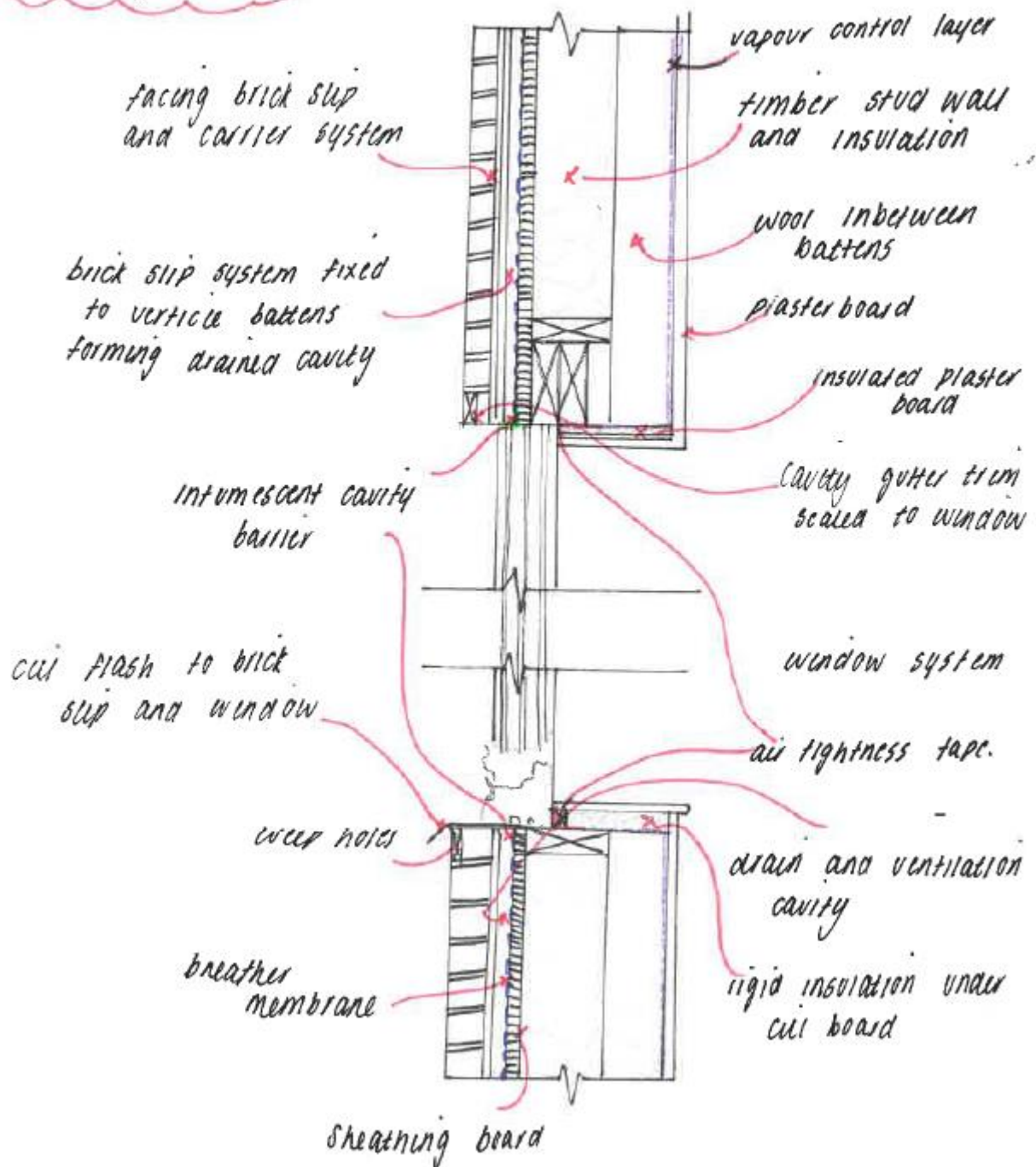
Brick and block window opening detail



SIP window opening detail



Timber frame window opening detail



Comparing a window detail for each construction method

Windows are a key part of the building envelope, providing natural light, ventilation, and thermal insulation. They enhance comfort, energy efficiency, and aesthetics, while also offering noise reduction, weather protection, and in some cases, emergency egress. Properly designed and installed windows play a crucial role in the overall performance and safety of a building. All three construction methods have a different approach when designing window opening to the external walls due to them using different materials and some openings being designed prior to delivery on site.

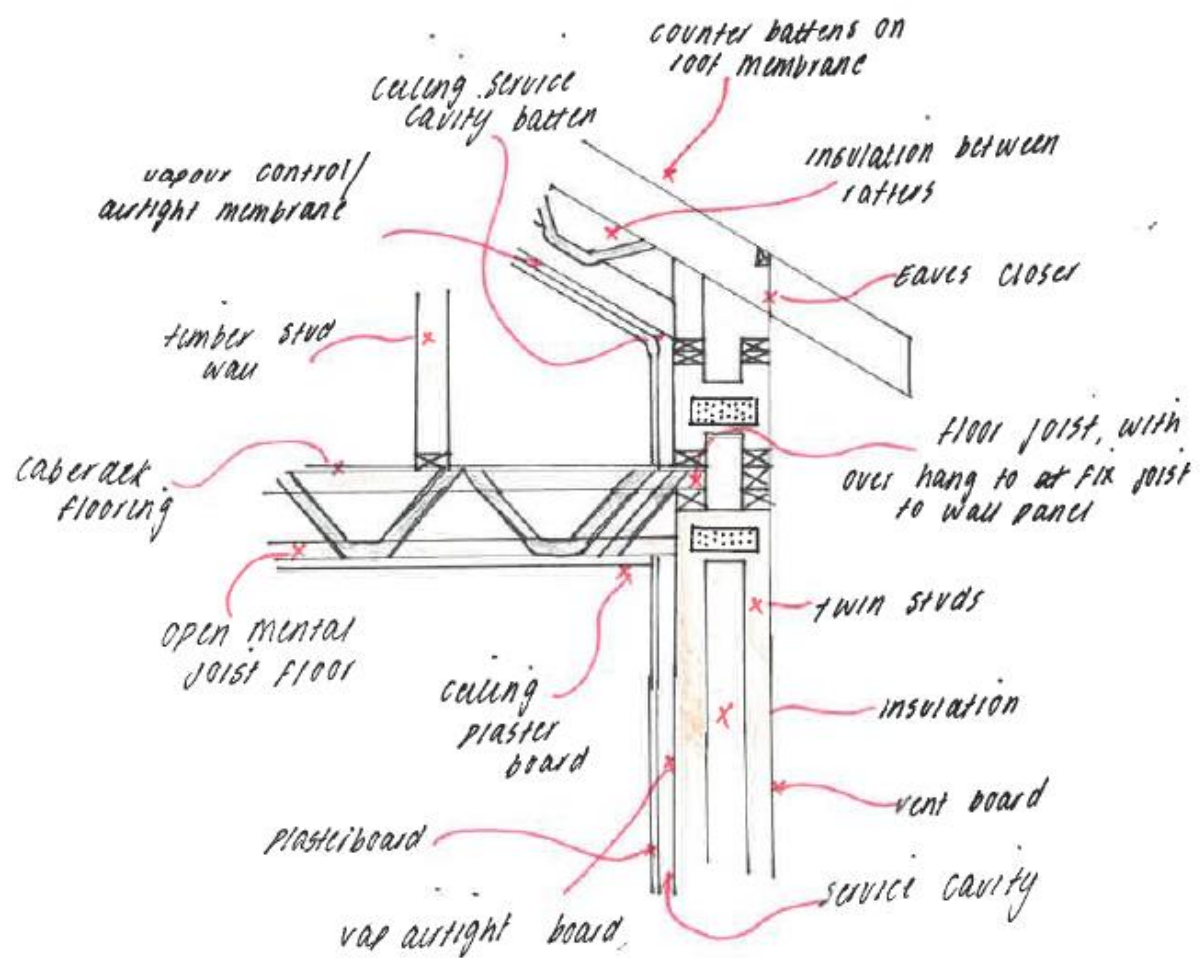
In Timber Frame Construction, window openings are formed within the timber studs, with a decorative timber lintel spanning the top, supported by vertical studs. The sill, made of wood, includes a damp-proof course or flashing to prevent water penetration. Insulation is placed between the studs, and an inner vapour control layer ensures an airtight seal. On the outside, a breather membrane allows moisture to escape while blocking water. Windows are installed in pre-formed openings and sealed with expanding foam or tapes. A gap between the frame and external cladding is kept with cavity closers or insulated reveals to maintain thermal efficiency.

In a traditional cavity wall, a steel lintel supports both the outer brickwork and inner blockwork at window openings. Cavity edges are sealed with a proprietary cavity closer or insulated blockwork. A damp-proof course is placed at the sill and above the lintel to prevent moisture entry. Window frames are fixed into the inner leaf, with the outer masonry laid tightly around them, or a separate sill unit may be used. Sealing is done with expanding foam or mortar, but modern methods use insulated closers to reduce cold bridging. Airtightness is achieved on the interior with sealing materials like plaster or special tapes, while the cavity ensures drainage and ventilation.

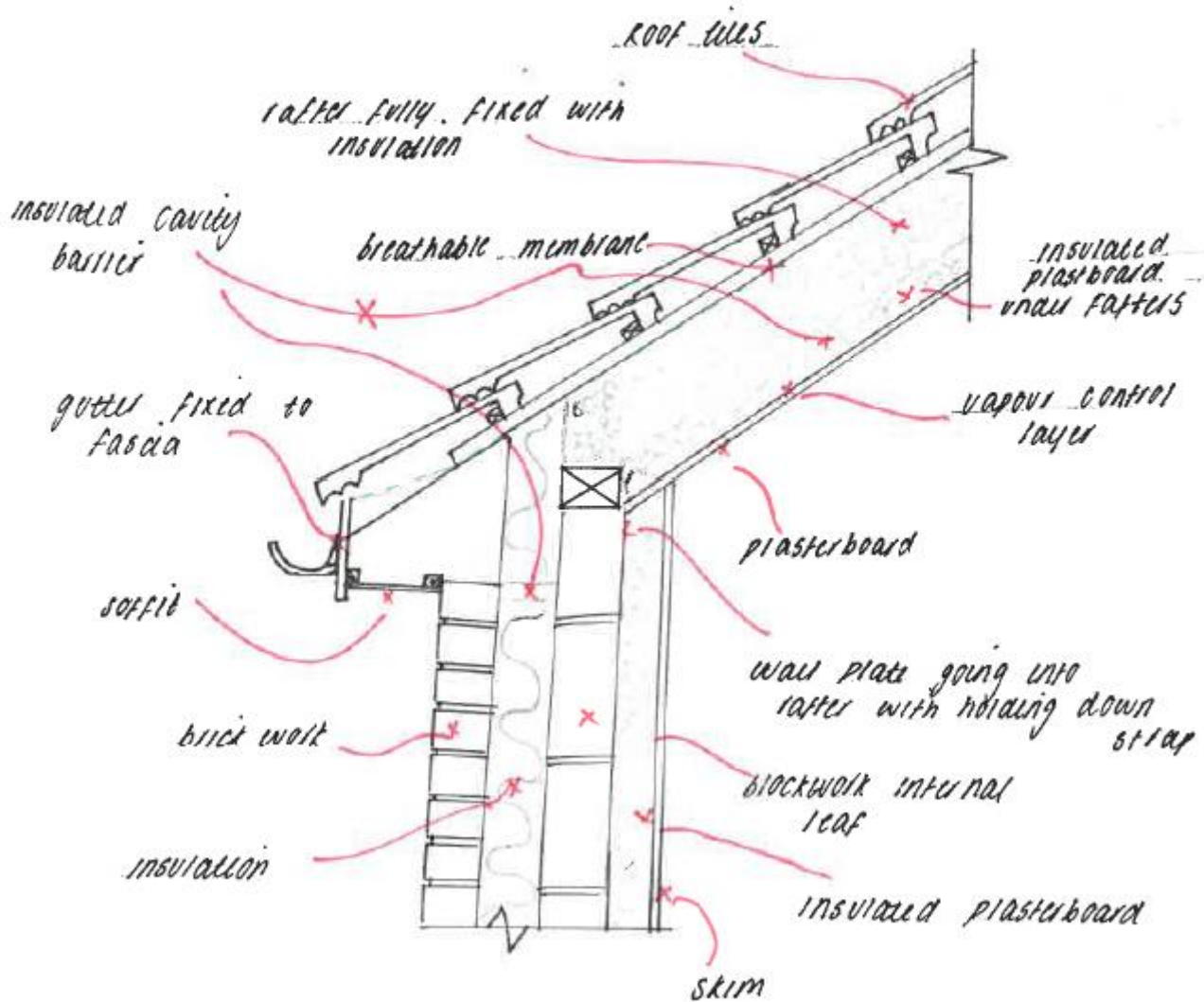
In SIPs buildings, window openings are created during panel manufacture or cut on-site. Additional support is provided by timber studs or Laminated Veneer Lumber posts along panel edges, with lintels selected for structural and thermal efficiency based on span needs. Airtightness around the window openings relies on closed joints and specific membranes, with proprietary sill pans or flexible flashings to direct water away. DPC or breather membranes are used at key junctions to prevent moisture issues. Continuous insulation in the panels minimizes thermal bridging, and cladding is fixed through battens or sheathing board, with cavity battens added for improved drainage if needed.

Eave details for all three construction methods

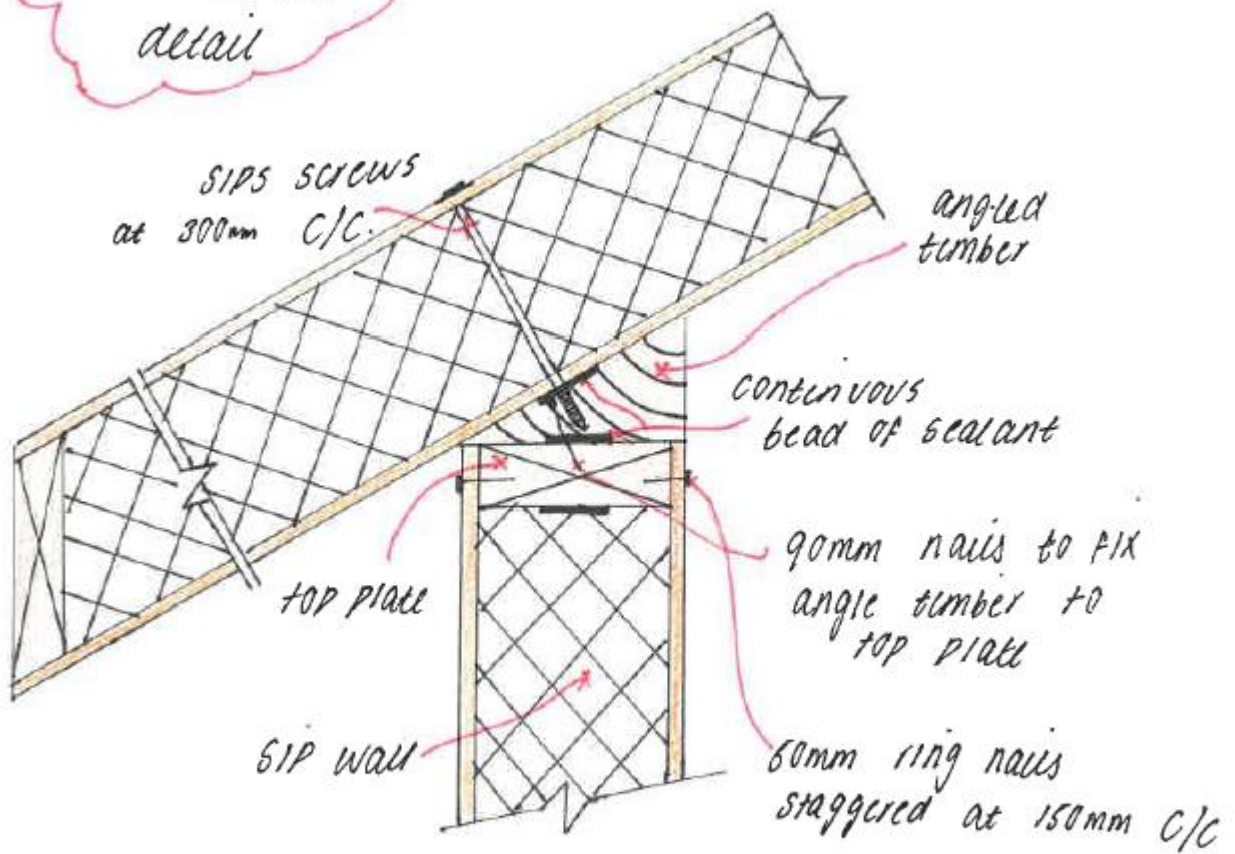
Timber frame (passive)
roof/Eaves detail



Brick and block Foot / Eave detail



SIP ROOF/EAVES detail



Comparing eave construction for all three construction methods

In timber frame construction, the eaves detail features a similar soffit and fascia system, often with a timber or uPVC fascia board. The roof structure is commonly built with timber trusses or rafters, which are either supported on the timber frame's top plate or directly on the external wall. The eaves are weathered with a breathable membrane, installed beneath the roof covering, ensuring the membrane laps over the top of the timber frame to direct water away from the structure. The fascia is usually fixed to the trusses or rafters and is sealed to prevent water ingress. As with traditional construction, the roof covering is secured with nails or clips, and proper laps are ensured to maintain the roof's weather-tightness. The eaves may incorporate ventilation to avoid moisture buildup in the roof space, with vents included in the soffit to allow airflow. A key consideration in timber frame construction is ensuring airtightness at the eaves, often achieved with careful sealing of joints and integration of a vapour control layer.

In traditional brick and block construction, the eaves feature a brick or concrete soffit, with a timber fascia and guttering. The roof is supported by timber trusses or rafters, which are fixed to the wall plate at the top of the external wall. A breathable membrane or roof felt is installed beneath the roof covering (such as tiles or slates), extending over the eaves and lapping onto the brickwork to prevent water ingress. The fascia is fixed to the rafters and sealed for weatherproofing, while the soffit offers additional protection and ventilation. Roof tiles or slates are secured with appropriate fixings, ensuring proper laps to shed water. A drip detail is often included at the roof edge to direct water away from the building.

In SIPs construction, the eaves feature continuous insulation in the panels, reducing thermal bridging. The roof structure is made from SIPs or timber framing, with a soffit and fascia system for weatherproofing. A vapour barrier or breathable membrane laps over the panels to prevent moisture ingress and must be sealed at eaves junctions. Fascia boards are fixed to the panel or frame edge, and flashing or sealants direct water away. Proper roof laps ensure effective water shedding, and airtightness is maintained by sealing joints. Ventilation may be included in the soffit to allow airflow and prevent moisture buildup.

Conclusion

Given the specific site conditions, including the reclaimed agricultural land, retaining wall, and the need for a raft foundation, timber frame construction is the most suitable choice for Miss A's project. This method offers significant advantages in terms of construction speed, thermal efficiency, and moisture management. Its lightweight nature and flexibility make it well-suited to handle potential site challenges, ensuring a stable and energy-efficient home. Furthermore, the quick assembly and sustainability of timber frame construction will not only reduce costs but also provide long-term benefits in terms of performance and environmental impact. Therefore, timber frame construction strikes the best balance between practicality, cost-effectiveness, and overall project success.

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