STRUCTURAL TIMBER ASSOCIATION
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Structure

This Technical Bulletin is intended to provide the reader with introductory information on using structural insulated panels for construction.

Structural insulated panels (SIPs) are prefabricated, high performance, lightweight, building panels that can be used in floors, walls and roofs for residential and commercial buildings. A SIP consists of two high density facings, typically Orientated Strand Board (OSB) which are bonded on both sides of a low density, cellular foam core.

The panels are typically made by sandwiching a core of rigid foam plastic insulation which is bonded to the two structural skins. A strong, structural bond between the three layers is essential to the load bearing ability of the SIP so that high loads can be transmitted by the relatively light units reducing the use of internal studding. SIP walls can bear considerable vertical and horizontal loads with reduced internal studding.

The load carried by the SIP is transferred to ground by the OSB skins, held in position by the fully bonded insulation core.

In the UK structural insulated panels are available with a number of different insulation cores; expanded polystyrene (EPS), extruded polystyrene (XPS), polyisocyanate (PIR) and polyurethane (PUR). In all cases the skins are typically OSB although there is increasing research into other forms of load bearing materials.

SIPs are manufactured under closely controlled factory conditions and can be custom designed for each application. The result is a building system that is extremely strong, energy efficient and cost effective. Strict quality control procedures are implemented in the manufacture of SIPs to ensure quality and consistency of panels. In terms of strength and resistance to fire there is little difference between the different core materials - both forms of manufacture will comply with the Building Regulations.

In all cases it is the insulation core that provides excellent thermal properties due to the limited amount of timber studs required. Equally air permeability due to the large format nature of the supplied panels is much lower than traditional construction due to the small number of joints in the structure.

There are two fundamental applications for SIPs; full structural and infill for a concrete, steel or engineered timber frame. In all cases the product will be engineered for load bearing capability, racking resistance and wind loading in accordance with the test results obtained by STA members.

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Walls

Walls are manufactured as either small individual panels, typically 1.2 x 2.4m (OSB sheet sized panels) or as larger panels made from multiple or single large format sheets of OSB. Panels with a length or height up to 6m can be manufactured to provide double height spaces or large panels for increased speed of erection.

Once the panels have been manufactured, openings can be formed. These can either be in the form of small framing panels that are site assembled to form the opening, or cut from a large blank wall panel. Solid timber lintels, studs and rails are normally inserted around the perimeter of the opening into the core of the panel. These timbers support any imposed loads from above (lintel, floor or roof loads) and provide a solid fixing for the installation of window or door sets. The location and size of window openings are considered in the site specific structural calculations for racking resistance.

If required, openings can be moved and additional openings formed with relative ease, however the size, location and method of creating these openings must be considered by a structural engineer.

Wall panels bear onto the foundations via a preservative treated timber sole plate (sometimes referred to as a locator plate) which is firmly secured to the sub-structure. The purpose of this horizontal timber sole plate is to provide a levelled substrate onto which the wall panel can be fixed and to transfer vertical load to the foundations. The way in which the wall panel bears onto the sole plate can differ between systems. Some systems incorporate a solid timber rail into the base of the SIP which in turn bears onto the sole plate. Other systems do not include this rail, and the inner and outer leaves of OSB fit over the sides of the sole plate. Either way, the wall panel is nailed or screwed to the sole plate to provide solid location of the panel and resistance to sliding, overturning and uplift forces. As with loadbearing timber studwork buildings, all structural timber should be at least 150mm above external finished ground level. Panels are jointed using either solid timber within the ends of the panels or SIP based insulated splines, depending on the manufacturer's specific system and/or structural requirements. The splines are fixed into the ends of the panels using either nail, screw or bolt fixings and sealed. At corner junctions long (200 to 300+ mm) specialist screw fixings are typically used to pass through the side of one panel into the end of the adjoining panel. The use of large screws at panel junctions may reduce the quantity of fixings required compared to nailed timber studwork wall junctions.

SIP buildings can be designed and built as either a platform or balloon framed structure. Platform framed buildings consist of room height panels with intermediate floors bearing onto the head of the walls panels.
Balloon framed buildings consist of storey or building height panels with the intermediate floors hung from the inside of the walls. The floor structures are nailed, screwed or bolted to the head of the lower wall panel or onto a timber ledger fixed to the inner face of the panel. In platform framed structures, the subsequent wall panels are then installed bearing on top of the floor structure above the lower wall panels. This process is then repeated for each storey of the building. Subsequent storey wall panels may or may not use a sole plate/locator plate.

Currently four storeys is the maximum practical height for loadbearing SIP buildings. Above this, additional structure needs to be incorporated into the building to carry the imposed loads. Whilst this is not impossible, it does present practical and economic limitations. SIPs used as infill panels is a practical and economic way of adding thermal insulation and infill structure to steel or concrete frame buildings, and allows a rapid cladding of the structural core with large panels craned into position.

Racking resistance of a SIP wall is typically 50% greater than that of a timber studwork wall sheathed with one layer of 9mm OSB. Therefore a low rise building designed to be constructed with loadbearing timber studwork, should also work as a loadbearing SIP structure. A structural engineer would need to confirm this by calculation.

Normally the structural calculations will be undertaken by the SIP manufacturer or supplier. SIP manufacturers will have data relating to racking resistance, load bearing capacity as well as flexural and bending strength. These values are based on test data and may vary between panel manufacturers.

Floors

Timber joisted floors used in SIP buildings are the same as those used in timber frame or masonry structures and consist of solid or engineered timber joists and deck, plasterboard ceiling linings and additional acoustic treatments as required.

Other types of floor system can also be used, such as hollow core concrete systems or timber joisted floors with flexible screeds. The imposed loads of the floor should be considered in the design calculations for the building.

Differential movement will occur in a SIP building as with any other timber building system. Timber rails and floor joists will dry and shrink once the building is complete and lead to movement of the building. For every 38mm

of horizontal cross gain timber, 1mm of movement is likely to occur. Each building design/system will differ slightly, so an assessment of the likely differential moment should be conducted on a building by building basis. The SIP walls should not experience any significant dimensional changes. As an example, a SIP building with an engineered timber floor zone may experience 3 to 5mm of differential movement per storey.

Differential movement gaps should be calculated based on the floor zone construction and depth of horizontal cross grain timber. Gaps should be left between masonry cladding and window cills etc as well as at floor zones between cladding supported from the SIP structure.

Roofs

SIPs can form both pitched and flat roof structures and can be finished with any form of normal roof covering. Trussed rafter or cut pitched roofs or timber joisted flat roofs can equally be used, and would be of the same design and construction as for any other build method.

Pitched SIP roofs have advantages over traditional cut or truss rafter roofs. SIP roofs usually consist of large panels supported on purlins and ridge beams. This provides an open, unobstructed roof void that is part of the thermal envelope of the building and ideal for use as a room in roof structure. Openings for roof lights are formed in the same way as similar openings in wall panels.

As with walls, additional or new openings can be formed with relative ease under the guidance of the structural engineer.

Coverings for pitched SIP roofs can be any type of covering that may be used on any other type of roof (e.g. tiles, slates, profiled metal etc). A ventilation void must be provided between the SIP and the roof covering, so the use of counter battens before tiling battens, profiled metal roofing or any other covering should be considered. Roofing battens should be fixed to the SIP roof with the use of screws.

SIP flat roofs are classified as cold flat roofs, and spans may ultimately be limited by requirements for ventilation. The SIP roof should be overlaid with battens or tapered furrings to maintain the required ventilation void, and then overlaid with a deck and roof covering.

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Cladding

SIP buildings can be clad with any type of material.

As with loadbearing studwork timber framed buildings, the cladding forms a rain screen for the structure behind. Masonry cladding will require wall ties secured to the SIP and built into the masonry cladding. Light weight cladding, e.g. timber or render systems, can be supported directly off the SIP structure. Cladding type may affect the structural design loads of the building and should be considered during the design. As there are minimal solid timber studs to fix the cladding, fixings used must provide adequate pull out resistance through the OSB alone. Screw fixings for wall ties or cladding battens should always be used. Specialist wall ties with screw fixings can be obtained specifically for masonry clad SIP buildings. British Standards and Eurocode 5 give pull out strengths for screw fixings in OSB and can be used in structural calculations.

Services

Experience has shown that it is better not to run services within the thickness of the SIP. Chasing out of a SIP to accommodate services compromises the structural performance of the panel, so a service void is typically formed using vertical timber battens on the inside of the wall. Once services are installed, wall linings are fixed to the battens.

Features

Features such as inset balconies, cantilevered overhangs and other architectural features are all possible with SIP structures. However, and as with most construction types, the consequences of these features should be considered. Additional structure may be required to carry increased imposed loads, or the overall performance of the building reduced, e.g. compromised air tightness detailing or increased thermal bridging.

Tolerances

The following tolerances are considered within acceptable limits and are achievable using a reasonable degree of care.

Concrete base and foundation walls

- Lengths of wall should be within +/- 10 mm.
- Diagonals should be equal. Acceptable deviation is:
  - up to 10 m: +/- 5mm
  - more than 10 m: +/- 10 mm.
- Ensure that walls or slab supporting sole plates are levelled to +/- 5 mm, and the perimeter lined within +/- 10 mm.
- Level concrete slabs with laser level to +/- 5 mm from datum, and avoid exceeding 10 mm variation generally.

Sole Plates

- Sole plates should be set out within +/- 10 mm in length and in line within +/- 5 mm, defined by the design drawings. Diagonals should be equal. Acceptable deviation is:
  - up to 10 m: +/- 5 mm
  - more than 10 m: +/- 10 mm.
- When the foundation edge is set back or extends beyond the sole plate by more than 10 mm the structural engineer needs to be consulted.
- Sole plates should be level. Acceptable deviation is up to +/- 5 mm.

Walls

- Panels should be plumb within +/- 10 mm vertical over any storey height.
- The building should be no more than 10 mm out of plumb over the building height.
- Line panels within +/- 3 mm on the sole/locator plate as the set-out template with maximum deviation of +/- 5 mm from drawings.
- Line within +/- 5 mm at mid height of wall panel.
- Tightly butt-joint panels together.