Reducing Costs of Affordable Housing

STRUCTURAL INSULATED PANEL

Introduction

Structural insulated panels (SIPs) offer a construction system that can reduce both the construction cost and the operating cost of affordable housing, while maintaining a high degree of occupant comfort.

Description

A structural insulated panel (SIP) consists of rigid insulation (such as extruded polystyrene foam [XPS] or polyurethane foam or, more often, expanded polystyrene [EPS]) sandwiched between two panels of structural material, such as oriented strand board (OSB) (figure 1) or plywood. The insulation is adhered to the panels with glue (commonly urethane glue); therefore, the structural integrity of a SIP is highly dependent on the quality of this adhesion. A typical SIP has 152 mm (6 in.) of EPS with 11 mm (7/16 in.) of OSB on either side. The resulting thickness of 165 mm (6.5 in.) maintains consistency with conventional construction. Dimensions vary by manufacturer, but a common panel size is 1,200x2,400 mm (4x8 ft.).

SIPs are most commonly used as exterior walls, with conventional wood construction for floors, roofs and interior partitions. Panels arrive on site, accompanied by a key plan for panel cutting and configuration. To allow for connection to the top and bottom plates and adjacent panels, the SIP insulation is recessed around the edges. To install the SIP, a bottom plate is fastened to the floor structure and then the SIP panels are tilted into position over the bottom plate and are nailed into place. A spline is nestled between each SIP and nailed to each panel to ensure structural and air barrier continuity. On either side of the spline is a foam sealant, which reduces the potential for air leakage at the joint. Dimensional lumber is provided within the SIP at load points (that is, lintels, headers, jack studs).

A vapour barrier is applied on the interior surface of the SIPs, similar to conventional construction. There are no limitations on cladding materials. Additional materials or tools needed for SIP construction include foam sealant and a hot knife for cutting insulation. A variable reach forklift (that is, a forklift with a telescopic boom) may be used for moving and lifting panels beyond the ground floor.

Credit: Enermodal Engineering

Figure 1 Structural insulated panel

SIPs may also be used in floors, and below-grade walls; however, this is less common for several reasons, including cost, perceived durability of wood installed underground and availability of established technologies. SIP roofs simplify construction where cathedral ceilings are desired.

Benefits and considerations

Because SIPs are pre-engineered panels, ease and speed of installation are increased without compromising the quality of construction.

Factory-built wall assemblies such as SIPs can reduce construction time and labour cost by 40 to 48 per cent.[1,2] At Habitat for Humanity (HfH) builds, most of the labour force is voluntary and has minimal or no construction experience, yet high quality

[1] Canada Mortgage and Housing Corporation. (2001). *About Your House: Building with Structural Panels – Repulse Bay.*

[2] Mullens, M. and M. Arif. (2006). "Structural Insulated Panels: Impact on the Residential Construction Process." *Journal of Construction Engineering and Management*, 132(7), 786-794.

exterior walls may be erected within a few days using SIPs. Fast envelope close in results in fewer weather induced delays, better protection for stored construction materials, quicker interior finishing and more comfortable working conditions.

Additionally, OSB undergoes negligible warping in comparison to dimensional lumber, so walls are installed straight and stay straight.[3] Another perspective is that less skilled labour can be used for panelized construction, without degrading quality or time of construction, which is beneficial for areas that lack skilled labour and have high demand for housing.

Another advantage of SIPs is energy savings. Overall energy savings for SIP homes is suggested to be 15 to 20 per cent as a result of reduced thermal bridging and increased airtightness.[4]

Continuous insulation through each 1,200 mm (48 in.) wide by 165 mm (6.5 in.) thick panel means that thermal bridging is minimized, relative to a conventional 38x140 mm (nominal 2x6 in.), 406 mm (16 in.) on centre stud wall. The nominal R-value in 38x140 mm construction with fibreglass batt is RSI-3.3 (R-19), but when the effects of thermal bridging are included, the insulation value decreases to RSI-2.4 (R-13.7). Meanwhile, the whole wall RSI-value of a 165 mm (6.5 in.) EPS SIP is RSI-3.8 (R-21.6).[5] Note that EPS SIPs are not subject to R-value degradation over time. The average nominal RSI-value of an aged 165 mm (6.5 in.) polyurethane SIP is RSI-6.5 (R-36.9).[6]

Some SIP systems use dimensional lumber splines for structural support; other products, such as the Thermapan system, use foam core splines, which virtually eliminate thermal bridging.[7]

Continuous insulation promotes more uniform wall temperatures, helps to reduce convection and increases occupant comfort. It also reduces moisture collection within the wall, which has building durability and indoor air quality benefits.

The airtightness of SIPs plays a large role in energy savings and occupant comfort. In a controlled experiment, a SIP home was 60-per-cent more airtight than its stick-frame counterpart (1.55 ACH versus 2.60 ACH).[8] One SIP home was measured at 0.3 air change per hour (ACH) in Grand Prairie, Alberta. The remarkable airtightness could be attributed to the builder's overall construction techniques. The HfH Toronto homes met the ENERGY STAR® airtightness target of 3 ACH but did not significantly outperform it. Therefore, attention to details and skillful sealing at joints are still required for high airtightness in SIP construction—particularly where SIP wall systems connect to the foundation and roof air barrier systems.

When high airtightness is achieved, mechanical ventilation is required to maintain good indoor air quality and to control indoor relative humidity levels.

The biggest challenges for SIP buildings are material and transportation costs. The additional material costs can render SIPs more expensive than conventional wood-framed buildings. Furthermore, transportation cost (dependent on SIP manufacturer proximity to the construction site) for panelized products can be several times greater than for conventional construction products. However, these incremental costs can be entirely offset by on-site labour cost savings.

Another consideration is the learning curve for electrical trades who work on SIP homes. The OSB skin on a SIP cannot be cut horizontally as the structural integrity of the OSB panels must be maintained. Wires can be run horizontally through precut chases, which can be challenging.

If OSB is exposed to water for prolonged periods, it will swell and compromise the structural integrity of the SIP. To prevent such damage, building paper can be used on the exterior of the installed SIP. Architectural details around windows, doors, other penetrations, intersections, and transitions between different materials must be done in such a way that rainwater cannot penetrate past the drainage plane (that is, building paper). During construction, stored SIPs must be adequately protected from standing water or rainwater.

Last, SIP assemblies are considered to be a form of combustible construction so building heights are limited.

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[3] Canada Mortgage and Housing Corporation. (2001). Op. cit. 1.

[4] Ibid.

[5] Oak Ridges National Laboratory. Kosny, J. and J.E. Christian (2001). *Whole Wall Thermal Performance.*

[6] Institute for Research in Construction. Bomberg, M.T. and M.K. Kumaran (1999). Construction Technology Update No. 32: Use of Field-Applied Polyurethane Foams in Buildings. Retrieved from http://www.nrc-cnrc.gc.ca/ctu-sc/ctu_sc_n32

[7] Shaw, A.B. and E. Bonnyman (2001). *Determination of Thermal and Moisture Behaviour of the Structural Insulated Panel.* A National Research Council/Industrial Research Assistance Program Final Report, prepared on behalf of Thermapan Industries Inc.

[8] Ibid.

Application

SIP construction has been used on the Habitat for Humanity (HfH) Toronto (figure 2) and Northumberland projects. Applications can include single-family dwellings, duplexes and townhomes.

In the HfH Toronto SIP homes, most wires were run horizontally through floor joists, then vertically to the receptacle or switch box. Mechanical services (that is, plumbing, heating and ventilation) are usually run through interior walls so installing these services is no different in a SIP-enclosed building.

Credit: Enermodal Engineering

Figure 2 Habitat for Humanity Toronto build site

Life expectancy

The first SIP home was built in 1952. Some of the oldest SIP homes have been occupied for over 40 years.[9] The life expectancy of a well-constructed and well-maintained SIP home is comparable to a conventionally built home, thanks to the similarity in materials and construction methods. Two Canadian SIP manufacturers have been selling their products for 30 years. SIP failures have been attributed to poor installation practices (for example, missing splines, improperly sealed joints) and not to the product itself.[10]

Manufacturer and/or industry support

There are four large manufacturers of SIPs in Canada and several small-scale operations.

Code acceptance

- Acceptance of the technology by local building officials varies but has generally been positive after more information is provided.
- SIPs that are 150 mm (6 in.) thick can meet the Ontario Building Code's new SB-12 (residential energy efficiency) requirements.
- Not all SIP manufacturers have sought Canadian Construction Materials Centre (CCMC) evaluation given its cost and voluntary nature. Having CCMC approval generally facilitates the building approval process.
- As an alternative to CCMC approval, a SIP building may be engineered and still obtain building code approval.
- Always consult with local building authorities.

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[9] Canada Mortgage and Housing Corporation. (2001). Op. cit. 1.

[10] Institute for Research in Construction. Said, M.N.A. (2006). Task 2: Literature Review: Building Envelope, Heating and Ventilating Practices and Technologies for Extreme Climates.

Further information

Structural Insulated Panel Association http://www.sips.org/

National Research Council of Canada – Areas of R&D in Construction
http://www.nrc-cnrc.gc.ca/eng/rd/construction/index.html

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