A BOUT YOUR HOUSE

North Series 1

BUILDING WITH STRUCTURAL PANELS—REPULSE BAY

Introduction

The challenges to building houses in the high latitudes of the Arctic include the short building season; variable weather; remote locations accessible only by sea or air; shortage of skilled trades; and the effects of the harsh climate on building performance and durability. The most common type of residential construction in the North is the wood-frame method with dimensional lumber for the structure, plywood or oriented strand board (OSB) for cladding, and fiberglass batts for insulation. The Repulse Bay project offered an opportunity to evaluate the adaptability of Structural Insulated Panels (SIPs) in a high latitude community compared to wood-frame construction.

Photograph 1: SIP cross-section

What are Structural Insulated Panels

Structural Insulated Panels are an alternative building material suitable for the floor, wall and roof assemblies of the building. SIPs are billets of expanded polystryrene (EPS) faced with OSB on either side. EPS contains no environmentally harmful chloroflourocarbons (HFCs). EPS is over 90 per cent air, captured in closed cells and is not subject to thermal drift.

SIP technology is not new. The first residential construction occurred in 1952, when Alden B. Dow, son of the founder of the Dow Chemical Company, began designing homes using structural insulated panels. The first of these houses was built in Midland, Michigan, using foam-core SIPs for the exterior walls, interior partitions and roofs. These houses are still occupied today.

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Why Structural Insulated Panels are a suitable product for northern housing

The following are some reasons why SIPs are suitable for Northern housing:

- The structural capacity of SIPs reduces structural framing, thereby reducing the potential for thermal bridging.
- SIPs are pre-cut to various shapes and sizes of panels. On-site waste is greatly reduced.
- SIPs do not rot, shrink, swell, split or warp to the extent that dimensional lumber does.
- SIP panels weigh about 35 per cent less than the same size wood-frame wall, floor or roof assembly of the same thermal resistance. As the insulation ratio increases, the weight ratio between SIPs and wood-frame also increases.
- SIP panel construction is faster than wood-frame construction, therefore, the SIP building is weathertight sooner.

Objectives of using Structural Insulated Panels in Repulse Bay

The first set of objectives involved the construction phase where factors as to the cost, suitability and difficulty of construction was compared with wood frame methods. In addition to SIPs, other alternative materials were also used on this home in Repulse Bay.

The second set of objectives was the post-construction evaluation of the building. Factors such as building performance, cost of utilities and occupant satisfaction were assessed.

Table 1: Comparison of material and freight costs between wood-frame house and SIP house

Commodity	Vendor	Cost
Lumber	Igloo Building Supplies	$1,350
Millwork	Umingmak Supplies	$13,394
Roof cladding	Igloo Building Supplies	$1,550
Cabinets	Igloo Building Supplies	$2,700
Screwjacks	Paul Bros. Welding	$3,238
Electrical	Bartle & Gibson	$3,978
Windows	Arctic Front Windows	$4,034
Structural Panels (SIP)	Plasti-Fab	$31,850
Doors	United Group	$3,254
Glulam beams	Igloo Building Supplies	$6,631
Mechanical	Kitikmeot Supplies	$13,394
Tanks	SEI	$4,010
Freight		$27,183
Total for the SIP house		**$116,566**
Total for the Wood-Frame House (include 3% annual inflation factor)		$104,768
Variance		$11,798
Components of the SIP House not included in the Wood-Frame House		
Adjustable screw-jack foundation system		$3,238
Combination integrated stainless steel boiler and domestic hot-water heater		$4,500
Heat Recovery Ventilation System		$1,500
	Additional cost of the SIP house	**$2,560**

Evaluation of the construction phase of the project:

1. The project demonstrated that material cost is comparable to wood-frame construction

A wood-frame house of identical design was used to compare the material costs for the SIP house (see note 1, p. 6). Cost of materials f.o.b. Repulse Bay for the wood-frame home was $104,768. Cost of materials f.o.b. Repulse Bay for the SIP house was $107,328 (see table 1) demonstrating little cost difference between the two.

2. The project demonstrated hours of labour required to back-up compared with wood-frame construction

In high latitude communities, the annual sealift arrives in late summer/early fall (August or

Photograph 2: Shipping

Photograph 3: Construction

September). There is a narrow window of good weather before winter. Often construction needs to be delayed until the spring to avoid winter conditions. Using "Means Unit Price Estimating Method," it was determined that it takes 480 hours of labour to build a wood-frame house to lock-up. Using the construction manager's daily progress reports, it was determined that the SIP house required only 264 hours of labour to lock-up (the house was completely weathertight, including insulation).

What this demonstrated in Repulse Bay is that it is practical to build right "off the boat" and achieve a weathertight building in a matter of days. In part, this is due to the prefabricated nature of the panels. Door and window openings, and gable walls are cut with the appropriate angle; cut-outs in the foam insulation to form pockets for dimensional lumber were all precision pre-cut at the factory prior to shipping (note 2, p. 6).

3. The project demonstrated the potential to reduce interim financing costs

As mentioned, in most high latitude and eastern Arctic communities, due to the short time between the arrival of the sealift and arrival of winter, it is necessary to store materials over winter and defer the start of construction to the following season.

Increasingly, Northern homeowners are financing their homes through bank mortgages. Having to store materials over winter means arranging interim financing which adds significantly to the cost of home ownership.

In Repulse Bay, the sealift arrived August 26, 1996. Construction started as soon as the foundation materials were delivered to the site, and the building was at lock-up (including doors, windows, insulation and exterior seal) five days later. Had the gravel pad been in place, a building using SIPs can be erected to lock up within three days, dramatically reducing financing costs.

4. The project demonstrated that semi-skilled workers readily adopt the skills needed to build with SIPs

An SIP house assembles in a predetermined sequence. Care must be taken to establish a square and level foundation to ensure the panels fit properly to the adjacent panels. In the Repulse Bay project, two days of training was provided by a factory representative, who then left. Construction was completed by a four-person crew. The lead person was a skilled general carpenter with previous supervisory experience. Two of the local workers had some building skills. The success was shown when the last of the roof panels, when installed, were within a tolerance of less than 1/8 of an inch (about 3 mm) proving that the skills required to assemble SIPs are easily mastered.

Photograph 4: Wall assembly

Photograph 5: Roof assembly

Photograph 6: Crew

Very few wood-frame homes are as square and plumb, with such close tolerances, even when built by tradespeople with years of experience.

Additional skills are needed in the North as well. Frequent strong and gusty winds are common in many Northern communities. Often production time is lost waiting for the wind to abate. Remarkably, on the Repulse Bay SIPs home, work was able to proceed despite 50—60 km/h winds, while work on a nearby wood frame building had to be halted. It was found that one diagonal brace back to the floor on the unsupported side of the panel was sufficient to hold it securely in place. Then the panels actually afforded protection from the wind and could be placed into position from the inside of the building. Therefore, these workers, new to SIPs construction, were able to find safe means of handling the panels, including the roof panels, despite the wind.

Evaluation of the post-occupancy phase of the project

1. One year warranty inspection

A post-occupancy inspection of the house was completed in October of 1997. A laser-beam level was used to check for foundation movement. The magnitude of differential movement was only 1 inch (2.54 cm) over a 17' 8" (5.38 m) span between a centre and corner screw jack. The interior inspection showed no damage to wall finishes, and all doors operated properly. One floor tile had cracked where the floor had settled away from the baseboard.

Normally, after the first year of occupancy, wood-frame houses require minor repairs to fix nail pops and drywall cracks due to settling and the climatizing of the lumber used for

Table 2: Utility Costs for the Period December 1996 to December 1997

Month	Liters of Fuel Oil	Cost	Liters of Water	Cost	KWH of Electricity	Cost
December	Nil		16,537	$44	330	$46
January	506	$328	16,007	$43	525	$73
February	437	$283	15,771	$42	478	$67
March	529	$343	19,885	$53	419	$58
April	Nil		18,537	$50	477	$67
May	Nil		16,382	$44	496	$69
June	414	$269	12,321	$33	413	$58
July	Nil		16,762	$45	377	$53
August	Nil		16,576	$44	448	$62
September	414	$269	16,874	$45	400	$56
October	414	$269	19,284	$52	531	$89
November	Nil		14,453	$39	549	$92
December	460	$299	16,285	$43	446	$75
Totals	**3,174**	**$2,062**	**215,674**	**$582**	**5,889**	**$871**
Averages	**317**	**$158**	**16,590**	**$44**	**753**	**$67**

1. Fuel oil is the energy source for space heating, domestic hot-water heating and pre-heat of make-up air drawn through the HRV. During this period, fuel oil cost $0.65/litre.
2. Electricity costs $0.148 a kilowatt for the first 700 kilowatts; consumption over 700 kilowatts costs $0.4204 per kilowatt.
3. Water and sewer services are subsidized for homeowners; the "real" economic cost is $0.055/litre, and the subsidized costs is $0.0027/litre.

Photograph 7: Moses and Louise

framing. These were not evident in the SIP house.

A fan door test was performed on the house to determine its air tightness. The test showed air exchange of 0.49 air changes per hour at 50 Pa (ACPH). The standard for R-2000 certification is 1.5 ACPH, therefore the SIP method has an excellent rating (note 3, p. 6).

2. One year operating costs

Table 2 shows the operating costs of the Repulse Bay SIP house for a 13-month period. The SIP house used about 25 per cent less heating fuel over the period than similar-sized homes in Repulse Bay.

3. Owner satisfaction

The owners, Moses and Louise Suisangnark, are very satisfied with the SIP house. Both were born and raised in Repulse Bay and have a two-year old daughter living at home with them. They commented upon the comfort of the house and during the post-occupancy interview, their daughter played on the vinyl floor in bare feet and legs—something their older children were never able to do in other houses in which the family has lived. While having a draft-free house is welcome, so are the reduced utility costs!

Intangible benefits affecting building durability and thermal performance

It is too early to draw long-term conclusions regarding the performance of the Repulse Bay home. Preliminary findings follow.

Photograph 8: Completed house

1. Foundation

A cost-effective foundation system frequently used in Northern communities consists of a level, compacted gravel base and adjustable screw jacks set on 3' X 3' (1 m x 1m) PWF wood pads. The screw jacks support glulam beams. Differential movement caused by frost jacking and/or settling causes homes to twist and wrack. At a minimum, this movement results in cracked drywall finishes, nail pops, and doors that stick. After repeated seasonal freeze-thaw cycles, the constant movement weakens the building's structure and destroys the integrity of the vapour barrier. Laboratory tests have proven that SIP construction has greater resistance to wracking forces, behaving as a semi-monocoque structure transferring bending and torsional stresses imposed by the differential movement of the foundation without damage to the structure.

2. Building envelope

According to research, the thermal performance, and therefore, the energy efficiency, of a SIP house should exceed that of a wood-frame house:

- SIP construction uses 70 per cent less dimensional lumber,
- there is less thermal bridging in a SIP wall compared to an identical wood-frame wall, and
- an SIP wall has a higher whole wall insulation rating than an identical wood-frame wall

The research results, which are expected to be seen over the years in Repulse Bay, indicate that SIP homes are 15 – 20 per cent more efficient with regard to heating than equivalent conventional wood-frame homes.

More importantly, SIP construction may avoid moisture damage often observed in above-treeline homes where, over time, unvented roof enclosures (to prevent snow infiltration and wind uplift) often experience moisture infiltration resulting in loss of insulating ability, growth of fungus and mildew and need for costly repairs.

Conclusion

At the present time, the data collected on the Repulse Bay SIP home indicates that structural insulated panels are a very suitable product for Northern house construction.

Note 1:
For purposes of comparison, the identical home was a HAP A-1 design home built in Repulse Bay in 1991 (the most recent comparison). Material and transportation costs were provided by NWT Housing Corporation (NWTHC). NWTHC uses a three per cent inflation factor which was used in calculating the comparables.

Note 2:
SIPs can be shipped as blank billets (i.e. no cut-outs for windows, doors, etc.). It is estimated that preparing the blank panels in the field would add about 100 hours of labour to erection time.

Note 3:
Using NRCan's HOT XP program for analyzing Energy Efficiency (similar to NRCan's Energuide for appliances), the simulation assigned a rating of 83 to the SIPs house versus a lower rating of 79 for an R-2000 standard house.

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