The Prospects of Applying Sandwich Insulated Panel Construction System for Energy Efficient Housing in Thailand

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Abstract

Structural Sandwich Insulated Panels (SIP) have been developed and accepted as an alternative construction system for energy efficient buildings in the temperate and cold climate zones for decades. In Thailand most SIPs are manufactured and used in construction only for industrial buildings especially cold rooms, clean rooms, and goods containers.

The objectives of this research are to study and design structural sandwich insulated panel, develop a construction system for energy efficient housing in Thailand, and study the construction costs and energy-saving efficiency of a model SIP house designed to evaluate the possibility for its further development and industrialized production.

The study was conducted by means of document research and interviews with individuals concerned to obtain an overview of the industry and find potential materials, their properties and costs, for use in SIP production. Laboratory testing for mechanical properties of SIP specimens using different composite materials was then conducted to select suitable materials for the study. Design and mock-up of wall panels were also tested under working conditions for their structural strength in the laboratory before designing a model SIP house. Structural calculations were made, construction costs were estimated and computer simulations of energy consumption

were carried out through the use of EnergyPlus software program (Version 1.22a). Finally, energy savings of the model house and cost recovery periods were calculated.

The results show that energy savings is considered minimal when taking into account the higher construction costs and would be more feasible if the system is applied to housing for high-income groups or to non-residential buildings that require heavy air conditioning loads. Being a lightweight system that is fast to construct, SIP would be suitable for projects that have sufficient enough quantity demands to justify its industrialized production.

Findings

The research findings can be summarized as follows :

1. Materials with good development prospects and are industry-based that have been found suitable for producing SIP to be used to construct houses in Thailand are sheet metals and fiber cement boards for panel facings while polystyrene (EPS) and polyurethane (PU) foam, which can be produced locally, are suitable for the insulation core. However, EPS foam industry has greater number of producers with more production power and are cheaper than PU foam.

2. Results from laboratory testing of SIP specimens[1] using different composite materials showed that SIP with plywood facings has greater strength than SIP with fiber cement board facings[2] and sheet metal facings[3] respectively. However plywood is not tolerant to dampness, termites or insects and thus was excluded from further consideration. SIP with sheet metal facings on the other hand, was found to have low ultimate compressive strength and

[1] The size of specimens = 100x50x150 mm (width x length x height) to represent a typical wall with 100 mm total thickness.

[2] Thickness of plywood or fiber cement board facings = 10 mm (each side).

[3] Thickness of sheet metal facings = 0.5 mm (each side).

also significantly lower flexural strength than SIP with fiber cement facings making it not economically viable for use in the study. Since SIP specimens with EPS core has higher ultimate bending moment than SIP with PU core, the former would be more suitable of the two for wall and floor building components.

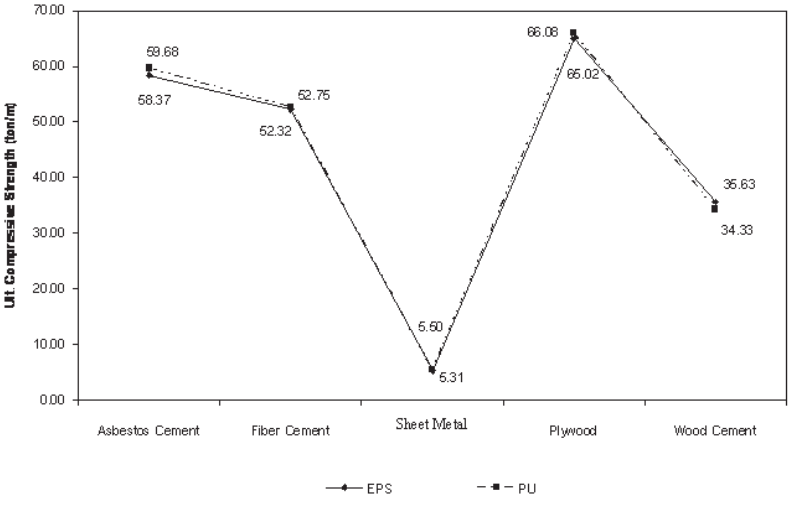

Fig. 1 Average ultimate compressive strength (ton/m) of SIP specimens using different composite materials.[4]

3. SIP wall component specimens composed of 10 mm fiber cement board facings with EPS foam core (density of 32 kg/m3) and the standard size of 1.20 x 2.40 x 0.10 m (width x length x thickness) designed for residential buildings tested under working conditions in the laboratory showed an average of 29,934 kg/m ultimate compressive strength and 9,978 kg/m allowable

[4] The size of specimens = 100x50x150 mm (width x length x height). The thickness of facings = 9-10 mm (each side) for plywood or cement boards and 0.5 mm for sheet metals. The density of foam core (EPS or PU) = 32 kg./ m^3

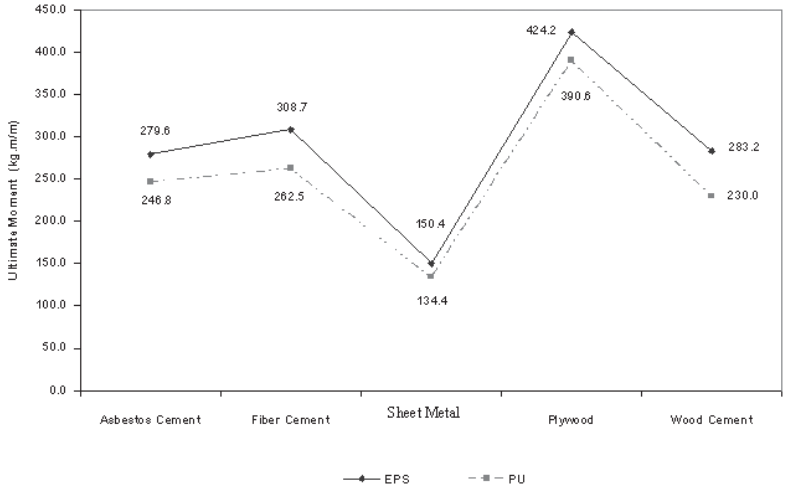

Fig. 2 Average ultimate bending moment (kg-m/m) of SIP specimens using different composite materials.[5]

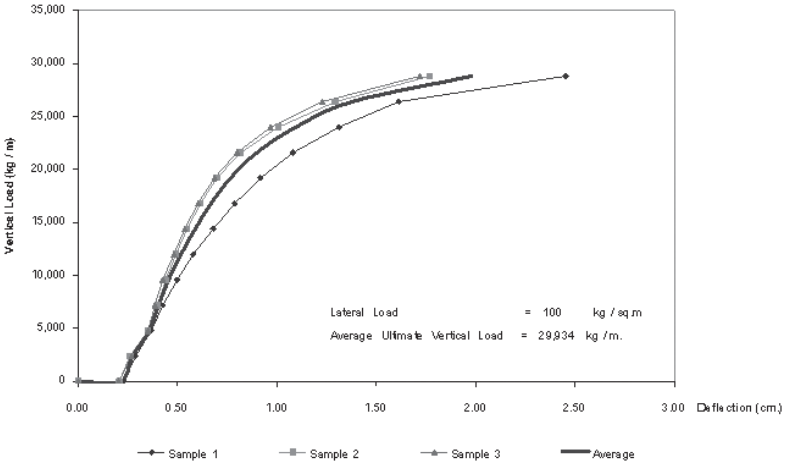

Fig. 3 The correlation between ultimate vertical load (kg/m) and deflection (cm) of SIP specimens.

[5] The size of specimens = 150x700x100(width x length x height). The thickness of facings = 9-10 mm (each side) for plywood or cement boards and 0.5 mm for sheet metals. The density of foam core (EPS or PU) = 32 kg./ m^3

compressive strength. Thus, as structural wall components, it can be used in the design of residential buildings more than 2 stories high[6].

4. The SIP model house designed for this study is a 2-storied detached house with total floor area of 167 m^2. The ground floor has reinforced concrete structure and the upper floor has cold-formed structural steel frames for floor and roofing structures while SIP are used as load bearing walls for both stories. The cost of construction for the house is estimated to be around 1,904,900 Baht or an average of 11,400 Baht/m^2 (which is 20% higher than the conventional type of construction) with structural cost being 37.5% of the total construction cost.

Fig.4 Perspective drawings of the SIP model house in the study.

5. In the case of operating the air conditioning system mainly at night time in general, the energy consumption of the SIP model house was found to be 8,130 KWh/year (28,480 Baht/year in electricity cost) compared to 8,750 KWh/year (30,850 Baht/year in cost) for the conventional house with a similar plan. The SIP house can therefore save electricity bills by up to 2,370 Baht/year. In the case of operating the air conditioning system the full 24 hours, energy

[6] A result of structural calculation conforming to design standards and regulations in Thailand.

consumption of SIP house was found to be 13,070 KWh/year (47,230 Baht/year in electricity cost) compared to 14,200 KWh/year (51,510 Baht/year in cost) for the conventional house. The SIP house can therefore save electricity bills by up to 4,280 Baht/year in this case.

6. For 2-storied house, SIP can be redesigned to reduce production cost by using 6 mm thickness fiber cement board facings. In addition, by using matt foundation instead of pile footings and do without the decorative sidings, the construction cost of SIP model house can be reduced to 10,600 Baht/m (11.6% higher than the conventional construction). In the case of operating the air conditioning system 24 hours, the SIP house can save electricity bills by 4,330 Baht/year with 42 years investment return period whereas operating the air conditioning system mainly at night can save the bills by only 2,990 Baht/year with 61.5 years for investment recovery.

7. By changing the material components for SIP walls and roofs to obtain higher R-value building envelope, the SIP house shows a tendency towards increased energy consumption, or less energy savings, in the case of normal operation of the air conditioning system mainly at night as opposed to full 24-hour operation.

Conclusion

The results of the study show that the application of SIP construction system for housing in Thailand can, in effect, save on energy consumption. However the actual savings is considered minimal when taking into account the higher construction cost which would take more than 30 years to recover the capital and therefore makes it not feasible for investment. Nevertheless SIP is a lightweight system that is simple and fast to construct, so it would be suitable for projects that have specific requirements with sufficient quantity demands to warrant industrialized production for construction.

Efficiency in energy-savings would have more positive results if the SIP construction system is applied to housing for high-income groups or to non-residential buildings that require heavy air conditioning loads operating either mainly during the day or over the full 24 hours.

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