Wood-Based Sandwich Panel with Low-Density Fiberboard for use as Structural Insulated Wall and Floor

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INTRODUCTION Ever-increasing attention has been directed to the safer and more comfortable houses against the fear of nature, such as earthquake and global warming trend. Recent years have seen dramatic developments in the applications of wood-based materials as construction materials. Wood has attractive appearances inherent in biomaterial features, and excellent functional characteristics as a construction material such as stiffness, lightweight, and thermal insulation. The potential of wood as a building material and the need for the advanced use of wood as a sustainable material insure that the wood-based materials will continue to be in demand for the progressed human habitat style.

In dwelling house, the non-steady-state insulation is important because house is exposed to the seasonal and diurnal variations in temperature outside. The plastic foam is occasionally used as the core of a sandwich structure, located between structural panel faces to fashion a structural insulated panel. However, the plastic foams and mineral wools are not advantageous in non-steady-state insulation for house over insulation board, whereas they are suitable for steady-state insulation.

OBJECTIVES The author has speculated that a wood-based sandwich panel with low-density fiberboard can serve as an alternate structural insulated panel. The lightweight fiberboard is required to be a high-performance wood-based insulator with improved mechanical properties for the core use. The wood-based sandwich panel with the low-density fiberboard is considered to have a potential to enable alternative house designs, providing with comfortable environments for human indoor life. The conventional optimization method for sandwich structure [1] must be extended to the sandwich panel with low-density fiberboard core for the optimum designing.

By using steam-injection pressing methods and isocyanate resin adhesives, the author aims to develop wood-based sandwich panels with low-density fiberboard for use as structural insulated walls and floors. Two main focuses are given as follows: the establishment the fundamental technologies to develop wood-based sandwich panels with low-density fiberboard, and the development of thick wood-based sandwich panels with a low-density fiberboard core and structural faces for the applications to structural insulated walls and floors.

CONCLUSIONS The properties of low-density fiberboard could be improved using the isocyanate resin adhesive and steam injection pressing technology. These low-density fiberboards (LDFB) were with good dimensional stability, improved specific mechanical properties, and superior thermal and sound insulation properties [2]. Low-density fiberboard was a promising insulator from sustainable wood resource, providing better warmth-keeping property than commercial insulators. The upgraded properties of low-density fiberboard could be applied to the core material of sandwich panels [3]. The lightweight veneer-faced sandwich (VSW) panels with low-density fiberboard provided with many-functions, such as good dimensional stability, high mechanical properties, and good thermal and sound insulation performance.

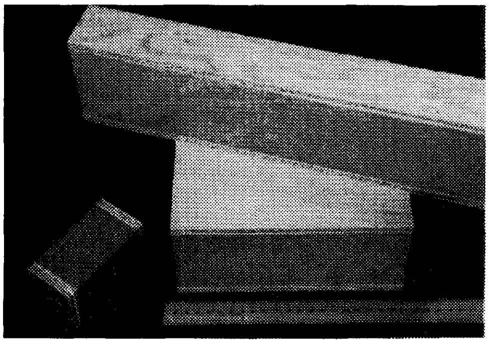

Fig. 1. Samples of plywood-faced sandwich (PSW-T100) panel

These results could be applied to the manufacture of thick wood-based sandwich panels with low-density fiberboard intended for use as structural insulated walls and floors [4]. It was concluded that the plywood-faced sandwich (PSW) panel with a thickness of almost 10 cm (PSW-T100, Fig.1) and with a density of 400 kg/m^3 had the optimum design as a structural insulated wall floor panel among the other several wood-based sandwich panels (Tables 1, 2). Knowledge about the manufacture techniques, the material constants in bending [4] and shearing [5] performance, and the other properties can provide a basis for the practical application of the wood-based sandwich panels to wall/floor panel member in house construction. Its well-balanced insulation properties [6] will improve the degree of comfort and energy efficiency of our indoor environments and activities in residences exposed to severe temperature changes.

Modern day wood is from species of trees that survived severe climate changes in the history of earth. Because of this, wood will play a greater role in building materials for humans in the future for long. Making most use of the potential of wood, the wood-based sandwich panels with low-density fiberboard were designed and developed for use as structural insulated walls and floors. The required characteristics such as stiffness, appropriate weight and insulation, which could be balanced by the optimized panel products, can ensure sustainable wood as a suitable building material and make contribution to progress the human habitation style in the future.

Table 1. Experimental material constants in four-point bending of the manufactured sandwich panels

No.	Specimen	ρ_{SW} (kg/m^3)	P/δ_L (MN/m)	E_LI (×10^{-6} GNm^2)	E_L (GN/m^2)	E_0I (×10^{-6} GNm^2)	E_0 (GN/m^2)	G_bA (×10^{-3} GN)	G_b (GN/m^2)	E_L/E_0
1	PSW-T100	320	0.071	4.2	1.2	19	5.1	0.028	0.0060	0.24
2		350	0.18	11	3.0	22	6.2	0.11	0.022	0.48
3		430	0.21	13	3.5	20	5.5	0.18	0.038	0.65
4	PSW-T50	430	0.067	4.0	6.4	5.1	8.1	0.10	0.036	0.79
5		480	0.042	2.5	7.4	2.7	7.8	0.25	0.114	0.95
6	MSW-T100	380	0.086	5.1	1.4	6.5	1.8	0.13	0.026	0.79

ρ_{SW}, density of sandwich panel; P/δ_L, stiffness; E_LI, apparent flexural rigidity; E_L, apparent elastic modulus; E_0I, pure flexural rigidity; E_0, pure elastic modulus; G_bA, shear rigidity; G_b, shear modulus. The data is average values of the specimens for the bending test. GN/m^2 = GPa = kN/mm^2

Table 2. Optimum design points of the virtual sandwich beams

No.	Face	$\rho_{SW\ opt}$ (kg/m^3)	c_{opt} (m)	f_{opt} (m)	h_{opt} (m)	W_{opt} (kg)	c_{opt}/c	f_{opt}/f	h_{opt}/h	W_{opt}/W
1'	PW	280	0.100	0.0046	0.109	2.29	1.28	0.52	1.14	0.97
2'		340	0.095	0.0077	0.110	2.83	1.23	0.86	1.16	1.08
3'		430	0.082	0.0099	0.102	3.28	1.06	1.10	1.07	1.00
4'		400	0.050	0.0064	0.063	1.89	1.43	0.71	1.18	1.03
5'		450	0.037	0.0060	0.049	1.66	1.43	0.67	1.13	0.99
6'	MDF	390	0.094	0.0098	0.114	3.36	1.22	1.09	1.19	1.20

Optimum core thickness (c_{opt}) and optimum face thickness (f_{opt}) are calculated setting $dW/dc = 0$. From these thicknesses, panel density ($\rho_{SW\ opt}$), panel thickness (h_{opt}), and weight (W_{opt}) at the optimum point are calculated. The results were compared to the data of the manufactured panels in ratios to core thickness (c), face thickness (f), panel thickness (h), and weight (W)

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