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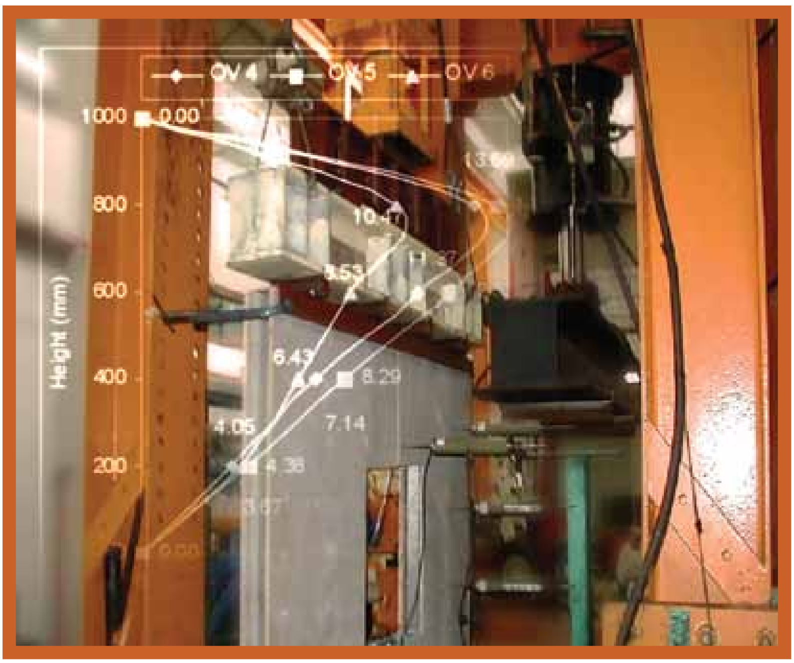

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The Effect of Butt Joint on the Structural Behaviour of PSSDB Wall Panel

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ABSTRACT

An experimental investigation was carried out to determine the effect of butt joint on the structural behaviour of profiled steel sheet dry board (PSSDB) load bearing wall with window opening. The samples tested were three (3) PSSDB walls with window opening and butt joint in the dry boards, and three (3) PSSDB walls with window opening but without butt joint in the dry boards. The samples were subjected to axial compressive load and comparisons were made between the two sets of samples. The average value of the ultimate load capacity for PSSDB load bearing wall with butt joint was found to be 286 kN, while that for the samples of PSSDB load bearing wall without butt joint was 260 kN. The average maximum lateral deflection values for both types of PSSDB walls were 8.9 mm and 13 mm respectively. Significant difference due to butt joint in dry board was seen in the reduced number of cracks by about 33 % in comparison to that without butt joint.

***Keywords**: profiled steel sheet dry board (PSSDB), butt joint, axial load*

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Introduction

Profiled steel sheet dry board or PSSDB system is a new and innovative composite construction system with a potential to be expanded in application as an alternative to flooring, wall unit and roofing system. The idea was originally conceived by Wright and Evans [1] at United Kingdom. At present, further research works are being conducted extensively at Universiti Kebangsaan Malaysia. The panel system consists of profiled steel sheeting compositely connected to dry boards (plywood, chipboard, Cemboard or particles boards) by mechanical or self-tapping screws to form panel that has far better features and attributes in comparison to the materials in their original forms separately [2].

The research done by previous researchers were concerned with PSSDB system as flooring, roofing units and wall without opening. The present study focused on the behaviour of PSSDB system as walling unit with window opening and butt joint effect on the dry boards. Therefore, PSSDB system can be said to have unlimited potential. It is also very light and therefore easily transportable, and can be erected quickly by unskilled labour. PSSDB serves as an alternative and a more practical solution to existing traditional forms of construction.

PSSDB system gives superior bending stiffness, higher load bearing and higher resistance to buckling failure compared to using PSS alone [3]. Furthermore, the depth can be designed to be much less than the traditional design to carry the same loading, thus a saving in cost and space. Various tests were carried out on the system including fire resistance, soundproofing, water resistance and others. In exploiting its usage further so as not to concentrate purely as a flooring structure, various studies were carried out as to its ability and behaviour as wall and roof structure [4-10].

Problem Statement

PSSDB has been found to be an innovative building material with the potential to be implemented in building construction. The research done by previous researchers were concerned with PSSDB system as flooring, roofing units and wall without opening. To make the research complete it is necessary to focus on effect of butt joint on the structural behaviour of PSSDB load bearing wall with window opening.

Objectives of Study

The objectives of the study are as follows:

i. To determine the structural behaviour of PSSDB load bearing wall with window opening.
ii. To determine the effect of butt joint in dry board on structural capacity of PSSDB load bearing wall due to compressive axial load.

Material and Methodology

In this section, the PSSDB samples used and the experimental set-up are described.

PSSDB Wall Panel

The PSSDB load bearing wall system consists of two dry boards (Cemboards) attached to profiled steel sheet (Bondek II), the core of panel, using mechanical connectors (self-drill screws). The properties of the materials are given in Table 1. Bondek II of 0.75 mm thick and Cemboard of 12 mm thick were adopted in this study. The size of each sample is 1000 mm high × 1320 mm wide × 78 mm thick with window opening of size 400 mm × 400 mm × 78 mm. The connectors were fixed at a 100 mm centre to centre in the longitudinal axis. Butt joints are introduced in the dry boards. A schematic view of the sample with butt joint is as shown in Figure 1. The specifications of test samples are shown in Table 2.

Table 1: Properties of Cemboard and Bontek II

Material	Modulus of Elasticity (MPa)	Bending Strength (MPa)
12 mm Cemboard	5250 (Parallel and perpendicular to grain)	9.0 (Parallel and perpendicular to grain)
0.75 mm Bontek II	205×10^3	Yield Stress (MPa) 550

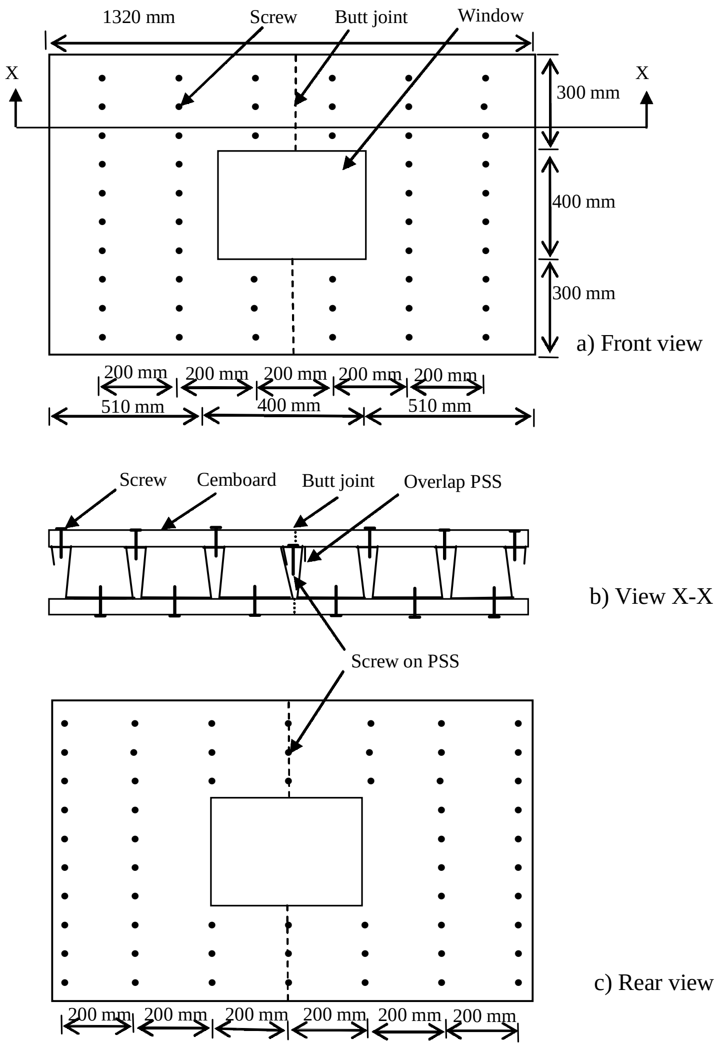


Figure 1: Schematic View of PSSDB with Butt Joint

Table 2: Specifications of Samples

Sample Label	Description of Sample
OVB 1, 2, 3	Overlapped PSS and butt joint in dry boards
OV 4, 5, 6	Overlapped PSS only

Experimental Set-up

The test rig consisted of a support beam at the lower end, and a movable loading frame on the upper end. In addition, to allow for equal distribution of load the upper C-channel was put on rollers. PSSDB wall sample was placed vertically on C-channel, which are clamped to the bottom beam. The samples were tested under in plane axial load delivered by means of hydraulic jack connected to a load cell having a capacity of 1000 kN placed at the upper end of the sample.

Displacement transducers to measure deflections perpendicular (lateral) to the height of the wall panels were placed at various locations as shown in Figure 2. The load cells and transducers were connected to a portable digital electronic data logger. The initial values for deflections and loads were zeroed on the measuring device once the sample, the loading system and the transducers had been assembled in position on the supporting and specimen frames. This condition was considered to represent the initial unloaded state of the panel.

Loads were then applied incrementally. The loads at initiation and propagation of cracks in different locations were observed and noted. The loading and the corresponding deflection were also recorded. Readings were recorded at interval of 0.2 kN. Loading was stopped when the ultimate load had been exceeded. The load and the corresponding deflection measurements taken from the experiment were then used to investigate the crack patterns and the behaviour of the PSSDB wall panels. The experimental set-up is shown in Figure 3.

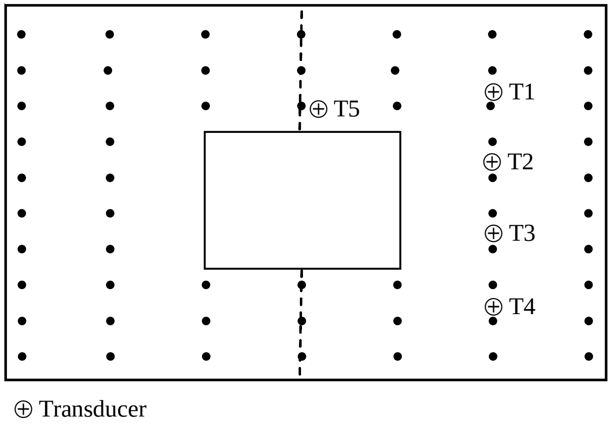


Figure 2: Positions of Transducers

Figure 3: Experimental Set-up

Results and Discussions

The deformation profiles of samples with butt joint (OVB 1, OVB 2 and OVB 3) showed that maximum lateral deflection occurred at about the same position, located at about 800 mm from the bottom support. The deformation profiles for the samples are as shown in Figures 4 and 5. Stress concentration occurred at this location due to the fact that the cross-sectional area is reduced. The maximum lateral displacements at ultimate load are 9.96 mm, 13.66 mm and 3.01 mm respectively (see Table 3). Similarly, maximum lateral displacement of samples without butt joint (OV 1, OV 2 and OV 3) also occurred at about the same height. The corresponding maximum lateral displacements are 13.69 mm, 14.62 mm and 10.47 mm respectively.

The ultimate load is the maximum load achieved before the load decreased again when the wall panel started to buckle. The ultimate load recorded in OVB ranged from 253 kN to 334 kN and for OV ranged from 237 kN to 281 kN. This showed that PSSDB wall with butt joint has higher average strength compared to PSSDB wall without butt joint.

The crack patterns of PSSDB OVB walls are shown in Figures 6 to 8. All the cracks occurred on the sides of the window opening. All OVB

Table 3: Lateral Displacement and Number of Cracks at Ultimate Load

Sample	PSSDB with butt joint (OVB)			PSSDB without butt joint (OV)		
	Ultimate load capacity (kN)	Max. lateral deflection (mm)	Number of cracks	Ultimate load capacity (kN)	Max. lateral deflection (mm)	Number of cracks
1	333.60	9.96	6	280.66	13.69	10
2	271.70	13.66	6	237.21	14.62	6
3	253.50	3.01	7	262.71	10.47	11
Average	286.3	8.9	6	260.2	13.0	9

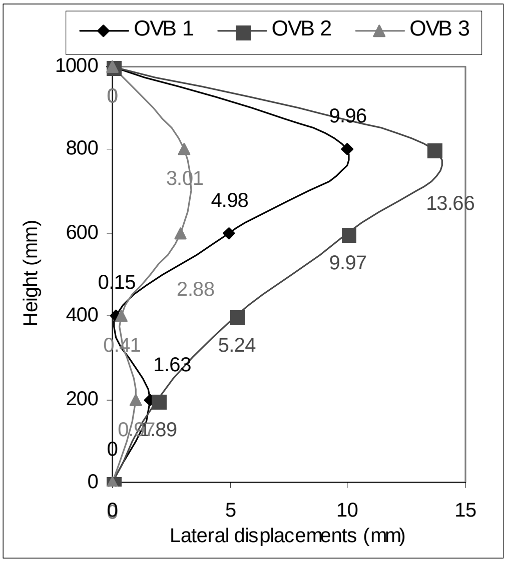


Figure 4: Deformation Profiles of OVB

samples showed similar crack patterns in the rear view. All cracks were seen on both sides in the column like sections of the wall that are considered as high stress areas because of the sudden decrease in the cross-sectional area. There were a total of six cracks in sample OVB 1 and OVB 2, whilst OVB 3 had seven cracks. The final failure mode was a combined crushing and lateral buckling on the sides of the opening. The crack patterns of PSSDB OV walls are shown in Figures 9 to 11. All samples showed similar crack pattern initiation, *i.e.* the crack started

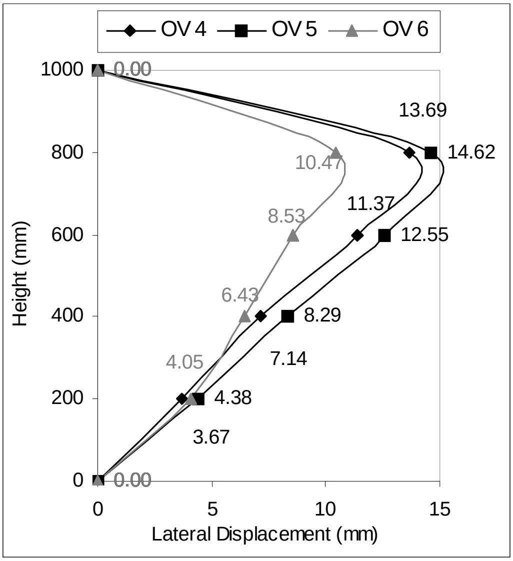


Figure 5: Deformation Profiles of OV

under flexural on upper middle portion of opening. The crack then propagated to the top of the wall as the load increased and more cracks appeared on the top corners and bottom of the opening. Some cracks were observed to pass through screw positions. There were 12, 6, and 11 crack lines in OV 4, OV 5 and OV 6 respectively. Thus, butt joint in the Cemboard reduces the number of crack line by 3 or 33 %.

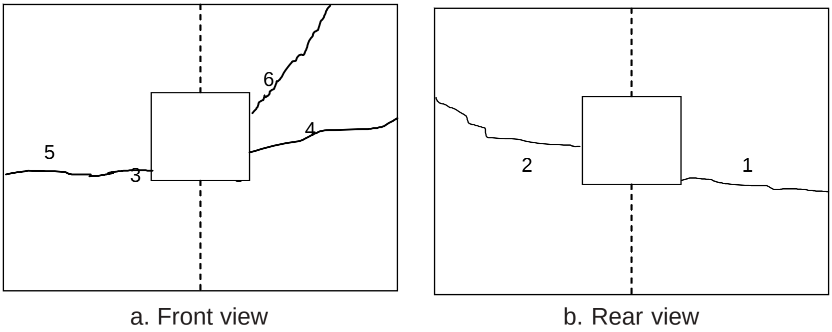


Figure 6: Crack Patterns for OVB 1

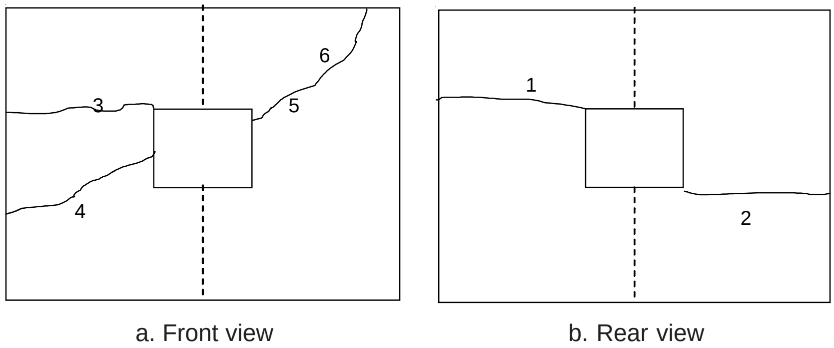


Figure 7: Crack Patterns for OVB 2

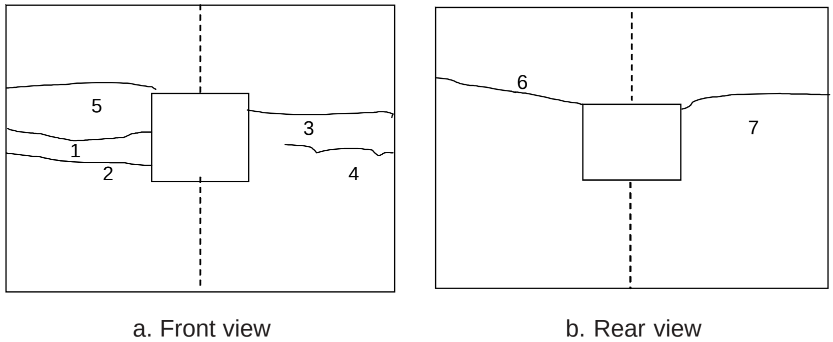


Figure 8: Crack Patterns for OVB 3

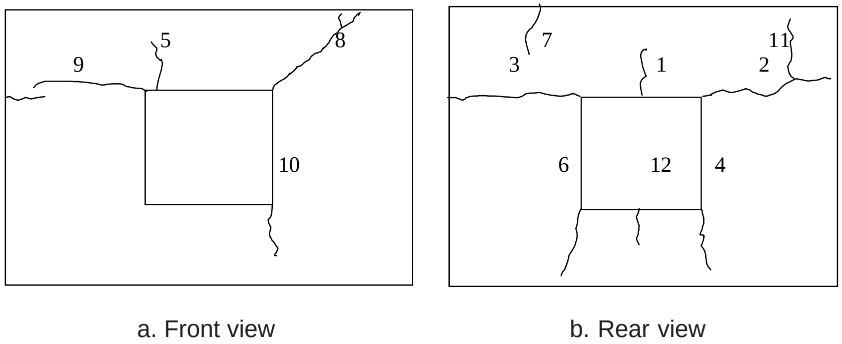
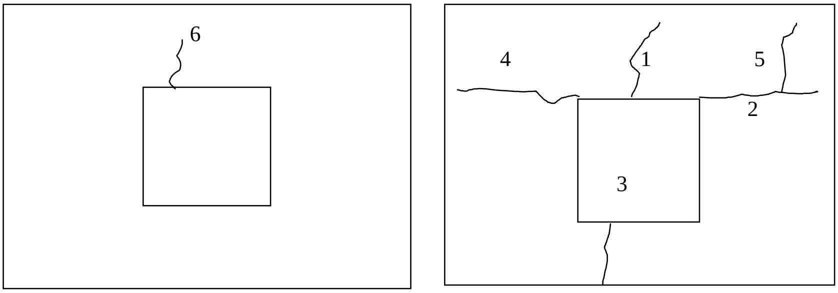
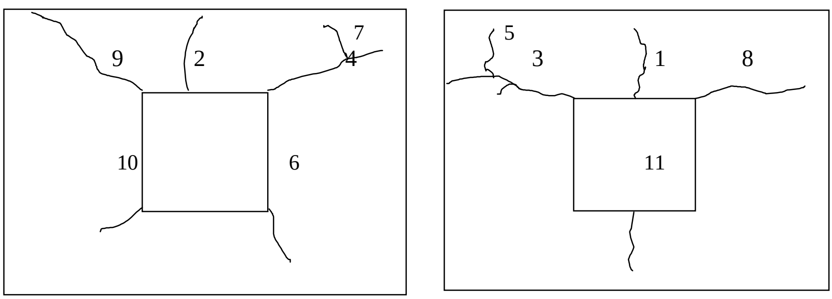


Figure 9: Crack Patterns for OV 4



a. Front view b. Rear view

Figure 10: Crack Patterns for OV 5



a. Front view b. Rear view

Figure 11: Crack Patterns for OV 6

Conclusions

The experimental study dealt with the behaviour of PSSDB wall under compressive axial load. It can be concluded that the ultimate load capacity for PSSDB walls with butt joint was higher than that without butt joint. The loads were 286 kN and 260 kN respectively.

The average deflection value obtained at ultimate capacity for wall with butt joint was 8.9 mm whilst for wall without butt joint was 13 mm. This showed that PSSDB wall with butt joint has higher strength compared to PSSDB wall without butt joint.

In general, samples with butt joint reduced the number of cracks by 33 % and at the same time are capable of sustaining about 10 % higher ultimate load compared to the samples without butt joint. Furthermore the lateral displacements for samples with butt joint are less than 10 mm whereas the samples without butt joint are more than 10 mm (1 % of the height of the wall), which is insignificant in terms of the wall height. Therefore PSSDB wall panel with butt joint is recommended for load bearing wall in building construction.

Limitation and Recommendation

This study involved butt joint in the central position of the wall and the samples were small scaled. So, future research is recommended to look into other positions of the butt joint and with full scale samples. Instead only focusing on Bontek II (PSS) and Cemboard (dry board), other alternative materials need to be studied.

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