THE EFFECT OF PLYWOOD THICKNESS ON THE PROFILED STEEL SHEETING DRY BOARD (PSSDB) FLOOR PANEL STIFFNESS

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ABSTRACT

Due to the increasing demand of construction in Malaysia, the government has embarked and taken initiative to implement the Industrial Building System (IBS) such as the Profiled Steel Sheeting Dry Board (PSSDB). PPSDB panelling system can be classified as lightweight composite structural system and can be used as a floor, roof and wall panel. This PSSDB system consists of Steel Sheeting (SS) and Dry Board (DB) which is connected to each other with self-tapping and self-drilling screws. PSSDB system can be used as temporary shelter and is suitable because it will reduce the time construction. Besides that, PSSDB system can also reduce the use of the materials like concrete and timber formworks hence reduce the overall cost. The objectives of this research are to determine the stiffness of the floor panel and to identify the relationship between thicknesses of dry board and panel stiffness. In this study, three pieces of 1.0 mm Peva45 and three different thicknesses of Plywood; 12 mm, 18 mm and 20 mm, have been used in the PSSDB floor panel as steel sheeting and dry board respectively. Meanwhile, MK-Fasteners screws type is used to attach the SS and DB together. Through the bending experiment, the stiffness of the panel can be determined by calculating the slope for each graph of Load vs. Deflection that has been obtained. The result shows that the stiffness value is increased from 109 kNm^2/m to 122 kNm^2/m when the thickness of plywood is increased from 12 mm to 18 mm. Similarly, when the thickness is 20 mm, the stiffness value is increased to 129 kNm^2/m. According to the results obtained, it showed that the thicker plywood will give the higher value of stiffness. In other words, the thicker the plywood, the higher the value of stiffness. Therefore, the thickness of the plywood plays the important role in determining the value of stiffness.

ABSTRAK

Oleh kerana pembangunan yang semakin pesat di Malaysia, kerajaan telah memulakan dan mengambil inisiatif untuk melaksanakan pembinaan dengan menggunakan Sistem Bangunan Perindustrian (IBS) seperti Sistem Kepingan Keluli Berprofil Papan Kering (PPSDB). PSSDB adalah satu sistem yang boleh di klasifikasikan sebagai sistem struktur komposit yang ringan dan boleh digunakan sebagai panel lantai, bumbung dan dinding. Sistem PSSDB ini terdiri daripada kepingan keluli (SS) dan papan kering (DB) yang bersambung antara satu sama lain dengan penggerudian skru. Sistem PSSDB ini boleh digunakan sebagai tempat perteduhan sementara dan sesuai kerana ia dapat mengurangkan masa pembinaan. Selain itu, penggunaan sistem PSSDB juga boleh mengurangkan penggunaan bahan-bahan seperti konkrit dan acuan kayu seterusnya mengurangkan kos keseluruhan. Objektif kajian ini adalah untuk menentukan kekukuhan panel lantai dan untuk mengenalpasti hubungan kekukuhan antara papan kering dan panel lantai. Dalam kajian ini, tiga keping Peva45 dengan ketebalan 1.0 mm dan tiga keping Papan Lapis dengan ketebalan berbeza; 12 mm, 18 mm, 20 mm, telah digunakan dalam PSSDB sebagai kepingan keluli dan papan kering. Sementara itu, skru yang digunakan pula adalah jenis MK-Fastener. Melalui ujikaji lenturan, kekukuhan panel telah ditentukan dengan mengira cerun bagi setiap graf Beban lawan Pesongan yang diperolehi setelah ujikaji siap dijalankan. Berdasarkan keputusan yang telah diperolehi, nilai kekukuhan telah meningkat daripada 109 kNm^2/m kepada 122 kNm^2/m apabila ketebalan papan lapis menaik daripada 12mm kepada 18mm. Perkara yang sama berlaku apabila ketebalan papan lapis adalah 20mm, maka kekukuhan yang diperolehi adalah 129 kNm^2/m. Menurut keputusan yang diperolehi, papan lapis yang lebih tebal memberikan nilai kekukuhan yang lebih tinggi. Dalam erti kata lain,semakin tebal papan lapis, semakin tinggi nilai kekukuhan. Oleh itu, ketebalan papan lapis memainkan peranan penting dalam menentukan kekukuhan panel lantai PSSDB.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PSSDB	Profiled Steel Sheeting Dry Board
SS	Steel Sheeting
DB	Dry Board
IBS	Industrial Building System
CH	Chainage
FKASA	Faculty of Civil Engineering and Earth Resources
UMP	Universiti Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays the demand in houses construction is increasing from year to year as the population of Malaysia is increasing. This matter prompted the government to embark on constructing affordable and sustainable low and medium residential houses using the Industrial Building System (IBS).

IBS is a lightweight structure system that is produced in the factory. Examples of the building components or structures are floor slab, wall, staircase, column and beam. IBS is a system that has many benefits, such as it can facilitate and reduce the time of construction and easy to handle due to its lightweight. The application of IBS is to ensure that the resources such as timber formwork and concrete material can be minimized.

According to Badir (2007), there are four types of building systems that are currently available in Malaysia. First is conventional, second is cast in-situ, third is prefabricated and the last is a composite building system. PSSDB can be classified as lightweight composite structural system under IBS. Ehsan (2007) stated that, PSSDB panel has been used successfully in a few constructions in Malaysia as flooring, wall and roofing system. This system consists of Steel Sheeting (SS) and Dry Board (DB) which is connected to each other by self-tapping and self-drilling screws (Badaruzzaman, 2013). Awang et. al (2008), had successfully implemented the PSSDB system in two school classroom modules at Sekolah Kebangsaan Telok Mas, Melaka.

1.2 BACKGROUND OF STUDY

The PSSDB system not only can be applied to the floor construction, but can also be applied in the construction of walls and floors of classrooms, walls and floors of houses and others. The main components of PSSDB consist of dry board, profiled steel sheeting and connectors. The dry board is attached to the surface of steel sheeting. Simple connectors such as self-tapping and self-drilling screws are used to connect them together. In PSSDB system, concrete could also be the infill material although the main components are steel sheeting and dry board only. However the use of concrete material in PSSDB floor system is less compared to the concrete floor slab. In addition to its lightweight, the installation and handling of the PSSDB system on site will become easier. The PSSDB panel flooring system carried out the shear and plane bending as the function of the floor is to safely support all the possible vertical loads, and then transfer the loads to the foundation via members supporting the floor (Awang, 2009). This application can reduce the construction time. Besides that, the application can also reduce the application of roof trusses in buildings and timber formwork hence this application of PSSDB system in construction can be more economical for industry.

1.3 STATEMENT OF PROBLEM

The growing population nowadays has increased the demand for houses. Year by year, the cost of living and houses construction has grown tremendously. As the solutions, the government need to develop affordable houses in order to provide the accommodations to the public. This study proposes to alleviate the problems due to the cost and long duration.

1.4 RESEARCH OBJECTIVES

- To determine the stiffness of the floor panel on different thickness of dry board
- To identity the relationship between thicknesses of dry board and panel stiffness

1.5 SCOPE OF STUDY

In this proposed study, the effect of plywood thickness on the PSSDB floor panel system will be investigated. In this experiment, the bending test will be carried out by using the compression and flexural test machine (Magnus Frame & Apparatus 30 Tonne) to identify the floor panel stiffness. The thicknesses of plywood are 12, 18 and 20 mm. While, the type of steel sheeting that will be used is Peva45 with a constant thickness of 10 mm. The different thicknesses of plywood are expected to have an influence on the value of stiffness which reflects the strength of PSSDB floor panel.

1.6 SIGNIFICANCE OF STUDY

The application of PSSDB system will help to reduce the cost of construction. This is because, the panel can be erected or handled quickly by unskilled labour and thus lowering down the overall cost. During transportation, the panel can also be stacked on top of each other. The easy installation of PSSDB floor panel on the site makes this application less time consuming.

Besides that, the application also doesn't require temporary formwork hence minimized the use of resources such as timber formwork. This application can be more economical as there is no need to install the formwork first. In terms of society's benefits, the PSSDB application can be a temporary shelter or backup building when disaster happens. For example, when flood occur the house might be damaged, and the installation of this system can be used temporarily. This will give benefits and facilities to the flood victims especially in terms of reducing the costs and make it easier for the victims to have shelter while their houses are being repaired.

1.7 CONCLUSION

This chapter has touched upon the background of the study, the problem statement, scope of the study, significance of the study and also outline the research objectives. All the subtopics have been summarized. The next chapter will be discussed about literature review which will elaborate more about the research in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The study of the Industrial Building Systems (IBS) was done by Trikha (1999) and Esa and Nuruddin (1998). An Industrial Building Systems (IBS) can be defined as building components such as wall, floor slab, column, beam and staircase that are produced in the factory (Trikha, 1999). Esa and Nuruddin (1998) stated that, IBS is a way in order to minimise the resource wastage and enhance value for end users. The IBS has many benefits to the construction work. For example, the use of IBS will reduce the labour requirement at the site as the prefabrication is take place at the factory.

The operation of construction by using the IBS will not be affected by the adverse weather condition because the building components are prefabricated in a factory. Furthermore, the time consuming of construction work will decrease as foundation work at site can occur simultaneously (Peng, 1986).

2.2 PROFILED STEEL SHEETING DRY BOARD (PSSDB)

According to Surat (2008), Profiled Steel Sheeting Dry Board (PSSDB) is a system that consists of Profiled Steel Sheeting (PSS) and Dry Board (DB) which are compositely connected together by using self-drilling and self-tapping mechanical connectors. A study of Profiled Steel Sheeting Dry Board (PSSDB) was done by previous researchers. Among them are Wan Badaruzzaman (1994), Wan Badaruzzaman et al. (1996), Wan Badaruzzaman and Wright (1998), Ahmed (1999), Ahmed et al.

(2000), Benayoune et al. (2000), Ahmed et al. (2001), Akhand (2001), Wan Badaruzzaman et al. (2003), Shodiq (2004), Ahmed and Wan Badaruzzaman (2003, 2005), Hamzah (2005), Rahmadi (2005), Awang and Wan Badaruzzaman (2007), Awang (2008) and Nordin (2008). All of them have studied the behaviour of the PSSDB floor, roof or wall panel.

Surat et al. (2008) stated that, the benefits of PSSDB system are can shorten construction time, simply installation, less wastage of materials, more durable and environmentally intelligent. Awang et al. (2008) stated that the PSSDB is a system that very light and easily transportable and delivered to the construction site. Table 2.1 below shows the weight of the PSSDB floor panel with different thicknesses of dry board. The procedure of installation is simple as it doesn't require the formwork and can be erected easily by unskilled labour.

Table 2.1: The weight of PSSDB floor panel with different thicknesses of dry board

Researcher	Thickness of Profiled Steel Sheeting, Peva45 (mm)	Thickness of Dry Board, Plywood (mm)	Weight of 1 x 2.4 m PSSDB panel (kg)
Hanizam Awang et. al (2008)	0.8	16	67.2
		18	73.2
		20	79.2

For roof panel, the use of PSSDB system will create space within the roof space. This is because it will eliminate columns, trusses and roof beams in buildings and thus can encourage natural cross ventilation for the space (Surat et al., 2008). Awang et al. (2010) stated that the disadvantages of the traditional system before PSSDB system are insect attack and rotting the timber which are always cannot be resolved by preservatives and treatments. Traditional system also difficult to provide the overall stability of the structure compared to that PSSDB system.

2.2.1 PEVA45 Profiled Steel Sheeting (PSS)

The profiled steel sheeting is a cold formed from flat steel 'coil'. The sheeting is coated with zinc/aluminium alloy. The alloy coated steel can be produced by continuous hot dip process. The stiffness of the steel sheeting increases with the increases depth of the profile (Awang, 2010). According to Gandomkar et al. (2013), Peva45 is easily available in the local market in Malaysia. The maximum width and length that available are 795 mm and 15 m respectively. The thickness of Peva45 plays main role in PSSDB system. This is because, when the thickness of Peva45 is reduced, the Fundamental Natural Frequency (FNF) of the system will increase. However, when the thickness of Peva45 is increased from 0.8 mm to 1.0 mm, peak accelerations were decreased.

2.2.2 Plywood Board (DB)

Many advantages of the plywood were investigated. Plywood has being manufactured locally in Malaysia. This type of dry board is good in weather, insect and fungal resistance. Other than that, plywood is also good in fire resistance. This has been classified as highly fire-resistant by relevant German and British Standards (2010).

The plywood can ease the construction work as the PSSDB system is light and no need the use of crane when lifting. Although with different thicknesses; 16 mm, 18 mm and 20 mm, the weight of PSSDB floor panel is still light which are 67.2, 73.2 and 79.2 kg respectively and it can be lifted by only two persons (Awang, 2008). Surat (2008) stated the strength of the plywood can be determined by the test of moment capacity. It was found that, plywood has a better potential to be used as components in load bearing structural system compared to other dry boards.

However, Awang (2008) stated that, Primaflex has better characteristics compared to the plywood to be used dry board in PSSDB floor panel system. This is because, Primaflex is good in resisting bending load. Although Primaflex is better than plywood to be used in PSSDB system, plywood still has its own advantage which is stronger than Primaflex. Previous researchers showed that, the stiffness of the plywood is higher than the stiffness of the Primaflex in PSSDB system.

In conclusion, the performance of the PSSDB depends on the type of materials, type of boards and material properties.

2.3 CONNECTORS

There are many types and sizes of screws produced locally in Malaysia. The degree of composite action achieved can be determined by the performance of the connections. This in turns depends on the type and spacing of the screws. The degree of composite action achieved will determine the stiffness of the structural composite unit. The connectors or screws play an important role in Profiled Steel Sheeting Dry Board (PSSDB). The connectors transfer horizontal shear between the boarding and the profiled steel sheeting. The stiffness and the strength of the system will increase also (Awang, 2009). Surat (2008) stated that by using the push-out test, the stiffness and capacity of the screws can be determined. Other than stiffness, the shear modulus and shear capacity of the screws also can be determined. The stiffness of the PSSDB also depends on the performance of connections between profiled steel sheeting and dry board. Table 2 shows the connectors stiffness and capacity for different types of board.

Table 2.2: The connector's stiffness

Board Type	Connectors' Stiffness (N/mm)	Connectors' Capacity (kN)
18mm Plywood	730	3.1
16mm Cemboard	625	3.0
18mm Chipboard	470	2.8

However, Nordin (2014) stated that the different thicknesses of the steel sheeting, dry board and different type of screws showed the difference value of connector's stiffness. She added that, the relationship between the PSSDB floor panel and connectors can be identified by compare the value of stiffness between them.

2.4 BENDING TEST

Based on BS 5950: Part 6: 1995, through the bending test the PSSDB floor panel is safe when the maximum deflection of the panel is not more than (length/200). The flexural test is executed to identify the stiffness of the floor panel in term of the deflection changes, the ultimate load and type of failures happened to the floor panel. In order to calculate the bending and deflection of the floor panel, three pieces of transducers are used (Nordin, 2014).

Awang (2009) found that, the model of PSSDB with timber strips performs better results by flexural test or bending test. The addition of timber strips on the edges of PSSDB panel will increase the stiffness and strength of the panel. The bending test of the panel without timber strips was found to be 57.6 $kNm^2\ m^{-1}$ while the bending test of the panel with timber strips is much more higher which is 79.3 $kNm^2\ m^{-1}$. The addition of timber strips also help in maintain the stability of the cross sectional dimensions of flexible PSSDB.

2.5 CONCLUSION

From the previous researcher, all of them had showed their result from their experiment and some of them had compared the materials they used in term of benefit and stiffness. Awang (2008) showed that PSSDB floor panel is a light and very easy to transportable to the construction site. She also stated the comparison of the physical characteristics between the plywood and Primaflex if used in the PSSDB floor panel system. Each of the dry board has its own advantages and disadvantages. In the next chapter, methodology of the research will be discussed after the literature review is done.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

PEVA45 and Plywood have been used in this experiment as steel sheeting and dry board in PSSDB. Meanwhile, the type of screws used is MK-Fastener with length of 30 mm. The size of the steel sheeting used is 2400 x 750 mm with the thickness 1.0 mm. While, the size for plywood used 2400 mm x 100 mm. They were screwed together by self-tapping or self-drilling screw. Three specimens of panels were prepared. These three panels were subjected to the bending experiment to determine its stiffness. Figure 3.1 and Figure 3.2 below represent the Peva45 and the cross section of Peva45.

Figure 3.1: Stack of PEVA45 Steel Sheeting

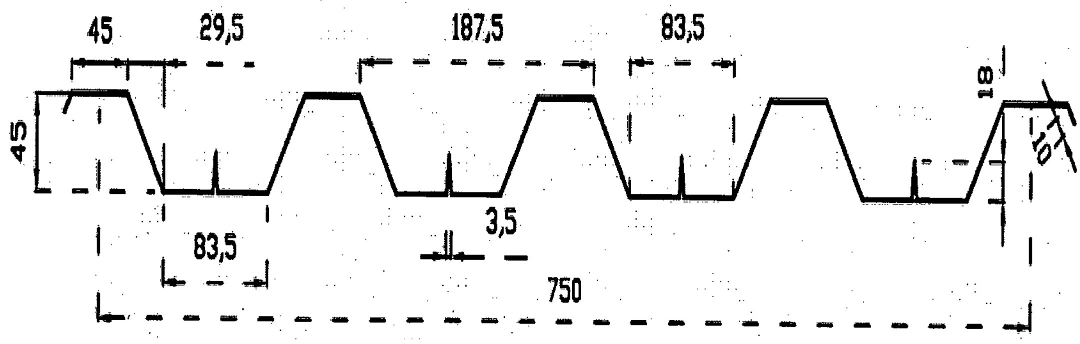

Figure 3.2: Cross-section of Profiled Steel Sheeting, PEVA45 in mm

Source : Seraji et al. 2013

From the dimension of Peva45 in the Figure 3.2 above, the marking for the each screw is done by marking it on the dry board by the distance of 150 mm between the each screw. It was marked first in order to easier the work before the screw tapping activity is carry out.

Table 3.1 below shows the information about the self-drilling screws that been used in the experiment. This type of screws is manufactured locally in Malaysia and easily available in hardware stores. Figure 3.3 below represents the screws that were used in the experiment.

Table 3.1: The information of self-drilling screws

P/code	Size	Length	Made in
DS-FH 432	8 * 1 ¼ ZPH	30 mm	Malaysia

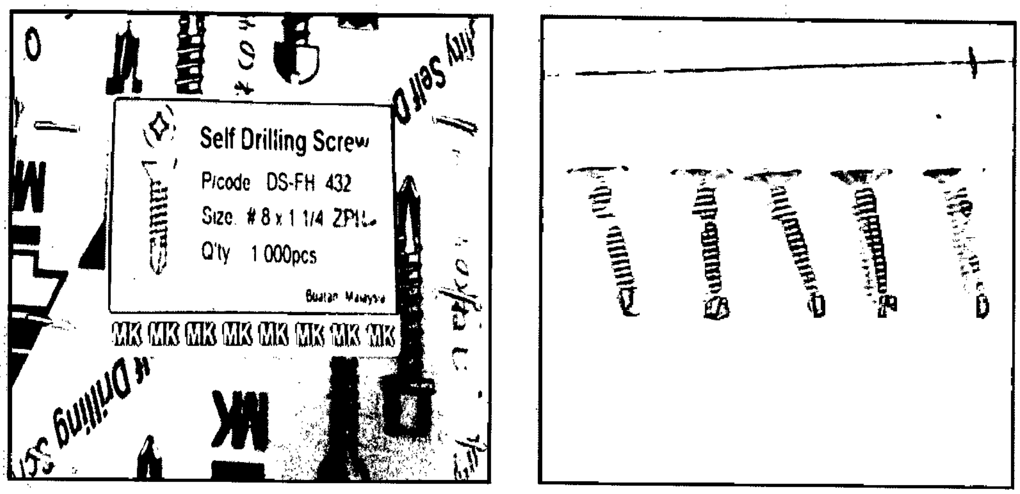

Figure 3.3: MK-Fastener Screw

The size of plywood that was used is 2400 mm x 1000 mm with different thickness which are 12mm, 18mm and 20mm respectively. Figure 3.4 below shows the stack of plywood in the lab.

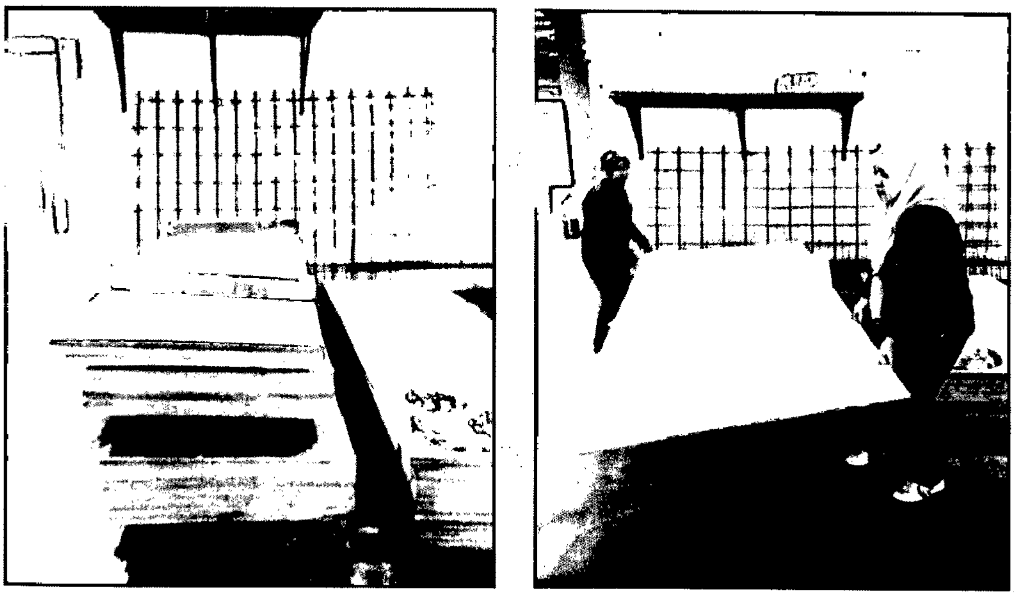

Figure 3.4: Stack of plywood

Besides using the materials like above, the addition equipment that was used in order to complete the PSSDB floor panel was the hand-drill. The function of this equipment is to tap the screws through the plywood and steel sheeting in order to make it attached together before the experiment is executed. The type of hand-drill used is Bosch Hand-Drill. Figure 3.5 below shows the type of hand-drill used.

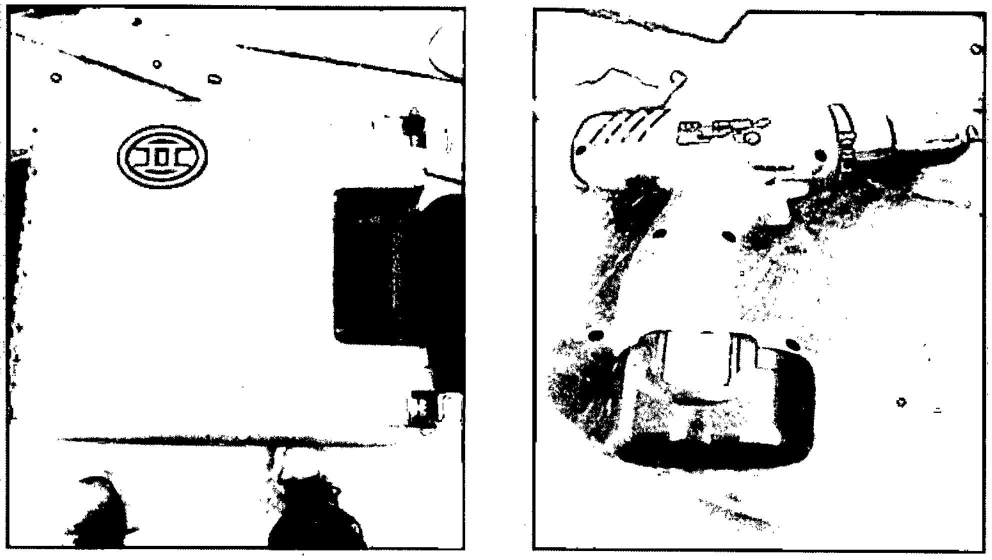

Figure 3.5: Bosch Hand-drill

3.2 PREPARATION OF TEST PANEL

In this experiment, three panels have been constructed in order to undergo a test called as compression and flexural test. The three panels are constructed by using different thicknesses of plywood which are 12 mm, 18 mm and 20 mm. 240 of screws were used in all three panels.

Each panel was used 80 pieces of screws. The Peva45 steel sheeting was placed below the plywood board before these two parts is connected together by self-drilling or self-tapping screws. The spacing of each screw on the panel is about 150 mm. Figure 3.6 shows the illustration of the PSSDB floor panel and Figure 3.7 shows the close diagram between the dry board and steel sheeting.

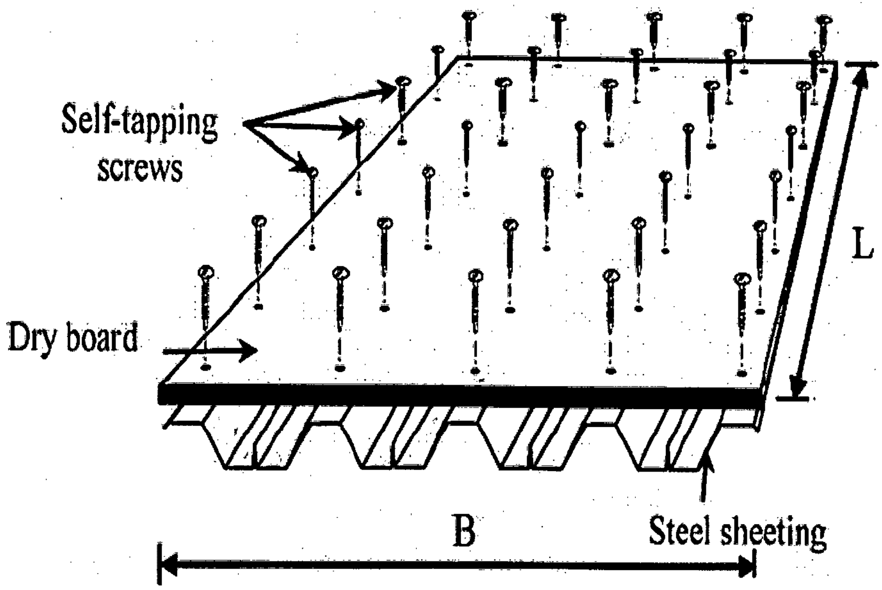

Figure 3.6: Typical PSSDB system

Source: Badaruzzaman et al. 2013

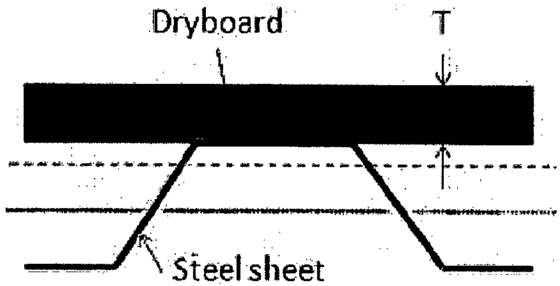

Figure 3.7: The close diagram of dry board attached with steel sheet

Source: Ehsan and Ahmad 2010

Figure 3.8 below shows the illustration of positioning the screws along the floor panel in longitudinal section and Figure 3.9 shows the illustration of positioning the screws along the floor panel in transverse section. Screw tapping activity of the panel is shown in Figure 3.10 and Figure 3.11 shows the complete of PSSDB floor panel after done screw tapping.

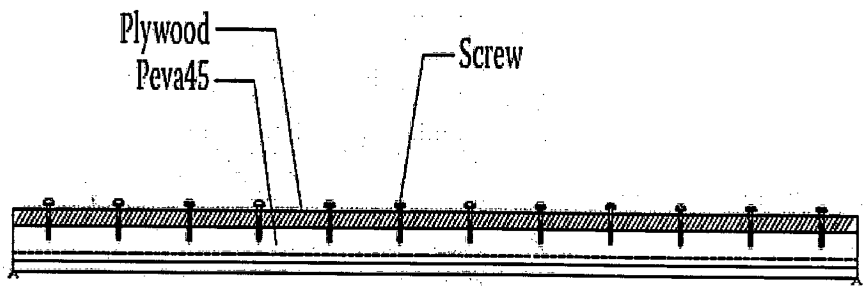

Figure 3.8: Positioning of screws in longitudinal section of PSSDB system

Source: Gandomkar et al. 2013

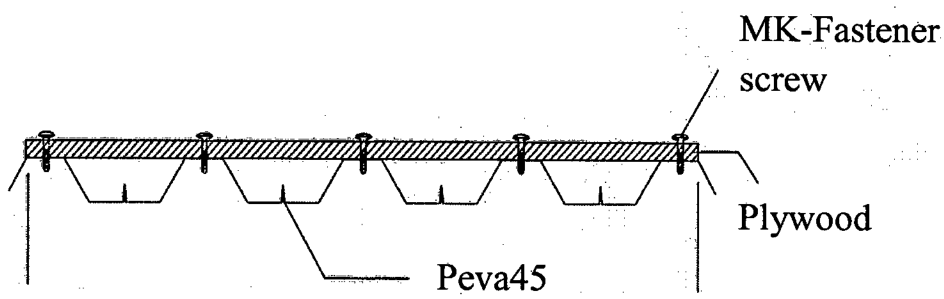

Figure 3.9: Positioning of screws in transverse section of PSSDB system

Source: Gandomkar et al. 2013

Figure 3.10: The screws tapping activity using hand-drill machine

Figure 3.11: The complete of PSSDB floor panel

3.3 TEST PROCEDURE

In order to analyse the effect of plywood thickness on PSSDB floor panel stiffness, the experimental test was conducted on three different panels. The first panel was tested with 12 mm thickness of plywood. Next, the panel was tested with 18 mm thickness and lastly with 20 mm thickness of plywood. The average of the results is then obtained. The panels described above are constructed and tested in the laboratory by using a Magnus Frame and Apparatus 30 Tonne. This machine was used to conduct a bending test in order to check and identify the stiffness and bending of the floor panel. The panels were focused on four points on the bending machine to determine its deflection and stiffness. Figure 3.12 below shows the Magnus Frame and Apparatus 30 Tonne used to conduct the experiment.

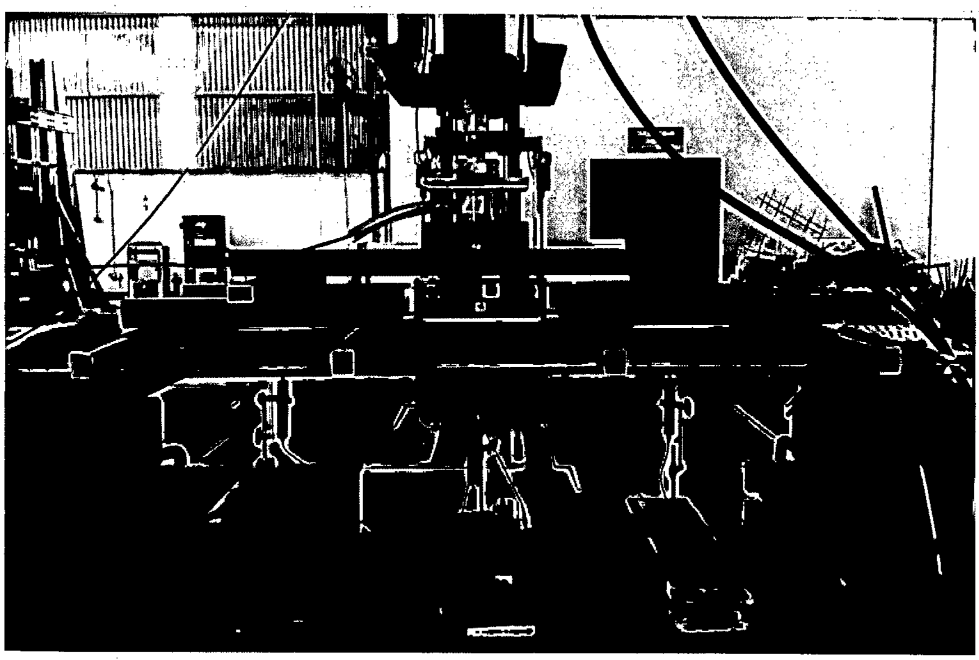

Figure 3.12: Magnus Frame and Apparatus 30 Tonne