THE EFFECT OF PLYWOOD THICKNESS ON PROFILE STEEL SHEETING DRY BOARD (PSSDB) FLOOR PANEL WITH FOAM CONCRETE IN-FILL

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ABSTRACT

Rapid growth and development in the construction industry has resulted in increasing demands for an effective and innovative construction systems and techniques. Construction normally will involve commonly using materials such as reinforced concrete and other similar industrialize building systems (IBS) that are more acceptable. The Profiled Steel Sheeting Dry Board (PSSDB) is a light composite system, thin walled that consisted of profile steel sheeting connected to dry-board with self-drilling and self-tapping connectors. The PSSDB floor panel 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 load to the foundation via members supporting the floor. The scope of this study is to determine the behaviour of in-filled mixture in Profile Steel Sheeting on the PSSDB floor panel. In this experiment, the bending test will be carried out by using the compression and flexural test machine (Magnus Frame & Apparatus 30 Tonne). This procedure will use different size of plywood, which are 3 mm, 4 mm and 6 mm each. The screws type that used to attach the steel sheeting and dry board are MK-Fastener. Based on 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 results of the stiffness are increased from 180 kNm^2/m to 184 kNm^2/m when the thickness of plywood is increased from 3mm to 6mm. According to the result obtained, it showed that the increasing thickness in plywood will give the increasing in stiffness. However, in this experiment, the foam concrete will be used as a filling. So, Foam concrete help to decrease deflection of floor compare to non filled profile steel sheeting dry board and increase the stiffness. In other words, thicker plywood will give the stronger floor panel compare to the thin plywood.

ABSTRAK

Pertumbuhan pembangunan yang pesat dalam industri pembinaan telah mengakibatkan peningkatan dalam permintaan untuk sistem pembinaan yang berkesan, inovatif dan teknikal. Pembinaan biasanya akan melibatkan bahan-bahan yang biasa digunakan seperti konkrit bertetulang dan dengan menggunakan Sistem Bangunan Perindustrian (IBS) yang boleh diterima pakai. Sistem Kepingan Keluli Berprofil Papan Kering (PSSDB) adalah sistem struktur komposit, yang terdiri daripada papan kering (DB) yang disambungkan dengan kepingan keluli (SS) melalui kaedah penggerudian skru.. Sistem panel lantai PSSDB yang dijalankan haruslah melalui kaedah ricih dan lenturan supaya ianya dapat digunakan dengan selamat, dan kemudian memindahkan beban ke asas melalui sokongan lantai. Skop kajian ini adalah untuk menentukan kelakuan Sistem Kepingan Keluli Berprofil Papan Kering (PSSDB) berisi konkrit ringan dengan menggunakan ketebalan papan kering yang berbeza. Dalam eksperimen ini, ujian lenturan akan dijalankan dengan menggunakan mesin mampatan dan lenturan (Magnus Frame & Peralatan 30 Tan). Prosedur ini akan menggunakan saiz papan kering yang berbeza iaitu 3 mm, 4 mm dan 6 mm setiap satu. Jenis skru digunakan untuk mencantum kepingan keluli dan papan lapis ialah MK-Fastener. Berdasarkan eksperimen lenturan, kekukuhan panel yang diperolehi dapat diguna pakai untuk mengira kecerunan bagi setiap graf Beban vs. Pesongan. Keputusan kekukuhan telah meningkat daripada 180 Nm^2/m kepada 184 Nm^2/m apabila ketebalan papan lapis dinaikkan daripada 3 mm ke 6 mm. Menurut keputusan yang diperolehi, ia menunjukkan bahawa ketebalan papan lapis yang semakin meningkat akan memberikan peningkatan dalam kekukuhan panel. Walau bagaimanapun, dalam eksperimen ini, konkrit ringan yang akan digunakan sebagai inti membantu mengurangkan pesongan lantai berbanding dengan kepingan keluli yang kosong dan ia akan meningkatkan kekukuhan. Dalam erti kata lain, ketebalan papan lapis akan memberikan panel yang lebih kukuh berbanding dengan papan lapis yang nipis.

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Δ	Maximum deflection of the floor panel

LIST OF ABBREVIATIONS

PSSDB	Profiled Steel Sheeting Dry Board
IBS	Industrialized Building System
PSS	Profiled Steel Sheeting
CH	Channel
DB	Dry Board

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Rapid growth and development in the construction industry has resulted in increasing demands for more effective and innovative construction systems and techniques. Construction is becoming less dependent on traditional methods of construction which normally would involve commonly using materials such as reinforced concrete and timber system, composite systems, modular systems such as lightweight panels, hollow blocks and other similar industrialized building systems (IBS) that are now becoming more acceptable. (Awang and Badaruzzaman, 2009)

IBS has been introduced into the construction industry in order to enhance the efficiency of construction processes, thus allowing higher productivity and quality, time and cost saving. The IBS is a methodology whereby the construction industry is driven and encouraged towards the production and utilization of pre-fabricated and mass produced building components off-sites in factories or in controlled environment, to be transported and installed rapidly at the sites. (Rahmadi, 2002).

According to Badir (2007), there are 4 types of building systems that available in Malaysia. First is conventional, second is cast in-situ, third is prefabricated and lastly is a composite building system. PSSDB can be classified as a lightweight composite structural system that under IBS. This system consists of Steel Sheeting and Dry Board, which is connected to each other by self-tapping and self-drilling screws (Badaruzzaman, 2013). The PSSDB system is a lightweight and therefore easy to transportable, and also can be easily erected by semi-skilled labor. Ehsan (2007) stated that, PSSDB system in construction are provide as an improvement walling system, flooring, roofing for small scale building as well as houses.

1.2 BACKGROUND OF STUDY

Wright et al. (1987,1994) were involved in testing several types of sheeting used for composite slabs that has dominated floor construction during in the United Kingdom. They studied the behaviour of sheeting under the load of wet concrete during the construction phase and the performance of the slab under service loading once concrete has reached its hardened stage.

The PSSDB floor panel 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 load to the foundation via members supporting the floor (Awang, 2009). This application will reduce time and also can decrease the application of roof trusses in building formwork. Hence, this application of PSSDB system in construction can be more economical for industry.

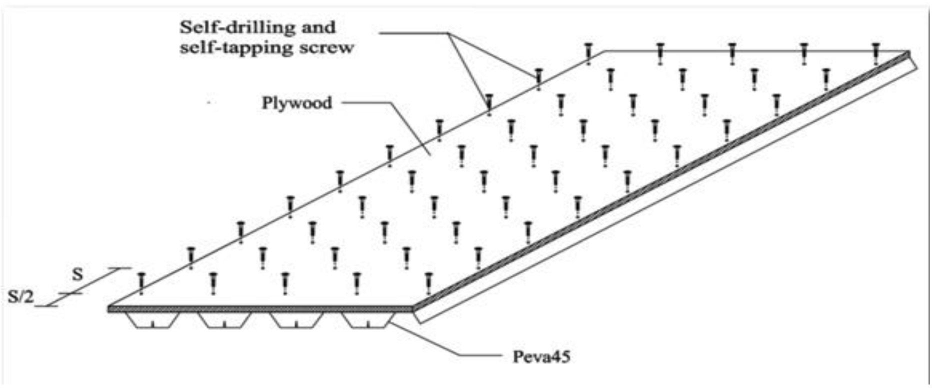

Figure 1.1 : Typical installation of the composite material to form a PSSDB panel

Source : Surat et. al (2001)

1.3 OBJECTIVE OF STUDY

The specific objective of this study and needed to be achieved are:

i. To determine the deflection of a profiled steel sheeting dry board infill with foam concrete by using different thickness of plywood.
ii. To determine the stiffness of Profiled Steel Sheeting (Peva45) performance using bending test and evaluate the properties of dry board (Plywood).

1.4 SCOPE OF STUDY

The scope of this study is to determine the behaviour of in-filled mixture in Profiled Steel Sheeting on the PSSDB floor panel. In this experiment, the bending test will be carried out by using the compression and flexural test machine (Magnus Frame & Apparatus 30 Tonne). The panel will be tested in compression and value reacted loading will be recorded. The thickness of plywood used are 3 mm, 4 mm and 6 mm respectively. While the type of profiled steel sheeting used is Peva45 with a thickness 1.0 mm.

1.5 PROBLEM STATEMENT

Enhancement in productivity and quality essential to build a sustainable local construction industry in order to compete with global industry. Thus, this system is introduced for the purpose of faster and better quality control in order to improve productivity and quality. From the previous researcher, the experiment was conducted and it was found that the possible to achieve approximately 30% increase in stiffness based on the material used. This study proposed to solve the problems due to the cost, durability and also the behavior of the material used.

1.6 CONCLUSION

This chapter has been included the introduction, background of study, scope of the study, problem statement and also an outline of the objective of study. All the subtopics have been summarized. The next chapter will be discussed about literature review which will elaborate more about the research of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The objective of this study is to determine the stiffness of a profiled steel sheeting dry board and to characterize the behaviour of the connector of profiled steel sheeting by using various types of filling.

PSSDB is a composite structural panel consists of three main elements which are the dry board, profiled sheeting and self-tapping screws as a connector. As a conclusion, the behaviour of PSSDB system depends on the type of material used, type of board, and material properties. Some of advantages of PSSDB floor panel systems are :

i. PSSDB are relatively very light.
ii. PSSDB could be designed to be 10 mm less deep than the traditional timber joist flooring system for a 4 m span floor carrying domestic loading.
iii. Construction procedure is simple and does not require temporary formwork or propping.
iv. Can be erected quickly by unskilled labor.
v. Saving cost.
vi. Easily transportable.
vii. Renovation work will much easier to handle.

2.2 PROFILE STEEL SHEETING DRY BOARD

Profiled steel sheeting is formed from steel 'coil' or 'strip' folded into continuous ridged profiles. According to Norhaiza et al. (2009,2011), Profiled Steel Sheeting Dry Board is a lightweight composite structural panel consist of the main element of profiled steel sheeting, dry board attached with self-drilling and self-tapping screws. This system can be used for a variety of applications such as floor, roof and wall. Easy handling and installation are the parts of advantages of this system in addition to its weight. PSSDB also can be dissembled and assembled and also promotes clean environment and minimizes waste and pollution.

The original idea of using this type of material as structural components was by Wright and Evan (1986) as a replacement for existing timber joist floors. Then the idea was expanded by Ahmed (1996, 1999), Ahmed and Wan Badaruzzaman (2003, 2005), Akhand (2001), Benayoune and Wan Badaruzzaman (2000), Shodiq (2004), Hanizam (2008), Monayem (2001) and Norhaiza (2008).

Surat et al. (2008) concluded that the PSSDB system has many advantages such as it can shorten time, easy to install and more durable. Awang et al. (2008) also stated that PSSDB is a system that very light in weight.

2.3 PROFILE STEEL SHEETING (PSS)

The profiled steel sheeting is made from high strength steel with the advantages that they will maintain the form firmly. They show high resistance to accidental buckling or damaged in handling during transportation, erection or services. According to Gandomkar et. al (2013), Peva45 is available in Malaysia. The thickness of Peva45 plays the main role in the PSSDB system because, when the thickness of Peva45 is reduced, the frequency will increase. However, when the thickness of Peva45 is increased, the peak acceleration will decrease. In this study, the thickness of Peva45 used were 1.0 m.

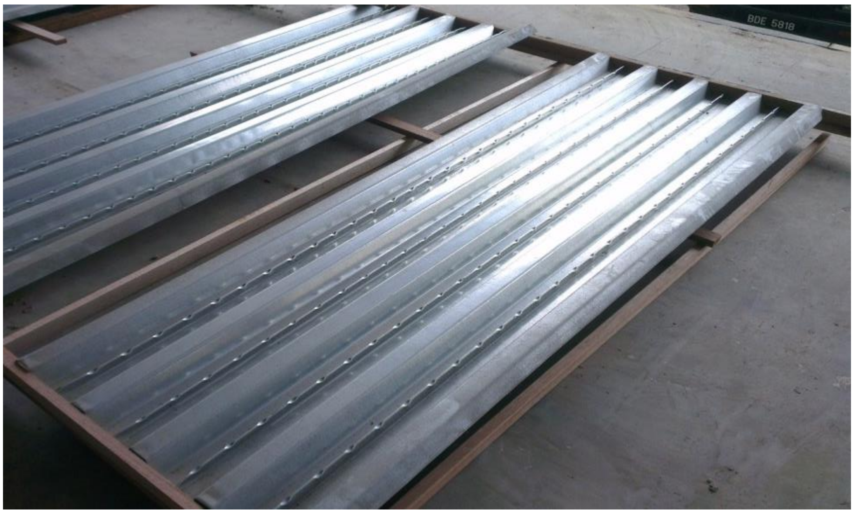

Figure 2.1 : Profiled Steel Sheeting (Peva45) with 1.0 m thickness

2.4 DRY BOARD (PLYWOOD)

Among the various types of dry board; plywood is widely available in Malaysia. However, plywood was chosen because it can be utilized more cheaply and more readily available. Plywood was also good in weather condition, insect and fungal resistance. Other than that, plywood also good in fire resistance. This has been classified as highly fire-resistant by relevant German and British Standards (2010).

Surat (2008) stated that the plywood has better potential to be used as components in a load bearing structural system compared to the other boards. Otherwise, Ehsan (1998) concluded that the plywood was not suitable to be used in construction as it does not provide better performance from cemboard because of the durability, protection from insect attack, fire resistance quality and others but this problem can be solved by adding finishing to the floor by coating or others.

Based on thesis from Hanizam (2008), she stated that the behaviour and the mode of failure are also different depends on the type of dry board used. She concludes that every dryboard has different strength of stiffness.

The plywood was easy for the construction due to its lightweight and no need machineries when lifting. However,Hanizam (2008) stated that, Primaflex has better characteristics compared to the plywood that be used in the PSSDB floor panel system. This is because Primaflex is good in resisting bending load. However, plywood has their own advantages which is stronger than Primaflex. Previous researcher proved that the stiffness of the plywood is higher than Primaflex in PSSDB system.

Figure 2.2 : Dry Board (Plywood) sized 2.4 m x 1.0 m

2.5 CONNECTORS

There are many types of screw that were available in the market which comes in various types of shape, size, material and others. The screw is important and it can determine the overall strength of PSSDB. According to Manoyem (2001), the hole can be damaged by oversize hole, misshape and misalignment that can eventually affect the cost of PSSDB.

Wright et al. (1994) has concluded that simple mechanical screws were the most suitable screw to be used. Ahmed (1996) also has concluded that self-drilling will be most suitable screw for PSSDB. The advantages of self-drilling screw are they can drill their own hole that suit with their size and it will also guarantee that it will not damage the material.

Norhaiza (2009, 2014) stated that it is better if the panel can be done nearing the actual panel by increasing the number of connectors. By increasing this type of connector, more accurate data can be obtained. She also added that the different type of screws shows the different value of connectors stiffness. She concluded that the relationship between the PSSDB floor panel and connectors can be identified by comparing the value of stiffness among them.

Figure 2.3 : Connectors (Screw Phil Flat Head SDS Zinc Plated)

2.6 LIGHTWEIGHT FOAMED CONCRETE

Foam concrete or classified as lightweight concrete, in which air voids are entrapped in mortar by using a suitable foaming agent. In this experiment, a density of foam is 700 kg/m^3. The production of foam concrete mix depends on many factors such as type of foaming agent, production of foamed concrete, method of preparation foam concrete and also design strategies. Volume of water required for a mix depends on the composition and the use of admixtures. According to Ramamurthy et al (2008), at lower water content, the mix will become stiff and causing bubbles to break. If water content was higher, mixture will become thin to hold the bubbles leading to separation of bubbles and thus cause segregation. When mixing, the foam must be firm and stable so that it can resist the load and pressure until the concrete or cement takes its initial set.

Table 2.1 below shows an overview of foam concrete compressive strength for different mixture composition and densities. The compressive strength will decrease when there is a reduction in density of foam concrete. The specimen size and shape, age, water content, and the method of curing will influence the strength concrete. Other factors that affect the strength of foam concrete are cement–sand and water–cement ratios, type and particle size distribution of sand and type of foaming agent. For dry density of foam concrete is between 500 and 1000 kg/m^3, the compressive strength will decreases with an increase in void diameter. If the densities are greater than 1000 kg/m^3, that means the air-voids are far apart and easy to break.

Table 2.1: Review of mixes used, compressive strengths and density ranges of foam concrete.

Author(s)	**Proportion of cement kg/m^3 or composition**	**Density range kg/m^3**	**Comp. strength MPa (28 days)**
McCormick	335–446	800–1800	1.8–17.6
Tam et al.	390	1300–1900	1.81–16.72
Regan and Arasteh		800–1200	4–16
Hunaiti		1667	12.11
Durack and Weiqing	270–398	982–1185 (DD)	1–6
	137–380	541–1003 (DD)	3–15 (77-days)
Jones and McCarthy	300	1000–1400	1–2
		1000–1400	3.9–7.3
Jones and McCarthy	500	1400–1800	10–26
	500	1400–1800	20–43
Nambiar and Ramamurthy	Cement–sand mix (coarse)	800–1350 (DD)	1–7
	Cement–sand mix (fine)	800–1350 (DD)	2–11
	Cement–sand–fly ash mix	650–1200 (DD)	4–19

Sources: E.P. Kearsley (1996)

2.7 CONCLUSION

From the previous researcher, all of the data from their experiment had been shown and some of them had compared the materials they used in term of benefit and stiffness. Hanizam (2008) stated that the PSSDB floor panel is very light material and easy to transportable to the site. She also showed the comparison between dry board. Different opinion with Norhaiza (2009, 2014), she stated that the stiffness of PSSDB related with the connectors. Increasing the number of connectors will obtain more data. Nearing the spacing of connectors will result in increasing stiffness of the PSSDB floor panel.

According to Ramamurthy et. al (2008), at lower water content will make the concrete become stiff and causing bubbles to break. However, if the water content was higher, segregation of the mixture will occur. Last but not least, Gondamkar et. al (2013) stated that the thickness of Peva45 plays the main role in determining the stiffness of the PSSDB floor panel. As a conclusion, each of the material have their own advantages and disadvantages. In the next chapter, the methodology of the research will be discussed.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

As mentioned in Chapter 2, the objective of this study is to increase the stiffness of PSSDB. The purpose of this study is to find out the stiffness and the values that can be used in the future. Previous studies have been carried out by past researchers such as Wright and Ahmed (1996), Akhand (2001), Harsoyo (2004) and Hanizam (2008) which is all of them have obtained different results based on different element and material used.

Peva45 and plywood have been used in this experiment as steel sheeting and dry board in PSSDB. Meanwhile, the type of screws used is Screw Phil Flat Head SDS Zinc Plated. For in filled, this experiment used foam concrete with a density of foam is 700 kg/m^3. The size of steel sheeting used is 2400 mm x 800 mm with the thickness 1.0 mm. While the size of plywood used is 2400 mm x 1000 mm with thickness 3 mm, 4 mm and 6 mm respectively. This dryboard will screw together with Peva45 by using self-tapping or self-drilling screw. These three panels were subjected to the bending test experiment to determine its stiffness by using Magnus Frame and Apparatus 30 Tonnes Machine. Figure 3.1 below represents the cross section of Peva45.

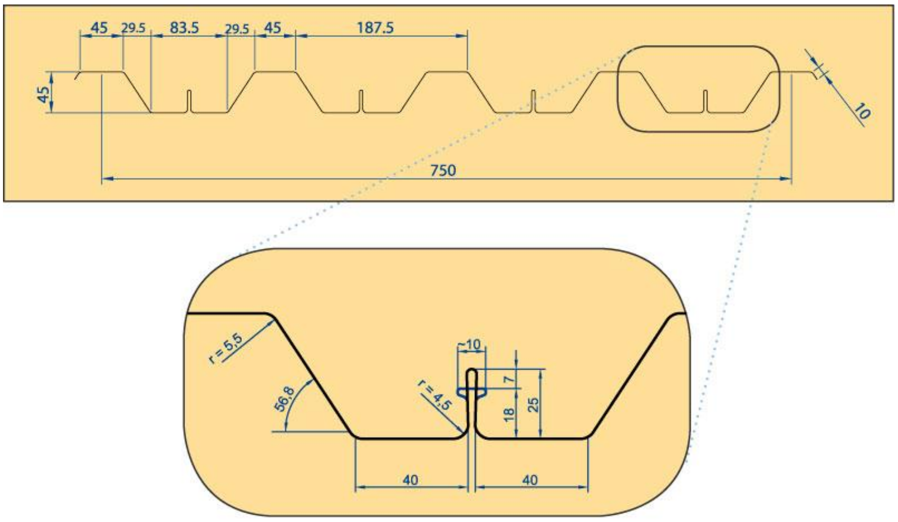

Figure 3.1 : Cross-section of Profiled Steel Sheeting, Peva45 in mm

Sources : Seraji et.al. 2013

Each dry board was marked first in order to make it easier and faster to do the work before the screw were drilling. The distance between each screw that need to be tapped on the dry board and profile steel sheeting are 150 mm. Table 3.1 below shows the type of screws that were used in this experiment.

Table 3.1 : The information of the screw

Code	Size	Length
DS 438 FH	½' x 8	30mm

The other equipment used in order to complete this project was hand-drill. The function of this equipment is to tap the screw through the plywood and steel sheeting to make sure it is attached with each other. The type of hand drill used is Bosch Hand-Drill. The figure below shows the image of a hand-drill.

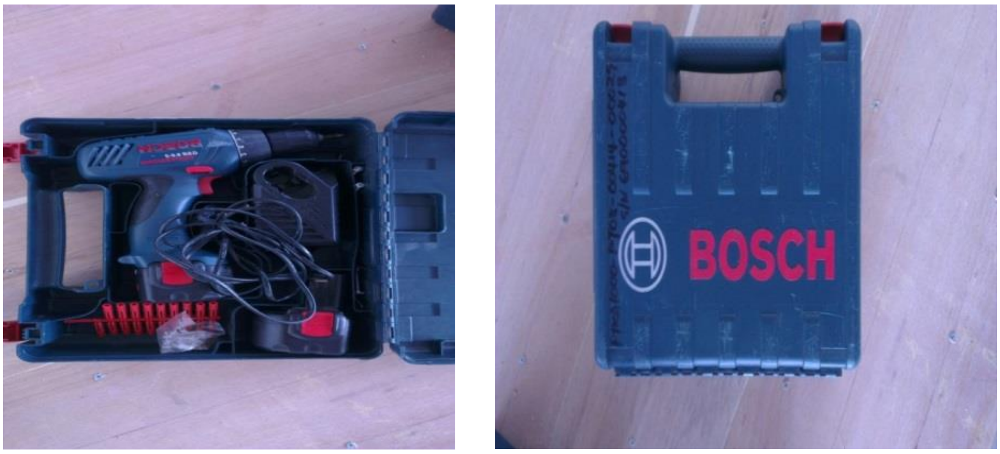

Figure 3.2 : Bosch Hand-Drill

Other than that, the filling that was used in this experiment is lightweight foam concrete by using Ordinary Portland cement. To make sure the foam concrete is mixed well, the density for each concrete and foam were weighed. 1 L foaming agent will be mixed with 24 L water. Then water will added in the machine, followed by cement and silica sand that were weighed earlier by using the ratio 2:1:1. Lastly, when the concrete reached the density, the foam will be added. The density of foam concrete needed to fulfill the hole of profiled steel sheeting are 700 kg/m^3 while the density of concrete is 1970 kg/m^3. Before the compressive strength of the concrete was determined, the samples of cubes needed to undergo curing process for about 7 days. After curing, the testing of the compression strength was carried out. The machine used for mixed the concrete were shown below.