THE EFFECT OF PEVA 45 STEEL SHEETING THICKNESSES ON PSSDB FLOOR PANEL SCREW STIFFNESS THROUGH PUSH-OUT TEST

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ABSTRACT

PSSDB is a composite combination of Profiled Steel Sheeting (PSS) and Dry Board (DB) such as Peva 45 steel sheeting and Primaflex board. It falls under the Industrial Building System (IBS) category and has many advantages as prefabricated floor panel system. It consists of three important elements which are profiled steel sheeting, dry board and screw by self-drilling and self-tapping. This research is conducted to determine the effect of each sheeting thickness of Peva 45 on Profiled Steel Sheeting Dry Board (PSSDB) floor panel screw stiffness through push out test. Nevertheless, despite the weakness of steel sheeting which has high strength but low in stiffness that might bring to failure, investigation is made through push out test by using at least two different thickness of Peva 45 sheet. Instead, the behavior of this steel-board composite structure through the experiment is recorded and compared with similar previous research. The result from the previous research done showed that the increase of steel sheeting thickness enhanced the strength on PSSDB floor panel screw stiffness. From the push-out test, it showed that the screw stiffness increase by 42.03% from 0.69 N/mm to 0.98 N/mm. The maximum force applied increase by only 7.45% from 1.61 kN to 1.73 kN. A hypothesis is draw where the thicker the steel sheet, the stiffer the screw stiffness. Therefore, the objectives are successfully achieved. This research has contributed a better understanding of the influence of steel sheeting thickness towards the screw stiffness.

KEYWORDS | Industrial Building System; Profiled Steel Sheeting; Primaflex; Peva 45; Screw Stiffness

ABSTRAK

PSSDB adalah gabungan komposit Kepingan Keluli Berprofil (PSS) dan Papan Kering (DB) seperti kepingan keluli Peva 45 dan papan Primaflex. Ia tergolong dalam Sistem Bangunan Industri (IBS) dan mempunyai banyak kelebihan sebagai sistem pasang siap panel lantai PSSDB. Ia terdiri daripada tiga elemen penting iaitu kepingan keluli berprofil, papan kering dan skru yang dipasang secara gerudi dan ulir sendiri. Kajian ini dijalankan untuk menentukan kesan setiap ketebalan kepingan oleh Peva 45 pada Keluli Kepingan Berprofil serta Kayu Kering (PSSDB) terhadap kekukuhan skru pada panel lantai melalui ujian tolakan. Namun begitu, kelemahan kepingan keluli yang mempunyai kekuatan yang tinggi tetapi rendah kekukuhan mungkin membawa kepada kegagalan. Jadi, kajian yang lebih mendalam harus dijalankan melalui ujian menolak keluar skru dengan menggunakan sekurang-kurangnya dua ketebalan Peva 45yang berbeza. Seterusnya, kelakuan struktur komposit keluli-kayu ini melalui eksperimen akan direkodkan dan dibandingkan dengan penyelidikan sebelumnya yang hampir serupa. Hasil kajian sebelumnya dilakukan menunjukkan bahawa penambahan daripada ketebalan kepingan keluli berprofil meingkatkan kekukuhan skru pada panel lantai PSSDB. Melalui ujian tolakan, kajian mendapati bahawa kekukuhan skru bertambah sebanyak 42.03% dari 0.69 N.mm kepada 0.98 N/mm. Daya maksimum yang dikenakan pula bertambah sebanyak 7.45% sahaja dari 1.61 kN kepada 1.73 kN. Satu hipotesis dapat disimpulkan dimana, lebih tebal kepingan keluli berprofil, maka lebih kukuh skru tersebut. Jadi, objektif kajian ini berjaya dicapai. Kajian ini telah menyumbang kepada pemahaman yang lebih baik mengenai kesan ketebalan kepingan keluli berprofil terhadap kekukuhan skru.

KEYWORDS | Sistem Bangunan Industri; Kepingan Keluli Berprofil; Primaflex; Peva 45; Kekukuhan Skru

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LIST OF SYMBOLS

y_1	Second slope point of y-axis
y_2	First slope point of y-axis
x_1	Second slope point of x-axis
x_2	First slope point of x-axis

LIST OF ABBREVIATIONS

PSSDB	Profiled Steel Sheeting Dry Board
PSS	Profiled Steel Sheeting
DB	Dry Board
IBS	Industrial Building System
CIDB	Construction Industry Development Board
CL	Clip Lock
LUSAS	London University Stress Analysis System
FEA	Finite Element Analysis
Sdn. Bhd	Sendirian Berhad

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter is the first stage of this research. It will introduce the research that describes the effect of Peva 45 steel sheeting thicknesses on PSSDB floor panel screw stiffness through push out test. This section will include five subsections which are background, problem statement, objectives, scope of study, together with significant of the study.

1.2 BACKGROUND

Construction demand in Malaysia nowadays has increased rapidly. However, there are still rooms for improvement with regards to its construction delay and cost reduction. Industrial Building System (IBS) has provided some solution to the problem. This current technology attracts more researchers to develop new composite structure and acts as an alternative to the common steel-concrete composite structure in floor panel system.

Steel-concrete composite structure is known to be high in strength and stiffness (Providakis, 2007). However, it requires additional time, increases the cost on material and labor while reducing the quality of structure when the weather is unpredictable. Another composite structure is implemented in IBS system which is Profiled Steel Sheeting Dry Board (PSSDB) that consists of dry board connected to steel deck by self-drilling and self-tapping.

Since this composite is lighter, it is easier to carry and construct on site as well as reducing the usage of heavy equipment and machineries. It has already been used in floor, wall and also roof. Nevertheless, despite its benefit, steel sheeting like Peva 45 as an example is high in strength but low in stiffness (M. Seraji et al., 2013). Thus, several research and experiment on different type of board and thickness were conducted to further understand the behavior. Common dry board such as Primaflex, Cemboard and plywood is used in previous researches. This thesis is conducted to study the effect of different Peva 45 sheeting thicknesses on PSSDB floor panel screw stiffness through push out test. Although similar research has been done previously, none were done more specifically in this matter. **Figure 1.1** shows the three main elements in PSSDB.

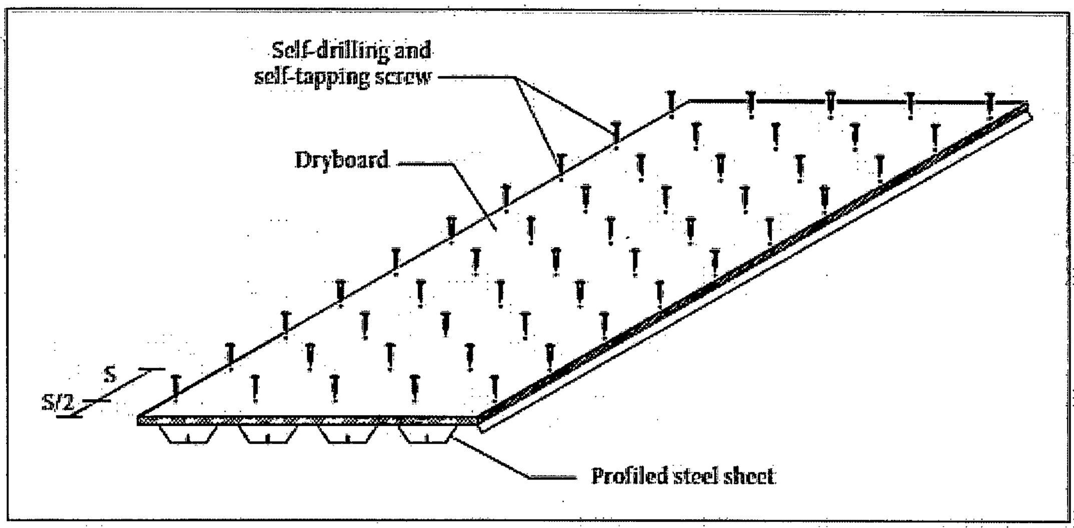

Figure 1.1: Profiled Steel Sheeting Dry Board (PSSDB)

Source: M. Seraji et al (2013)

1.3 PROBLEM STATEMENT

The demands of construction industry nowadays are increasing rapidly with the growth of population in Malaysia. As the development is increasing as well, modern technologies are used as alternatives to facilitate the construction works. Traditional method is no more relevant to be used as it lacks in some aspects compared to modern such as late completion of project, high cost on material and labor and most of it is not environmental friendly. Thus, the usage of Industrial Building System (IBS) is now on a rise since it is more economical. Steel-concrete composite structure is implemented in IBS as it is high in strength and stiffness but leads high dynamic amplification effect due to resonance, thus resulting some forces on the ground (Gandomkar, 2013). Profiled Steel Sheeting Dry Board (PSSDB) is recently used in IBS instead of steel-concrete composite structure in slab, wall and roof even though slip between steel sheeting and dry board is inevitable. Besides, deficiency of screws when transfer the horizontal forces making it as a partial interaction system (M. Seraji et al., 2013). Meanwhile, this research is to be conducted to figure out about one of the element in Profiled Steel Sheeting Dry Board (PSSDB), which is Peva 45 sheeting thickness on PSSDB floor panel screw stiffness through push out test.

1.4 OBJECTIVES

The objectives for this research are as follows:

1) To study the screw stiffness on floor panel system through push out test.
2) To determine the effect of Peva 45 steel sheeting thickness on PSSDB floor panel.

1.5 SCOPE OF STUDY

The scopes of studies for this research are as follows:

1) To study the screw stiffness between Peva 45 steel sheeting and Primaflex floor panel with the same spacing between screws through push-out test.
2) To identify the effect of different thickness of Peva 45 steel sheeting on Primaflex floor panel.

1.6 SIGNIFICANT OF STUDY

This research is conducted to improve the knowledge regarding PSSDB system as well as promoting it to increase the usage of IBS system. The behavior of this floor panel system is studied mainly by using Peva 45 steel sheeting with two different thicknesses, Primaflex dry board and screws. It is important to identify the screw stiffness through push out test using different thickness of steel sheet to see whether it is improving and finally enhanced the performance or vice versa. This is important in order to better understand the behavior of the panel before it can be widely received by the public. Therefore, this study is very essential in order to enhance the PSSDB system in Malaysia and eventually increase the usage of IBS in floor panel system.

1.7 CONCLUSION

This chapter discussed the five main elements in introducing the research including background, problem statement, objectives, scope of study, and significant of the study. Background of study is first to be analyzed in understanding the title of this research. Problem statement is the idea on how this research is developed. Meanwhile, the objectives are implemented to draw the hypothesis and conclusion whether it can be achieved or not. Scopes of studies are draw to specify the range of this research which is in Malaysia. Lastly, significant of study illustrated the importance of this research.

As such, IBS has many advantages in enhancing the performance of construction. However, the usage of PSSDB in IBS system is not on top as it is a new composite product. PSSDB is indeed a lightweight prefabricated system with several benefits but it still has its limitation in order to replace the current prefabricated reinforced concrete system. Therefore, further investigation should be conducted in the next chapter to understand the behavior of this new system through screw stiffness in push-out test.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

As in many other countries, the construction industry in Malaysia is one of the driving forces of the country economy. Thus, according to Nor Azmi A. B. and Hamima A. (2007), other industries are majorly dependent on construction industry performance. However, some negative issues concerning construction industry frequently occur. Baloi and Price (2003), states that poor cost performance of construction project gives great impact to both contractors and client. Meanwhile, the unpredictable weather in this country might decrease the quality and hence demanding extra time leading to delay. Therefore, the government decided to privatize several companies in order to enhance the construction industry.

Instead of privatization, modern technology has eventually found their way to improve this industry's performance by establishing IBS not long ago. This prefabricated system mainly focuses on the usage of steel structures as well as pre-cast concrete for construction. For example, bridges, building components, drains and other infrastructure part are IBS main product. CIDB (2003) conducted a survey where majority of the respondents agrees with the benefit of IBS in terms of quality and time used to complete one project, nevertheless, half disagree that it is cheaper. That argument however does not affect the usage of steel-concrete composite structure in IBS system as it is used widely nowadays. This composite structure is then lead to new products from IBS which is PSSDB system.

This literature reviews will highlight the need for further investigation regarding this research. Explanations for each part will be discussed for clearer illustration.

2.2 INDUSTRIAL BUILDING SYSTEM (IBS)

The construction demands nowadays forces the industry in Malaysia to implement Industrial Building System (IBS) replacing the conventional method of construction several years ago. According to Redzuan Abdullah (2006), this modern with high technology system is approved by Construction Industry Development Board (CIDB) of Malaysia in order to overcome some issue regarding construction industry. With the existence of IBS, the performance of construction industry shall be enhanced. IBS in Malaysia have five advantages as discussed by Maryam et al (2010). Those include save construction time, decrease the use of timber formwork, increase quality of building, decrease solid waste and reduce air pollution.

However, the usage of this system is said to be very low compared to the conventional method and the industry would rather use traditional method like employing foreign worker at the cheapest price instead of IBS. They also said that 15 percent of foreign workers shall be reduced by using this system. (Hjh Hamimah Adnan and Nor Azmi Ahmad Bahri, 2007).

2.3 STEEL CONCRETE COMPOSITE STRUCTURE

Subsequently, this current technology attracts more researchers to develop new composite structure and eventually acts as an alternative to the common steel-concrete structure composite structure in floor panel system.

Steel-concrete composite structure is known to be high in strength and stiffness. This type of construction has become a common feature in multistory steel frame buildings in several countries. In Greece, steel-concrete composite structure has been used widely in structural applications, particularly for high-rised industrial buildings. The simplest form of those composite structures comprise a bare-steel frame of common H-type section columns supporting I-type section beams which then sustain the overlaid composite floor slab. Alternatively, the composite floor slab consists of cold-formed profiled steel sheets that act not only as the permanent formwork for an in situ cast concrete slab but also as the appropriate tensile reinforcement.

According to Providakis (2008), this type of structure is very relevant in order to resist earthquake loads as the inherent ductility infatuated by it allows a greater level of energy dissipation to be achieved and finally rising their applicability to seismic-resistant structure. However, it requires additional time, increasing the cost on material, labor while reducing the quality of structure when the weather is unpredictable.

2.4 PROFILED STEEL SHEETING DRY BOARD (PSSDB)

Profiled Steel Sheeting Dry Board is a new composite system after steel-concrete composite structure developed by Wright et al (1989) combining a wood panel and profiled steel deck by using screws of either self-drilling or self-tapping. Below is the description of the major components of PSSDB system which are profiled steel sheeting, dry board as well as connectors.

2.5 PROFILED STEEL SHEETING

Steel has high strength but lack in terms of fatigue, corrosion and ductility, thus, this type of structure will frequently facing the problem of demonstrating feasibility in the market, (T. V. Galambos, 2000). Nevertheless, Fukumoto Y. and Kuwamura H. (1994, 1988) have research new high-performance steels economically which is produced recently. Such steel strength can be produced with variety of weld ability, corrosion and toughness characteristic with yield points around 500 to 700 MPa. Three common type of profiled steel sheeting are Peve 45, Bondek and Clip Lock. Peve 45 is the most commonly used as profiled steel sheeting in the PSSDB system.

2.5.1 Ajiya Peva 45

The structural floor decking is an innovative and highly efficient product used in composite slabs (Asia Roofing, 2006). It combines the laying of the form and reinforcement, and gives remarkable savings in materials, labour and expenses. The cold roll-forming process used in producing the AJIYA ensures a high degree of consistency and dimensional accuracy (Ajiya, 2013). Designs are in accordance to British Standard 5950. Clear picture and its sectional profile shall be view through **Figure 2.1**.

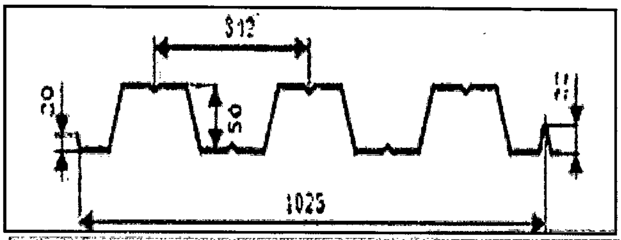

Figure 2.1 Peva 45 Manufactured by Ajiya

Source: Ajiya (2013)

2.5.2 Lysaght Bondek

This type of profiled steel sheeting is a highly efficient, versatile and robust formwork, reinforcement and ceiling system for concrete slabs. It is widely accepted by the building and construction industry to offer efficiency and speed of construction. Bondek is said to have excellent spanning capacities for greater strength and less deflection. It also acts as permanent formwork with minimal propping and no stripping of formwork is required. Furthermore, it is fast and easy to install (590mm wide) with less handling required. Moreover, it works as composite slab, saving on concrete and reinforcement costs. Ribs at 200mm centres creating a safe working platform with slip resistant embossments. In addition, it has advance design for fire resistance. Besides, new Bondek software gives added flexibility and ease of design as well as backed by a BlueScope warranty together with nationwide technical support (Lysaght, 2014). Sectional Profile of Bondek shall be seen on **Figure 2.2**.

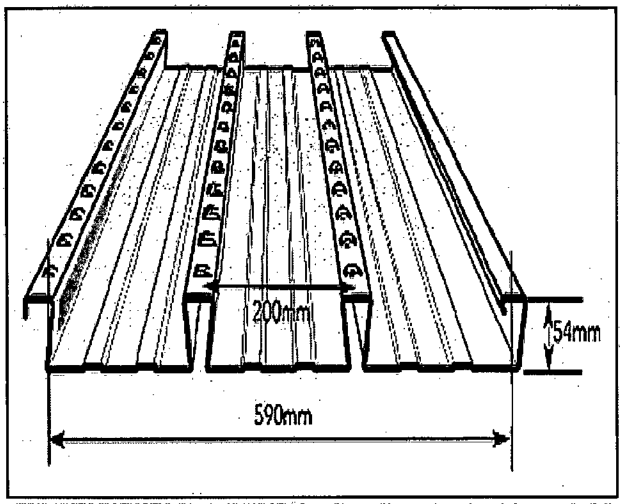

Figure 2.2 Bondek Manufactured by Lysaght

Source: Lysaght (2014)

2.5.3 Clip Lock Cl 660

The CL 660 has been widely used as roofing system. It is a premium concealed fixing profile roll formed from high-tensile steel substrate which is protected with corrosion inhibitive treatment. A single sheet has an effective cover width of 660mm, with ribs height of 44mm spaced at 221.6mm between the three pans. The wide pans and high ribs is said to ensure excellent water discharge capacity for a minimum roof pitch of 1 degree. As this kind of profiled steel sheeting is installed using clips, the possibility of water leakage can be significantly minimized (Roofseal, 2008). The sectional profile is shown in **Figure 2.3**.

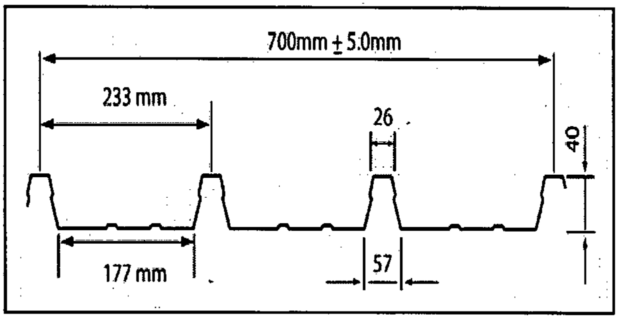

Figure 2.3 Cliplock CL 660 Type Manufactured by Roofseal (M) Sdn Bhd
Source: Roofseal (2014)

The properties of Bondek, Peva 45 and Cliplock CL 660 which are commonly used in PSSDB system shall be seen on **Table 2.1** in terms of yield strength according to thickness. Cliplock CL 660 turns out to have the highest yield strength.

Table 2.1: Yield Strength of Profiled Steel Sheeting

Profiled Steel Sheet	Thickness (mm)	Yield Strength (Mpa)
Bondek	1.00	550
Peva 45	0.8	350
Cliplock CL 660	0.48	550

2.6 DRY BOARD

In PSSDB floor panel system, dry board also plays an important part as it is the main material other than profiled steel sheeting. Common dry board used in this system is PRIMAflex, Plywood, Cemboard, and Chipboard. Former research using those boards in this system is also available.

2.6.1 Primaflex

Primaflex is a non-asbestos flat sheet that is perfect for your building needs. It is autoclaved for superior durability and flexibility. This process cures the product, giving it outstanding dimensional stability. Quality has never been better with the state-of-the-art technology and ultra modern processes employed in manufacturing Primaflex It has demonstrated strong resistance to termite attacks, tested by CSIRO Forest Biosciences. Other benefit of using Primaflex are fire,impact and weather resistant, lightweight, excellent workability, fungus resistant , low maintenance as well as it will not warp. In addition to that, Primaflex can also be adopted to various application such as ceiling eaves and soft lining, external cladding, flooring, permanent form work and also roofing (Prima, 2014). **Figure 2.4** is the picture of Primaflex.

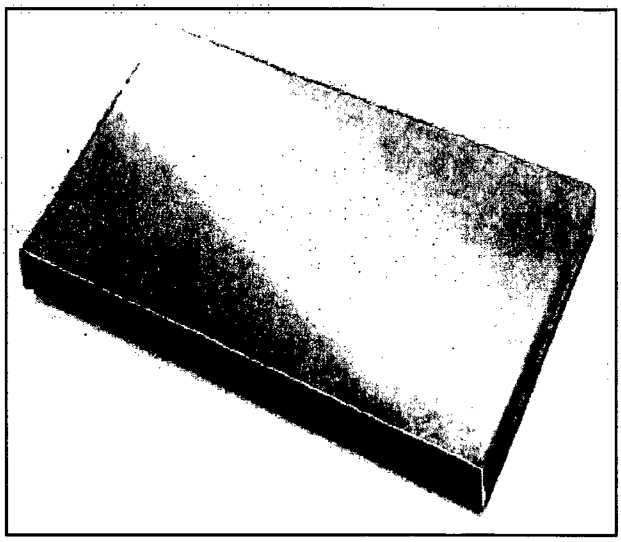

Figure 2.4 Primaflex

Source: Prima (2014)

2.6.2 Plywood

Plywood is a manufactured wood panel from the family of manufactured boards made from thin sheets of wood veneer. The layers are glued together, with adjacent plies having their wood grain rotated relative to adjacent layers up to 90 degrees. All plywood bind resins and wood fiber sheets to form a composite material. This alternation of the grain is called cross-graining and has several important benefits: it reduces the tendency of wood to split when nailed at the edges; it reduces expansion and shrinkage, providing improved dimensional stability; and it makes the strength of the panel consistent across all directions. Because plywood is bonded with grains running against one another and with an odd number of composite parts, it is very hard to bend it perpendicular to the grain direction of the surface ply.

Smaller thinner plywood and lower quality plywood may only have their plies arranged at right angles to each other, though many better quality plywood products will by design have five plies in steps of 45 degrees, giving strength in multiple axes. The highest quality specialty plywood often have plies at 30 degrees in seven layers, or have nine layers with two layers of 45 and 135 degrees in the sandwich. The smaller the step rotations the harder it is to manufacture, increasing manufacturing costs and consequently retail price (P. W. Plywood, 2013). The picture can be seen on **Figure 2.5**.

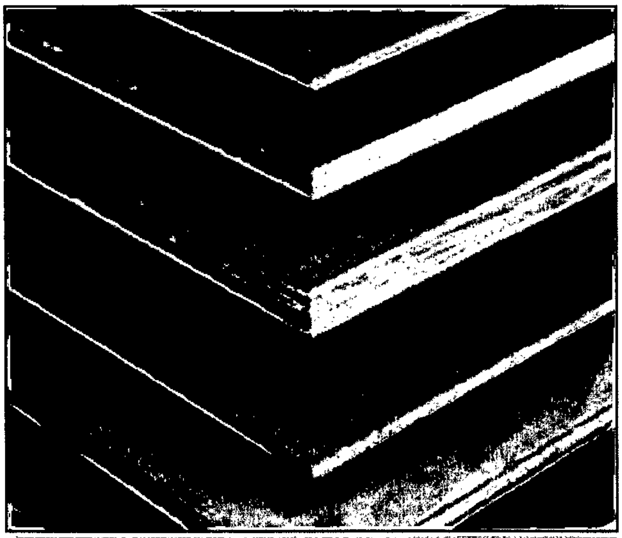

Figure 2.5: Plywood
Source: P. W. Plywood (2013)

2.6.3 Cemboard

Cemboard is a rigid, high performance cement building board which combines the strength and durability of a concrete product but with the workability of timber (Hume Cemboard, 2013). Cemboard is manufactured from rubber wood, wood chips and mixed with Portland cement. It is classified as a class 0 building material: Cemboard fire rated partition systems have been tested in accordance with BS 476: Part 22:1987. 1 and 2-hour fire rating systems are available to cater for building regulation requirements.

This board is also classified as a sheathing and acoustic building board. Cemboard can be used for a variety of general purpose applications: behind external cladding systems as a sheathing board, or in acoustic applications in walls, floor and roof structures.

As for its advantages, it can be cut to size, drilled, nailed and worked in a similar fashion to timber and chipboard with a standard circular saw, but offers a much longer performance life. Cemboard possesses a stable crystalline structure and is reasonably resilient to water penetration, humidity changes, rot, insects, termites and vermin. Cemboard has a very low maintenance cost and so this board provide a cost effective choice. **Figure 2.6** is illustrating cemboard where the materials and looks is almost the same as PRIMAflex.

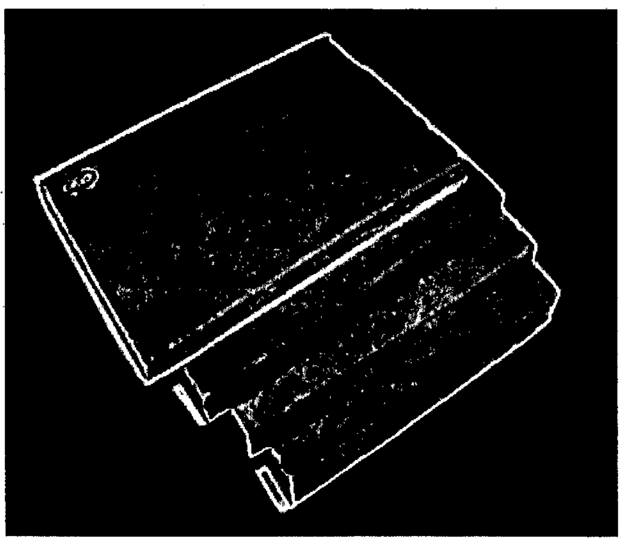

Figure 2.6 Cemboard

Source: Hume Cemboard (2013)

2.6.4 Chipboard

Chipboard is normally glued together wood particles with an adhesive, under heat and pressure makes chipboard. This creates a rigid board with a relatively smooth surface. Chipboard is available in a number of densities: -normal, medium and high-density. Normal density of chipboard is fairly soft. It's high-density is solid and hard. Chipboard is often used for kitchen tops and fire doors. Its medium density is somewhere between normal and high density. There are exterior grades of chipboard available but most are only suitable for internal use. However, all grades of chipboard except the high-density variety tend to soak up water. Once it is water logged, chipboard tends to swell and breakdown. Chipboard with a veneered surface is widely used for flat-pack furniture and work surfaces. High-density chipboard is often used as the carcass for kitchen units and worktops and flooring. This type of chipboard is hardwearing, rigid and heavy. Other grades of chipboard are standard, flame-retardant, flooring, and moisture-resistant. Ironing or gluing on strips of veneer may disguise the unattractive edge of veneered chipboard (Hume Cemboard, 2013). The picture is as shown in **Figure 2.7.**

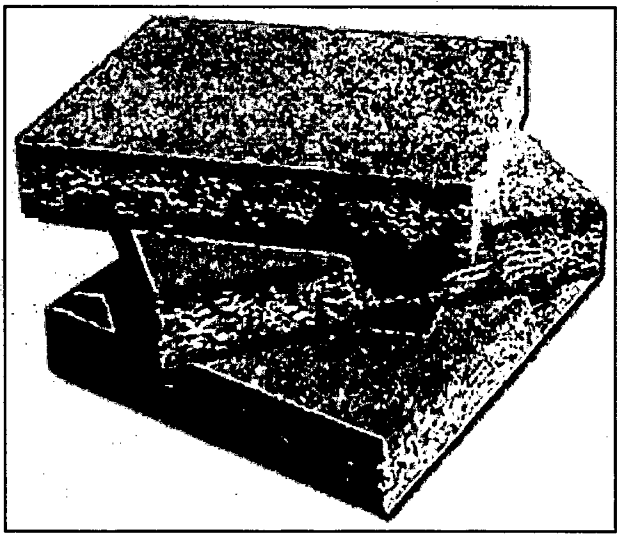

Figure 2.7: Chipboard
Source: Hume Cemboard (2013)

Among all the dry boards mentioned, Primaflex has the highest modulus of elasticity as shown in **Table 2.2**.

Table 2.2 Modulus of Elasticity of Dry Boards

Dry Board	Thickness (mm)	Modulus of Elasticity, E (N/mm²)
Primaflex	18	8030
Plywood	18	6960
Cemboard	16	5250
Chipboard	18	1950

2.7 CONNECTORS

In order to form a composite structure between steel deck and dry board in PSSDB system, either self-drilling screws or self-tapping screws, both are commonly used as simple mechanical connectors. M. Surat et al (2008) said that it is normally used in small grids from 50mm to 300mm. In a clearer image, **Table 2.1** will show the properties of typical screws of type 14X used for investigation produced by Power Drive Sdn. Bhd. Malaysia.

Table 2.3 Properties of 14X Screw Connectors

Description		Properties	
Material	10 – 15 mm zinc	Tensile Breaking Load	6.3 kN
Coating	Chromate	Shear Breaking Load	4.3 kN
Length	30 mm	Twist-off Torque	4.7 kN
Diameter of Thread	4.2 mm	Pull-out Load from 1mm	1.0 kN

Source: Surat M. et al (2008)

The screws usage is certainly simple and quick, however, efficient as well as positive connection between the component layers. The connections are responsible for transferring horizontal shear between wood panel and steel deck. Typical composite structure like composite beam as an example, the performance of it determines the degree of composite action achieved and eventually the stiffness of the structure as a