THE EFFECT OF BOAR STIFFNESS OF A

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ABSTRACT

Rapid development in construction industry has resulted in increasing to demand for effective and innovative construction systems. Nowadays, construction no longer depends on current systems such as using timber bases and reinforcement concrete structures There are many problems with the current techniques such as high costing, low quality, and long construction time. One of the viable solution is to employ Industrialised Building System (IBS) which is a more efficient construction technology. Profiled Steel Sheeting Dry Board (PSSDB) is one type of Industrialised Building System (IBS). The PSSDB is a composite system that comprises of two main components which are profiled steel sheeting (PSS) and dry board (DB). They are attached by self drilling and self tapping screws. This research study about the effect of Primaflex dry board thickness towards the screw stiffness which has not been done before. The objectives of this study are to identify the screw stiffness using Primaflex dry board from push out test and to evaluate and also identify effect of Primaflex with different thicknesses. The results from this study have two parts which are effect of dry board from different thickness and effect of the screw. The result show that the Primaflex that has 9mm of thickness has higher screw stiffness (0.46 kN) than Primaflex that has 6mm of thickness (0.40 kN). Moreover, the result of an effect of the screw, the screw is easy to fail when the thickness of Primaflex is 6mm more than Primaflex 9mm. It is because, the hold between Peva and Primaflex is strong when the dry board is thick. As a conclusion, the thick board has a higher stiffness than thin board.

ABSTRAK

Teknologi dalam pembinaan semakin mempunyai peningkatan permintaan. untuk menaik taraf dan inovatif dalam pembinaan struktur. Pembinaan tidak akan dapat bertahan lama dan kekal jika menggunakan bahan daripada struktur kayu dan konkrit bertetulang. Hal ini kerana, banyak masalah yang berlaku dalam sistem struktur pembinaan sedia ada seperti perbelanjaan bahan yang tinggi dan mahal, kualiti yang rendah, dan juga memerlukan tempoh masa pembinaan yang lama dan panjang. Dewasa ini, Sistem Industri Pembinaan (IBS) lebih diterima dan telah digunakan untuk pembinaan kerana lebih efektif berbanding kayu dan konkrit bertetulang. Profiled Steel Sheeting Dry Board (PSSDB) adalah salah satu daripada sistem IBS. PSSDB adalah satu sistem dimana dua komponen utama yang dikenali sebagai papan kering dan juga kepingan keluli Dua komponen ini akan dicantumkan menggunakan skrew jenis gerudi dan ulir sendiri. Banyak maklumat dan kajian tentang PSSDB sistem yang telah dibuat oleh penyelidik-penyelidik terdahulu. Walaubagaimanapun, tesis ini akan mengkaji tentang kesan ketebalan papan kering yang dinamakan Primaflex keatas kekukuhan skrew dalam panel lantai menggunakan PSSDB sistem melalui ujian tolak keluar. Objektif utama tesis ini adalah untuk mengkaji kekukuhan skrew terhadap papan kering Primaflex daripada ujian tolak keluar dan juga untuk mengkaji kesan Primaflex dengan menggunakan ketebalan yang berbeza. Keputusan kajian yang diperolehi dari ujian tolak keluar ialah Primaflex berketebalan 9mm mempunyai kekukuhan skrew yang lebih tinggi (0.46 kN) lebih tinggi dari Primaflex berketebalan 6mm (0.40 kN) Sebagai kesimpulan, kesan skrew mempunyai perhubungan dan kaitan antara ketebalan papan kering. Ketebalan papan kering yang tebal mempunyai tahap kekukuhan skrew yang lebih tinggi berbanding papan kering yang nipis.

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IBS	Industrialized Building System
PSSDB	Profiled Steel Sheeting Dry Board

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE RESEARCHES

Industrialized Building Systems (IBS) is a term used in Malaysia for a technique of construction that manufacture in a controlled environment (CIDB 2003). The Malaysian Government has mandated that project should comprise of 70% IBS components. The total number of IBS precast manufacturing has increased over the years from 2009 to 2011.The application of Industrialized Building Systems had been implemented in Malaysia for decades. Industrialized Building System (IBS) has low overall cost and offer more advantages in various aspects.

Profiled Steel Sheeting Dry Board (PSSDB) is one type of Industrialised Building System (IBS) that is gaining acceptance and importance in the construction arena. PSSDB is a composite system that comprise of two main components which are profiled steel sheeting (PSS) and dry board (DB). They are attached by self drilling and self tapping screw. In Malaysia, the technology using PSSDB is more effective and economic. This new concept has been promoted as an efficient, low costing, higher quality and importantly it shortens the construction time. Moreover, Profiled Steel Sheeting Dry Board (PSSDB) has already been used in the project of classroom module at Sekolah Kebangsaan Teluk Mas, Melaka (Hanizam et al 2008), UiTM Tower, Shah Alam, and 5 star Hyatt Hotel in Kota Kinabalu, Sabah (Wan Badaruzzaman et al 2003).

The push out test will be carried out to determine the effect of Primaflex dry board thickness towards the screw stiffness. In the previous researches, the push out test has already be done by Wan Badaruzzaman (1994), Wan Baduruzzaman (1996), Wan Baduruzzaman and Wright (1998), Ahmed (1998), Hamzah (2005), and Awang (2008) but the samples are made of different element and thickness.

1.2 PROBLEM STATEMENT

Nowadays, in the process of nurturing the industry towards less labour dependent, the goverment of Malaysia had aggresively promoting the development and usage of a new relevant technologies in the area. Using the PSSDB system, had seen as the alternatives that can greatly reduce construction time compare to the current systems. Malaysia is presently taking a hard look at IBS as an answer to a rapid development shortage problem.

They are dependent upon an influenced by many other aspects of the housing situation such as land use, user needs, continuity of demand, and labour. There was rapid economic and social development, leading to a great expansion of construction, but most of the houses constructed were medium and high costs. While the problem of housing grows more acute, Malaysia is struggling to meet its own housing need. The current systems, due to the slow pace of construction and higher cost is not be able to meet the demand.

1.3 OBJECTIVES OF STUDY

The main objective of this research is to investigate the effect of board thickness on the screw stiffness of a PSSDB floor panel. The specific objectives are :

i. To identify the screw stiffness using Primaflex dry board from Push Out Test.

ii. To evaluate and identify the effect of Primaflex dry board with different thickness on the screw stiffness.

1.4 SCOPE OF STUDY

This research concentrates on stiffness screw and the panel performance. The push out test will be conducted to determine the effect of Primaflex board thickness on the screw stiffness of a PSSDB system. Firstly, samples are prepared in order to conduct the experiment. There are six samples with two different thicknesses. The samples include 6mm (3 samples) and 9mm (3 samples) of thicknesses.

After the first stage, the samples will be determined the stiffness of screw with Universal Tensile Machine. The data will be collected from the computer after the test is finished. The deflection and force will be recorded by the computer for each of the sample. The result of screw stiffness is carried out from slope of the graph.

For the final stage, the effect board performance was concluded. All the data from the test machine were analyzed between two different thicknesses of board to make comparisons which thicknesses of board have a higher screw stiffness.

1.5 SIGNIFICANCE OF STUDY

Presently, many of the construction system built with form technique, but none of the construction procedure explore and analysed. The contributions of this research ascertained in terms of benefits gained by the industry. The usage of PSSDB system widely used in Malaysia construction particularly for wall, floor, and roof.

The signification of this study expending the use of PSSDB on floor panel system that can reduce the cost in construction. Beside that, the PSSDB system has many advantages such as relatively very light, the construction procedure is simple, the system is easily transportable, and it renovation work is much easier to handle.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In the previous chapter (chapter 1), there are already to know about the background of the Profiled Steel Sheeting Dry Board (PSSDB). This chapter was focused on the work done by previous researchers. First stage describes about the PSSDB component material. The component material of PSSDB includes profiled steel sheeting, dry board, and screw connector. After that, this chapter also identifies the experimental programme.and last stage describes the specific studies of PSSDB system.

2.2 PSSDB COMPONENT MATERIAL

Profiled Steel Sheeting Dry Board (PSSDB) is a composite system that comprises of two main components which are profiled steel sheeting (PSS) and dry board (DB). They are attached by self drilling and self tapping screws.

2.2.1 Profiled Steel Sheeting

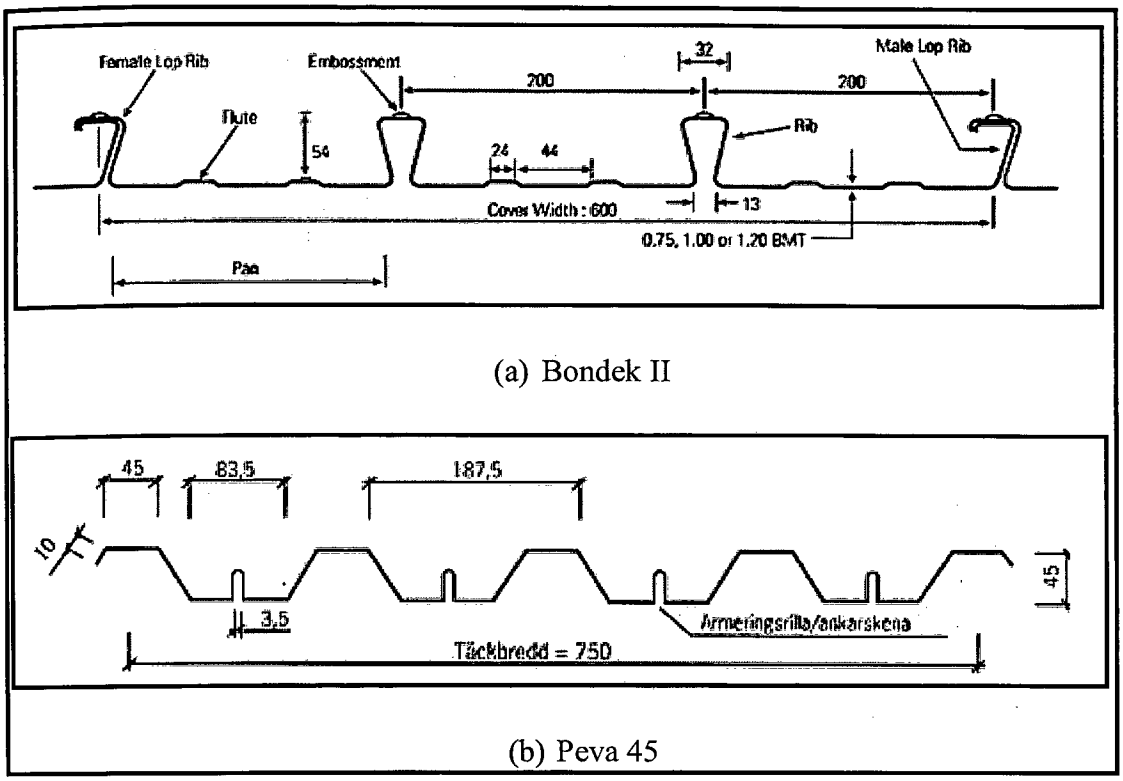
Profiled steel sheeting (PSS) is a component made of cold form flat steel coil. The sheeting is coated with zinc or aluminium alloy. It also reconigsed as zincalumn which followed the Australian Standard AS 1397:1993. Zincalumn is a corrosion-resistant that is produced by a continunous hot dip process (Wan Badaruzzaman 2008). In Malaysia, profiled steel sheeting is largely used on roof and wall structure. Apart from the cost and economy, the profiled steel sheeting made from high strength steel that has an advantage where it can maintain its form firmly. Besides that, PSS show high resistance to accidental buckling, denting or damage during transportation and service.

PSS also is one of the main structural element that is currently sourced from the local markets. It is more obvious that optimising the PSS can result in a more efficient in PSSDB system (Wan Badaruzzaman 2013). Moreover, PSS is one of the important component in PSSDB system. The most common profiled steel sheeting is used on the floor system are Bondek II, and Peva 45. Profiled steel sheeting that are used in another countries are also available in Malaysia for the conventional cast in-situ concrete composite slab system. Table 2.1 and Figure 2.1 below shows different properties between profiled steel sheeting and cross section of profiled steel sheeting.

Table 2.1 : Different Properties between Profiled Steel Sheeting

	Thickness	Bondek II	Peva 45
Self Weight (kg / m^2)	1.0 mm	13.3	13.3
	0.75 mm	10.3	-
	0.8 mm	-	10.67
Yield Strength (N / mm^2)		550	350

Source : Norhaiza (2013)



(a) Bondek II

(b) Peva 45

Figure 2.1 : Cross Section of Profiled Steel Sheeting

(Source : Ahmed 2011)

2.2.2 Dryboard

Dry board is a very important material and component in PSSDB because it provides a flat surface to carry load. In the Malaysian market, there are various types of dry boards such as plywood, cemboard, and chipboard. These are already used in PSSDB. Based on investigations, three types of boards were originally proposed by Wright et. al.(1989) which are chipboard, cemboard and plywood. Now a days, a new type of dry board Primaflex is gaining popularity. Table 2.2 shows the connectors stiffness and capacity obtained from push out test.

Table 2.2 : Connectors Stiffness and Capacity obtained from Push Out Test

Board Type	Connector's Stiffness (kN / mm)	Connector's Capacity (kN)
18 mm plywood	0.730	3.11
16 mm cemboard	0.625	3.00
18 mm chipboard	0.470	2.80

Source : Wan Badaruzzaman (2010)

2.2.3 Screws Connectors

There are two types of screws connector that are used in PSSDB system which are self drilling and self tapping screw . The function of screw connector is to connect the dry board to steel sheeting to form a composite unit. Usually, the size of the screw spacing is 100 to 300 mm. The screws ensure simple and quick but efficient and positive connection between the dry board and steel sheeting. Figure 2.2 below shows one of self drilling screw type.

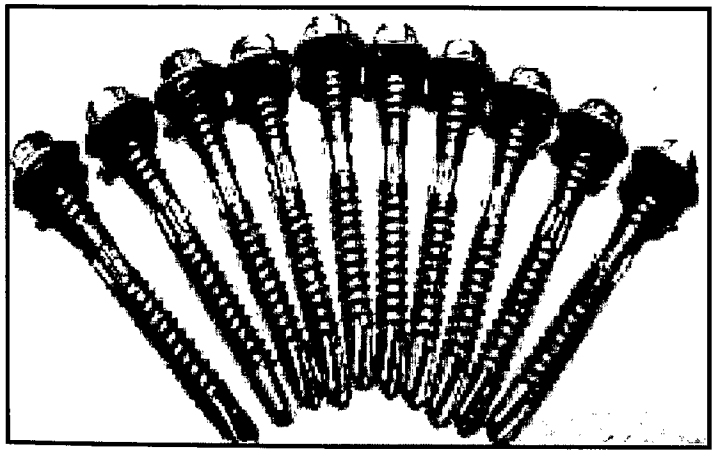


Figure 2.2 : MK Fasteners Self Drilling Screw

The capacity of a screw connection can determined and expressed by its shear modulus which means the amount of shear force transferred per unit length of shear

displacement (Norhaiza 2013). Table 2.3 shows two types of screws that already used in previous reseaches of PSSDB.

Table 2.3 : Properties of Screw Connector

	DX14 Powerdrive	DS-FH 432
Material	Carbon Steel	Carbon Steel
Length	25 mm	32 mm
Diameter of thread	4.2 mm	4.2 mm
Shear Breaking Load	6.3 kN	70 kN
Twist off Torque	4.7 Nm	3.4 Nm

Sources : MK Fasteners (2011) and Powerdrive (1991)

The connectors play in important role to transfer horizantal shear strength. The basic test that for the assessment to connector's behaviour is the Push Out Test. In the previous study, Wright et al (1989) attempted to establish the behaviour of the fasteners. Besides, Wan Badaruzzaman (2008) in his researches used different board and different thicknesses on the same screws spacing.This screw spacing of 300 mm centre to centre was find to increase 30% compared to the stiffness by that of steel sheeting alone. Table 2.4 below show that the effect of board thickness on the screw stiffness.

Table 2.4 : Connector's Stiffness and Capacity for Different Types of Board

Board Type	Connector's Stiffness (kN / mm)	Connector's Capacity (kN)
18 mm plywood	730	3.1
16 mm cemboard	625	3.0
18 mm chipboard	470	2.8

Source : M. Surat (2008)

The screw spacing is important and influence the PSSDB performance system. Ahmed (1996) used different screw spacing on the different boards and thickness.

Table 2.5 : Effect of Screw Spacing to interaction percent on Different Types of Board

Types of Board	Screw Spacing		
	50 mm	100 mm	200 mm
Bondek - Plywood	42.50%	16.20%	4.50%
Bondek - Cemboard	52.90%	21.30%	5.80%

Source : Norhaiza (2013)

2.3 EXPERIMENTAL PROGRAMME

There are two types of experiment to analyse and investigate the Profiled Steel Sheeting Dry Board (PSSDB) system which are Push Out Test and Bending Test. The push out test and bending test have the same components and materials such as dry board, profiled steel sheeting, and screw connectors, but used the different machine. Bending test is to determine the panel system while push out test is to determine the screw stiffness.

2.4 SPECIFIC STUDIES OF PSSDB SYSTEM

This part describes about the specific studies of PSSDB system in previous researhes.There are many researchers investigate the push out test such as Hanizam (2012), Gamdokar (2011), Ahmed (2011), and M. Surat (2008).

2.4.1 Push Out Test

a. Mahmood Seraji (2012)

His researches describe about in order to quantify the amount of horizontal movement of PSSDB floor under vertical load. This test is one bay PSSDB floor composed of Peva 45, Primaflex, with concrete infill. The characteristic of the materials can be show in Table 2.6 below. The primaflex is composite material flat sheet composed of top grad cellulose fibre, portland cement, and finely ground sand.

Table 2.6 : Details of Push Out Test

	Types	Thickness / size
Profiled Steel Sheeting	Peva 45	1.0 mm
Dry Board	Primaflex	12 mm
Screw	DS-FH 432	4.2 mm
Sample Size	not specified	
Bil. Of Test	3	
Bil. Of Sample	1	

Source : Mahmood (2012)

In this researches, the corrugations were filled with concrete of grade 30 and after the curing period, the Primaflex was installed on the Peva 45 by self-tapping and self-drilling screws. He was detected that the initial part of the curve is approximately linear before the appearance of the local buckling and material nonlinearity at profiled steel. Beside that, the load increases to reach the ultimate capacity point and then reduces to show the ductile failure of the specimen when in spite of occured local buckling.

b. Gandomkar (2011)

As mentioned before, he in his previous researches used PSSDB system without concrete infilled selects 0.8 mm Peva 45 thick as the PSS, 18 mm plywood thick as the DB, and DS-FH 432 self drilling and self-tapping screws with 200mm screw spacing. In this study, he used the similar material but with adding grade 30 concrete as an infill material through Peva 45. The test of the specimen carried out 28 days after their preparation in laboratory.

Moreover, this study has focused on finding the connection stiffness between Peva 45 and concrete with different grades of C25, C30, and C35 where plywood has been chosen as covering. The detailed about push out test was showns in Table 2.7 below.

In this experiment, the results showed that increasing the thickness of Peva 45 and plywood respectively enhanced and by use of C30 instead of C25 and C35 instead of C30 the connection of the stiffness increased about 10.3% and 8.2%.

c. Ahmed (2011)

In his research, the test specimen were conducted by using locally available Bondek II profiled steel sheeting, connected by 16 mm thick cement board by self-drilling and self-tapping screws. The capacity of screw connection was expressed by its shear modulus which is the amount of shear force transferred per unit length of shear displacement. The result from this test stated that the value of connector's stiffness is 625 N/mm. The most detailed about his research is shown in Table 2.7 below.

Table 2.7 : Detailed of Push Out Test

	Types	Thickness / size
Profiled Steel Sheeting	Bondek II	1.0 mm
Dry Board	Cement board	16 mm
Screw	self drilling and self tapping	not specified
Sample Size	not specified	
Bil. Of Test	1	
Bil. Of Sample	3	

Source : Ahmed (2011)

d. Surat (2008)

Surat et al. (2008) in his research about connector's behaviour has the similar test with Wright. The test are carried out for the current application of PSSDB modulation panels for Annex Classroom Blocks in Melaka. The profiled steel sheeting that he used is Bondek II and three types of dry board includes plywood, chipboard, and cement board.

The result from this test for 18 mm plywood is 730 N/mm, 16 mm cemboard is 625 N/mm, and 18 mm chipboard is 470 N/mm. The thickness and types of board give an effect for connector's stiffness. The solution for previous researches shown in Table 2.8 below.

Table 2.8 : Some of Researches from Push Out Test

Researher	Surat 2008	Ahmed -2011	Gandomkar 2011	Hanizam 2012
Profiled Steel Sheeting	Bondek II 1.0 mm	Bondek II 1.0 mm	Peva 45 0.8 mm	Peva 45 1.0 mm
Dry Board	18 mm plywood 16 mm cemboard 18 mm chipboard	16 mm cemboard	18 mm plywood	12 mm primaflex
Types of Screw	DX14 4.2 mm	self drilling and self tapping	DS-FH 432	DS-FH 432 4.2 mm
Connector's Stiffness (N/mm)	730 625 470	625	610	345

Source : Ahmed (2011), Gamdokar (2011) Hanizam (2011), and Surat (2008)

2.5 CONCLUSION

There are two important things that can conclude in this chapter. The difference between the size of the screw not given an effect to connectors stiffness and types of board give more effects to connector's stiffness. Besides, from the previous researches, this study about PSSDB can be improved.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Chapter 3 investigated more details about push out test. This chapter describes the experiment details, sample preparation, test machine, and analysis of sample. At the beginning, the sample preparation are presented in details. After that, the test machine was prepared and the samples were analysed.

3.2 EXPERIMENT DETAILS (PUSH OUT TEST)

The objectives of the experiment of this study are to.identify the screw stiffness using Primaflex dry board from Push Out Test and to evaluate and identify the effect of Primaflex dry board with different thickness on the screw stiffness. For this purpose, six specimens were prepared as illustrated in figure 3.1. The different thicknesses of Primaflex that were used for this test are 6 mm and 9mm. The thickness of Peva 45 is 0.8 mm and the type of screw connections is MK Fasteners self-drilling and self-tapping. Table 3.1 shows the detailed material that used and whole structural model of the PSSDB system is shown in Figure 3.1.

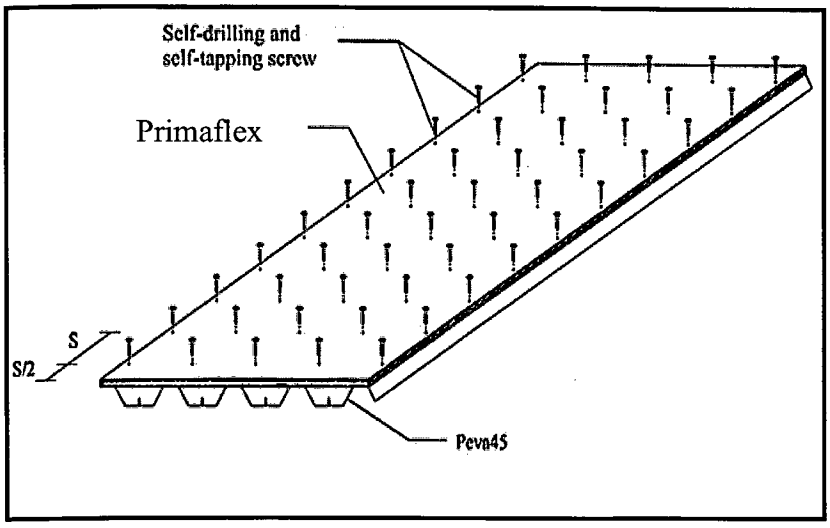


Figure 3.1 : Isometric view for PSSDB System

(Source : Gamdokar 2011)

Table 3.1 : Detailed of Material for Push Out Test

	Material
Profiled Steel Sheeting	Peva 45 0.8 mm
Dry Board	6 mm Primaflex 9 mm Primaflex
Types of Screw	MK Fasteners
i) diameter	4.2 mm
ii) height	30 mm

Size of primaflex is 2440 mm x 1220 mm and the size of each samples is 390mm x 280mm. The size of sample for Primaflex is 320mm x 280mm and for Peva 45 is 345mm x 280mm. The screw spacing that was used is 75mm. The machine that was used in the push out test known as Universal Tensile Machine.

3.3 SAMPLE PREPARATION

The whole panel of Primaflex and size of peva 45 are shown in Figure 3.2 and Figure 3.3, respectively and the characteristic of the studied system is presented in the following section. Six (6) samples were used in the push out test which have Primaflex thicknesses of 6mm and 9mm and 0.8mm of thickness for Peva 45. Each test was repeated three times. Therefore, altogether six samples were tested.

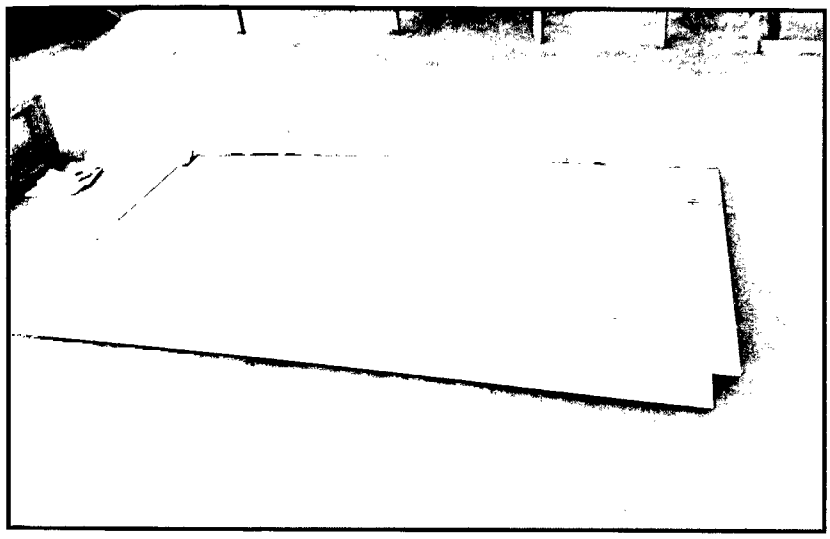


Figure 3.2 : The panel size of Primaflex before cutting in to six (6) samples

Figure 3.3 : The size of Peva 45 before cutting in to six (6) samples