Recent Trends in Civil Engineering and Built Environment Vol. 3 No. 1 (2022) 1940-1947

RTCEBE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
e-ISSN :2773-5184

Determination of Screw Withdrawal Resistance of Empty Fruit Bunch Fibre Board

Nor Ain Syanieza Mahayuddin[1], Emedya Murniwaty Samsudin[1,2]*

[1]Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2]Jamilus Research Center (JRC), Faculty of Civil Engineering and Built Environment,
Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rtcebe.2022.03.01.215
Received 4 July 2021; Accepted 13 December 2021; Available online 15 July 2022

Abstract: The utilization of oil palm for all intents and purposes empty fruit bunch fibre on bio-composite product basically has been found to for the most part replace current kind of substance mainly in wood fibre. EFB particularly available as palm oil and known as one of the important agricultural crops in Malaysia. Furthermore, the contains of the cement ratio on EFB essentially has been exposed to really be the reason for incompatibility issue between cement ratio and EFB Fibre. Relating to this issue, a research has been conducted to find the effect of EFB cement ratio on physical properties and to evaluate the screw withdrawal resistance of EFB cement board and its relationship on physical properties. The design mix ratio for cement fibre fabrications with the selection materials such as cement, water and EFB was selected namely 2:1, 2.5:1 and 3:1. A sample were tested for density, thickness monitoring and screw withdrawal resistance. The sample was analysed after 28 days curing. The effect of screws on withdrawal resistance was investigated using universal screw. Results obtained shows that the optimum ratio that support the screw insertion is 3:1 by using vibration table method

Keywords: Empty Fruit Bunch, Physical Properties, Screw Withdrawal Resistance

1 Introduction

Fibre reinforcement of cement materials still particularly endure a kind of innovative and exciting innovation because of the generally basic engineering properties of ductility, crack resistance, and energy absorption that literally for the most part enhance of the construction. Composite materials such as cement bonded particle boards (CBPB), cement-bonded wood wool boards (CBWW) and fibre-reinforced cement boards have been introduced long time ago, which specifically is quite significant.

*Corresponding author: emedya@uthm.edu.my

Cement-bonded (CB) composites literally are form of particles of wood fibre that mixed with additive materials and Portland cement into building element that used in the construction industry.

The potential by using sort of natural fibre as a composite material specifically is highly accepted because it specifically is sustainable, biodegradable and low cost, which really is quite significant. Other than that, it also definitely reduces the amount of the carbon dioxide, CO2 that will affect in many ways. Furthermore, the uses of wood as fibre reinforcement will lead the way to the high request for forest sources. And it will cause deforestation. This kind of activity are not worth for the production of wood fibre in future. Hence, another natural fibre needs to be established for replacement the wood fibre in cement boards.

Nowadays, sort of cement board by using natural fibre mostly made from wood in a subtle way. Due to decline in wood resources across with massive deforestation and economic development, the wood resources for all intents and purposes needs to really be minimised. Cement board products need to replace wood fibres with other lignocellulosic fibres, which basically is fairly significant. The aim of this study is to determine the screw withdrawal resistance of oil palm empty fruit bunch (EFB) fibre board. The objectives of this research are to study the effect of EFB cement ratio on physical properties of EFB cement fibre board and evaluate the screw withdrawal resistance of EFB cement fibre board and its relationship physical properties. The materials for this EFB fibre are cement, water and sodium hydroxide. Several factors can impact on the amount of force the screw can hold. Resistance of a screw to very direct the generally withdrawal from a piece of board intimately related to the density or specific gravity of the boards, the diameter of the screw, and the depth it literally has penetrated. Based on the EFB properties, it will basically help the researcher to understand much more detail about the effect of cement-board ratio that particularly come out with different results particularly due to uniformity of board density and thickness. This fibre ratio will essentially contribute optimum physical properties.

2 Materials and Methods

2.1 Materials

In this research, the EFB samples were obtained from an oil palm plantation located at Ban Dung Palm Oil Industries Sdn Bhd, 79, Jalan Muar, Parit Sulong, 83500 Batu Pahat Johor. The main ingredients for EFB fibre board are fibre, cement, water and sodium hydroxide.

2.2 Methods

The EFB undergo sun dry process for two days to reduce the moisture content of the EFB. Afterwards, EFB was shredded using hammer mills to shorten the size of the EFB particle. EFB were sieved to remove dust that could affect the quality of the cement board. Pre-treatment were done to the fibre after being sieved. The raw fibres were washed with tap water to eliminate any unwanted particles on the fibre. In this research, sodium hydroxide (NaOH) is used in the pre-treatment where EFB were soaked for 24 hours to remove inhibitory substances and oil residues in the fibre that could affect the hydration of cement. Water and cement with ratio of 2:1,2.5:1 and 3:1 was used as a binder to form EFB-CB which was pressed with a cold press machine. Two methods are used to fabricate the cement board which is hand forming and hand forming plus vibration table. The process is illustrated in Figure 1 that was mention by previous researchers [1].

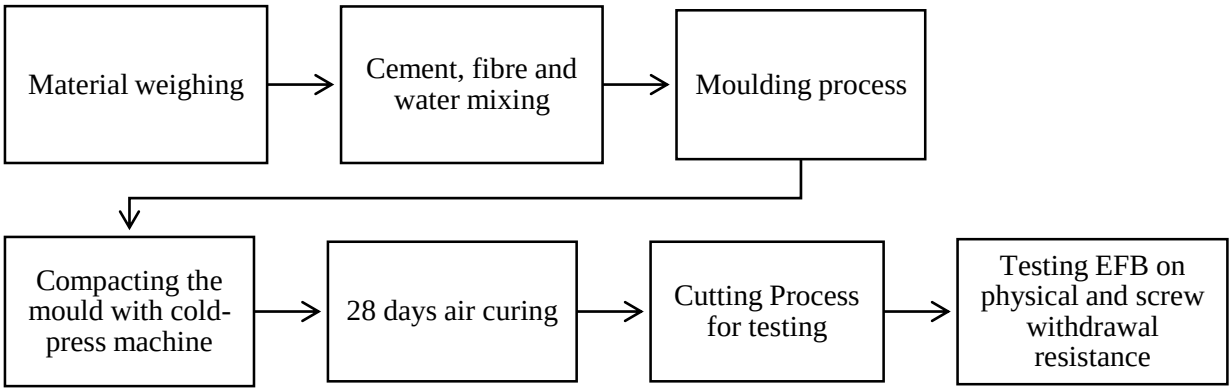

Figure 1: Fabrication process of EFB

Shredded EGB, water and cement are weighted before mix. The weight of the materials is 40% from cement weight and 30% based on EFB oven dried weight. Materials were mixed for 5 minutes to obtain a homogenous mix. The total duration was 10 minutes as recommended by researcher [2]. The mixture was uniformly blended and then immediately transferred to a wooden mould measuring 400 x 400 mm^2. Before being compacted with a cold press machines, the fibre and cement that has been mix together needs to spread into the wooden mould. The mixture was evenly spread into a wooden mould and flattened by hand to produce a cement board composite. A piece of plywood was put on top of it to pre-compact the mat. The wooden mould was then removed before placing the steel mould on top of the mat that was covered with a polythene sheet at top and bottom of the board to replace the plywood. Steel mould were used in this research to clamp the mixture and obtain the target thickness. For vibration table method, the same procedure applied as hand forming method but the difference is the mixture are flattened by vibration table to produce the cement board sample. After the forming process, the sample was clamped with the reinforced steel plate before compressing process. The moulds were compressed under high pressure until cement boards with a target thickness of 12 mm are formed. Placed a spacer with thickness of 12mm between the steel moulds before the compaction of the mixed. The board were de-clamped after 24 hours and stacked horizontally and cured for 28 days. The cement board was cut based on the type of testing for physical and screw withdrawal resistance and the size are considered according to the BS EN 3261.

2.3 Testing

The laboratory test was performed in the fabrication laboratory and structure laboratory and evaluated the physical properties and the screw withdrawal resistance of the cement board. A sample test was performed to obtain the physical properties of cement board samples. The laboratory test was conducted to investigate the screw withdrawal resistance with EFB-cement ratio on physical properties included density, internal bonding (IB) and thickness swelling (TS).

2.4 Equations

The results of internal bonding, density and screw withdrawal resistance were calculated based on the equation given.

Density,

$$\rho = \frac{m}{b1\ x\ b2\ x\ t}\ x\ 10^6$$

where:

m = mass of the sample (g)

t = thickness of the sample (mm)

$b1\ x\ b2$= Area of the sample (mm)

Internal Bonding,

$$\text{IB} = \frac{P}{wl}$$

where:

P = maximum load (N)

W = width(mm)

l = length (mm)

Screw withdrawal resistance,

$$f = \frac{F_{max}}{d l_p}$$

where:

f = specific withdrawal capacity of screw (N/mm^2)

F_{max} = ultimate load (N)

d =diameter of the screw, (mm)

l_p = depth of penetration of the screw, (mm)

3 Results and Discussion

Based on the previous research, cement fibre ratio in cement boards fabrication significantly affected the performance on the uniformity of board density and the thickness of the cement board samples. There are 3 types of the mix design ratio that used in this research which is 2:1, 2.5:1 and 3:1 was used to fabricated the cement boards. Based on the results that has been conducted, the difference mixture of EFB fibre cement ratio able to produced different appearance such as colour and texture of the cement board surface. The results of the IB, TS, density and screw withdrawal resistance also affected due to the different mix ratio[3].

3.1 Results

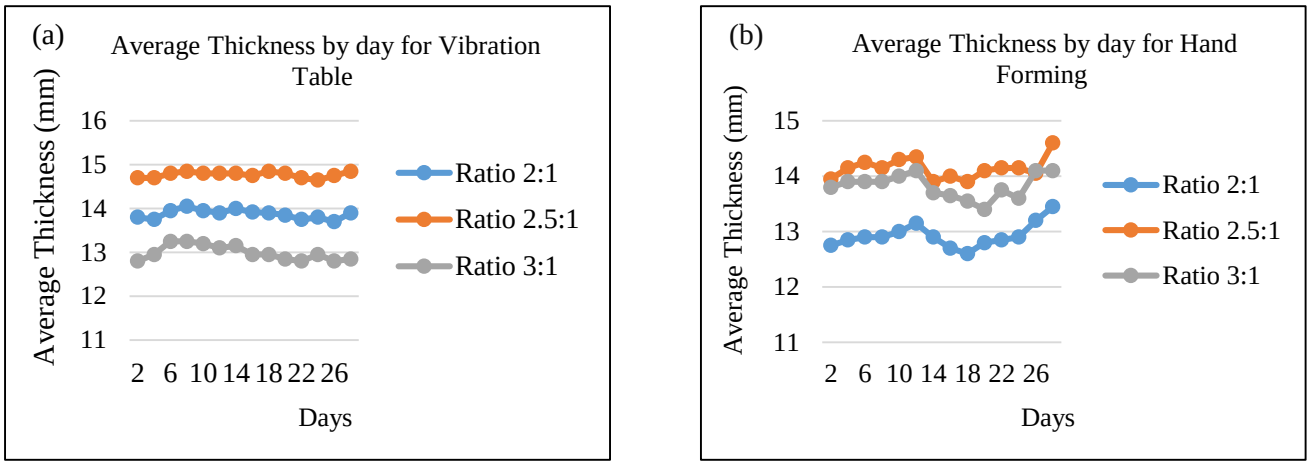

Figure 2 (a-b): Average thickness by days with different mix ratio

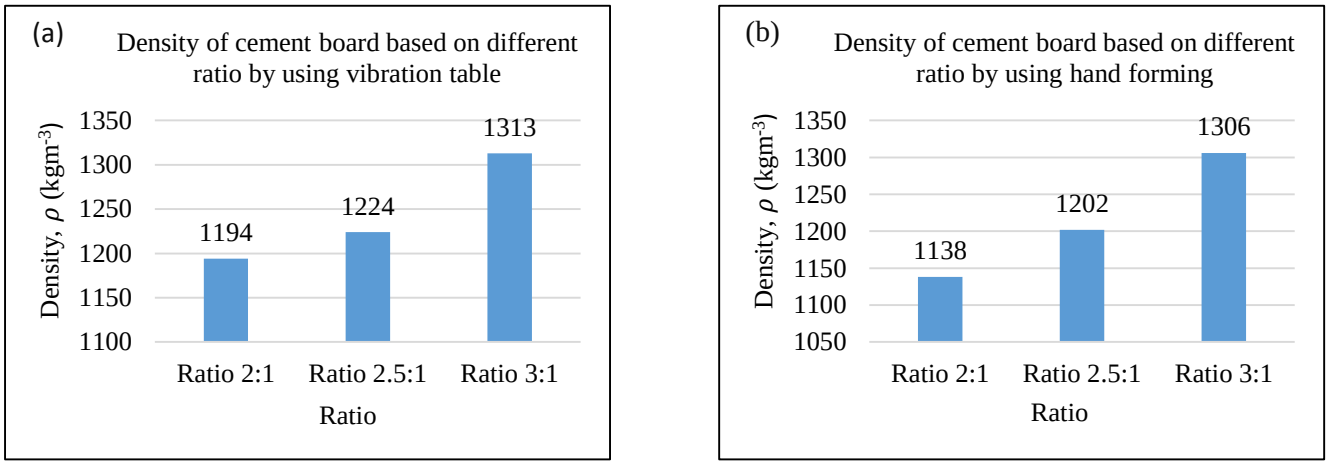

Figure 3 (a-b): Density of cement board based on different ratio

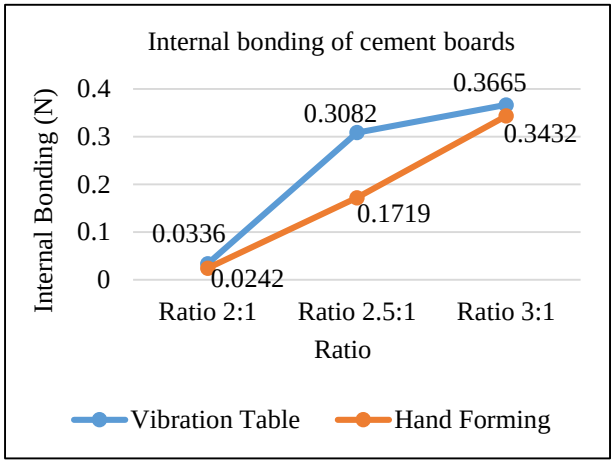

Figure 4: Internal Bonding of cement board

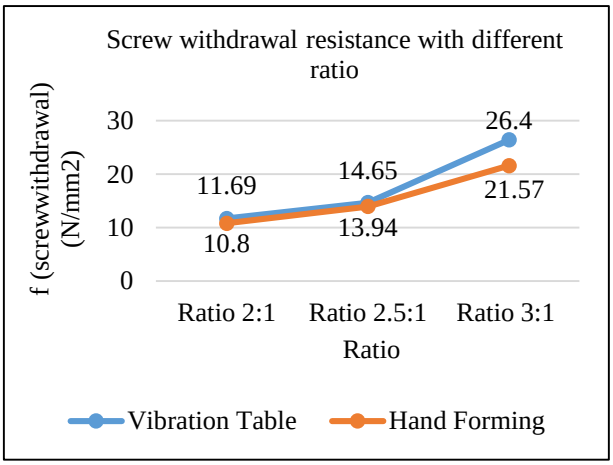

Figure 5: Screw withdrawal resistance with different ratio

Table 1: Ultimate load and specific withdrawal capacity of screw Ø4

Method	Mix Ratio	Thickness, *t* (mm)	Density (kg/m3)	$F_{Screwithdrawal}$ (N)	$f_{(screwwithdrawal)}$ (Nmm^{-2})	F_{IB} (N)	IB (Nmm^{-2})
Vibration Table	2:1	13.65	1194	638.33	11.69	84.0	0.0336
	2.5:1	14.65	1224	858.33	14.65	513.7	0.3082
	3:1	12.85	1313	1356.30	26.40	916.3	0.3665
Hand Forming	2:1	13.45	1138	581.30	10.80	60.7	0.0242
	2.5:1	14.60	1202	814.30	13.94	429.7	0.1719
	3:1	14.10	1313	1216.70	21.57	858.0	0.3432

3.2 Discussions

Thickness monitoring was tested that carried out to observe the spring back effect of the cement board with the different fibre cement board ratio. Testing was done after samples are unclamped form the steel clamp. The thickness monitoring is recorded every two days interval until 28 days of curing process. This study observed the increment in thickness of EFBCB that lead to spring back effect. The designed thickness of EFB cement board composite is 12mm with allowable ± 1 mm (BS EN 364:1995) which the thickness must be in range 11mm to 13 mm, to make it acceptable to be use as structural in construction industry. In this study there are two methods were used during fabrication process which is hand forming and vibration table. The result that obtained from the vibration table method for thickness monitoring with ratio 2:1 was increase from 13.8 mm to 13.9 mm, while for the ratio sample 2.5:1 it also increases from 14.7 mm to 14.9 mm and same goes to ratio 3:1 which is from 12.8 mm to 12.9 mm. Similar trend was observed for the hand forming method. Form this results, it observed that the cement board that fabricate in both methods achieved the standard design thickness by BS EN 364:1995. Cement board specimens with longer EFB fibres tend to affect the results thus it will increase the thickness of the cement board and it also may result the workability and decline in strength of the cement board. It also will reduce the density of the cement board and increase the void space [4].

Density was observed to know the effect of spring back towards cement board density based on the cement-board ratio. Samples were design to have density of 1300kg/m^3 [5]. Testing was conducted based on BS EB 323-1993. Based on the results obtained from the vibration table method above, it can clearly be seen that the value of density for cement board with ratio 3:1 is the highest among the other two ratios which is 1313 kgm^{-3}. This is because, it contained less fibre and high cement content whereas the value of density decreased for ratio 2:1 because of the high content of EFB. Since, the density of the boards is most likely to get influenced by the mass of its constituents, therefore the main reason that can attributed for the decrease in density is the difference in mass of fibres and cement content. Based on the results obtained from the hand forming method above, it can clearly be seen that the value of density for cement boards with ratio 3:1 is highest which are contained less fibre and high cement content whereas the value of density between ratio 2:1 and 2.5:1 had slightly different because its high content of EFB. The existing of the void in low-density cement board will be higher than high density cement board will produce higher water absorption in the low-density board. The highly porous structure on the board allows penetration of water into the board and increases the water uptake resulting in high water absorption at the same time, causes the board to swell and subsequently causes a rise of thickness swelling [6]. The higher the density, the better result of thickness swelling and it will decrease the amount of water absorption of the board. The boards with higher density can absorb more water than the boards with lower density.

Internal bonding test conducted on cement boards sample aims to observed the strength of cement boards after the force is applied until rupture occurred. It is also known as a tensile strength. The tensile strength is calculated by dividing the maximum load at failure by cross-sectional area of the sample. Testing is conducted based on the BS EN 319-1993 specifications. The result for internal bonding (IB) with different cement-EFB ratios. It was clear that the EFBCB in vibration table with ratio 3:1 gave the highest IB value which is 0.0.3665 Nmm^{-2}, followed by ratio 2.5:1 which is 0.3082 Nmm^{-2}, and 0.0336 Nmm^{-2} for the ratio 2:1. However, the IB values obtained from the hand forming EFB cement

board were slightly lower than vibration table. The lower IB values found; the lower the density of the boards due to the existence of more voids compared to the higher density of cement boards [7].

The screw withdrawal resistance was conducted to determine the screw holding strength of the boards. A screw was inserted upright into face side of the test sample and placed in a stirrup attached to the load. Results of screw withdrawal resistance obtained when the load was applied in a pulling action. Screw withdrawal resistance is highly associated with the board density. From the results given in this research, the different mix ratio is a main factor affecting on specific withdrawal resistance of universal screw. The results from the test carried out to determine the screw withdrawal resistance of universal screw Ø4x40 mm into different mix ratio. Statistical data from the value of ultimate load (F_{max}) will calculated the specific withdrawal capacity (*f*). According to the results, both method between hand forming and vibration table has a slightly difference in screw withdrawal resistance results. The comparison data for the methods of the fabrication, it has a little difference which is statistically significant. Higher screw withdrawal resistance is shown by vibration table compare to hand forming. It is obvious from the results; the ratio of the cement board is a main factor affecting the specific screw withdrawal resistance [8].

4 Conclusion

The main objective of this study was to investigate the effect of EFB cement ratio on physical properties of EFB cement board and to evaluate the screw withdrawal resistance of EFB cement board and its relationship between physical properties. The results of the investigation were very encouraging. The following conclusions may be drawn according to the objectives of the study. The main objective of the study is to identify the effect of cement- fibre ratio of EFBCB on uniformity of board density and thickness. Based on the results obtained in thickness which are provided the results where the density was increased and the weight of the cement boards was decreased. Therefore, the uniformity of the thickness and the board density was observed. For this study, the optimum ratio of the EFB cement board is 3:1 by using vibration table method. This is because the higher the cement content, the higher the strength of the cement board and it also will affect the density and internal bonding of the cement board. The lower the density, the higher the presence of air void that will affect the strength of the cement board [9]. The screw withdrawal resistance was conducted with the EFBCB by using universal screws in the direction of the perpendicular to the plain. It can be concluded that, the different mix ratio has significant influence on the screw withdrawal resistance of the universal screw [10]. Highest screw withdrawal resistance and ultimate loading capacity for universal screws was performed by mix ratio in vibration table method. Lowest screw withdrawal resistance and ultimate loading capacity for universal screw was performed by mix ratio in hand forming method. All the tested cement board different mix ratio, EFB as well the universal screw, the results can be used for predicting the withdrawal resistance of similar ratio and screws.

Acknowledgement

The author would like to thank Universiti Tun Hussein Onn Malaysia at the Faculty of Civil Engineering and Built Environment for providing financial support and infrastructure needed for this research. Appreciation also goes to everyone involved directly and indirectly toward the completion of this research.

References

[1] E.O. Onuorah, C.A. Okeke, J.T. Nwabanne, E.L.C. Nnabuife, S.O.M. Obiorah, the effects of production parameters on properties of single and 3-layer cement-bonded composites made from oil palm empty fruit bunch and tropical hardwood sawmill residue, World Journal of Engineering. 12 (2015) 577–589. https://doi.org/10.1260/1708-5284.12.6.577.

[2] S. Maleki, S. Kazemi Najafi, G. Ebrahimi, M. Ghofrani, Withdrawal resistance of screws in structural composite lumber made of poplar (Populus deltoides), Construction and Building Materials. 142 (2017) 499–505. https://doi.org/10.1016/j.conbuildmat.2017.03.039.

[3] R. Wahab, M. Sukhairi, M. Rasat, M.A. Salam, M. Mohamed, Measurement on Properties of Empty Fruit Bunch Oil Palm Composite Boards at Different Density and Resin Contents Investigating the contribution of carbon nanotubes and graphene (nano-fluid on bio-diesel & Biofuel) View project Rattan Project View project, 2015. http://www.aensiweb.com/AEB/.

[4] H.P.S. Abdul Khalil, M.R. Nurul Fazita, M. Jawaid, A.H. Bhat, C.K. Abdullah, Empty fruit bunches as a reinforcement in laminated bio-composites, Journal of Composite Materials. 45 (2011) 219–236. https://doi.org/10.1177/0021998310373520.

[5] M.D.H. Beg, M.F. Mina, R.M. Yunus, A.K.M. Moshiul Alam, The use of oil palm biomass (OPB) fibres as reinforcements in composites, in: Biofibre Reinforcements in Composite Materials, Elsevier Inc., 2015: pp. 342–382. https://doi.org/10.1533/9781782421276.3.342.

[6] M.A. Norul Izani, M.T. Paridah, M.Y. Mohd Nor, U.M.K. Anwar, Properties of medium-density fibreboard (MDF) made from treated empty fruit bunch of oil palm, Journal of Tropical Forest Science. 25 (2013) 175–183.

[7] N.B. Shawia, M.A. Jabber, A.F. Mamouri, Mechanical and physical properties of natural fiber cement board for building partitions, Physic Science Research International. 2 (2014) 49–53.

[8] V. Jivkov, B. Kyuchukov, R. Simeonova, A. Marinova, Withdrawal Capacity Of Screws And Confirmat Into Different Wood-Based Panels Withdrawal Strength of Screws, Confirmat and Special Screws for Lightweight Panels View Project Furniture design from thin wood-based materials View project, 2017. https://www.researchgate.net/publication/322509130.

[9] R. Ramli, S. Shaler, M.A. Jamaludin, Properties of Medium Density Properties Fibreboard from Oil Palm Empty, Journal of Oil Palm Research. 14 (2002) 34–40.

[10] F. Abu, M. Ahmad, Effects of screw insertion on screw withdrawal strength, International Journal of Advanced and Applied Sciences, 2 (12) 2015 25-29.