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THE EFFECT OF OIL PALM TRUNK AND OIL PALM FRUIT BUNCH FIBRE ON THE MECHANICAL PROPERTIES OF LATERITE BRICKS

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Abstract
The main aim of this study was to compare the physical properties and mechanical properties of Oil Palm Trunk (OPT) fibre and Oil Palm Fruit Bunches (OPFB) fibre reinforced laterite bricks. For comparison purposes, the properties such as dimension, density, water absorption and the compressive strength of both types of bricks were determined. The effects of the incorporation of various amounts of fibres on the above properties were analysed. The tests were carried out according to BS 3921: 1985 for clay bricks.The samples were pressed at the factory Majpadu Bricks Sdn. Bhd., Malaysia and tested at the Material Testing Laboratory, Universiti Teknologi MARA, Shah Alam, Malaysia.The findings of this research were, firstly, the dimension of bricks content with OPFB fibres were less accurate than bricks with OPT fibres. Secondly, the density of bricks with OPFB fibres was higher than the density of bricks with OPT fibres. Thirdly, in compressive strength of the bricks with OPFB fibres was higher than bricks with OPT fibres, with the maximum fibre content identified as 3 percent fibres. Finally, the water absorption of bricks with OPFB fibres was lower than the water absorption of bricks with OPT fibres. It can be concluded that the bricks with OPFB fibres had better physical and mechanical properties than bricks with OPT fibres. OPFB fibres is better for reinforcement in the laterite bricks and properties of the bricks with OPT Fibres were to be improved.

Keywords: Natural fibres, Oil palm trunk fibre, Oil palm fruit bunch fibre, Laterite bricks

1. Introduction

Generally, oil palm is the most important agricultural and commercial plantation crop in Malaysia. Oil palm which better characteristics that people recognized as 'tree of life' because all part such as fruits, trunks, leaves and can be effectively utilized for living. In order which utilities of the palm oil residue is better to added to make the value product, two of the utilities were chosen for study, it was Oil Palm Trunk fibre and Oil Palm Fruit Bunch fibre. This research is In order to determine which fibre is better for reinforcement, the bricks have to be pressed from the same source of raw materials and testing in the same period.Natural fibres, as a substitute for glass fibres in composite components, have gained interest in the last decade, especially in the housing sector. Fibres like jute, sisal, coconut fibre (coir), ramie, banana, flax, hemp etc. are cheap and have better stiffness per unit weight and also have a lower impact on the environment. Structural applications are rare since existing production techniques are not applicable for such natural fibre concrete products and non-availability of semi-finished materials with adequate quality. An experiment carried out by Corson at the Building Research Station, United Kingdom, on sisal fibre reinforced concrete.

Noticed that an addition of sisal fibres in concrete increased the need of water in the matrix. The cement reactions were distributed by substances, which were dissolved from sisal fibre (Zonsveld, 1984). In Brazil discovered that vegetable fibres have been used for reinforcement in many types Of mortar and concretes. For instance, building component was develop with coir and sisal fibres, and also incipient research work was done with jute, sugar-cane baggage and bamboo fibres (Agopyan, 1988) . The research carried out by Saleh A.M had found that the density of OPFB fibre reinforced laterite bricks decreased with the increase in the volume of fibre incorporated. The highest compressive strength was 8.67 MN/m^2 (Saleh, 1999). Research by Abas (2001), on the use of coir fibres on compress Laterite brick. The main objective of her research was to study the physical and mechanical properties of the pressed laterite brick with an addition of coir fibres. It was found that the physical property of coir fibre reinforced laterite bricks which is density decreased with an increase volume of coir fibres in coir fibre reinforced laterite (CFRL) bricks compare to control brick (no fibre). Secondly, the compressive strength of coir fibre reinforced laterite bricks increased with increase of coir fibre content. A research on the effects of the incorporation of different types of fine aggregates which were mine sand, quarry dust and river sand into non-fired pressed laterite bricks. She found that the quarry-dust laterite bricks gave the highest compression strength. (3.34 MN/m2 in mix 1 and 2.31 MN/m2 mixes 2) (Zairani, 2001). A research on the effects of rubberwood fibre incorporated into the pressed laterite brick. Finding on this report that increased in fibre content had resulted in the density of rubberwood fibre reinforced laterite (RFRL) bricks. The water absorption of the RFPL bricks increased with an increase in fibre content and the compressive strength were increased with the increase the fibre contents. It was showed that, increase in moisture content of the sand and laterite soil can decrease of compressive strength of bricks (Sairi, 2002). Research to compare two fibres compare the Oil Palm Fruit Bunches (OPFB) fibre and Coconut Coir fibre reinforced laterite bricks. The result stated, firstly, the dimension of bricks content with OPFB fibres were more accurate than bricks with coir fibres. Secondly, the density of bricks with OPFB fibres was lower than the density of bricks with coir fibres. Thirdly, in compressive strength of the bricks with OPFB fibres was higher than bricks with coir fibres, with the maximum fibre content identified as 3% fibres. Finally, the water absorption of bricks with OPFB fibres was lower than the water absorption of bricks with coir fibres (Ismail S, 2002). Therefore the objectives of this research is to compare the physical properties and mechanical properties between oil palm trunk (OPT) reinforced laterite bricks and oil palm fruit bunches (OPFB) reinforced laterite bricks.

2. Experiment

The first stage of this experimental work was to determine physical properties of the above both bricks namely dimension and density. The second stage of this experimental work was to determine their compressive strengths and the water absorption properties. This testing was according to the experimental procedures as described in BS 3921:1985 .The specimen design mix used in this research was 70% of soil, 24% of sand and 6% of cement. The OPT fibres and OPFB fibres used were from Wood Chemistry Division from Forest Research Institute Malaysia (FRIM) refer to photo1. The laterite soil was taken from the hill nearby the factory and the sand used was from puchong tin mines. The both fibre content incorporated in bricks were from 1% to 5% of cement weight. The bricks specimens were prepared at Majpadu Bricks Sdn Bhd factory located at Jalan Kebun, Klang, Malaysia. The fibres were firstly mixed with cement and packed in air tight plastic begs at Material Testing Laboratory, Faculty Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, Malaysia. Before transported to the brick factory (Majpadu Sdn. Bhd.) at Shah Alam to be pressed into bricks. The two types of brick samples prepared in this research used the same proportion of constituent materials. The experimental works carried out involved 6 types sample of laterite bricks contained OPT fibres and 6 types sample of laterite bricks contained OPFB fibres. Each type of samples consisted of 20 bricks used to determine compressive strength and water absorption giving the total number bricks approximately were 240 units. The mix proportion used for the all samples was 70% of soil, 24% of sand and 6% of cements. The material wastage allowance was 45% which allow for wastage during mixing and pressing of bricks. Table 1 shows the total quantity of materials prepared for 20 units bricks for 6 sample of OPT fibre reinforced laterite bricks and OPFB fibre reinforced laterite bricks.The amounts of OPT and OPFB fibres were calculated based on the percentage of cement weight. Table 2 shows the percentage and quantity of OPT fibres used for laterite bricks. The percentage and quantity of OPFB fibres used for laterite bricks is shown in Table 3.The preparation of laterite bricks for this research was carried at Majpadu Bricks Sdn Bhd. There were four stages of process to produce OPFB fibre reinforced laterite bricks and coir fibre reinforced laterite bricks. Both fibres were cut at an interval length about 25 mm. The fibres were kept properly in dry area. Fibres and cement were mixed earlier at laboratory before mixing done with soil and sand at factory. The fibres and cement were weighing based on the ratio of the cement weight before mixing. Their mixed by hand to spread the fibres in cement were not clinging evenly.

Next step of the process is by packing the cement –fibres mixes separately in plastic bags based on different types of percentage fibres. After that, the cement and fibres were transported to the factory and the cement and fibres were mixed with laterite soil and sand. The soil and sand were weight earlier according to the specified mix proportion before mixing with cement and fibres. Then all the material was mixed together about 8 to 10 minutes. The constituent materials and fibres were mixed by hand to ensure that fibres dispersed evenly in the cement. After the mixing by hand shovel, the constituent materials were mixed again into the pressing machine which has a mini mixer about 4 to 5 minutes to thoroughly mix the materials before pressing into bricks. The pressure of the pressing machine to produce the bricks was 9 – 10 MN/m² depend on the weight of bricks. Secondly, the process is the pressing machine was pressed out the bricks.

The bricks were collected and identifications of the types samples by mark and stacked on the palette. In the curing process, the bricks were wrapped and used plastic film to avoid rapid. The bricks were kept under sheltered area for 24 hours and were sprayed with water. The bricks were stored in open air for 21 days before delivered to testing laboratory for testing at the age 28 days. Six types of laterite bricks contained OPT fibres and six types of laterite bricks contained OPFB fibres had been prepared for testing. The detail of the samples is given in Table 4 and Table 5.

Table 1. Total quantity materials for 20 units of bricks for each type of sample.

Material	***Quantity of material***			
	1 type of sample	6 types (OPT fibre)	6 types (OPFB fibre)	**Total**
Soil (70%)	58.9 kg	353.4 kg	353.4 kg	**706.8 kg**
Sand (24%)	20.2 kg	121.2 kg	121.2 kg	**242.4 kg**
Cement (6%)	5 kg	30 kg	30 kg	**60 kg**

Table 2. Quantity of oil palm trunk fibres required for 20 units of bricks

Percentage of fibre content	**Cement**	**Fibres**
0%	5 kg	0 gram
1%	5 kg	50 gram
2%	5 kg	100 gram
3%	5 kg	150 gram
4%	5 kg	200 gram
5%	5 kg	250 gram
Total		**750 gram**

Table 3. Quantity of OPFB fibres required for 20 units of bricks

Percentage of fibre content	**Cement**	**Fibres**
0%	5 kg	0 gram
1%	5 kg	50 gram
2%	5 kg	100 gram
3%	5 kg	150 gram
4%	5 kg	200 gram
5%	5 kg	250 gram
Total		**750 gram**

Table 4. Sample descriptions for bricks content with coir fibre

Sample	**Quantity**	**Descriptions**
AT	20	Bricks with no fibre
BT	20	Bricks with 1% of fibre
CT	20	Bricks with 2% of fibre
DT	20	Bricks with 3% of fibre
ET	20	Bricks with 4% of fibre
FT	20	Bricks with 5% of fibre

Table 5. Sample descriptions for bricks content with OPFB fibre

Sample	**Quantity**	**Descriptions**
AB	20	Bricks with no fibre
BB	20	Bricks with 1% of fibre
CB	20	Bricks with 2% of fibre
DB	20	Bricks with 3% of fibre
EB	20	Bricks with 4% of fibre
FB	20	Bricks with 5% of fibre

3. Results and Discussion

The dimension of Oil Palm Trunk fibre reinforced laterite (OPT) bricks and oil palm fruit bunches (OPFB) fibres reinforced laterite bricks had been obtained by measuring the length, width and depth of the bricks which were used in the calculation of volume. Table 6 show the comparison dimension between oil palm trunk fibre reinforced bricks and Oil Palm Fruit Bunch fibre reinforced laterite brick. From the results standard deviations show that dimension of bricks with OPT fibre content are more accurate between bricks with OPFB fibre contents. The standard deviation for average length, width, depth, area and volume for both bricks with OPT and OPFB fibre content were almost zero and lower. But generally OPT have a zero standard deviation. So it can be summarized that bricks with OPT fibre have more accuracy from OPFB fibre. Bricks dimension, weight of material and percentage of fibre content may influence the density of bricks.

In Table 7 shown the comparison on average density of OPT bricks and OPFB fibre reinforced laterite bricks with variable percentage of fibre content. From the results, generally density bricks with OPT fibre content are lower than bricks content with the OPFB fibre. Illustration of the comparison results as shown in Figure 1. Figure 1 shows the average density bricks with two different type of fibre content. The results show that the both bricks content with OPT fibre and OPFB fibre are reduces statically decrease with increase the percentage of fibres content. With comparison of two types of bricks the results shows bricks with OPT fibres have lower density than bricks with OPFB fibre. The OPT fibre get lower density than OPFB fibre because OPT fibre had bigger width (35.30 microns) than the width of OPFB fibres (25 microns) refer to Figure 1. Therefore the OPT fibres had displaced more heavy constituent materials, resulted in lower density of OPT fibre bricks.

Referring to Table 8, shows the average of compressive strength OPT fibre reinforced laterite bricks and OPFB fibre reinforced laterite bricks. Generally the compressive strength for OPFB fibre reinforced laterite bricks was higher than OPT fibre reinforced laterite bricks. The results showed the maximum compressive strength for OPFB fibre reinforced laterite bricks was with 3% fibre content and it strength is higher by 1.1% than control bricks. It was strongly believe that the higher strength obtained from OPFB fibre reinforced laterite bricks cause by the form of fibres that had curly form that had successfully reinforced the matrix and have the lower moisture contents of fibres. The brick may behave similarly to the concrete by the addition of the cement in its matrix. Figure 2 shows the comparison the compressive strengths of bricks with the same percentage of fibre content of both types of fibres. Table 9 shows the average percentage of water absorption for OPFB fibre reinforced laterite bricks. Generally from the table below show the water absorption bricks with fibre content for both types are increase than control samples. The water absorption of laterite bricks were related to the density of bricks. In the table shows some water absorption of bricks decrease with increase the addition of fibre. Although the results decreasing, but its still higher than bricks without fibre. The comparison in average water absorption of bricks is illustrated in bar chart Figure 3.

Figure 3 shows the comparison bricks with different type of fibre but same in their percentage fibre content. From the bar chart shows the water absorption OPT fibre reinforced laterite bricks and OPFB fibre reinforced laterite bricks increase with an increase the fibre content. Compare two type of bricks the results show bricks with OPT fibre have higher water absorption than bricks with OPFB fibre. The OPT fibre get high water absorption than OPFB fibre because it is believed that the OPT fibres were more porous and permeable due to the greater width of the fibre. The moisture content of the materials; laterite soil, sand and fibre were obtained to know the consequences to influence whereby to the compressive strength. Generally, the moisture content of the constituent of materials and fibres influence the compressive strength of the OPT fibre laterite bricks and OPFB fibre laterite bricks. By referring to the Table 10 the results shows that the moisture content on laterite soil and fibre for bricks with OPT bricks was higher than moisture content in laterite soil for bricks with OPFB. Also in mine sand whereby the moisture content in sand for bricks with OPT bricks was higher than moisture content in sand for bricks with OPFB.As discussed earlier, the compressive strengths of bricks were influenced by the moisture contents of constituent materials and fibres. In this research, it is believe that the porosity of the bricks was influenced by the presence of moisture content in the constituent materials and fibres. Therefore, the bricks which contained high moisture contents reduce the strength of the bricks. The moisture content caused the high porosity in bricks. The constituent materials and fibres that have more moisture content contribute to the porosity of the bricks and consequently reduce the strength of the bricks.

Table 6. The comparison dimension of OPT bricks and OPFB fibre reinforced laterite bricks

Dimension Of Bricks	**OPT Fibre Reinforced Laterite Bricks**		**OPFB Fibre Reinforced Laterite Bricks**	
	Average	Std. Deviation	Average	Std. Deviation
Length (mm)	217	0.21	217	0.25
Width (mm)	97	0.12	97	0.22
Depth (mm)	72	0.56	72	0.43
Area m2	0.0211	0.0000	0.0211	0.0001
Volume m3	0.00152	0.00001	0.00151	0.00001

Table 7. The comparison density of OPT fibre reinforced laterite bricks and OPFB fibre reinforced laterite bricks

OPT Fibre Reinforced Laterite Bricks			**OPFB Fibre Reinforced Laterite Bricks**		
Type	**Fibre Contents**	**Average Density (Kg/m3)**	**Type**	**Fibre Contents**	**Average Density (Kg/m3)**
AT	0%	2106.06	AB	0%	2135.62
BT	1%	2092.41	BB	1%	2120.19
CT	2%	2087.04	CB	2%	2114.44
DT	3%	2079.89	DB	3%	2106.28
ET	4%	2074.11	EB	4%	2101.99
FT	5%	2066.82	FB	5%	2098.75

Table 8. The comparison compressive strength of OPT fibre reinforced laterite bricks and OPFB fibre reinforced laterite bricks

OPT Fibre Reinforced Laterite Bricks			**OPFB Fibre Reinforced Laterite Bricks**		
Type	**Fibre Contents**	**Average Strength(KN/M2)**	**Type**	**Fibre Contents**	**Compressive Strength(KN/m2)**
AT	0%	7.92	AB	0%	8.93
BT	1%	7.52	BB	1%	8.57
CT	2%	8.49	CB	2%	8.87
DT	3%	8.41	DB	3%	9.03
ET	4%	8.35	EB	4%	8.47
FT	5%	8.00	FB	5%	8.33

Table 9. The comparison water absorption of OPT bricks and OPFB fibre reinforced laterite bricks

OPT Fibre Reinforced Laterite Bricks			**OPFB Fibre Reinforced Laterite Bricks**		
Type	Fibre Content	average water Absorption%	Type	Fibre Content	average water Absorption%
AT	0%	18.88	AB	0%	18.82
BT	1%	19.84	BB	1%	19.71
CT	2%	19.52	CB	2%	18.89
DT	3%	19.46	DB	3%	19.33
ET	4%	19.53	EB	4%	19.43
FT	5%	19.93	FB	5%	19.39

Table 10. The moisture content of laterite soil and sand for bricks with different type of fibre content.

Type of brick	**Material**	**Mass of Container (gram)**	**Mass of Container + Wet sample (gram)**	**Mass of Container + Dry sample (gram)**	**Mass of water (gram)**	**Moisture Content (%)**
OPT	fibre	660	804	786	18	2.30
OPT Fibre Reinforced Laterite Bricks	Laterite Soil	650	4370	3539	831	23.48
	Sand	660	5650	5422	228	4.21
OPFB	fibre	660	810	797	13	1.63
OPFB Fibre Reinforced Laterite Bricks	Laterite Soil	670	4340	3531	809	22.91
	Sand	670	6120	5887	233	3.96

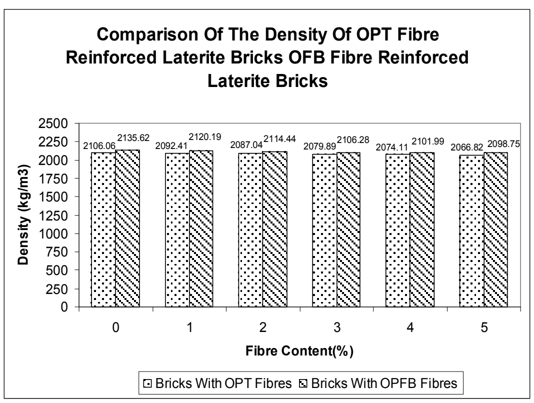

Figure 1. Comparison the density of OPT fibre and OPFB fibre reinforced Laterite bricks

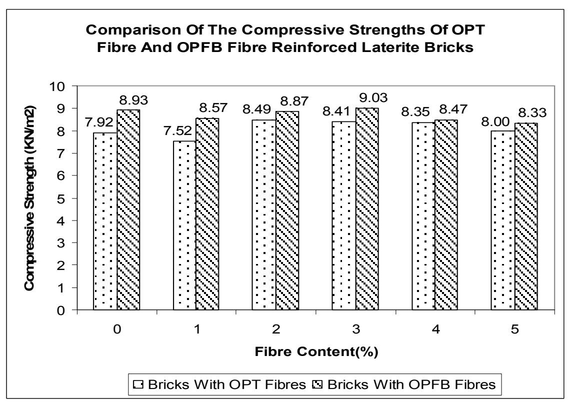

Figure 2. Comparison the compressive strength of OPT fibre and OPFB fibre reinforced laterite bricks

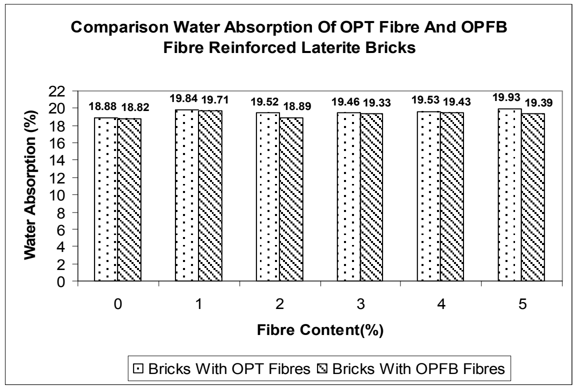

Figure 3: Comparison the water absorption of OPT fibre and OPFB fibre reinforced laterite bricks

4. Conclusion

The dimension of the brick in their length, width, depth, area and volume showing the bricks with OPT fibres were more accurate with lower standard deviation than bricks with OPFB fibre. The reason may be due to the OPT fibres causing less balling up and clinging each other and well distributed in the bricks. The density of bricks with OPT fibres was lower than bricks with OPFB fibres. The OPT fibre bricks had lower density than OPFB fibre bricks because the OPT fibres had bigger width than the width of OPFB fibres. Therefore the OPT fibres had displaced more heavy constituent materials, resulted in lower density of OPT fibre bricks. The compressive strength of OPT fibre reinforced laterite bricks was lower than the strength of OPFB fibre reinforced laterite bricks. The OPFB fibres in the form of curly fibres, than the OPT fibres which in straight form of fibre. Therefore the OPFB fibres give better reinforcement than OPT fibres. The moisture content of OPT fibres was higher than OPFB fibres, therefore the strength of the OPT fibres was expected to be to be lower than OPFB fibres, hence, reduced the compressive strength of OPT fibre bricks.The water absorption of bricks with OPT fibres was higher than the water absorption of bricks with OPFB fibres. The bricks with OPT fibres had higher water absorption than OPFB fibre bricks because it is believed that the OPT fibres were more porous and permeable due to the greater width of the fibre, which expected to have more pores in the fibre strands.On the whole it can be concluded that each type of the bricks has different advantages. OPFB fibres bricks had better physical properties than bricks with OPT fibres. The results showed the density bricks with OPFB fibres were denser and the bricks had lower water absorption characteristics. The OPFB fibres had higher mechanical property that is, compressive strength than bricks with OPT fibres. It can be concluded that the bricks with OPFB fibres had better physical and mechanical properties than bricks with OPT fibres and OPFB fibres is better for reinforcement in the laterite bricks.

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