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Effects of Palm Fiber on the Mechanical Properties of Lightweight Concrete Crushed Brick

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Abstract: Problem statement: Researches has been conducted worldwide on a large number of natural or artificial lightweight aggregates. In spite of many of the researches of using natural fibers show considerable promise, the use of natural fibers to improve the properties of lightweight concrete still required to be a subject of further research and investigation. **Approach:** This experimental investigation was carried out to study the properties of lightweight crushed brick concrete containing palm fiber of different volume fractions. An experimental programme was planned in which the tests such as density, compressive strength and flexural strength were conducted to investigate the properties of lightweight crushed brick concrete reinforced by palm fiber. The specimen incorporated different volume fractions of palm fiber, i.e., 0, 0.2, 0.4, 0.6, 0.8 and 1.0%. **Results:** Tests results showed that the use of this fiber slightly increases the density of lightweight concrete. The use of 0.8% of palm fiber increases the compressive strength and flexural strength by about 13.4 and 16.1% respectively. **Conclusion:** The results indicated that the use of palm fiber with lightweight crushed brick concrete enhances the mechanical properties of the concrete and the optimization of the palm fiber fractions is required to get the best performance.

Key words: Crushed brick, palm fiber, reinforcing material, lightweight concrete

INTRODUCTION

There has been a growing interest in utilizing natural fibers for making low cost construction materials in recent years. Knowledge of natural fiber use in cement composites, mechanisms of mechanical behavior, insulating behavior has increased substantially. Many Research papers indicated various advantages in the use of natural fibers in cement composites, among them the following: increased flexural strength, post-crack load bearing capacity, increased impact toughness and improved bending strength (Do and Lien, 1995). Natural fibers exhibit many advantageous properties as reinforcement for composites (Toledo *et al*., 2003; Bilba *et al*., 2003; Asasutjarit *et al*., 2007). By far the best advantage of using natural fibers is that they offer significant cost reduction and benefits associated with processing as compared to synthetic fibers. That's why they are currently getting a lot of attention for replacing synthetic fibers (Thielemans and Wool, 2004). At the present time, due to simultaneous awareness increase on environment and energy, increasing attention should be paid to natural fibers with a view to conserving energy and protecting the environment. The addition of natural fiber also reduces the thermal conductivity of the composite specimens and yielded a lightweight product (Khedari *et al*., 2003). Beside that, some investigations have already been carried out on various mechanical properties and physical performance of concrete materials using natural fibers from coconut husk, sisal, sugar cane begasse, bamboo, jute, wood, akwara, elephant grass, water-reed, plantain and musamba and cellulose fibers. These investigations have shown encouraging results. Despite the widespread interest, it is not easy to show examples in which the natural fiber reinforced concretes have been an automatic choice. A wide variety of natural fibers has been used for numerous trial applications but, whilst many of these show considerable promise, the use of natural fibers to reinforce cement pastes, mortar and concrete still remains to be a subject of further research and investigation (Aziz *et al*., 1981; Do and Lien, 1995).

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In this study, the idea is to use palm fiber with lightweight concrete mixes which are produced from the crushed brick aggregate and study the different percentages of this fiber on the mechanical properties of lightweight concrete.

MATERIALS AND METHODS

The cement used in mortar mixtures was ordinary Portland cement a product of (Tasek Corporation Berhad). The chemical composition of Ordinary Portland and is given in Table 1. The Superplasticizer (SP) (Conplast SP1000) was used at 1.5% to give the properties of desirable workability for all mixes. The fine aggregate used is natural sand, whose fineness modulus is 2.86 and the maximum size is less than 5 mm and fine lightweight crushed brick aggregate (FLWA). The coarse lightweight aggregate used is also from crushed brick with a maximum aggregate size of 20 mm. The palm fiber is produced by fiber-X(M) Sdn. Bhd and its characteristics shown in Table 2.

Mix proportions: Approximate concrete composition is given in Table 3. The mixture is designed according to the absolute volume method given by ACI (American Concrete Institute, 2003). At the beginning, the control mix (CF0) was prepared using the mix proportion 1: 1.5: 1: 1.95 /0.45 (Cement: Sand: FLWA/water-cement ratio) (Dawood and Ramli, 2008). The oil palm fiber of the volumetric fractions 0.2, 0.4, 0.6, 0.8 and 1.0% of the mixes were used in preparing mixes CF1, CF2, CF3, CF4 and CF5 respectively.

Table 1: Chemical composition of Portland cement

Constituent	Ordinary Portland cement by weight (%)
Lime (CaO)	64.64
Silica (SiO_2)	21.28
Alumina (Al_2O_3)	5.60
Iron Oxide (Fe_2O_3)	3.36
Magnesia (MgO)	2.06
Sulphur Trioxode (SO_3)	2.14
N_2O	0.05
Loss of ignition	0.64
Lime saturation factor	0.92

Table 2: Characteristics of palm fiber

Fiber properties	Quantity
Average fiber length (mm)	30.00
Average fiber width (microne)	21.13
Tensile strength (MPa)	21.20
Elongation at break (%)	0.04
Specific gravity	2.14
Water absorption (%), 24/48 h	0.60

Test methods: Three cube samples 100 mm were used for each mix to test the density and compressive strength after water curing condition until the age of test. The slump test for mixes was performed according to ASTM C143, C 567 (2009). The slump design for all mixes were 150±10 mm. The test of the fresh density was achieved directly after casting in cubes according to ASTM C143, C 567 (2009). The cube specimens were left in the molds for 24 h at 20°C. After demolding, the specimens were kept in water curing till the age of test. The test of saturated surface dry of specimens at the age of test was adopted and implemented according to BS 1881: Part 114 (1983). The test of compressive strength was achieved directly after the density test according to BS: Part 116 (1983) for each test age. Beside that, the prismatic steel molds (100×100×500 mm) were used for the flexural strength test according to BS 1881: Part 118 (1983).

RESULTS

Table 3 and 4 show the results of the fresh and hardened density for all mixes and from the results, it can be noticed that the inclusion of palm fiber in the crushed brick lightweight concrete mixes will slightly increase the Fresh and hardened density as shown in Fig. 1. The compressive strength results also listed in Table 4. The increase in compressive strength resulted from palm fiber inclusion was observed. The highest value of compressive strength was obtained by using 0.8% of palm fiber as shown in Fig. 2. The increase percentage for compressive strength was 13.4% compared with the control mix (CF0) as seen in Fig. 3. The relation between density and compressive strength is shown in Fig. 4. The flexural strength of the lightweight concrete mixes is shown in Table 4.

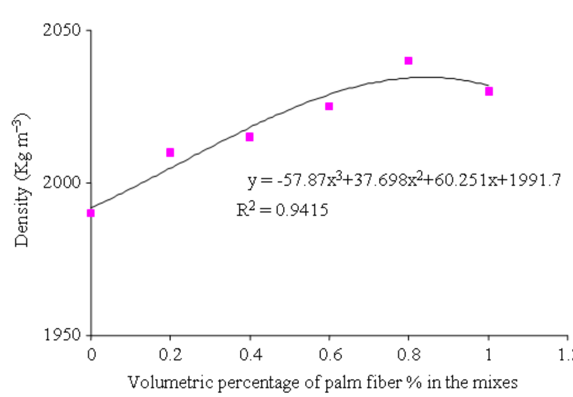

Fig. 1: Relation between fiber content and saturated surface dry density

Table 3: Crushed brick lightweight concrete mixes

Index	Cement (Kg m^{-3})	Water (Kg m^{-3})	SP (%)	W/C	OPF by cement volume (%)	Sand (Kg m^{-3})	FLWA (Kg m^{-3})	CLWA (Kg m^{-3})	Fresh density (Kg m^{-3})
CF0	360	160	1.5	0.45	0.0	540	360	700	1940
CF1	360	160	1.5	0.45	0.2	540	360	700	2000
CF2	360	160	1.5	0.45	0.4	540	360	700	2010
CF3	360	160	1.5	0.45	0.6	540	360	700	2000
CF4	360	160	1.5	0.45	0.8	540	360	700	2000
CF5	360	160	1.5	0.45	1.0	540	360	700	2020

Table 4: Mechanical properties of lightweight concrete mixes

Index	Density (Kg m^{-3}) 7 days	Density (Kg m^{-3}) 28 days	Compressive strength (MPa) 7 days	Compressive strength (MPa) 28 days	Flexural strength (MPa) 28 days
CF0	1960	1990	16.2	23.1	4.15
CF1	2000	2010	16.8	24.2	4.41
CF2	2000	2015	16.3	24.5	4.60
CF3	2020	2025	16.2	24.9	4.64
CF4	2030	2040	17.6	26.2	4.82
CF5	2020	2030	15.8	22.8	4.46

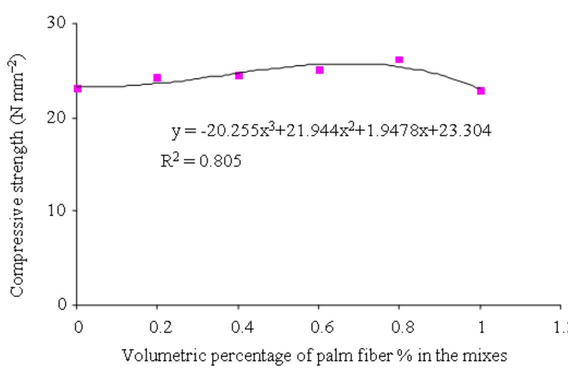

Fig. 2: Relation between fiber content and compressive strength 28 days

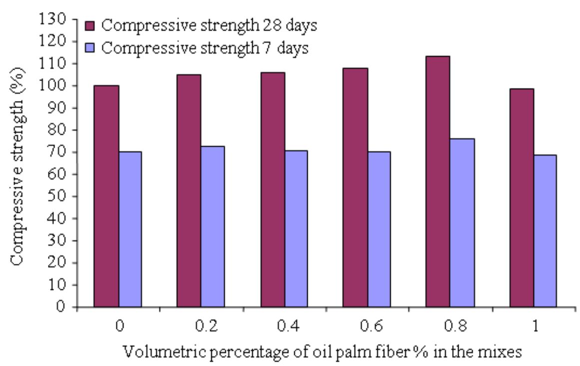

Fig. 3: Relation between fiber content and compressive strength percentage

The increase of the flexural strength is compatible with the compressive strength increase and again Fig. 5 illustrates that the increase of the flexural strength with the palm fiber continuing up to 0.8% volumetric

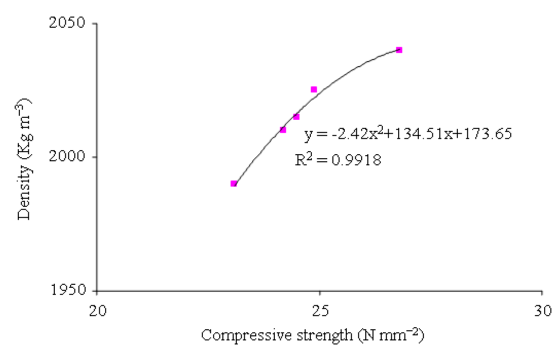

Fig. 4: Relation between and compressive strength and density at 28 days

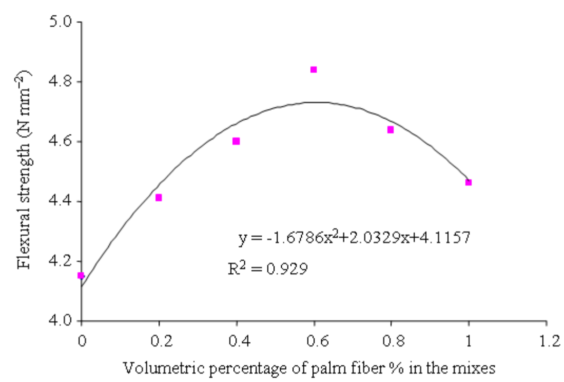

Fig. 5: Relation between fiber content and flexural strength at 28 days

fraction inclusion in the mix. The highest increase percentage increase was 16.1% compared with control mix as shown in Fig. 6. The relation between compressive strength and flexural strength is shown clearly in Fig. 7.

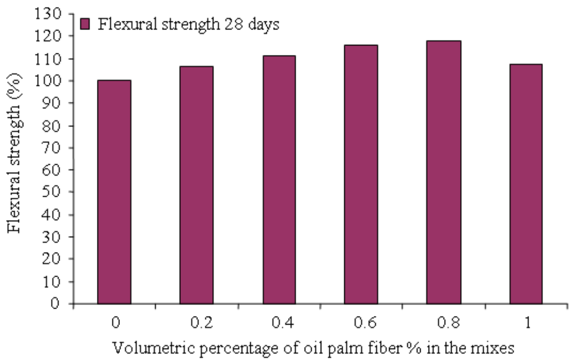

Fig. 6: Relation between fiber content and flexural strength percentage

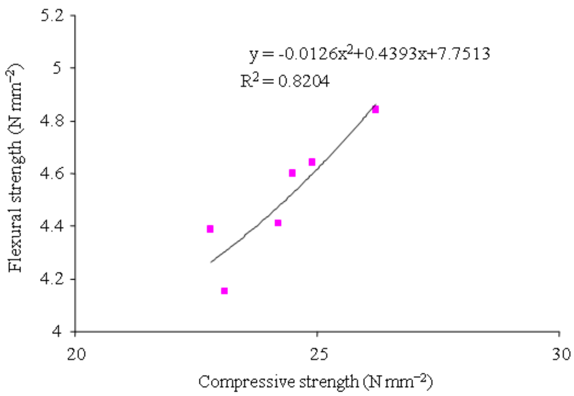

Fig. 7: Relation between compressive strength and flexural strength at 28 days

DISCUSSION

The most disadvantage of incorporating a fiber is the workability thus, leading to high volumes of entrapped air in concrete mixes (Felekoglu *et al*., 2007). The results of this study indicate that the use of palm fiber with the lightweight crushed brick concrete can improve the properties of this type of concrete. The results of density for lightweight crushed concrete as its shown well in Table 4 and Fig. 1, indicate that the inclusion of palm fiber leads to higher density. This can be attributed to the reduction of air in the mix when the optimum percent of palm fiber used in mix (Mohammadi *et al*., 2008). The compressive strength of palm fiber mixes show that the increase of the compressive & flexural strength due to the reduction of porosity in the lightweight concrete mixes continuing up to 0.8% of fiber as volumetric fraction of the mix. But using 1.0% of the fiber, the compressive strength reduces clearly and this can be attributed to the voids introduction in the mix due to excessive fiber content that may lead to reduce bonding and disintegration (Balaguru and Shah, 1992) as its shown well in Table 4 and Fig. 2-7.

CONCLUSION

- The density of the palm fiber lightweight concrete has increased slightly by the inclusion of palm fiber in the mix
- The use of 0.8% of volume fraction of palm fiber can be considered an optimal percentage for this type of concrete from the view of highest compressive strength and flexural strength
- The increase percentages of the compressive strength and flexural strength using the optimal volume fraction of fiber are 13.4 and 16.1% respectively

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REFERENCES

American Concrete Institute, 2003. ACI 213R-03: Guide for structural lightweight aggregate concrete. http://www.techstreet.com/cgi-bin/detail?doc_no=ACI%7C213R_03&product_id=1155427

Asasutjarit, C., J. Hirunlabh, J. Khedari, S. Charoenvai, B. Zeghmati and U.S. Shin, 2007. Development of coconut coir-based lightweight cement board. Const. Build. Mater., 21: 277-288. DOI: 10.1016/j.conbuildmat.2005.08.028

ASTM C143, C 567, 2009. Annual book of ASTM Standard. ASTM international, West Conshohocken, PA. http://www.library.umaine.edu/science/astm.htm

Aziz, M.A., P. Paramasivam and S.L. Lee, 1981. Prospects for natural fiber reinforced concrete in construction. International J. Cement Compsite Lightweight Concrete, 2: 123-132. DOI: 10.1016/0262-5075(81)90006-3

Balaguru, P.N. and S.P. Shah, 1992. Fiber Reinforced Cement Composites. McGraw-Hill Inc., New York, pp: 530.

Bilba, K., M.A. Arsene and A. Ouensanga, 2003. Sugar cane bagasse fiber reinforced cement composites. Part I influence of the botanical components of bagasse on the setting of bagasse. Cement Conc. Comp., 25: 91-96. DOI: 10.1016/S0958-9465(02)00003-3

BS 1881: Part 114, 1983. Testing Concrete. Methods for Determination of Density of Hardened Concrete. British Standard Institution, ISBN: 0580129489, pp: 8.

BS 1881: Part 116, 1983. Testing Concrete. Methods for Determination of Compressive Strength of Concrete Cubes. British Standard Institution, ISBN: 0580129500 pp: 8.

BS 1881: Part 118, 1983. Methods for Determination of Flexural Strength. British Standard Institution, p: 8.

Dawood, E.T. and M. Ramli, 2008. Development of high strength flowable mortar with hybrid fiber. Constr. Build. Mater. DOI: 10.1016/j.conbuildmat.2009.11.013

Do, L.H. and N.T. Lien, 1995. Natural fiber concrete products. J. Ferroce., 25: 17-24. http://cat.inist.fr/?aModele=afficheN&cpsidt=3546706

Felekoglu, B., S. Turkel and B. Baradan, 2007. Effect of water/cement ratio on the fresh and hardened properties of self-compacting concrete. Build. Environ., 42: 1795-1802.

Khedari, J., S. Charoenvai and J. Hirunlabh, 2003. New insulating particleboards from durian peel and coconut coir. Build. Environ., 38: 245-254. DOI: 10.1016/S0360-1323(02)00030-6

Mohammadi, Y., S.P. Singh and S.K. Kaushik, 2008. Properties of steel fibrous concrete containing mixed fibers in fresh and hardened state. Constr. Build. Mater., 22: 956-965. DOI: 10.1016/j.conbuildmat.2006.12.004

Thielemans, W. and R.P. Wool, 2004. Butyrated Kraft lignin as compatibilizing agent for natural fiber reinforced thermoset composites. Compos. Part A: Applied Sci. Manuf., 35: 327-338. DOI: 10.1016/j.compositesa.2003.09.011

Toledo, R.F., K. Ghavami, G.L. England and K. Scrivener, 2003. Development of vegetable fiber-mortar composite of fiber-mortar composites of improved durability. Cement Concrete Compos., 25: 185-196. DOI: 10.1016/S0958-9465(02)00018-5