JASEM ISSN 1119-8362

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://ww.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 22 (3) 421 –425, March 2018

Compressive Strength Characteristics of Carbon, Palm Kernel and Steel Fibre Reinforced Polyster+ Polymer Concrete

***RAHMON, RO; OZIGI, PB; BABATUNDE, OY; TAZOU, OL; OGUNKUNBI, GA**

Department of Civil Engineering, University of Ilorin, Ilorin, Nigeria
**Email: rorahmon2222@gmail.com, Tel: +2347061276187; philipozigi@gmail.com; babatundeyusuf990@gmail.com; oliviertazou@gmail.com; gaogunkunbi@gmail.com*

ABSTRACT: Particle-filled reinforced polymer composite (PC) is formed by combining mineral aggregates with a resin system. This study presents the compressive strength characteristics of carbon, palm kernel and steel fibre reinforced polymer concrete. The binder was locally produced by dissolving 600g of styrofoam in a litre of gasoline , it was then mixed with river sand at a binder aggregate ratio of 18% binder to 82% fine aggregates. The various fibres were added in the mix at 0%, 1% and 2% by weight of the binder. A total of 27 specimens of 100 x 100 x 100 mm cubes were cast, cured (air dried curing) and tested after 28 days. The results obtained show that the compressive stength of the fibre reinforced polymer concrete increases with fibre content up to 2% for all fibre types used except for palm kernel concrete and which decreases at 2% fibre content. Likewise the deflection decreases generally for all fibre type used except the case of palm kernel fibre.

DOI: https://dx.doi.org/10.4314/jasem.v22i3.23

Dates: Received: 20 January 2018; Revised: 15 March: 2018; Accepted: 25 March 2018

Keywords: Binder, Composite, Compressive strength, Polymer

Particle-filled reinforced polymer composite (PC) is formed by combining mineral aggregates with a resin system. Due to rapid setting and high strength properties, polymer composites are being used in a variety of construction, rehabilitation and repair applications such as bridges, pipelines and other types of constructions (Fowler, 1983; Barnaby and Dikeou, 1984; Fowler and De Puy, 1986; Vipulanandan and Dharmararjan, 1987; Guerrini, 2000). In order to produce economic and high strength particle-filled polymer composite systems, an optimum amount of polymer is used in the composite formulation. Repair and retrofit of structures will be an increasingly important issue as infrastructure continues to age and deteriorate. More options are becoming available for those structures for which it is more economical to retrofit than to demolish. Fibre reinforced polymer (FRP) composite materials have come to the forefront as promising materials and systems for structural retrofit.

American Concrete Institute (ACI) Committee 544 (2002), categorized fibre Reinforced Concrete into four which are SFRC (Steel Fibre Reinforced Concrete), GFRC (Glass Fibre Reinforced concrete), SNFRC (Synthetic Fibre Reinforced Concrete) and NFRC (Natural Fibre Reinforced Concrete) (ACI, 2002). Fibres have been used as reinforcement since ancient times (Abolarin *et al.*, 2017). History has it that horsehair was used in mortar and straw in mud-bricks. In the 1900s, asbestos fibres have been used in concrete. Similarly, in the 1950s, the concept of composite materials came into being and fibre-reinforced concrete was one of the topics of interest. Once the health risks associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. In the 1960s, steel, glass, and synthetic fibres such as polypropylene fibres were used in concrete. Polymer concrete has a lot of advantages over the Portland cement concrete, some of which includes higher strength characteristics, lighter density and a shorter curing period (Martinez *et al.*, 2011).

Nowadays, Fibre Reinforced Polymer (FRP) has been proposed as one of the key material of reinforced concrete. The advantages of using FRP in reinforced concrete depends on some factors like shape, length, cross section, fibre content and bond characteristics of FRP (Onal, 2009). Nigeria is endowed with a lot of mineral and agro-based resources including Palm oil from Palm Kernels that could be used in the development of environmental- friendly composite materials such as Eco-pad used in modern vehicle braking systems. Raji *et al.* (2016) investigated on the methods of making a resin out of polystyrene to

*Corresponding athour *Email: rorahmon2222@gmail.com, Tel: +2347061276187*

be used in the construction industry as a binder for aggregates. It was reported that polyster resin content should be between 10-25% by weight of aggregate. It is important to note that, the durability of the polymer concrete needs to be addressed as reported by Parveen *et al.* (2012). The aim of this study is to evaluate the compressive strength of carbon, palm kernel and steel fibre polyster reinforced polymer concrete.

MATERIALS AND METHOD

Materials: The materials used in this research work are as follows: steel fibre, carbon fibre, palm kernel fibre, polyser+, river sand. The carbon fibre used in this research was a ready-made carbon fibre that is factory made carbon fibre. The carbon fibre was found to be in various diameters, varying from 8mm to 20 mm and of various lengths. The carbon fibres used in this study as shown in Figure 1 were gotten from Ibrahim Taiwo Road, Ilorin, Kwara State. However, palm kernel shell fibre used in this research as shown in Figure 2 was obtained naturally from Alausa village in Odo Oba, Ogo Oluwa Local Government area of Oyo State, Nigeria. Straight, smooth, drawn wire Steel fibres 1mm diameter, 50 mm length and a span to depth ratio (l/d) of 50 as shown in Figure 3 were gotten from a building materials merchant at Tanke, Ilorin, Kwara State. The resin (Polyster+) consists of a mixture of Styrofoam (the polyster+ used) and gasoline which act as a binder for the polymer concrete.

The mix ratio employed was, dissolving of 600g of Styrofoam in 1 litre of petrol (this was arrived at through trial mixes) and the mixture was properly stirred. This gave a sticky but viscous liquid which has the adhesive property to bind the materials together. Fine aggregate (sand passing 4mm I.S sieve) and batching of the materials used in producing polymer concrete was done by weight. The properties of the fine aggregates used are presented in Table 1.

Table 1: Property of sand

S/N	Property	Value
1	Sieve analysis	Zone II
2	Specific gravity	2.6

The mass of the binder and fine aggregate was 18% and 82% respectively with the addition of the steel, carbon and palm kernel fibres at (0%, 1% and 2% by weight of binder). The constituents were mixed properly by hand and the mixes were filled into the moulds, the moulds were initially polished with grease to ease the removal of the specimen. Finally, after the mixture had been filled into the moulds, it was left at room temperature for 24 hours to be fully cured and hardened. In the experimental investigation, four concrete cubes of size 100 x 100 x 100 mm were cast for compressive strength. All the specimens were tested after a curing period of 28 days. Figures 1-3 show the carbon, palm kernel and steel fibres used for the experiments while Figure 4 and 5 show the specimens under compressive strength test in the Testometric Universal Testing Machine.

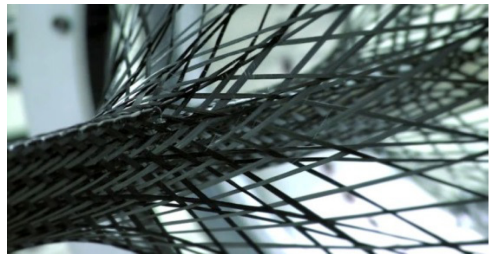

Fig 1: Carbon fibre

Fig 2: Palm kernel fibres

Fig 3: Steel fibres

Fig 4: Carbon, steel and palm kernel fibre reinforced polymer concrete

Fig 5: Compressive strength test using the Testometric machine

RESULTS AND DISCUSSION

Compressive strength of carbon fibre reinforced polymer concrete was tested at the age of 28 days as shown in Table 2. It was observed that the compressive strength of concrete was 1.464 N/mm^2 for the control and 2.966 N/mm^2, 3.328 N/mm^2 for the replacement of 1% and 2% carbon fibres respectively. During the crushing of cubes, a graph of Force (N) against the deflection was plotted as shown in Figure 6 and it was observed that the deflection decreased with an increase in carbon fibre content, as presented in Figure 7. The deflection results are 12.905. 10.782, and 5.843 mm for 0%, 1% and 2% of carbon fibre content, respectively.

Table 2: Compressive Strength data at the age of 28 day for Carbon Fibre

Test No	Percentage of Fibre (%)	Force at Peak (N)	Compressive Stress at Peak (N/mm^2)	Deflection at Peak (mm)
1	0	14643	1.464	12.905
2	1	29656	2.966	10.782
3	2	33276	3.328	5.843

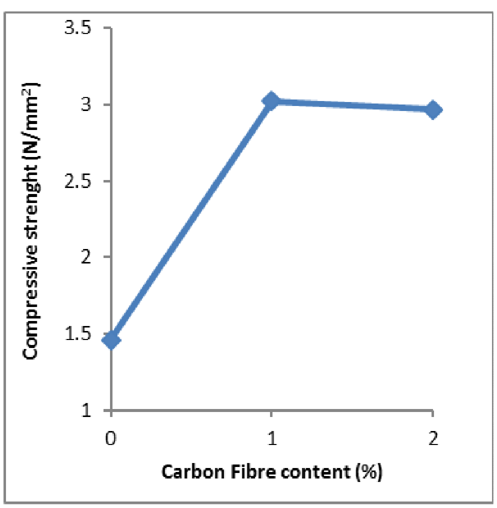

Fig 6: Compressive Strength (N/mm^2) against Carbon fibre content (%)

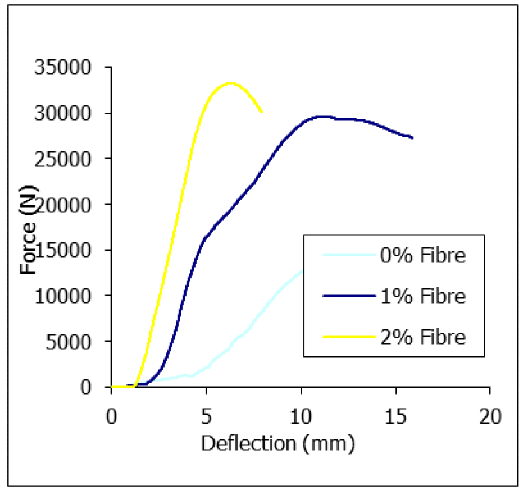

Fig 7: Load vs Deflection Curve for carbon fibre

The compressive strength of palm kernel fibre reinforced polymer concrete was tested at the age of 28 days as shown in Table 3. It was observed that the compressive strength of concrete was 1.464 N/mm^2 for the control and 3.021 N/mm^2, 2.966 N/mm^2 for the replacement of 1% and 2% carbon fibres respectively. During the crushing of cubes, a graph of Force (N) against the deflection was plotted as shown in Figure 8, and the deflection was seen to be decreasing with increase in the palm kernel fibre content as presented in Figure 9, that is, 12.905 mm, 6.191 mm, and 10.782 mm for 0%, 1% and 2% of carbon fibre content, respectively.

Table 3: Compressive Strength data for Palm Kernel Fibre Reinforced Concrete

Test No	Percentage of Fibre (%)	Force at Peak (N)	Compressive Stress at Peak (N/mm^2)	Deflection at Peak (mm)
1	0	14643	1.464	12.905
2	1	30208	3.021	6.191
3	2	29656	2.966	10.782

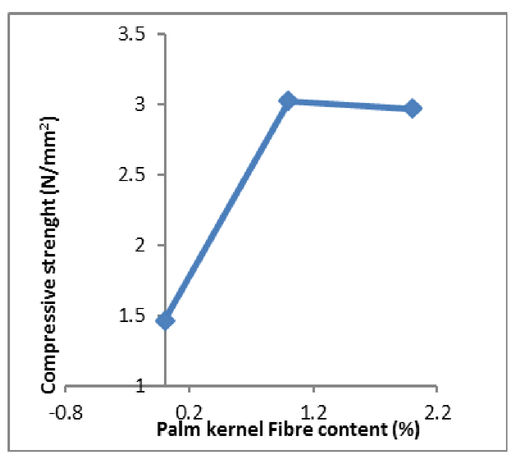

Fig 8: Compressive Strength (MPa) against Palm kernel fibre content (%)

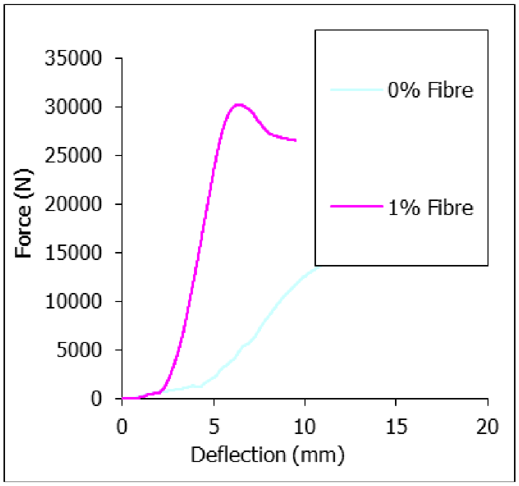

Fig 9: Load - Deflection curve for palm kernel fibre

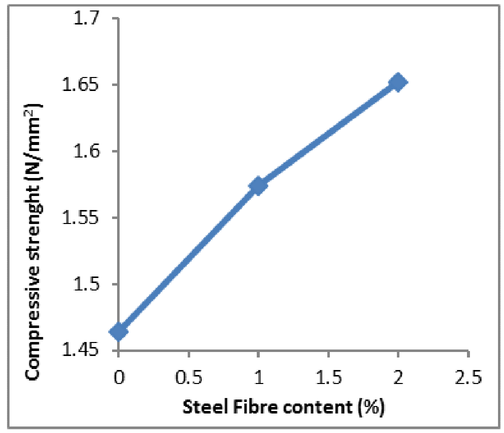

Fig 10: Influence of steel fibre content on compressive strength

The compressive strength of steel fibre reinforced polymer concrete was tested at the age of 28 days as shown in Table 3. It was observed that the compressive strength of concrete was 1.464 N/mm^2 for the control and 1.574 N/mm^2, 1.652 N/mm^2 for the replacement of 1% and 2% carbon fibres respectively. During the crushing of cubes, a graph of Force (N) against the deflection was plotted as shown in Figure 10, and the deflection was observed to decreased with an increase in the steel fibre content, as presented in Figure 11 i.e; 12.905 mm, 11.744 mm, and 9.083 mm for 0%, 1% and 2% of carbon fibre content respectively.

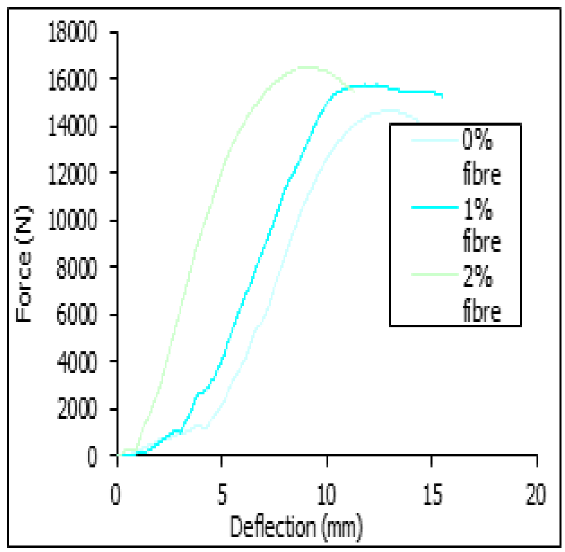

Fig 11: Load-deflection curve for steel fibre

Table 4: Compressive Strength data of 28 days for Steel Fibre

Test No	Percentage of Fibre (%)	Force at Peak (N)	Compressive Stress at Peak (N/mm^2)	Deflection at Peak (mm)
1	0	14643	1.464	12.905
2	1	15742	1.574	11.744
3	2	16522	1.652	9.083

The compressive strength has an increasing trend up to 2%. Strength decreased with the increase in palm kernel fibre content. Palm kernel, carbon and steel fibre polymer concrete with 2% fibre content has higher compressive strength as compared to that of Plain Polymer Concrete. The graphs of compressive strength against fibre content and Force against the deflection was plotted as shown in the Figures for all the various fibre type, and the deflection was seen to be decreasing with increase in the fibre content for all the fibres type except for palm kernel fibre at 2% fibre content.

Conclusion: Reinforced polymer concrete has an optimum compressive strength at 2% fibre content for carbon and steel fibre whereas the strength decreases at 2% fibre content for palm kernel. The deflection decreases with fibre content for all the fibres used except for palm kernel fibre where it increases at 2% fibre content. Further experimental studies can be done to investigate the effects of increasing these fibres content beyond 2% and also adjusting the mix ratio of say 10% binder and 90% fine aggregates. Therefore, reinforced polymer concrete can be used as light weight concrete.

REFERENCES

Abolarin, JS; Rahmon, RO; Ogunkunbi, GA; Olaleye, KJ (2017). Performance of a Coconut Fibre Reinforced Polyester Polymer Concrete. *USEP: J. Res. Info. Civil Engineer*. 14(2): 1465-1477.

American Concrete Institute (ACI) (2002). State-of-the-Art Report on Fiber Reinforced Concrete. Reported by ACI Committee 544.

Barnaby, D; Dikeou, JT (1984). Applications of permanent precast polymer concrete forms for concrete rehabilitation. *Transportation Research Record No. 1003*, Trans. Res. Board.

Fowler, DW (1983). Polymers in Concrete. In Handbook of Structural Concrete. New York: McGraw-Hill Book Co.

Fowler, DW; De Puy, DW (1986). Guide for the use of polymers in concrete. ACI Committee 548, J. ACI 83.

Guerrini, GL (2000). Applications of High-performance Fibre-reinforced Cement-based Composites. *Applied Composite Materials*. 7(2-3): 195 - 207.

Martinez, B; Virgueras, S; Gencel, O; Hagg-Lobland, H (2011). Polymer Concretes: A Description and Methods for Modification and Improvement. *Journal of Materials Education*. 33(2): 37 -57.

Onal, MM (2009). Reinforcement of beams by using carbon fibre reinforced polymer in concrete buildings. *Scientific Research and Essay*. 4(10): 1136 – 1145.

Parveen, S; Rana, S; Fangueiro, R (2012). Natural Fiber Composites for Structural Applications. *Mechanics of Nano. Micro and Macro Composite Structures*. Politecnico di Torino, 18 – 20 June, 2012. 1 – 2.

Raji, SA; Abolarin, JS; Osunkunle, AB; Opolana, MO (2016). Investigation on the Strength Characteristics of Polymer Concrete. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*. 3(12): 6222 - 6225.

Vipulanandan, C; Dharmarajan, N (1987). Flexural behaviour of polyester polymer concrete. *Cement and Concrete Resources*. 17(2): 219 – 230.