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Structural Behaviour of Fibre Reinforced Concrete Using PET Bottles

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ABSTRACT

This research work reports the experimental study of Fibre Reinforced Concrete (FRC) using recycled PET bottle as the fibre. The PET fibre was added at 0.5%, 1.0%, 1.5%, 2.0%, 2.5% and 3.0% volume of the total aggregates. The workability tests and compressive strength tests were carried out and results of workability show that the volume fraction of fibre between 0.5% and 1.5% are workable with 0.6 water-cement ratio while that between 2.0 and 3.0 were not workable. Also too, the compressive strength for the volume fraction of fibre of 0.5% and 1.0% improve more than the control while those above 1.0% have a reduced strength compared with the control. It is recommended that PET bottle fibre up to 1.0% can be used for structural works particularly ground floors

Keywords: *Fibre Reinforced Concrete, PET bottle, Concrete, Workability, Compressive strength*

1. INTRODUCTION

Concrete is the most frequently use material in the construction world. However, it has low tensile strength, low ductility and low energy absorption which are caused by low toughness and the presence of defects. A way of improving the toughness and reducing the shrinkage due to defects is the introduction of small fraction (usually 0.5% - 3%) of short fibre to the concrete matrix during mixing. The introduction of the fibre in concrete has been seen to bridge the crack gaps and improve the tensile properties of concrete over plain concrete [1, 2, 3, 4]

The development of fibre reinforced concrete started with earlier works by Norman de Bryne [5] in the United Kingdom. It was of great interest to the aviation industry. Keyvani and Saeki [6] found in a series of tests that steel fibre resulted in 94% increase in flexural strength, 113% increase in tensile strength, 62% increase in splitting tensile strength and 80% increase in the flexural toughness index compared to the control. Voldran [7], investigated the potential use of nylon fibre to reduce plastic shrinkage in concrete and found that the properties of the concrete (flexural, compressive and splitting tensile strengths) were not affected significantly by the inclusion of 0.6kg/m^3. In a laboratory experiment conducted by Auchey and Dutta [8], using recycle High Density Polyethylene (HDPE) as fibre adding them at 0.1, 0.2 and 0.4% by volume of concrete in an extremely freezing thaw. It was discovered that HDPE fibre reinforced specimens provided an equal or a higher resistance than the control specimen.

Teng et al [9] presented a finite element study for interfacial stresses in reinforced concrete beams strengthened with a bonded soffit plate. They validated the results with the prediction of the approximate analytical solution by Smith and Teng [10]. Also too, Chen and Teng [11] developed a simple, accurate and rational design model for the shear capacity of FRP strengthened beams which fail mainly by FRP debonding which was validated against experimental data from existing research works. The model explicitly recognizes the non-uniform stress distribution in FRP along the shear crack as determined by the bond strength between FRP strips and concrete.

Huang et al [12] presented an experimental study on strengthening reinforced concrete beams using pre-stressed glass fibre reinforced polymer (PGFRP). The ultimate loads and deflections of the strengthened beams using GFRP and PGFRP sheets were tested and compared. The results shows that the beams strengthened with PGFRP sheets can withstand larger ultimate loads than the ones strengthened with GFRP. Likewise the deflection is smaller in PGFRP reinforced concrete.

In his parametric studies on the influence of FRP wrapping techniques, with carbon fibre reinforced plastic sheets, on the compressive behaviour of concrete prisms involving local reinforcement at the corners, continuous layers, horizontal and vertical continuous strips, Ginseppe [13] found that a good agreement with analytical model prepared to determine the maximum bearing capacity of compressed concrete members.

Xiong et al [14] tried to device a way of preventing tension delamination of concrete cover at mid-span of FRP strengthened beams by combining CFRP and GFRP polymer sheets on the tension face of the beam continuously by using unidirectional carbon fibre reinforced polymer sheets on the tension face of the beams and bi-directional GFRP sheets wrapped on 3 sides of the beam continuously. They concluded that the hybrid CFRP-GFRP system could not only prevent the tension delamination of the bottom concrete cover, but also lead to a significant increase of deformation capacity of the strengthened beams.

2. METHODOLOGY [EXPERIMENT]

This study is an experimental work. It was aimed at studying the impact of using PET bottle as a fibre in a concrete matrix. Apart from this, the used PET bottles are

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causing nuisance to the environment. The PET bottles were collected from open sources, thoroughly cleaned and extruded, cut into strips with average nominal length of 60-90mm with average width of 1.5mm and thickness of 0.6mm with aspect ratio ranging from 40 to 60. Sieve analysis of the coarse and fine aggregate was carried out to ascertain the particle size distribution.

The method used for mixing the concrete was weight batching method. The quantity of materials required were calculated using mix ratio [1:2:4]. Having obtained various mix portions with the addition of PET fibres in the volume ratio of 0.5%, 1%, 1.5%, 2%, 2.5% and 3%, a water cement ratio of 0.6 was then added. The workability was determined by the slump [vertical cone] and compacting factor tests which were carried out according to BS 1881. The essence is to determine how workable the concrete is. The mixed concrete was then placed in the 150mm cube mould and compacted.

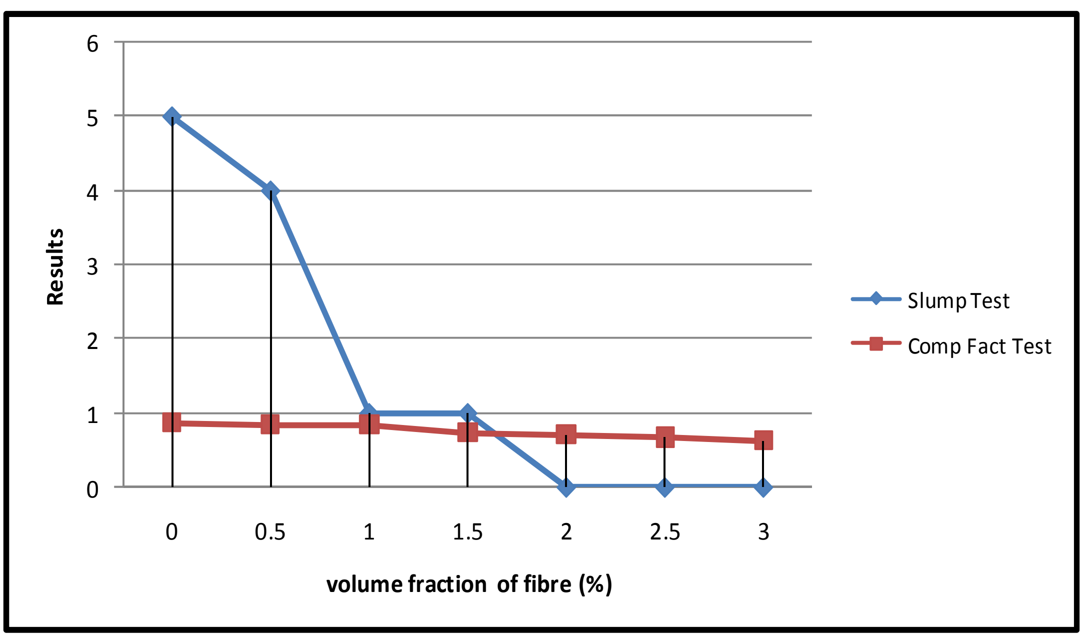
The cube samples were de-moulded after 24hours and cured in the curing tank for a period of 7, 14 and 28 days. At the end of each period, the samples were tested for deflection using the compression testing machine.

3. RESULTS

The workability tests and corresponding water-cement ratio for each mix is shown below:

Table 1: Workability tests

Mix proportion	Volume fraction of fibre (%)	w/c ratio	Workability tests	Results
1:2:4	0% (Control)	0.6	Slump test	5mm
			Compacting Factor test	0.86
1:2:4	0.5	0.6	Slump test	4mm
			Compacting Factor test	0.83
1:2:4	1.0	0.6	Slump test	1mm
			Compacting Factor test	0.83
1:2:4	1.5	0.6	Slump test	1mm
			Compacting Factor test	0.72
1:2:4	2.0	0.6	Slump test	0mm
			Compacting Factor test	0.69
1:2:4	2.5	0.6	Slump test	0mm
			Compacting Factor test	0.66
1:2:4	3.0	0.6	Slump test	0mm
			Compacting Factor test	0.62



Graph 1: Workability Tests

From the workability test table in Table 1, it shows that as the percentage of fibre increases, the slump and compacting factor tests values decreases which made the concrete workability to reduce.

Compressive strength after 7, 14 and 28 days are given below:

Table 2: Compressive Strength after 7, 14 and 28 days

Volume fraction of fibre (%)	Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
0	16.91	18.67	21.75
0.5	21.83	24.91	18.50
1.0	14.92	14.00	23.42
1.5	11.67	16.50	19.92
2.0	6.08	9.50	12.83
2.5	3.33	6.83	8.42
3.0	7.92	6.17	7.16

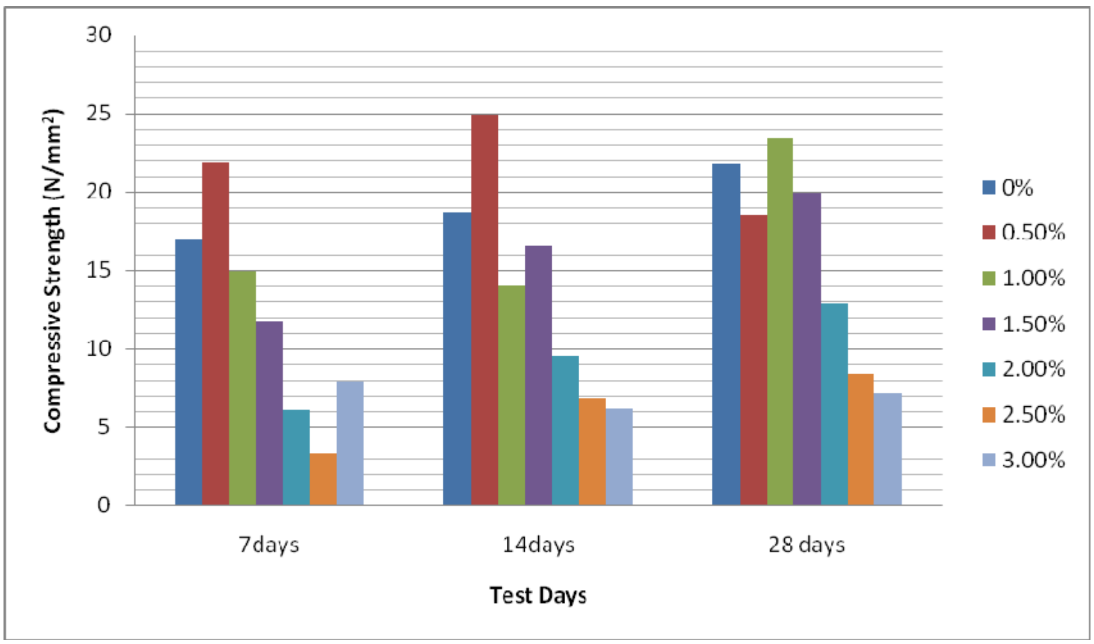


Fig 1: Compressive Strength at 7, 14 and 28 days

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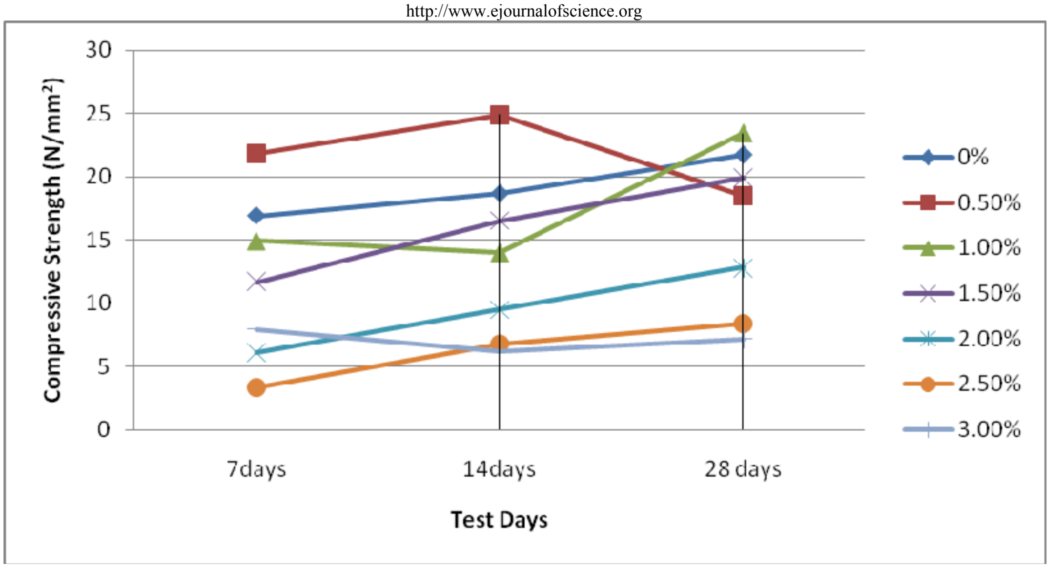

Graph 2: Compressive Strength at 7, 14 and 28 days

As noticed, the control and up to 1% volume fraction of fibre provided the same flexural properties and have about the same strength across 7, 14 and 28 days, while volume fraction from 1.5% and above have a drastic reduction in strength from the control

4. CONCLUSION AND RECOMMENDATION

The workability reduced as the amount PET fibre increased thus the addition of PET fibre will requires more water to improve the workability. However addition of more than 1.0 % PET fibre did not lead to any improved properties. This research clearly shows that increases in the volume fraction of fibre to the concrete matrix will lead to an increase in the amount of water required for a workable concrete.

The 0.5% and 1.0% volume fraction of fibre were able to attain comparable strengths as that of the control mix. Hence the addition of 1.0% PET fibre by volume produces a higher compressive strength and thus is recommended for attaining concrete with improved properties as ordinary concrete. It can also serve as a crack resistance both in floor and walls. With good quality control mechanism, the 1.5% can be used where low strength concrete is required particularly in lintels while the remaining can be used for non-load bearing component of structures. The use of PET bottles can reduce the environmental pollution and conserve our natural resources.

REFERENCES

[1] Sheikh S.A (1982): A comparative Study of Confinement Models. ACI

[2] Keer J. (1984): Fibre Reinforced Concrete in Concrete Technology and Design. Vol 2: New Reinforced Concrete, Ed. Swamy RN, Surry University Press, London

[3] Wang Y., Backer S., and Li V.C. (1987): An Experimental Study of Synthetic Fibre Reinforced Cementitious Composite. Journal of Materials Science 22(12) pp 4281-4291

[4] Bautur A, and Mindess S. (1990): Fibre Reinforced Cementitious Composites. Elsevier Applied Science. Essex. England

[5] Norman de Bryne (1930): The Temperature Dependence of Field Currents. Phys Rev. 35(177)

[6] Keyvani S.A and Saeki N (1997): “Effect of Galvanized Steel Fibres in Corrosion-Protection of Reinforced Concrete”, Transactions of the Japan Concrete Institute, 19, pp. 113-120

[7] Vondran Gary L. (1989): “Plastic Fibre Reinforced Concrete”. Dept of Civil and Environmental Engineering, Michigan State University, East Lansing, Mich.

[8] Auchey F.L and Dutta P.K (1996): The Use of Recycled High Density Polyethylene Fibres as Secondary Reinforcement in Concrete Subjected to Severe Environment. Proceedings of the 6th International Offshore and Polar Engineering Conference. Los Angeles. pp 287-291

[9] Teng J.G, Chen J.F, Smith S.T, and Lam L (2002): FRP Strengthened RC Structures. UK. John Wiley & Sons

[10] Smith S.T and Teng J.G (2002): FRP-Strengthened RC Structures –I: Review of Rebonding Strength Models. Engineering Structures. 24(4), pp 385-395

[11] Chen J.F and Teng J.G (2003): "Shear Capacity of FRP Strengthened RC Beams: FRP Debonding". Journal of Structural Engineering, ASCE 129(5) pp 784-791

[12] Huang Yue-lin, Hung Chien-hsing, Yen Tsong, Wu Jong-hwei and Lin Yiching (2005): Strengthening RC Beams using Prestressed Glass Fibre Reinforced Polymer-Part I: Experimental Study. Journal of Zhejiang University Science. 6A(3): pp 166-174

[13] Ginseppe Campione (2006): Influence of FRP Wrapping Techniques on the Compressive Behaviour of Concrete Prisms. Journal of Cement and Concrete Composites 28(5) pp 497-505

[14] Xiong G.J, Jiang X, Liu J.W and Chen L (2007): A Way for Preventing Tension Delamination of Concrete Cover in Midspan of FRP Strengthened Beams. Construction and Building Materials Vol 21 (2) pp 402 - 408