International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

Study On Strength Properties Hybrid Fibre Reinforced Concrete

K. RAJKUMAR
PG Student, Department of Civil Engineering,
PRIST University, Thanjavur, Tamil Nadu, India.

***Abstract*— An enormous increase in construction activities has resulted in a large scale consumption of basic materials for making concrete. Performance of conventional concrete (CC) is enhanced by the addition of fibre to it. The brittleness of concrete is reduced and its ductility is adequately improved by the addition of fibre to it. In this thesis concrete cubes, cylinders and prisms were cast using M30 grade concrete designated as per relevant Indian standard. The steel, polypropylene (PP) and hybrid polypropylene (PP) and steel (crimped) fibres were used individually in various proportions, i.e., 4% of steel fibre, 4% of polypropylene (PP) fibre and 4% of combined hybrid polypropylene (PP) and steel (crimped) fibres by weight of cement in the preparation of concrete mixes.**

I. INTRODUCTION

In modern years Fibre reinforced concrete is a cement based composite material has been developed. It has been successfully used in construction with its outstanding flexural tensile strength, resistance to splitting, impact resistance and outstanding permeability and frost resistance. It is a successful way to raise toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Fibre is added as a reinforcing material possessing certain characteristic properties. They can be circular, triangular or flat in cross-section. The fibre is often described by a convenient parameters called - aspect ratio. The aspect ratio of the fibre is the ratio of its length to its diameter. The main reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. For FRC to be a possible construction material, it must be able to compete economically with existing reinforcing system.

Fibre reinforced concrete is a cementitious concrete composite reinforced with fibre by adding discrete short fibres randomly in concrete. It exhibits several sustainable and improved engineering properties such as compressive strength, tensile strength, flexural strength, etc. The fibres are able to prevent surface cracking through bridging action leading to better impact resistance of the concrete. The combination of two or more different types of fibres is becoming more common nowadays with the objective of optimizing the overall behavior of the system. The aim is that the performance of these hybrid systems would exceed that induced by fibre of each type alone.

Hybrid is based on the fibre constitutive response, in which one fibre is stronger and stiffer and provides strength, while the other is more ductile and provides toughness at high strains (Banthia and Nandakumar 2003). Hybrids are based on fibre size, where one fibre is very small and it provides micro crack control at early stages of loading and the other fibre is larger, provides a bridging mechanism across macro cracks. Hybrids are also based on the function of fibre, where one type of fibre provides strength or toughness in the hardened composite, while the second type provides fresh mix properties suitable for processing. The benefits of FRC in various Civil Engineering applications are immeasurable. Hence, this study explores the viability of hybrid fibre reinforcement; the aim here is to conduct parametric study on compressive strength, flexural strength, tensile strength, etc., with a given grade of concrete proportions and percentage of steel. The characteristics of the fibres are categorized into four categories, namely, the geometrical, mechanical, physical and chemical properties and material types. For the practical execution of fibres in FRC applications, properties which are given significant considerations in their selection are material type, tensile strength, elastic modulus and the aspect ratio (the ratio of fibre length to the diameter or equivalent diameter). The PP fibres are actually man-made synthetic fibres resulting from research and development in the petrochemical and textile industries. These fibres are derived from organic polymers which are available in a variety of formulations. The FRC, is a composite material made of hydraulic cement, water, fine and coarse aggregates, and a dispersion of discontinuous fibres.

Yusof et al. (2011) have described the mechanical properties of fresh and hardened state hybrid steel FRC with different aspect ratios and volume fractions. Twenty one mixes including one control mix without fibre were prepared and tested in the laboratory. The properties of the fresh concrete mixes were assessed by workability tests. Meanwhile, the properties of the hardened concrete were investigated using compression tests, split tensile tests and flexural strength tests. The results indicated that the hybrid steel FRC at volume fraction of 1.5%, consisting of 70% long fibres and 30% short fibres gave the highest value of flexural strength and split tensile strength. On the contrary, the concrete mix containing 30% long fibres and 70% short fibres at 1.5% volume fraction gave the highest compressive strength. It was also observed

that by rising the percentage volume of fibre in the mix, the workability of the concrete mix got decreased.

An experimental programme was carried out by Yusof et al. (2011) to investigate the effect of combining hooked end steel fibre with different volume fractions of steel fibres to characterize its properties, especially the mechanical properties in the fresh and hardened state. The main conclusions that were drawn were as follows: The increase in the percentage of volume of fibre in the mix reduced the workability. The concrete mix with 2% fibres showed that it was stiff and difficult to compact. In addition to this, concrete with shorter fibres had better workability as compared to concrete with longer fibres. Fibre combination of 70% long fibre and 30% short hooked end steel fibre at 1.5% volume fraction gave the most appropriate combination as regards to the highest in the flexural and split tensile strength. While the concrete mix containing of 70% short fibre and 30% long fibre at 1.5% volume fraction gave the highest compressive strength. The results revealed that longer fibre performed better in flexural and tensile strength. On the other hand, concrete with short steel fibre performed better in compression as compared to concrete with longer steel fibre.

The paper suggested that the performance of conventional concrete is improved with the addition of fibres in concrete. The brittleness in concrete is decreased and the adequate ductility of concrete is ensured by the addition of fibres in concrete. In the paper by Ramadevi and Venketesh babu (2012), the performance of RC beams strengthened using HFRC was analysed. The concrete beams were cast for a grade of M25 concrete designed as per the department of Bureau of Indian standards guidelines for mix design 10262: 2009. The fibres used were polyolefin and steel (crimped) in various volume fractions. The major reasons for adding steel fibres to concrete matrix was to improve the post - cracking reaction of the concrete. It has increased its energy absorption capacity and noticeable ductility, and to has provided crack resistance and crack control. The base polyolefin was extremely resistant to the majority of aggressive agents and would never oxidize when exposed to the conditions which caused steel to rust. The hybrid fibres of various proportions from 0.5%, 1%, 1.5% and 2% of volume of concrete were used in the concrete mixes. The workability of HFRC mix was increased by addition of super plasticizer Conplast SP 337. Totally five beams were cast and tested including control beam specimen. The test results showed that use of HFRC improved the flexural performance of the beams during loading. Based on the experimental results, the following conclusions were drawn for HFRC beams which were subjected to flexural loading.

II. MATERIALS AND EXPERIMENTATION

Cement: In this experimental work, ordinary Portland cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used.

Sand: Locally available river sand zone II with specific gravity 2.58, water absorption 1% and conforming to I.S. – 383-1970.

Coarse aggregate: Crushed granite stones of 20 mm down size, having a specific gravity of 2.61 conforming to IS 383-1970

Steel fibre - Crimped steel fibres have equivalent diameters of 0.15 mm to 2 mm and length from 7 mm to 75 mm. Aspect ratio, generally, ranges from 20 to 100. Aspect ratio is defined as the ratio between fibre length and its equivalent diameter, which is the diameter of a circle with an area equal to the cross section area of the fibre. Steel fibres have high tensile strength ranging from 0.5 - 2.0 GPa with modulus of elasticity of 200 GPa.

Polypropylene fibre - It is Endura-600 Macro synthetic Polypropylene fibre. These fibres are tough but with low tensile strength and modulus of elasticity. They have plastic stress-strain characteristics. Furthermore, their ability to cause interference with the capillary forces by which water bleeds to the surface of concrete reduces the risk of plastic settlement due to water evaporation. A blend of steel and polypropylene fibres can combine structural elements with plastic cracking in fresh concrete and drying shrinkage cracking in hardened concrete. This also improves post-cracking toughness.

Water: Potable water was used for the experiment.

III. EXPERIMENTAL RESULTS

Compressive strength

The comparison of the 7, 14, 21, and 28 days cube strength results shows that,

1. Cubes of SFRC (Steel Fibre Reinforced Concrete) for 7 days show 41% increase in compressive strength with 14th and 21st days equal strengths and at 28 days 14% increase when compared to conventional concrete of M30 grade. 2. Compressive strength of PPFRC (Polypropylene Fibre Reinforced Concrete) at 7, 14, 21, and 28 days show an increase in percentages of 11, 10, 18 and 11, respectively when compared to conventional concrete for M30 grade. 3. Hybrid Polypropylene and steel (crimped) fibres 7, 14, 21, and 28 days compressive strength results show a decrease in compressive strength for percentage of 22, 10, 3, and 9, respectively, when compared to conventional concrete for M30 grade of concrete.

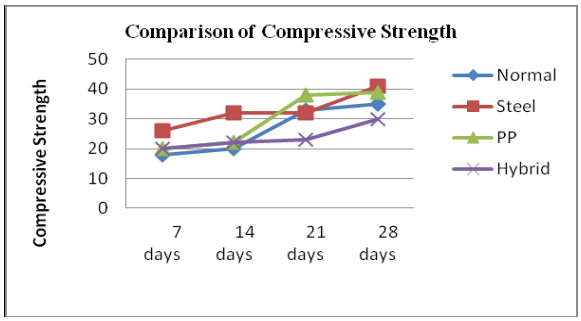

Fig. 1: Comparisons of compressive strength

Split Tensile strength

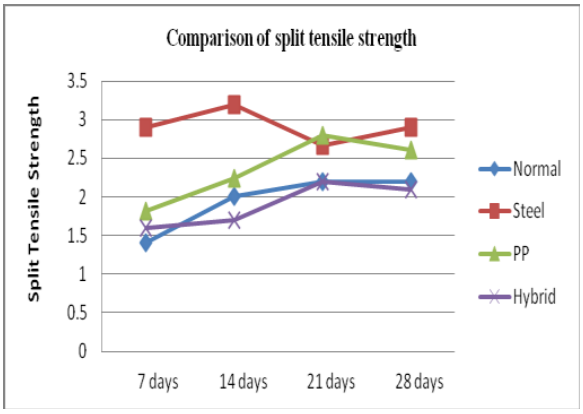

Fig. 2: Comparison of split tensile strength

The comparison of the 7, 14, 21, and 28 days split tensile strength of cylinders in the case of SFRC show an increase of 100%, 60%, 21% and 45%, respectively, when compared to conventional concrete for M30 grade of concrete. In the case of PPFRC split tensile strength results show an increase of 21, 10, 27 and 25 per cents at 7, 14, 21, and 28 days, respectively, when compared to conventional concrete for M30 grade of concrete. In the case of concrete reinforced with Hybrid Polypropylene and steel (crimped) fibres, split tensile strength results show 7% increase in 7 days, 15% decrease in 14 days, equal strength in 21 days and 5% increased in 28 days when compared to conventional concrete for M30 grade of concrete.

CONCLUSIONS

Based on the experimental results the following conclusions are drawn. Using three types of fibers with 4% by volume of cement the results were compared with the conventional concrete specimen.

The concrete mix with 4% steel fiber shows that the concrete was stiff and difficult to compact. In addition to this, concrete with shorter fiber has better workability as compared to longer fiber.

The concrete mix with 4% Endura-600 Macro synthetic Polypropylene fiber shows that concrete was more slippery and difficult to compact. Increase in compressive strength of SFRC was observed to be in range of 3 per cent to 60 per cent between 7 and 28 days.

The compressive strength of PPFRC was observed to increase between 10 per cent and 18 per cent for 7 and 28 days. Corresponding values for Hybrid concrete was increased by 3 per cent to 22 per cent for 7 to 28 days when compared to conventional concrete.

In conventional concrete, specimen splits into two halves exactly under the loaded area, but using SFRC, PPFRC, Hybrid fibers cylinders did not split into halves under the loaded area. Because of toughness it did not yield to sudden breakage. An increase in ductility of the specimens by the introduction of fibers was observed in this investigation.

REFERENCES

[1] Liu Yu, Zhou Aiguo Lin Zhenyu "Study on the mechanical properties of the bamboo fibre reinforced cement composite materials," International Conference on Agricultural and National Resources Engineering Advance in Bio Medical Engineering, vol. 3-5, pp. 978-996, 2011.

[2] A.L. Ardeshana, and A. K. Desai, "Durability of fiber reinforced concrete of marine structures," International Journal of Engineering Research and Applications (IJERA), vol. 2, Issue 4, pp. 215-219, July –August 2012.

[3] D. Whiting, (1981), "Rapid determination of the chloride permeability of concrete," Federal Highway Administration, Washington, DC., Final Report No. FHWA/RD-81/119.

[4] ASTM C1202, "Electrical indication of concrete's ability to resist Chloride Ion Penetration," Annual Book of American Society for Testing Materials Standards, vol. C04.02, 1993.

[5] V. Ramadevi, and D.L. Venkatesh Babu, "Flexural behavior of hybrid (steel and polypropylene) fibre reinforced concrete beams," European Journal of Scientific Research, vol. 70 no. 1, pp. 81 – 87, 2012.

[6] IS: 4031, "Indian Standard Specification for Physical Test for Hydraulic Cement–Determination of Compressive Strength, Bureau of Indian Standards, New Delhi, 1988.

[7] IS: 12269 "Indian Standard Specification For 53 Grade Ordinary Portland Cement," Bureau of Indian Standards, New Delhi, 1987.

[8] IS 383, "Indian Standard Specification for Coarse and Fine Aggregate for Natural Sources for Concrete," Bureau of Indian Standards, New Delhi, Second revision, Feb. 1997.

[9] IS: 516 (1959), "Indian standard methods of tests for strength of concrete," Bureau of Indian Standards, New Delhi, India.

[10] Patodi, S. C. and Kulkarni, C. V., (2012), "Performance evaluation of hybrid fiber reinforced concrete matrix," International Journal of Engineering Research and Applications (IJERA), vol. 2, Issue 5, September-October, pp.1856-1863.

[11] Vikrant, S Vairgade Kavita S. Kene, (2012), "Experimental investigation on hybrid fiber reinforced concrete," InternationalJournal of Engineering Research and Applications (IJERA), vol. 2, Issue 3, May-June, pp. 1037-1041.

[12] G. Deschutter and K., Andernaert, Evaluation of water absorption of concrete as a measure for resistance against carbonation and chloride migration Materials and structures / materiaux et constructions, vol. 37, pp. 591 – 596, November 2004.

[13] Rathan Raj, Perumal, E.B., and Santhakumar, A.R., (2013), "Studies on strength and diffusion characteristics of blended cement concrete," ICI Journal, Vol. 13, No. 4, January – March, pp.7 – 16..

[14] Belgian Standard NBN B15 – 2159 (1989), Water absorption test.