

Experimental Investigation on Hybrid Fibre Reinforced Concrete

S.P.Senthil Kumar¹, Ashwath Narayanan V.B² & Richie Mathew³

Associate professor, Department of Civil Engineering, St. Joseph's College of Engineering, Chennai, India¹

UG students, Department of Civil Engineering, St. Joseph's College of Engineering, Chennai, India^{2,3}

ABSTRACT: An experimental investigation was made by the partial replacement of fine aggregates with hemp and steel fibres in concrete. Hybrid Fibre Reinforced Concrete (HFRC) can be defined as concrete that is reinforced by two or more types of fibres. Partial replacement was done for mono fibre(hemp) and hybrid fibre (hemp and steel) concrete. The above fibres were cut into fine pieces. Steel and hemp fibres were partially replaced by the weight of cement in various proportions of 0.5%,1%,1.5% respectively in the concrete mixture. Concrete having compressive strength of 25 N/mm² (M25) was used. Test were carried out for each mix in fresh state to test the workability of concrete. In addition, compressive strength, flexure strength and split tensile strength were carried out and compared with conventional concrete. The test conducted reveals that mono fibres(hemp) shows higher strength when compared with hybrid and conventional concrete in compressive and flexural nature but decreases in tensile nature.

KEYWORDS: HFRC-Hybrid Fibre Reinforced Concrete, Hemp fibre, steel fibre

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementations materials, water, aggregate and sometimes admixtures in required proportions. Latest developments in concrete technology now include reinforcement in the form of fibres. There are different types of fibre reinforced concrete that are categorized based on the fibre that is employed. A composite can be stated as a hybrid when two or more type of fibres is used in a combined matrix to produce a composite that will reflect the benefit of each of the individual fibre used. This will finally provide a synergetic response to the whole structure. Such a composite of concrete is termed as the Hybrid Fibre Reinforced Concrete (HFC). The mechanical properties of concrete are enhanced appreciably using short lengthened fibres. This increases the modulus of elasticity of the concrete. This will also reduce the chances of brittleness and small crack formation, as small cracks are the main factors behind propagation and larger cracks formation. There is a hardly any type of fibre that can improve all the desired properties of fresh and hardened concrete. The basic purpose of using hybrid fibre is to control cracks at different size levels in different zones of concrete, stress levels and to enhance the properties of concrete by combining the benefits that each particular type of fibre can impart. In this paper an experimental study on the compressive, flexural & split tensile behaviour of hybrid fibre reinforced concrete was carried out using the combination of hemp and steel fibres.

II. OBJECTIVE

- The objective of this paper is to determine optimum percentage combination of HFRC.
- To compare the compressive, flexural and split tensile strength of cube, beam & cylinders of conventional concrete, mono fibre(hemp) concrete and hybrid fibre(hemp-steel) concrete with (0.25%-0.25%), (0.5%-0.5%), (0.75%-0.75%) proportions of steel and hemp fibre.

III. MATERIALS

3.1 Cement

Cement is a binder material which is used in construction for adhering purposes. The Ordinary Portland Cement (OPC) having minimum compressive strength of 53 MPa at 28 days, with the specific gravity of 2.85, was used for all concrete mixes

3.2 Fine aggregate

Natural river sand conforming IS 383-1970 is used as the fine aggregate which is passed through 2.36 mm IS sieve. It is used in cement mortar and concrete.

3.3 Coarse aggregate

Locally available, aggregate passing through 20 mm sieve and retained on 12.5 mm sieve as per IS: 383 – 1970 is used for all the specimens.

3.4 Fibre

Fibre-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. fibres include steel fibres, glass fibres, synthetic fibres and natural fibre. In addition, the character of fibre-reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities. The use of two or more different types of fibres in concrete matrix is called hybrid fibre reinforced concrete. In this project, crimped steel fibre and hemp fibre are used and certain percentage of mass of cement is replaced by these fibres.

3.5 Hemp Fibre

Hemp fibres are obtained from the bast of the Cannabis sativa plant and belong to the cannabis family. It is an annual herbaceous plant with a slender stem, ranging in height from 4 to 15 feet and a diameter from 1/4" to 3/4". It has various applications when used in concrete from roof insulation to wall construction to flooring. Hempcrete (concrete with hemp fibre) is waterproof, fireproof, insulates well, does not rot [when used above ground] and is completely recyclable. In this experiment, sun hemp fibre was used, which was obtained from local dealer and later on chopped into fine sizes of 18-22 mm length.

3.6. Crimped Steel Fibre

Steel fibre in concrete can provide superior resistance to minimize cracks in hardened concrete, as well as maximum resistance to withstand heavy loads, either dynamic or static. Steel fibre reinforced concrete is commonly used in tunnel construction, as it provides additional flexural strength, reduces shrinkage cracking and reduces permeability. In this experiment, crimped steel fibres were used of size 30mm in length and 0.5mm in diameter.

IV. TESTS CONDUCTED

4.1 Specific gravity test

Specific gravity is the ratio of the density of a substance to the density of a reference substance. The experiment is done with the help of the pycnometer. The fine aggregates like river sand, coarse aggregates and cement used for investigation are tested to determine the specific gravity. Water is used in pycnometer for testing the fine aggregates and coarse aggregates, but in case of cement water is replaced with kerosene.

4.2 Slump cone test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. A frustum having height 30 cm with top and bottom diameter of 10 cm and 20 cm respectively is used.

4.3 Compressive strength test

The maximum compressive strength is that under gradually applied load given solid material will sustain without fracture. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compression test. The mould used is of dimensions 150mm ×150mm ×150mm.

4.4 Split tensile strength test

A test for tensile strength in which a cylindrical specimen is loaded to failure in diametral compression applied along the entire length. The resistance of a material to longitudinal stress, measured by the minimum amount of longitudinal stress required to rupture the material. The concrete cylinder used for split tensile strength test is 150mm in diameter and 300mm long.

4.5 Flexural strength test

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The flexural strength represents the highest stress experienced within the material at its moment of yield. Beam mould of size 150 x 150 x 700 mm is used.

V. MIX DESIGN

Grade designation	– M25
Type of cement	- OPC 53 confirming IS12269-1987
Nominal size of aggregate	- 20mm (passing) –12.5mm(retaining)
Minimum cement content	- 320 kg/m ³ (as per IS456 table 8),
Maximum cement content	- 450 kg/m ³ Max water content ratio - 0.45(As per IS456 table 5)
Workability	- 100 mm (slump)
Type of aggregate	- Crushed angular aggregate
Mix proportion obtained	– 1: 1.59: 2.47

The following designations were followed in the below tests

M1	- Control mix
M2, M3, M4	- Hemp Fibre Reinforced concrete
M5, M6, M7	- Hybrid Fibre Reinforced Concrete

VI. RESULTS

6.1 Specific gravity test

Table 6.1: Specific gravity

Contents	Specific gravity
Cement	2.85
Fine aggregate	2.74
Coarse aggregate	2.74

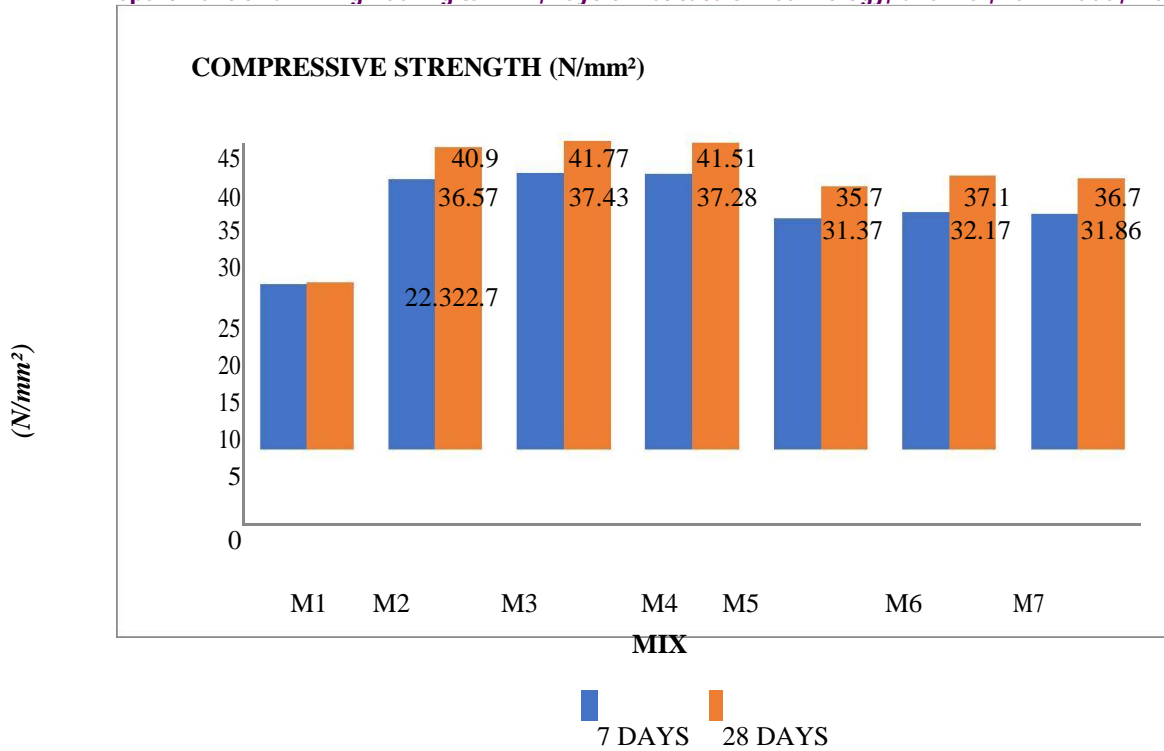
6.2 Compressive strength test

Table 6.2: Compressive strength

Mix	Hemp fibre (%)	Steel fibre (%)	7 days (N/mm ²)	28 days (N/mm ²)
M1	0	0	22.3	27.9
M2	0.5	0	36.57	40.9
M3	1	0	37.43	41.77
M4	1.5	0	37.28	41.51
M5	0.25	0.25	31.37	35.7
M6	0.5	0.5	32.17	37.1
M7	0.75	0.75	31.86	36.7



Fig 6.1 Compressive strength test



6.3 Split tensile strength test

Table 6.3 Split tensile strength

Mix	Hemp Fibre (%)	Steel Fibre (%)	7 days (N/mm ²)	28 days (N/mm ²)
M1	0	0	1.79	1.99
M2	0.5	0	2.14	2.57
M3	1	0	2.24	2.88
M4	1.5	0	2.18	2.78
M5	0.25	0.25	2.33	2.88
M6	0.5	0.5	2.57	3.19
M7	0.75	0.75	2.46	3.06

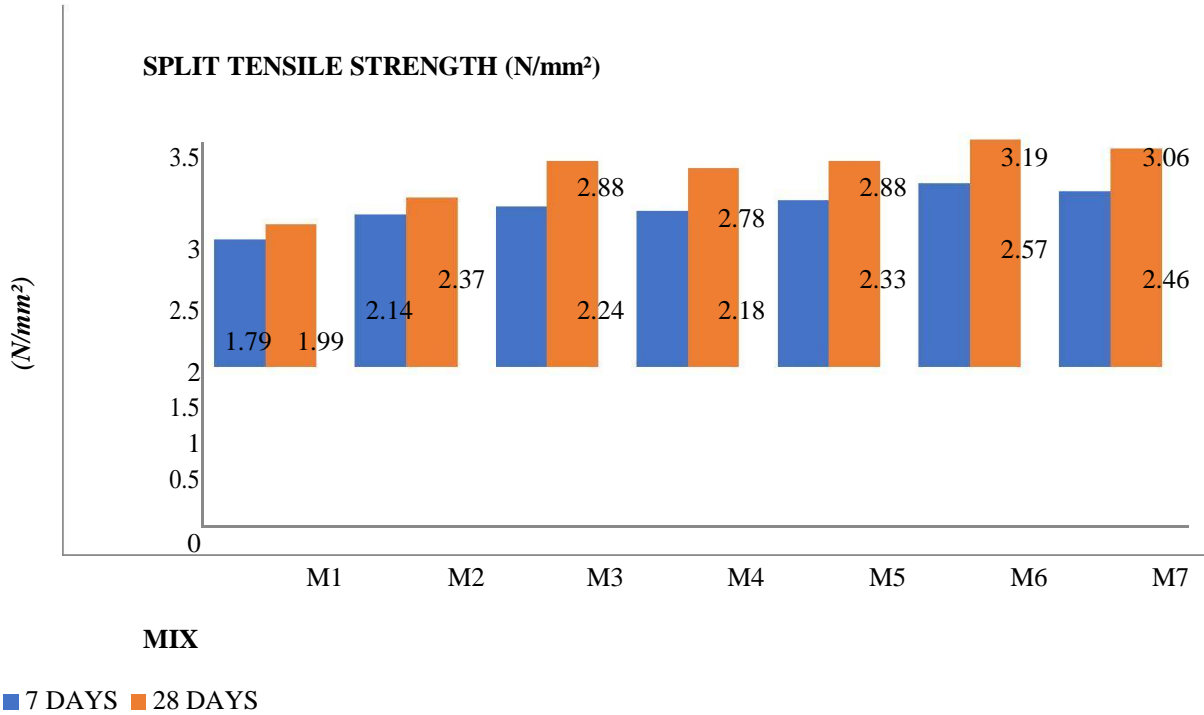


Fig 6.2 Split Tensile Strength Test

6.4 Flexural strength test

Table 6.4 Flexure strength

Mix	Hemp Fibre (%)	Steel fibre (%)	7 days (N/mm ²)	28 days (N/mm ²)
M1	0	0	4.53	4.92
M2	0.5	0	5.46	5.72
M3	1	0	5.92	6.44
M4	1.5	0	5.68	6.17
M5	0.25	0.25	5.24	5.47
M6	0.5	0.5	5.82	6.17
M7	0.75	0.75	5.6	6.05

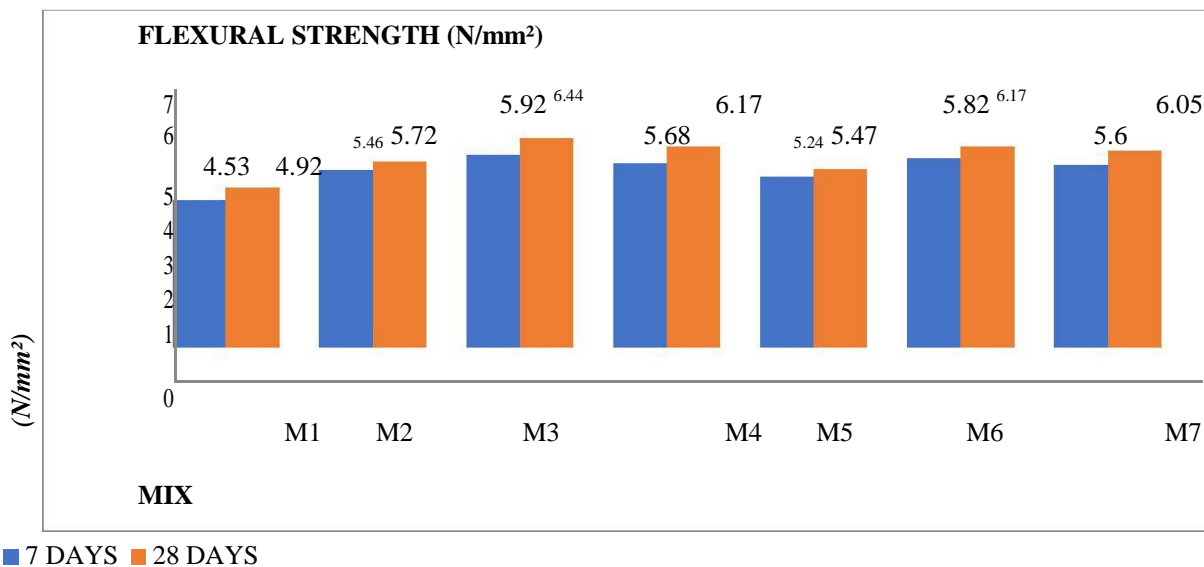


Fig 6.3 Flexural Strength test

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization

Volume 7, Special Issue 5, April 2018

1st International Conference on Recent Innovation in Civil Engineering and Management (ICRICEM '18)

22nd March 2018

Organized by

Department of Civil Engineering & MBA, Loyola Institute of Technology, Chennai, Tamilnadu, India

VII. CONCLUSION

Based on the experimental investigation on HFRC, the following observations can be drawn.

- 1) The addition of steel fibre and hemp fibre results in an increase in compressive strength & flexural when compared to conventional concrete but decreases noticeably when compared with mono(hemp) fibre concrete.
- 2) The addition of steel fibre and hemp fibre results in increase in split tensile strength when compared to conventional concrete and mono(hemp) fibre.
- 3) Thus, the optimum percentage of fibres for reinforcement is 1% for both mono(hemp) fibre and hybrid fibre concrete.

VIII. ACKNOWLEDGEMENT

The authors are thankful to St. Joseph's College of Engineering, Chennai – 600 119 for their support, guidance and encouragement throughout the entire project.

REFERENCES

- [1] S. Kumaravel, N. Veeragurunat, D. Anandram, E. Vairavi (2015), "Influence Of Hybrid Fibre Reinforced Concrete" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.51.
- [2] Banthia N and Gupta R (2004), "Hybrid fibre reinforced concrete (HYFRC): fibre synergy in high strength matrices", Journal of Materials and Structures, Vol. 37, pp. 707-716.
- [3] Navilesh J, Rahul B, Shankar B, Shivakumar Patil, Vivekanand A Gutteder (2017) "A Study on Hybrid Fibre Reinforced Concrete" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 06.
- [4] Xiangming Zhou, Harmeet Saini and Gediminas Kastiukas (2017) "Engineering Properties of Treated Natural Hemp Fibre-Reinforced Concrete" Front. Built Environ. 3:33. doi: 10.3389/fbuil.2017.00033.
- [5] Ganbavale, Mandar & Kumbhar, Digambar & Jain, Ankit Kuhad & Reddy, Ritesh & S, Gayathri. (2014). "Compressive Strength Of Hybrid Fibre Reinforced Concrete" DOI 10.13140/2.1.3894.9446.
- [6] K. Ramadevi and S. Deepa Shri (2015) "Flexural Behaviour Of Hemp Fibre Reinforced Concrete Beams" ARPN Journal of Engineering and Applied Sciences, VOL. 10, NO. 14
- [7] Mohammadi, Y., Carkon-Azad, R., Singh, S. P. and Kaushik, S. K., (2009). "Impact Resistance of Steel Fibrous Concrete Containing Fibres of Mixed Aspect Ratio," Construction and Building Materials, Vol. 23, pp.183_189 .doi: 10.1016/j.conbuildmat.2008.01.002
- [8] Boobalan S, Karthik Raj, Sandeep R (2017) "Experimental Investigation Of Fibre Reinforced Concrete Using Hemp Fibre And Silica Fume" IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308
- [9] IS 383-1970 "Specification for Coarse and Fine aggregate from natural sources for concrete" Bureau of Indian Standards, New Delhi, India.
- [10] IS 456-2000 "Code practice for Plain and cement concrete" Bureau of Indian Standards, New Delhi, India.
- [11] IS 516-1959 "Methods of test for strength of concrete" Bureau of Indian Standards, New Delhi, India.
- [12] IS 2386-1963(part-III) "Determination of Specific gravity, voids, Absorption" Bureau of Indian Standards New Delhi India.
- [13] IS 10262-2009 "Guidelines for Concrete Mix Design" Bureau of Indian Standards, New Delhi.
- [14] <https://www.wikipedia.org/>