Experiment on Hybrid Fibre Reinforced Concrete Using Steel Fibre along With Polyester Fibre

Loma Verma, Anil Suman

Abstract— **This project includes the experiment on hybrid fiber reinforced concrete in rigid pavement of M40 grade by using steel fibre and polyester fibre. The various factors that may lead to cracks in the concrete would be structural, environmental or economic condition. Hybrid fibre reinforced concrete can be utilized actually in many types of constructions because of its unique quality. The structural strength of the concrete could be evaluated through performing the compressive strength test along with flexural strength test. In this research work M40 grade of concrete is used and the ratio is determined with the help of testing of cement, sand and aggregate. This paper presents a comparison between ordinary concrete and hybrid fibre reinforced concretes. Steel fibres along with polyester fibres used in various percentages to check the durability of concrete. Addition of this fibre has helped us to find out the fluctuations in compressive strength along with flexural strength of hybrid fibre reinforced concrete.**

Index Terms— **Hybrid Fibre Reinforced Concrete, Steel Fibres, Polyester Fibres, Compressive Strength, Flexural Strength**

I. INTRODUCTION

Concrete are the building material comprising of cement, fine aggregates along with coarse aggregate mixed by means of water which gets harder with time. Plain concrete acquires extremely little tensile strength, inadequate ductility and minute resistance to cracking. Therefore, fibres are utilized for reinforcing of concrete, to improve strength of concrete. Various types of fibres that are utilized in reinforcement are steel, polyester, polypropylene, glass fibres along with carbon fibres etc.[8]. Reinforcing concrete using steel fibre is a tiny, detached lengthwise measurement of steel fibres with an aspect ratio, with unusual cross sections, which are adequately small to randomly disperse in an unhardened concrete mix. A definite quantity of the steel fibre in concrete can be reason for qualitative changes in material property of concretes, increase resistance to cracking, impact, durability and other properties [14]. Polyester Fibre is a category of polymer group that contain the ester functional group in their chain. The polyester fibre reinforced concrete enhances the compressive as well as flexural strength along with reduced drying shrinkage over that of plain concrete. Hybrid fibre reinforced concrete is uses multiple number of fibres are included in particular concrete mixture to get advance and better overall characteristics of concrete. The mechanical characteristics of concrete are compressive strength, flexural strength, and tensile strength along with elastic modulus is enhanced by using of short length fibres. The hybridization of fibres gives a superior and definite characteristic which cannot be obtained by any of the innovative fibre performing by itself [1]. Further to develop the mechanical characteristics of concrete that is better to make mixture of cement by means of fibre which contains superior tensile force. The effectiveness of hybrid fibres reinforced concrete is utilized in diverse range of civil engineering applications similar to precast concrete tube, industrial pavement, highway pavement, airport landing strip and many more [13]

II. OBJECTIVE OF THE STUDY

1. *To Improve Structural Strength*

Use of hybrid fibre in this experiment is to achieve the maximum compressive and flexural strength of the hardened concrete. Hybrid fibre increases the structural strength of concrete, which reduces the steel reinforcement requirements.

2. *To Improve the Mechanical Property of Concrete*

In this study; other mechanical property of concrete such as impact resistance, abrasion resistance, toughness and ductility are also improved by using of fibre. Hence the hybrid fibre reinforced concrete pavement have more durable than that of plain concrete; which reduces the thickness of pavement and minimize the cost of the construction.

3. *To Reduce Cracks in Pavement*

The main reason of addition of fibre in this study is to reduce the cracks in pavement. The fibres added in concrete are short, discrete length which is distributed in uniform manner; which provide bonding property between them. This property of fibre provides concrete with protection against the cracking of pavement.

III. EXPERIMENTALWORK

a) Material Used

Cement: In this project work Portland pozzolana flyash based cement of 53grade is used with the brand name of Emami Double Bull Cement.

Fine aggregate: The fine aggregates are obtained from the river bed. Fine aggregate which are passing through IS sieve 4.75mm and retained on IS sieves 0.075mm are used. The specific gravity as well as water absorption is 2.61 and 0.80 correspondingly.

Coarse aggregate: coarse aggregate of different sizes such as 10mm, 20mm, 31.5mm and 40mm is used in various constructions. In this research work 40mm sizes of coarse aggregate is used. The coarse aggregate have specific gravity 2.64 and water absorption 0.82.

Steel fibre: These are short length fibre with an aspect ratio along with different cross section. In this paper, steel fibre of rounded crimped type is used having the length is 50mm and diameter is 1mm. It is added in proportion 0.25%, 0.50%, 0.75%, 1%, 1.25% and 1.50% by means of

weight of cement.

Polyester fibre: In this experiment Polyester triangular synthetic fibre are used. The length of polyester fibre is 12mm and diameter is 0.4mm. The proportion of polyester fibre is 0.1% 0.2%, 0.3%, 0.4%, 0.5% and 0.6% by the weight of cement.

b) *Mix Design*

The main reason in favor of mix designing for concrete is to make sure the most advantageous proportions of the materials to fulfill the necessity of the construction before built. Mix design for M40 grade of concrete is done as stated by IS code 10262-2009 and IS code 456-2000 and it shown in table below-

TABLE I. MIX PROPORTION DESIGNED FOR M40 CONCRETE

S. No.	Mix proportion		
	Item	*Quantity , for 1m3 Concrete*	*Mix ratio*
1	Cement	367kg	1
2	Fine aggregate	474.34kg	1.3
3	Coarse aggregate	1365.56kg	3.7
4	Water	165kg	0.45

c) Test Performance

a) Compressive Strength Test: Compressive strength are the most important plus helpful characteristics of concrete. Strength of hardened concrete is measured by the compression assessment. Additional properties of concrete like young• s modulus, toughness, resistance to contraction, imperviousness and so on are depends upon the compressive strength of concrete [17]. This test is performed to check the strength of M40 grade of concrete on 7, 14 as well as 28 days. Dimension of mould 150mm*150mm*50mm is used Two types of fibre used in proportion of 0.25%, 0.50%, 0.75%, 1%, 1.25%, 1.50% of steel fibre and 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6% of polyester fibre as hybrid fibre. Fibre is added before use of water and the concrete is mixed uniformly. Three cube of each proportion is prepared for 7, 14 along with 28 days. Later than, 24 hour of casting, cubes are removed from mould and it should be taken for curing. Cube is removed from water and it can be taken for dry. When the cube is completely dry, testing should be done on compression test machine on 7 days, 14 days, also 28 days. Compressive strength of concrete are determined by load (in which cube is failed) alienated by side view area of mould.

Calculation: the compressive strength of the concrete can be calculated by using the following equation

$$\text{Compressive Strenght} = \frac{\text{Maximum Compressive Load}}{\text{Cross-Sectional Area}}$$

b) Flexural Strength Test: Flexural strength is the measurement of an unreinforced concrete slab to resist collapse in bending. The flexural strength tests are done to check the flexural strength of beam on 28 days. The beam of size 150mm*150mm*700mm is casted. Three beams are casted for each proportion at 28 days. All ingredient of concrete is mixed uniformly and it takes in mould of beam. The beam is placed in vibrating machine to compact the mixture uniformly. Later than 24 hours of casting of beam it can be detached from mould and take cured for 28 days. When 28 days is completed, the beams are removed from water and keep for drying. The testing of beams is done in flexural testing machine.

Calculation: The flexural strength of concrete are calculated by using the following formula-

$$F_c = \frac{3^{*}p^{*}a}{b^{*}d^{2}}$$

Where,

a = Distance between the line of fracture along with the closer support, measured on the centre line of the tensile side of the Beam.

b = Thickness of Beam (mm)
d = Failure point depth (mm)
P = Maximum load (kg)

IV. RESULT AND DISCUSSION

A. Result of Compressive Strength Test

The standard compressive strength of hybrid fibre reinforced concrete would be obtained at 7, 14 as well as 28 days which is given in table below-

TABLE II. AVERAGE COMPRESSIVE STRENGTH OF HFRC

Sample	Average Compressive Strength			
	% of fibre	*Avg. compressive strength of HFRC(N/mm2)*		
		7 days	14 days	28 days
PC	0%	19.85	31.55	49.04
A1	SF=0.25% PF=0.1%	21.19	29.48	49.48
A2	SF=0.50% PF=0.2%	25.04	30.82	51.56
A3	SF=0.75% PF=0.3%	29.48	42.96	55.85
A4	SF=1% PF=0.4%	31.99	48.29	58.51
A5	SF=1.25% PF=0.5%	26.67	34.67	50.37
A6	SF=1.50% PF=0.6%	25.63	31.00	48.59

It is seen that the concrete without fibre should be produce minimum compressive strength as comparison between HFRC. Addition of fibre in proper amount have produce great changes in compressive strength and develop strength continue. The combination of Sample A4 (SF=1%, PF=0.4%) obtain higher compressive strength of HFRC

The fluctuations in value of compressive strength of hybrid fibre reinforced concrete is shown within Fig.1-

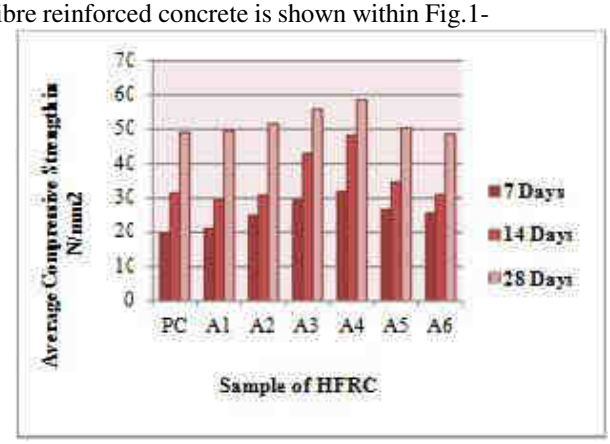

Fig. 1. Average Compressive Strength of HFRC

Figure shows the average compressive strength of plain concrete and HFRC at 7, 14 and 28 days. The strength of HFRC should be increased as percentages of fibre increased and again increasing the percentages of fibre the strength should be getting decreased

B. Result of Flexural Strength Test

The average flexural strength of hybrid fibre reinforced concrete on 28 days are given in table below-

TABLE III. AVERAGE FLEXURAL STRENGTH OF HFRC

Sample	Average Flexural Strength	
	% of fibre	*Avg. flexural strength of HFRC(N/mm2)*
		28 days
PC	0%	3.05
B1	SF=0.25% PF=0.1%	3.09
B2	SF=0.50% PF=0.2%	3.28
B3	SF=0.75% PF=0.3%	4.38
B4	SF=1% PF=0.4%	4.95
B5	SF=1.25% PF=0.5%	5.83
B6	SF=1.50% PF=0.6%	5.75

It is observed that the plain concrete as compared to HFRC can be obtained lower flexural strength. Increasing percentages of fibre slightly increased the flexural strength. Sample B5 (SF=1.25%, PF=0.5%) give the maximum flexural strength.

The fluctuations in value of flexural strength of hybrid fibre reinforced concrete is shown within Fig.2-

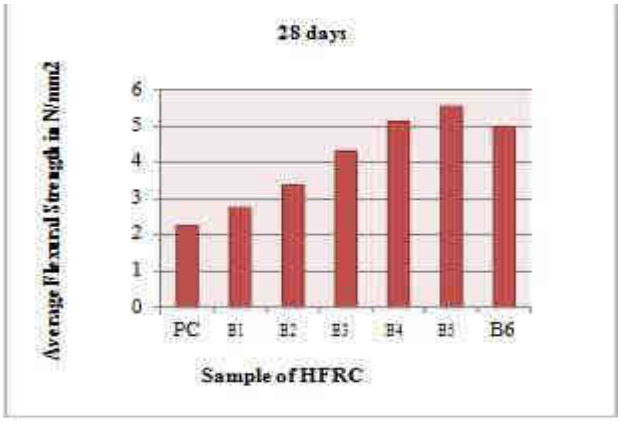

Fig. 2. Average flexural strength of HFRC

Figure shows the average flexural strength of plain concrete and HFRC at 28 days. The maximum flexural strength produced by sample (SF=1.25%, PF=0.5%) and after increasing the fibre percent strength should be decreased.

It have been seen that the fibre added in concrete, increase the compressive strength as well as flexural strength of hybrid fibres reinforced concrete. The compressive strength of hybrid fibre reinforced concrete at 1% of steel fibres and 0.4% polyester fibres gives the maximum strength over the normal concrete. Furthermore flexural strength of hybrid fibre reinforced concrete is obtained maximum at steel fibre (1.25%) and polyester fibre (0.5%). Maximum compressive strength of hybrid fibre reinforced concrete is 58.51N/mm2 along with the maximum flexural strength is 5.83N/mm2. After elevating the proportion of fibre, strength of hybrid fibre reinforced concrete is decrease

CONCLUSION

This paper presents hybridization of steel fibre along with polyester fibre gives higher strength than the plain concrete. (SF 1% + PF 0.4%) is optimum dosage for compressive strength. After increasing the percentage of fibre strength can be reduced. For flexural strength, (SF 1.25% + PF 0.5%) is best combination of hybrid fibre reinforced concrete. It has been seen that using of hybrid fibre in construction of rigid pavement, it make pavement more durable which reduce the cracks in pavement and also minimize the thickness of pavement at certain limit as compared to plain concrete. Using of small percentage of fibres greatly increase the strength of concrete, so we can use this fibres in construction of pavement which help to make pavement more durable, reduce cracks and improve riding quality in future

REFERENCES

1. S.C. Patodi, C.V. Kulkarni, “Performance evaluation of hybrid fibre reinforced concrete matrix,” International Journal of Engineering Research and Applications, Vol. 2, Issue5, ISSN: 2248-9622, October, 2012.
2. Gajanan Akkimaradi, Prof. Kashinath B. Rugi, Dr. K.B. Prakash, Dr. Jagadish G. Kori, “An investigation on the behavior of hybrid textile fibre reinforced concrete,” International Research Journal of Engineering and Technology, Vol. 5, Issue: 08, e-ISSN:2395-0056, p-ISSN: 2395-0072, August, 2018.
3. Srinivas Angadi, K Sudhakar Reddy, S Selvaprakash, J S R Prasad and M Venu, “Experimental study on structural behavior of hybrid fibre reinforced concrete,” IOP Conf. Series: Material Science and

Engineering431,042003,doi:10.1088/1757-899x/431/4/042003, 2018.

4. Anithu Dev, Dr. Sabeena M.V, "Mechanical properties of hybrid fibre reinforced concrete," International Research Journal of Engineering and Technology, vol. 05, Issue: 04, e-ISSN: 2395-0056, p- ISSN: 2395-0072, April, 2018.
5. H. S. Jadhav, M. D. Koli, "Flexural behavior of hybrid fibre reinforced concrete beams," International Journal of structural and Civil Engineering Research, Vol.2 No.3, August, 2013 .
6. Dipan patel, "Use of steel fiber in rigid pavement," In Global research analysis, Vol.2, 2277- 8160, June, 2013.
7. Dr. Vagheesha S. Mathda, Ms. Hemali K. Khaire, "Study on effect of polyester fibers on compressive strength of concrete," International Journal for Research in Applied Science & Engineering Technology, Vol. 4 Issue I, IC Value: 13.98 ISSN:2321-9653, January, 2016.
8. Parveen Kaur, Mohit Talwar, "Different types of fibres used in FRC," International Journal of Advanced Research in Computer Science. Vol. 8, No. 4, ISSN: 0976-5697, 2017.
9. Rajarajeswari B vibhuti, Radha Krishna, "Mechanical properties of hybrid fiber reinforced concrete for pavement," International Journal of Research in Engineering and Technology, e-ISSN: 2319-1163, p-ISSN: 2321-7308, November, 2013.
10. Y.M.Ghugal and S.V. Naghate, "Performance of extruded polyester fibre reinforced concrete," Journal of Structural Engineering, Vol. 43, No.3, September, 2016.
11. IS: 10262-2009, "Recommended guidelines for concrete mix design, Bureau of Indian standards".
12. IS: 456-2000, "Code of practice for plain and reinforced concrete, Bureau of Indian Standards".
13. Navilesh J, Rahul B k, Shankar B K, Shivakumar Patil, Vivekanand A Gutteder, "A study on hybrid fibre reinforced concrete," International Research Journal of Engineering and Technology, Vol.04, Issue:06, June, 2017.
14. Baoguo Han, XunYu, Jinping Ou, "Compositions of self-sensing concrete," Elsevier BV, 2014.
15. A.M.Shende, A.M.Pande, M. Gulfam Pathan, "Experimental study on steel fibre reinforced concrete for M-40 grade," International Refereed Journal of Engineering and Science (IRJES), Vol. 1, Issue: 1, ISSN: 2319-183X, September, 2012.
16. Geethu Asok, Dr. Sunilaa George, "Investigation on hybrid concrete using steel and polypropylene fiber," International Journal of New Technology and Research ISSN:2454-4116, Vol. 2, Issue-5, May, 2016.
17. P. Ramya Shree, Arunika Chandra, B.L.P. Swamy, M. Bhaskar, "Study of compressive and flexural strength of fibrous triple blended high strength concrete with fly ash and condensed silica fume," International Journal of Engineering And Science. Vol. 6, Issue: 4, ISSN: 2278-4721, 2016