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FLEXURAL BEHAVIOR OF HYBRID FIBRE REINFORCED CONCRETE BEAMS UNDER CYCLIC LOADING

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ABSTRACT

Hybrid fibre reinforced concrete is the one in which more than one or two types of fibers are used as secondary reinforcement. Fibres have been used to reinforce materials that are weaker in tension than in compression. However for any reinforcement to be effective, it must be stiffer than the concrete matrix that is reinforcing. Generally the less stiff fibres only offer benefits in improving the tensile strength of plastic and semi-hardened concrete and are therefore mainly used to reduce plastic shrinkage and plastic settlement cracking until now, most of the production of HFRC has been for non-structural applications, with the fibres added primarily for control of cracking due to plastic or drying shrinkage. The aim of this project is to determine the behaviour of the hybrid fibre reinforced concrete slabs under cyclic loading. The fibres used here are polyolefin and steel corrugated fibres. The percentage of fibres used here are 0.5%, 1%, 1.5% and 2%. So far the experimental works has been done under impact loading. The main aim of this project is to determine the flexural behaviour of hybrid fibre reinforced concrete beam under cyclic loading .the beam size adopted here is 1000mmx 150mmx170mm.

Keywords : Hybrid, tension, compression, shrinkage, polyolefin, steel corrugated fibres.

1. INTRODUCTION (FRC)

FRC is very widely used and the principal applications are beams on grade, shortcrete, and precast members, as well as a number of specialty applications. Until now, most of the production of FRC has been for non-structural applications, with the fibres added primarily for control of cracking due to plastic or drying shrinkage. However for any reinforcement to be effective, it must be stiffer than the concrete matrix that is reinforcing. Generally the less stiff fibres only offer benefits in improving the tensile strength of plastic and semi-hardened concrete and are therefore mainly used to reduce plastic shrinkage and plastic settlement cracking. The stiffer fibres improve both the tensile strength and the toughness of harden concrete.

The most widely used stiff fibre is steel. Low volume fractions of fibres (less than 1%) are used to reduce shrinkage cracking. Moderate volume fractions (between 1% to 2%) increase flexural strength, fracture toughness and impact resistance. High volume fractions (greater than 2%) lead to strain hardening of the composites. The shape and length of the fibres also play a role in the fibres' effectiveness in improving the properties of the concrete. The use of fibres in concrete can have a marked effect on the workability of the concrete and this need to be taken into account in the mix proportion of fibre-reinforced concrete.

Hybrid fiber reinforced concrete is the one in which more than one or two types of fibers are used as secondary reinforcement. In Fiber Reinforced Concrete (FRC), fibres can be effective in arresting cracks at both macro and micro levels. For an optimal response, different type of fibres may be suitably combined to produce Hybrid Fiber Reinforced Concrete (HFRC) .The use of optimized combinations of two or more types of fibres in the same concrete mixture can produce a composite with better engineering properties than that of individual fibres.

STEEL FIBERS

The fibers used here are corrugated steel fibres. These fibres are used to reduce shrinkage cracking. It increases the flexural strength, fracture toughness and impact resistance. The main aim of using steel fibers is to control cracking and to increase the concrete strength.

POLYOLEFIN FIBER

Polyolefin fibers are those fibers produced from polymers formed by chain growth polymerization of olefins (alkenes) and which contain greater than 85% polymerized ethylene, propylene, or other olefin units. The fibers are unaffected by solvents at room temperature and are swollen by aromatic and chlorinated hydrocarbons only at elevated temperatures.

The hybrid fibers used here are 30% of poly olefin fiber and 70% of steel fiber.

2. OBJECTIVE

- The main objective of this project is to determine the behaviour of hybrid fibre reinforced concrete beams under cyclic loading.
- The fibres such as polyolefin and steel fibres of varying percentage (0.5%, 1%, 1.5%, and 2%) are used to determine the strength of concrete slabs.
- To compare the strength of hybrid fibre reinforced concrete beams varying percentage fibres with conventional concrete beam and also to compare the result with the STAAD Pro analysis.

3. METHODOLOGY

The main aim of this project is to improve the flexural behaviour by adding fibres and also to study the behaviour of hybrid fibre reinforced concrete beams with controlled concrete beams under cyclic loading condition. The following steps are involved.

- Initially the materials used are tested and the test results are shown in table 1.

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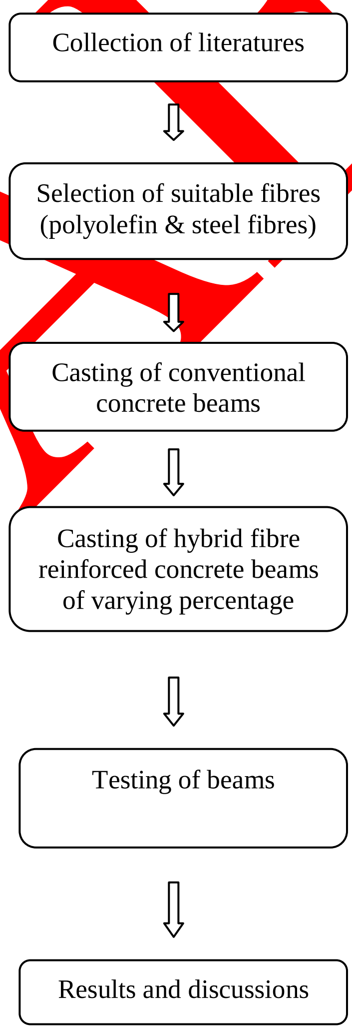
- Cubes, cylinders and prisms are casted for varying percentage of hybrid fibres and they are used for determining the compressive strength split tensile strength and flexural strength of concrete using varying percentage of fibres (poly olefin and steel)
- Tests are conducted using universal testing machine and also cylinders are tested using lateral extensometer. By using these extensometer secant modulus can be determined.
- After determining the test results suitable percentage of fibre is determined to cast the hybrid fibre reinforced beams.
- The results shows that fibres varying from 0.5% to 1.5% shows good strength and bonding.
- The experimental works were conducted on concrete beams by applying cyclic load. Here the beams are subjected to cyclic load by using push-pull load cell.
- Then the crack pattern were analysed and results were observed.

The following flow chart shows the methodology of this project



4. EXPERIMENTAL WORKS

The preliminary tests were conducted on cement, fine aggregate, coarse aggregate and the test results were obtained. Based on the results obtained the mix proportion for M_{25} concrete is done.

The properties of materials tested are as follows,

Table 1 : Properties of Cement, FA, CA

Property	Cement	FA	CA
Fineness	1%	4.72	8.21
Consistency	30%		
Initial setting time	122 mins		
Specific gravity	3.18	2.62	2.78

Mix Proportion For M_{25} Concrete

Cement = 425.73 Kg/m^3
Fine aggregate = 649.498 Kg/m^3
Coarse aggregate = 1174.42 Kg/m^3
Water-cement ratio = 0.45
Water content = 191.58 Kg/m^3
C:FA:CA = 1:1.52:2.75

The mix proportion for M_{25} concrete is calculated using IS 456:2000, IS 10262:2009. Superplastizicer is also added to increase the workability of concrete.

Test Specimens

The compressive stress , split tensile strength and flexural strength of concrete are determined by casting cubes of size 150x150x150 mm , cylinders of size 300x150 mm and prisms of size 500mmx100mmx100mm and allowed for 28 days curing and the test results were obtained for various percentage of fibers (poly olefin and steel fibers).

Table 2: compressive stress of controlled concrete cubes and hybrid fiber reinforced cubes

specimen	Compressive stress(N/mm^2)
CC	32.44
HF 0.25%	24.74
HF 0.5%	27.89
HF 0.75%	28.17
HF 1%	42.25
HF 1.5%	30.55
HF 2%	26.39
HF 2.5%	23.08
HF 3%	28.17

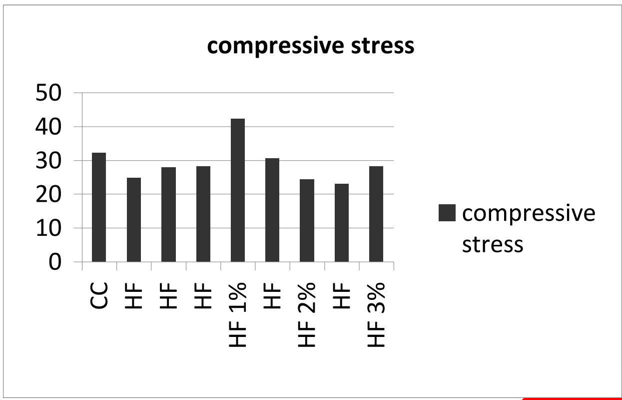


Figure 1, shows the compressive stress of cubes
Note : CC- controlled concrete, HF- hybrid fibers

Table 2: Split Tensile Strength Of controlled concrete Cylinders and hybrid fiber reinforced concrete cylinders

specimen	Split tensile strength
CC	2.73
HF 0.25%	2.07
HF 0.5%	1.53
HF 0.75%	2.3
HF 1%	2.9
HF 1.5%	1.9
HF 2%	2.22
HF 2.5%	1.85
HF 3%	1.95

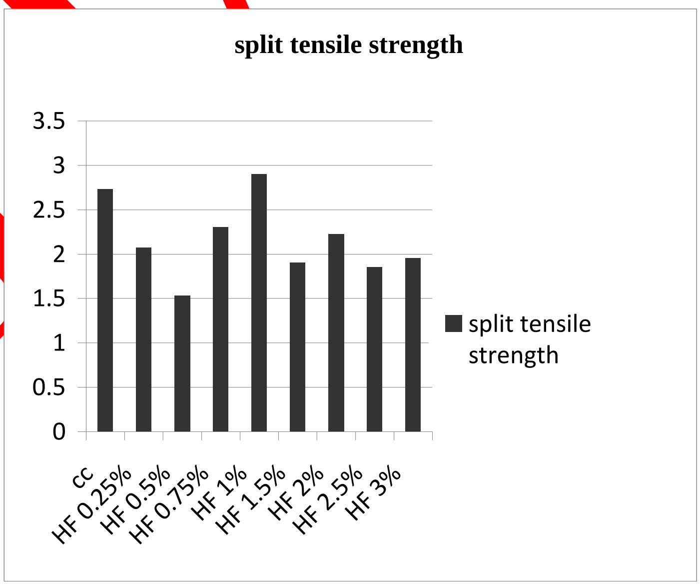


Figure 2, shows the split tensile strength of cylinders
Note : CC- controlled concrete, HF- hybrid fibers

Table 3: Flextural Strength Of controlled concrete prisms and hybrid fiber reinforced concrete prisms

specimen	Flexural strength
CC	1.24
HF 0.25%	1.35
HF 0.5%	1.46
HF 0.75%	1.27
HF 1%	1.67
HF 1.5%	1.95
HF 2%	1.23
HF 2.5%	1.73
HF 3%	1.73

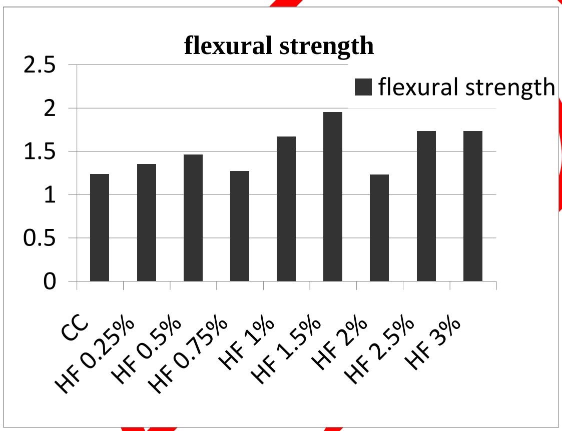


Figure 3, shows the flexural strength of concrete

Note : CC- controlled concrete, HF- hybrid fibers

Based on the test results obtained the strength of the concrete increases from 0.25% to 1.5% and it decreases gradually to 2%. Hence slabs of size 1000mm x300mmx70mm are casted for 0.75%,1.5%,2% and 3% and also for normal concrete. The beam is designed as a rectangular beam .

CONCLUSION

The results obtained shows that the flexural behaviour of the beam increases and also there is a good bonding in concrete due to these polyolefin and steel fibers. There is also a reduction of micro cracks due to shrinkage. Hence the use of these poly olefin and steel fibers shows good durability and it also arrests many micro cracks and also improves the flexural behaviour of the beam under cyclic load.

REFERENCES

1. Recommendations for design of beam-column-joints in monolithic reinforced concrete structures, **American Concrete Institute, ACI 352R-02, ACIASCE, Committee 352, Detroit, 2002.**

2. **Subramanian, N., and Prakash Rao, D.S.** Seismic Design of Joints in RC Strucutres, The Indian Concrete Journal, February 2003, Vol.77, No.2, pp. 883-892.

3**. Leon, R.T.**, Shear Strength and Hysteretic Behaviour of Beam-Column Joints, ACI Structural Journal, V.87, No.1, Jan-Feb, 1990, pp. 3-11

4**. Park, R., and Paulay, T.,** Reinforced Concrete Structures, John Wiley and Sons, 1975, 786p.

5. **Paulay, T. And Priestley, M.J.N.,** Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, 1992, 767p.

6. **Ichinose, T.,** Interaction between Bond at Beam Bars and Shear Reinforcement in RC Interior Joints, Design of Beam-Column Joints for Seismic Resistance, SP-123, American Concrete Institute, Farmington Hills, Mich., 1991, pp. 379-400.

7**. Cheung, P.C., Paulay, T., and Park, R.** Mechanisms of Slab Contributions in Beam Column Subassemblages, Design of Beam-Column Joints for Seismic Resistance, SP-123, American Concrete Institute, Farmington Hills, Mich., 1991, Pp.259-289.

8**. IS:13920-1993,** "Indian Standard code of practice for ductile detailing of concrete Structures subjected to seismic forces, Bureau of Indian Standards, New Delhi, 1993.

9**. IITK-GSDMA** Project on "Review of Building Codes and Preparation of Commentary And Handbooks

10. Website: **http://www.nicee.org/IITKGSDMA**

11. Reinforced concrete limit state deign - **Ashok k. Jain**

12. Design of reinforced concrete structures - **S.Ramamurtham**

13. Work shop on **"Earthquake Resistant Structures "--** conducted by Government College of Technology,Coimbatore.

14. **IS 456: 2000**- Plain and Reinforced Concrete Code of Practice

15**. IS 1893 (Part 1): 2002** - Criteria for Earthquake Resistant Design of Structure

16. **IS 13920: 1993** - Ductile Detailing of Reinforced Concrete Structures Subjected To Seismic forces- Code of Practice