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Behaviour of Composite Fibre Reinforced Self Compacting Concrete Beams

T. Sathya[1*], and R. Dineshkumar[2]
[1]Assistant Professor, Department of Civil Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India. Email: sathyat.civil@mkce.ac.in
[2]Assistant Professor, Department of Civil Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India. Email: dineshkumarr.civil@mkce.ac.in
*Corresponding Author

Abstract: Honey combs were formed in structural members due to improper compaction, hence self compacting concrete can be used to get better strength. As the concrete gets compacted itself due to gravitational force, additional use of vibrators can be avoided. Provision of steel fibres in concrete can reduce the crack, impact and shrinkage. The mix ratio for self compacting concrete with steel fibres has been arrived with the reference of EFNARC*. The purpose of this project is to perform experimental and analytical investigation to explore the flexural behavior of steel fibre reinforced concrete beam and hybrid fibre reinforced concrete beam. The relationship between the various strength tests are established using the graphs.

Keywords: Gravity, self compacting concrete, segregation, vibration equipment.

I. Introduction

The strength and durability of the concrete depends on the homogeneity of the concrete. Improper compaction and segregation affects the flexural behavior of concrete. Self compacting concrete (SCC), one of the most significant advances in concrete technology will overcome the ill effects of compaction and segregation. SCC helps in reduction in honeycombs in the heavily congested areas like beam column joints. The durability of the concrete structures depends on the quality of concrete and construction practice. To avoid honey combs and to attain homogeneity of concrete, self compacting technique can be applied. Self compaction of the concrete can be attained due to the self weight of the constitutions of concrete. Application of SCC can be used in places where compaction cannot be done using mechanical vibrators. Cracks in concrete surface may arise due to plastic shrinkage and drying shrinkage, which can be controlled using fibers. The uses of fiber in concrete will also reduce the permeability and bleeding of water and increases the impact and abrasion resistance. It also delays the propagation of cracks.

The outcome of the research work is to obtain the flexural behavior of the reinforced concrete beams enhanced with the hybrid fibres. Steel fibre and polypropylene were added in concrete as hybrid fibres.

II. Materials

A. Cement

OPC 53 grade cement was used in the experiment. In order to avoid shrinkage cracks, the maximum cement content used in concrete is limited to 350kg/m^3.

i. Fine Aggregate

The sand (Zone II) used should be free from clay materials and other organic materials.

ii. Coarse Aggregate

In SCC, the coarse aggregate used is to be well graded and size of the aggregate used is smaller than that of normal concrete. Usually the size ranges from 10 mm to 20 mm. The size of coarse aggregate is confirmed as per the BIS specifications. To improve the flow ability of concrete, lesser size of aggregates is used.

iii. Steel Fibres

To control the effect of corrosion, Steel fibers are made with low carbon content of cold-drawn steel wire or stainless steel wires. The application of steel fibers may reduce the propagation of cracks thus by increasing the crack resistance and also reduces the shrinkage cracks.

iv. Polypropylene Fibres

Polypropylene fibre is a 100% synthetic textile fibre. It is formed by about 85% propylene. It is a strong fibre.

III. Results And Discussion

A. Fresh Properties

Workability of SCC depends on filling ability, passing ability and resistance to segregation, which can be assessed by the help of experiments such as slump flow test, L-box test, U-box test and V-funnel test.

As per guidelines of EFNARC, for slump flow, the typical range of value is 650-800 mm, for T50cm, range is 2 to 5 sec and for V-funnel, range is 6-12 sec, for L-box, the range is 0.82 to 1, for U-box, the range is 0 to 30 mm. The addition of steel fibres reduces the workability of fresh concrete. But the mix almost satisfies the range specified by EFNARC guidelines.

Table I: Fresh Concrete Test Results

Addition Of Steel Fibres In %	T_{50cm} Slump Flow (sec)	Slump Flow (mm)	L-Box (H_2/H_1)	V-Funnel (sec)	U-Box (mm)
0	2	750	0.95	6	28
0.5	2	740	0.95	6	26
1	3	720	0.9	8	25
1.5	3	700	0.85	9	22
2	4	690	0.8	11	20
2.5	5	680	0.8	12	17
3	6	660	0.75	14	16

B. Hardened Properties

i. Compressive Strength Test

Compressive strength tests are carried out on cubes of size 150 mm x 150 mm x150 mm. The specimens are tested after keeping it for curing at the age of 7 and 28 days and the results are plotted in Fig 1.

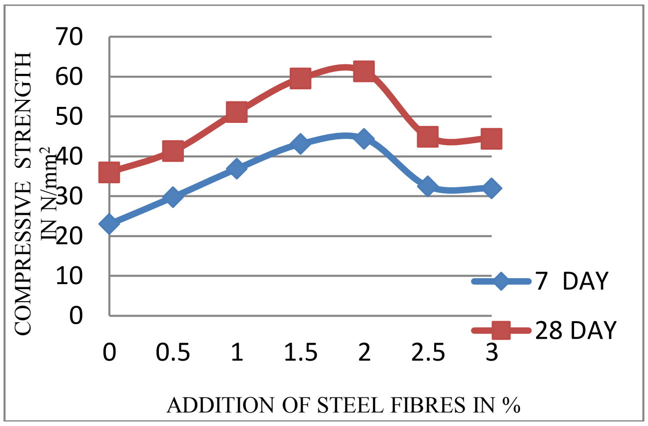

Fig. 1: Compressive Strength Results

ii. Split Tensile Strength Test

The tensile strength of the concrete can be indirectly determined using 150 mm X 300 mm cylinder specimens. The cylinders were casted for different addition of steel fibres. The tests were conducted on cylinders at an age of 7 and 28 days.

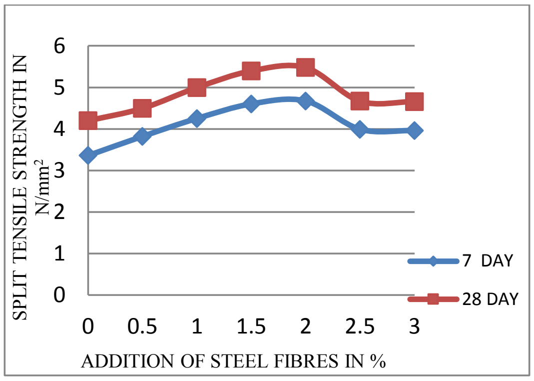

Fig. 2: Split Tensile Strength Results

iii. Compressive Strength Versus Split Tensile Strength

The relation between compressive strength and split tensile strength of the concrete is established by plotting a graph between them. The compressive strength is plotted in x-axis and corresponding split tensile strength values are plotted in y-axis. The graph is given in Fig 3.

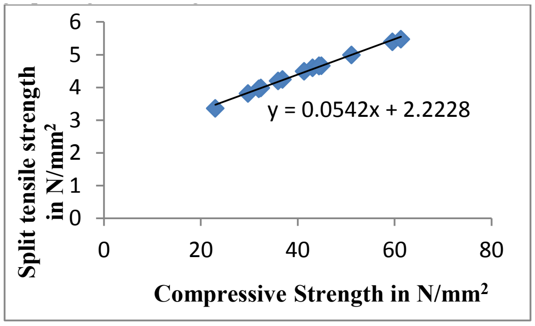

Fig. 3: Relation between Compressive Strength and Split Tensile Strength

From the graph, the relation is given by

Split tensile strength = (0.0542*compressive strength) + 2.2228

iv. Flexural Strength Test

Flexural strength test is carried out on prism specimens of dimensions 100 mm x 100 mm x 500 mm by two point loading set up at flexure testing machine. Fig. 4 shows the comparison of flexural strength of concrete for different proportions of fibres.

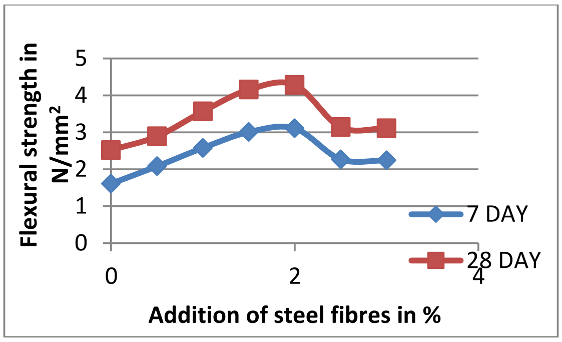

Fig. 4: Flexural Strength Results

v. Compressive Strength Versus Flexural Strength

The relation between compressive strength and flexural strength of the concrete is established by plotting a graph between them. The compressive strength is plotted in x-axis and corresponding flexural strength values are plotted in y-axis. The graph is given in Fig 5.

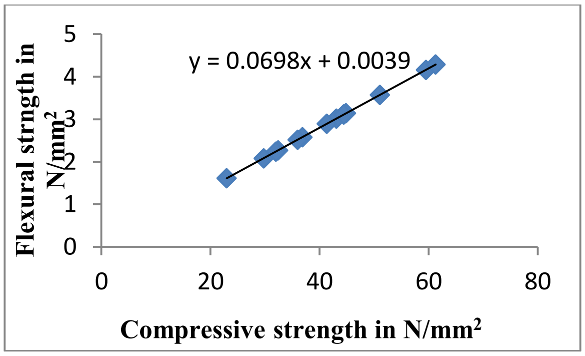

Fig. 5: Relation between Compressive Strength and Flexural Strength

From the graph, the relation is given by

Flexural strength = (0.0698* compressive strength) + 0.0039

vi. Flexural Behaviour

The beams were tested to an effective span of 1800 mm with simply supported conditions under two point loading. Deflections were measured under the loading point and at mid span using LVDT. The crack pattern was also recorded at every load increment. The strains were measured using deflectometer.

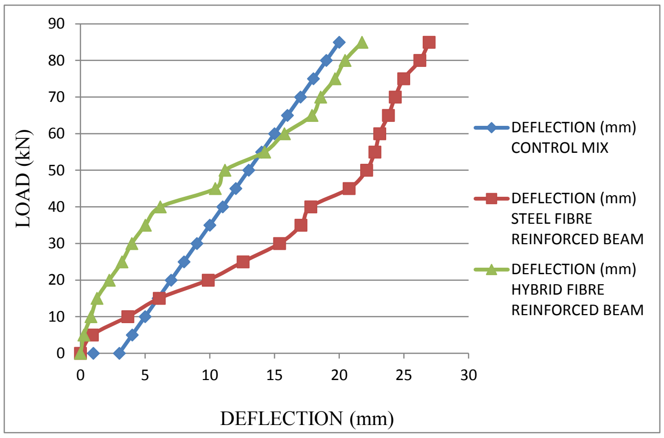

Fig. 6: Load vs. Deflection at Mid-span

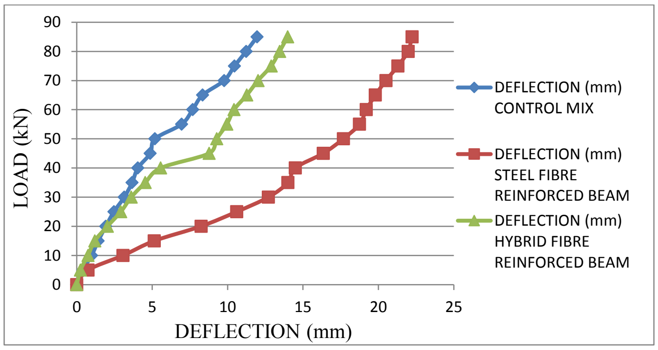

Fig. 7: Load vs. Deflection at L/3

vii. Initial Crack

According to loading on beam, initial crack is very important parameter, because initial crack decides the strength and life of the structure. Beam casted with steel fibres shows initial crack at later stage.

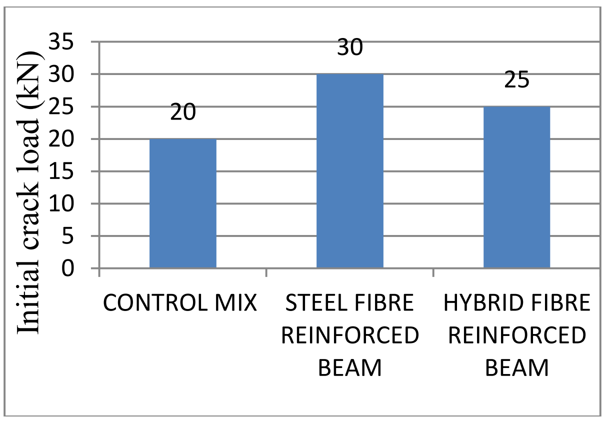

Fig. 8: Initial Crack of Beams

viii. Ultimate Load

Beam casted with steel fibre is subjected to high ultimate load than control mix and hybrid fibre reinforced beam.

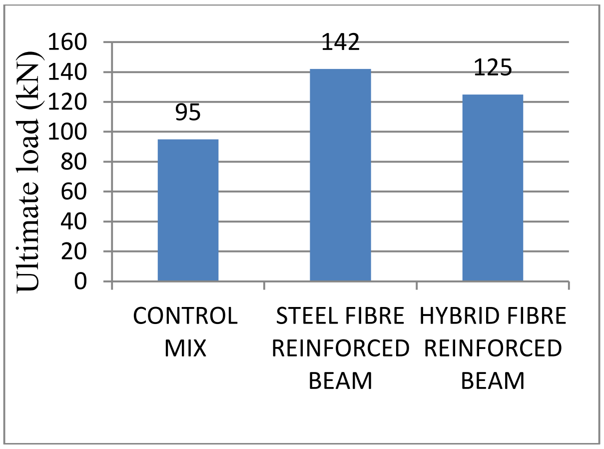

Fig. 9: Ultimate Load on Beams

ix. Ultimate Deflection

The ultimate deflection of the beam at mid span under static load is shown in Fig. 10. The steel fibre reinforced beam shows maximum deflection than control beam and hybrid fibre reinforced beam.

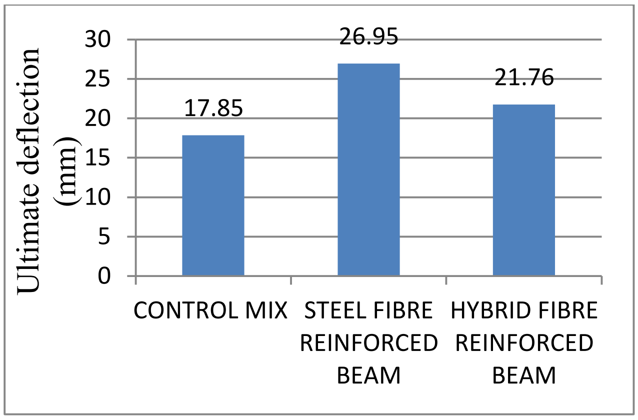

Fig. 10: Ultimate Deflection

x. Load And Deflection Behaviour

The steel fibre reinforced beam has an ultimate load of 142 kN, which is 49.47% higher than control mix and 13.6% higher than the hybrid fibre reinforced beam. The crack starts to propagate at the load of 30 kN for the steel fibre reinforced beam and it can withstand the higher deflection up to 26.95 mm.

IV. Conclusion

- From the experimental results, it was found that the compressive strength of control mix increased with the addition of steel fibres and shows better results for 2%.
- The addition of end hook steel fibres improves the crack resistance and strength of concrete.
- The addition of steel fibres shows better improvement in ductile properties of concrete.
- The relation between compressive strength and split tensile strength is given by the following expression,
- Split tensile strength = (0.0542* compressive strength) + 2.2228
- The relation between compressive strength and flexural strength is given by the following expression,
- Flexural strength = (0.0698* compressive strength) + 0.0039
- From the experimental and analytical results, it is obtained that the steel fibre reinforced beam has greater influence on compressive strength and load carrying capacity.

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