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AN EXPERIMENTAL STUDY ON BEHAVIOUR OF STEEL FIBRE REINFORCED CONCRETE BEAMS

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ABSTRACT:

Concrete is a relatively brittle material, when subjected to normal stresses and impact loads. As a result for these characteristics, plain concrete members could not support loads and tensile stresses that occurred, on concrete beams and slabs. Concrete members are reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. The addition of steel reinforcement significantly increases the strength of concrete, and results in concrete with homogenous tensile properties; however the development of micro cracks in concrete structures must be checked. The introduction of fibers is generally taken as a solution to develop concrete in view of enhancing its flexural and tensile strength. M40 grade of concrete are arrived with the following ingredients such as Cement, Fine aggregate, Coarse aggregate, Water, Steel fibre, Fly ash, Silica fumes and Superplasticizers. Then variables in this study include the steel fiber (Hooked end and crimpled) percentage in addition to the weight of cement. The Compressive strength, tensile strength and flexural behavior of steel fiber reinforced concrete beam with the varying percentage of fiber of M40 grade of concrete.

INTRODUCTION:

Concrete is weak in tension and micro cracks are developed in conventional reinforced concrete. To avoid the propagation of micro cracks in RCC, fibres are added as secondary reinforcement and it also improves the mechanical properties of concrete. The influences of hooked end fibres in conventional RCC will be studied in this project. The beams with fibres and without fibres are to be tested under monotonic loading, to study the behaviour of SFRC beams in the ultimate and post ultimate regions. Now a days natural disaster such as earthquake, wind force etc plays an important role in the construction industry. So buildings and other construction work should be designed in good manner, which resist higher loads and seismic forces. Ductility and energy absorption capacity are the main requirement of the earthquake resistant structure. Fibre reinforced concrete posses high strength, improved ductility and enhancing energy absorption capacity. So the study on the flexural behaviour of beams

LITERATURE REVIEW:

Mariappan Mahalingam et al presented the an experimental investigation conducted on Steel Fiber Reinforced Concrete (SFRC) beams with externally bonded Glass Fiber Reinforced Polymer (GFRP) laminates with a view to study their strength and ductility. The test results show that the beams provided with externally bonded GFRP laminates exhibit improved performance over the beams with internal fiber reinforcement. Banthia N concluded that the hardened state, when fibers are properly bonded, they interact with the matrix at the level of micro-cracks and effectively bridge these cracks thereby providing stress transfer media that delays their coalescence and unstable growth. This post peak macro-crack bridging is the primary reinforcement mechanisms in majority of commercial fiber reinforced concrete composites. Choi, E. et al conducted the experimental and analytical investigation on debonding of hybrid FRPs for flexural strengthening of RC beams is done. The debonding strength is also influenced by the arrangement of layers and the higher debonding strengths were achieved when a layer of CFRP is attached to the concrete prior to a GFRP layer. Mukesh Shukla conducted an experimental investigation of the behavior of concrete beams reinforced with conventional steel bars and steel fibres and subjected to flexural loading is presented. The ultimate loads obtained in the experimental investigation were also compared with the theoretical loads for all types of beams.

MATERIALS USED:

The materials used in this study is cement, fine aggregate- natural river sand, coarse aggregate- 20mm aggregate, fly ash, silica fume, steel fibers- hooked end & crimpled fiber, super plasticizers- conplast SP 430.

Cement:

Cement is a binding material in concrete that binds the ingredients into a compact mass. The chemistry of concrete is the chemistry of reaction between cement and water (i.e) hydration process. The hydration products are tricalcium silicate, calcium hydroxide and calcium aluminum hydrates which influence the proprties of concrete to a greater extent. Table 1 shows the Physical properties of ordinary Portland cement with 43 grade of cement.

Table 1 Physical properties cement

Type of Cement (Indian standard)	**Grade 43 IS :8112-1989**
compressive strength 28-days N/mm^2	44
Fineness	225
Setting time (min) Initial Final	 60 306

Flyash:

Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Mettur thermal power plant fly ash used for this study. Table2 shows the Composition of fly ash.

Table 2: Composition of fly ash

Component	**Proposition**
SiO_2 (%)	30
Al_2O_3 (%)	23
Fe_2O_3 (%)	10
CaO (%)	32
LOI (%)	5

Super plasticizer:

The super plasticizers was used as Conplast SP 430.

Steel fiber:

The fibres used in this project are Hooked End Fibres and Crimpled Fibre

Aggregate

Locally available fine and coarse aggregate is used for this study. Portable water is used in required proportions.

MIX PROPORTIONS:

WATER	CEMENT	F. A.	C. A.
160	400	660	701
0.45	1	1.65	2.92

Mix combination
M1 – C - 0.5%, SF - 0.1% and FA - 0.4%.
M2 - C - 0.5%, SF - 0.25% and FA - 0.25%
M3 – C - 0.5%, SF - 0.4% and FA-0.1%.
C – Cement, SF- silica fume and FA – fly ash.

TESTING OF CONCRETE:

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M40 grade of concrete. The moulds were filled with 0% and o.5% fibers by cement. Compressive strength (MPa) of concrete is the ratio of failure load to cross sectional area. For tensile strength test, cylinder specimens of dimension 100 mm diameter and 300 mm length were cast.

Flexural strength test

To investigate the ductile behavior of fibre reinforced high strength concrete beams, four full scale beams were cast and tested until failure under two point loading condition. The concrete used in the study had a compressive strength of 67MPa. All beams were 1.25m long with 150 width and 150mm depth. All beams were reinforced with 4 bars of 10mm dia giving a steel ratio of 0.9306 % having yield stress of 537MPa, and 8mm dia stirrups at 150mm spacing were also provided. Hook-ended steel fibres have a length of 30mm and diameter of 0.5mm and crimppled steel fibres have a length 12.5mm and diameter 0.5mm. (Aspect ratio – L/ϕ = 60 and 25) were added to the beams with different fibre volume fractions as 0%, 0.5%, 1.0%, 1.5% and 2.0%. Figure 1 and 2 show the geometry of beam and Flexural strength test setup for beam.

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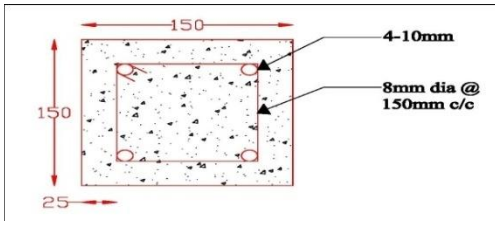

Figure 1 Geometry of beam

Figure 2 Flexural strength test setup for beam

RESULTS:

Compressive strength:

The compressive strength of concrete without steel fibre with various mix combinations is shown in table 4. Table 5 and 6 show the compressive strength of concrete with hooked end steel fibers and crimpled type steel fibre respectively.

Table 4 compressive strength of concrete without fibres

S. No	Mix Id	Days	Compressive Strength (N/mm^2)
1	M 1	7	25.1
		28	42.16
2	M 2	7	27.5
		28	44.2
3	M 3	7	30.5
		28	46.47

Table 4 showed the comparison of result of compressive strength of concrete without fibers using M40 grade of concrete. The compressive strength of the conventional concrete was 25.1 N/mm^2 and 42.16 N/mm^2 respectively at 7 days and 28 days for mix 1. Mix 3 possessed higher compressive strength than mix 2 and mix 3. The compressive strength of the mix 3 is **46.47 N/mm^2**.

Table 5 Compressive strength of concrete with steel fibers (Hooked end)

S. No	Aspect ratio	Hooked end fibre	Days	Compressive Strength (N/mm^2)
1	60	1.0%	7	31.43
			28	47.2
2	60	1.5%	7	33.3
			28	49.7
3	60	2.0%	7	35.3
			28	**51.7**

Table 5 shows that the result of compressive strength of concrete with fibers (Hooked end) using M40 grade of concrete. It is observed that for addition of 2.0% of hooked end Fiber gives **51.7 N/mm^2** slightly more compressive strength than 1.0% and 1.5% at different volume fraction.

Table 6 Compressive strength of concrete with steel fibers (crimpled type)

S. No	Aspect ratio	Hooked end fibre	Days	Compressive Strength (N/mm^2)
1	25	1.0%	7	33.1
			28	49.9
2	25	1.5%	7	35.3
			28	51.1
3	25	2.0%	7	36.7
			28	**53.2**

Table 6 showed result of compressive strength of concrete with fibers (crimpled type) using M40 grade of concrete. It is observed that for addition of 2.0% of crimpled type Fiber gives **53.2 N/mm^2** slightly more compressive strength than 1.0% and 1.5% at different volume fraction.

Split tensile strength

Table 7 showed the split tensile strength of concrete with conventional, crimpled and hooked fibre. The crimpled steel fibre of concrete possessed higher split tensile strength.

The split tensile strength of conventional and crimpled steel fibre concrete are 3.15 N/mm^2 and 3.68 N/mm^2 respectively.

Table 7 test result of split tensile strength

S. No	Description	Days	Tensile Strength (N/mm^2)
1	Conventional Mix	7	3.03
2		28	3.15
3	Crimpled 2 % Fibre Aspect ratio -25	7	3.25
4		28	3.68

Table 7 showed comparison of result of split tensile strength of concrete with fibers (crimpled type) using M40 grade of concrete. It is observed that for 2.0% of crimpled Fiber gives **3.68 N/mm^2**.

Flexural strength test

Table 8 shows the load with deflection values of control and crimpled fibre concrete.

Table 8 Load Vs Deflection value of control and steel fibre beam

Load (KN)	Deflection in mm	Deflection in mm
	conventional	Steel fibre
0	0	0
10	0.97	0.25
20	2.26	0.85
22.5	2.54(initial)	0.93
25	2.79	1.08(initial)
30	3.35	1.32
40	4.53	2.04
50	6.75	2.94
60	8.72	3.94
65	9.42(ultimate)	4.46
67.5		4.67
70		4.83
72.5		5.18
75		5.51(ultimate)

From table showed the load carrying capacity of fiber beam is more as compare to normal beam and it is also having high deflection. Initial cracks appear is also taken more loads as compare to normal beams.

CONCLUSION:

From experimental results it is studied that

- The optimum dosage of silica fumes (0.4%), fly ash (0.1%) by partial replacement of cement for this study.
- The addition of steel fibers in concrete, the compression strength has increased by **53.2 N/mm^2.**
- The addition of steel fibers in concrete, the split tensile strength has increased by **3.68 N/mm^2.**
- Deflection in fiber beams is less when compared to control beam. At load of 65KN, the deflection for control beam is 9.42mm where as in fiber beam deflection is 5.51mm.
- This experimental investigation helps to strengthen the beam using fiber.
- Addition of steel fibers reduces bleeding and it improves the surface integrity of concrete. Also it increase the homogeneity and reduces the probability of cracks.
- This experimental investigation helps to know the properties and behavior of steel fiber reinforced concrete.

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