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A Study on Steel Fiber Reinforced Normal Compacting Concrete

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ABSTRACT
Plain concrete which is strong in compressive strength possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete due to drying, shrinkage and poor tensile strength, eventually leading to brittle fracture of concrete. Hence fibres are added to concrete to overcome these disadvantages. Fibre Reinforced Concrete (FRC) is a concrete composite of cement, fine and coarse aggregate and fibres with different proportions. In plain concrete, micro cracks develop even before loading, particularly due to drying, shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds few microns. When loaded the micro cracks propagate and open up, due to the effect of stress concentration additional cracks form in place of minor defects. Fibres enable concrete to progress from plastic state to hardened state without weakness. This is achieved by the reduction of micro crack formation, reduced segregation and decreasing the scope of capillary formation, thus reducing permeability. Generally, fibres are chosen depending upon the aspect ratio.
Out of all types of fibres, steel fibres are mostly used because steel has high modulus of elasticity, high elongation, high tensile strength and the bond between steel and the fibre is enormous. The present experimental investigation was carried out to evaluate the influence of steel fibres on physical and mechanical properties of concrete, containing cold drawn carbon steel fibres of hooked end type having aspect ratio of 50 with diameter 0.6mm and length 30mm with varying percentages of 0.5%, 1%, 1.5% and 2.0% volume fraction is added to the concrete. Concrete is evaluated for compressive, split tensile and flexural strength at 7, 28 and 90 days, with the addition of 1.5% fibres, test results show the maximum compressive, split tensile and flexural strength, it becomes the optimum value. Split tensile and flexural strength of concrete is done only up to 1.5% volume. Moreover, the results confirmed that the steel fibre reinforced concrete reduce cracking and improves flexure.
***Keywords**:* workability, strength, steel fiber, aggregate and cement

I. INTRODUCTION

Fiber reinforced concrete is a composite material essentially consisting of conventional concrete or mortar reinforced by randomly oriented, short continuous and discrete fibers of specific geometry. The fiber is a piece of reinforcing material usually described by aspect ratio. Aspect ratio is the ratio of length to diameter of fiber. The quantity of fiber is specified by volume fraction. These fibers act as crack arrestors, thereby increasing first crack strength and also ultimate strength. This chapter tries to bring some basic information on the subject and the objective of the study is reported.

II. LITERATURE REVIEW

Siddique R. and Kukreja C.B. Carried out investigation on "Properties of san fiber reinforced high fly ash concrete". In this investigation to study the effects of replacement of cement by mass with three percentage of high fly ash content, and the effect of addition of san fibers on the slump, vipe time, compressive strength, split tensile strength and compressive stress strain behavior of high fly ash concrete are studied. Cement has been replaced by mass with 40%, 45%, and 50% of fly ash content three percentages of san fibers (0.25%, 0.5% and 0.75%) of 25mm in length have been used in this investigation. The test results indicated that replacement of cement with fly ash increased the workability (slump and Vee bee) and decreases compressive strength, split tensile strength and static modulus of plain concrete. Addition of san reduced the workability does not significantly affect the compressive strength, and increased the split tensile strength of high fly ash concrete with an increase in percentage of fibers. San fibers are reported not to have significant effect on the static modulus of high fly ash concrete was found to increase with an increase in fiber percentages.

III. EXPERIMENTAL DETAILS

The present work is made to investigate experimentally and the following tests are carried out, namely compressive strength, split tensile strength and flexural strength tests. These experimental investigations comprises the addition of steel fiber with 0.5, 1.0, 1.5 and 2.0 percentages by total volume and have been attempted over the concrete specimens such as cubes, cylinders and beams respectively. The program consists of casting and testing of specimens for various mixes. A detailed test program and results of testing are presented in this paper.

Properties of the materials:
Cement: Ordinary Portland Cement (OPC) of 53 Grade from a single lot was used throughout the course of the investigation. It was fresh and without any lumps. The specific gravity and fineness of cement are 3.07 and 5.62.

Coarse Aggregate: Crushed granite angular aggregate of size 20mm are used and the aggregates are free from dust before used in the concrete. The specific gravity and fineness modulus are 2.74 and 7.28 respectively.

Water: This is the least expensive but most important ingredient of concrete. A good thumb rule to follow is that if water is pure enough for drinking it is suitable for mixing concrete. Locally available portable water was used for mixing and curing.

Steel fibers: The cold - drawn carbon steel fibers (hooked end type) of equivalent diameter 0.6 mm and 30 mm long with aspect ratio of 50 were used in concrete.

Specimen Details: Cube specimen of size 150mm x 150mm x 150mm for compressive strength, Cylinder specimen of diameter 150 mm diameter x 300 mm height and prism of size 100mm x 100mm x 500mm were cast to study the mechanical strength properties such as compressive, split tensile and flexural strength according to Indian standards.

Mix Proportion: Cement: Fine aggregate: Coarse aggregate = 1: 1.9596: 2.6793, with a constant water/cement ratio is 0.46, as shown in table:1.

Table: 1 Details of Mix Proportion

S. No	**Mix Id.**	**Volume of fiber (%)**	**Steel fiber (kg/m³)**	**Cement (kg/m³)**	**W/C-ratio**	**Water (liters)**	**Fine aggregate (kg/m³)**	**Coarse aggregate (kg/m³)**
1.	M0	0.0	--	396	0.46	182	776	1061
2.	M1	0.5	12.10	393.92	0.46	181.2	772.08	1055.7
3.	M2	1.0	24.18	391.94	0.46	180.29	768.20	1050.39
4.	M3	1.5	36.24	389.96	0.46	179.38	764.32	1045.09
5.	M4	2.0	48.33	387.98	0.46	178.47	760.44	1039.78

IV. RESULTS AND DISCUSSION

The concrete specimens using cold-drawn carbon steel fibres are prepared in the laboratory have been tested as per the standard specifications. Observations of slump and compaction factor in respect of fresh concrete are noted. The results of the compressive strength, split tensile strength and flexural strength for M25 grade of concrete with addition of 0%, 0.5%, 1%, 1.5% and 2% percentage volume of fibre content at 7, 28 and 90 days are reported. The graphs are plotted based on the test results.

Table: 2 Fresh Properties

S.No	**Mix Id.**	**Volume of fiber (%)**	**Slump (mm)**	**Compaction factor**
1.	M0	0	80	0.9
2.	M1	0.5	75	0.91
3.	M2	1	65	0.93
4.	M3	1.5	50	0.94
5.	M4	2	30	0.98

Table: 3 Hardened Properties

S. No	Mix Id.	Volume of fiber (%)	Compressive strength (MPa)			Split tensile strength (MPa)			Flexural strength (MPa)		
			7d	28d	90d	7d	28d	90d	7d	28d	90d
1.	M0	0.0	28.3	32.92	39.24	1.94	2.5	2.94	5.00	6.25	7.25
2.	M1	0.5	30.22	35.31	44.90	1.98	2.68	3.26	5.25	6.75	8.75
3.	M2	1.0	31.8	38.58	49.12	2.08	2.84	3.46	5.50	7.00	9
4.	M3	1.5	33.13	40.83	51.01	2.15	2.91	3.65	5.70	7.25	9.75
5.	M4	2.0	32.77	39.82	50.14	--	--	--	--	--	--

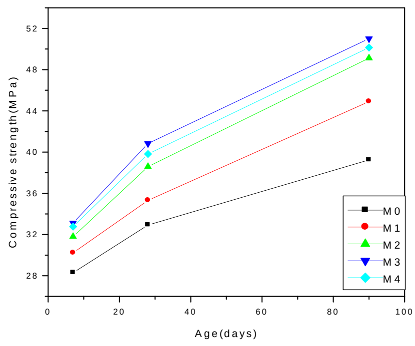

Fig.1 Compressive strength Vs. Age

It was observed that the compressive strength of 0.5% SF at the age of 7, 28 and 90 days has increased by 14.9%, 7.26% and 14.42% respectively when compared with M0, It was observed that the compressive strength of 1% SF at the age of 7, 28 and 90 days has increased by 20.91%, 17.19% and 25.17% respectively when compared with M0. It was observed that the compressive strength of 1.5% SF at the age of 7, 28 and 90 days has increased by 25.96%, 24.02% and 29.9% respectively when compared with M0, It was observed that the compressive strength of 2% SF at the age of 7, 28 and 90 days has increased by 13.64%, 17.33% and 21.74% respectively when compared with M0, as shown in Fig.1.

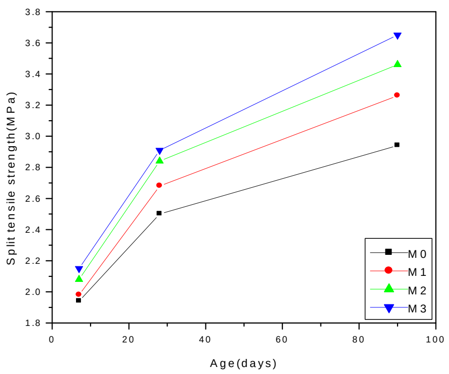

Fig.2 Split tensile strength Vs. age

It was observed that the split tensile strength of 0.5% SF at the age of 7, 28 and 90 days has increased by 2.06%, 7.2% and 10.88% respectively when compared with M0, It was observed that the split tensile strength of 1% SF at the age of 7, 28 and 90 days has increased by 7.21%, 13.6% and 17.68% respectively when compared with M0, It was observed that the split tensile strength of 1.5% SF at the age of 7, 28 and 90days has increased by 10.82%, 16.4% and 24.14% respectively when compared with M0, as shown in Fig.2.

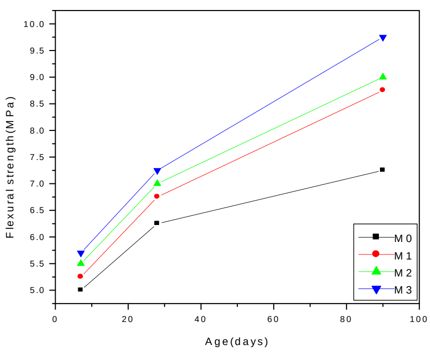

Fig.3 Flexural strength Vs age

It was observed that the flexural strength of 0.5% SF at the age of 7, 28 and 90 days has been increased by 5%, 8% and 20.68% respectively when compared with M0, It was observed that the flexural strength of 1% SF at the age of 7, 28 and 90days has increased by 10%, 12% and 24.13% respectively when compared with M0, It was observed that the flexural strength of 1.5% SF at the age of 7, 28 and 90days has increased by 22.4%,16% and 34.48% respectively when compared with M0, as shown in Fig.3.

V. CONCLUSIONS

On the basis of experimental studies carried out and the analysis of test results, the following conclusions are drawn.

The fibrous concrete is found to have maximum ultimate load carrying capacity and is stiffer than the conventional concrete.

It is observed that the compressive strength, split tensile strength and flexural strength for M25 grade of concrete from different Volume Fraction (VF) of fiber increases with increase of percentage of steel fiber VF.

By the addition of 1.5% fiber, test results shows maximum compressive strength and it becomes the optimum value.

As the value of compressive strength decreases at 2% VF, spilt tensile strength and flexural strength is done only up to 1.5% VF.

Maximum increase in compressive strength obtained at 0.46 w/c ratio with 1.5% of fiber is 33.13MPa which is 25.96% more than the reference mix at the age of 7 days.

Maximum increase in compressive strength obtained at 0.46 w/c ratio with 1.5% of fiber is 40.83 N/mm^2 which is 24.02% more than the reference mix at the age of 28 days.

Maximum increase in compressive strength obtained at 0.46 w/c ratio with 1.5%of fiber is 51.01 N/mm^2 which is 29.9% more than the reference mix at the age of 90 days.

Maximum increase in split tensile strength obtained at 0.46 w/c ratio with 1.5% of fiber is 2.15 N/mm^2 which is 10.82% more than the reference mix at the age of 7 days.

Maximum increase in split tensile strength obtained at 0.46 w/c ratio with 1.5% of fiber is 2.91 N/mm^2 which is 16.4% more than the reference mix at the age of 28 days.

Maximum increase in split tensile strength obtained at 0.46 w/c ratio with 1.5% of fiber is 3.65N/mm^2 which is 24.14% more than the reference mix at the age of 90 days.

Percentage increase of compressive strength of SFRC is less in 28 and 90 days when compared with 7 days.

There is an increase in percentage of split tensile and flexural strength of SFRC in both 28 and 90 days when compared with 7 days.

Addition of steel fiber in the concrete effect the workability of concrete. Addition of 0.5%, 1%,1.5% and 2% steel fibers reduces the slump value and increases the compaction factor of fresh concrete. This problem of workability and flow property of concrete can be overcome by using suitable admixtures such as Super plasticizers.

The ductility characteristics were found to improve by adding steel fibers to concrete.

The crack widths in fibrous concrete are less when compared to conventional concrete and these fibers act as crack arresters in concrete.

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