Effect of Steel Fibres on Compressive & Tensile Strength of Concrete using M -Sand as Fine Aggregate

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***Abstract*—This paper describes the experimental study of fibre reinforced concrete with manufacturing sand (M-Sand) in addition of crimped steel fibres. To over-come the difficulties due to excessive sand mining, M-Sand is used as fine aggregate. M-Sand is uniformly in size, produced from gravel crushers.**

The main objective of this research is to investigate the effect of steel fibres on concrete manufactured by M-sand as fine aggregate and develop a high performance concrete. It is proposed to determine and compare compressive strength and tensile strength of the concrete grades M25 & M30 having different percentage of steel fibre (0%, 1%, 1.5% & 2%). The chemical admixtures is used to increase the workability of concrete. The experimental investigation is carried out on a total no of 96 specimen by conducting compressive strength test and, and split tensile test.

Keywords—M-Sand, steel fibre, crimp steel fibre, compression test & split tensile test.

I. INTRODUCTION

Concrete plays a major role in the construction industry and a large quantum of concrete is being utilized. River sand, which is one of the constituent used in the production of conventional concrete, has become expensive and also a scarce material. River sand becoming a scare commodity and hence exploring alternatives to it has become imminent. Depletion of the virgin natural river sand is the main issue concerning the construction industry. And also the biggest challenge. The objective of the present study is to examine the suitability of M-Sand as fine aggregate in concrete and an attempt is made to evaluate the effect of the steel fibres on concrete grade of M-25 & M-30 prepared by M-Sand.

Stone crushed in require grain size is called M-Sand. Manufacturing of M-Sand process involves three stages, crushing of stones in to aggregate by vertical shaft impact (vsi), then fed to Rotopactor to crush aggregate into sand to required grain size. Screening is done to eliminate dust particles and washing of sand eliminates very fine particles present within. The end product will satisfy all the requirements of IS: 383-1970 and can be used in concrete.

The formation of cracks is the main reason for the failure of the concrete. To increase the tensile strength of concrete, many attempts have been made. One of the successful and most commonly used method is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encountering are bar. Thus need for multidirectional and closely spaced steel reinforcement arises. That cannot be practically possible. Fibre reinforcement gives the solution for this problem so to increase the tensile strength of concrete a technique of introduction of fibres in concrete is being used. These fibres act as crack arrestors and prevent the propagation of the cracks. These fibres are uniformly distributed and randomly arranged in the concrete mass. This concrete is named as fibre reinforced concrete.

In this present study fully replacement of natural sand by M-sand and using different percentage of steel fibres had taken in both concrete mix M-25 & M-30. Total 96 specimen were casted for both grade of concrete. 48 cube specimen of size 150 × 150 × 150 mm and 48 cylinder specimen 150mm dia. × 300 mm height were casted and tested for both concrete mix.

Note: In this paper, 0M-25 like these type of abbreviations first initial denotes the percentage of steel fibre and M is stand for mix and last two digit denotes the grade of concrete.

II. MATERIAL USED

The materials usually used in the concrete mix are cement, M-Sand as fine aggregate, coarse aggregate, admixture and crimped steel fibre.

A. Cement:

Ordinary Portland cement of 53 grade was used in this experimentation conforming to I.S. – 12269-1987.

TABLE I. Properties of cement

No.	Property	Value observed in Investigation	Standard value for OPC
1	Fineness (%)	1.66	Not exceed 10 %
2	Specific Gravity	3.15	-
3	Initial setting time (min.)	65	>30 min
4	Final setting time (min.)	290 min	<600 min
Compressive strength			
1	3 days	28.58	>27
2	7days	45.81	>37
3	28 days	56.21	>53

B. Fine aggregate:

M-Sand is used as fine aggregate and conforming to IS: 383.

TABLE II Properties of M-Sand

Sr.no	Property	Value
1	Specific Gravity	2.61
2	Fineness modulus	3.35
3	Water Absorption	4.52
4	Zone	I
5	Surface texture	smooth

C. Coarse aggregate:

Coarse aggregate of nominal size of 20mm & 10mm are chosen and tests to determine the different physical properties as per IS 383-1970.Test results conform to IS: 383 part-III

TABLE III. Properties of coarse aggregate

PARTICULARS	**C.A-I**	**C.A-Π**
Maximum size of aggregate (MSA)	10 mm	20mm
Specific gravity	2.71	2.85
Water absorption	3.3	1.1

D. Steel Fibre

Additionally, a commercial crimped steel fibre with a length and a cross section of 50mm and 0.5 mm respectively, and with an equivalent aspect ratio 100 were added into the both mix.

Taking into account the workability problem (balling and clumping of fibres) of composites associated with the addition of fibers and cost effectiveness, maximum dosage of fiber in concretes

was limited to 2%.

E. Admixture

An admixture is defined as a material, other than the cement, water and aggregate, used as an ingredient of concrete and is added to the batch immediately during mixing. An admixture CONPLAST SP430 of FOSROC was used. It is based on Sulphonated Naphthalene Polymers and supplied as a brown liquid instantly dispersible in water. Its specific gravity is 1.2 to 1.225 at 30^0C temperature. It is non-flammable. CONPLAST SP430 complies with IS: 9103:1999 and IS2645:1975

F. Water

Water is an important ingredient of concrete as it initiates the chemical reaction with cement, and the mix water was completely free from chlorides and sulphates. Ordinary potable water was used throughout the investigation as well as for curing concrete specimens.

III.CONCRETE MIX DESIGN

The concrete used for the study which grades were M-25 & M-30 Concrete was designed to achieve this strength (31.6 N/mm^2 & 38.25 N/mm^2 target mean strength respectively) at 28days.

The concrete mix design was carried out by using IS 10262:2009 and IS 456:2000.The mix design was done on a trial and error basis performing variations and combinations with the aggregate and cement content, so as to achieve the desired target strength. The targeted slump to be achieved was in the range 50-100mm. CONPLAST SP-430 super plasticizer was used as admixture in the concrete. Proportion of mix for M-25 & M-30 were 1:2.13:2.18:1.38 & 1:1.89:1.94:1.133 [C: F.A: (C.A 20mm): (C.A 10mm)] respectively.

VI.TEST ON HARDENED CONCRETE

1. Compressive strength
2. Tensile strength

A. COMPRESSIVE TEST

Cube specimens of dimensions 150 x 150 x 150 mm were casted for M-25 & M-30 grade of concrete. Super plasticizer (1.0% by weight of cement) was added during mixing. Percentage of steel fibres 0%, 1% 1.5% and 2% by weight of concrete mix are add during the mixing but before addition of water. The compaction of the concrete mould was carried out by using table vibrator. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank. Where, concrete mould were cured for 7 days & 28 days by ponding method. After 7days & 28 days curing, these cubes were tested on 2000 T capacity of digital compression testing machine. The specimen was subjected to uni-axial loading at rate of 140 $kg/cm^2/min$ as per I.S. 516-1959. The failure load was noted. In each category three cubes were tested and their average value is reported. The compressive strength was calculated as follows.

- Compressive strength (MPa) = Failure load / cross sectional area of cube specimen.

B. SPLITING TENSILE TEST

In Split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These specimens were tested under compression testing machine. Load on applied on cylinder, by keeping it in lateral position along its length;in between two hardened steel plates, one at top and other under the specimen. The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2 N/ (mm^2/min) to 2.4 N/ (mm^2/min). In each category three cylinders were tested and their average value is reported.

- Split Tensile strength was calculated as follows as split tensile strength: Split Tensile strength (MPa) = $2P / \pi dl$, Where, P = failure load, d = diameter of cylinder, l = length of cylinder

V.RESULTS AND DISCUSSION

A. Compressive strength

Results of Compressive strength for M-25 & M-30 grade of concrete on cube specimen with 0% , 1.0%, 1.5% & 2% steel fibers for both mixes are shown in table and graph below:

TABLE IV. Average compressive strength of concrete grade M-25 & M-30

Specimen id	Percentage of steel fibre	Avg.Compressive strength of concrete grade M-25 & M-30		Increase percentage of compressive strength	
		7days	28 days	7 days	28 days
0.0M-25	0.0	21.29	31.38	ref	ref
1.0M-25	1.0	23.90	33.12	12.26	5.55
1.5M-25	1.5	24.16	34.09	13.48	8.63
2.0M-25	2.0	23.37	33.04	9.77	5.28
0.0M-30	0.0	23.96	38.64	ref	ref
1.0M-30	1.0	28.62	42.395	9.71	9.72
1.5M-30	1.5	30.39	43.46	12.47	12.48
2.0M-30	2.0	26.52	43.09	11.51	7.7

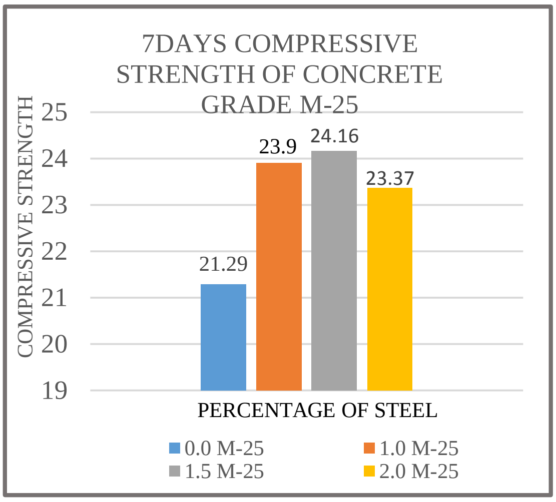

Fig.1.Average Compressive strength of concrete grade M-25 at 7 days

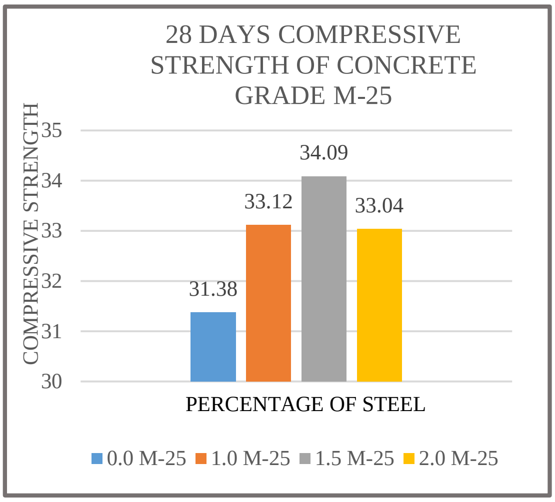

Fig.2.Average Compressive strength of concrete grade M-25 at 28 days

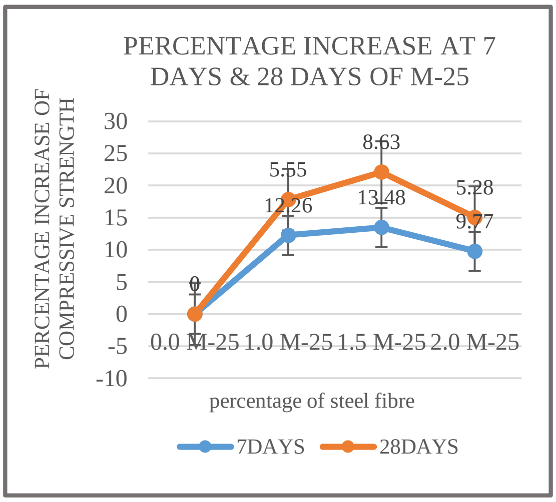

Fig.3. Percentage of compressive strength of concrete grade M-25 increased at 7days and 28 days

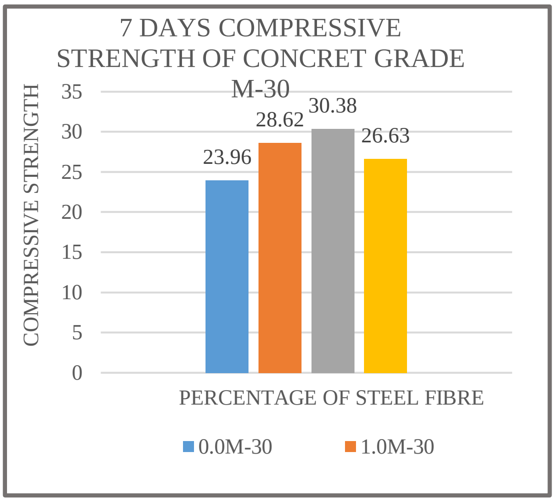

Fig.4.Average Compressive strength of concrete grade M-30 at 7 days

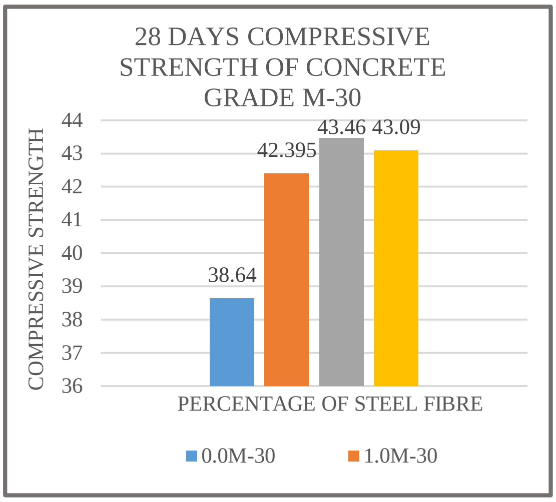

Fig. 5. Average Compressive strength of concrete grade M-30 at 28 days

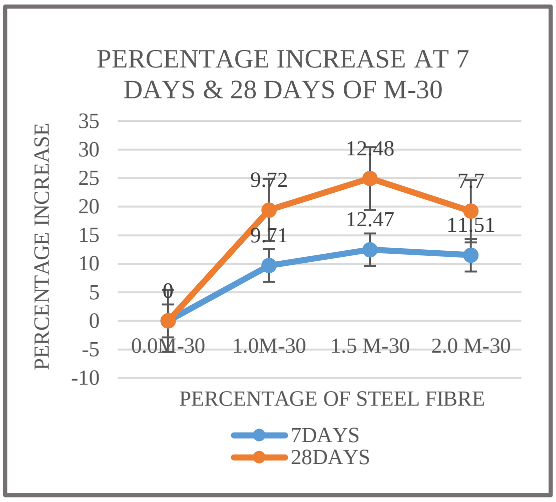

Fig.6. Percentage of compressive strength of concrete grade M-30 increased at 7days and 28 days

B. *Tensile strength*

Results of splitting tensile strength for M-25 & M-30 grade of concrete with 0%, 1.0%, 1.5% & 2.0%crimped steel for both mixes are shown in table and graph below:

TABLE V. Average tensile strength of concrete grade M-25 & M-30

Specimen id	Percentage of steel fibre	Avg.Compressive strength of concrete grade M-25 & M-30		Increase percentage of compressive strength	
		7 days	28 days	7 days	28 days
0.0M-25	0.0	21.29	31.38	ref	ref
1.0M-25	1.0	23.90	33.12	12.26	5.55
1.5M-25	1.5	24.16	34.09	13.48	8.63
2.0M-25	2.0	23.37	33.04	9.77	5.28

0.0M-30	0.0	23.96	38.64	ref	ref
1.0M-30	1.0	28.62	42.395	9.71	9.72
1.5M-30	1.5	30.39	43.46	12.47	12.48
2.0M-30	2.0	26.52	43.09	11.51	7.7

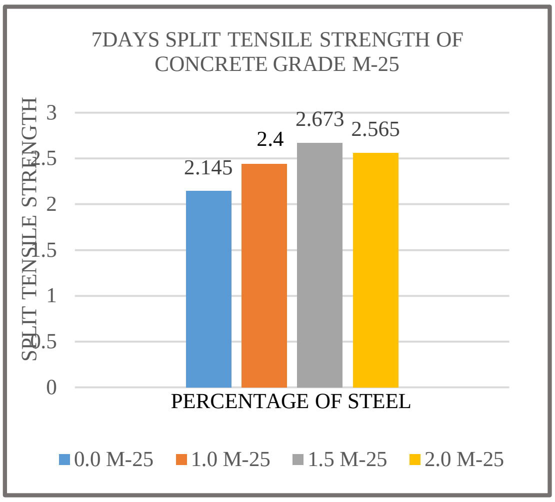

Fig.7.Average split tensile strength of concrete grade M-25 at 7 days

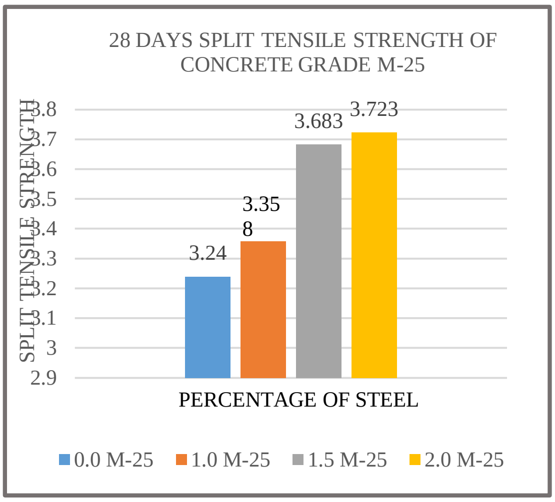

Fig.8.Average split tensile strength of concrete grade M-25 at 28 days

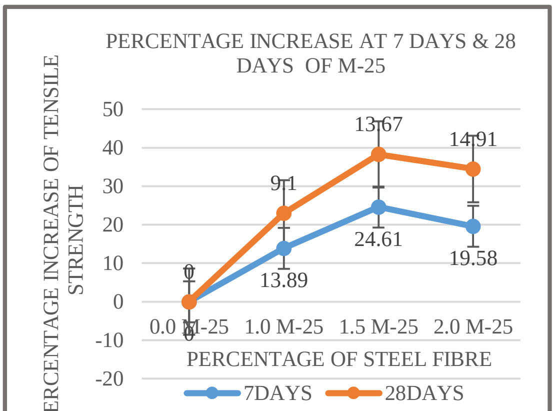

Fig.9. Percentage of compressive strength of concrete grade M-25 increased at 7days and 28 days

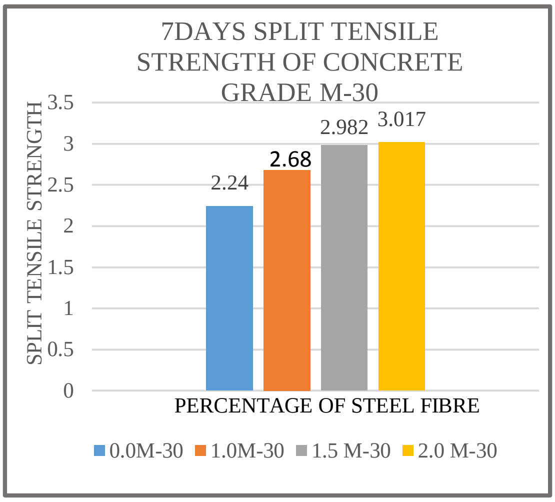

Fig.10. Average split tensile strength of concrete grade M-30 at 7 days

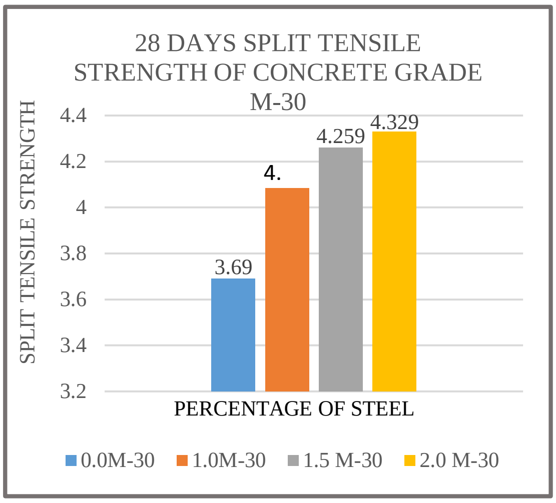

Fig.11. Average split tensile strength of concrete grade M-30 at 28 days

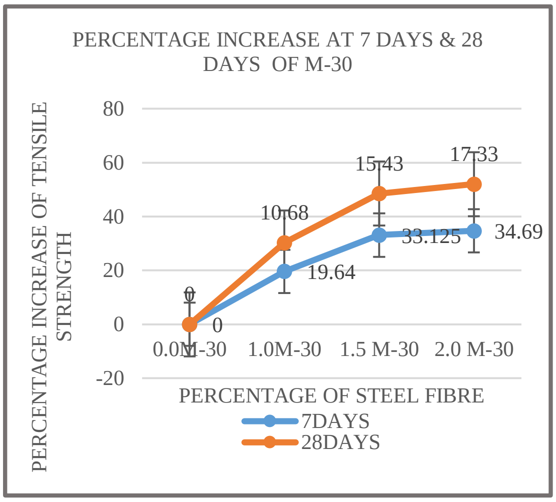

Fig.12. Percentage of split tensile strength of concrete grade M-30 increased at 7days and 28 days

VI.CONCLUSION

Based on the experimental investigation the following conclusions are given within the limitations of the test results.

- Addition of crimped steel fibres, resulted in significant improvement on the strength properties of concrete with M-Sand used as fine aggregate.
- Compared to plain concrete, the fibre addition resulted in better matrix strengthening and enhanced compressive & tensile properties of concrete.
- The reinforcing efficiency of fibre addition was dependent on the optimum dosage level of steel fibre up to 1% to 1.5 % of crimped steel fibres since increased fibre addition resulted in loss in workability.
- Unrestricted failure of plain concrete specimens was restricted with volumetric bulging due to presence of fibres and gradual release of fracture energy was anticipated.
- The maximum increase in compressive strength (34.09 & 43.46MPa) was observed of concrete grade M-25 & M-30 respectively at 1.5% of crimped steel fibres.
- in the case of 1.5% crimped steel fibre compressive strength was increased maximum up to 13.48% & 12.47% corresponding to both grade of concrete M-25 & M-30 at 7days compared to the reference concrete (21.29 & 23.96 MPa) same as increase max compressive strength 8.63% & 12.48 % separately for both mixes with respect to 0.0M-25 0.0M-30 at 28 days.
- Compressive strength was decreased of both concrete grade in the case of 2% steel fibre were used.
- Tensile strength is continuously increased with increasing the percentage of steel fibre and maximum tensile strength was achieved in the case of 2% steel fibre for both grade of concrete M-25 and M-30. These was occurred due to ultimately we provide the reinforcement to the concrete.
- A maximum split tensile strength of 3.723 & 4.329 MPa was observed with 2% steel fibre concrete (28 days) at a maximum volume fraction of steel fibre which was compared to reference concrete and the roles of fibres in delaying the crack formation with subsequent increase in strength were realized.
- The compressive and split tensile strength for all mix proportions of fibre content showed a favourable improvement in the strength properties due to crack arresting mechanism of fibres at different scales of cracking.
- Interaction of steel fibres with concrete were realized in fibre reinforced concrete which provided a maximum crack tie together and stress transfer mechanism to yield a superior performance.
- Effect of crimped steel fibres on both grade of concrete is almost same, some variation may occurred because of fibre is uniformly distributed but randomly oriented.

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