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A Study on Compressive and Flexural Strength of Concrete using Steel Fibres

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***Abstract*— Concrete is widely used in Civil Engineering, but it is used in the cases where the nature of forces/loads are compressive, and in the case where the forces/loads are tensile in nature then it is required to enhance the tensile strength of concrete. Generally we use steel rebar in concrete for enhancing the tensile strength of concrete. In this study steel fibres were used for enhancing the tensile strength of concrete, and the effect of steel fibres in the properties of concrete, like its effect in the workability, flexure strength and compressive strength of the concrete.**

Keywords*— *Steel Fibre; Ductility; Compression Strength;Stress Strain;Workability:Flexure Strength

I. INTRODUCTION

The inadequate tensile strength of concrete causes sudden failure of concrete and sometimes tensile cracks may develop. To armament the material in respect of flexural strength we have used steel rebar in concrete. In the present study we concentrated on steel fibres to intensify the tensile strength of the concrete, and its effect on the auxiliary properties of the concrete, special emphasis has been given on the three properties i.e. workability, flexural strength and compressive strength of the concrete.

Workability is an important parameter in concrete designing; basically it depends on the several factors like aggregate scale, water cement scale. And in this case where a steel fibres reduce the quantity of aggregates, therefore it is necessary to check the effect of steel fibre on the workability of concrete.

Flexural strength is correlated with the tensile strength of concrete, for checking the flexural strength of concrete some sample of unreinforced beam were made and Center-Point load and Third-Point load was applied on the beam and deflection was measured.

Compressive strength is the utmost paramount constant. Compressive strength of concrete directly depends on the material which are used for making the concrete. Compressive strength of constant was tested in the workshop as per the Indian code provision. Two types of test are generally done for determining the compressive strength of the concrete. Both the tests are similar to each other , the only difference is that shape of concrete sculpts. In cylindrical test the exemplar is casted on cylindrical sculpt, and in cubical test the exemplar is casted on cubical sculpt.

II. STEEL FIBRES

Steel fibres are the fibres of steel, and steel fibre reinforced concrete is a composition of binding material especially cement, and aggregate both fine and coarse aggregate and small percentage of steel fibre are added in it. Steel fibres are used to enhance abnormally the flexural Strength. Over percentage of Steel fibre skeptically distressed the auxiliary holdings of concrete.

Steel Fibre has a good tensile tenacity .It ranges between 200 to 2600MPa, and in terms of traditional Reinforced cement concrete Steel fibre reinforced concrete is 2 to 3 times more tensile. Generally the steel fibres are produced from the types of steel, which are as cold drawn sheets, cut sheet, and milled blocks, Melt extracted.

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III. PROPERTIES OF STEEL FIBRES[1]

Generally the properties of steel fibres are similar to the properties of types of steel from which fibres are extracted.

Following table illuminates the properties of Steel Fibre.

TABLE I. Properties

S.No	Parameter	Value
1	Relative Density	7.80
2	Diameter	100-1000(µm)
3	Tensile Strength	200-2600 Mpa
4	Modulus of elasticity	210000 Mpa
5	Strain Failure	0.5-3.5

IV. METHODOLOGY

In this extant research endeavor the following approaches embraces.

Mix Design= Concrete mix designing were done as per the relevant Indian Standard codes. For mix designing the ingredients of following parameters were used.

Cement = Cement is the crucial constant in this designing. Assorted categories of cement is attained from the market according to the requirement .In this preparatory endeavor we had used grade 43 cement.
And following test are done on it.

A. Normal Consistency= This is the most crucial test on the cement because normal consistency test tells us about how much amount of water is required by the cement to fully hydration. From the test we found out that normal consistenty of 43 grade cement was about 29%.

B. Initial Setting Time : Initial setting time is the time when cement starts to attain plasticity , it calculated from the time when water is added to the cement . From the vicat appratus we found that initial setting time of cement was about 33 minutes.

C. Final Setting Time: Final setting time is the time when cement fully attains the plasticity it includes the time of initial setting time.From the test we found out that 623 minutes was the time taken by the 43 grade cement to fully attains the plasticity.

D.Compressive Strength Test: For the Compressive strength the consecutive gears were used.

Table II. Apparatus

S.No	Item	Range
1	Mould	70.6*70.6*70.6 mm
2	Balance	1000 g
3	Tamping Rod	10 mm diameter
4	CTM	-

After 7 days testing the compressive strength of cement was found about 41.2 Mpa.
After conducting the above explained test we had taken fine aggregate and coarse aggregate according to the Indian Standard particularization for mix design.

E. Fine Aggregate: Bureau of Indian Standards defines that fine aggregate are those aggregates which passes through 4.75 mm aggregate and BIS further classified the fine aggregate into four categories.
1. Natural Sand: The sand produce due to the putrefaction of rocks is known as natural sand or in simple word we can say when rock losses cohesion then natural sand is formed. It is available on the banks of rivers.
In the present research work we used this sand. Sieve analysis test was performed and the following result had arrived.

Table III. Sieve Analysis

S.No	Sieve Used	Percentage of Sand Passed
1	4.75	96.4
2	2.36	91.2
3	1.18	73.5
4	600µ	52.4
5	300µ	30.7
6	150µ	9.8
7	Pan	0.0

2. Stone Crushed Sand: Stone Crushed sand is also known as sand. This type of sand is generally produced by the crushing of stones in crusher.

3. Gravel Crushed Sand: Process of formation of this type of sand is similar to stone crushed sand, but in the gravel crushed sand gravels are crushed in crusher.

F. Coarse aggregate: It is desirable to take maximum size of aggregate but in no case it is larger than 1/4th of the smallest thickness of member[2]. In our study we used the aggregate of size between 10mm to 20mm.

Table IV. Sieve Test for Upper limit of Coarse Aggregate

S.No	Sieve Size	Percentage of aggregate passed
1	40 mm	100
2	20 mm	89.68
3	10 mm	0.70
4	4.75 mm	0.04

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Table V. Sieve Test for Lower limit of Coarse Aggregate

S.No	Sieve Size	Percentage of aggregate passed
1	40 mm	100
2	20 mm	100
3	12.5 mm	100
4	10 mm	92.6
5	4.75 mm	7.77

G. Steel Fibres: In this study steel fibre in the form of hooked was used which had the below described properties.

Table VI. Properties of Steel Fibre (Hooked)

Parameter	Specification
Diameter	0.75 mm
Length	50.00 mm
Tensile Strength	1195 Mpa
Aspect ratio	67.00

Fig 2: Steel Fibre

V. DESIGN ANALYSIS

Concrete mix design was prepared as per the particularization available in the IS: 10262-2009 and IS 456:2000.
A few stipulation of Mix design are as follows.

A. Compressive Strength: The minimal Compressive strength for civil work.
B. Workability: Proper workability for appropriate compaction and stand of concrete.
C. Cement Quantity: Mix design was done by considering ultimate quantity of cement.

For M 30 grade of concrete mix design was prepared by taking different application of Steel fibre. The amount of steel fibres was increased by 0.5 percent for every new design. First amount of steel fibre was taken 0.5 percent and it increased up to 2 percent.

Table VII. Material Specification

S.No	Material	Specification/ Grade/Size
1	Cement	43 Grade
2	Concrete Grade	M30
3	W/C ratio	0.40
4	Sand Zone	II

Then Targeted strength of concrete is calculated from the formula as given in IS 456-2000.
$T_s = fck + K\,\sigma$
Where T_s= Targeted strength
f_{ck} = characteristic strength
K = a constant, derived from mathematical Nominal Distribution.
σ = Standard Deviation
We take value of K=1.65 when test fall not more than 5 Percent.
So we can say $Ts = f_{ck} + 1.65\sigma$
So, Intend strength of M30 (Mix Design) T_s= 30+1.65X5

=38.25N/mm^2.
Now the following steps are displace in the design of M30 grade concrete.

Step 1.*Calculation of appropriate amount of water for proper hydration of cement*:
Ultimate ratio of water and cement was taken 0.40.
As per Indian Standard Code Specification for 20 mm aggregate water required is 186 liters for the slump requirement of 50 mm and for slump greater than 50 mm we need to increase the quantity of water. For example If Slump requirement is up to 75 mm then water is added by 3 percent that means =3/100 X186+186=191.5 liters.

Step 2. Cement Quantity Estimation.
We had taken water cement ratio about 0.40.Therefore amount of cement needed was 413 kg/m3.

Step 3.Course and Fine aggregate ratio.
In this study we had taken 0.40 water cement ratio .If 1 percent of water cement lowered than the volume of coarse aggregate is increased and figure of fine aggregate abounded. Figure of coarse aggregate expanded about 0.00606 and the correct fraction of coarse aggregate was 0.606.So figure of fine aggregate was 0.394.

Step 4. Admixture: One percent Plasticizer is combined with cement.

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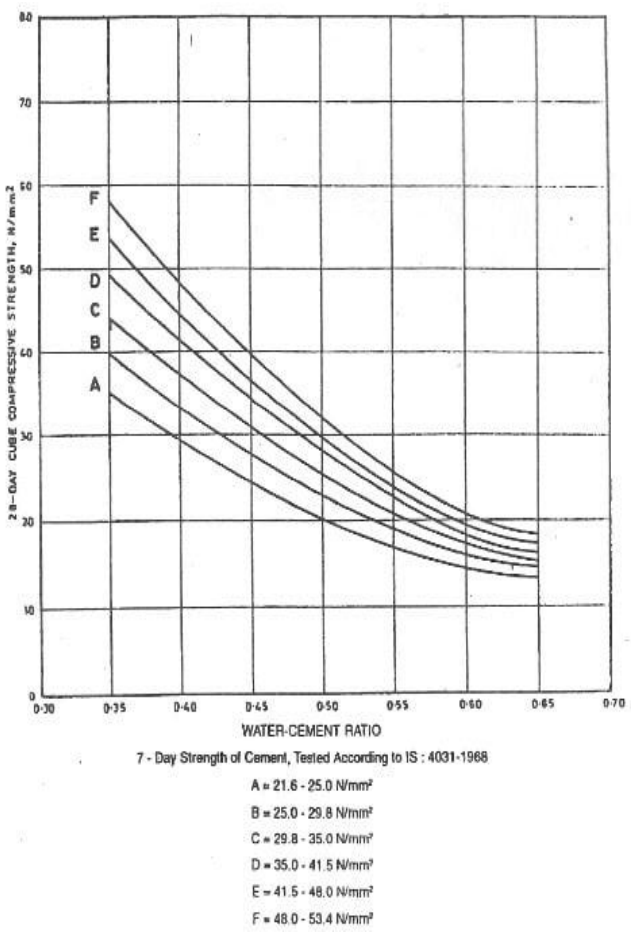

Fig 3: W/C ratio (Source: IS 10262-2009)

Step5. Preparation of mix: 5 M30 mix was sewed-up correspondingly to raise acknowledged steps. Particulars are compiled in the below table.

Table VIII. Mix Summary

Sample	1	2	3	4	5
Steel Fibres Percentage	0	0.5	1	1.5	2.0
Water Cement Proportion	0.40	0.40	0.40	0.40	0.40
Cement	413	413	413	413	413
Admixture	0	4.13	4.13	4.13	4.13
Steel Fibres	0	2.06	4.13	6.19	8.26
Sand	586	586	586	586	586
Coarse Aggregate	1204	1204	1204	1204	1204
Water	165	165	165	165	165

VI. RESEARCH WORK

Subsequent explorations had been done to check the accountability of steel fibres in concrete. First the ingredients were collected and their condition was checked. Then the samplings of ingredients were to be done separately for each and every batch. Then for the compression and flexural strength test thirty and thirty nine samples were made. For cube 15cmX15cmx15 cm size sculpt were used and for flexural test 50x10cmx10cm sculpt was used. Individual cluster was weight batch, and perfectly mixed in cement mixture machine.
Each sculpt were filled in layers and properly compacted.

Then sculpts were left for 24 hrs in a temperature about 30℃, after this process every sample was cured for 28 days in a curing tank.
After this samples were tested according to the stipulation given in Indian Standards.

Fig 4: Curing tank

VII. RESULTS

Consecutive results were obtained from the laboratory test A. *Compressive Strength*: *Compressive Strength test are done at an interval of 7-days and 28-days. Particulars are compiled in the below table.*

Table IX. 7 Days Test

Mix Design	C1	C2	C3	C4	C5
Steel fibres	0	0.5	1.0	1.5	2.0
Compressive Strength (3 cube Average taken)	25.10	27.20	29.50	29.70	30.30

Table X. 28 Days Test

Mix Design	C1	C2	C3	C4	C5
Steel fibres	0	0.5	1.0	1.5	2.0
Compressive Strength (3 cube Average taken)	39.3	40.80	42.2	44.3	44.7

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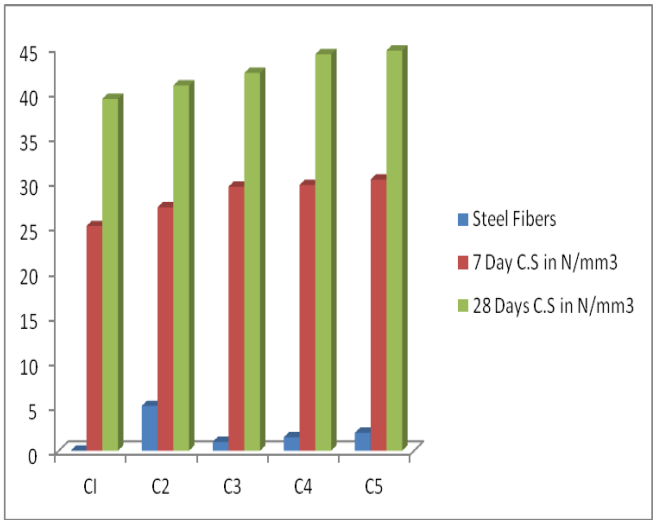

Fig. 5: Comparison graph between above two test results

*B. Flexural Strength:*Flexural Strength test was to be done on 13 samples (Each sample consist 3 beams).

Table XI. Flexural Strength

S.No	Sample	Steel Fibres quantity	Direction	Flexural Strength (N/mm^3)
1	B1	0	Random	3.90
2	B2	0.5	Random	4.30
3	B3	1.0	Random	4.90
4	B4	1.5	Random	5.20
5	B5	2.0	Random	5.70
6	B6	0.5	Parallel	4.80
7	B7	1.0	Parallel	5.30
8	B8	1.5	Parallel	6.10
9	B9	2.0	Parallel	6.90
10	B10	0.5	Perpendicular	4.00
11	B11	1.0	Perpendicular	4.10
12	B12	1.5	Perpendicular	4.60
13	B13	2.0	Perpendicular	5.00

VIII. CONCLUSION

From the examination consecutive outcomes are derived.

- It is seen that both flexural and Compressive strength can be enhanced by increasing the percentage of steel fibres.
- There are some adverse effects of steel fibres on the workability of concrete.
- Steel fibre enhanced the compressive strength of concrete about $1/4^{th}$ times to the conventional concrete.
- Both tensile and compressive strength of concrete boost up by adding Steel fibre.

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