Experimental Study on Toughness of Concrete with Inclusive Steel fibre and Glass Fibre

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Abstract— Concrete has been used in the various forms of structures all over the world from last two decades. The development of concrete has carried around the major essential need for essences of chemical as well as mineral for the improvement in the act of concrete. The usage of different types of fibers and their orientation in matrix have shown the positive response among the researchers. In this study the performance of fiber reinforced concrete (FRC) beams under two-point loading system is discussed and comparative studies were made with normal mix concrete. The mineral admixtures used in this study are steel fibers and glass fibers. In this study, we are casting the cubes for 3, 7, 28 days and beams only for 28days. The percentage addition by volume of concrete for mineral admixtures used is 0.5% and 1%. We are going to compare the results of compressive as well as flexural strength to normal concrete through different (0.5 and 1) percentages. The experimental study on normal strength concrete grade for 0.5% and 1% were also prepared respectively. Rebound hammer tests were conducted to assess the quality of concrete. Test results presented that the adding of suitable fraction volume of steel and glass fiber can improve the mechanical properties of the self-compacting concrete (SCC) and at the same time the flowing and passing abilities still within the accepted limits. In addition, incorporation of glass fibers had increased the ductility of self-compacting concrete. NDT tests discovered inclusion of fibers improves the surface hardness, homogeneity and quality of concrete.

Key words: Steel Fibers; Glass Fibers; Portland Cement

I. INTRODUCTION

Concrete is the most important building material in all countries and its consumption is increasing day to day. Inspired from the ancient application of techniques of natural fibres artificial fibres' are commonly used nowadays in order to improve the mechanical properties of concrete. Especially vitreous, synthetic, carbon and steel fibres used in concrete caused good results to improve numerous concrete properties. In general, tensile, flexural, impact, fatigue and wear strength, deformation capability, loads bearing capacity after cracking and toughness properties of concrete are significantly improved by use of fibres' in concrete mix.

In SFRCs and GFRCs, the most important factors affecting the concrete properties are l/d ratio and V_f of fibres. L/d ratio is important at mixing and replacement stages of concrete production. Steel fibres' and glass fibres used in conventional concrete are used for prevention of crack propagation in concrete. Thus, propagation of micro cracks that occur due to internal stress in concrete is prevented by stress transfer capability of fibres'. According to their shape and quantity, fibres bear some stress that occurs in cement matrix themselves and transfer the other portion of stress at stable cement matrix portions. This behaviour of fibres' under stress dominates the SFRC compared to the conventional concrete. To determine the compressive, split tensile and flexural strengths with the use of glass fibre sand steel fibres in concrete. The glass fibres' and steel fibres were added by 0.5 and 1.0% by volume.

Steel fibres' in lower strength concretes increases their compressive strength significantly compared to plain un-reinforced matrices and is directly related to volume fraction of steel fibre used. This increase is more for hooked fibres in comparison with straight steel.

A. Steel Fiber

The Steel Fibers are procured from STEWOLS INDIA (P) Ltd, Nagpur. The steel fibers used in this study is Hooked End Steel Fiber in size MSH 7560 (Cold Drawn Type) from Mild Steel Wire for General Engineering which The percentages adopted in this study are 0.5% and 1% by the total volume of concrete.

B. GLASS FIBER

The glass fibers used in this study are Alkaline resistant (AR) of length 6 mm, aspect ratio 428 with an Elastic Modulus of 73 GPa which is shown in Fig1.2 From the table 1.6 and 1.7 the physical and chemical properties of glass fiber are shown. Conplast SP430 is used as a super plasticizer. It is a chloride free, chemical admixture. To maintain the water cement ratio and to increase the workability of concrete mixes the super plasticizer is used.

C. Need for Fiber Reinforced

1) Concrete

Micro cracks are present in concrete and because of its poor tensile strength; the cracks propagate with the application of load, leading to brittle fracture of concrete. concrete experience relatively low tensile strains, at about 25 to 35% of the ultimate strength in compression.Fiber in the cement based matrix acts as crack arrester, which restricts the growth of flaws in the matrix, preventing these from enlarging under load into cracks, which eventually cause failure.

II. LITERATURE REVIEW

Prof. Ram Meghe et al (2014) presented the experimental study of the steel fibers reinforced self-compacting concrete by addition of different content of steel fibers. The result showed that the split tensile strength found to be increased with the addition of steel fibres and the optimum fibers content for increasing the split tensile strength was found to be 1.75% it was been observed that the steel fibers' are used in the concrete to give the maximum strength as compared to other fibres such as glass fibers polypropylene fibers.The compressive strength and the flexural strength observed to be increased as the percentage of steel fibers are increased in the steel fibers reinforced concrete.

Milind V mohod (2012) et al in this experimental investigation for M30 grade of concrete containing fibers varied by 0.25%, 0.50%, 0.75% 1% 1.5% and 2% by volume of cement cubes of size 150mmX150mmX150mm to check the compressive strength. All the specimens were cured for the period of 3, 7 and 28 days before crushing the result of fibers reinforced concrete 3 days, 7 days, and 28 days curing with varied percentage of fiber.It has been observed that with the increase in fiber content up to the optimum value increase the strength of concrete.

Nitinverma ,Hemanthkumar (2016) Two types of fibers used are crimped steel fiber of length 45mm with aspect ratio 50 and glass fiber of length 12 mm with aspect ratio 857.1. The main aim of this experiment is to study the strength properties of hybrid reinforced concrete of M20 grade with 0.2%, 0.25%, 0.30%, 0.35% of glass fiber containing by weight of cement and 0.40%, 0.45%, 0.50%, 0.55% of steel fibers containing by volume of concrete. From the experimental results it was observed that samples containing steel and glass fibers showed enhanced properties compared to the normal specimen.

III. MIX DESIGN FOR M20 CONCRETE BY ADDED STEEL AND GLASS FIBER

A. Mix design for M20 Grade

1) Grade designation : M 20
2) Type of cement : OPC 43 grade confirming to IS 8112
3) Maximum nominal size of aggregate : 20 mm
4) Minimum cements content :300kg/m3
5) Maximum water-cement ratio : 0.45
6) Workability : 50-75mm (slump)
7) Exposure condition : Moderate (RCC)
8) Degree of supervision: Good
9) Type of aggregate: Crushed angular aggregate
10) Maximum cement content: 450kg/m3

B. TEST DATA FOR MATERIALS

1) Cement used : OPC 43 grade confirming to IS 8112
2) Specific gravity of cement: 3.11
3) Specific gravity of coarse aggregate: 2.75
4) Specific gravity of M-sand: 2.42

C. Target Strength for Mix Proportioning

$$fck` = fck + 1.65\, s$$

Where *fck`* = target average compressive strength at 28 days
fck= characteristic compressive strength at 28 days,
s = standard deviation
From Table 1 of IS 10262-2009, standard deviations=4 N/mm2

Target strength=20+ (1.65×4) =26.60N/mm2

D. Selection of Water-Cement Ratio

From Table 5 of IS 456, maximum water-cement ratio=0.50
Based on experience, adopt water-cement ratio as 0.45
0.45<0.50, hence O.K.

E. Selection of Water Content

From Table 2 of IS 10262-2009,
Maximum water content = 186 litre (for 25 to 50mm slump range) for 20 mm aggregate

Estimated water content for 75mm slump = 186+ $(\frac{3}{100}\times 186)$

=191.6 litre

F. Calculation of Cement Content

Water-cement ratio = 0.45

Cement content $= \frac{191.6}{0.45}$

Cement content = 425.731 kg/m3

From Table 5 of IS 456, minimum cement Content for 'moderate' exposure condition = 300 kg/m3

425.73 kg/m3>300 kg/m3,

HENCE O.K.

G. Proportion of Volume of Coarse Aggregate and Fine Aggregate Content

From Table 3 of IS 10262-2009, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone 2) for water-cement ratio of 0.5 = 0.62
For 0.45= (0.62+0.01) = 0.63
Volume of fine aggregate = 1- 0.61 = 0.3

H. Mix Calculations

The mix calculations per unit volume of concrete shall be as follows:

1) Volume of concrete = 1 m3

2) Volume of cement

$$\frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$$

$$= \frac{425.7}{3.11 \times 1000}$$

= 0.1368 m3

3) Volume of water

$$= \frac{\text{Mass of Water}}{\text{Specific gravity of Water}} \times \frac{1}{1000}$$

$$\frac{191.6}{1} \times \frac{1}{1000}$$

=0.1916 m3

4) Volume of all in aggregate = a-(b+c)

= 1-(0.1368+0.1916)

= 0.672m3

*5) Mass of coarse aggregate = d × (volume of coarse aggregate ×specific gravity of Coarse aggregate *1000) = 0.672×0.63× 2.75 ×1000*

= 1144.73kg

6) Mass of fine aggregate = d× volume of fine aggregate ×specific gravity of fine Aggregate ×100 = 0.37 ×0.672× 2.67×1000

=664.85kg

ADJUSTMENTS FOR WATER ABSORPTION

Water absorption by coarse aggregate = Mass of coarse aggregate × $\frac{0.75}{100}$

= 1144.773 × $\frac{0.75}{100}$

= 8 kg/m3

Water absorption by fine aggregate = Mass of fine aggregate × $\frac{1}{100}$

= 664.85 × $\frac{1}{100}$

= 6.64 kg/m3

Final mass of water = mass of water + (water absorbed by coarse aggregate and fine aggregate)

= 192+ (8.58+ 6.64)

= 208 litres

Cement =476.7kg/m³
Water = 208 litres
Fine aggregates = 659 kg/m³
Coarse aggregate=1136.19kg/m³
Proportion
1:1.54:2.67 for Water Cement Ratio 0.45

IV. Tests Conducted On Fiber Reinforced Concrete

To study the behaviour of concrete and various strength parameters that are compressive, tensile and flexural strength with laboratory samples are evaluated. The mixed glass and steel fibres with varying percentages of 0.5,

S1.0 percentages of total fibre content are used for structural concrete.

A. *Compressive Strength:*

At the end of the curing period, thecube specimens were tested under the compression testing machine. The test specimen was placed in the correct position and then the load was applied. The cubes were tested for compressive strength using compression testing machine. In the machine, the cube is placed with cast faces at right angles to that of compressive faces .according to I.S specification the load on the cube is applied at constant rate of 4KN/sq.cm/minute up to failure and the ultimate load is noted.

Compressive Strength (fcu) =$\frac{PU}{A}$

Split Tensile Strength: For the split tensile strength, cylindrical specimens were tested in compression testing. The cylindrical specimens are placed horizontally the loading surfaces of a compression testing machine and the load was applied until the failure of the cylinder, along the vertical diameter. The split tensile strength of cylinder is obtained from the formula.

Split Tensile Strength =$\frac{2P}{\pi DL}$

V. Test Results

The results of the Compressive Strength, Split Tensile Strength and Flexural Strength for 0.5, 1.0 percentage total fibre content at 28 days are reported.

Compressive strength for different percentage of Steel Fiber and Glass Fiber used for M 20 grade

SL NO	% OF GF	COMPRESSIVE STRENGTH Mpa		
		3days	7days	28days
1	0.5	13.4	27.3	42.4
2	1	13.2	26.5	40.8

Table - 1

SL NO	% OF SF	COMPRESSIVE STRENGTH Mpa		
		3days	7days	28days
1	0.5	12.52	24.1	42.4
2	1	14.4	30.1	42.6

Table - 2

Split Tensile Strength for Different Percentage of Steel Fiber and Glass Fiber for M 20 Grade

SL NO	% OF GF	SPLIT TENSILE STRENGTH
		28days
1	0.5	6.92
2	1	7.27

Table - 3

SL NO	% OF SF	SPLIT TENSILE STRENGTH
		28days
1	0.5	7.23
2	1	8.09

Table - 4

Flexural strength for different percentage of steel fiber and glass fiber for m20 grades

SL NO	% OF GF	FLEXURALTENSILE STRENGTH
		28days
1	0.5	4.58
2	1	5.68

Table - 5

SL NO	% OF SF	SPLIT TENSILE STRENGTH
		28days
1	0.5	4.25
2	1	6.44

Table - 6

VI. Conclusions

From the study conducted on the strengthening of concrete beams using Fibers at different
depths of beam; the following conclusions were drawn:

- The FRC of all types have shown improvement in terms of first crack, ultimate load and
- deflection characteristics when compared to that of control beam.
- By the addition of steel and glass fibers the surface hardness increases slightly.
- From the study, it shows that the compressive strength of steel fiber with control specimen increases 4.48N/mm for 0.5% and 10.24N/mm for 1%
- From the results, it shows that the compressive strength of glass fiber with control specimen increases 2.9N/mm for 0.5% and 5.64N/mm for 1%
- The deflection of FRC beams was greater than the NMC specimens
- The cracking behaviour of FRC beam specimens shows greater strength with those of NMC beam specimens.
- Addition of Steel Fibers give the better strength compared to that of Glass Fibers.

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