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EXPERIMENTAL STUDY ON MECHANICAL AND DURABILITY PROPERTIES OF HIGH STRENGTH CONCRETE USING STEEL FIBRE

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Abstract-*The dissertation work is to study the influence of GGBS and STEEL FIBRE in achieving High strength fibre reinforced concrete (HSFRC). High strength concrete requires high amount of cement compared to the nominal grade. Several research works have been carried out in past decades limiting to admixtures which provide the pathway to identify supplementary cementitious material. This study investigates the performance of various mixtures which are addition with cement includes GGBS and SILICA FUME 10% with STEEL FIBRE 0%, 1%, 1.5%, 2% respectively. Manufactured sand is used instead of river sand. The employment of manufactured sand in concrete is gaining momentum recently. Con-plast SP430 of 1.5% for every specimen is used in order to improve the workability of the mix. Specimens are casted for M60 grade as per mix design. Concrete specimens are tested for mechanical properties which includes Compressive strength test, Split tensile strength and Flexural strength test. Durability test includes, Water absorption test. The testing is done as per Indian standards and curing process is done under normal water conditions. The maximum compressive strength obtained in 28 days 69.5 N/mm².*

Key Words: steel fibre (SF), GGBS, Silica Fume,

1. INTRODUCTION

The term high-strength concrete is generally used for concrete with compressive strength higher than 60Mpa. When added to concrete mixes, steel fibres distribute randomly through the mix at much closer spacing than conventional reinforcing steel. Depending on their aspect ratio, fibres act to arrest cracking by decreasing the stress intensity factor at the tip of inherent internal cracks. The main purpose of the tests is to examine the effect of fibre addition on the shear strength concrete.

2. SPECIAL MATERIAL USED

2.1 GGBS

Ground Granulated Blast Furnace Slag is a by-product from the blast-furnace used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and lime-stone.

Table 1.1 Properties of GGBS

Properties	Test results
Specific gravity	2.9
Bulk density	1200 kg/m³
Fineness	>350m²/Kg

2.2 SILICA FUME

Silica fume is a finely-divided mineral admixture, available in both un-compact and compacted forms. The ultra-fine material will better fill voids between cement particles and result in very dense concrete with higher compressive strength and extremely low permeability. It is an artificial Pozzolanic material.

Table 1.2 Properties of silica fume

Properties	Test results
Specific gravity	2.2
Bulk density	1350-1510 kg/m³
Fineness	15000 m²/Kg

2.3 STEEL FIBRE (CRIMPED FIBRE)

Steel fibre (SF) is small piece of reinforcing material introduced in concrete to increase its tensile strength. Steel fibers have been given more and more attention for its better performance of crack controlling and preventing deadly flaws.The crimped steel fibers are made of either carbon steel or stainless steel. They are quite rigid materials and this rigidity imposes mechanical properties of High Strength Fibre Reinforced Concrete

Table 1.3 Properties of steel fibre

Properties	VALUE
Fibre Diameter(mm)	0.45
Fibre length (mm)	40
Aspect ratio l/d	80
Ultimate tensile Strength (Mpa)	910
Elastic Modulus(Gpa)	210

3. MIX DESIGN

Table 1.4 Mix proportioning

Mix	Cement Kg/m³	Fine aggregate Kg/m³	Coarse aggregate Kg/m³	Micro silica Kg/m³	GGBS Kg/m³	Water Kg/m³
SF %0	496	693	988	49.6	49.6	149.73
SF 1%	496	693	988	49.6	49.6	149.73
SF 1.5%	496	693	988	49.6	49.6	149.73
SF 2%	496	693	988	49.6	49.6	149.7

4. EXPERIMENTAL STUDY

4.1 MECHANICAL PROPERTIES OF CONCRETE

4.1.1 COMPRESSIVE STRENGTH

For cube compressive strength of concrete, 150 x 150 x 150 mm size cubes were used. All the cubes were tested in saturated conditions after wiping out the surface moisture. For each combination, the cubes were tested at the age of 7, 14 and 28 days curing using compressive testing machine of 2000KN capacity.

Fig. 1.1 Cube Testing

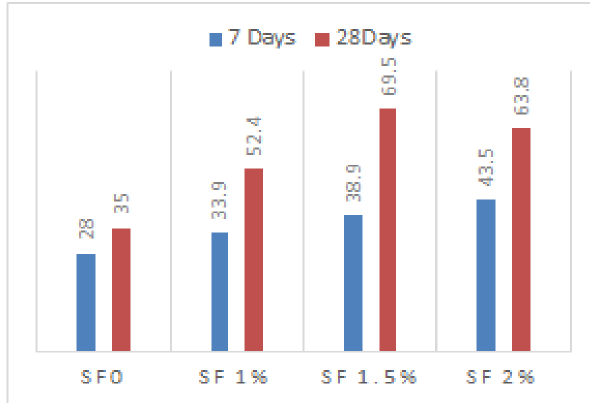

Fig. 1.3 28 Days compressive strength variation

From chart it is clear that increase in compressive strength of cubes having various percentages of Steel Fibre 0, 1%, 1.5% and 2%. Average compressive strength is increased at 1.5% of steel fibre.

4.1.2 SPLIT TENSILE STRENGTH

This is an indirect test to determine the tensile strength of the cylindrical specimen and it is performed by placing the cylindrical specimen horizontally between the loading surfaces of the compressive testing machine. Standard cylinder size of 150x300 mm are casted and test are conducted after 7, 14 and 28 days curing. The load is applied until the failure of the cylinder along with the vertical diameter takes place.

Fig. 1.2 split tensile strength test

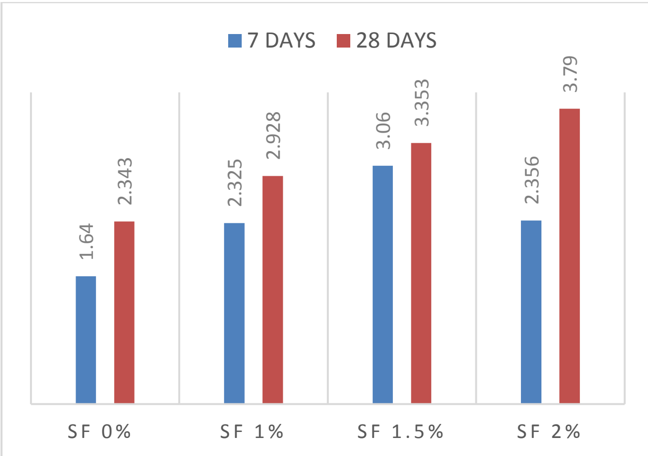

Fig. 1.4 28 Days Split Tensile Strength variation

From the chart, It was observed that the increase in the split tensile strength at 28 days in 2% of Steel Fibre when compared with the conventional mix.

4.1.3 FLEXURAL STRENGTH

The flexural strength of the specimen is expressed as modulus of rupture in which "a" equals to the distance between the line of fracture and nearest support measured on the centre line of the tensile side of the specimen.

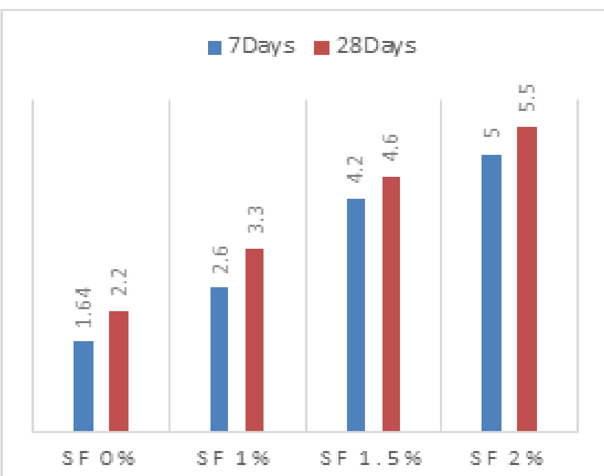

Fig. 1.5 28 Days flexural Strength variation

From chart, It is observed that increase in percentage of flexural strength for the mix containing SF 2%.

Fig 1.6 Specimen After Testing

4.1.4 ULTRASONIC PULSE VELOCITY TEST

It is a non-destructive method of testing on hardened concrete to measure the quality of concrete. The test was conducted based on IS 1311:1992 PART 1. This test was performed on all prisms. Clean the surface of the specimen to be tested and apply the coupling paste on two places as required for placing two transducers. The two transducers which are connected to the display unit which may be in opposite sides, adjacent side or on the same side as necessary. The ultrasonic pulse produced by the transducer which is held in contact with one another and uv rays are made to pass through the concrete specimen and received by the another transducer (receiver).

The distance travelled by the concrete and the time taken are measured from the display unit. Specimen having different percentages of steel fibre and corresponding velocities were calculated.

Table 1.5 ultra-sonic pulse velocity test results

Mix	Velocity (km/sec)	Concrete quality grading
SF 0%	4.26	Good
SF 1%	4.02	Good
SF 1.5%	4.18	Good
SF 2%	4.21	Good

4.2 DURABILITY TESTS ON CONCRETE

4.2.1 WATER ABSORPTION TEST

The cube size of 150x150x150 mm were casted and immersed in water for 28 days. The specimens are oven dried for 24 hrs at the temperature 110˚c until the mass becomes constant and again weighed at room temperature.

$$\% \text{ water absorption} = \frac{w_1 - w_2}{w_2} * 100$$

w_1 = oven dried weight

w_2 = final weight after 24 hrs

Table 1.6 Average % Water Absorption Test Results

Mix	Oven dried weight (kg)	Weight of specimen (kg)	% Water absorption
SF 0%	8.711	8.90	1.16%
SF 1%	8.45	8.53	0.93%
SF 1.5%	8.95	9.02	1.73%
SF 2%	8.70	8.85	1.55%

Comparing the results with different mix percentage of concrete, the mix SF 1% has low percentage of water absorption but its percentage of water absorption is greater than control mix concrete

4.2.2 CARBONATION TEST

This test involves measuring the depth of carbonation of concrete. Specimens with 500x100x100 mm prisms were casted with different mix percentages from 0% to 2% addition of steel fibre. phenolphthalein used as indicator.

Fig. 1.7 Carbonation Test

It is observed that the specimen tested remains colourless indicates carbonated and if the specimen became pink in colour indicates that it was uncarbonated.

4.2.3 WATER PERMEABILITY TEST

Specimen of size 150 x 150 x 150 mm cube were used. This method is used to measure the resistance of concrete against penetration of water under pressure of 0.5 N/mm^2. After the pressure is released it is divided and depth of penetration is measured.

Table 1.7 Permeability Test Results

MIX	DEPTH OF PENETRATION (cm)
SF 0%	3.45
SF 1%	3.14
SF 1.5%	3.5
SF 2%	3.57

It is found that depth of penetration is less in SF 1% mix compared to other percentage mixes of concrete respectively.

CONCLUSIONS

- Mix proportion for high strength concrete (M60) using steel fibre, 10% GGBS and 10% silica fume is arrived.
- Compressive strength of cube mix with 1.5% of steel fibre was higher compared to all other mixes.
- Split tensile and Flexural strength of mix with 2% steel fibre was higher compared to all other mixes.
- Less water absorption and good im-permeability properties were witnessed in mix with 1% steel fibre.
- Thus optimum percentage of steel fibre is 1.5%, 10% GGBS and 10% silica fume

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