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COMPARATIVE STUDY ON STRENGTH OF STEEL FIBER REINFORCED CONCRETE WITH CONVENTIONAL CONCRETE

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ABSTRACT

The objective of this investigation was to study the behavior of Steel Fiber Reinforcement Concrete (SFRC). Fibers are generally used as resistance of cracking and strengthening of concrete. Steel fibers give the maximum strength in comparison to glass and polypropylene fibers. From the exhaustive and extensive experimental work it was found that with increase in steel fiber content in concrete there was a tremendous increase in Flexural strength and compressive strength. The aim of our project is to use the Steel Fibers with hooked ends as Fiber reinforcement to concrete. to study the strength properties of concrete The strength properties being studied in our thesis are as follows: Steel fiber reinforcement is widely used as the main and unique reinforcing for industrial concrete floor slabs and prefabricated concrete products. It is also considered for structural purposes in the reinforcement of slabs on piles, tunnel segments, concrete cellars, foundation slabs and shear reinforcement in prestressed elements. Apart from increased load- carrying capacity, one of the main benefits of adding fibers to concrete is the potential reduction in crack width, which depends on the amount of fibers added and positively affects the durability of the finished structure. Specimens were cast without Fibers and with Fibers Tests were conducted for studying the compressive, tensile and flexural strength.

Keywords: Compressive, Tensil, Flexural Strength, Prestressed, Prefabricated.

I. INTRODUCTION

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 methods 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. Fiber reinforcement gives the solution for this problem.

So to increase the tensile strength of concrete a technique of introduction of fibers in concrete is being used. These Fibers act as crack arrestors and prevent the propagation of the cracks. These Fibers are uniformly distributed and randomly arranged. This concrete is named as Fiber reinforced concrete. The main reasons for adding Fibers to concrete matrix is to improve the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large volume of follow up research have led to the.

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. So we can define Fiber reinforced concrete as a composite material of cement concrete or mortar and discontinuous discrete and uniformly dispersed Fiber. Steel Fiber is one of the most commonly used Fibers. Generally round Fibers are used. The diameter may vary from 0.25 to 0.75mm.The steel Fiber sometimes gets rusted and lose its strength. But investigations have proved that Fibers get rusted only at surfaces. It has high modulus of elasticity. Use of steel Fibers makes significant improvements in flexure, impact and fatigue strength of concrete. It has been used in various types of structures.

II. LITERATURE REVIEW

Balaguru et al. [1992] conducted flexural tests on deformed steel Fibers reinforced concrete beams. The variables investigated were Fiber type, length and volume fraction, and matrix composition. The results indicate that Fiber content in the range of 30 to 60 kg/m provide excellent ductility for normal strength concrete. The Fiber content has to be increase to about 90 kg/m3 for high strength concrete.

The load-deflection curves for normal strength concrete beams and high strength concrete beams with 30 mm long hooked-end Fibers. It has been reported by Ashour [1993] that steel Fibers also enhance the strength and ductility of high strength concrete beams.

No standard test (specimen size, type of loading, loading rate, fatigue failure criteria) is currently available to evaluate the flexural fatigue performance of Fiber reinforced concrete. However, several earlier experimental fatigue studies were conducted on steel Fiber – reinforced concrete and mortar in bending by Batson et al.[1972]; Zollo [1972] using a testing procedure, specimen sizes and loading conditions similar to those employed for static flexural test of FRC or tests for conventional concrete with reserved and non-reserved fatigue loading.

EXPERIMENTAL INVESTIGATION

In order to study the interaction of Steel Fibers (hooked end) with concrete under compression, flexure, split tension and impact, 8 cubes, 8 beams and 16 cylinders were for each percentage casted respectively. The experimental program was divided into four groups.

- The first group is the control (Plain) concrete with 0 % Fiber (PCC)
- The second group consisted of 0.5 % of Steel Fibers (hooked end), with aspect ratio 80, by volume.
- The third group consisted of 1 % of Steel Fibers (hooked end), with aspect ratio 80, by volume.
- The fourth group consisted of 1.5 % of Steel Fibers (hooked end), with aspect ratio 80, by volume.

CEMENT

Cement acts as a binding agent for materials. Cement as applied in Civil Engineering Industry is produced by calcining at high temperature. It is a mixture of calcareous, siliceous, aluminous substances and crushing the clinkers to a fine powder. Cement is the most expensive materials in concrete and it is available in different forms. When cement is mixed with water, a chemical reaction takes place as a result of which the cement paste sets and hardens to a stone mass. Depending upon the chemical compositions, setting and hardening properties, cement can be broadly divided into following categories.

FINE AGGREGATE

Robo sand is an ideal substitute to river sand. It is manufactured just the way nature has done for millions of years. Robo sand is created by a rock-hit – rock crushing technique using state of the art plant and machinery with world class technology. Created from specific natural rock, it is crushed by a three stage configuration consisting of a Jaw crusher followed by a Cone crusher and finally a Vertical Shaft Impactor (VSI) to obtain sand that is consistent in its cubical particle shapes and gradation.

COARSE AGGREGATE

The material whose particles are of size as are retained on I.S Sieve No.480 (4.75 mm) is termed as coarse aggregate. The size of coarse aggregate depends upon the nature of work. The coarse aggregate used in this experimental investigation are of 20 mm, 10 mm and 6 mm sizes, crushed angular in shape. The aggregates are free from dust before used in the concrete.

FIBERS

The Fibers selected for our project is Steel Hooked End Fibers. This shape is probably the most popular and successful in the history of SFRC. Hooked-End HE Fibers can be used in almost any known application for SFRC. For example HE 55/35 and HE 75 / 35 are primarily used in concrete applications. They provide excellent workability when using Fibers with up to an aspect ratio of 60. Aspect ratios up to and including 80 provide satisfactory workability. Load transfer in the crack is very good with this Fiber shape. Thus after the appearance of the first crack the loss of load- bearing capacity occurs quickly, but then stabilizes and in some cases even begins to increase again after large cracks have developed. HE Fibers have lengths in the range of 35 to 60 mm, diameters range from 0.55 to 1 mm and tensile strength range from 1100 to 1900 MPa.

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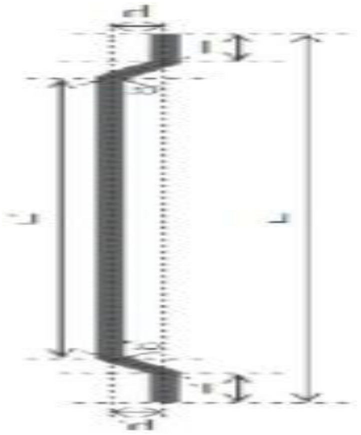

Hooked End Fiber of length 60 mm and diameter 0.75 mm

MIXING OF SPECIMEN

Hand mixing is adopted throughout the experimental work. First the materials cement, fine aggregate, coarse aggregate, steel (hooked end) Fibers weighed accurately as per the above mentioned calculations.

The sand is laid in a layer of approximately 10 cm thick. Then cement is added to the sand and mixed thoroughly to get a uniform color. The coarse aggregate is spread on the ground and then the cement-sand mixture is mixed with it to get a uniform matrix. The steel (hooked end) Fibers of 60mm lengths are dispersed in the water. The water along with the Fiber is added to the mixture and mixed thoroughly to get a uniform mass in color and consistency. After mixing the fresh concrete is tested for the workability using compaction factor and slump tests.

COMPACTION FACTOR TEST

It is one of the most efficient tests for measuring the workability of concrete.

This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction called the compaction factor is measured by the ratio of density of actually achieved in the test to the density of the same concrete fully compacted.

SLUMP TEST

Slump test is the most commonly used method for measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

Slump cone - a mould of 1.6 mm thick galvanized metal in the form of the lateral surface of the frustum of a cone with the base 200 mm in diameter, the top 100 mm in diameter and the height 300 mm. The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mould shall be provided with a foot

CASTING OF SPECIMENS

For casting the cubes, beam specimens, standard cast iron metal moulds of size 150 x 150 cubes, 150 x150 x 70mm beam moulds are used. The moulds have been cleaned of dust particles and applied with mineral oil on all sides, before the concrete is poured into the moulds. Thoroughly mixed concrete is filled into the mould in three layers of equal heights followed by tamping. Then the mould is placed on the table vibrator for a small period. Excess concrete is removed with trowel and top surface is finished to smooth level.

CURING

Curing is the process of preventing the loss of moisture from concrete while maintaining a satisfactory temperature. More elaborately curing is defined as process of maintaining satisfactory moisture content and favorable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement at service.

CUBE COMPRESION TEST

This test was conducted as per IS 516-1959. The cubes of standard size 150 x 150 x 150mm were used to find the compressive strength of concrete.

Specimens were placed on the bearing surface of UTM, of capacity 100tones without eccentricity and a uniform rate of loading of 550 Kg/cm^2 per minute was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated. The results are tabulated in Table 5.1

Cube compressive strength (f_{ck}) in MPa = P/A Where, P= cube compression load.

FLEXURAL TEST

SFRC beams of size 150 x 150 x 700mm are tested using a flexure testing machine. The specimen is simply supported on the two rollers of the machine which are 600 mm apart, with a bearing of 50 mm from each support. The load shall be applied on the beam from two rollers which are placed above the beam with a spacing of 200 mm. The load is applied at a uniform rate such that the extreme Fibers stress increases at 0.7 N/ mm^2/ min i.e., the rate of loading shall be 4 KN / min. The load is increased till the specimen fails. The maximum value of the load applied is noted down. The appearance of the fracture faces of concrete and any unique features are noted.

The modulus of rupture is calculated using the formula. $\sigma_s = Pl / bd^2$, where,

P = load in N applied to the specimen

l = length in mm of the span on which the specimen is supported (600) b = measured width in mm of the specimen

III. RESULTS AND DISCUSSIONS

Compressive strength test results

Type	Percentage of Fibers	3 days Compressive strength in N/mm^2	7 days Compressive strength in N/mm^2	14 days Compressive strength in N/mm^2	28 days Compressive strength in N/mm^2
Conventional	0 %	14.68	23.6	30.9	32.4
SFRC	0.5 %	17.34	29.22	31.5	34.91
SFRC	1 %	19.63	30.8	32.07	37.58
SFRC	1.5 %	21.12	32.13	33.39	39.83

SPLITTING TENSILE STRENGTH TEST RESULTS

Type	Percentage of Fibers	3 days	7 days	14 days	28 days
Conventional	0 %	1.28	1.54	2.58	2.78
SFRC	0.5 %	1.54	1.88	2.54	3.14
SFRC	1 %	2.12	2.12	2.66	3.22
SFRC	1.5 %	2.14	2.17	2.78	3.35

Flexural strength test results

S. No	Percentage of Fibers	3 days	7 days	14 days	28 days
Conventional	0%	2.47	5.12	6.14	7.14
SFRC	0.5%	2.25	5.14	6.55	8.25
SFRC	1%	2.66	5.25	7.12	9.54
SFRC	1.5%	2.22	5.55	7.55	9.65

IV. CONCLUSION

- ✓ The Steel Fibers (hooked end) used in this project has shown considerable
- ✓ Improvement in all the properties of concrete when compared to conventional concrete like,
- ✓ Compressive strength by 29.99 % for 1.5 % of steel Fibers and Split Tensile strength by 24.15 % for 1.5 % of steel Fibers.
- ✓ Flexural strength (Modulus of Rupture) by 34.48 % for 1.5 % of steel Fibers.

The steel Fibers are free from water absorption.

With improved understanding of the link between Fiber characteristics and composite or structural performance, the tailoring of Fibers for use in high volume construction market exists, particularly for load carrying structural systems and for several applications especially in Earthquake prone areas. The time is not far that such materials will be used in building better and safe constructions for the future.

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