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A STUDY ON CHARACTERIZATION OF CEMENT CONCRETE BY THE ADDITION OF STEEL FIBRE AS AN ADMIXTURE

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ABSTRACT

In the modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. There is a growing awareness of the advantages of fibre reinforcement techniques of construction. Even though concrete possesses several desirable properties, its relative low tensile strength and deformation properties prompted many researchers to work on to improve these properties. One such development of improving or modifying the brittle characteristics of concrete is by supplementing the concrete matrix with fibre reinforcement. Steel fibre reinforced concrete has become very popular due to its exceptional mechanical performance compared to the conventional concrete. It has been found that different types of fibres added in specific percentages to concrete to improve mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation.

In the present work, the effects of fibres on the strength of concrete for M25 grade have been studied by varying the percentage of fibres in concrete. Fibre content was varied by 1, 2 and 3% by volume of cement. Cubes of size 150 mm × 150 mm × 150 mm to check the compressive strength and cylinder of size 150 mm diameter and 300 mm height for checking split tensile strength. All the specimens were cured for the period of 7 and 28 days before crushing. The results of fibre reinforced concrete for 7 days and 28 days curing with varied percentage of fibre were studied. It has been found that there is significant strength improvement in steel fibre reinforced concrete. Also, it has been found that with the increase in fibre content up to the optimum value increases the strength of concrete. The present work deals with a comparative study between ordinary reinforced concrete and steel fibre reinforced concrete.

Key words: Concrete; Steel Fibre; Workability.

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I INTRODUCTION

Concrete is composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and the finally makes the concrete to fail. 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, reinforced 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. This concrete is named as fibre reinforced concrete. The main reasons for adding fibres 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.

This paper aims to have a comparative study between ordinary reinforced concrete and steel fibre reinforced concrete thereby adding to that body of knowledge through experimental investigation and analysis by performing tests on steel fibre incorporated cubes & cylinders and motivating sustainable development.

II NEED FOR THE PRESENT STUDY

It is now well established that one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking. The net result of all these is to impart to the fibre composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading.

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III OBJECTIVES OF THE PRESENT STUDY

The objective is to add the Steel fibres (hooked end) to the concrete and to study the strength properties of concrete with the variation in fibre content. i.e., to study the strength properties of concrete (M25 Grade) for fibre content of 1, 2 and 3%. The strength properties being studied in this paper are Compressive strength and Split tensile Strength and these properties are compared to the plain cement concrete.

IV EXPERIMENTAL PROGRAM

In order to study the interaction of Steel fibres (hooked end) with concrete under compression and split tension, l6 cubes and 16 cylinders were casted respectively (for 7 and 28 days of curing). The experimental program was divided into four groups.

Each group consists of 8 cubes and 8 cylinders of 15 cm × 15 cm × 15 cm and 15 cm (diameter) and 30 cm length respectively for each 7 and 28 days of curing.

- The first group is the control (Plain) concrete with 0% fibre (PCC)
- The second group consisted of l% of Steel fibres (hooked end), with aspect ratio 80, by volume.
- The third group consisted of 2% of Steel fibres (hooked end), with aspect ratio 80, by volume.
- The fourth group consisted of 3% of Steel fibres (hooked end), with aspect ratio 80, by volume.

V MATERIAL USED AND TESTS

CEMENT

The cement used in this experimental investigation is ordinary Portland cement 53 grade. Storage of cement requires extra special care to preserve its quality and fitness for use. To prevent its deterioration it is necessary to protect it from rain, winds and moisture.

FINE AGGREGATE

The material we have used as fine aggregate in the present work sand. Sand is an ideal substitute to river sand. It is manufactured just the way nature has done for millions of years.

COARSE AGGREGATE

The material whose particles are of size as are retained on I.S Sieve No.480 (4.75mm) 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 20mm sizes, crushed angular in shape. The aggregates are free from dust before used in the concrete.

FIBRES

The fibres selected for the present work is Steel (Hooked End Fibres). This shape is probably the most popular and successful in the history of SFRC. Hooked-End (HE) fibres can be used in almost any known application for SFRC.

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Load transfer in the crack is very good with this fibre 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 wire strengths range from 1100 to 1900 MPa.

VI RESULTS AND DISCUSSION

6.1 COMPRESSION TEST VALUES FOR M25 GRADE OF SFRC AT 7 AND 28 DAYS OF CURING

(Total 8 cubes are require d for 7 or 28 days of curing days with different percentages of fibres)

Quantity of ingredients required for 1 cube

For 0% fibre; Cement=l.44 kg

For 1% fibre; Cement=l.425 kg and fibre=0.0144kg or14.4 g

For 2% fibre; Cement=1.411 kg and fibre=0.0288 kg or 28.8 g

For 3% fibre; Cement=l. 39kg and fibre=0.0432 kg or 43.2 g

Sand and C.A=1 .742 kg and 4.028 kg

Water=0.635 lit

CALCULATIONS:

Area of cube=225 cm^2

Compressive strength=Load /area at 7 or 28 days

S.No	Percentage of Fibres	Average Compressive Strength N/mm^2	
		7 days	28 days
1	0	28.8	32.7
2	1	34.4	33.5
3	2	32.4	35.3
4	3	36.8	38.6

Table1. Compressive Strength

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6.2 SPLIT TENSILE TEST VALUES FOR M25 GRADE OF SFRC AT 7 AND 28 DAYS OF CURING

(Total 8 cylinders are required for 7 or 28 days of curing with different percentages of fibres)

Quantity of ingredients required for 1 cylindrical specimen

For 0% fibre; Cement=2.268 kg

For 1% fibre; Cement=2.245 kg and fibre=0.022 kg or 22 g

For 2% fibre; Cement=2.22 kg and fibre=0.045 kg or 45 g

For 3% fibre; Cement=2.19 kg and fibre=0.068 kg or 68 g

Sand and C.A=2.29 kg and 6.42 kg

Water=0.99 lit = 1 lit

CALCULATIONS:

Split Tensile strength=Load /area at 7 or 28 days= $2p/\pi ld$ at 7 or 28 days curing

S.No	Percentage of Fibres	Average Compressive Strength N/mm^2	
		7 days	28 days
1	0	1.71	3.13
2	1	2.01	3.43
3	2	2.04	3.90
4	3	2.81	4.26

Table 2. Split Tensile Strength

The variation in the compressive stress and split tensile stress with respect to changes in the fiber content i.e., at l, 2 and 3% can be observed. From the results obtained, it is clear that the compressive and split tensile strength of concrete is maximum when the fiber content is 3% of the concrete.

From the above tables it is clear that the compressive strength of SFRC with 3% fiber is 36.8N/mm^2 and 38.6 N/mm^2 at 7 and 28 days and more over split tensile strength is 2.81N/mm^2 and 4.26N/mm^2 at 7 and 28 days compared to the plain concrete. Increase of fiber content beyond 3% will decrease the workability and compaction and thereby reduce the strength of concrete.

According to many researchers, the addition of steel fiber into concrete creates low workable or inadequate workability to the concrete, therefore to solve this problem; super plasticizer or pozzolans (admixtures) are used without affecting other properties of concrete.

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VII CONCLUSIONS

- The Steel fibres (hooked end) used in this project has shown considerable improvement in all the properties of concrete when compared to conventional concrete.
- The time is not far that such materials will be used in building better and safe constructions for the future.
- No workability problem was encountered for the use of hooked fibres as far as possible.
- It is clear that the compressive strength of SFRC with 3% fibre is 36.8 N/ mm^2 and 38.6 N/mm^2 at 7 and 28 days and fibre over split tensile strength is 2.81N/mm^2 and 4.26 N/mm^2 at 7 and 28 days compared to the plain concrete. Increase of fibre content beyond 3% will decrease the workability and compaction and thereby reduce the strength of concrete.
- Use of fibre produces more closely spaced cracks and reduces crack width.
- The mechanical properties of FRC are much improved by the use of hooked fibres than straight fibres.
- Although different types of steel fibres have been used, hooked-end steel fibre are found to perform better than the other type because of its hooked-end and/or high tensile strength which requires additional loads for pulling out and/or breaking.

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