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A Review on Steel Fiber Reinforced Concrete

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ABSTRACT

Concrete is extensively used material in construction industry because of good workability and ability to be moulded to any shape. Ordinary cement concrete possesses very low tensile strength, limited ductility and less resistance to cracking. The concrete shows the brittle behaviour and fails to handle tensile loading hence leads to internal micro cracks which are mainly responsible for brittle failure of concrete.

This paper describes the applications of SFRC and its use in many effective ways improving the strength with developing improved resistance to crack and etal.,

Keywords: Steel Fiber Concrete, Steel Fibers, Strength

I.INTRODUCTION

In the present world concrete is most used material for compressive strength in construction. Tensile load carrying capacity is very low of concrete. This results in brittle failure of concrete components. To increase the performance of concrete under tensile loading different types of the fibers are used in concrete. Mainly Steel fiber reinforced concrete （SFRC） has the ability of excellent tensile strength, flexural strength, shock resistance, fatigue resistance, ductility and crack arrest. Therefore, it has been applied abroad in various professional fields of construction, irrigation works and architecture. Concretes containing steel fiber have been shown to have substantially improved resistance to impact and greater ductility of failure in compression, flexure and torsion. It has been extensively used in various civil engineering structures.

1.1 Steel Fibers

Steel fibers have been used in concrete since the early 1900s. The early fibres were round and smooth and the wire was cut or chopped to the required lengths. The use of straight and smooth fibres has largely disappeared and modern fibres have either rough surfaces or hooked ends or are crimped or undulated through their length.

Modern commercially available steel fibres are manufactured from drawn steel wire, from slit sheet steel or by the melt-extraction process which produced fibres that have a crescent-shaped cross section. Typically steel fibres have equivalent diameters (based on cross sectional area) of from 0.15 mm to 2 mm and lengths from 7 to 75 mm. Aspect ratios generally range from 20 to 100. (Aspect ratio is defined as the ratio between fibre length and its equivalent diameter, which is the diameter of a circle with an area equal to the cross-sectional area of fibre.)

ASTM A 820 classifies four different types based on their manufacture. Type I-Cold-drawn wire fibres are the most commercially available manufactured from drawn steel wire. Type II-Cut sheet fibres are manufactured as

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the name implies: steel fibres are laterally sheared of steel sheets. Type III-Melt-extracted fibres are manufactured with a relatively complicated technique where a rotating wheel is used to lift liquid metal from a molten metal surface by capillary action. The extracted molten metal is then rapidly frozen into fibres and thrown off the wheel by centrifugal force. The resulting fibres have a crescent-shaped cross section. Type IV – Other fibres. For tolerances for length, diameter, and aspect ratio, as well as minimum tensile strength and bending requirement, see ASTM A 820.

Figure 1.1: Cold-drawn wire fibres Cut sheet fibres

Figure 1.2: Melt-extracted fibres

Figure 1.3: Flat End Steel Fiber

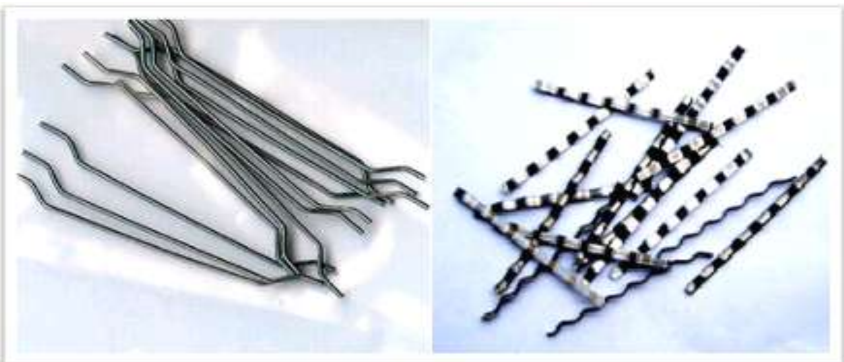

Figure 1.4: Hook tain Steel Fibre Crimped Fibre

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II. RELATED WORK

James Romualdi (1963), [1] in at the Carnegie Institute of Technology that a clearer understanding of the properties of SFRC emerged. Steel fibre reinforce concrete has been a later extension of this understanding, with the first application being to stabilise the rock slope of a tunnel portal, Idaho in 1972.

Ramakrishnan V., Wu G.Y., and Hosalli G. (1989), [2] in their paper entitled **'Flexural behavior and toughness of fiber reinforced concrete'** have presented the results of an extensive investigation to determine the behavior and performance characteristics of the most commonly used fiber reinforced concretes (FRC) for potential airfield pavements and overlay applications. A comparative evaluation of static flexural strength is presented for concretes with and without four different types of fiber: hooked-end steel, straight steel, corrugated steel and polypropylene. These fiber were tested in four different quantities (0.5, 1.0, 1.5 and 2.0 percent by volume), and the same basic mix proportions were used for all concretes. The test program included (a) fresh concrete properties, including slump, ve-be time, inverted cone time, air content, unit weight and concrete temperature and hardened concrete properties; (b) static flexural strength, including load deflection curves, first crack strength and toughness, toughness indexes and post-crack load drop; and (c) pulse velocity. In general, placing and finishing concretes with less than 1 percent by volume for all fibers using laboratory-prepared specimens was not difficult. However, the maximum quantity of hooked-end fibers that could be added without causing balling was limited to 1 percent by volume. Corrugated steel fibers (Types C) performed the best in fresh concrete; even at higher fiber contents (2 percent by volume), there was no balling, bleeding, or segregation. Higher quantities (2 percent by volume) of straight steel fibers caused balling and higher quantities of polypropylene fibers (2 percent by volume) entrapped a considerable amount of air.

The authors have concluded that, compared with plain concrete, the addition of fibers increased the first crack strength (15 percent to 90 percent), static flexural strength (15 percent to 129 percent), toughness index, post crack load-carrying capacity, and energy absorption capacity. Comparing with an equal 1 percent by volume basis, the hooked-end steel fiber contributed to the highest increase and the straight steel fiber provided the least (but appreciable) increase in the above-mentioned properties.

Sustersic J., Mali E., and Urbancic S. (1991), [3] in their paper entitled **'Erosion-abrasion resistance of steel fibre reinforced concrete'** have discussed the results of investigation on the erosion-abrasion resistance according to CRD-C 63-80 test method and abrasion resistance according to Bohme test method of steel fibre reinforced concrete specimens. They have used nine mix proportions. The w/c ratios were varied from 0.30 to 0.65. The volumetric percentage of hooked steel fibres were varied from 0.25 to 2.0 vol. percent at the w/c of 0.30 and at the others the quantity of fibres was constant. In addition, mixes without fibres were made at each w/c.

The authors have concluded that adding steel fibres into the concrete improves the resistance as measured by both test methods. The erosion-abrasion resistance is improved by an increase of compressive strength and by an increase in fibre content. It can be correlated to improvements of abrasion resistance from the Bohme test method but only at constant w/c and different content of fibres.

Ghugal Y.M. (2003) [4]**, 'Studied Effects of Steel Fibers on Various Strengths of Concrete'.** They have presented the results of the experimental investigation of various strengths of steel fiber reinforced concrete

(SFRC). Variables considered in the research work are various strengths and fiber volume fractions. Various strengths considered for investigation are compressive strength, flexural strength, split tensile strength, bond strength and shear strength. Concrete mix of M25 grade and crimped steel fibers with aspect ratio 50 are used. The fiber volume fraction is varied from 0.5% to 4.5 % at an interval of 0.5% by weight of cement. Standard test specimens for compressive strengths, split tensile strength, flexural strength and push-off specimens for shear strength were cast and water cured for 7 and 28 days. All the test specimens were tested according to relevant Indian Standards and standard test procedures available in the literature wherever applicable. All the strengths are found to be increasing continuously with increase in fiber volume fraction. The experimental results obtained for various strengths are modeled in terms of the material properties of matrix, fiber and compressive strength. The mathematical expressions developed for various strengths are presented. The inclusion of steel fiber in to the normal concrete showed the excellent strength performance in this investigation compared to the normal concrete. The results predicted by mathematically modeled expressions are in excellent agreement with experimental results.

Murthy Dakshina N R et al (2005) [5], in their paper entitled **'Splitting tensile strength of high volume fly ash concretes with and without steel fibres in different grades'** have discussed about the effect of combination of fly ash and random steel fibres in improving tensile strength of concrete in lower, medium and higher grades. They have studied M25, M50 and M60 grades of concrete. They have used steel fibres with aspect ratio of 75 and volume fraction of 1%.

They have made following comments on their studies. In lower grades ductility of concrete can be increased by replacing the cement by fly ash upto 20%. At 40% replacement ductility can be achieved by adding steel fibres of 1%. In medium grade the split tensile strength of concrete has been increased upto 30% replacement. 1% addition of fibres can improve tensile strength even at 40% replacement of cement by fly ash. There is an improvement in ductile behavior of concrete when steel fibres are added to it. In higher grade concrete ductility has been increased upto 10% replacement of cement by fly ash. At higher percentage replacement the brittleness of concrete has been increased. With steel fibres ductility can be improved upto 20% replacement. There is a drop in the split tensile strength at 30% and 40% replacements. For all grades on concrete there is overall improvement in the ductility when 1% fibres are added.

Ganeshan N et al (2007) [6], in their entitled **'Steel fibre reinforced high performance concrete for seismic resistant structure'** have attempted to carry out large scale investigations on SERHPC structural elements like columns, beams and beam column joints. In this paper they have presented consolidated details of the investigations. They have used crimped steel fibres in FRC. Also they have considered 10% replacement of cement by silica fume and 20% by fly ash.

Regarding compressive behavior the authors have given following findings.

1) SFRHPC can be obtained using conventional constituents of concrete and fibres, with due care in the selection of ingredients and proportioning of the mix.

2) An increase in the volumetric ratio of transverse reinforcement increases the ultimate strength of HPC and SFRHPC. However the percentage of increase is higher for SFRHPC specimens than for HPC.

3)As the confinement increases strain at peak load increases. Addition of steel fibres improved this peak strain further.

4)The addition of short discrete randomly oriented steel fibres improves the dimensional stability of the structure to a great extent.

5)This investigation indicates that the combined effect of confinement in the form of square/rectangular/circular hoops and randomly oriented steel fibres enhances the strength and ductility of compression members such as columns to a great extent and this is the major requirement for a seismic resistant structure.

Ghugal Y.M., Nandanwar & Bansode C.V. (2010) [7], Studied **'Effect of different sizes of aggregate on steel fiber reinforced concrete'**. They have found by using short and randomly distributed fiber in concrete arrests the propagating of micro cracks and results in better strength of concrete. He considers the variables as different sizes of aggregates. Concrete mix design for M20 grade is carried out with giber. Beams of size 500x100x100 mm were cast for flexural strength. In this test beam break into two parts and broken pieces after test were used for compressive strength and prism split tensile strength. The maximum flexural strength, compressive strength, split tensile strength in case of M20 grade concrete is found to be maximum at 1 % steel fiber.

Gediminas Marciukaitis, Remigijus Salna, Bronius Jonaitis (2011) [8]**,** Studied **'A model for strength and strain analysis of steel fiber reinforced concrete'.** They have to developed the proposes a model for strength and stain analysis of steel fiber reinforced concrete (SFRC). The model is based on general principles for creating and modeling structural composites and on reinforced concrete code. Differently from other examples, the elastic and plastic properties of the components (concrete and steel) of the introduced model are directly taken into account. The model gives an opportunity to determine tension and compression strength, the elasticity modulus of fiber concrete and the main parameters of its elasticity and plasticity. A good agreement between the obtained results and those of experiments performed by other investigators was confirmed. Differences between the ratios of theoretical and experimental values are insignificant and vary within the limits of 1.06–1.10. This model may be used for the analysis of reinforced concrete members reinforced by steel fibers (SFRC) in a dispersible way assuming stress distribution diagrams.

Nitin Kumar et al (2015) [9],**,** presented the use of steel fibers as reinforcement material with concrete. In this study, the mixing of various materials weather chemicals natural or official for improving the strength and durability of parent substance. Critical investigation for M 40 grade of concrete

having mix proportion 1:4:3 with water cement ratio 0.35 to study the compressive strength flexural strength, split tensile strength of steel fibers reinforced concrete containing fibers of 0%, 1%, 2% and 3% volume fraction of hooks the result shown that steel fiber reinforced concrete increase strength toughness ductility and flexural strength of concrete.

Ali Amin and Stephen J. Foster [2016] [10]**,** Despite the increased awareness of Steel Fibre Reinforced Concrete (SFRC) in practice and research, SFRC is yet to find common application in load bearing or shear critical building structural elements. Although the far majority of studies on SFRC have focused on members containing fibres only, in most practical applications of SFRC construction, structural members made of SFRC are also reinforced with conventional reinforcing steel for shear ligatures. In this paper, results are presented on shear tests which have been conducted on ten 5 m long by 0.3 m wide by 0.7 m high rectangular simply supported beams with varying transverse and steel fibre reinforcement ratios. The tests have been analyzed along with complete material characterization which quantifies the post-cracking behaviour of the SFRC.

III. CONCLUSION

A comprehensive review of literature covering papers from Journals and conferences was carried out; papers reviewed were predominantly based on fiber reinforced concrete.

The literature review indicates that very few publications are available on the fiber reinforced concrete with hook tain steel fibers. Variables such as aspect ratio, different grades of concretes and different percentages of steel fibers are simultaneously not covered in papers reviewed. No work is reported in the development of mathematical models and their validation using own experimental values and values from other researches, considering parameters like compressive strength, Split tensile strength and Flexural Strength for Steel fiber reinforced concrete.

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