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Behaviour of Steel Fiber Reinforced Self Compacting Concrete in Short Column

[#1]Akshay V. Deshmukh, [#2]Rashmi S. Unone, [#3]Priya Sheshrao Deshmukh

[1]deshmukhakshay70@gmail.com
[2]rashuunone@gmail.com
[3]deshmukhp033@gmail.com

[#1]Department of Structural Engineer, College of Engineering & Technology, Akola,
[#2]Department of Structural Engineer, College of Engineering & Technology, Akola,
[#3]Department of Civil Engineer, STCSPRT, Khamgaon

ABSTRACT

Construction of durable concrete structures requires skilled labor for placing and compacting concrete. Self-Compacting Concrete achieves this by its unique fresh state properties. In the plastic state, it flows under its own weight and homogeneity while completely filling any formwork and passing around congested reinforcement. In the hardened state, it equals or excels standard concrete with respect to strength and durability. This work is aimed to study the performance of steel fiber reinforced self-compacting concrete as plain self-compacting concrete is studied in depth but the fiber reinforced self-compacting concrete is not studied to that extent.

Key words: Self compacting concrete, fibers, compressive strength, flexure strength

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I. INTRODUCTION

Though concrete possess high compressive strength, stiffness, low thermal and electrical conductivity, low combustibility and toxicity but two characteristics limited its use are, it is brittle and weak in tension. However the developments of Fiber Reinforced Composites (FRC) have provided a technical basis for improving these deficiencies. Fibers are small pieces of reinforcing materials added to a concrete mix which normally contains cement, water, fine and course aggregate.[1]

Among the most common fibers used is steel, glass, asbestos, polypropylene etc. When the loads imposed on the concrete approach that for failure, crack will propagate, sometimes rapidly, fibers in concrete provides a means of arresting the crack growth. If the modulus of elasticity of fiber is high with respect to the modulus of elasticity of concrete or mortar binder the fiber helps to carry the load, thereby increasing the tensile strength of the material. Fibers increase the toughness, the flexural strength, and reduce the creep strain and shrinkage of concrete. [2]

Several European countries recognized the significance and potentials of SCC developed in Japan. During 1989, they founded European federation of natural trade associations representing producers and applicators of specialist building products (EFNARC). The utilization of SCC started growing rapidly. EFNARC, making use of board practical experiences of all members of European federation with SCC, has drawn up specification and guide lines to provide a framework for design and use of high quality SCC, during 2002[3].

The main features of Self-Compacting Concrete (SCC) concern the fresh state condition (high flow ability which avoids external vibration and a good segregation resistance); but in the last two decades many researches have been carried out regarding the features of the hardened state of the SCC and the structural effects due to its utilization. The behaviour of structural elements fabricated using SCC, like walls beams, beam-column nodes and frames has been analysed by means of experimental tests and analytical studies.

The aim of the studies was to highlight possible differences of the behaviour of the SCC members, in comparison to the Normal vibrate Concrete (NVC) – under the same conditions -, due to the greater compactness and the better bond to the steel bars of the SCC. Some researchers refers that the SCC members have a better structural performance than a NVC members, because the SCC allows to obtain a better crack control ability, but sometimes a more brittle behaviour appeared.

There are many advantages of using SCC, especially when the material cost is minimized. These include:

- Reducing the construction time and labor cost;
- Eliminating the need for vibration;
- Reducing the noise pollution;
- Improving the filling capacity of highly congested structural members.
- Facilitating constructability and ensuring good structural performance.

II. LITERATURE SURVEY

In this chapter, an eloborative discussion is made regarding works done so far in this area as literature review. Fibre reinforced concrete with different fibres and their behaviour studies are discussed at the initial subheadings. Works on waste materials are discussed in the subsequent headings comprehensively.

REVIEWS ON FIBRE REINFORCED CONCRETE

History and Development

The concept of using fibres in a brittle matrix was first recorded with the ancient Egyptians who used the hair of animals and straw as reinforcement for mud bricks and walls in housing. This dates back to 1500 B.C. (Balaguru et al, 1992).

Ronald F. Zollo (1997) presented an overview regarding the history and development of Fibre Reinforced Concrete 30 years ago. According to this report, in the early 1960s, the works on fibre reinforced concrete had been started. A lot of research work has been conducted by many researchers on different fashions. But these projects have studied about steel fibres alone. So far, there were only a few works which have studied the other fibres like nylon, plastic, rubber and natural fibres. But those researches are completely different from the current study, since they have concentrated along the material strength properties not on their strucutral behaviour.

According to the terminology adopted by American Concrete Institute (ACI) Committee 544, there are four catagories of Fibre Reinforced Concrete namely 1) SFRC (Steel Fibre Reinforced Concrete), 2) GFRC (Glass Fibre Reinforced concrete), 3) SNFRC (Synthetic Fibre Reinforced Concrete) and 4) NFRC (Natural Fibre Reinforced Concrete). It also provides the information about various mechanical properties and design applications. Cement and Concrete Institute also published the classification of FRC in their website. Based on their classification, Fibres are classified into Glass, Steel, Sythetic (includes Acrylic, Aramid, Carbon, Nylon, Polyster, Polyethylene, Polypropylene) and Natural Fibres.

Mechanical Properties

Kukreja et al (1980) conducted some experiments and reported that, based on the results of three methods such as split tensile test, direct tensile test and flexural test, split tensile strength test was recommended for fibrous concrete. Also increase in tensile strength and post cracking strength, toughness were reported.

Researchers like Goash et al (1989) studied tensile strength of SFRC and reported as inclusion of suitable short steel fibres increases the tensile strength of concrete even in low volume fractions. Optimum aspect ratio was found as 80 and the maximum increase in tensile strength was obtained as 33.14% at a fibre content of 0.7% by volume. Also it was reported that cylinder split tensile strength gave more uniform and consistent results than the modulus of rupture test and direct tension test.

Sabapathi and Achyutha (1989) stress strain characteristics of steel fibre reinforced concrete under compression. Cube compressive strength and Initial Tangent Modulus of Elasticity were obtained and equation for stress-strain relation was also proposed. Distribution and orientation of fibres in FRC significantly affects the properties of FRC. Based on this concept, Paviz Soroushian and Cha-Don

Lee (1990) have carried out some investigation, by counting the number of fibres per unit cross sectional area of SFRC specimen incorporationg various volume fractions of different fibres. Theoretical expressions were derived for the number of fibres per cross sectional area in fibre reinforced concrete as a function of volume fraction and length, assuming the cross sectional boundaries as the only factors distributing the 3-D random oriention of fibres. They made comparisions between number of fibres per cross sectional area and the reorientation fibres in concrete due to vibration. To ascertain the tensile strength of fibre reinforced concrete, a simple test set up was introduced to replace the costly direct tensile strength test apparatus by Youjiang Wang et al (1990). Methodology and testing procedure were also given. But it requires a servo controlled testing machine.

Ganesan and Ramana Murthy (1990) ascertained the stress – strain behaviour of short, confined, reinforced concrete column with and without steel fibres. The volume fraction of 1.5% with aspect ratio of 70 of steel fibres was used. The variable of the study was percentage reinforcement of lateral reinforcement. The strain at peak loads was increased to certain extent.

Ziad Bayasi and Paviz Soroushian (1992) reported that the rhelogical properties of SFRC are significant. The large surface area and interlocking property of fibres lead to the formation of balls among the concrete during mixing which can create damage to the hardened material properties. An experimental investigation was conducted by them to study the fresh concrete properties of concrete with different types of steel fibres. It was concluded that the fresh concrete workability preoperties of FRC were significantly affected by fibre reinforcing index. At a specific fibre reinforcing index, crimpled fibres seem to give slightly higher value than plain fibres.

Balaguru and Shah (1992) have reported that the fibres that are long and at higher volume fractions were found to ball up during the mixing process. The process called ‘balling’ occurs and causes the concrete to become stiff and a reduction in workability with increase volume dosage of fibres. This has a tendency to influence the quality of concrete and strength.

III. CONCLUSIONS

Following conclusion are drawn based on the result discussed above

1. In general, the significant improvement in various strengths is observed with the inclusion of Hooked end steel fibres in the plain concrete. However, maximum gain in strength of concrete is found to depend upon the amount of fibre content. The optimum fibre content to impart maximum gain in various strengths varies with type of the strengths.

2. In general the compressive strength and the flexural strength increase with increase in the percentage of fibre content.

3. In addition to the compressive strength and the flexural strength on the concrete split tension test was also performed on the SFRSCC the results of which are not mentioned in the paper (because the scope is limited to compressive and flexural strength of the SFRSCC) and it was found that the split tensile strength went on increasing with the addition of fibers. The optimum fiber content for increase in split tensile strength is 1.75% and percentage increase is 24.49% of SFRSCC over normal SCC.

4. The increase in compressive strength is 25.75% and increase in flexural strength is 19.47% of SFRSCC over normal SCC for the fibre content of 1.75%.

5. Satisfactory workability was maintained with increasing volume fraction of fibers by using super plasticizer.

6. With increasing fiber content, mode of failure was changed from brittle to ductile failure when subjected to compression and bending.

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