International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 - 6435 (Online) Volume 2, Issue 5, May 2014)

Study of Flexural Strength in Steel Fibre Reinforced Concrete

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***Abstract*— Concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Various types of fibre reinforced concrete are being used against plain concrete due to their higher flexural strength, better tensile strength, modulus of rupture and crack resistance. In the present investigation properties of steel fiber reinforced concrete like flexure and compressive strength are studied. Tests were conducted to study the flexural and compressive strength of steel fibre reinforced concrete with varying aspect and varying percentage of fibre. In the experiments conducted four aspect ratio were selected i.e. 40,50,60,70 and percentage of steel in each case varied from 0.5% to 2.5% at interval of 0.5%. The various strength parameters studied are compressive strength and flexural strength as per the relevant IS standards. The experimental results indicate that the addition of steel fibre into concrete significantly increases the flexural strength. It also indicates that at constant percentage of fibre, that is 1.5% by increasing the aspect ratio of fibre from 40 to 70, flexural strength increased from 36.7% to 58.65%. The research paper proposes that due to these properties of steel fibre reinforced concrete, it can be used for the design of curvilinear forms.**

***Keywords*— Experimental investigation, Fibre reinforced concrete, flexural strength, compressive strength, aspect ratio, steel fibres.**

I. INTRODUCTION

Fibre reinforced concrete is a relatively new construction material developed through extensive research and development work during the last two decades. It has been proved as a reliable construction material having superior performance characteristics compared to the conventional concrete. Incorporation of fibres in concrete has been found to improve several of its properties; cracking resistance, ductility and fatigue resistance , impact and wear resistance.[1]

Even though interest in this new material was generated about two decades ago, large scale use of FRC has been on the increase only over the past ten years. Several improvements have been made in mixing and placing of the fibre reinforced concrete.

A fibre-reinforced composite is a material system made primarily of varying amount of particular fibre reinforcement embedded in a protective material called a matrix. The degree of performance of a fibre reinforced composite depends on the fibre, its orientation, loading and the matrix.

Fibre reinforced concrete has found interesting new applications in the past two decades due to its inherent superiority over normal plain and reinforced concrete in the following properties: higher flexural strength, better tensile strength and modulus of rupture, higher shear strength, higher shock resistance, better ductility and fatigue resistance, crack resistance and failure toughness [2]. FRC is now increasingly used in structures such as airport pavement, bridged decks, machine foundations, blast resistant structures, piles, pipes, sea protective structure, hip-hulls and storage tanks.

A. Significance

Though Concrete is most commonly used structural material it possess very low tensile strength, limited ductility and little resistance to cracking.

In past two decades, compressive strength of concrete has improved substantially but this has not been accompanied by noticeable improvement in either tensile strength or extensibility. Compressive strength of 50-60N/mm^2 are easily achieved at present. The flexural tensile strength however for the same concrete would be less than 7N/mm^2, with its extensibility varying between 0.015 to 0.03 percent. These defects in the concrete properties make it difficult to meet the serviceability requirements of deflection or cracking [3].

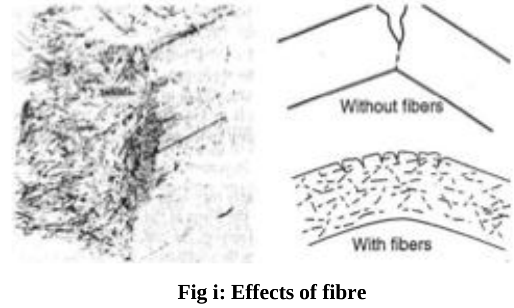

Fig i: Effects of fibre

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In plain concrete and similar brittle material, structural cracks (micro cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns. When loaded these micro cracks propagate and open up and due to stress concentration, additional micro cracks are formed as shown in Figure i [3]. The micro cracks are the main cause for elastic deformation in concrete. Fibre reinforced cement and concrete were developed to overcome these problems [4]. The incorporation of short discrete cracks propagates into a slow controlled growth. This gives the cement-based materials maximum ductility overcoming its low tensile strength properties.

II. Types Of Fibre Reinforced Concrete

Several types of fibres are now being used like steel, glass, polypropylene fibres, choir and jute. Woven meshes, continuous meshes and long wire or rods are not considered as discrete fibres.

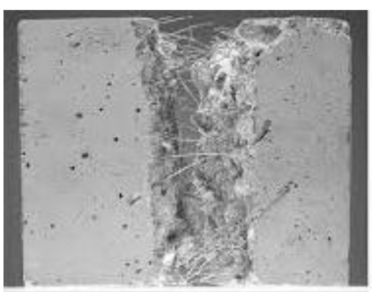

Fig II: Steel fibre reinforced concrete

Research efforts are also in progress in the use of vegetables fibres and polymer impregnated glass fibres. There is a vast scope for application of fibre reinforced concrete in the present construction and in in-situ repair works.

A. Steel Fibre Reinforced Concrete (SFRC)

The mix proportions for SFRC depend upon the requirements for a particular job, in terms of strength, workability, and so on. (Figure ii) [5] Several procedures for proportioning SFRC mixes are available, which emphasize the workability of the resulting mix. In general, SFRC mixes contain higher cement contents and higher ratios of fine to coarse aggregate than do ordinary concretes [6].

B. Advantages of SFRC:

- Fast and perfect mixable fibers and High performance and crack resistance
- Optimize costs with lower fiber dosages
- Steel fibres reinforce concrete against impact forces, thereby improving the toughness characteristics of hardened concrete.
- Steel fibres reduce the permeability and water migration in concrete, which ensures protection of concrete due to the ill effects of moisture. [7]

C. Materials

Ordinary Portland cement of 43 grade (IS 8112) [8] with specific gravity 3.18 was used in making the concrete. The fine aggregate used was sand of zone I and its specific gravity was 2.4 [9]. Coarse aggregates used in experimentation were 20m and down size and their specific gravity was found to be 3.1 and fineness modulus of 5.01[8]. Fibre used in the investigation was procured from local market in bundles. The diameter of steel fibre is 1.0mm, young's modulus is $2.0\text{x}10^5$N/mm^2 and unit weight is 78000N/mm^3. Concrete mix design for M20 grade concrete is done by using I.S method and is found to be 1:1.3:3.6 by weight and water/cement ratio is 0.5.Cement, fine aggregates and coarse aggregates are first mixed in dry. Then required volume of fibre is added in 3 stages. After mixing properly in dry condition, required quantity of water is added. Care is taken to check the balling of fibres. Beams and cubes of size 100mmx100mmx500mm and 150mmx150mmx150mm respectively were casted. The concrete is poured in three layers by compacting each layer properly with tamping rod. For each volume of the fibres and aspect ratio 3 beams and cubes were casted in order to get average strength. Formwork is removed after 24 hours and beams and cubes are immersed in water for curing up to 28 days. They were later taken to the lab to universal testing machine. Two point loading system is used at a distance 1/3 in order to get pure bending. Cubes are tested in the compression-testing machine by keeping cube perpendicular to the direction of compaction.

III. Test And Discussions

1) The results of flexural strength tests are tabulated. It was observed from graph 5,6 that addition of steel fibres to cement concrete, the flexural strength significantly increased. It is seen that addition of 2.5% of fibre with aspect ratio 70, the flexural strength is nearly twice the plain concrete strength.

2) It was observed from graph 7&8 that addition of steel fibres to concrete, the compressive strength is slightly decreased. At aspect ratio 50 & 2.5% volume of fibres shows strength, which is nearer to the strength of plain concrete.
3) It was observed that the addition of fibres decreases the workability. Also it was observed that at constant volume of fibre as aspect ratio increases, the workability is decreased.
4) From graph nos 1,2,3,4 it is seen that as aspect ratio increases, the deflection increases for the same percentage volume of fibres.

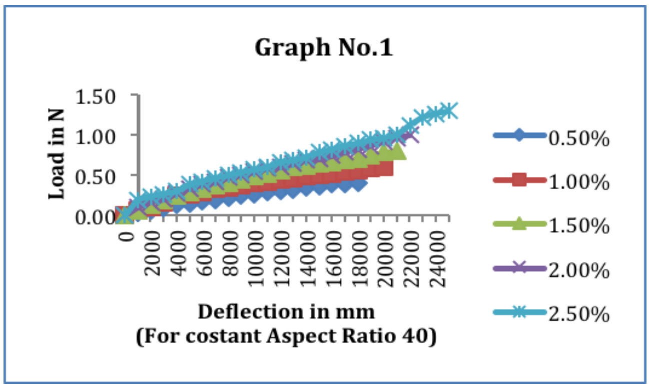

Fig iii: Deflection by fibre content with aspect ratio 40

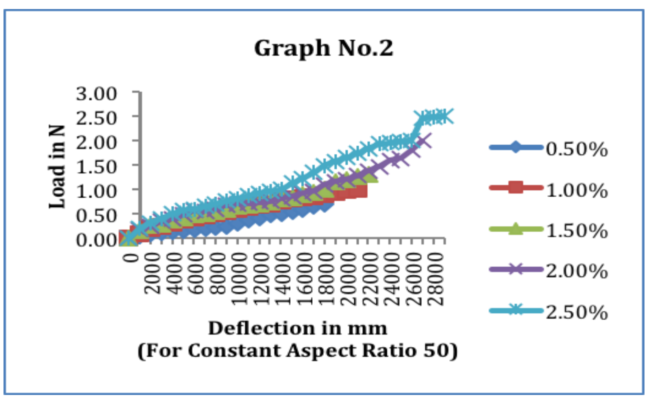

Fig iv: Deflection by fibre content with aspect ratio 50

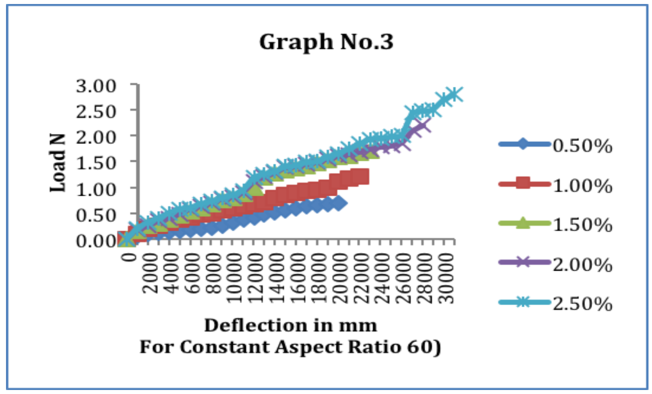

Fig v: Deflection by fibre content with aspect ratio 60

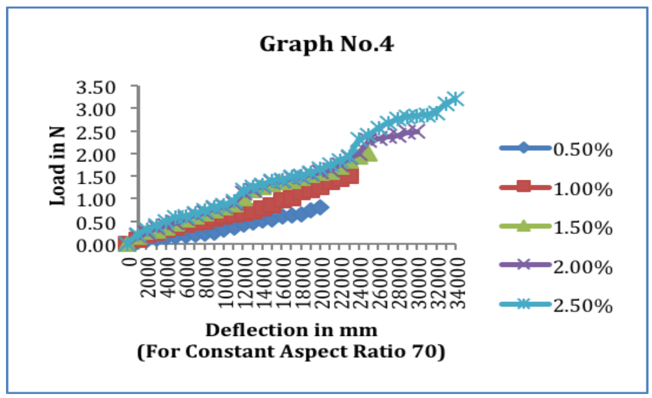

Fig vi: Deflection by fibre content with aspect ratio 70

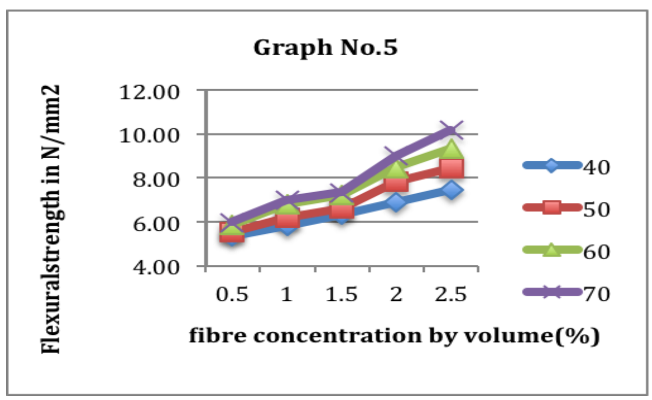

Fig vii: Flexural Strength with fibre content by volume.

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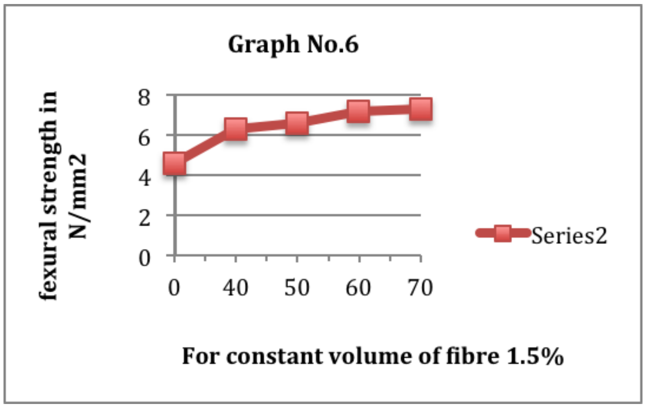

Fig viii: Flexural Strength with constant volume of fibre 1.5%

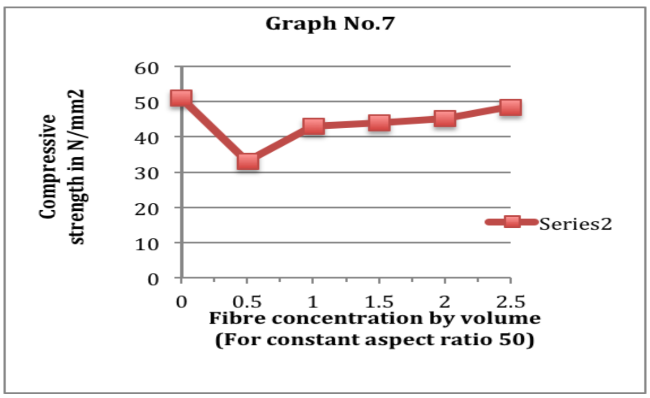

Fig ix: Compressive Strength with fibre content aspect ratio 50

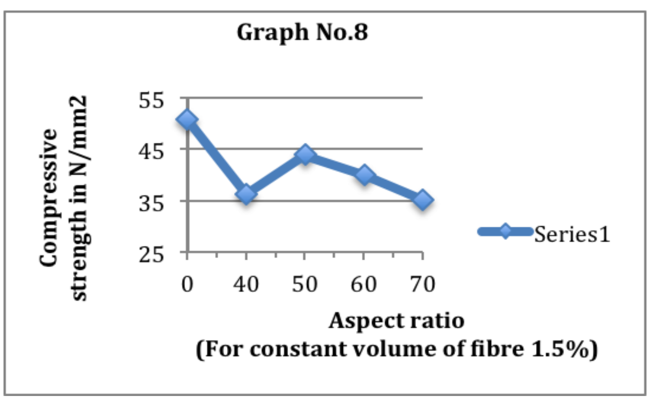

Fig x: Compressive Strength with constant volume of fibre 1.5%

IV. CONCLUSION

Based on the laboratory test conducted the following conclusions are made.

1. The addition of binding wire or a steel fibre into the concrete significantly increases the flexural strength.
2. At constant percentage of fibre=1.5%& by increasing aspect ratio of fibre from 40 tp 70, it is observed that the flexural strength is increased from 36.7% to 58.65% as compared to plain concrete strength.
3. At constant aspect ratio 70 and by increasing percentage volume of fibres from 0.5% to 2.5%, it is observed that the flexural strength is significantly increased from 29.2% to 119.69% as compared to plain concrete.
4. By addition of binding wire as a steel fibre to the concrete, it is observed that the compressive strength slightly decreased.
5. The maximum drop in compressive strength (decrease of 31.10% as compared to plain concrete) is observed with the aspect ratio 70 & percentage volume of fibre of 1.5%.
6. From load deflection curve , it is observed that as the percentage of fibre increases with constant aspect ratio, the deflection of the beam is also increased before failure. The maximum deflection is observed with 2.5% fibre and 70 aspect ratio and it was 3.2mm.

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