Behaviour of SFRC with Varying Mixes and Percentages of Fibres

Iqbal Khaleel Khan[1], M.S. Jafri[2]

Abstract- Fibre reinforced concrete is a concrete mix that contains short discrete fibres that are uniformly distributed and randomly oriented. Fibre material can be steel, cellulose, carbon, polypropylene, glass, nylon, and polyester. Addition of steel fibres slightly increases compressive strength, but it considerably increases the tensile strength, toughness, ductility etc. It also increases the ability to withstand stresses after significant cracking (damage tolerance) and shear resistance.

Present study is to ascertain the behaviour of steel fibre reinforced concrete with varying composite mixes and percentages of fibres. The experiments were conducted on concrete mixes of M20, M25 and M30 grades. Straight fibres of length 28 mm and diameter of 0.28 mm with aspect ratio of 100 was used. Every grade of mix was further reinforced with different percentage of above mentioned fibres i.e. 0%, 0.5%, 0.75% and 1% by weight. A total of 36 cubes of standard size 150 mm x 150 mm x 150 mm and 36 cylinders of 150 mm diameter and of 300 mm height were cast, three samples each for a particular grade of mix and particular fibre content. The experimental program involved the evaluation of the compressive strength and ultimate compressive strains of concrete cubes under uniaxial compression using two dial gauges placed on opposite faces. The cylinders were tested for splitting tensile strength and the tensile strains were recorded under uniaxial compression. Ultimate compressive strength, ultimate compressive strain, ultimate splitting tensile strength and ultimate splitting tensile strain were obtained with the variation in the percentage of fibre content.

From the experimental study, it has been observed that ultimate compressive and splitting tensile strength as well as strain increases with the increase in grade of concrete and percentage of steel fibres.

Keywords---Concrete mix, cylinder, compressive strength, splitting tensile strength.

I. INTRODUCTION

MANY researchers have studied the effect of fibre addition on the mechanical and durability properties of ordinary Portland cement concrete. Review of literature of SFRC on workability, compressive strength, tensile strength and modulus of elasticity are given below.

V. Bindiganavalie, N. Banthia [1] , crried out their research on "Some studies on the Impact Response of Fibre Reinforced Concrete" and made an attempt to examine two major issues related to impact loading on plain and fibre reinforced concrete. Firstly, within the context of drop weight impact tests, a number of machine parameters were examined including capacity size (150J – 15,000J) and drop heights (1.2m – 2.5m). It was found that the machine parameters strongly control the experiential material response to impact. Secondly, a comprehensive test program launched where steel and polymer fibres with widely different constitutive properties were compared as reinforcement in concrete under impact loading.

O. Kayali *et al.* [2] carried out experimental investigation on the effect of polypropylene and steel fibres on high strength light weight aggregate concrete. Sintered fly ash aggregates were used in the light weight concrete. By adding polypropylene fibres at 0.56% by volume of the concrete caused a 90% increase in the indirect tensile strength and a 20% increase in the modulus of rupture, whereas addition of steel fibres at 1.70% of volume of concrete increased the indirect tensile strength by about 118% and 80% increase in modulus of rupture. Finally there is a significant gain in ductility when steel fibres are used.

S.K. Kaushik, Y. Mohammadi [3] carried out experimental investigation on the mechanical properties of reinforced concrete by adding 1.0% volume fraction of 25mm and 50 mm long crimped type flat steel fibres. It was observed that short fibres acts as crack arrestors and enhances the strength, where as long fibres contributed to overall ductility. They concluded that best performance was observed with mixed aspect ratio of fibres.

P.H. Bischoff [4] studied the post cracking behaviour of reinforced tension members made with both plain and steel fibre - reinforced concrete. He concluded that specimens with steel fibres exhibited increased tension stiffening and smaller crack spacing, which both contributed to a reduction in crack widths. Also it is observed that cyclic loading did not have a significant effect on either tension stiffening (or) crack width control for the specimens tested.

Song, Hwang, Shou [5] carried out experimental investigations to study the impact resistance of steel fibre reinforced concrete using drop weight test method. They used hooked end fibres with 0.55mm in diameter and 35mm long. They concluded that steel fibrous concrete improved to various degrees to first crack and failure strengths and residual impact with standing capacity over the non-fibrous concrete.

II. EXPERIMENT PROGRAMME

A. Materials Used

Ordinary Portland cement of 43 grade, locally available coarse sand (grading zone II, fineness modulus: 2.83, specific gravity: 2.45) as fine aggregate, locally available crushed stone aggregate, mainly quartzite in mineralogical

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composition, of maximum nominal size of 10 mm (fineness modulus: 5.92, specific gravity: 2.60) and 20 mm (fineness modulus: 6.98, specific gravity: 2.64) as coarse aggregate, commercially available steel wires were cut in the length of 2.8 cm (0.28 mm dia, aspect ratio =100) and used as steel fibres in the concrete mix M20, M25 and M30 in the proportion of 0, 0.5, 0.75 and 1.0% by weight, and potable water were used throughout experimental investigation.

B. Casting and Curing of Specimens

For the assessment of compressive and splitting tensile strength of concrete at various fibre contents 36 cubes of 150 mm × 150 mm × 150 mm and 36 cylinders of 150 mm diameter and 300 mm height were cas respectively. These specimens were demoulded 24 hours later and after labelling were put under water for a period of 28 days for curing. After 28 days, the concrete specimens were taken out and dried sufficiently and were tested at room temperatures. The cubes and cylinders were tested in a uniaxial compression machine and the deflections were noted using two dial gauges placed diametrically opposite to the specimen face.

C. Testing of Specimens

After 28 days curing, the cubes were taken out of curing tanks and dried sufficiently to be tested under compression for the measurement of compressive strength at room temperature. Also, the longitudinal deformations were measured using two dial gauges placed on the opposite faces on the cubes. The strains were evaluated using these dial gauge readings. Graphs were plotted between the mean strain and mean stress to bring out the stress strain relationship in varying concrete mixes with different percentages of fibres.

The fibre reinforced concrete cylinders were tested to assess their splitting tensile strength. In the process, the cylinders were placed on the compression testing machine in a lying down position with the longitudinal axis of the cylinders perpendicular to the longitudinal axis of the loading arrangement. The position is displayed in the Fig. 1. The deflections were measured at two diametrically opposite points using dial gauges having a least count of 0.01 mm and mean deformation was evaluated.

Fig. 1 Test setup

III. Results And Discussions

An extensive experimental testing was conducted to determine the compressive and splitting tensile strength of cubes and cylinders containing different percentages of fibres (0%, 0.5%, 0.75% and 1.0%) by weight as well as different composition in terms of mix proportions (M20, M25 and M30). Three cubes have been tested for a particular fibre content pertaining to each mix. The compressive and splitting tensile strength were determined in the compression testing machine. The specimens were tested at an increasing load of 25kN applied gradually up to failure or extensive cracking and the corresponding deflections were observed using two dial gauges placed along opposite faces in the case of cubes and in case of cylinders, the dial gauges were placed diametrically opposite to each other.

On the basis of test results obtained by testing cubes and cylinders under compression testing machine graphs were polotted for stress verses strain for M20, M25 and M30 grde of concrete with varying perncetages of steel fibre for cubes and cylinders as shown in Fig. 2, Fig. 3.

Graphs were also plotted for stress/splitting tesile strain verses varying perntage of steel fibre for M20, M25 and M30 grade concrete as shown in Fig. 4, Fig. 5 respectively.

IV. Conclusions

On the basis of limited experimental investigation undertaken, following conclusions are drawn:

With the increase in the percentage of fibres from 0% to 1%, the ultimate compressive strength increases from 35.69 MPa to 38.7 MPa (8.43%), 39.13 MPa to 42.7 MPa (8.8%) and 44.72 MPa to 50.31 MPa (12.5%) for M20, M25 and M30 concrete mixes respectively.

The ultimate compressive strain increases from 8.6 x 10^{-3} to 10.83 x 10^{-3} (25.59%), 9.2 x 10^{-3} to 12.27 x 10^{-3} (33.37%) and 12.13 x 10^{-3} to 15.93 x 10^{-3} (31.33%) with the increase in the percentage of fibres content from 0% to 1%, for M20, M25 and M30 concrete mixes respectively.

With the increase in the percentage of fibres content from 0% to 1%, the ultimate splitting tensile strength increases from 3.36 MPa to 4.48 MPa (33.33%), 3.78 MPa to 5.11 MPa (35.12%) and 4.27 MPa to 5.88 MPa (37.7%) for M20, M25 and M30 grade of concrete mixes respectively.

The ultimate splitting tensile strain increases from 3.53 x 10^{-3} to 9.2 x 10^{-3} (160.62%), 5.03 x 10^{-3} to 9.27 x 10^{-3} (82.84%) and 6.53 x 10^{-3} to 10.13 x 10^{-3} (55.13%) with the increase in percentage of fibres content from 0% to 1%, for M20, M25 and M30 grade of concrete mixes respectively.

Split tensile strength, compressive strength, ductility of the concrete increases when the fibres are added in the concrete as well as when grade of concrete is improved from M20 to M30.

When the fibres are added in the concrete as well as when grade of concrete is improved from M20 to M30, the ultimate compressive strain and ultimate splitting tensile strain increases.

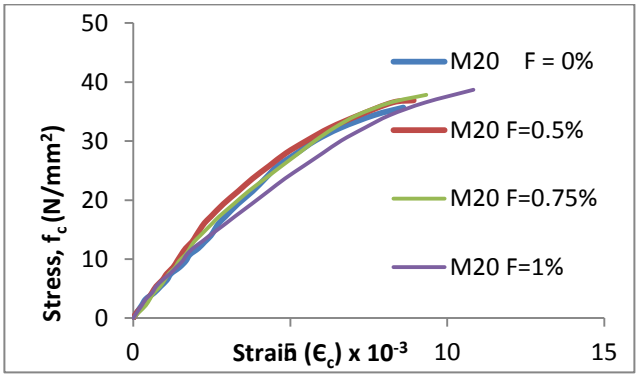

Fig. 2 Stress strain curve for M20 with different fibre contents (cubes)

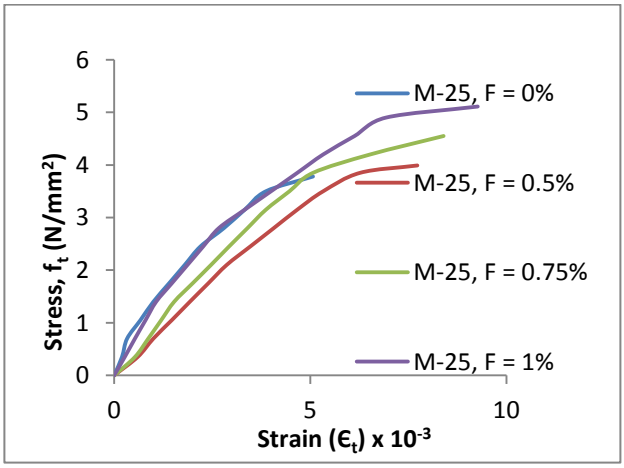

Fig. 3 Stress strain curve for M30 with different fibre contents (cylinders)

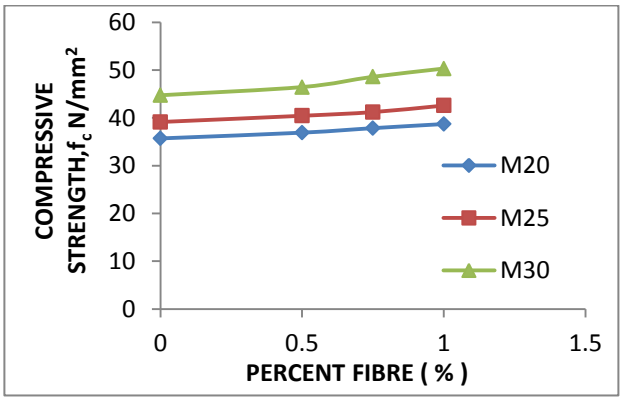

Fig. 4 Compressive strength vs percent fibre curve for cubes

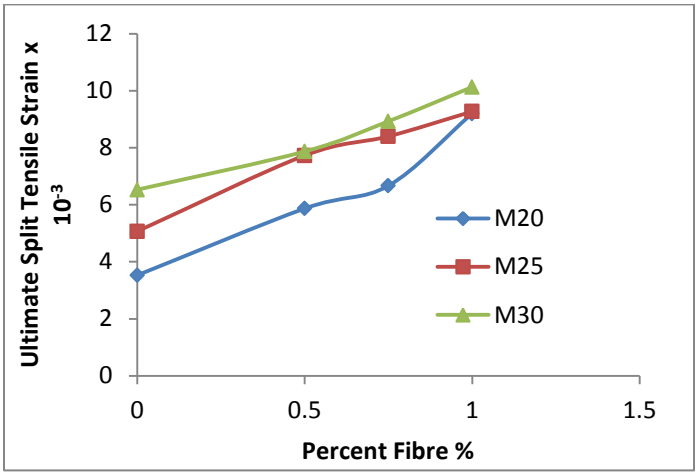

Fig. 5 Splitting tensile strain vs percent fibre curve for cylinders

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