Flexural behavior of SIFCON beams under three point loading

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Abstract— **This study is to investigate the flexural behavior of SIFCON (Slurry Infiltrated Fibrous Concrete) beams under three point loading. The matrix usually holds cement-sand slurry or fluent mortar. SIFCON have greater advantage towards its excellent energy absorption capacity, greater strength and high ductility. The steel fibers used in this study are hook end fibers having 0.5 mm of diameter and aspect ratio of 70. Totally three beams of size 1500x120x150mm are cast and tested. From testing load carrying capacity, crack formation, load deflection response for SIFCON beams were found out.**

Index Terms— **SIFCON, load carrying capacity, three point loading, steel fibers.**

I. INTRODUCTION

Slurry Infiltrated Fibrous Reinforced Concrete (SIFCON) is a relatively new high performance and advanced material and can be considered as a special type of Steel Fiber Reinforced Concrete (SFRC). SIFCON is the unique construction material possessing high strength as well as large ductility and excellent potential for structural applications when accidental (or) abnormal loads are encountered during services. SIFCON also exhibit new behavioral phenomenon, that of ”Fiber lock” which believed to be responsible for its outstanding stress-strain properties. The matrix in SIFCON has no coarse aggregates, but a high cementious content. However, it may contain fine (or) coarse sand and additives such as fly ash, micro silica and latex emulsions. The matrix fineness must be designed so as to properly infiltrate the fiber network placed in molds, since otherwise, large pores may form leading to substantial reduction in properties. A controlled quantity of high range water reducing admixtures (super plasticizer) may be used for improving flowing characteristics of SIFCON. All steel fiber types namely straight, hooked and crimped can be used. The fibers are subjected to frictional and mechanical interlock in addition to the bond with the matrix. The matrix plays the role of transferring the forces between fibers by shear, but also acts as bearing to keep fibers interlock.

1.1 Compositions of SIFCON

Proportions of cement and sand generally used for making SIFCON is in the ratio of 1:1. Water cement ratio varies between 0.3 to 0.4. The percentage of fibers by volume can range from 10% to 12%.

1.2 Process of making SIFCON

The process of making SIFCON is different, because of high steel fiber content. While in SFRC the steel fibers are mixed intimately with wet (or) dry mix of concrete, prior to mix being poured into forms. SIFCON is made by infiltrating low viscosity cement slurry in to a bed of steel fibers “pre packed” in forms (or) molds.

Design principles

The design methods for SIFCON members must take into account their application (or) end, the property that needs to be enhanced, minimum proportion, strength as well as its constructability and service life.

In general, a high strength SIFCON mix can easily be designed and obtained with virtually any type of steel fibers available today, if slurry is also of high strength like conventional concrete, the strength of slurry is a function of water-cement ratio. The term “water-cement plus admixtures” is used when designing slurry mix. In addition, the ratio of “admixtures to cement” is also an important parameter in design of SIFCON higher volume percentages of fibers need lower viscosity slurry to infiltrate the fibers thoroughly. Generally, higher the slurry strength greater is SIFCON strength.

Factors affecting the efficiency of SIFCON

There are four variables to consider when evaluating a SIFCON specimen. They are:-

(1) Slurry strength
(2) Fiber volume
(3) Fiber alignment and
(4) Fiber type

“Cement slurry” greatly affects the behavior of SIFCON specimens because the slurry is the back bone of specimen. The elastic moduli, tensile strength and compressive strength of slurry affect the behavior of composite SIFCON matrix. Fiber pull-out strength is least one variable that depends upon slurry compressive strength.

“Fiber volume” depends upon fiber type and vibration effort. Smaller (or)
Shorter fibers will pack denser than longer fibers. Higher fiber volume can be achieved with added vibration time.

"Fiber alignment" greatly affects the behavior of a SIFCON specimen. Fibers can be aligned normal to loading (or) parallel to loading. The ultimate strength, ductility and energy absorption are all affected by fiber alignment.

"Fiber types" are mainly two types. They are:-

(1) Steel fibers
Steel fibers come in three main shapes and several sizes and strengths. The shapes are hooked, crimped and deformed with various aspect ratios (l/d).

(2) Glass fibers
Glass fibers were generally rod like in shape with various lengths, diameters and strengths.

Study Of Literature Review

- The ultimate load of SIFCON is observed to be 40% more than conventional specimen.
- The stiffness of the SIFCON specimen is nearly about 50% more than conventional specimen.
- Results shows that water absorption capacity of SIFCON decreases with increase of supplementary cementitious materials of SIFCON and may be attributed to the decrease in number of pores in the specimen due to the optimum amount of cementitious materials.
- Experimental results show that the SIFCON slabs with 12% fiber volume fraction exhibits excellent performance.
- 12% addition of steel fibers increases the strength about 36.2% when compared to conventional concrete.

II. MATERIALS AND METHODOLOGY

2.1 Materials

Cement

Portland Pozzolona Cement of 53 grades available in market was used. cement used was tested for various proportions and conforms to IS 10262-2009.

Fine Aggregate

Fine aggregate river sand, passing through 4.75 mm size was used. Specific gravity of fine aggregate is 2.67.

Steel Fiber

Hook end steel fibers were used. The properties of steel fiber with their specification are mentioned below

- ***compliance***
  - Conforms to ASTM A820, Type 1 cold drawn wire
  - Testing conforms with astm a820
- ***Type***
  Hooked End
- ***Nominal Dimensions***
  Diametre D : 0.60 mm
  Length L : 30 mm
  Aspect Ratio L/D : 50
  Yield strength of wire : > 1000 MPa
  Wire mechanical properties
  M (Tensile strength of the wire) >1450 MPa
  H (Strain at failure) < 4%
- ***Shape***
  The ending shapes of hooked end steel fibre are very important to grant adhesion between fiber and concrete.

2.2 METHODOLOGY

Initially collection of materials is done. Proportions of cement and sand used for making SIFCON is 1:1 cement slurry. Water cement ratio varies between 0.3 to 0.4. The percentage of fibers volume used is from 10% to 12%. Totally 12 number of specimens were casted and cured for 28 days. After curing is done the specimens were subjected to flexural loading under three point loading using load frame to find the loading carrying capacity, energy absorption capacity of the beam specimen.

III. RESULTS AND DISCUSSIONS

3.1 Load Vs Deflection

Load-deflection behavior is the principle constituent of the flexural behavior of the beams. As the load increases the deflection of the beam begins. Load will be directly proportional to deflection. Load-deflection curve serves as the basis for calculating many structural parameters like deflection, etc.

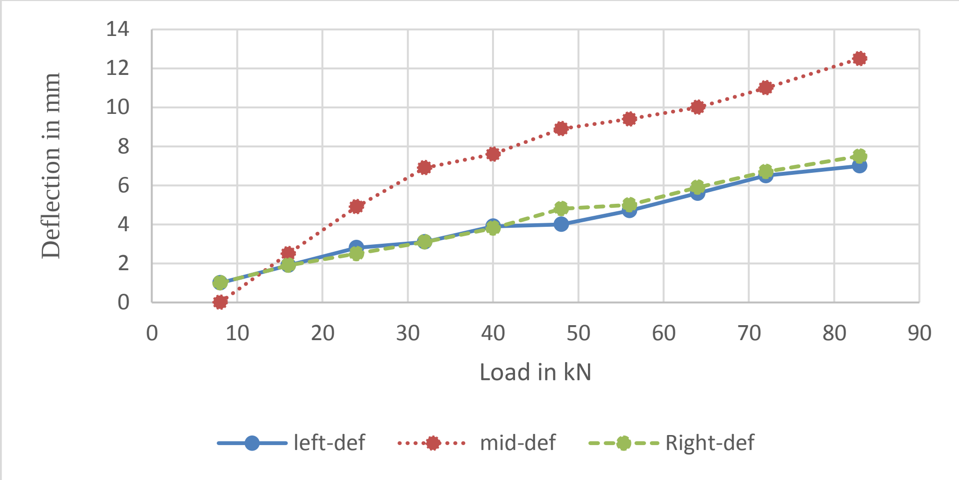

Figure 1: Load Vs Deflection Curve for 12% of Steel Fiber

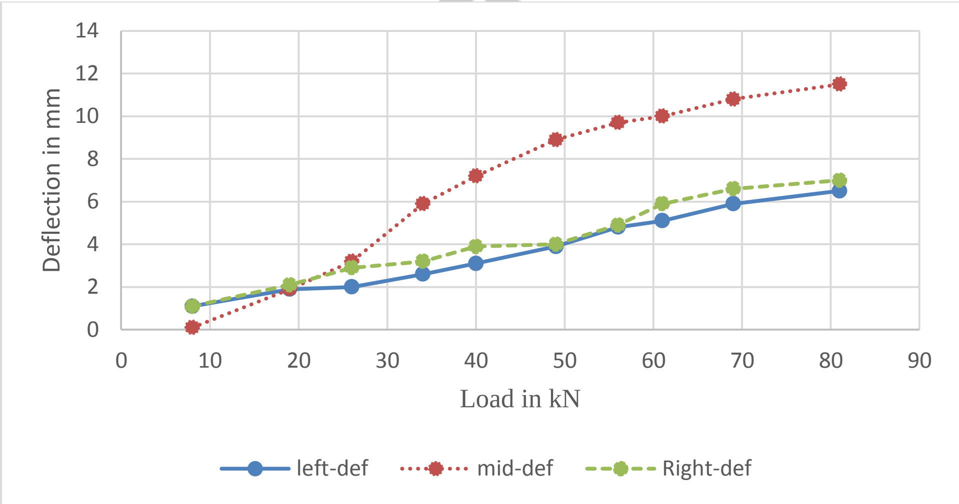

Figure 2: Load Vs Deflection Curve for 11% of Steel Fiber

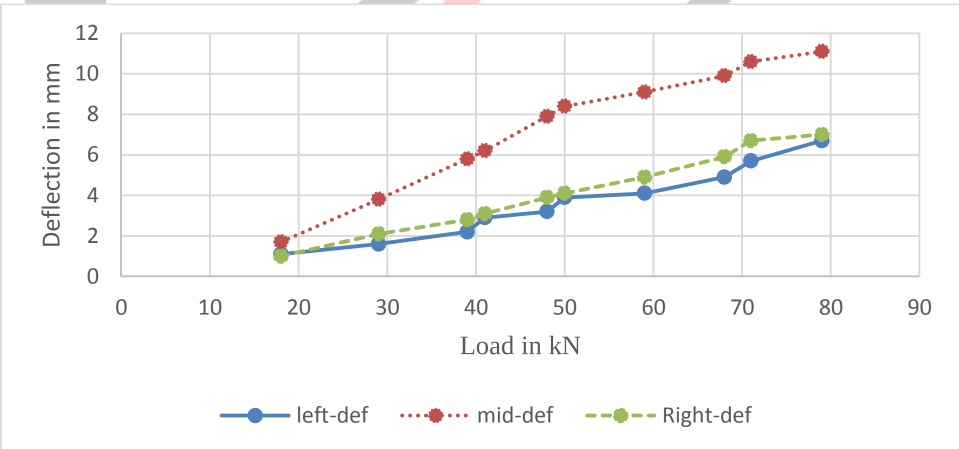

Figure 3: Load Vs Deflection Curve for 10% of Steel Fiber

3.2 Stress Vs Strain Characteristics

Stress strain curve is a behavior of material when it is subjected to load.in this diagram stresses are plotted along horizontal axis and a result of these stresses, corresponding strains are plotted along the vertical axis.

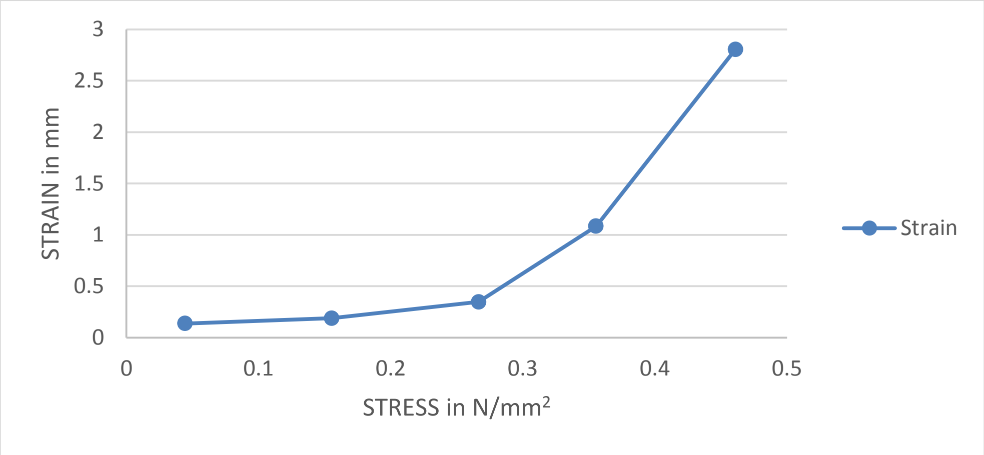

Figure 4: Stress Vs Strain Curve for 12% of Steel Fiber

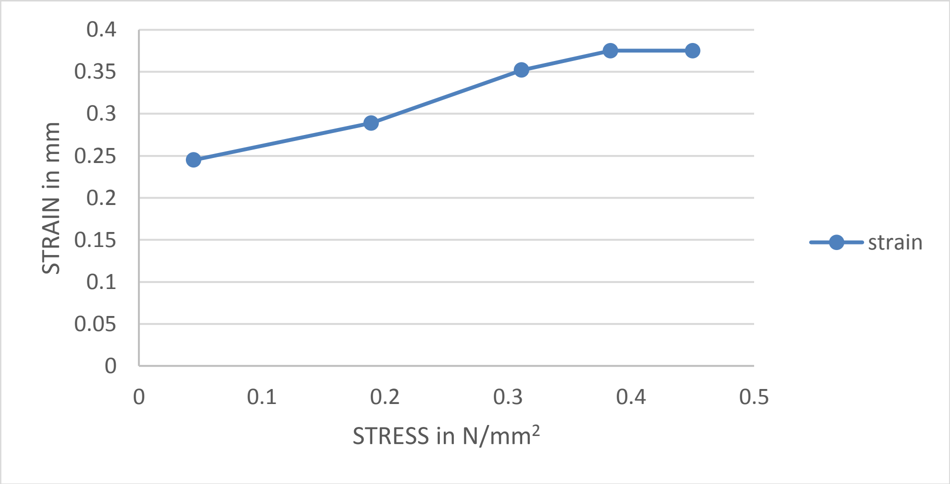

Figure 5: Stress Vs Strain Curve for 11% of Steel Fiber

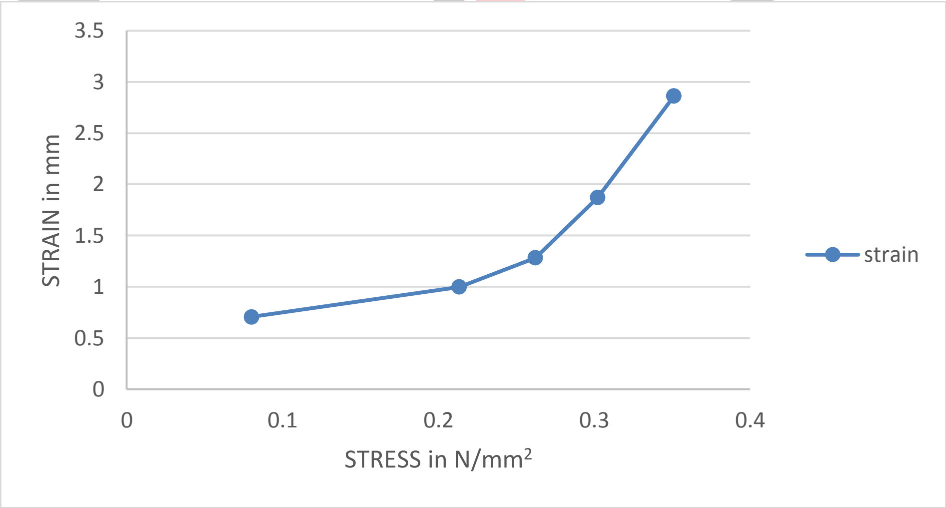

Figure 6: Stress Vs Strain Curve for 10% of Steel Fiber

IV CONCLUSIONS

- The flexural strength of plain concrete (without Reinforcement) can be improved clearly by incorporating SIFCON and the addition of SIFCON in conventional concrete results in improvements in strength and ductility under static loading.
- Increase in the layer depth of SIFCON showed positive effect in the reduction of beam deflection.

- Increasing fiber volume increase in peak stress and flexural strength.
- The addition of SIFCON in conventional concrete shows significant reduction in the number of cracks and their widths.
- While adding fibers at 10%, 11% and 12% the strength keeps increases. From this increasing fibers will increase the strength of the beam.

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