Evaluation of Young's Modulus of SFRC Members

Prashant C. Hargude[1], Suresh R. Parekar[2]

[1]Research Scholar, Department of Civil Engineering
All India ShriShivaji Memorial Society College of Engineering, Pune-01, Maharashtra, India

[2]Head ofCivil Engineering Department.All India ShriShivaji Memorial Society College of Engineering, Pune-01, Maharashtra, India

Abstract: ***The modulus of elasticity of concrete is a very important parameter reflecting the ability of concrete to deform elastically. The aim of study is to verify the influence of steel fibers on the modulus of elasticity of reinforced concrete members. Study carries casting and testing of 12 cube specimens, 3 specimens of RCC and 6 specimens of SFRC beams. The concrete grade considered for study is M30. In the experimental study the concrete mix has been design as per the guidelines given in IS: 10262-1982 published by Bureau of Indian Standards. In SFRC cube specimens, volume fraction (Vf) of steel fiber varies from 0.5% to 1.5% at an increment of 0.5%. The volume fractionof steel fiber used for beam specimen is 1.5%. The aspect ratio of steel fiber is 65 and 80. The size of cubes and beams are 150mm × 150mm × 150mm and 150mm × 150mm × 700mm respectively as per IS: 516-1959. The value of modulus of elasticity (E_b) is evaluated from the load vs. deflection curve of beam specimens.***

Keywords: Steel fibers, volume fraction, aspect ratio, modulus of elasticity, load vs. deflection curves

1. Introduction

Unreinforced concrete is a brittle material, with a low tensile strength, limited ductility and little resistance to cracking. In order to improve the inherent tensile strength of concrete there is a need of multidirectional and closely spaced reinforcement. This can be provided in the form of randomly distributed fibers. Steel fiber is one of the most commonly used fibers. Short, discrete steel fibers provide reinforcement that carries load and transfer stresses at maximum efficiency. Steel fibers increased tensile strength, compressive strength and flexure strength of concrete members.

2. Literature Survey

SemsiYazici, GozdeInan and Volkan Tabak, studied the effects of aspect ratio (l/d) and volume fraction (V_f) of steel fiber on the concrete [1].Tayfun Uygunoglu, studied the effect of the steel-fiber length and content on bleeding of steel fiber reinforced concrete [2]. B.W. Xu and H.S. Shi, investigated the relations among compressive strength, splitting tensile strength and flexural strength of normal concrete, polypropylene fiber reinforced concrete (PFRC) and glass fiber reinforced concrete (GFRC) to steel fiber reinforced concrete (SFRC) [3]. BensaidBoulekbacheet. al., studied and examined the influence of the yield stress and compressive strength on the behavior of fiber-reinforced concrete (FRC) versus direct shear [4]. S K Kulkarni, et. al., studied the material and geometrical properties of members [5].

3. Materials

1. Cement
2. Coarse aggregate
3. Fine aggregate
4. Steel bars for reinforcement
5. Steel fibers

OPC of 53 grade is used which has specific gravity 3.15. Its standard consistency is 38%. The initial and final setting time is 175 minutes and 542 minutes respectively. Maximum size of aggregate selected for the mix design is 20 mm. specific gravity of coarse aggregate was 2.88 and water absorption 1.8%.River sand passing through 4.75 mm sieve is used as fine aggregate in concrete mix design. It has specific gravity of 2.60 and water absorption 1.5%.TMT bars are used as reinforcement in beams**.** 10 mm diameter bars are used as tension reinforcement and 8 mm diameter bars are used as the compression reinforcement. The steel fibers used are of aspect ratio 65 and 80. The diameter of steel fiber is 0.55 mm and 75 mm and the length of steel fiber is 35 mm and 60 mm respectively.

4. Testing Program

A] Casting and curing of specimens

As per the calculated design mix all the ingredients is properly weighed in proportion. The fibres are weighed on electronic balance and kept in a separate plastic container. They are thoroughly mixed and poured in the mould. First the mould is cleaned and the oil is applied on the sides and at the bottom of internal portion of mould. For the beam specimen, steel reinforcement is then kept in a mould. The concrete is then filled in the mould in approximate 3 to 4 layers. Each layer is compacted with not less than 35 blows per layer with the help of tamping rod. After the mould is filled completely, the top surface is leveled.

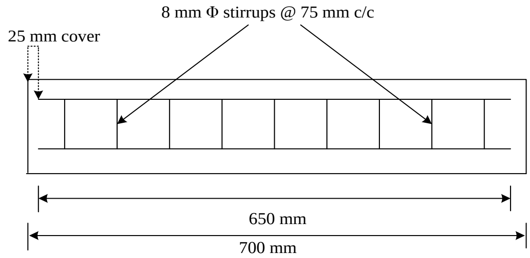

Figure 1: Longitudinal Section of Beam

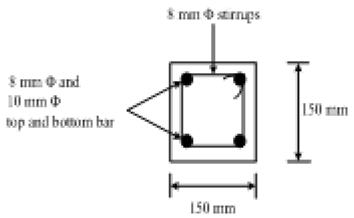

Figure 2: Details of Beam

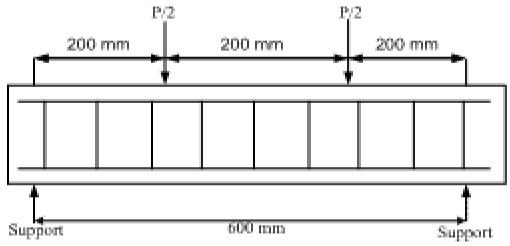

Figure 3: Loading on beam

B] Testing of cubes and beam

All the cube specimens were tested at constant rate of loading using CTM of3000 kN capacity. The beam specimen was tested using UTM of 1000 kN capacity. The load was applied using two point loading procedure with a constant rate until the beam was failed. The deformation was recorded at a constant interval of 5 kN up to failure of beam. The failure load and deflection was recorded.

5. Results and Discussion

A] Compressive strength

Table 1: Experimental compressive strength

Sr. No.	Specimen Designatio	Experimental Strength in MPa
1	M30	39.60
2	M30 65 0.5	40.74
3	M30 65 1.0	42.22
4	M30 65 1.5	45.18
5	M30 80 0.5	42.22
6	M30 80 1.0	53.33
7	M30 80 1.5	47.85

B] Flexural strength- f_r

Table 2: Experimental flexural strength

Sr. No.	Specimen Designation	Moment in N.mm	f_r in MPa
1	CB1	11.2	31.11
2	CB2	10.8	30.00
3	CB3	11.0	30.55
4	B1 65	13.74	38.16
5	B2 65	13.61	37.81
6	B3 65	13.67	37.97
7	B1 80	14.89	41.36
8	B2 80	14.91	41.42
9	B3 80	14.91	41.42

C] Modulus of elasticity - E_b

Modulus of elasticity is evaluated from load vs. deflection curve of beam using the formula [5]:

$$\delta = \left(\frac{5}{384}\right) \times \left(\frac{wl^4}{E_b I}\right) + \left(\frac{23}{648}\right) \times \left(\frac{Wl^3}{E_b I}\right) \text{ ----- (1)}$$

For a 2-point loading test of a rectangular beam, band d are the width and depth of the beam, l is the distance between the two outer supports, δ is the deflection due to the load p applied at the middle of the beam, I is the moment of inertia and E_b is the modulus of elasticity.

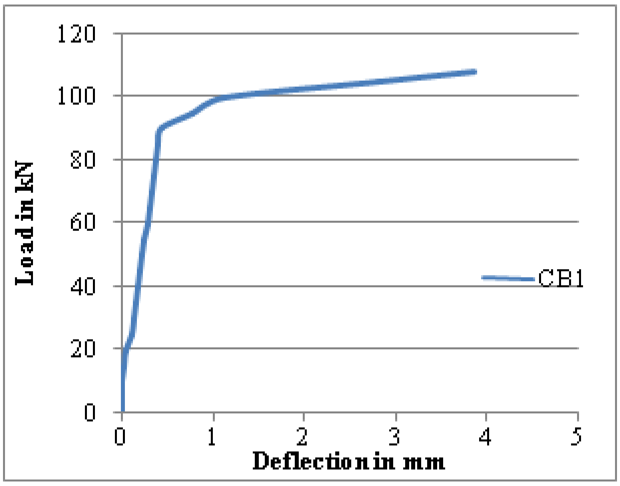

Figure 4: Graph of beam without steel fiber

Table 3: Load vs. deflection of beam

Load	δ = CB1
0	0
5	0.005
10	0.02
15	0.09
20	0.257
25	0.28
30	0.32
35	0.35
40	0.37
45	0.39
50	0.42
55	0.45
60	0.472
65	0.497
70	0.52
75	0.547
80	0.57
85	0.626
90	1.224
95	2.855
100	3.355
105	3.92
110	4.515

Table 4: Modulus of elasticity fromload vs. deflection curve of beam

Specimen Designation	E_b in MPa
CB1	33099.77
CB2	33122.33
CB3	33025.01
B1 65	35950.07
B2 65	35650.08
B3 65	34929.55
B4 80	36278.84
B5 80	36369.77
B6 80	36292.61

6. Conclusion

The compressive strength has increased by 12% for steel fiber reinforced concrete with steel fibers having aspect ratio of 65.The compressive strength has increased by 25% for steel fiber reinforced concrete with steel fibers having aspect ratio of 80.The compressive strength starts to decrease with increase of aspect ratio and volume fraction of steel fibers.The flexural strength has increased by 19% for steel fiber reinforced concrete beams with the steel fiber having aspect ratio 65. The flexural strength has increased by 26% for steel fiber reinforced concrete beams with the steel fiber having aspect ratio 80. It is observed that the Young's Modulus of SFRC members increases with the increase in aspect ratio of steel fiber. The hooked end steel fibers used in present study can be replaced with other type of steel fibers.

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Author Profile

Prashant C. Hargude, received degree of B.E. in Civil Engineering (2013), pursuing the post graduate degree of M.E. in Structures from A.I.S.S.M.S COE Pune-01 (2015).

Dr. Suresh R. Parekar, head of the civil engineering department A.I.S.S.M.S COE., received degree of B.E in civil Engineering (1994), completed the post-graduation in Structural Engineering (1998) and completed his PhD in 2010.