Behaviour of Normal, Medium and High Strength Fibrous RC Slab Under Flexur

Manjunath Shevatkar*, B.K.Kolhapure**
*Student, Department of Civil Engineering (M.Tech Structures), P.D.A. College of Engineering, Gulbarga, Karnataka State, India
**Associate Professor, Department of Civil Engineering, P.D.A. College of Engineering, Gulbarga, Karnataka State, India

Abstract

An experimental investigation on the behavior of concrete slabs reinforced with conventional steel bars and steel fibers and subjected to flexural loading is presented. An experimental program consisting of tests on steel fiber reinforced concrete (SFRC) slabs with conventional reinforcement and reinforced concrete (RC) slabs was conducted under flexural loading. SFRC slabs include two types of slabs containing steel fibers in two different volume fractions i.e. 1% and 1.5%. The size of slab was fixed. The dimensions of the slabs were (900 x 450 x 50mm and 900 x 450 x 75mm). Tests on conventionally reinforced concrete slabs showed enhanced properties compared to that of RC slabs. The ultimate loads obtained in the experimental investigation were also compared with the theoretical loads for all types of slabs specimens, containing steel fibers in different proportions, have been conducted to establish load–deflection curves. The various parameters, such as, first crack load, ultimate load and with and without steel fibers have been carried out and comparison was made on significant stages of loading.

Keywords; *SFRC Slab, RC Slab, Steel fibers, Flexural loading.*

1. Introduction

Concrete is the most widely used structural material around the world, because of its higher compressive strength, low cost and can be easily manufactured with the locally available materials [1]. But concrete lacks tensile strength, ductility, fatigue, and resistance to cracking and crack propagation. Direct and flexural tensile strength can be imparted to concrete by embedding the steel rods [2]. A challenge for engineers was created to develop a new construction material since the resulting matrix lacks in ductility and resistance to cracking. As the consequences of research, the use of fibers along with ingredients of concrete was investigated to produce a composite material called -Fiber Concrete [3].

Steel Fiber reinforced concrete is defined as a composite material made with Portland cement, aggregate and addition of discrete discontinuous fibers. Now why should we add such fibers to concrete? Plain unreinforced concrete is a brittle material with a low tensile strength and low strain capacity [4]. The role of randomly distributed discontinuous fibers to bridge across cracks that develop, to provide some post cracking ductility [5]. If the fibers are sufficiently strong, sufficiently bounded to material and permit the fiber reinforce concrete to carry significant stress over relatively large strain capacity in the post cracking stage [6]. There are of course other ways of increasing the strength of concrete. The real contribution of fibers to increase the toughness of the concrete under any type of loading.

Fiber is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fiber is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fiber composite and its ability to withstand repeatedly applied shock or impact loading.

Depending on the use for which the fiber reinforced concrete is intended, different types of fibers are used. They are made out of Glass, Carbon, Wood, Akwara, Coir, Polypropylene, Polyethylene, Synthetic, Galvanized Iron, Steel, Organic and Inorganic Fibers etc.

2. Research significance

A comparative study has been undertaken to investigate into the flexural behavior of normal, medium and high strength with M_{20}, M_{40}, M_{60} grade of concrete using fiber at 0%, 1% and 1.5% by volume of concrete. The size of slab is kept constant (450 x 900mm). Two types of slabs were casted with varying thickness i.e. 50mm and 75mm. 18 slabs were casted and tested under 4 point bending ($1/3^{rd}$ two point loading). The main variables are the grade of concrete M_{20}, M_{40}, M_{60}, the thickness of the slab of 50mm and 75mm, the variation of steel fibers at 0%, 1% and 1.5% and also variation of main reinforcement of 1.56% and 1.04%.

3. Objective

To study the Behavior of Normal, Medium and High Strength Fibrous RC Slab Under Flexure.

4. Laboratory Tests

4.1 Materials & Mix proportions

Ordinary Portland cement of 53 grade satisfying the requirements of IS 8112-1989, from single batch has been used in the present investigation. The coarse fraction consisted of equal fractions of crushed stones of maximum size of 20mm. Fine aggregate used was natural sand with grading conforming to Zone II. High range water-reducing admixture (HRWA) of type Conplast SP-430 is used in the present investigation to enhance workability. Steel fibers of round crimped type with diameter 0.55mm and length 30mm (aspect ratio = 54) has been used in the present investigation.

Mix proportions

M_{20}, M_{40} and M_{60} grade concrete with water to cementitious ratio of 0.55, 0.35 and 0.30 in order to achieve workability High range water-reducing admixture (HRWA) of type Conplast SP-430 has been used in the present investigation. The dosage of superplasticizer used for M_{40} - 1.25% and M_{60} - 2.5% by weight of cementitious materials for Non fibrous and fibrous concrete respectively and mix proportions for different grades are given in table 1,2 and 3

Table 1 Mix proportion of M_{20} grade concrete

Ingredients	Proportion
Water (kg/m^3 of concrete)	186
Cement (kg/m^3 of concrete)	338.18
Fine Aggregate (kg/m^3 of concrete)	624.44
Coarse Aggregate (kg/m^3 of concrete)	1191.20
Mix Proportion	W : CM : Fine Agg : Coarse Agg
	0.55:1.0:1.846:3.522

Table 2 Mix proportion of M_{40} grade concrete

Ingredients	Proportion
Water (kg/m^3 of concrete)	186
Cement (kg/m^3 of concrete)	541.42
Fine Aggregate (kg/m^3 of concrete)	565.66
Coarse Aggregate (kg/m^3 of concrete)	1078.57
Mix Proportion	W : CM : Fine Agg : Coarse Agg : Superplasticer
	0.35:1.0.1.04:2.029: 1.25%

Table 3 Mix proportion of M_{60} grade concrete

Ingredients	Proportion
Water (kg/m^3 of concrete)	150
Cement (kg/m^3 of concrete)	536
Fine Aggregate (kg/m^3 of concrete)	581.63
Coarse Aggregate (kg/m^3 of concrete)	1150
Mix Proportion	W : CM : Fine Agg : Coarse Agg : W/b : Superplasticer
	0.30:1.0.1.09:2.15:1. 6:2.5%

4.2 Test procedure and test results

a) Compressive strength

Cube specimens of size 150mm×150mm×150mm were used for determining compressive strength. 28days compressive test results are given in table 4, where each value represents the average of three specimens

Table 4 Compressive strength results

Type of concrete M20	Compressive strength in N/mm^2
	28 days
Cvc(nf)	36.62
Sfrc 1%	45.48
Sfrc 1.5%	52.31

Type of concrete M40	Compressive strength in N/mm^2
	28 days
Cvc(nf)	48.47
Sfrc 1%	49.41
Sfrc 1.5%	52.75

Type of concrete M60	Compressive strength in N/mm^2
	28 days
Cvc(nf)	71.44
Sfrc 1%	72.41
Sfrc 1.5%	74.45

b) Testing of slabs

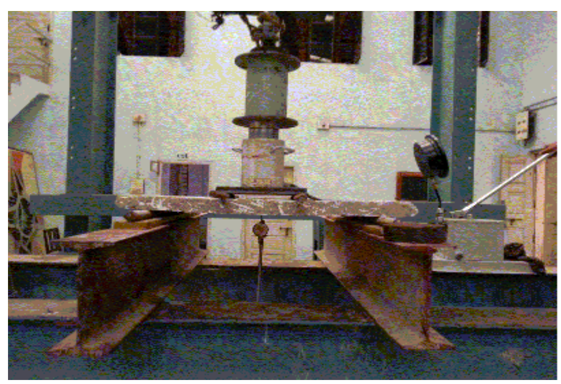


Fig. 1: Test Setup for slab

A typical loading frame as shown in figure-1. The load was applied by a 500KN hydraulic jack through steel section and steel plates acting as two point load.

The deflection of the slabs were measured using dial gauge before application of the load the initial readings were recorded then the load was gradually applied with constant increment of 2kn and corresponding deflection was recorded for every increment of load and slabs surface was checked for any visible cracks the load at which first crack development is observed and it is noted and corresponding deflection also noted then with further increment of the load the occurrence of different cracks and the corresponding load were noted the load was increased till the slabs fail completely and that load is noted as ultimate load and with corresponding deflection

The test results of the slabs are given in table-5. reinforcement provided as Ast1=1.56% with 4-8mm @ 150mm and 7-6mm@150mm and Ast2=1.02%with 4-8mm @ 150mm and 7 -6mm@150mm both side

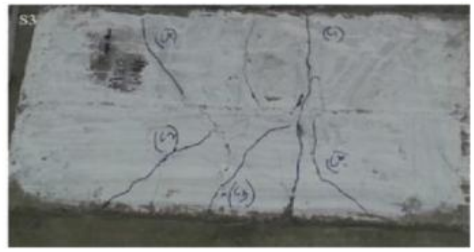
Table 5: Test results of slabs

SLAB	Width b (mm)	Depth d (mm)	Length in (mm)	First crack load Pcr (KN)	Ultimate load Pu (KN)
S1 M_{20} – NF	450	50	900	14	22
S3 M_{20}–1%F	450	50	900	20	32
S5 M_{20}–1.5%F	450	50	900	20	32
S2 M_{20}–NF	450	75	900	24	36
S4 M_{20}–1%F	450	75	900	22	36
S6 M_{20} – 1.5%F	450	75	900	26	40
S7 M_{40}–NF	450	50	900	12	28
S9 M_{40}–1%F	450	50	900	16	32
S11 M_{40}–1.5%F	450	50	900	16	34
S8 M_{40}–NF	450	75	900	16	36
S10 M_{40}–1%F	450	75	900	16	36
S12 M_{40}–1.5%F	450	75	900	18	40
S13 M_{60}–NF	450	50	900	20	50
S15 M_{60}–1%F	450	50	900	28	54
S17 M_{60}–1.5%F	450	50	900	32	58
S14 M_{60}–NF	450	75	900	36	64
S16 M_{60}–1%F	450	75	900	36	66
S18 M_{60}–1.5%F	450	75	900	44	70

*S-Slab type
*F-Fiber
*NF- Non-fiber

Discussion on failure pattern of slabs

Crack pattern of slab M_{20} 50mm thickness without fiber

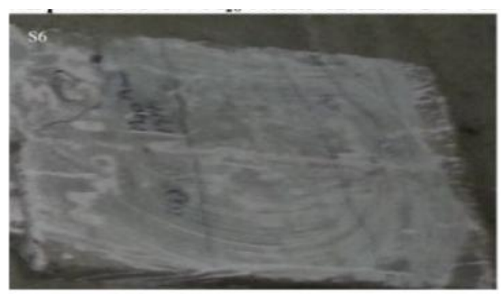


Crack pattern of slab M_{20} 75mm thickness without fiber

Crack pattern of slab M_{20} 50mm thickness 1% fiber

Crack pattern of slab M_{20} 75mm thickness 1% fiber

Crack pattern of slab M_{20} 50mm thickness 1.5% fiber

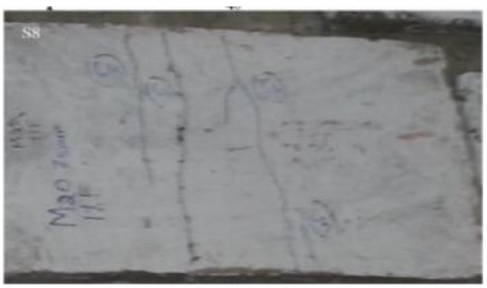


Crack pattern of slab M_{20} 75mm thickness 1.5% fiber

Crack pattern of slab M_{40} 50mm thickness without fiber

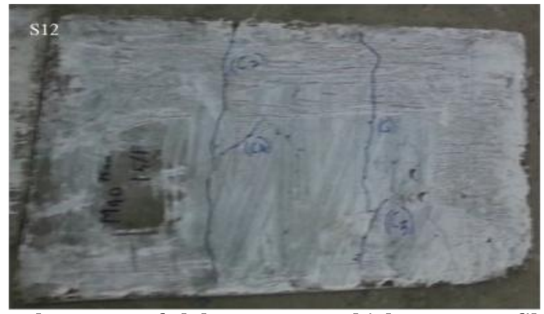
Crack pattern of slab M_{40} 75mm thickness without fiber

Crack pattern of slab M_{40} 50mm thickness 1% fiber



Crack pattern of slab M_{40} 75mm thickness 1% fiber

Crack pattern of slab M_{40} 50mm thickness 1.5% fiber



Crack pattern of slab M_{40} 75mm thickness 1.5% fiber

Crack pattern of slab M_{60} 50mm thickness without fiber

Crack pattern of slab M_{60} 75mm thickness without fiber

Crack pattern of slab M_{60} 50mm thickness 1% fiber

Crack pattern of slab M_{60} 75mm thickness 1% fiber

Crack pattern of slab M_{60} 50mm thickness 1.5% fiber

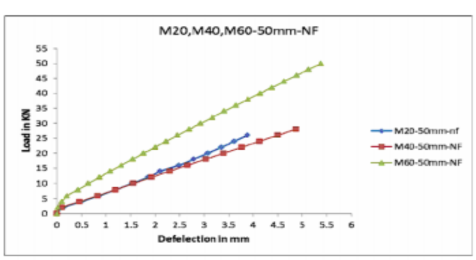
Crack pattern of slab M_{60} 75mm thickness 1.5% fiber

- It is observed that as the percentage of fibers increases from 0%, 1% and 1.5% more number of cracks were observed and the failure linear for 0% or are parallel to supports and a for 0% the number of diagonal cracks develops.

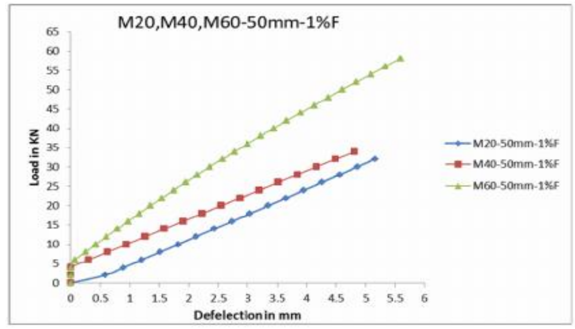
- It is also observed that the failure of slabs with 0% fibers completely crushed were as addition of fibers failure was rather ductile.

- Same observations are found as in M_{20} grade concrete but the cracks were bit wider for M_{40} grade concrete

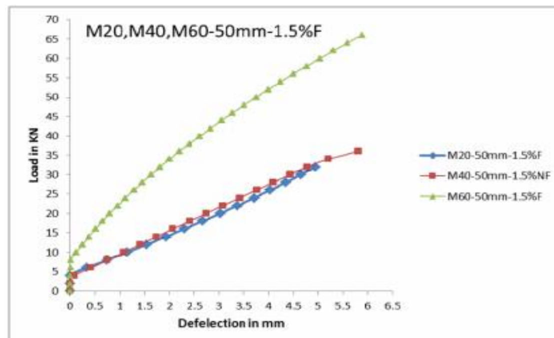
- For M_{60} grade concrete similar observations were found as for M_{40} grade concrete as its is observed as the strength of the concrete increases from M_{20}, M_{40} to M_{60} the cracks were are the straight at higher strength may be because of increase in brittleness of concrete as the thickness of the slabs increases the load carrying capacity increases but at 75mm thickness the failure was with the less no of cracks.
- **5. Result and Comparison**



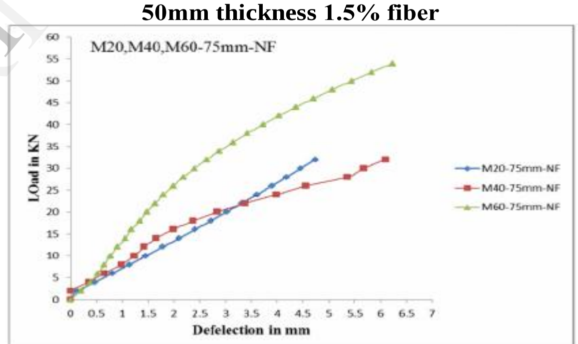
Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 50mm thickness non fiber



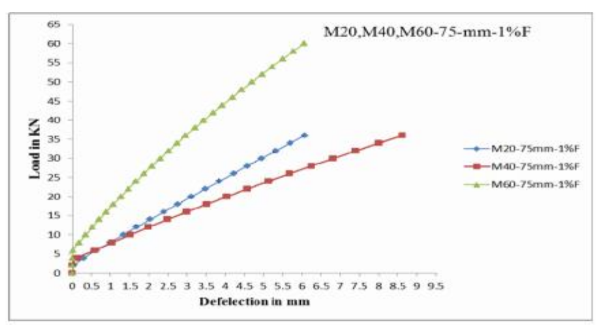
Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 50mm thickness 1% fiber



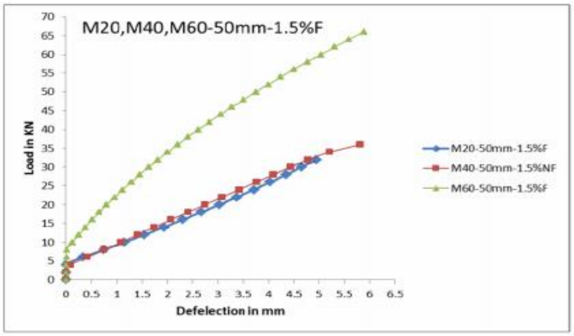
Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 50mm thickness 1.5% fiber



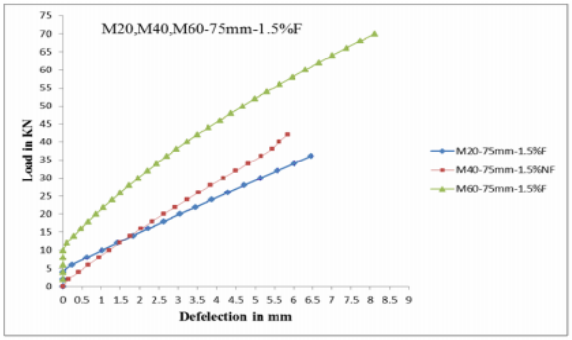
Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 75mm thickness non fiber



Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 75mm thickness 1% fiber



Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 50mm thickness 1.5% fiber



Comparison between the slabs of M_{20}, M_{40} and M_{60} grade 75mm thickness 1.5% fiber

6. Conclusion

Following conclusion can be drawn:

1. Result of control specimen
   a) The percentage increase compression strength for M_{20} concrete with 1% and 1.5% were found to be 18.84%, and 23.25% respectively.
   b) The percentage increase compression strength for M_{40} concrete with 1% and 1.5% were found to be 18.48%, and 19.49% respectively.
   c) The percentage increase compression strength for M_{60} concrete with 1% and 1.5% were found to be 17.18%, and 18.01% respectively. It is observed that with addition of fibers the strength of concrete improves upto 1 and 1.5%.

2. Load v/s deflection behavior observed to be linear upto 10% of ultimate load and non-linearity started till the failure of the slabs.

3. It is observed that as the thickness of the slab increases the load carrying capacity increases and corresponding deflection and crack width and number of cracks also increases. It is also observed that increase in percentage of steel fibers increases the load carrying capacity of the slab.

4. It is observed that as the thickness of the slab increases the load carrying capacity increases and corresponding deflection and crack width and number of cracks also increases. It is also observed that increase in percentage of steel fibers increases the load carrying capacity of the slab at 75mm thickness the cracks were developed were less than for 50mm thickness of slab.

5. It is observed that as the grade of concrete increases from M_{20}, M_{40} and M_{60} there is a increase in the load carrying capacity and deflection of the slabs. It is also observed that at higher strength M_{60} grade of concrete there is a large increase in load carrying capacity with deflection and crack width compare to M_{20} and M_{40} grade of concrete of slabs.

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