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Expert Opinion Article

Analysis And Experimental Study On Fiber Reinforced Concrete With Steel Fibers

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Abstract:
Experimental study on Steel Fiber concrete for M20 grade having mix proportion 1: 2.23: 3.99 and water cement ratio of 0.47 to study the compressive, flexural and split tensile strength of Steel Fibred Reinforced Concrete (SFRC) containing fibers of 0%, 0.5%, 1%, 1.5%, 2% volume fraction. The result obtained is analyzed and compared with a control specimen (0% steel fiber).The Two Pont loading carried out on a test specimen. The Results are compared with each other in compressive strength, flexural strength and split tensile strength for 28days for 1% steel of 100mm and 150mm stirrups spacing.

Key words: *Concrete, Steel Fiber, Compressive Strength, Flexural Strength, Split Tensile Strength .*

1) INTRODUCTION

Concrete is the most important material in construction industry and a large quantum of of it is being utilized. River sand, the constituent material of conventional concrete, has become expensive and also a scarce material. River sand becoming a scare commodity and hence exploring alternatives to it has become imminent. Depletion of the virgin natural river sand is the main issue concerning the construction industry. And also the biggest challenge. The objective of the present study is to examine the suitability of M-Sand as fine aggregate in concrete and an attempt is made to evaluate the effect of the steel fibers on concrete grade of M-25 prepared by M-Sand.

M-Sand, short for Manufactured Sand, is created by crushing larger stones into the desired grain size. The production process involves three main stages. Initially, aggregates are crushed into smaller stones using a vertical shaft impactor. Subsequently, these crushed aggregates are fed into a Rotopactor, which further refines them into sand with the required grain size. The sand is then screened to remove any dust particles and washed to eliminate extremely fine particles. The final product meets all the specifications outlined in IS: 383-1970 and can be effectively utilized in concrete applications.

Fibre-Reinforced Concrete Advantages

1. Reduced Cracking:
2. Increased Impact Resistance:
3. Improved Flexural Strength:
4. Enhanced Durability:
5. Enhanced Fire Resistance:
6. Better Toughness:

Fiber Types Used in FRC

Steel fibers: Polypropylene Fibers: Glass Fibers:
Natural Fibers:
Synthetic Fibers:

2) OBJECTIVES OF THE RESEARCH

Investigate the physical properties of FRC materials.
Analyze the characteristics of fiber-reinforced concrete in both its fresh and hardened states.
Evaluate the concrete's compressive, flexural, and split tensile strength when incorporated with steel fibers.
Examine the shear properties through the use of SFRC beams.

3) MATERIALS USED

Concrete is a composite material, made by mixing

- Cement
- Manufactured Sand
- Coarse Aggregate
- Steel Fibres
- Admixtures
-

4) MIX DESIGN PROPORTION OF MATERIALS FOR MIX:

- Cement = 326.1 kg/m3
- Water = 176.27 Lt/m3
- Fine aggregate (M-Sand) = 729.15 kg/m3
- coarse aggregate 20mm = 1301.75 kg/m3
- Super plasticizer = 3.26 kg/m3
- Water-cement ratio = 0.47
- Mix Proportion By weight = 1: 2.23: 3.99

Table no. 4.1: Nomenclature

Sl No.	Steel Fibre	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (lt/m^3)	Super Plasticizer (kg/m^3)
Mix 1	0 %	326.1	729.15	1301.75	176.27	3.26
Mix 2	0.5%	326.1	729.15	1301.75	176.27	3.26
Mix 3	1%	326.1	729.15	1301.75	176.27	3.26
Mix 4	1.5%	326.1	729.15	1301.75	176.27	3.26
Mix 5	2%	326.1	729.15	1301.75	176.27	3.26

Table no. 4.2: Mix Calculation:

Sl No.	Specimen	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (liter)	Super Plasticizer (ml)
1	Cube	1.43	3.19	5.70	0.67	14.3
2	Cylinder	2.02	4.51	8.07	0.95	20.24
3	Prism	1.82	4.05	7.26	8.55	18.2
4	Beam	16.92	15.44	27.63	3.25	500

Table no. 4.3: Steel Fiber Calculation:

Mixes	% of Steel Fibre	Cube (grams)	Cylinder (grams)	Prism (grams)	Beam (grams)
Mix 1	0 %	0	0	0	0
Mix 2	0.5%	51.75	73.1	66	275
Mix 3	1%	103	146.2	132	550
Mix 4	1.5%	155	219.3	198	825
Mix 5	2%	207	292.4	264	1100

5) RESULTS AND DISCUSSION 5.1) COMPRESSIVE STRENGTH

Table no. 5.1: Results of Compressive strength(MPa):

Mixes	7 Days	28 Days
Mix1	17.9	33.5
Mix2	19.6	34.2
Mix3	21.4	35.6
Mix4	23.7	36.9
Mix5	20.4	34.8

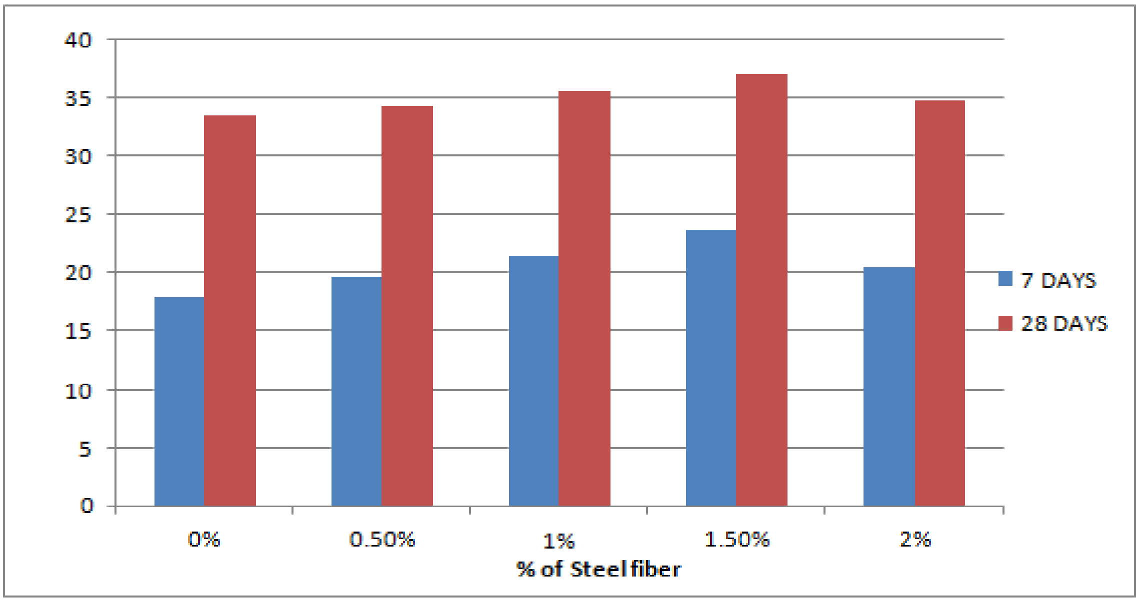

Figure No. 5.1: Compressive Strength Test

5.2) SPLIT TESNSILE STRENGTH

Table no. 5.2: Split Tensile Strength Test

Mixes	7 Days	28 Days
Mix1	2.65	4.71
Mix2	4.44	5.32
Mix3	5.38	7.44
Mix4	9.12	11.85
Mix5	7.08	10.4

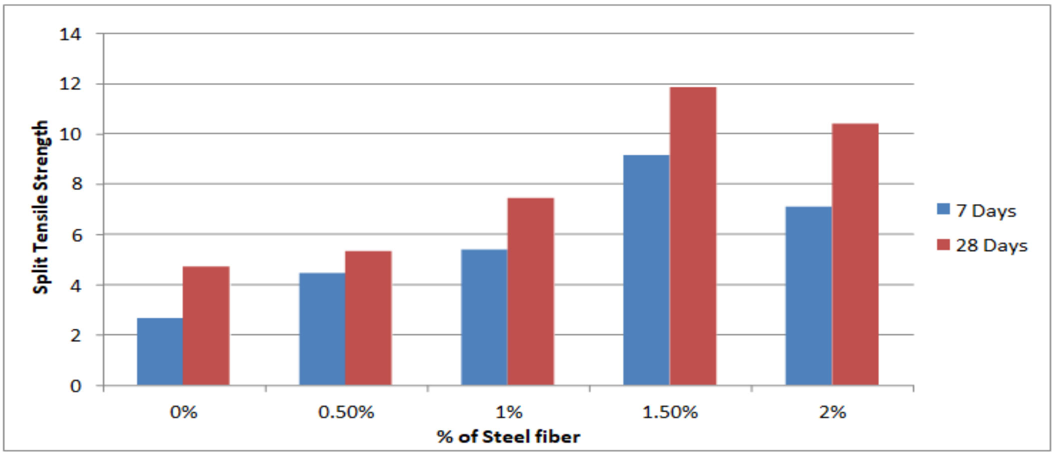

Figure No. 5.2: Split Tensile Strength Test

5.3) FLEXURAL STRENGTH:

To find the concrete Flexural strength of 500 X 100 X 100mm prisms will be casted and it will be tested for 3, 7 and 28 days. Equation (3) will be used for finding the Flexural strength of the concrete Flexural Strength = $F = PL/bd2$where, P is the Failure of Load, L is the Prism Length (500 mm), b is the Breadth of Prism (100 mm), d is the Width of Prism (100 mm).

Table no. 5.3: Result of Flexural Strength (MPa):

Mixes	7 Days	28 Days
Mix1	3.55	5.35
Mix2	4.85	7.05
Mix3	6.22	8.3
Mix4	11.2	14.55
Mix5	8.4	12.6

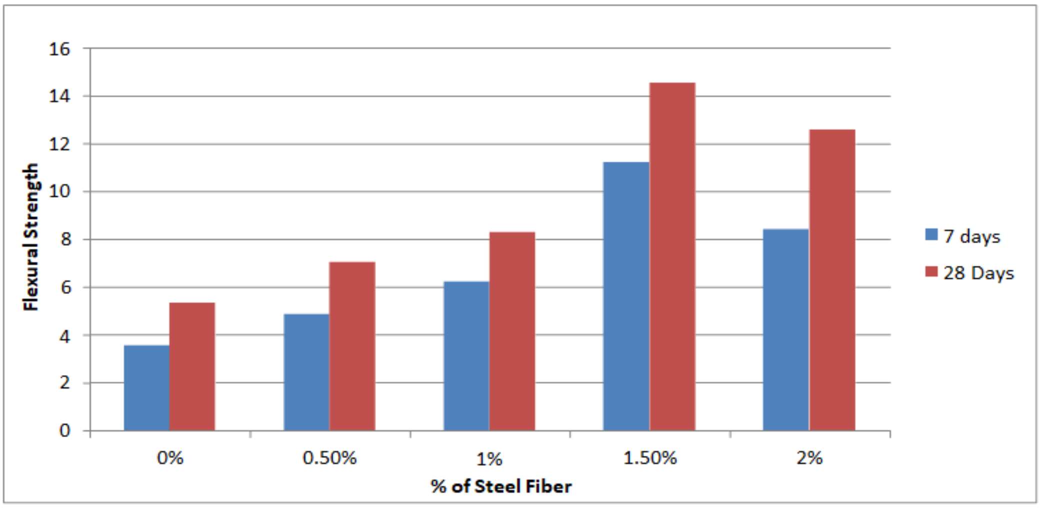

Figure No. 5.3: Flexural Strength Test

SUMMARY OF FRESH AND HARDENED CONCRETE:

As the proportion of Steel Fibers rises, the slump value experiences a reduction.

Increasing the fiber ratio leads to a decrease in the compaction factor.

The Compressive Strength improves with a higher fiber percentage, reaching an optimal ratio of 1.5%. But, above this point, there is a decline in strength over both the 7-day and 28-day periods.

Elevating the fiber percentage enhances the Split Tensile Strength, but this effect is observed only up to 1.5%. Afterward, there is a decrease in strength for both the 7-day and 28-day intervals.

The flexural strength shows improvement with an increase in fiber percentage, up to 1.5%. Subsequently, beyond this threshold, there is a reduction in strength for both the 7-day and 28- day durations.

FRC BEAMS

A) Fabrication of Reinforcement Formwork:

Reinforcement formwork was fabricated in workshop conferring to required dimensions. Formwork was constructed using metal sheets and connections were made with the help of nuts and bolts. The formwork was made sure to be leak proof so as to avoid and leakage of cementitious materials while casting of the beams. All the interior faces of formwork were oiled before concrete placement.

Figure No. 5.4 : Fabrication Of Reinforcement Formwork

B) Casting Of Beams:

The precise configuration of the beams involves the use of M25 grade Concrete and Fe500D HYSD Steel bars. The physical dimensions of these essential elements are outlined as follows: a width measuring 100mm, a height of 200mm, and a length spanning 1000mm. The arrangement of reinforcement is carefully devised, incorporating two 8mm diameter bars in both the sections experiencing tension and compression. Furthermore, two-legged stirrups with a diameter of 6mm are thoughtfully positioned at intervals of 100mm and 150mm center-to-center.

Figure No. 5.5: Casting Of Beam

C) REINFORCEMENT DETAILS:

1.5 % Steel Reinforcement

Top reinforcement: 2 Nos of 8 mm dia bars in compression zone Bottom reinforcement: 2 Nos of 10 mm dia bars in tension zone Stirupps reinforcement: 6mm dia 2 legged stirrups

Total Ast = 257 mm^2, % of Steel=1.5 %

Spacing: According to IS 456: 2000 minimum Spacing is 100mm and maximum spacing is limited to 0.75d. So here we have minimum spacing is 100mm and maximum spacing is 150mm.

Representation of Reinforcement details: **<u>For 100mm spacing:</u>**

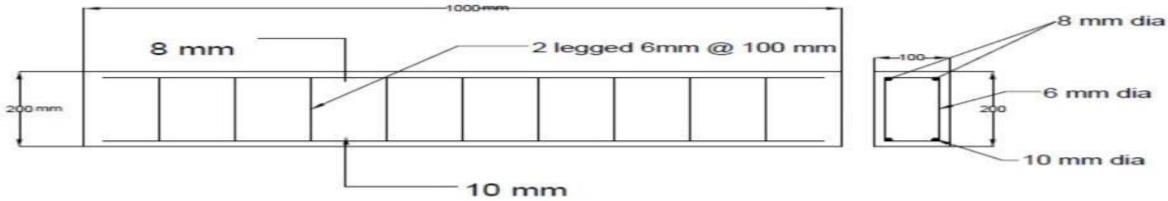

Figure No. 5.6: L/s and c/s of beams

<u>For 150mm spacing:</u>

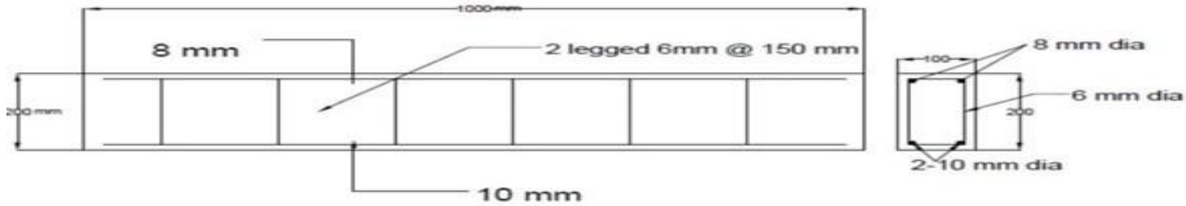

Figure No. 5.7: L/s and c/s of beams

D) TWO- POINT LOADING FRAME: Shear Force Testing:

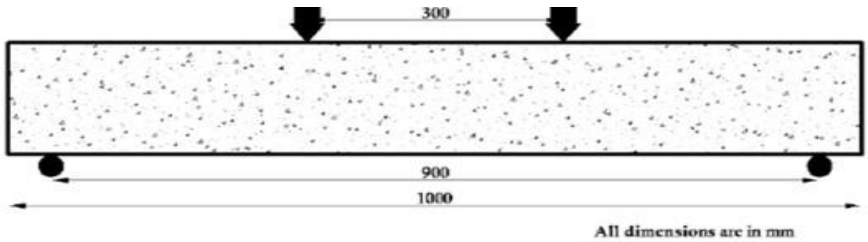

Figure No. 5.8: Set up Of Beam For Testing

5.4) 1% steel @ 100mm spacing c/c

Table no. 5.4: Test On Beam

Mixes	Load (KN)	Deflection(mm)	Shear strength (Vu/bd)
Mix1	94	8.2	4.7
Mix2	96	7.8	4.8
Mix3	102	6.7	5.1
Mix4	112	5.2	5.6
Mix5	119	4.1	5.95

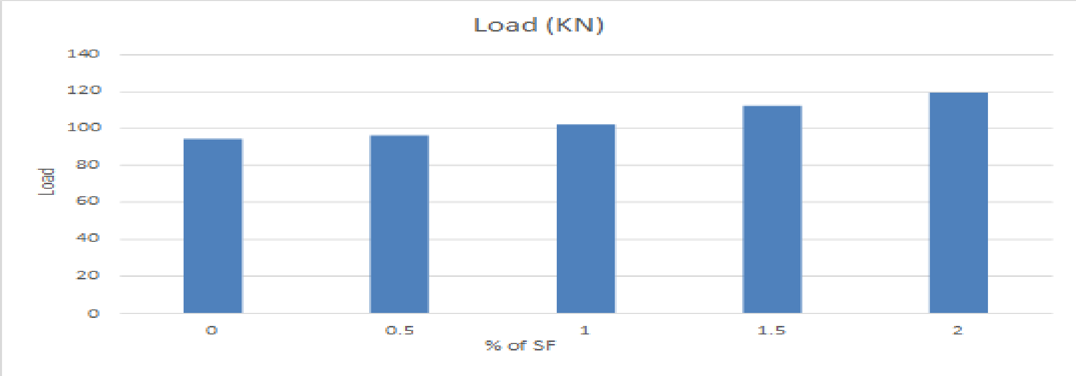

Figure No. 5.9: Load On Beam

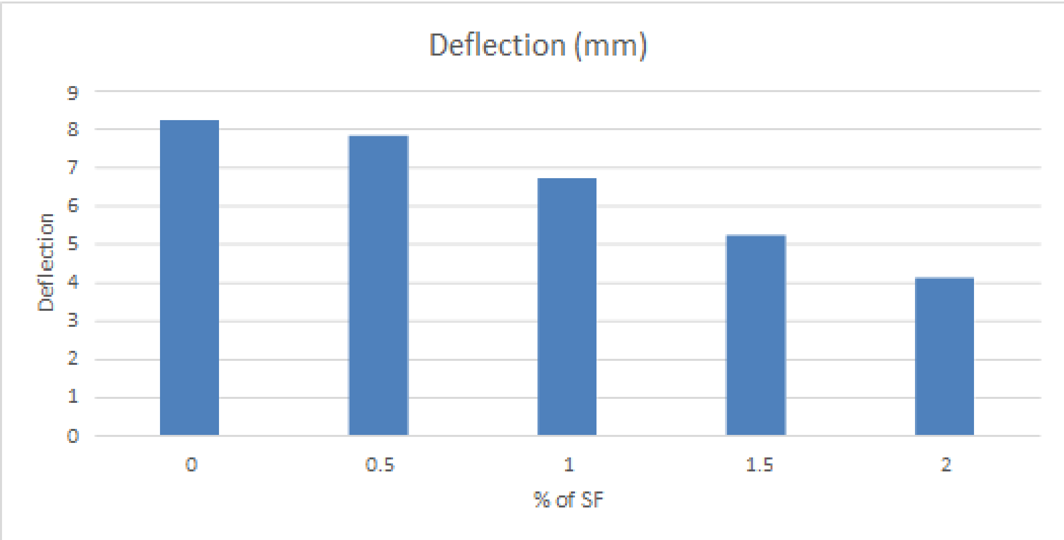

Figure No. 5.10: Deflection Of Beam

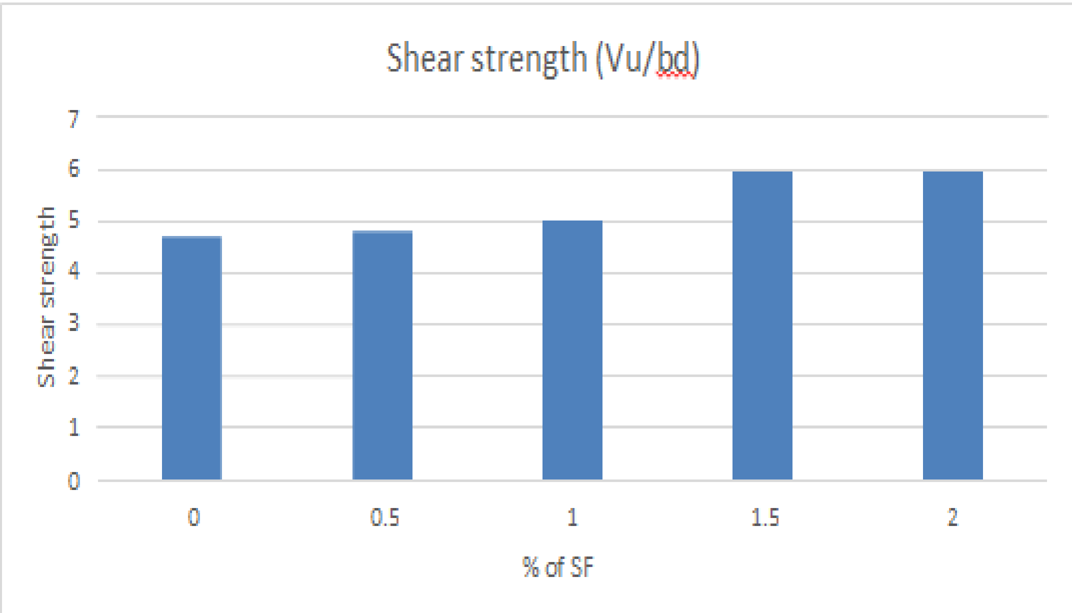

Figure No. 5.11: Shear Strength Of Beam

5.5) 1% Steel @150mm spacing c/c

Table no. 5.5: Test On Beam

Mixes	Load (KN)	Deflection (mm)	Shear strength (Vu/bd)
Mix1	82	9.2	4.1
Mix2	88	8.7	4.4
Mix3	97	7.2	4.85
Mix4	101	6.7	5.05
Mix5	109	5.1	5.45

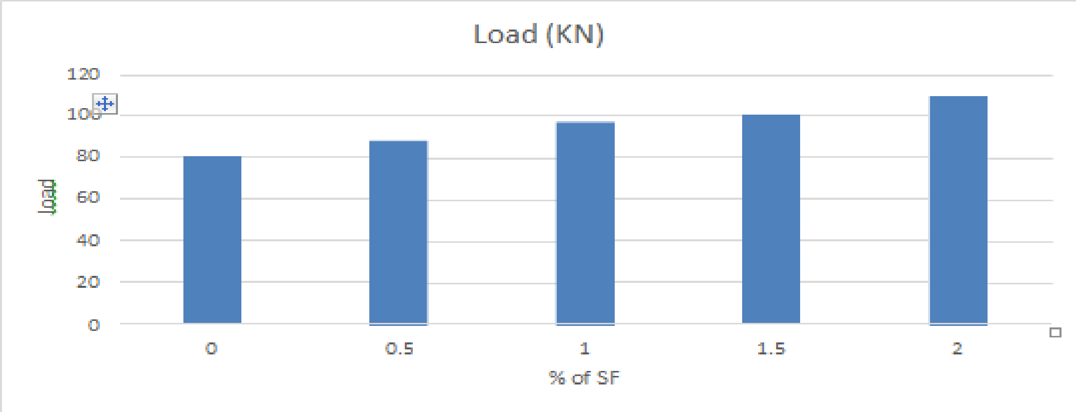

Figure No. 5.12: Load On Beam

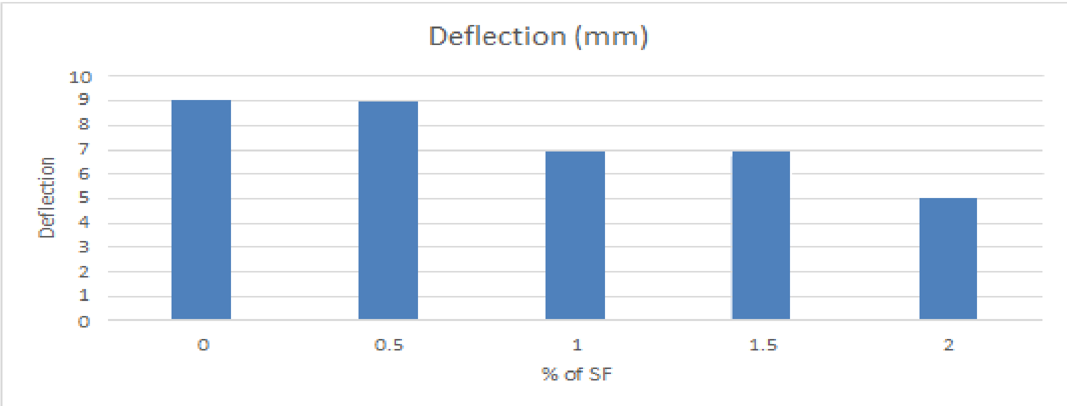

Figure No. 5.13: Deflection Of Beam

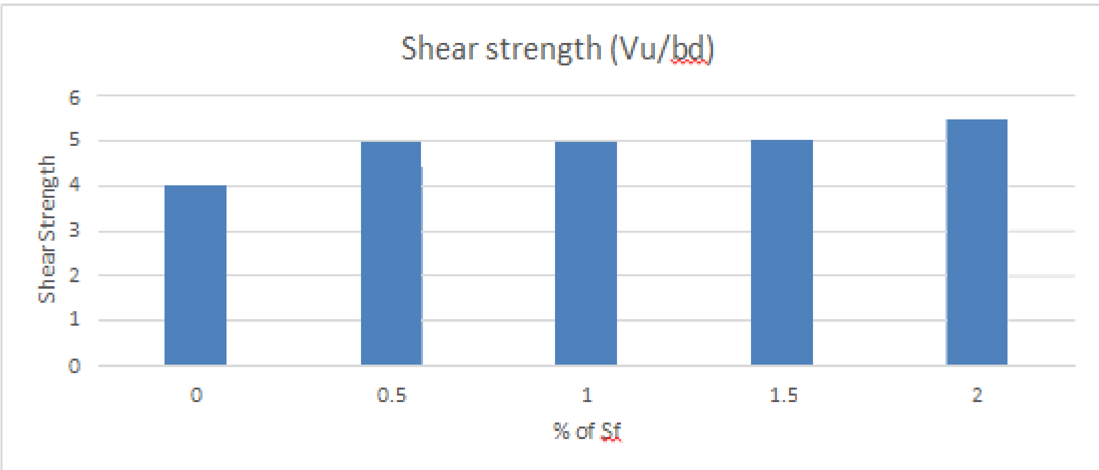

Figure No. 5.14: Shear Strength of Beam

6) CONCLUSIONS

- Slump value and compaction factor value decreases as fibers ratio increases.
- The compressive strength of FRC increases as Fiber percentage increases up to 1.5% by 10%.
- The Split Tensile Strength increases as the Fiber percentage increases up to 1.5% of increase by about 150%.
- Similarly, flexural strength also increases by an increase in the percentage of steel fibers by about 150% for 28 days.
- FRC beams also shows the improvement in load carrying capacity by increase in steel fiber content.

For 1.5% Steel @ 100mm spacing c/c.

- Load capacity increases as steel fiber percentage rises from 0% to 1.5%, while deflection decreases.
- Shear strength improves with higher SF content, indicating enhanced shear resistance.

For 1.5% Steel @ 150mm spacing c/c,

- Similar to the previous case, higher SF content (up to 1.5%) leads to increased load capacity and decreased deflection.
- Shear strength also improves with more steel fibers, showing enhanced shear resistance.

Optimal balance in performance is achieved at 1.5% SF content in both spacing configurations.

- Effect is more intense at 100mm spacing compared to 150mm spacing.
- While 2% SF content provides further gains in shear strength, practicality and cost effectiveness should be considered.

In summary, adding steel fibers at 1.5% content enhances load capacity, reduces deflection, and improves shear strength. This improvement is particularly notable at 100mm spacing.

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