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Experimental Investigation Of Steel Fibre Reinforced Concrete Beam Using Gfrp Rebar

D.Radhakrishnan[1], C.Sushma[2], Balla Biju[3], Smruthy C.R[4], Sreekutty S[5]
[1]Engineering Faculty, Kuppam Engineering College, Kuppam
[2]Student, Kuppam Engineering College, Kuppam
[3]Student, Kuppam Engineering College, Kuppam
[4]Student, Kuppam Engineering College, Kuppam
[5]Student, Kuppam Engineering College, Kuppam

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ABSTRACT

The experimental investigation of flexural behaviour of SFRC beam reinforced with GFRP rebar and compared with steel reinforcement beams is presented in this project. Three beams were casted using SFRC and longitudinally reinforced with GFRP rebar. Three beams were casted with conventional concrete and steel bar. Six beams were casted and tested under two-point load. Along with beam, cube, cylinder and prism were casted and tested for compressive strength, split tensile and flexural strength. To improve the concrete's property steel fibres were utilized. From testing of beam load vs deflection, load carrying capacity and stiffness were also calculated. The average load carrying capacity of GFRP rebar is 125.3kN and the average load carrying capacity of normal steel is 99.3kN.The highest deflection found in the GFRP rebar and standard steel reinforcement beam at their ultimate load is 21.5mm& 16.87mm respectively. It was also discovered GFRP beam returned to its original position.

Key words: Deflection, GFRP, Load carrying capacity, SFRC, Stiffness.

1. INTRODUCTION

A form of concrete called fibre reinforced concrete (FRC) uses fibrous material to increase structural strength. It is constructed of isolated, short fibres that are randomly oriented and uniformly scattered. One of the fibres is steel. Examples of fibres include glass fibres, synthetic fibres, and natural fibres. Among these are the various fibres, concretes, materials, morphologies, distributions, orientations, and other variables that affect how fibre reinforced concrete behaves. and densities Concrete fibres are frequently used to prevent shrinkage, drying cracking, and cracking due to shrinkage in plastic[1].The impact, abrasion, and shatter resistance of Concrete can be improved by using certain fibres.

1.1 Steel Fibre

Steel reinforcement has been increasingly replaced with steel fibre reinforced concrete in recent years. Steel fibre reinforced concrete has a wide range of applications, making it difficult to categorise. Tunnel linings, slabs, and airport pavements are the most common applications.

Various steel fibres are used for concrete reinforcement. Round fibres, which have a diameter of 0.25 to 0.75 mm, are the most prevalent variety. Steel fibres can range in thickness from 0.3 to 0.5 mm but are typically 0.25 mm thick. The fundamental advantage of twisted fibres continuously present throughout the matrix is their ability to scatter. Fibres are fairly expensive, and as a result, their use has been limited to some extent.

Fibres having a greater aspect ratio strengthen the fibre-matrix bond, which improves the hardened concrete's performance[2]. A high aspect ratio, on the other hand, has a negative impact on the fresh mix's workability. With growing fibre length and volume, both workability and uniform distribution difficulties become more prevalent.

1.2 Glass Fibre Reinforced Concrete (GFRP)

Corrosion of the reinforcing steel is the leading cause of degradation in reinforced concrete structures[3]. One potential alternative is to reinforce concrete with non-corrosive glass Fibre reinforced polymer (GFRP) bars, among others.

Glass fibres are used to make GFRP reinforcement bars. Because GFRP bars are non-corrosive, they can significantly extend the lifecycle of reinforced concrete structures while also lowering maintenance, repair, and replacement costs[4].

The main disadvantage of GFRP reinforcing bars, aside from the brittle failure mode, is their poor rigidity when compared to steel. At any load level, this reduced stiffness, when combined with additional considerations such as altered bond behaviour and lower tension stiffening, leads in higher deflections than typical steel-reinforced beams. Deflection constraints may commonly dictate designs due to these significant deflections. As a result, it's vital that load-deflection behaviour be predicted precisely [5]-[6]. The goal of this study is to see if such procedures are accurate and, if not, to suggest changes.

2. REINFORCEMENT DETAILS

Six beams of 1800 mm length, 150 mm width, and 250 mm depth are being cast and tested as part of the experimental inquiry. Beams with an effective span of 1500 mm were simply supported at their ends. Figure shows a longitudinal and cross section view of a typical beam specimen. Three beams were cast using SFRC and longitudinally reinforced with GFRP rebar. Three beams were cast with standard concrete and steel rebar. GFRP 2nos of 10 mm diameter rebar were utilised as reinforcement at the top and bottom and At 150mm c/c, 6mm diameter 2 legged verticals were employed. conventional concrete with TMT 10 mm diameter main bar and 6 mm stirrups were used for three beams. Bottom and top side concrete clear cover of 25 mm was maintained for all beams.

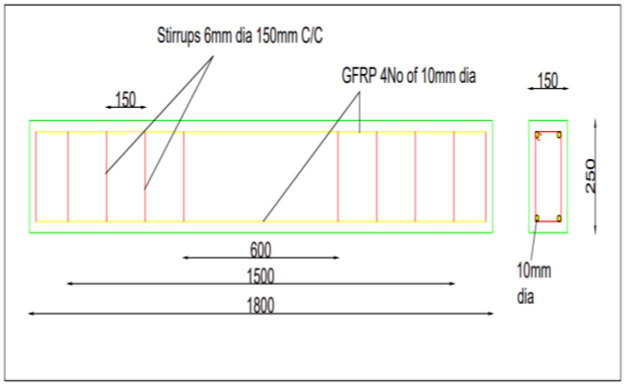

Figure 1: Reinforcement details

3. TEST PROGRAMME

A spread beam and two rollers are used in the test setup to create a two-point loading system. To measure deflection at the mid span of the beam along the tension side, three LVDTs were used: one 100mm and two 50mm. Deflection was measured using two 50mm LVTDs under two-point loads. To measure the rotation, a 50mm dial cage was installed near the beam end. To assess 23 concrete strains, pellets were placed at mid-span across the cross section of the beam as indicated in Figure. Along the compression side of the beam, the point loads act at a distance of 200mm from the mid span.

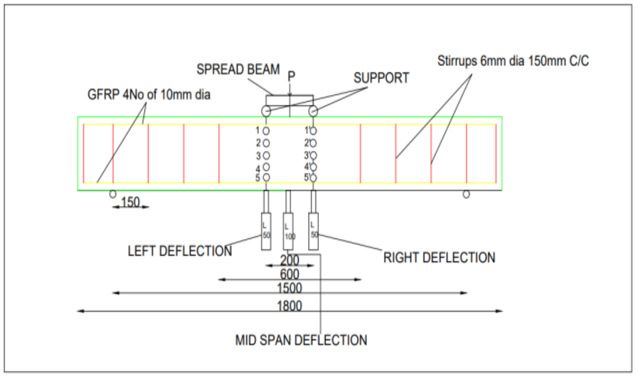

Figure 2: Placing of LVDT

Figure 3: Loading frame setup

4. RESULTS

4.1 Load Carrying Capacity

A beam is a structural component that can resist loads that are applied laterally to its axis. It deflects primarily through bending[7].

Table 1: Test result of Load carrying Capacity

SL.NO	SPECIMEN	INITIAL CRACK LOAD (kN)	ULTIMATE LOAD (kN)
1	SFRC-1	40.4	160
2	SFRC-2	31	110
3	SFRC-3	34.9	106
4	CC-1	21.2	75
5	CC-2	20.5	125
6	CC-3	30.7	98

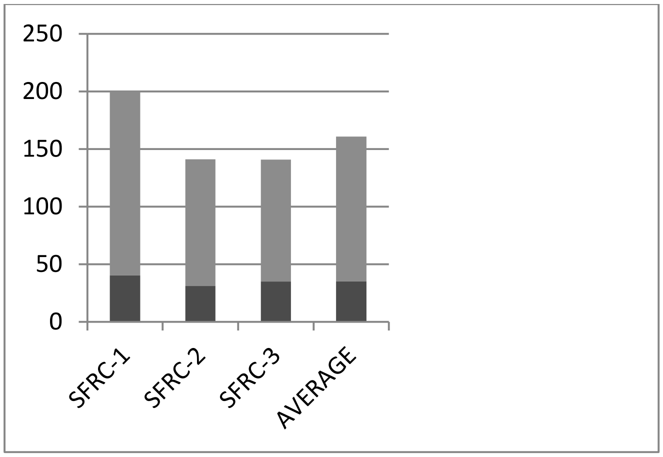

Figure 4: Load carrying capacity of SFRC beam reinforced with GFRP rebar

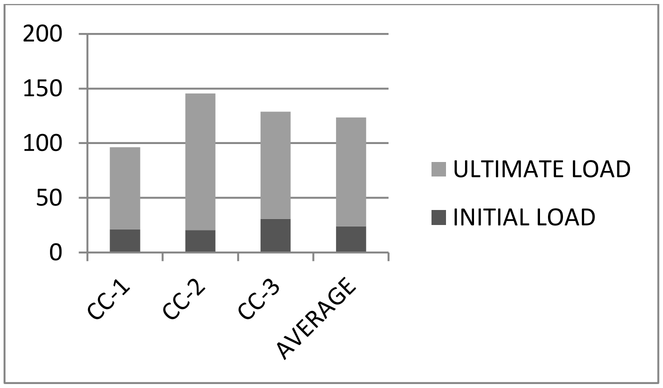

Figure 5: Load carrying capacity of conventional concrete beam reinforced with steel bar.

4.2. Load vs Deflection

By integrating the function that mathematically depicts the slope of the deflected shape of the member under that load, the deflection distance of a member may be determined. This is cited from [8]-[9]

Table 2: Various Deflection of SFRC-1

SL.NO	LOAD	DEFLECTION	DEFLECTION	DEFLECTION
1	0	0	0	0
2	27	0.5	0.5	0.5
3	39	0.9	1.2	1.0
4	51	4.1	4.5	4.2
5	67	9.1	9.8	9.3
6	79	13.1	13.9	13.3
7	94.6	14.4	16.2	14.4
8	107	18.8	19.8	19.1
9	120	19.2	20	19.9

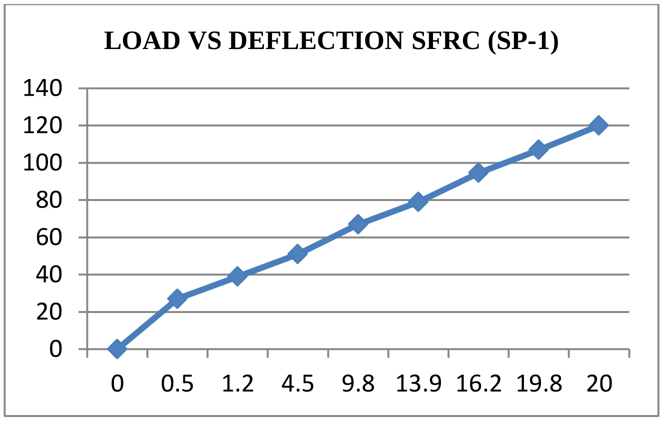

Figure 6: Load Vs Deflection SFRC – 1

Table 3: Various Deflection of SFRC-2

SL. NO	LOAD(KN)	DEFLECTION 1	DEFLECTION 2	DEFLECTION 3
1	0	0	0	0
2	10	0.1	0.1	0.1
3	20	0.3	0.5	0.3
4	30	0.9	1.1	0.8
5	41	1.0	1.8	0.9
6	50	4.6	5.0	4.4
7	61	7.9	8.4	7.5
8	70	11.3	12.3	10.2
9	81	13.6	15.2	14.8
10	91	18.9	19.4	18.6
11	102	19.9	20.2	19.8
12	112	20.1	21.3	20.3

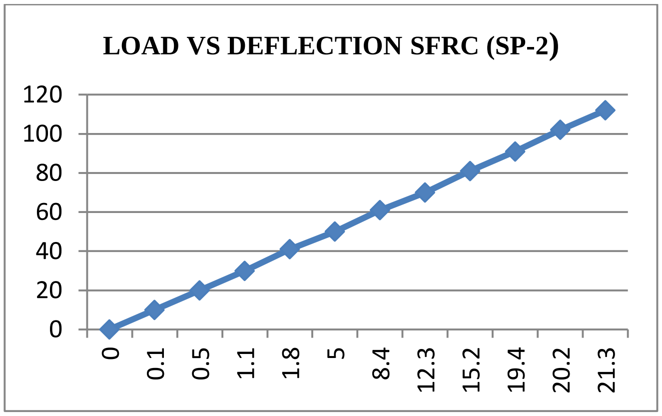

Figure 7: Load Vs Deflection SFRC – 2

Table 4: Various Deflection of SFRC-3

SL.NO	LOAD	DEFLECTION 1	DEFLECTION 2	DEFLECTION 3
1	0	0	0	0
2	10	0.5	1.0	0.6
3	20	3.4	3.6	3
4	30	4.8	5.9	5.2
5	40	7.2	7.5	6.7
6	50	9.9	10.8	10.5
7	60	12.8	13.2	12.5
8	70	14.7	15.3	15
9	80	17.3	17.8	16.8
10	90	19	19.4	19.2
11	100	20.9	21.6	20.5
12	118	21	23.3	21.2

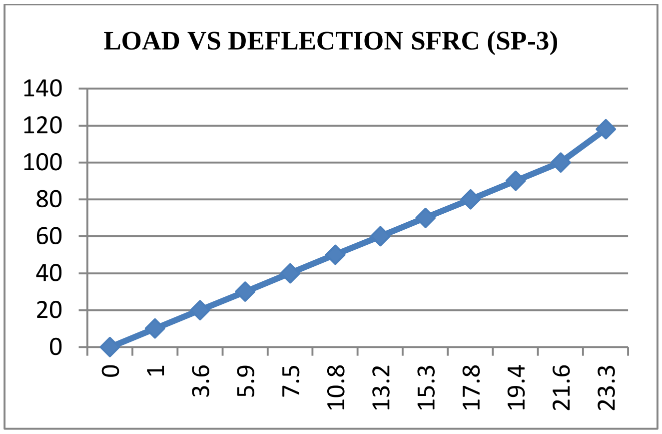

Figure 8: Load Vs Deflection SFRC – 3

Table 5: Various Deflection of Conventional concrete -1

SL.NO	LOAD	DEFLECTION 1	DEFLECTION 2	DEFLECTION 3
1	0	0	0	0
2	30.6	0	1.2	0.4
3	40.6	0	1.3	0.4
4	53.8	0.3	2.9	1.1
5	57.2	0.5	3.4	1.4
6	67.6	0.9	4.2	1.7
7	76.5	2.8	8.1	3.5
8	81.2	3	8.5	3.9
9	87	11.9	15.5	13.2

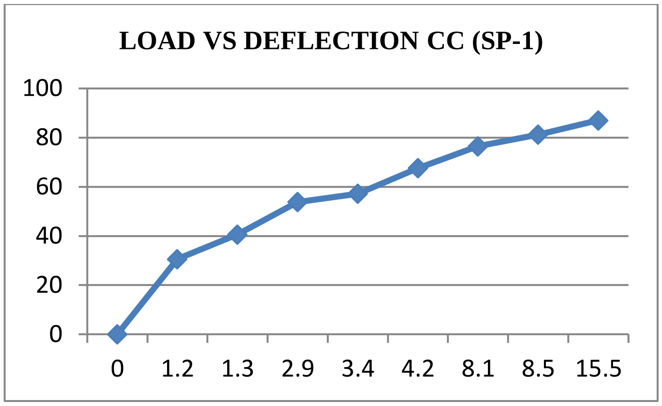

Figure 9: Load Vs Deflection CC– 1

Table 6: Various Deflection of Conventional concrete -2

SL.NO	LOAD	DEFLECTION 1	DEFLECTION 2	DEFLECTION 3
1	0	0	0	0
2	20.6	0.9	0.9	0.8
3	30.6	1.4	1.8	1.3
4	44	2.3	2.8	2.3
5	54	3.4	3.9	3.4
6	64.5	3.7	4.4	3.8
7	76	4.3	5.1	4.5
8	86	5.3	6.3	5.8
9	89.7	7.8	12.8	7.1
10	91	14.8	17.1	17.6

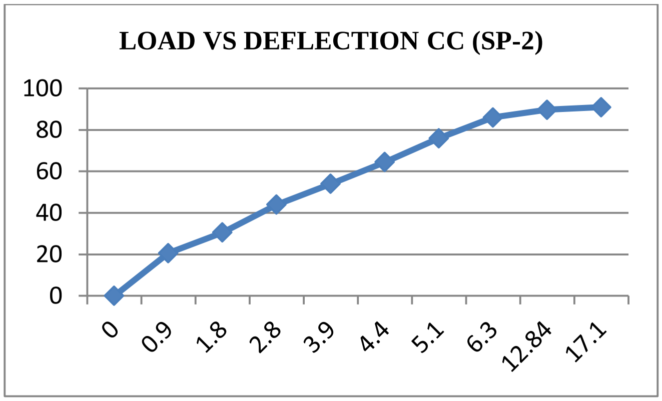

Figure 10: Load Vs Deflection CC – 2

Table 7: Various Deflection of Conventional concrete -3

SL.NO	LOAD	DEFLECTION 1	DEFLECTION 2	DEFLECTION 3
1	0	0	0	0
2	21	0.3	1.3	1.0
3	32	1.5	2.6	2
4	42	2.2	3.4	3
5	52	2.5	3.7	3.2
6	63	3.4	4.8	4
7	73	5.3	7	7
8	83	15.8	16.7	16.4
9	89	17.8	18	17.5

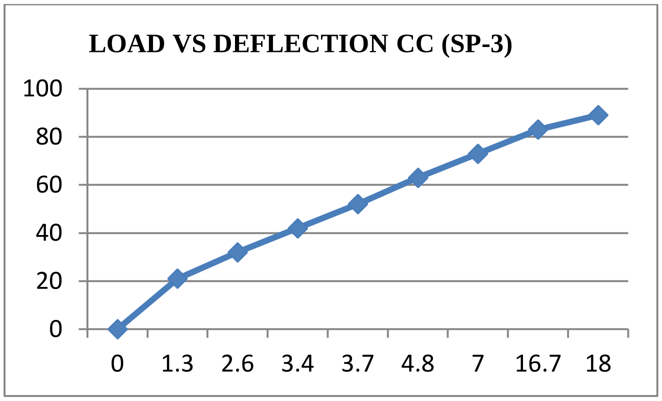

Figure 11: Load Vs Deflection CC –3

4.3 Load vs Moment

As the result of the load and the moment, it is defined. The moment is the angle at which the force's line of action and the centre of moments are perpendicular to one another. This is cited from [10]-[13]

Moment = Load x Perpendicular Distance

Table 8: Ultimate Moment for SFRC-1

SL.NO	LOAD (KN)	M (kN-m)
1	0	0
2	27	24.3
3	39	35.1
4	51	45.1
5	67	60.3
6	79	71.1
7	91	81.9
8	107	96.3
9	120	108

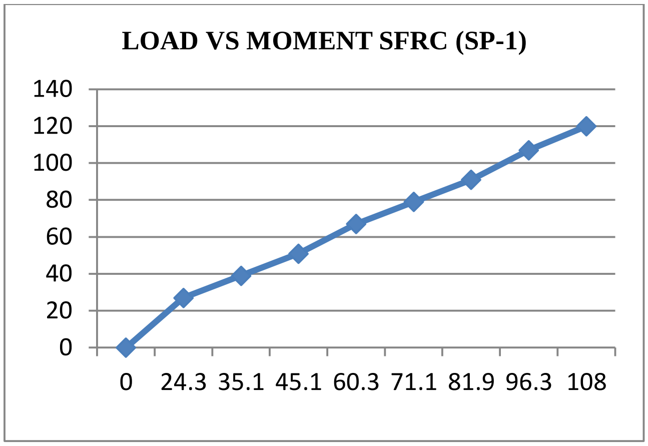

Figure 12: Load Vs Moment SFRC –1

Table 9: Ultimate Moment for SFRC-2

SL.NO	LOAD (KN)	M (kN-m)
1	0	0
2	10	9
3	20	18
4	30	27
5	41	36.9
6	50	45
7	61	54.9
8	70	63
9	81	72.9
10	91	81.9
11	102	91.8
12	112	100.8

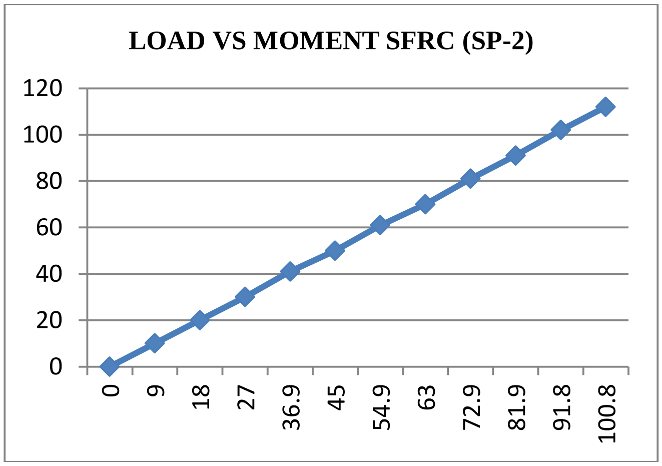

Figure 13: Load Vs Moment SFRC –2

Table 10: Ultimate Moment for SFRC-3

SL.NO	LOAD (KN)	M (kN-m)
1	0	0
2	10	9
3	20	18
4	30	27
5	40	36
6	50	45
7	60	54
8	70	63
9	80	72
10	90	81
11	100	90
12	118	106.2

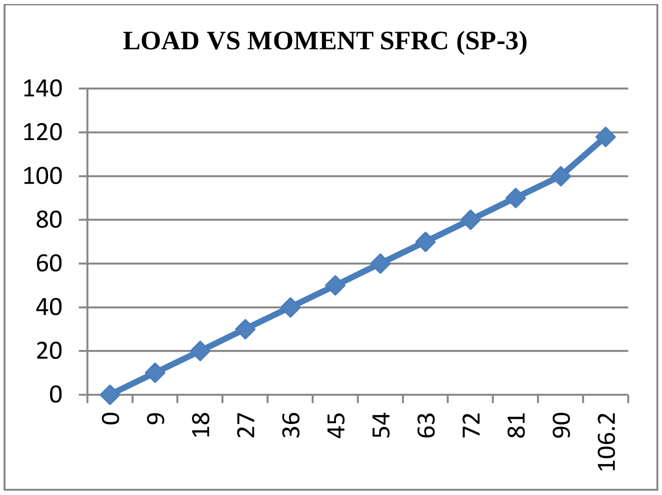

Figure 14: Load Vs Moment SFRC –3

Concrete Beam Reinforced With Steel Rebar

Table 11: Ultimate Moments for Conventional concrete -1

SL.NO	LOAD (KN)	M (kN-m)
1	0	0
2	30.6	27.54
3	40.6	36.54
4	53.8	48.42
5	57.2	51.48
6	67.6	60.84
7	76.5	68.85
8	81.2	73.08
9	87	78.3

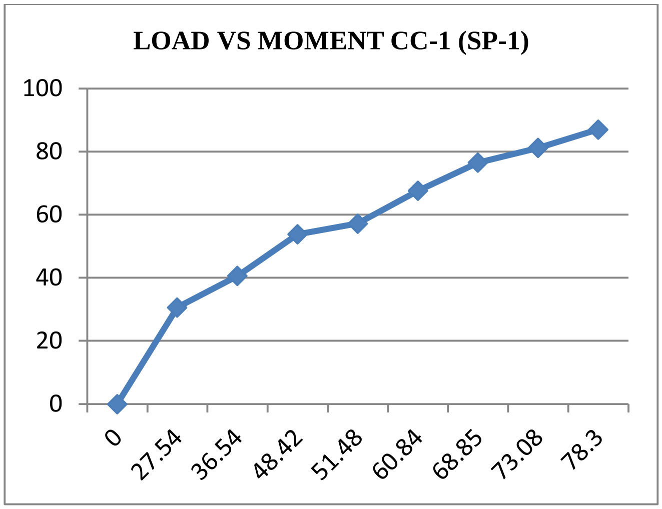

Figure 15: Load Vs Moment CC –1

Table 12: Ultimate Moments for Conventional concrete -2

SL.NO	LOAD (KN)	M (kN-m)
1	0	0
2	20.6	18.54
3	30.6	27.54
4	44	39.6
5	54	48.6
6	64.5	58.05
7	76	68.4
8	86	77.4
9	89.7	80.73
9	91	81.9

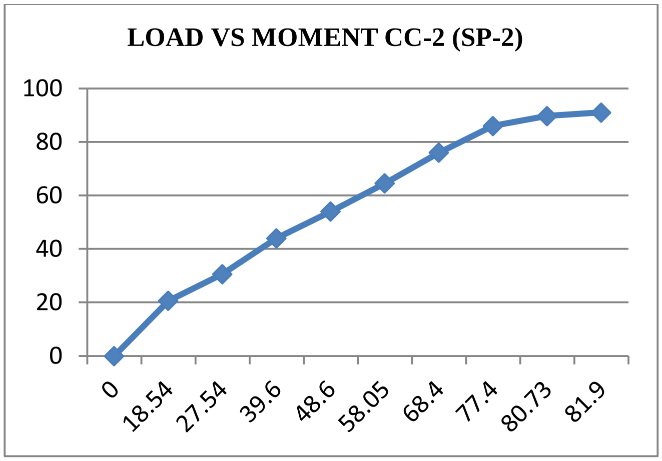

Figure 16: Load Vs Moment CC –2

Table 13: Ultimate Moments for Conventional concrete -3

SL.NO	LOAD (KN)	M (kN-m)
1	0	0
2	21	18.9
3	32	28.8
4	42	37.8
5	52	46.8
6	63	56.7
7	73	65.7
8	83	74.7
9	89	80.1

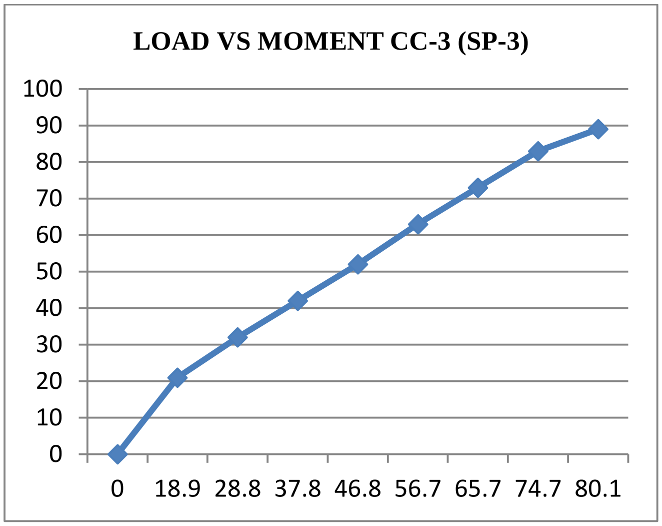

Figure 17: Load Vs Moment CC –3

5. STIFFNESS

It relates to how a component bends under load while still returning to its original shape once the load is removed. Since the component dimensions are unchanged after load is removed stiffness is associated with elastic deformations [14]-[15]

$$S=\frac{F}{\delta}$$

Table 14: Stiffness

SL	SPECIM	INITIAL	FINAL	AVERA
1	SFRC-1	54	6	$5.43X10^3$
2	SFRC-2	100	5.25	
3	SFRC-3	60.67	5.06	
4	CC-1	25.5	5.61	$5.24X10^3$
5	CC-2	22.88	5.17	
6	CC-3	16.15	4.94	

Figure 18: Beam

6. CONCLUSION

Based on an experimental study done using beams under two point loading. The conclusions made are as follows:

- SFRC Beams have more compressive, tensile and flexural strength compare to conventional concrete.
- The compressive strength of SFRC cube specimen is 14% greater than conventional concrete cube specimen.
- The split tensile strength for SFRC cylinder specimen is 0.5% greater than conventional concrete cylinder specimen.
- The flexural strength for SFRC prism specimen is 4%greater than conventional concrete prism specimen.
- Under loading conditions by adding steel fibre to concrete minimize the cracks. The addition of steel fibre to concrete can improve better brittleness. The fibres are advantageous in axial stress to enhance tensile strength even though concrete is week in tension.
- Load carrying capacity of SFRC Beam is 26% greater than the conventional concrete beam.
- Stiffness of SFRC Beam is 0.5% greater than conventional concrete beam.
- The highest deflection found in the GFRP rebar and standard steel reinforcement beam at their ultimate load is 21.5mm& 16.87mm respectively.

REFERENCES

[1] Meikandaan, T P,“Effect of Strengthening Schemes on Performance of Rc Beams Retrofitted With GFRP CFRP And Ultra High Strength Concrete”.
[2] anita Jessie**,** **“**A Review on behavior of rcc beam exposed at elevated temperature”.
[3] Mahendra Kumawat**,** “Experimental Study on GFRC Beam Reinforced With GFRP Rebar Under Flexure”

[4] Patel Hemanth Kumar "Behaviour of reinforced concrete beams strengthened with Glass Fibre Reinforced Polymer laminates subjected to corrosion damage".
[5] M D Muslim Ansari, "Progressive Damage of GFRP Composite Plate under Ballistic Impact: Experimental and Numerical Study"
[6] K Mohandas**,** "Rehabilitation of Reinforced Concrete beams by using Micro-cement and Glass Fiber Reinforced Polymer (GFRP)".
[7] Vipin George ,"Comparative Study of GFRP Rebar and Steel Rebar used in Concrete Sections".
[8] D Radhakrishnan**,** "Structural performance of hyfrc beam reinforced with gfrp rebar under flexure**".**
[9] G Ganesan, "An experimental study on the behaviour of GFRP pultruded I beam reinforced with CFRP laminates".
[10] Yuvasankar,"Experimental Study on GFRC Beam Reinforced With GFRP Rebar Under Flexure".
[11] Patel Hemanth Kumar "Behaviour of reinforced concrete beams strengthened with Glass Fibre Reinforced Polymer laminates subjected to corrosion damage".
[12] R Kumutha**,** "Behaviour of reinforced concrete rectangular columns strengthened using GFRP".
[13] R Anuradha,"Flexural Studies on Reinforced Concrete Beams with Glass Fiber Reinforced Polymer".
[14] Sayan Sirimontree,"Flexural Behavior of Concrete Beam Reinforced with GFRP Bars Compared to Concrete Beam Reinforced with Conventional Steel Reinforcements".
[15] Muhammed Kashif,"Structural Performance of GFRP Bars Based High-Strength RC Columns: An Application of Advanced Decision-Making Mechanism for Experimental Profile Data".