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USE OF GLASS FRP SHEETS AS EXTERNAL FLEXURAL REINFORCEMENT IN RCC BEAM

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ABSTRACT

The maintenance, rehabilitation and upgrading of structural members is perhaps one of the most crucial problems in civil engineering applications. This could manifest itself by poor performance under service loading, in the form of excessive deflections and cracking, or there could be inadequate ultimate strength. Additionally, revisions in structural design and loading codes may render many structures previously thought to be satisfactory, noncompliant with current provisions. This research study presents to Study the Effect of Different Strengthening Patterns Using GFRP (Glass Fibre Reinforced Polymer) on Flexural strength of the Beam. Totally six rectangular beams having 1500 mm x 100 mm x 200mm were casted. The grades of concrete M20. Flexural strength test, using simple beam with two- point loading was adopted in Frame loading testing Machine to study for the performance of GFRP wrapped beams in terms of increase in flexural capacity and deflection and it was compared with the control beams. The test results show that the beams flexural with GFRP laminates exhibit better performance. Three main variables namely, strength, ductility and damage level of R.C.C. under reinforced beam and R.C.C. beam weak in flexure were investigated. Comparison has been made between results of two sets.

Key words: RCC BEAM, GFRP

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1. INTRODUCTION

Glass reinforced composite materials are becoming more frequently used in civil engineering structures. Glass reinforced polymer/plastic is a recently developed material for flexural strengthening of RC and masonry structure. One of the most practical applications of these new materials concerns the strengthening of reinforced concrete beams by means of confinement with fibre composite sheets. The principal advantages of this technique are the high strength-to-weight ratio, good fatigue properties, non-corroding characteristics of the fibre reinforced.

The world's population depends on an extensive infrastructure system. Roads, sewers, highways, buildings. The system has suffered in past years. The resin matrix binds the fibre together and also provides bond between concrete and GFRP. It has been found to be an effective replacement of steel plates for strengthening of beams by exterior wrapping. The main advantage of GFRP is its high strength to weight ratio and high corrosion resistance. Two techniques are typically adopted for the strengthening of beams, relating to the strength enhancement desired: flexural strengthening or shear strengthening. In many cases it may be necessary to provide both strength enhancements. For the flexural strengthening of a beam, GFRP sheets or plates are applied to the tension face of the member (the bottom face for a simply supported member with applied top loading or gravity loading). Principal tensile fibers are oriented in the beam longitudinal axis, similar to its internal flexural steel reinforcement. This increases the beam strength and its stiffness (load required to cause unit deflection), however decreases the deflection capacity and ductility.

1.2. NITOWRAP EP (GF)

1.2.1. Description

NitowrapEP (GP) is a glass fibre composite wrapping system where Nitowrap GF is used in conjunction with an epoxy sealer cum primer, Nitowrap 30, and a high build epoxy saturant Nitowrap 410. The system is projected by a polyurethane top coat of Nitowrap 512 in case of atmospherically exposed structures.

12.3. Advantages

- Enhanced stiffness, shear & tensile capacities.
- Chemical resistance
- Flexible
- Thin section
- Economical

1.2.4. PROPERTIES OF NITOWRAP EP (GF)

NitowrapEP(GP)	Type I	Type II
Weight of fibre	920 g/m^2	750 g/m^2
Density of fibre	2.6 g/cc	2.6 g/cc
Fibre thicknes	0.90 mm	0.6 mm
Fibre orientation	unidirectional	unidirectional
Nominal thickness		
Per layer	1.5 mm	1 mm
Tensile strength	3400 N/mm^2	3400 N/mm^2
Tensile modulus	73000 N/mm^2	73000 N/mm^2

1.3.4.2. Nitowrap 30 Primer

Density1.14 g/cc	
Plot life	25 mins @ 27^0 c
Full cure	7 days

2. EXPERIMENTAL INVESTIGATION

The following tests are conducted on cement, fine aggregate and coarse aggregate and the results are tabulated in the table.

2.1. TEST ON CEMENT, FINE AGGREGATE AND COARSE AGGREGATE

Table 2.1 Tests on Cement

TESTS	VALUES
Specific gravity	3.15
Fineness	90%
Consistency	29%
Initial setting time	35 mints

Table 2.1.2 Tests on Fine Aggregate

TESTS	VALUES
Specific gravity	2.44
Gradation (sieve analysis)	Zone I1

Table 2.1.3 TEST ON COARSE AGGREGATE

TESTS	VALUES
Specific gravity	2.77
Aggregate impact value	38.60%
Aggregate crushing value	22.76%
Aggregate abrasion value (los angel)	10%

2.2. WORKABILITY TEST ON FRESH CONCRETE-

Table 2.2.1. Slump Value Test

Water cement ratio (%)	Workability measured slump (mm)
0.45	17
0.50	35
0.55	90
Average slump	47.33

Table 2.2.2 Compaction Test

Water cement ratio (%)	Compaction factor
0.45	0.86
0.50	087
0.55	0.88
Average (C.F)	0.88

Table 2.2.3 Mix Proportion

Water	Cement (kg/m3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)
186	413.33	633.10	1172.64
0.45	1	1.531	2.837

Therefore the mix ratio is 1:1.531:2.837

2.3. PROPERTIES OF BEAM

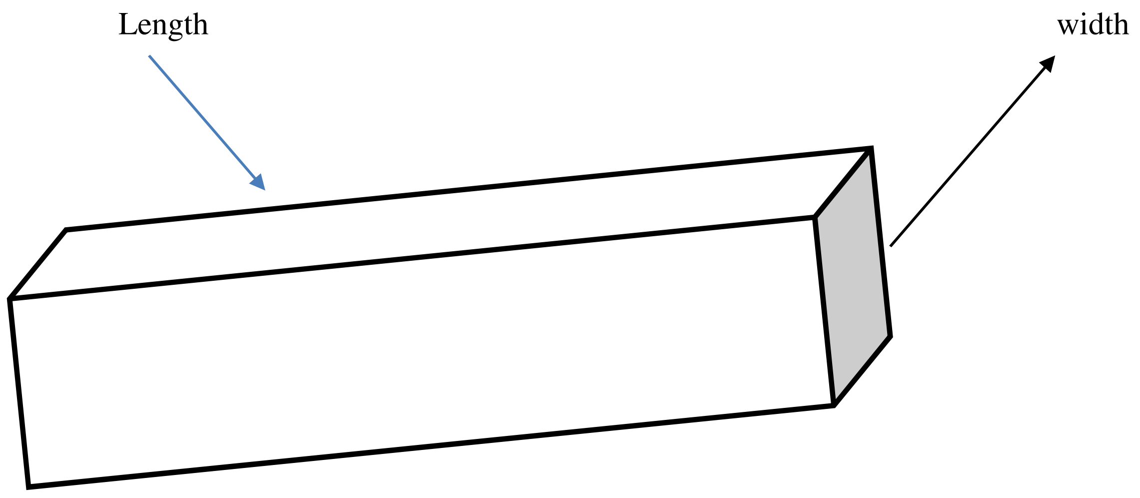


Figure 2.3. Dimension of beam

Width-100mm, Depth-200mm, Length-1500mm.

Volume of beam-

0.1×0.2×1.5=0.03 m3

For cast one beam concrete needs (with wastage)

According to our mix design-

Cement= (413.33×0.03) =12.40 kg = 15kg

Fine aggregate=(633.10×0.03) =19 kg = 22 kg

Coarse aggregate= (1172.64×0.03) =35.20kg = 40 kg

40% 10 mm Coarse aggregate = 16 Kg

60% 20mm Coarse aggregate = 24 Kg

2 nos. of Hanger bar

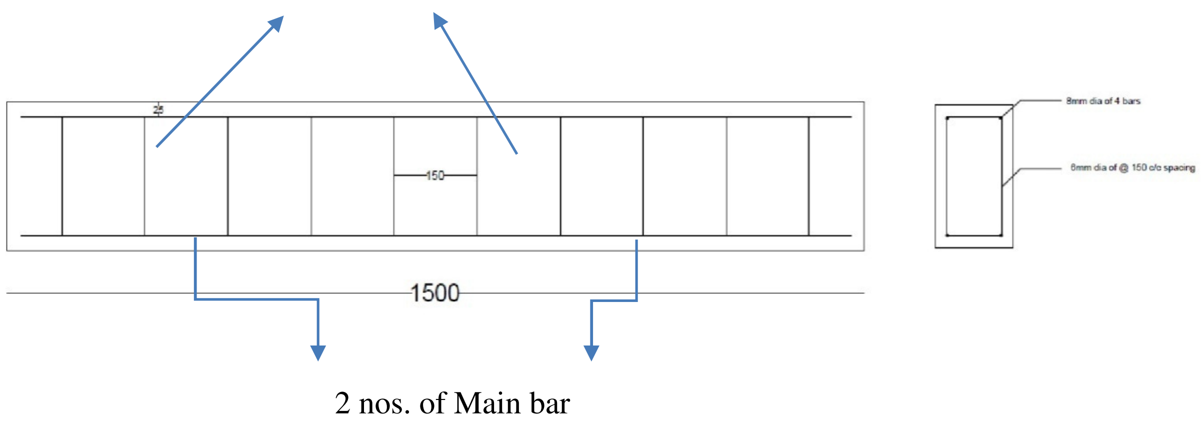


Figure 2.3. Details of reinforcement in the beam

2.3. PROCEDURE OF WRAPPING

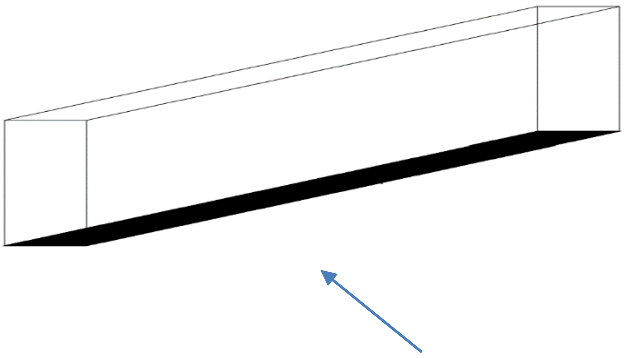
- Clean the bottom surface of beam with the help of sand paper.
- Resin, catalyst and epoxy is mixed uniformly.

- Apply the material on beam surface with the help of brush.
- Paste the GFRP sheet.

2.4. MATERIALS

- Epoxy Resin
- Pigment
- Catalyst
- Glass Fibre
- Brush
- Measuring jar

Figure 2.4. Material for wrapping



GFRP Layer

Figure 2.5. Rough diagram of wrapped beam.

3. RESULT AND DISCUSSION

3.1. Test specimens

Flexural tests are conducted up to failure on three control beams and three concrete beams wrapped with GFRP. The GFRP fabric is a stitched unidirectional sheet of 0.18 mm thick. The length and breadth and depth of all concrete beams is kept as 1500mm x 100mm x 200mm. each concrete beam is reinforced with four 8mm dia steel bars. Strips bars at a spacing of 150 mm c/c for flexure reinforcement.

The concrete control beams are designed. Three beams are wrapped with one layer of GFRP fabric.

3.2. Load vs span deflection values and graph is given below-

W1 side deflection

W2 side deflection

3.3. Procedure of testing

- Beam is measured with the help of measuring tape and marked.
- Both side of the beam 200 mm is taken for supporting.
- In center of beam 100 mm is taken both sides and marked well.
- Beam is kept on the loading frame machine.
- Two concentrated load is applied.
- In bottom two LVDT is used for knowing the displacement.
- Note the initial crack and final crack.
- Load is found with the help of data logger machine and displacement is found with the help of LVDT machine.

Table 3.1 Flexural Control Beam1

Load (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.1	0.1
1.0	0.3	0.4
1.5	0.9	0.5
2.0	1	0.7
2.5	2	1.1
3.0	2.4	1.3
3.5	2.9	1.6
4.0	3.4	1.9
4.5	4	2.3
5.0	5.3	3.3
5.5	7.9	5.6
6.0	13.2	10.6

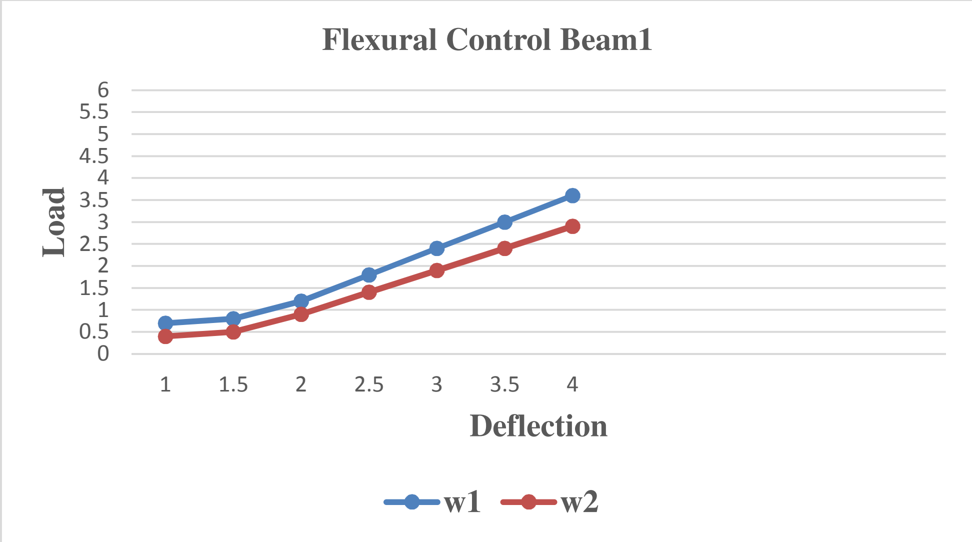


Figure 3.1 Deflection test on Flexure control beam1

Table 3.2 Flexural Control Beam2

Load (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.2	0.1
1	0.5	0.2
1.5	1.1	0.6
2	1.7	0.9
2.5	2.3	1.2
3	2.9	1.6
3.5	3.5	2.1
4.0	4.1	2.5
4.5	4.7	3.0
5.0	7.6	5.6
5.5	10.2	8.5
5.9	16.6	15.6

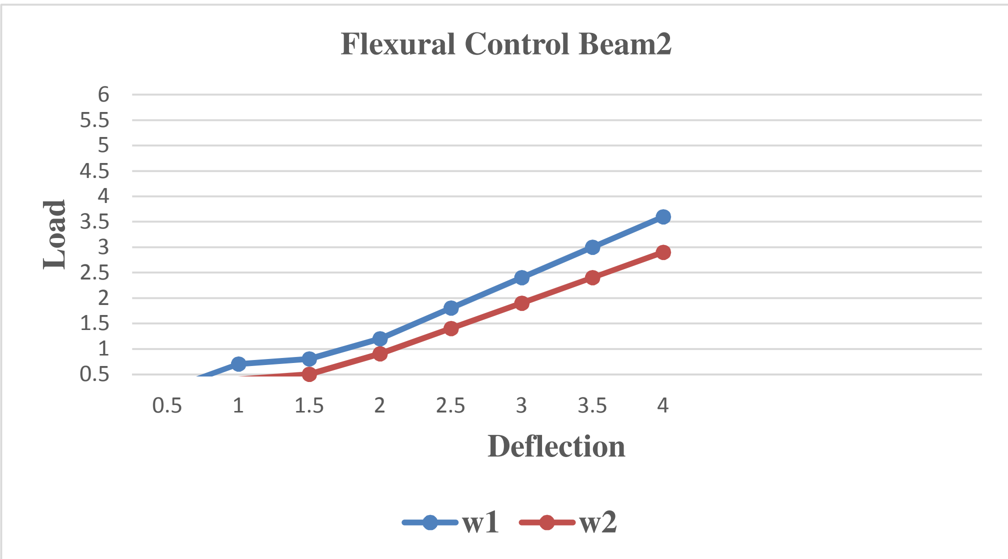


Figure 3.2 Deflection test on Flexure control beam2

Table 3.3 Flexural control Beam 3

Load (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.2	0.1
1	0.4	0.2
1.5	1.2	0.3
2	1.6	0.8
2.5	2.2	1.6
3	2.7	1.9
3.5	3.3	2.4
4	4.0	2.7
4.5	4.6	3.2
5.0	7.8	5.9
5.5	10.1	9.0

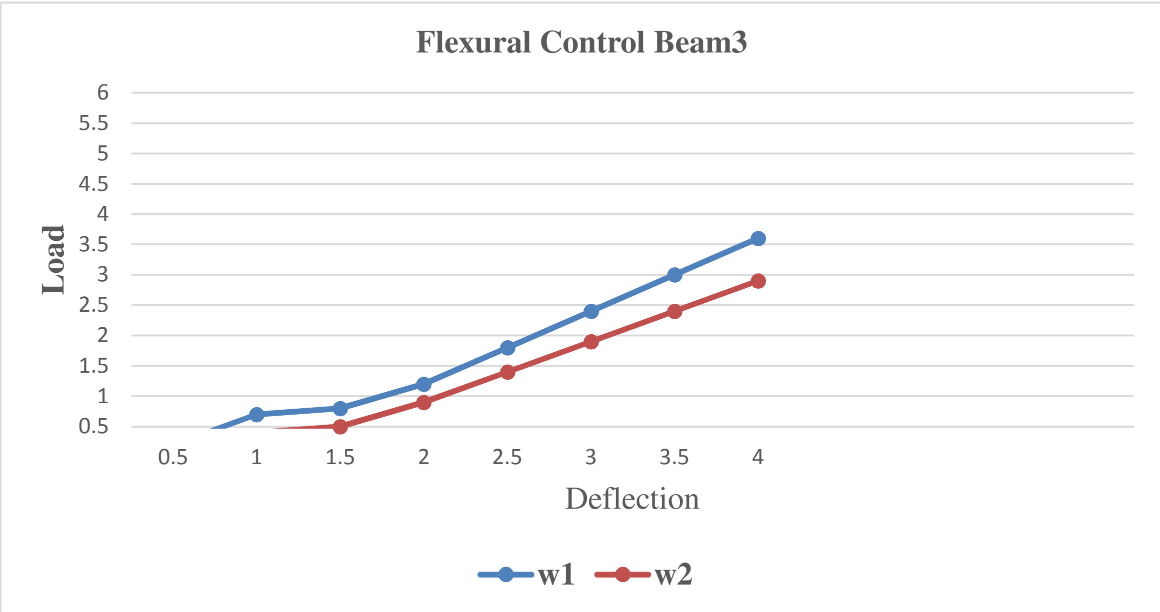


Figure 3.3 Deflection test on Flexure control beam3

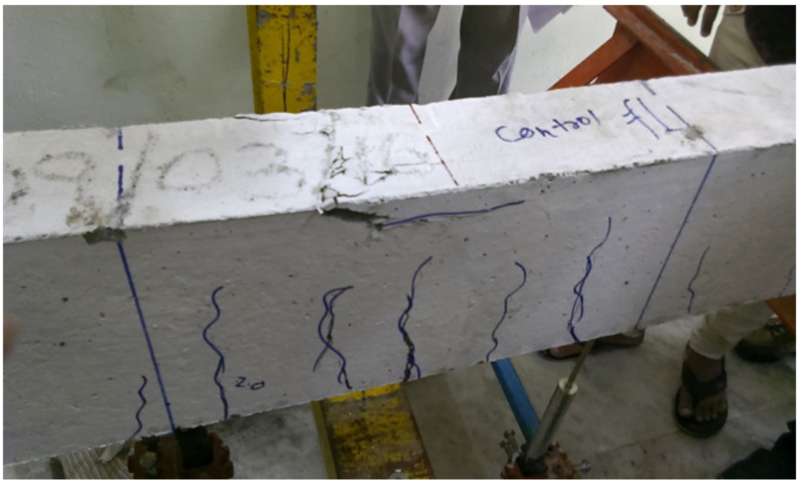


Figure 3.4 Flexure control beam

Figure 3.5 Flexure control beam

Table 3.4 70% Preloading Flexural Wrapped Beam 1

LOAD (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.4	0.3
1.0	0.6	0.5
1.5	0.8	0.7
2.0	1.2	1.1
2.5	1.5	1.6
3.0	2.3	2.2
3.5	2.8	2.7
4.0	3.5	3.4

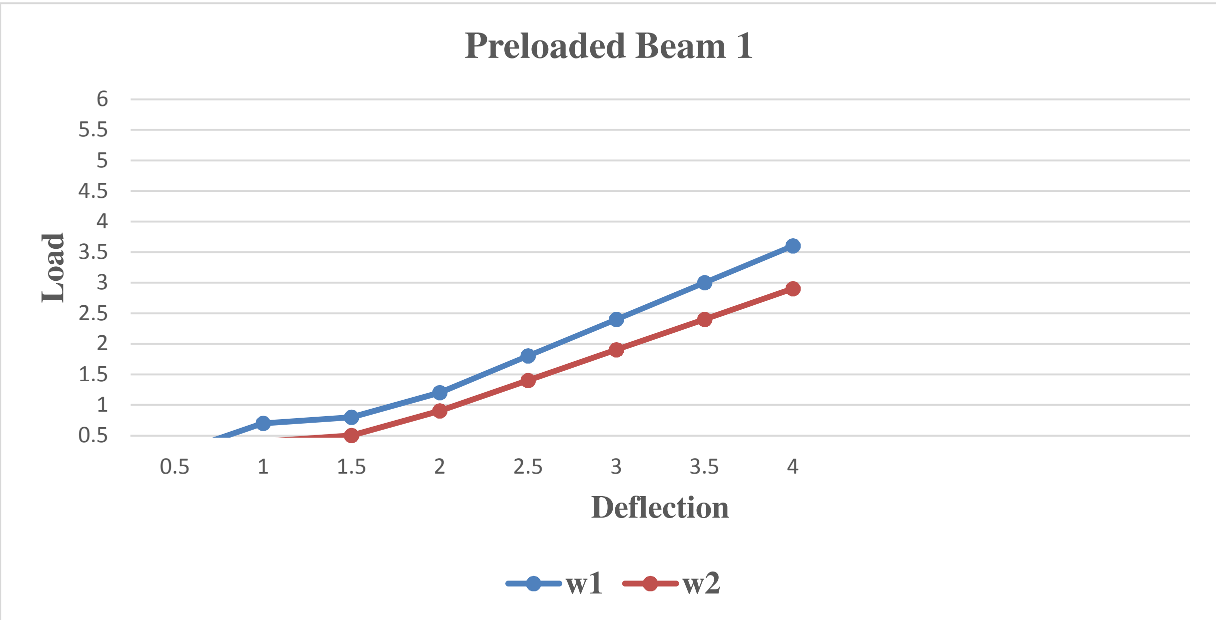


Figure 3.6 Deflection test on 70% Preloading Flexural Wrapped Beam1

Table 3.5 70% Preloading Flexural Wrapped Beam 2

LOAD (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.2	0.1
1.0	0.5	0.3
1.5	0.8	0.6
2.0	1.0	0.9
2.5	1.6	1.3
3.0	2.1	1.7
3.5	2.6	2.3
4.0	3.1	2.7

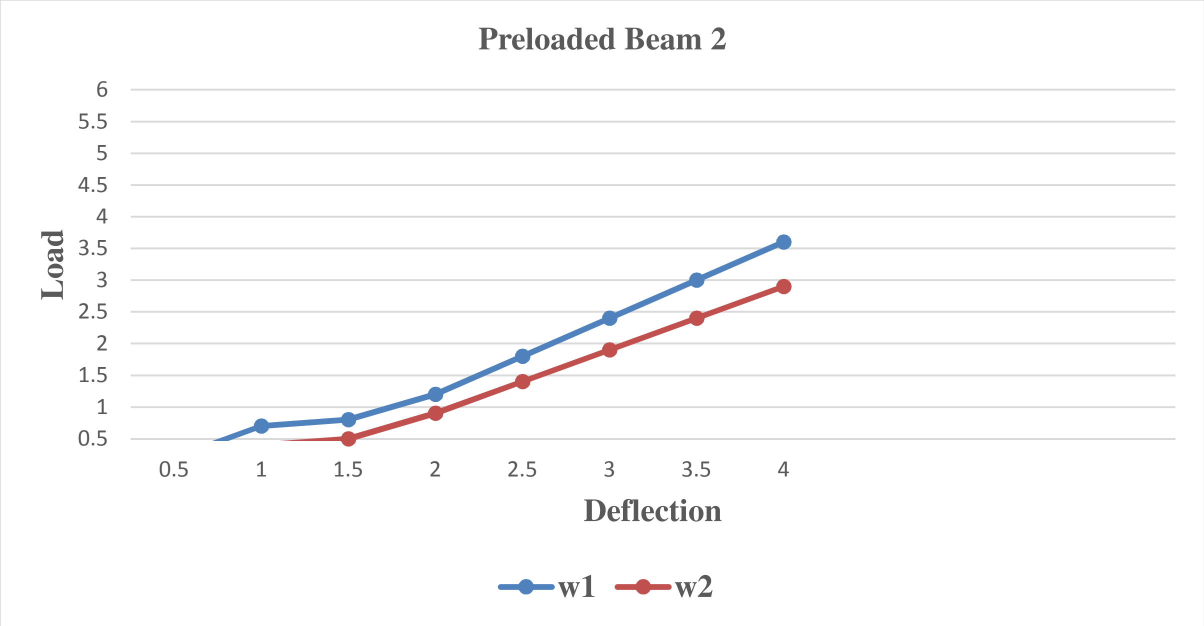


Figure 3.7 Deflection test on 70% Preloading Flexural Wrapped Beam2

Table 3.6 70% Preloading Flexural Wrapped Beam 3

LOAD (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.2	0.3
1.0	0.7	0.4
1.5	0.8	0.5
2.0	1.2	0.9
2.5	1.8	1.4
3.0	2.4	1.9
3.5	3.0	2.4
4.0	3.6	2.9

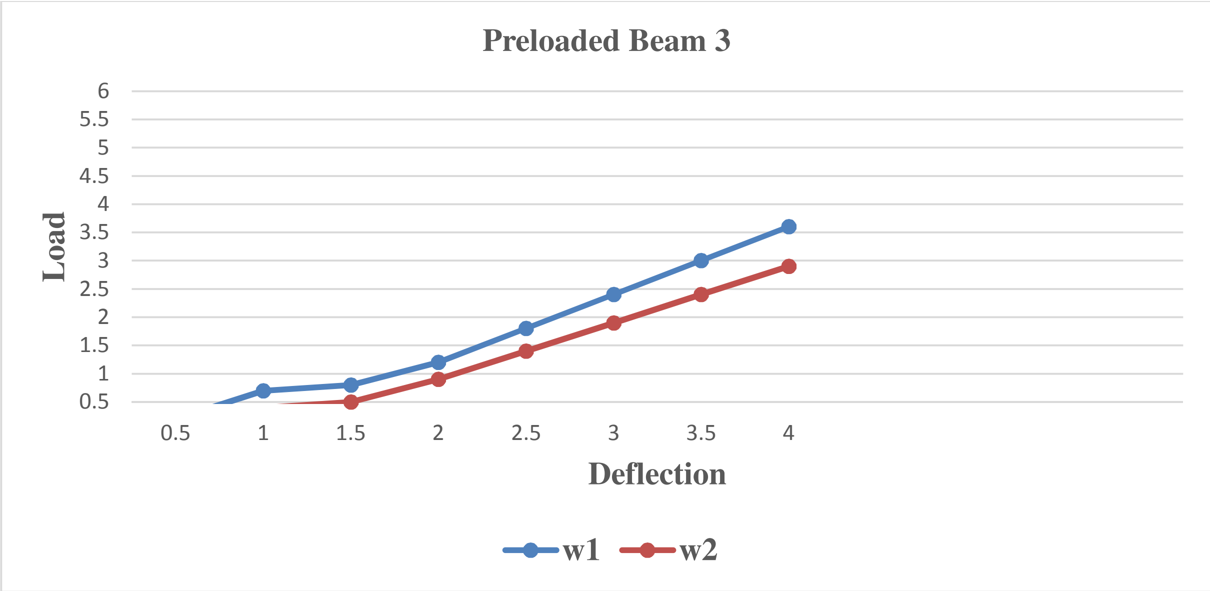


Figure 3.8 Deflection test on 70% Preloading Flexural Wrapped Beam3

Figure 3.9 70% Preloading Flexural Wrapped Beam

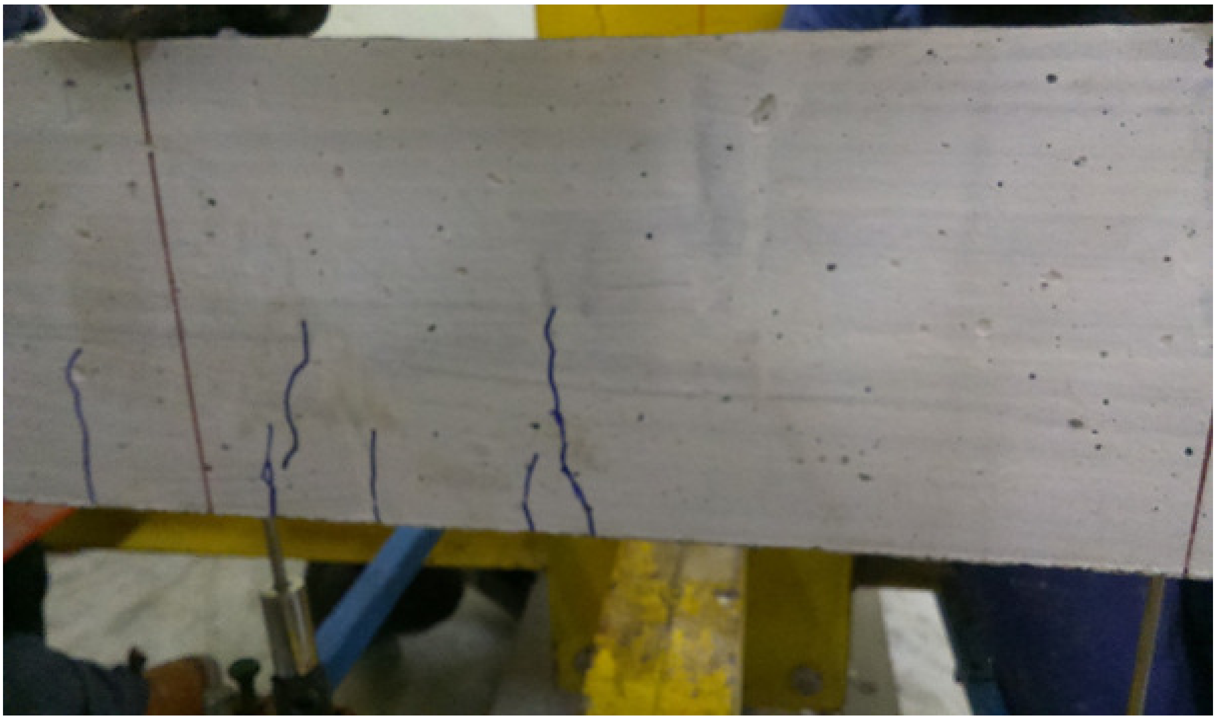


Figure 3.10 70% Preloading Flexural Wrapped Beam

Table 3.7 Flexural Wrapped Beam 1

LOAD (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.2	0.1
1.0	0.6	0.2
1.5	1.3	0.3
2.0	1.7	0.8
2.5	2.3	1.6
3.0	2.9	1.9
3.5	3.5	2.4
4.0	4.1	3.0
4.5	4.7	3.9
5.0	7.4	5.9
5.5	9.2	7.0
6.0	14.2	8.3
6.5	16.6	14.4

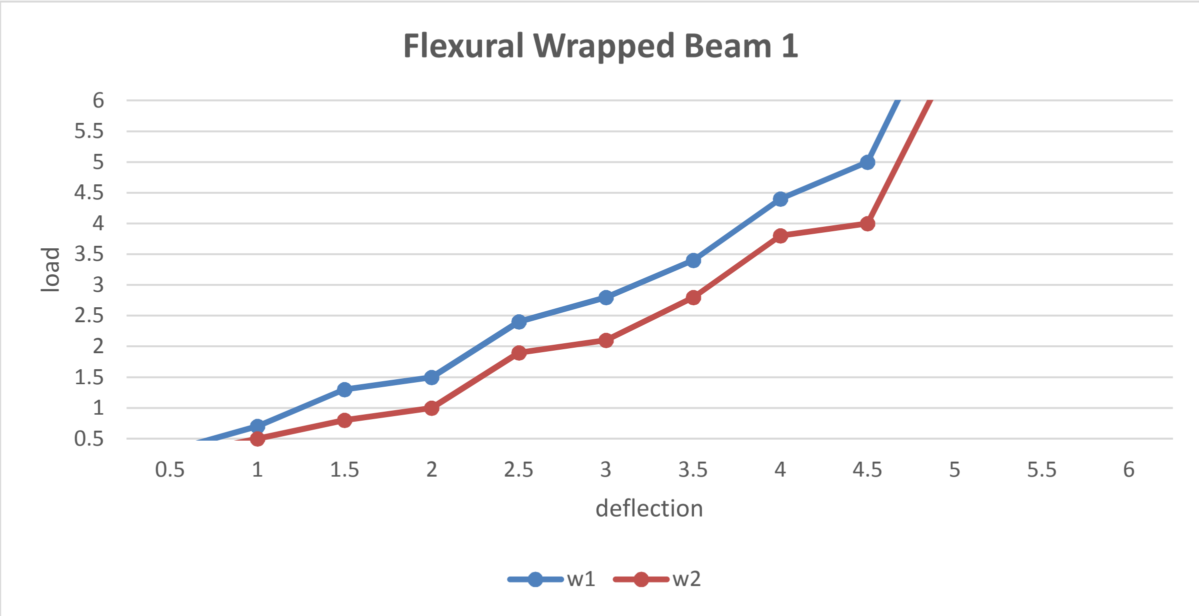


Figure 3.11 Flexural Wrapped Beam1

Table 3.8 Flexural Wrapped Beam 2

LOAD (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.2	0.1
1.0	0.6	0.4
1.5	1.2	0.6
2.0	1.7	0.8
2.5	2.2	1.2
3.0	2.6	1.9
3.5	3.5	2.3
4.0	4.1	2.9
4.5	4.8	3.5
5.0	7.8	5.0
5.5	10.3	8.6
6.0	13.1	10.6
6.5	15.8	12.6

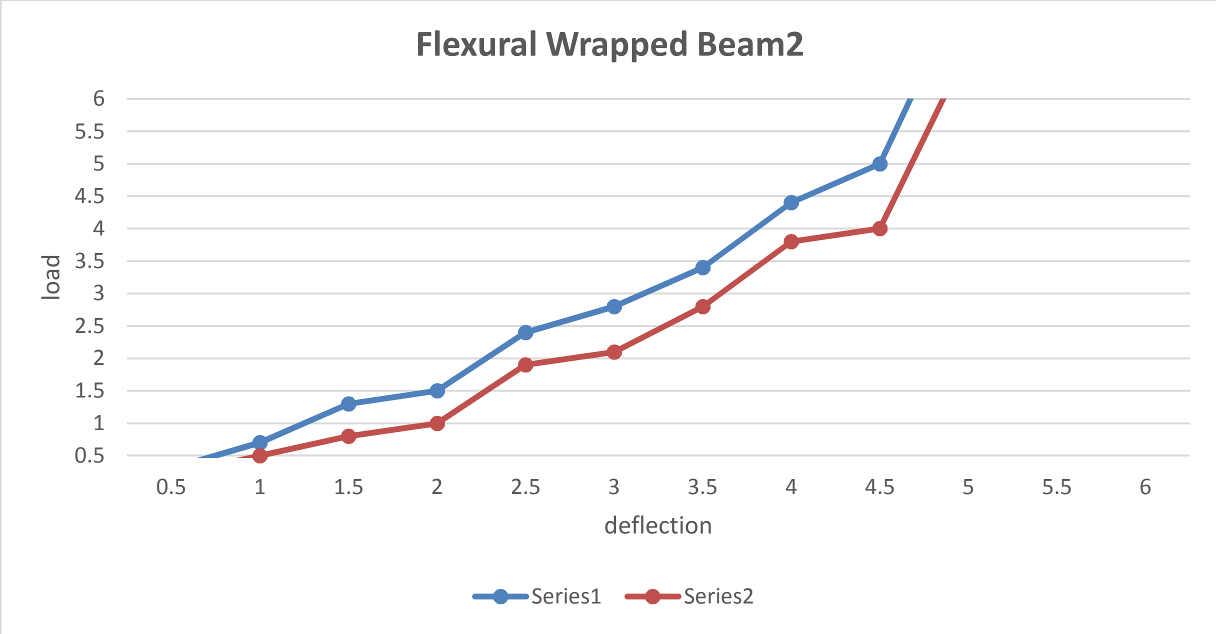


Figure 3.12 Flexural Wrapped Beam2

Table 3.9 Flexural Wrapped Beam 3

LOAD (Ton)	LVDT 1 (mm)	LVDT 2 (mm)
0.5	0.3	0.2
1.0	0.7	0.5
1.5	1.3	0.8
2.0	1.5	1.0
2.5	2.4	1.9
3.0	2.8	2.1
3.5	3.4	2.8
4.0	4.4	3.8
4.5	5.0	4.0
5.0	7.9	6.8
5.5	10.6	8.9
6.0	13.4	12.0
6.3	15.3	14.1

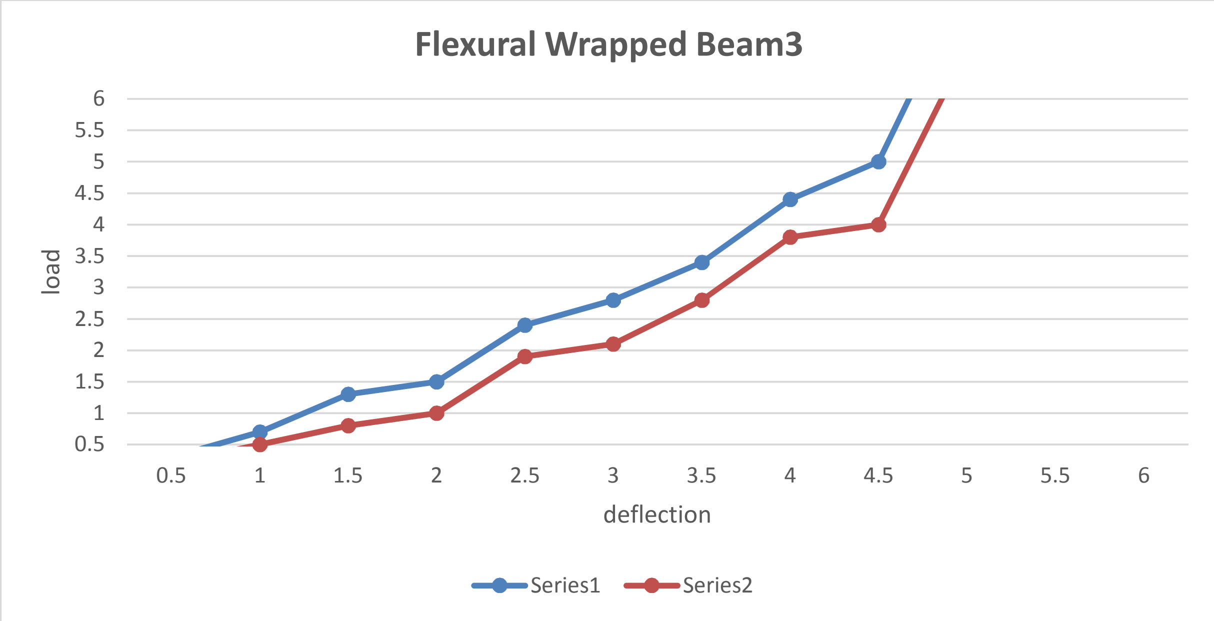


Figure 3.13 Flexural Wrapped Beam3

3.4. Result of Initial crack and Ultimate load

Table 8.10 Flexure control beams

Beam No.	Initial crack load (ton)	Ultimate load (ton)
1	2.0	6.0
2	1.5	5.9
3	1.5	5.5

Table 8.11 Wrapped beams.

Beam No.	Initial crack load (ton)	Ultimate load (ton)
1	2.5	6.5
2	3.0	6.5
3	2.7	6.3

Average Ultimate Load of flexure control beams = (6+5.9+5.5)/3 = 5.8 ton
70% preloading of Wrapped beams Ultimate Load = (5.8x70)/100 = 4.06 ton
Average Ultimate Load of flexure wrapped beams = (6.5+6.5+6.3) = 6.43 ton

4. CONCLUSIONS

- After strengthening the beam the initial cracks appears at the shear zone of the beam and the crack widens and propagates towards the neutral axis with increase of the load. The final failure is flexural failure which indicates that the GFRP sheets increase the flexural strength of the beam
- The flexural strength is increased up to 9.8% on concrete beams wrapped with unidirectional woven GFRP.
- The ultimate load of control beam was 5.8 ton and the ultimate load of wrapped beam was 6.43 ton.
- After the wrapping of GFRP the breaking point increased.

- The bonding between GFRP sheet and the concrete is intact up to the failure of the beam which clearly indicates the composite action due to GFRP sheet.

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