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An experimental study on mechanical properties of concrete using composite material (GFRP)

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Abstract

Concrete may be defined as a concrete which has closely – spaced special Transverse reinforcement which restrains the concrete in directions perpendicular to the applied stress. The maintenance and upgrading of structural members is perhaps one of the most crucial problems in civil engineering applications. The objective of this research was to determine the mechanical properties of cubes, beams and cylinders on applying GFRP. The size of the cube is taken as 150mm x 150mm x150mm, of beam is taken as 1500mm x 100mm x 200mm, and that of cylinder as 300mm x 150 mm. The mix design M25 ratio was formulated and specimens were casted. The GFRP was applied on 28 days cured concrete specimens. A relation between mechanical strength and age of specimens is also arrived. From the test results it is concluded that the mechanical strength increases by using GFRP confinement.

Keywords: GFRP, concrete, mechanical

Introduction

Structures can be classified in many ways according to their shape, their function and the materials from which they are made. A structure or structural element may be a fully three dimensional solid object like a monolithic pyramid or it might have some dimensions notable smaller than a ball bearing. Structural engineers have long known the value of combining materials into a composite structural system that takes advantage of the strength inherent in each of its constituents. Steel reinforced concrete is a classic example of this type of structural system. The use of composite material has been prominently increased in the field of civil, marine and aerospace structures. It is a recent trend that composite materials are increasingly used as a means of developing new alternative materials with high performance for infrastructure applications.

Glass-reinforced plastic (GRP) is a composite material or fiber-reinforced plastic made of a plastic reinforced by fine glass fibers. Like graphite-reinforced plastic, the composite material is commonly referred to as fiberglass. The glass can be in the form of a chopped strand mat (CSM) or a woven fabric. As with many other composite materials (such as reinforced concrete), the two materials act together, each overcoming the deficits of the other. Whereas the plastic resins are strong in compressive loading and relatively weak in tensile strength, the glass fibers are very strong in tension but tend not to resist compression. By combining the two materials, GRP becomes a material that resists both compressive and tensile forces well. The two materials may be used uniformly or the glass may be specifically placed in those portions of the structure that will experience tensile loads.

Scope and Objective

Scope

1. Concretes with composites are used for many structural purposes due to its high strength, light weight, resistance to shock, and standard resistance to lateral pressure.
2. External confinements with composites have been used in strengthening slabs, beams columns etc.
3. The main aim is to enhance the load carrying capacity, compressive strength and the ductility which can be especially useful in seismic areas.

Objective

1. To investigate the mechanical properties of concrete using GFRP.
2. To Study the effect of concrete in comparison with control specimens.
3. To compare the test results of 7 and 28 days curing.

Methodology

Table 1

Preliminary Tests
Collection of Materials
Mix Design M25 Grade Concrete
Tests on Fresh Concrete
Casting of Specimen
Tests on Hardened concrete
Evaluation of Strength Properties
Analysis and Discussion of test results
Conclusion

Results and Discussion

To study and compare the behaviour of concrete confined with GFRP, The experimental investigations as mentioned were carried out on concrete samples for their strength and properties. The comparison was drawn between control specimens and confined concrete specimens and an average value of strength was taken at different ages.

The concrete samples were cast with 1: 1.53:2.4 ratio .The tests were carried out after 7 and 28 days of the casting of concrete specimens. Summary of the test result for concrete cubes is shown in tabulation.

Test results of average compressive strength of different aged cubes, GFRP confined Cubes and unconfined cubes are shown

Table 2

S. No	Details of specimen	Age	Average Compressive Strength In N/mm^2
1	Unwrapped cube	7 days	18.47
2	Wrapped cube	28 days	20.83
3	Unwrapped cube	7 days	30.24
4	Wrapped cube	28 days	41.70

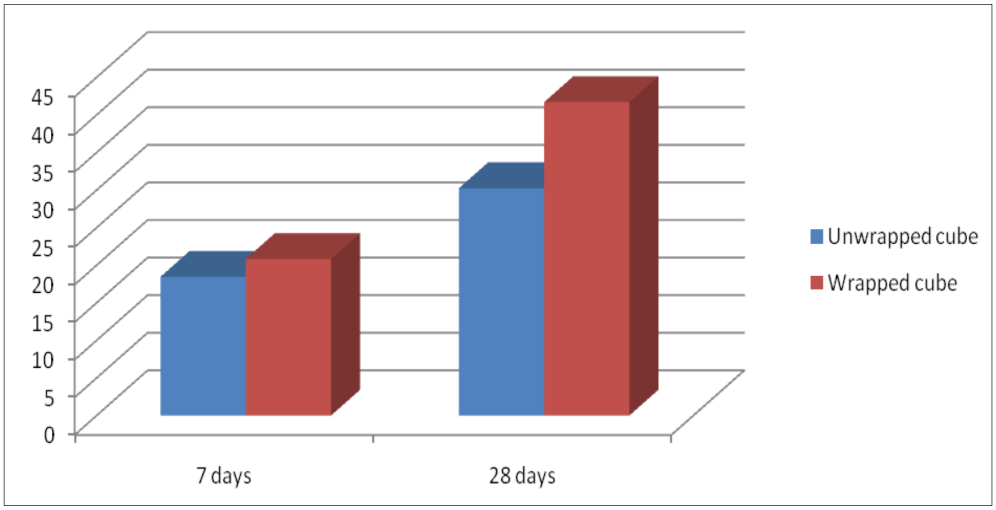

Fig 1: Age of cubes in days

Test results of average Tensile strength of different aged cylinders, GFRP confined cylinders and unconfined cylinders are shown

Table 3

S. No	Details of Specimens	Age	Average Tensile Strength in N/mm^2
1	Unwrapped cylinder	7 days	2.5
2	Wrapped cylinder	28 days	3.1
3	Unwrapped cylinder	7 days	3.33
4	Wrapped cylinder	28 days	4.47

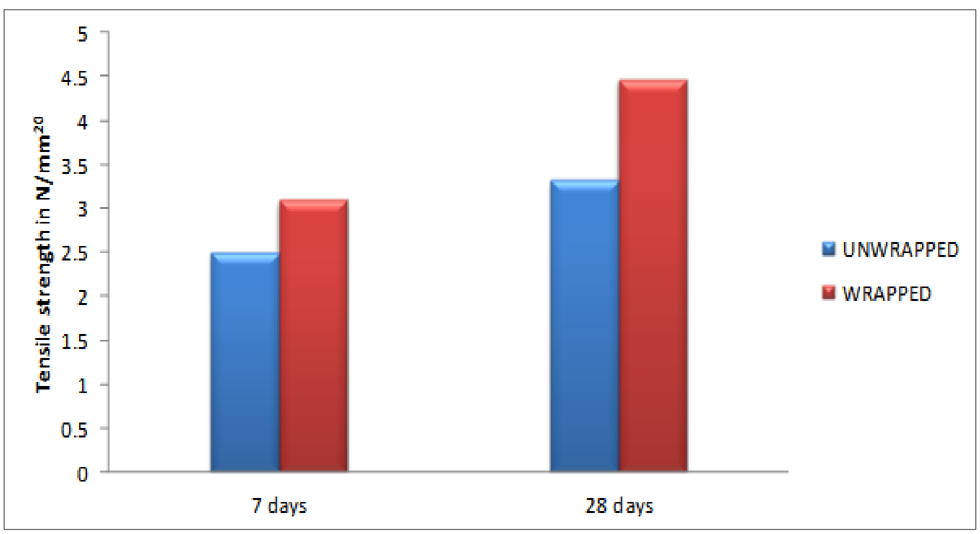

Fig 2: Age of cylinder in days

Load vs Deflection Graph

From the figures of load vs Deflection and the table from appendix, it is observed that the deflection of beams increases with the increase in load. Under two point static loading of beam specimens, at each increment of load, deflection and crack development were observed.

Test on control beam (1)

Table 4

Load (Ton)	LVDT 1	LVDT 2
0	0	0
0.5	0.1	0.2
1	0.5	0.5
1.5	0.7	0.7
2	1.1	1.1
2.5	1.4	1.3
3	1.9	1.8
3.5	2.3	2.2
4	2.8	2.7
4.5	3.3	3.2
5	3.8	3.7
5.5	4.2	4.1
6	4.9	4.7
6.5	5.9	5.7
7	8.7	8.9

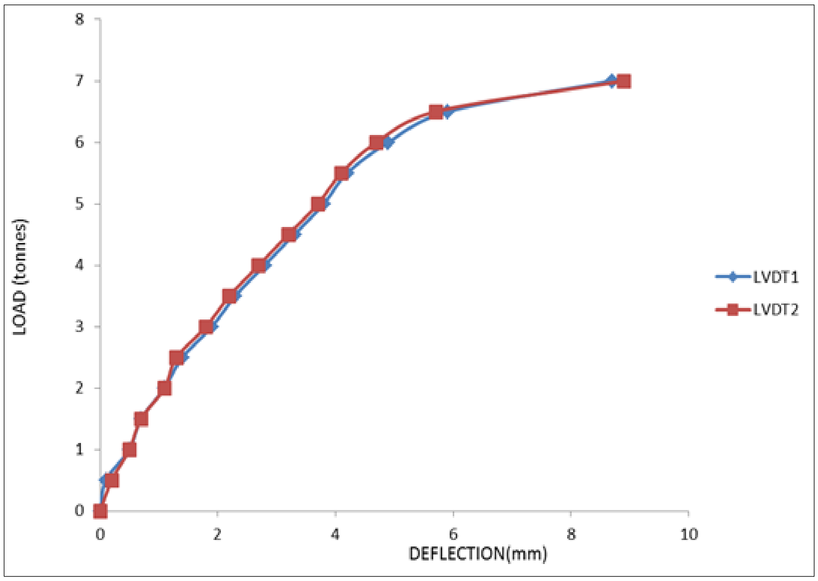

Fig 3: Load vs Deflection for CB

Test on control beam (2)

Table 5

Load (Ton)	LVDT 1	LVDT 2
0	0	0
0.5	0.5	0.4
1	0.7	0.7
1.5	1.1	1.1
2	1.5	1.4
2.5	1.9	1.9
3	2.4	2.3
3.5	2.3	2.7
4	2.8	3.2
4.5	3.3	3.6
5	3.8	4
5.5	4.8	4.6
6	5.8	5.8
6.5	7.9	8.2

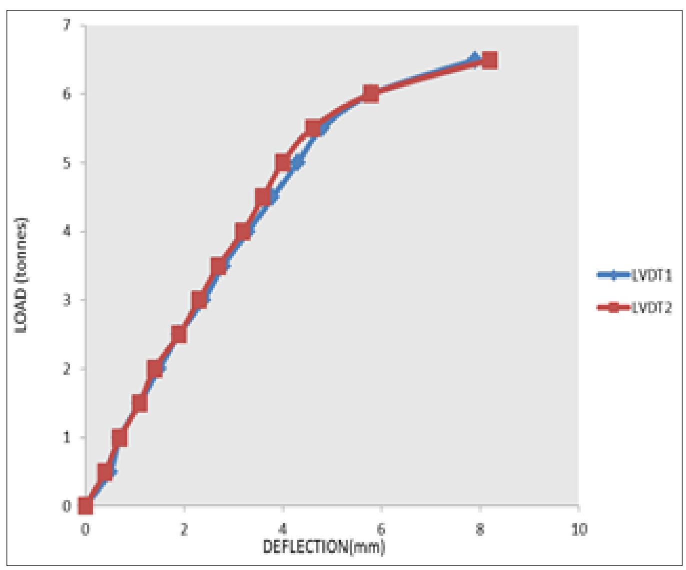

Fig 4: Load vs Deflection graph

Load at Initial Cracks and Ultimate Load

Table 6

Type	Initial Cracks (kN)	Ultimate Load (Kn)
Control Beam 1	15	70
Control Beam 2	15	65

Test on Preloading Beams (80%)
Test on preloading beam 1 (80%)

Table 7

Load (Ton)	LVDT1	LVDT2
0	0	0
0.5	0.1	0.3
1	0.3	0.6
1.5	0.5	0.8
2	1	1.3
2.5	1.2	1.5
3	1.8	2
3.5	2.2	2.4
4	2.6	2.9
4.5	3.2	3.5
5	3.6	3.9
5.46	4	4.3

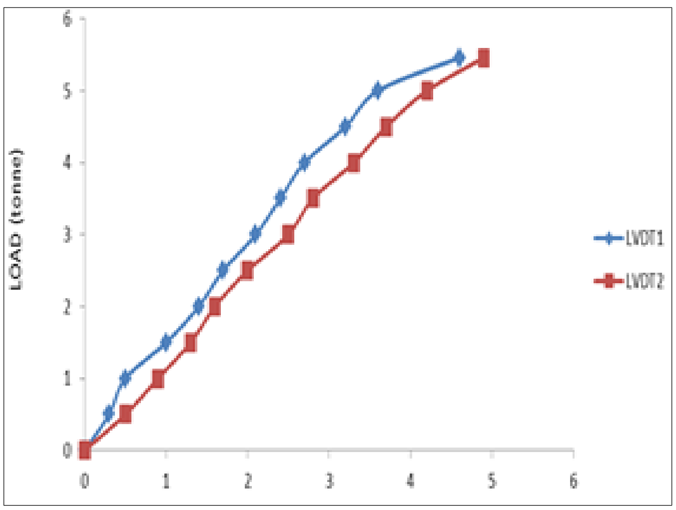

Fig 5: Load vs Deflection graph

Test on preloading beam 2 (80%)

Table 8

Load (Ton)	LVDT1	LVDT2
0	0	0
0.5	0.1	0.2
1	0.3	0.5
1.5	0.5	0.8
2	0.8	1.1
2.5	1.1	1.4
3	1.6	1.8
3.5	2	2.2
4	2.5	2.8
4.5	3	3.3
5	3.5	3.7
5.46	3.9	4.5

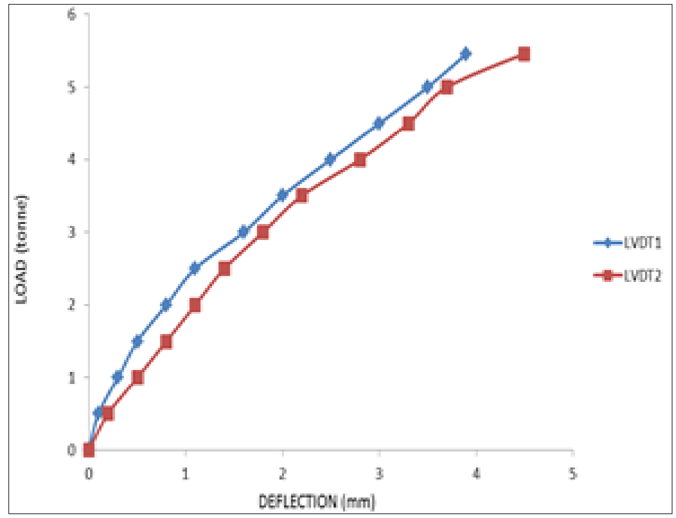

Fig 6: Load vs Deflection graph

Load at Initial Cracks and Ultimate Load for Preloading Beams

Table 9

Type	Initial Cracks (kN)	Ultimate Load (Kn)
preloading of 80% for F1	16	54.6
Preloading of 80% for F2	21	54.6

GFRP -Wrapping For PRE Loading 80 % OF FB
Test on wrapping beam 1

Table 10

Load (Ton)	LVDT1	LVDT2
0	0	0
0.5	0.1	0.1
1	0.3	0.2
1.5	0.5	0.4
2	0.7	0.5
2.5	1.1	0.7
3	1.7	1.2
3.5	2	1.5
4	2.4	2
4.5	3	2.5
5	3.5	3.1
5.5	3.9	3.6
6	4.3	4
6.5	5.4	4.6
7	5.8	5
7.5	6	5.7
8	7.5	6.8
8.5	8.5	7.4
9	9.7	8.5
9.5	10.5	9.2
10	10.8	9.8

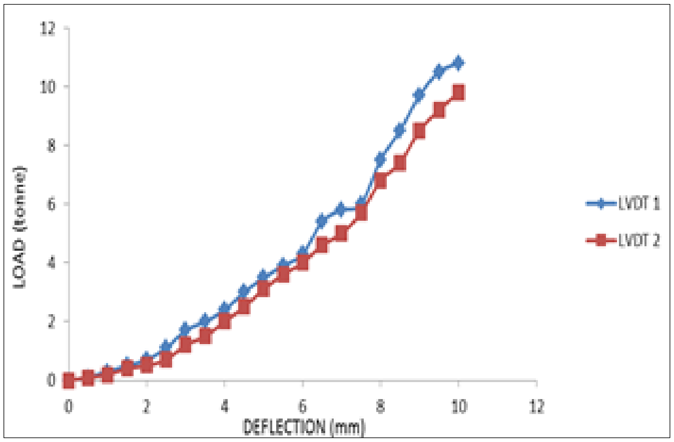

Fig 7: Load vs Deflection graph

Test on wrapping beam 2

Table 11

Load (Ton)	LVDT1	LVDT2
0	0	0
0.5	0.1	0.1
1	0.4	0.3
1.5	0.6	0.4
2	1	0.8
2.5	1.2	1
3	1.6	1.2
3.5	2.1	1.5
4	2.5	2
4.5	3.1	2.5
5	3.7	3.1
5.5	4.1	3.5
6	4.5	4
6.5	5.7	4.6
7	6.6	5.3
7.5	7.8	6.1
8	8.3	7.5
8.5	8.9	8.5
9	9.4	8.8
9.5	9.8	9.3
10	10.5	9.7

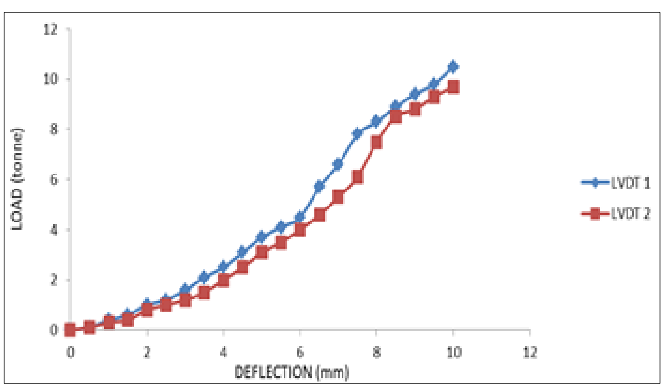

Fig 8: Load vs Deflection graph

Load at initial cracks and ultimate load for wrapping beams

The crack initiation of beam specimens FB 1 and 2 were not visible due to application of GFRP around the beam. The cracks only visible after reaching ultimate load.

Table 12

Type	Ultimate Load (Kn)
GFRP Wrapping FB1	99
GFRP Wrapping FB2	100

From the figures of load vs Deflection and the table from appendix, it is observed that the deflection of beams increases with the increase in load.

Test results of ultimate load (pu) for beams

Table 13

Type	Ultimate Load, Pu (kN)
Control Beam	67.5
Preloading Beam (FB)	54.6
GFRP Wrapping FB	99.5

The ultimate loads for the specimens are tabulated in table 8.5.4 and a plot is made between ultimate load on different specimens as shown in Fig 8.5.4 It is observed that the ultimate load increases after GFRP wrapping.

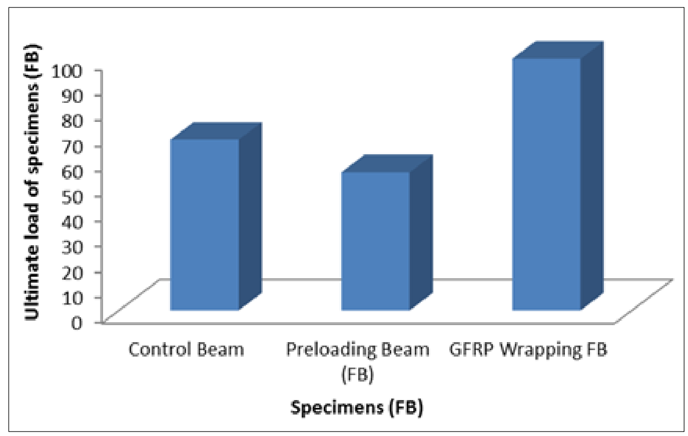

Fig 9: Ultimate loads on different specimens

Under two point static loading of beam specimens, at each increment of load, deflection and crack development were observed. In CB initiation of crack takes place at a load of 16.6 KN. The cracks were only visible after reaching ultimate load.

Conclusion

Based on the experimental investigations, the following conclusions have been arrived:

1. The test results indicate that the mechanical properties increase with the confinement of GFRP on concrete with respective to curing periods
2. In comparison with the control specimens, it is found that the compressive strength of GFRP confined concrete increased to 7% and 33% at 7 and 28 days of curing period respectively.
3. In comparison with the control specimens, it is found that the split tensile strength of GFRP confined concrete increased to 24% and 35% at 7 and 28 days of curing period respectively.
4. It was found that the ultimate load of the beam wrapped by GFRP was increase by 3.17 tonne

5. The wrapped beams resisted more load than controlled beams.
6. The deflection of Reinforced Concrete Beams increases with increase in load within the elastic range.
7. Flexural Strengthening of RCC beams using Glass Fibre Reinforced Polymer Composites conclude the strength of the beams can be increased by wrapping with Glass Fibre Reinforced Polymer Composites.

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