Comparative Analysis of Load and Deflection for Different Beam

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***Abstract*- In this study, experimental analysis of various beam which were strengthened with the use of GFRP laminates was carried out and after that the result were compared with the non-strengthened beam called control beam. Three types of beam were casted, out of which two were rectangular beam and one was T-beam. Each type of beam has three specimens and among them one was un- strengthened and two were strengthened beam specimen. After the test results were obtained following conclusions can be made in all the set of beam it was clear that the ultimate load carrying capacity of Control Beam was lesser than that of strengthened beams. In strengthened beams Initial flexural cracks were visible at much higher load as compared to control beam. The load carrying capacity of the U shape Jacket wrapping of beam with laminates was found to be maximum of all the beams. For third set of beam i.e. T-beams it enhances the load to about 40% greater than control beam TB1 and nearly 12% greater than beam strengthened with FRP at the soffit only i.e. TB2.**

Key Words- FRP, GFRP, Deflection, CFRP

I. INTRODUCTION

A structure once constructed does not remain as it is forever and it has to bear certain different load and their combination during it life span. These loads result in decrease in efficiency and hence strength of structures. Various load which acts over structure are gravity load acting as self-weight of structure, temperature load acting as change in temperature in due course of time, environmental effects, chemical effects and the major and uncertain load that is earthquake load which is most dangerous to structure. Earlier our structures were not built considering earthquake as major force and some of those structures are antiques to us. Earthquake load is dynamic in nature and also we are not aware when it will occur and of what nature. It may have tendencies to weaken the bond of structure. It can completely destroy our structure. So in present scenario such loads are given due considerations Whenever a structure is affected by all such loadings we are left with two options i.e. either Repair or Reconstruction. But among these reconstruction proves to be very costly and that may be double to that of initial cost of structure. As structure built in past are not constructed as per our new codes of design which make them structurally unsafe and replacement of such structures require a huge amount and in the same time it destroys their antiquity if they are of ancient time. So at last we are left with Repairing or Retrofitting methods which are economical to us. But maintenance, rehabilitation and up gradation of structure is also a challenging task. Basically there are two types of techniques used i.e. seismic resistance based design and Seismic response control design. In former we use Concrete jacketing, Steel jacketing and FRP wrapping whereas in latter we uses Elastic-plastic, dampers Base isolators and Tuned liquid dampers and many other options are possible. For long time we have been using methods such as addition of shear walls, infill walls, buttresses, etc. but with the advancement of technology and research of new material retrofitting of structures can be done with many advantages and FIBRE reinforced composite is one among them. The rest of the paper is organized as follows. Section II& III outlines the complete design of FRP & strengthing of beam. Experimental setup results analysis of the proposed beam are discussed in Section IV & VI. The conclusions are given in Section VII.

II. FIBER REINFORCED POLYMER (FRP)

FRP can be regarded as heterogeneous, composite, and anisotropic materials having a common linear elastic behavior up to failure. They are broadly used for strengthening of civil structures. There are many advantages of FRPs i.e. good mechanical properties, corrosion-resistant, lightweight, etc. They are available in several geometries from sheet used for intensification of members with normal surface to bidirectional fabrics easily adjustable to the outline of the member to be strengthened. Composites are also suitable for applications where the aesthetic of the original structures needs to be preserved (buildings of historic or artistic interest) or where strengthening with traditional techniques cannot be effectively employed. Fiber reinforced polymer (FRP) is a composite material made by combining two or more materials to give a new combination of properties. On the other hand, FRP is poles apart from other in that its component materials are dissimilar at the molecular point and are mechanically detachable.

FRP = Fiber+ Matrix

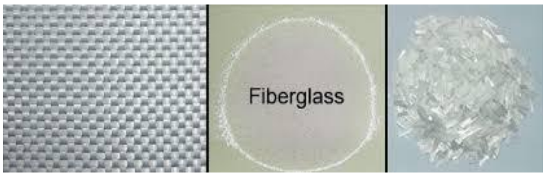


Fig 1. FRP formation

The mechanical along with physical properties of FRP are proscribed by its ingredients properties also by structural configurations at small level. As a result, the designs as well as analysis of any FRP structural member necessitate a fine understanding of the material properties, which are reliant on the manufacturing process along with the properties of constituent materials. It is a two phased material, for this reasons it have anisotropic properties. It is composed of fiber and matrix, which are bonded at interface. All of these diverse phases have to act upon its requisite function based on mechanical properties, thus the composite system performs acceptably as a whole. The reinforcing fiber offers FRP composite with strength as well as stiffness, whereas the matrixes provide environmental protection along with rigidity.

III. STRENGTHENING OF BEAMS

Prior to bonding the fabric composite to the concrete surface, the requisite region of concrete was finished uneven by means of a coarse sand paper texture and also cleaned by means of an air blower to remove all dirt and debris. On one occasion the surface was ready to the requisite standard, the bonding agent was mixed in harmony with manufacturer's instructions. Mixing of compound Araldite LY 556 – 100 parts by weight and Hardener HY 951 – 8 parts by weight was carried out in a plastic container and was continuous until the mix was in homogeneous color. As soon as this was completed and the fabrics were cut to size, the bonding agent was applied on the concrete surface.

Fig 2. Application of epoxy resin

Fig 3 Fixing of GFRP sheet

Fig 4 Removing air bubbles with the help roller

The fabric composite was then placed on top of bonding agent coating and the resin was pressed through the nomadic of the fabric with the roller. Entrapped air bubbles at the interface were to be removed. After that the second layer of the bonding agent was applied in addition to that GFRP sheet was subsequently placed on top of coating and the resin was pressed through the nomadic of the fabric with the roller furthermore the above process was repeated. Throughout hardening of the epoxy, a steady uniform pressure was applied on the fabric composite surface in order to extrude the surplus epoxy resin and to ensure high-quality contact between the epoxy resin, the concrete as well as the fabric. The process was carried out at room temperature. Concrete beams strengthened with GFRP were cured for 24 hours at room temperature prior to testing.

IV. EXPERIMENTAL SETUP & PROCEDURE

The testing method for the whole specimen was same. Subsequent to the curing period of 28 days was complete; the beam was washed along with its surface and was dirt free for clear visibility of cracks. The load arrangement for testing of beams consists of two-point loading. If it is required to assess the shear capacity of the, the load will generally be concentrated at an appropriate shorter distance from a support.

Two-point loading can suitably be provided by the arrangement shown in Figure. The load is spread through a load cell and spherical seating on to a spreader beam. This beam stand on rollers accommodated on steel plates bedded on the test member with high-strength plaster mortar, or some similar material. The assessment member is hold up on roller bearings acting on similar spreader plates. The loading frame should be capable of hauling the probable test loads with no significant deformation. Accessibility to the middle third for deflection readings, crack observations, and possibly strain measurements is an important concern, as is safety when failure occurs.

The sample was positioned above the two steel rollers bearing parting 150 mm from the ends of the beam. The residual 2000 mm was alienated as shown in the figure into three equal parts of 667 mm. as shown in the figure Two point loading arrangement was done. Loading was made by hydraulic jack of capability 100 KN. Three dial gauges were used for recording the deflection of the beams. One of the dial gauges was placed immediately beneath the center of the beam also the left over two dial gauges were placed immediately beneath the point loads to measure deflections. The members were checked dimensionally before testing, as well as a detailed check was made with carefully recording all the information. After locating and reading all gauges, the load was enlarged incrementally up to the designed working load, by recording loads and deflections at each stage.

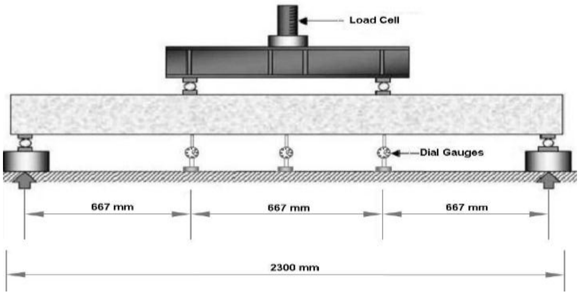


Fig 5 Two point loading experimental set up

Loads will then usually be increased yet again in like increments up to failure, by replacing deflection gauges by a properly mounted scale as failure come near. It is essential to keep away from damage to gauges, and even though accuracy is decreased, the deflections at this stage will more often than not be large and can be effortlessly measured from a distance. in the same way, cracking and manual strain annotations must be balanced as failure approaches if not special safety measures are taken. If it is necessary that exact deflection readings are taken up to failure. Cracking and failure mode was ensured visually, as well as a load-deflection plot was arranged.

V. ASSUMPTIONS

The subsequent assumptions are used in manipulating the flexural strength of a section strengthened by means of an externally bonded FRP system:

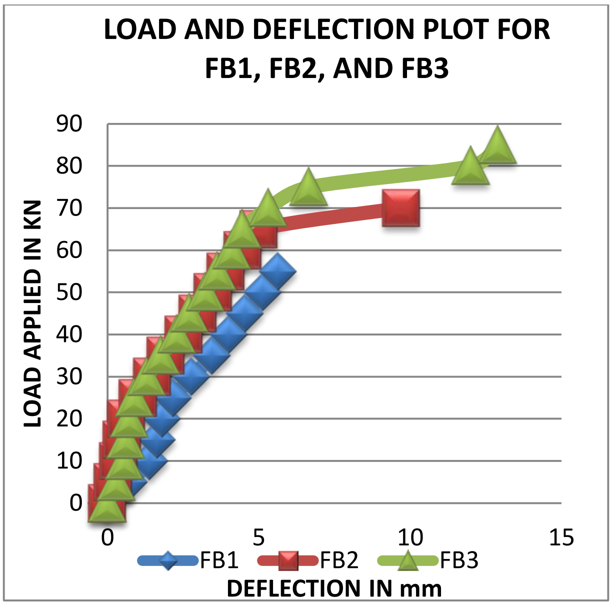
- ➢ All the design calculations are based on the real dimensions.
- ➢ A plane section before loading will remains plane after loading. That is, the strain in both the reinforcement and the concrete is in a straight line proportional to the distance from the neutral axis.
- ➢ There will be no virtual slip among FRP and the concrete;
- ➢ The shear warp within the epoxy resin layer is neglected as this layer is very thin with small variations in thickness.
- ➢ The utmost compressive strain in concrete is 0.003;
- ➢ The tensile strength of concrete is ignored.
  - ➢ The FRP has a linear elastic stress-strain correlation to collapse.

VI. RESULT ANALYSIS

The load and its respective deflection history were recorded for all beams in a tabular form. The deflection of beams at mid-span i.e. L/2 was compared with that of their respective control beams. The load deflection behaviour of beams was also compared among two wrapping schemes in every set with the same reinforcement. We observed the performance of the flexure and shear lacking beams which when strengthened with GFRP sheets were much better than their related control beams.From data of the load and deflection of first set of beams i.e. FB1, FB2 and FB3, a curve is plotted.

Table 7: Load and deflection analysis of beam FB1, FB2, AND FB3

LOAD APPLIED IN KN	DEFLECTION in mm		
	FB1	FB2	FB3
0	0	0	0
5	0.72	0.19	0.3
10	1.4	0.38	0.58
15	1.64	0.49	0.63
20	1.81	0.63	0.74
25	2.17	1.02	0.9
30	2.79	1.49	1.32
35	3.46	1.94	1.77
40	4.02	2.53	2.3
45	4.55	3	2.72
50	5.14	3.5	3.25
55	5.64	3.92	3.64
60		4.48	4.12
65		5.01	4.48
70		9.71	5.32
75			6.67
80			12.02
85			13.27



Graph showing combined behaviour of FB1, FB2, AND FB3 From load and deflection plot, it was made clear that beam FB1 has lesser ultimate load as compared to beams FB2 as well as FB3. In analysis the beam FB1 have undergone elevated deflection as compared to beams FB2 and FB3 at the same load. For beam FB2 ultimate load carrying capacity as compared to the control beam FB1 was higher but lesser than beam FB3. As far beam FB3 have greater ultimate load carrying capacity when compared to the beams FB1 and FB2. Both the beams FB2 and FB3 have undergone approximately similar deflection upto 60 KN load. But after 60 KN load, the beam FB3 have shown same deflection as beam FB2 but at a elevated load as compared to beam FB2. The deflection for beam F3 is highest.

VII. CONCLUSION

In first set of beam when the beam was strengthened in flexure its load carrying capacity increased notably different for different strengthening. It was brought into notice that increase in capacity for FB2 was 40% and for FB3 it was more than 50%.The difference in capacity of strengthened beam of first set was nearly 5 to 15%.Also theoretically it was obtained that the moment of resistance of a section increases after the use of GFRP laminated for strengthening purposes.

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