Flexural Strengthening of RC Beams Using Jute FRP

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Abstract- *The present experimental works focus the external strengthening of reinforced concrete (RC) beams using jute fibre reinforced polymer. An experimental study is mainly carried out to study the change in structural behaviour of R.C.C. beams using externally wrapped jute FRP, to enhance the shear and flexural capacity of the beams. The effect of pattern and orientation of the strengthening fabric on the shear capacity of the strengthened beams will be examined. An RC beam with minimum shear reinforcement is designed and then external confinement using jute FRP is carried out using epoxy resin. Both single and double layer confinement is executed to study and analyse the behaviour of confined beams with respect to control beam. Experimental results showing the advantage of beam strengthened using the various lay-ups of jute FRP are to be discussed.*

Keywords- Jute FRP, Confinement, Epoxy resin, External strengthening.

I. INTRODUCTION

The maintenance, rehabilitation and upgrading of structural members, is perhaps one of the most crucial problems in civil engineering applications. Moreover, a large number of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe according to the new design codes. Since replacement of such deficient elements of structures in occurs a huge amount of public, money and time. Strengthening has become the acceptable way of improving their load carrying capacity and extending their service lives. One of the challenges in strengthening of concrete structures is selection of strengthening method that will increase the strength and serviceability of the structure while addressing limitations such as constructability, building operation and budget. Structural strengthening of members subjected to shear and flexure failure is mainly required.

II. OBJECTIVES

- To study the contribution of externally bonded JFRP in confinement of RC beams.
- To determine the compressive strength and split tensile strength of conventional and jute fibre reinforced polymer.
- To strengthen the reinforced concrete beams using externally bonded jute fibre reinforced polymer.

III. SCOPE

- To study the shear and flexural behaviour of RC Beams under static loading condition.
- To study the behaviour of shear deficient RC beams with wrapping portion.
- To study the bonding characteristics between concrete and FRP.

IV. LITERATURE REVIEW

AtaurRahman et al. (2018) presents the results of experimental investigation on concrete cylinders confined with two different types of fiber reinforced polymer (FRP) sheets, they are synthetic high strength CFRP composites and composites using natural fiber like Jute. An experimental study was conducted, where twenty six small scale cylindrical concrete specimens (100 × 200 mm) were subjected to uniaxial compression up to failure and the corresponding stress-strain behaviours were observed. The ultimate failure load and the deformation at peak load were the two important observations. The results demonstrate that a significant increase in the compressive strength can be achieved by confining the concrete with CFRP but both strength and ductility are compromised when concrete is wrapped with jute FRP. However, jute FRP shows reasonably good ductile behavior for the case of low strength concrete and can safely be used for brick masonry column. For low cost strengthening work, jute FRP can be an alternative option for low strength concrete and masonry works.

Pannirselvam et al. (2008) presented a study to evaluate the structural behaviour of reinforced beams with externally bonded FRP reinforcements. Total fifteen beams specimen having three different steel ratios, wrap thickness and wrap material were tested. The variables in study were longitudinal steel ratio, type of GFRP laminates, thickness of GFRP laminates and composite ratios. A two point loading system was adopted for testing and authors found 28.57% to 40% increment of ultimate load for 3 mm thick GFRP sheet and 28.57% to 128.57% increment of ultimate load for 5 mm thick GFRP sheet.

Sudheer Reddy et al. (2010) investigated about the shear resistance of high strength concrete beams without shear reinforcement. This paper deals with the review of available data base and shear models to predict the shear strength of reinforced concrete beams without web reinforcement. An attempt has been made to study shear strength of high strength concrete beams (70 Mpa) with different shear span to depth ratios (a/d = 1, 2, 3 & 4) without web reinforcement and compare the test results with the available shear models. Five shear models for comparison are considered namely, ACI 318, Canadian standard, CEP-FIP model, Zsutty equation and Bazant equation. The results revealed that the most excellent fit for the test data is provided by Zsutty's Equation and a simplified equation is proposed to predict the shear capacity high strength concrete beams without shear reinforcement.

Shamim (2002) studied on retrofitting with fiber reinforced polymers (FRP) to strengthen and repair damaged structures, which was a relatively new technique. In an extensive research programme at the University of Toronto, application of FRP in concrete structures was being investigated for its effectiveness in enhancing structural performance both in terms of strength and ductility. The structural components tested so far include slabs, beams, columns and bridge culverts. Research on columns had particularly focused on improving their seismic resistance by confining them with FRP. All the specimens tested were considered as full-scale to two-third scale models of the structural components generally used in practice. Results indicated that retrofitting with FRP offers an attractive alternative to the traditional techniques.

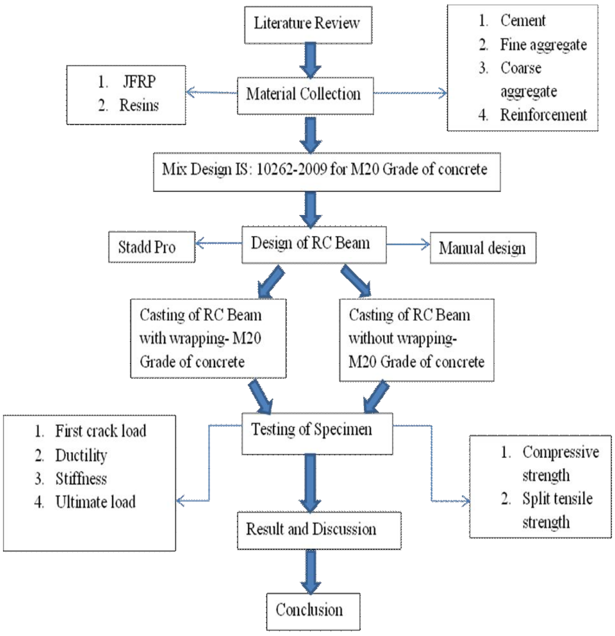
Hadi (2003) examined the strength and load carrying capacity enhancement of reinforced concrete (RC) beams, those had been tested and failed in shear. A total of sixteen sheared beam specimens with a length of 1.2m and cross-sectional area of 100 x 150 mm were retrofitted by using various types of fiber reinforced polymer (FRP) and then retested. The retrofitted beam specimens wrapped with different amounts and types of FRP were subjected to four-point static loading. Load, deflection and strain data were collected during testing the beam specimens to failure. Results of the experimental program indicate that there were several parameters that affect the strength of the beams. The results also show that the use of FRP composites for shear strengthening provides significant static capacity increase.

Panda et al. (2011) have investigated the performance of 2500mm long reinforced concrete (RC)T-beams strengthened in shear using epoxy bonded glass fiber fabric. The experimental program consisted of testing of 18 full scale simply supported RC T-beams. The experimental result indicates that RC T-beams strengthened in shear with side-bonded GFRP sheet increases the effectiveness by 12.5% to 50%.

Grace et al. (1999) have studied the behaviour of reinforced concrete beams strengthened with various types of fiber reinforced polymer (FRP) laminates. The ratio of absorbed energy at failure to total energy, or energy ratio, was used as a measure of beam ductility. It is concluded that the presence of vertical FRP sheets along the entire span length eliminates the potential for rupture of the longitudinal sheets. The combination of vertical and horizontal sheets, together with a proper epoxy, can lead to a doubling of the ultimate load carrying capacity of the beam. However, all the strengthened beams experienced brittle failure, mandating a higher factor of safety in design.

Dora Foti and Francesco Paparella (2014) researched on PET reinforced concrete has been extended to basic components, for example, plates. They have been reinforced with long discrete strands – arranged as a grid – in substitution of the steel support and they have been tested to impact loads.From the consequences of the tests, it can be accepted that the presence of the support has effectively given to the concrete slabs an extremely malleable conduct, which enabled them to stay away from the total disappointment, in this manner affirming the change of the effect quality and proposing different conceivable uses for the PET strengthened cement, as, in the generation of modern floors, new jersey barriers and wharfs in concrete.

V. METHODOLOGY



VI. MATERIALS

Cement

Ordinary Portland Cement 53 grade IS 12269: 1987 with the following properties was used are shown in Table 6.1

Table 6.1 Physical properties of cement

S.No	Components	Specific weight
1	Specific gravity	3.15
2	Fineness (m^2/kg)	225
3	Initial setting Time (min)	45
4	Final setting time (min)	240

Fine aggregate

Natural river sand was used as fine aggregate. The fine aggregate was passing through a 4.75 mm sieve and specific gravity and water absorption value (IS: 2386 (Part-III) 1963) of sand used was 2.67 and 1.23% of weight respectively.

Coarse aggregate

Coarse aggregates used in this project are the crushed aggregates. The commercial stones are quarried, crushed and graded. These are mainly the crushed angular granite metal stones. The maximum size of coarse aggregate used for this investigation is 20 mm and the specific gravity is 2.74 and water absorption 0.97%.

Water

Portable water free from salts was used for casting and curing of concrete for this project.

Jute fibre

The mechanical properties of Jute, mentioned in the following table 6.2 were evaluated from the ASTM standard testing procedures. For each case, three samples were tested and the average results of these three are tabulated. The following table 6.2 shows the mechanical properties of the jute FRP.

Table 6.2 Mechanical Properties of Jute FRP

Properties	JUTEFRP
Tensile strength (MPa)	250
Elastic modulus (GPa)	1.6
Elongation at fracture (%)	22.7
Thickness (mm)	3.42
Stiffness (kN/m)	2

Epoxy Resin

Based on previous research and on the recommendation of one of the resin known as epoxy resin was chosen for its high peel strength, excellent shear strength properties, and its ability to bond dissimilar substrates. The following table 6.3shows the properties of the adhesive.

Table 6.3 Properties of Epoxy Resin

Properties	RESIN(D-90 R)
Tensile strength (MPa)	45
Elastic modulus (GPa)	1.56
Elongation at fracture (%)	28

VII. EXPERIMENTAL STUDY

Test Setup

The figure 7.1 shows that a) Test setup for flexural strength of prism b) Test setup for axial compressive strength of cylinder

Figure 6.1 Test setup for a) Prism b) Cylinder

VIII. EXPERIMENTAL RESULTS

8.1 Flexural Strength

The flexural strength of concrete is mainly determined by testing prisms of standard size in centimeter (15x15x70). Ordinary mix proportions for M20 gradeisadopted for theprism and then it is casted and cured for 7 days and 28 days. Both single and double layer of confinement is wrappedexternally to the prism then it is tested in flexural testingmachine ofcapacity 10 ton and the average test results are compared with the conventionalconcrete prism.

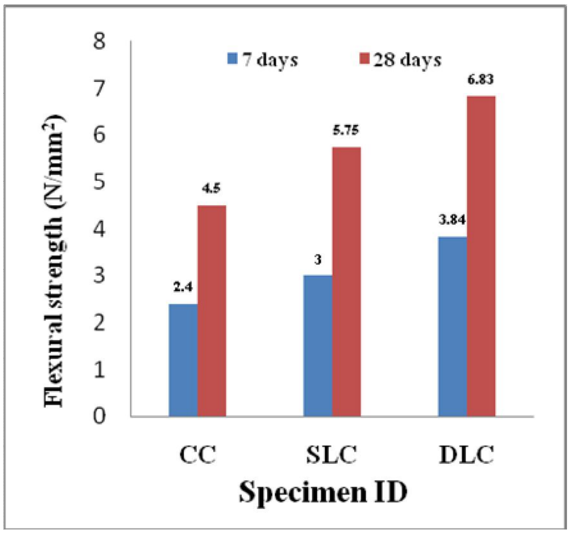


Figure 8.1 Flexural strength (N/mm^2) of confined and unconfined element

8.2 Compressive strength

The size of cube 150mm x 150mm x 150mm different concrete mixing has been casted to test compressive strength. The cube specimen after de-forming were put away in curing tank and on expulsion of cube from water tank and then tested the specimens of compressive strength for 7 days and 28 days and the results are shown in figure 8.2

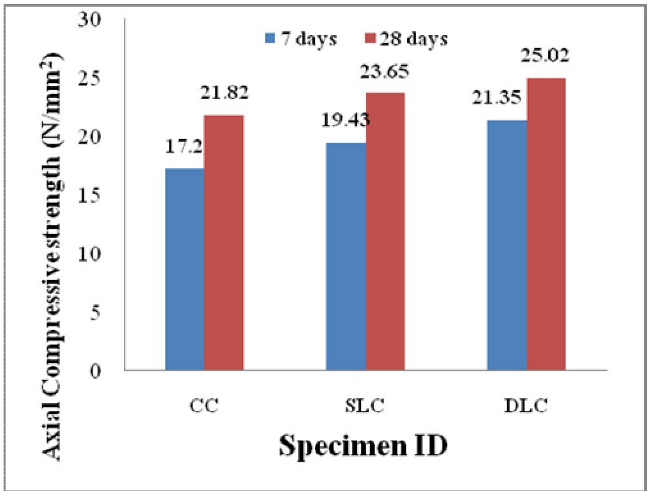


Figure 8.2Compressive strength (N/mm^2) of confined and unconfined element

IX. CONCLUSION

- From the review of literature and experimental investigation on strengthening of reinforced concrete beams by jute FRP the following conclusions were drawn.
- The application of jute fiber reinforced polymer composite layer has given adequate confinement for the reinforced concrete beams.
- The addition of external confinement of jute fiber reinforced polymer composites in reinforced concrete beams increases the load carrying capacity and reduces deflection.
- Moreover the bonding of jute fiber reinforced polymer composite bonding technique has less labour involvement and it is economical compared to other methods of external strengthening of reinforced concrete beams.

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