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Experimental Study on Behaviour of Rc T-Beam Strengthened with Jute Fiber Laminates - A Review

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ABSTRACT

The present investigation addresses the external strengthening of reinforced concrete (RC) T-beams using jute fiber laminates. An experimental study is mainly carried out to study the change in structural behaviour of RC T-beams using externally wrapped jute fiber laminates, 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. RC T-beams with minimum shear reinforcement is designed and then external confinement using jute fiber laminates is carried out using epoxy resin. The layer confinement is executed to study and analyze 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 fiber are to be discussed. For all developed composites, experimental results revealed that the tensile properties of the developed composites are strongly dependent on the tensile strength of jute fiber and that the tensile properties of jute fiber are very much defect sensitive. Jute as a natural fiber is eco-friendly, low cost, versatile in textile fields and has moderate mechanical properties, which replaced several synthetic fibers in development of many composite materials. However, the hydrophilic nature of the jute fiber affects the mechanical properties of the developed composites. As a result to arrest crack and improve the strength of beam.

Keywords: Jute fiber laminates, epoxy resin.

INTRODUCTION

Jute as a natural fiber is eco-friendly, low cost, versatile in textile fields and has moderate mechanical properties, which replaced several synthetic fibers in development of many composite materials. However, the hydrophilic nature of the jute fiber affects the mechanical properties of the developed composites. Another important issue to note that the tensile strength of jute fiber is extremely defect and span sensitive. As a result, the stiffness values are usually corrected as per various failure strains following the proposed mathematical relationships. Usually, it is difficult to make unidirectional (UD) jute perform manually under dry condition. Hackling under dry or wet condition introduces more defects on the fibrous perform. However, fiber matrix interface is better understood by UD composite. As a result, UD jute perform or roving preparation has become a valuable step and that, nowadays, it is gaining a great importance. Multidirectional isotropic behavior can be achieved by staking the UD ply in different angles, which yields Composite with anisotropic physical and mechanical properties.

The composites can be prepared with desired properties by orienting the fibers according to the application. The composites are comparatively cheaper to manufacture and there are various manufacturing processes available for the composites. The surface finish of the composite is comparatively much higher and it can be manufactured in different techniques. The use of composites has given more flexibility to design engineers to develop new design and for modifications in the existing design. Since the composites are easier to handle and synthesize.

The microstructures of the fiber reinforced composites were observed in scanning electron microscope composites. The prepared composites were subjected to mechanical characterization such as hardness, flexural strength, impact, tensile test and the mechanical properties were evaluated and analyzed.

MATERIALS USED

CEMENT

In this study Ordinary Portland Cement (OPC) was used. Many tests were conducted to cement like specific gravity, consistency and initial setting time. The cement is tested for various properties like specific gravity, Initial setting time, Standard Consistency in accordance with IS 383:1970

FINE AGGREGATE

The locally available river sand was used as fine aggregate in the present investigation. The sand is tested for various properties like specific gravity, fineness modulus and water absorption in accordance with IS 383:1970.

COARSE AGGREGATE

Coarse aggregate is the crushed stone, which is used for making concrete. The particles are greater than 4.75mm, but generally range between 9.5 mm to 37.5 mm in diameter. The aggregate is tested for various properties like specific gravity, fineness modulus and water absorption in accordance with IS 383:1970.

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.

REVIEW OF LITERATURE

Tara Sen and Jagannatha Reddy (2011) discussed about the application of sisal, bamboo, coir and jute natural composites in structural up gradation. They suggest that the use of natural fibres, sisal fibre reinforced composite, bamboo fibre reinforced composite, coir reinforced composite and jute fibre reinforced composite are of particular interest as these composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres. Economic and other related factors in many developing countries where natural fibres are abundant, demand that scientists and engineers apply appropriate technology to utilize these natural fibres as effectively and economically as possible for structural up gradation and also other purposes for housing and other needs and also for various other applications etc.

Anumol Raju and Liji Anna Mathew (2013)described about the retrofitting of RC beams using FRP. This paper presents an experimental study on reinforced concrete beams retrofitted with various types of fibres externally. Full wrapping technique is adopted on all four sides of the beam. The objective of the study is to investigate the behaviour of beams after retrofitting using various natural and synthetic fibres including steel fibres, polypropylene fibres, glass fibres, coir fibres, carbon fibres etc.

Ismail Qeshta et al. (2016) carried out the research progress on the flexural behaviour of externally bonded RC beams. The flexural behaviour of strengthened reinforced concrete(RC) beams is more complicated compared to the normal beams due to the different bond conditions and properties of the externally bonded material. Beams bonded with unconventional materials, such as sprayed FRP, TRM, FRC and aluminum-glass, showed a considerable increase in the load carrying capacity and stiffness according to the limited number of studies reported. The overall enhancement in ultimate load, yield load and service load stiffness was above 35%.The cement based composites have attracted significant attention in the past few years. The use of a cementitious matrix instead of a polymeric adhesive makes it a more economic replacement to the currently commonly used FRPs. This paper discussed the available literature concerning the materials used for the strengthening of RC beams using the external bonding (EB) technique.

Michael Chajes et al. (1994) studied the flexural strengthening of concrete beams using externally bonded composite materials. A series of reinforced concrete beams were tested in four point bending to determine the ability of externally bonded composite fabrics to improve the beams flexural capacity. The fabrics used were made of aramid, E-glass and graphite fibres, and were bonded to the beams using a two-part epoxy. The results of this study indicate that externally applied composite fabrics can be effectively used to rehabilitate or strengthen concrete beams.

Attari et al. (2012) examined the flexural strengthening of concrete beams using CFRP,GFRP and hybrid FRP sheets. This study is conducted to examine the efficiency of external strengthening systems for reinforced concrete beams using FRP fabric (Glass Carbon). A total of seven flexural strengthened reinforced concrete beams are instrumented and tested under repeated loading sequences using a 4-point bending device to complete a failure analysis. This paper highlights the efficiency of external strengthening for RC beams using FRP fabric. The results reveal the cost-effectiveness of twin layer glass–carbon FRP fabric.

Tara Sen and Jagannatha Reddy (2013) evaluated the efficacy of jute textile reinforced polymer composite (JFRP) as compared to CFRP and GFRP for the flexural strengthening of reinforced concrete beams was compared by carrying out bending test on reinforced concrete beams in three groups of fourteen beams. The work carries out the study of failure modes, flexural strengthening effect on ultimate load and load deflection behaviour as well as the deflection ductility study of RC beams bonded externally with JFRP, CFRP and GFRP, wrapped in U configuration in single layer, along the entire length of the beam in full wrapping and strip wrapping technique. The results depicted that JFRP, CFRP and GFRP, strengthening improved the ultimate flexural strength of the RC beams by 62.5%, 150% and 125% respectively, with full wrapping technique and by 25%, 50% and 37.5%, respectively with strip wrapping technique. JFRP strengthening displayed highest deformability index and proved that jute textile FRP material has huge potential as a structural strengthening material.

Poorna Prasad Rao and RamaMohan Rao (2016) presented about the retrofitting of reinforced concrete beams using Rubberized coir fiber, a natural laminate,inboth flexure and shear for which is subjected under two point loading. The main aim of this study is to rehabilitate the structurally deficient beam and to make it serviceable in both flexure and shear. The beams retrofitted with rubberized coir fibre sheets(RCFS) are used to make structure efficient and to restore stiffness and strength values greater than those of control beams.

Lakshmikandhan et al. (2013) checked performance of the beams under cyclic loading. Firstly, applied load on beam through hydraulic jack in sequential cyclic load increment with a suitable increment for two point bending. The stiffness degradation in each cycle had been observed for an equivalent damage assessment. Then beam was repaired by CFRP at bottom and again loaded until the failure. In the end they found that the repaired beam restored the original strength with about 30% additional load capacity. They also found that the presence of damage improves the performance of repaired RC beam with more energy dissipation and delays deboning or delamination.

Prasanna Venkatesan Ramani et al., (2015) Conducted an experimental study on the strength and durability properties of geopolymer concrete prepared using the ground granulated blast furnace slag and black rice husk ash. Test results reveal that the addition of BRHA beyond 20% is not beneficial for geopolymer concrete. The 30% of BRHA replaced specimens neither achieved significant strength nor proved durable. The strength results showed that an optimum proportion of BRHA that can be used in geopolymer concrete is 20% considering the target strength of 30 Mpa. It can also be seen from the durability studies that the geopolymer concrete performed remarkably well with regard to chloride penetration and corrosion resistance for up to 20 % BRHA replacement.

Ataur Rahman 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 behaviors 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.

CONCLUSION

1. From the literature studies, It is found that the use of jute FRP material bonded with adhesive resin by confinement to RC structures is one of the efficient method for external strengthening.

2. The literature studies conducted on various beam specimens clearly shows that ductility, energy absorption capacity, stiffness and load carrying capacity of the specimens have been increased.
3. The flexural strength test conducted on prism shows increase in modulus of rupture for single layer confinement compared to conventional concrete prism.
4. The axial compressive strength for cylinder also shows increase in axial compression for single layer confinement compared to conventional concrete cylinder.
5. From the above two test results it is concluded that RC structures withstand high strength compare to conventional and single layer confinement.
6. The RCC beams have been casted and it is in curing process. The confinement for RC beam using jute FRP will be discussed in future.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.