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Experimental Study On Strengthening Of R.C Beam Using Glass Fibre Wrapping

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Abstract — *In today's today lifestyles, it's miles vital to alter, restore, rehabilitate, or reconstruct present structures due to the various factors like bond failure among the beam and column joint, corrosion, which results in deterioration, natural failures, etc. These factors affect in cracking of the structures. That is, the structures turn unserviceable. Hence the modification of those structures could be very much required. Consequently, structural enhancing or strengthening and retrofitting constructed structures have become vital aspects of the production enterprise. Nowadays, FRP composites gain a good deal reputation due to their excessive energy to weight ratio, minimal fee/cost in structural geometry, smooth and rapid and corrosion, and fatigue resistance. In this experimental study, the mechanical behavior of reinforced concrete beams wrapped using glass fibers is studied. The beams were cast out of which one was a control beam, and the other beams were used for different patterns of GFRP wrapping, which is three sides, two sides, bottom side wrapping. As a result, it was found that GFRP wrapping strengthens the beams by delaying the initiation of cracks.*

Keywords *— GFRP, Retrofitting, Wrapping, Strength*

I. INTRODUCTION

Concrete is one of the common and very widely utilized human-made production materials within the whole world, commonly achieved by means of blending cement materials like sand, coarse aggregates, water, and even admixtures are also utilized in the needed quantity. This concrete is low-cost and high in compression strength, but it is weak/low in tensile strength—the reinforced concrete, the concrete with metallic bars embedded in it. Concrete is the most inexpensive material used extensively in the state's buildings, enterprise, transportation, protection, software, and residential sectors. Reinforced concrete systems ought to regularly face modifications and development of their overall performance for the duration of their service existence. In such situations, there are two feasible solutions. The first is the alternative, and another one is retrofitting.

Nowadays, international constructions are no longer secure because of the trade-in load, inferior building substances used, extended load specifications within the layout codes, or maybe due to natural calamities. Consequently, structural enhancing or strengthening and retrofitting of constructed structures have become vital aspects of the construction field. Nowadays, FRP composites gain a good deal reputation due to their excessive energy to weight ratio, minimal fee/cost in structural geometry, smooth and rapid and corrosion, and fatigue resistance. There is an urgent want to repair the homes and civil infrastructure all around the sector in the world. In this modern era, the modernization of buildings has increased from time - time, perfect to get rid of helping partitions or particular help, increasing the structures. Numerous strategies have been conducted and accompanied by the strengthening of structures. In the previous few years, numerous tries had been made international to grow the existence of deteriorated concrete systems by appropriating retrofitting techniques. It is the process of increasing the strength and enhancing the performance of the poor structures with different techniques known as retrofitting of structures. Retrofitting especially focuses on reinforcing a concrete structure to meet present-day codes' necessities for the seismic aspects designs. There are different retrofitting techniques such as concrete jacketing, steel jacketing, polymer injection, and many methods using advanced materials like FRP and many more.

A selected retrofitting approach's desire relies on kind, character, the reason for the failure that has to repair. Retrofitting of structures using the Ferro cement increases its recognition in India and different developing countries due to its high strength to weight ratio and simplicity of construction. Ferro cement is a pretty flexible shape of strengthened concrete with tightly spaced layers of small diameter mesh, made of a hydraulic cement motor. The mesh


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that is used is mostly made up of metal or any other suitable material. GFRP, CFRP, and so on are typically used as retrofitting material these days because of their mild weight, excessive strength, and terrific corrosion resisting skills. A wide variety of studies were carried out internationally by research scholars, engineers, concrete technologists, etc. To assess the performance of beams retrofitted the usage of various substances.

Retrofitting

The method of increasing the strength of the existing structures includes damaged structures, and it is a new technique adopted to regain or increase the strength of the damaged /deteriorated existing structure to protect from further damage of the structure. It is mainly utilized in the structures which are in earthquake zones. It helps in increasing the seismic strength of the existing or damaged structures. It is an improvement over the original strength. This method plays a vital role in civil infrastructure and improving the capability and standard of the structures.

Objectives of Retrofitting

- The main objective is to increase the strength, stiffness of the concrete structures.
- It helps in increasing the ductility in the load versus deformation behavior.
- It helps in increasing the energy dissipation capability.
- Provides unity to the concrete structures.
- It helps eliminate the components that are the main source of causing damage or weakness to the structure.
- It also helps in preventing the possibility of the brittle mode of failure.
- It improves of redundancy of the lateral load resisting elements.
- Factors for the collapse of concrete structures is eliminated.
- It is cost-effective.
- Each technique or method of retrofit must achieve the intended performance or objective.
- Most importantly, to save or protect human life from the collapse of structures.

II. LITERATURE REVIEW

Researchers carried out numerous studies in the area of fiber-reinforced polymers, specifically glass fiber polymer. Fiber-reinforced polymer composites are accepted in the construction industry as one of the best promising materials in repairing concrete structures as they have the best properties such as resistance to corrosion, high strength to weight ratio, electromagnetic transparency, and also good fatigue and damping resistance. Fiber polymers have gained too much importance and value because of their good performance and versatility. Punit Tilekar [1] conducted a study that deals with retrofitting RC beams with glass fibers with epoxy as a bonding material for different wrapping conditions. The retrofitted beams show an increase in the flexural strength. It also proved that if more glass fiber layers were wrapped, then the strength and load-carrying capacity of the Beam was increased based on the number of layers of glass fibers wrapped.[2].

GFRP wrapping strengthened the beams by delaying the crack initiation and propagation and growing the ultimate load-carrying capacity. GFRP wrapping additionally brought about a greater moment of resistance and stiffness when compared with the controlled Beam. However, the GFRP wrapping turned into reduced beams' deflection, making them much less ductile. With the increase in the range of layers and duration of GFRP wrap, the preliminary cracking load, final load wearing ability, second of resistance, and the stiffness became located to be accelerated [3]. GFRP wraps had been powerful in enhancing the bond power and ductility of failure mode of the anxiety lap splices, especially while non-forestall strips have been accomplished over the splice location[4].

III. MATERIALS & METHODOLOGY

GFRP: Glass Fibres Reinforced Polymer sheet was used for wrapping in this study given in fig1. These glass fibers are relatively less expensive than other fibers such as carbon and aramid fibers. So glass fiber composites have emerged as famous in lots of constructions. Glass fibers are touchy to corrosion at excessive pressure ranges and can have issues with rest. Glass fibers are touchy to water moisture. Still, with the suitable preference of matrix, the fibers are blanketed. Production manner for glass fibers glass uses massive furnaces to melt the sand/chemical mix to liquid shape regularly and then extrude it thru bundles of very small E-glass, the most common type of glass fiber used in resin matrix composite structures became used on this investigation. Glass fiber is high in strength material with a strength between 517-1207 MPa. It has got a lower strain at failure ranging between 2-4.5%.

- **EPOXY:** Epoxies are the thermostat plastics prepared by reactions of two or more industrial chemical components. These epoxy resins are used very widely in industrial applications. They have many qualities, such as good toughness and strong adhesion, high chemical resistance, and other specialized properties and applications. The epoxy used in this study was Epoke Art resin. It consists of a primer and hardener. While applying the epoxy to the beams, the primer and hardener were mixed well in the required proportion.

Figure-1: Glass Fiber

A concrete mix of M30 grade was used in this experimental study to cast all the beams. In this experimental study, R.C Beams were cast out, of which one was considered a control beam, and the other beams were used for different percentages of GFRP wrapping. The cross-section of the beams was 150*150 mm and 1000mm in length. The specimens, beams are placed or submerged in water and cured for 28days or gunny bags can be used for curing. The longitudinal reinforcement used was of high yield strength with 12mm, and 10mm dia were used as hanger bars. The stirrups of 8mm diameter steel bars were used.

IV. GFRP WRAPPING

A. Preparation of specimen surface

Firstly surface is prepared, very important to clean the Beam free from dust, oil residues, demolding agents, grout holes, curing components, and other unwanted materials. The beam surface is made rough using proper materials like sandpaper, and it is cleaned with the help of an air blower or brush to remove all the dust and unwanted materials. In case of damage or distress, the surface is repaired with different and suitable techniques.

Epoxy Mixing

Mixing is a very important process. The primer and hardener must be stirred well for proper functioning. The stirring is done so that to disperse any settlement that might have taken place during storage. The mixing is done at least for 3mints for proper mixing.

B. Applying of Epoxy to Beams

Once the epoxy is mixed well, it is applied to the cleaned surface of the Beam. The epoxy application is done with the help of a brush, and mixed epoxy is applied on the beams carefully. Once the epoxy is applied on the beams, 15-20 mints are given to dry, and later, fiber wrapping is done.

C. Placing of GFRP

The glass fibers which are to be wrapped on the Beam must be cut into the required dimensions. The epoxy resin is applied to the cleaned surface of the Beam with the help of a brush. A period of at least 10-15mints is left for the epoxy to get dried applied on the beam surface. Then the glass fibers are placed on the Beam where epoxy is applied, once the glass fibers are placed on the Beam, it must be squeezed with the help of roller or simply tapping carefully on the beams to make sure the fiber get stuck and placed properly on the Beam as in fig 2. There may be air bubbles entrapped, so to remove this, pressure is applied on the surface to ensure good contact between the beam and glass fibers. Once the fiber is applied, another coating of epoxy is done on the glass fiber. Concrete beam strength is done after curing it for at least 24 hours. This is carried out at room temperature.

Figure-2 Glass Fiber wrapping on Beam

V. RESULTS & DISCUSSIONS

Testing of R.C Beams

Beams cast were wrapped with GFRP for 3 different cases as given in table1. The control beam and retrofitted beams were tested in the loading frame, and the experimental set up for the is given in fig 3

Table 1

Sl No	Type of Beam	Type of wrapping
1	Case-1	Control Beam
2	Case-2	U shaped wrapped Beam
3	Case-3	Two side wrapping
4	Case-4	Bottom side wrapping

Figure-3 Experimental setup

Beams were tested, and the load-deflection pattern was studied. The ultimate load values for different ways of wrapping are given in fig 4. It is observed an increase in the strength with an increase in GFRP wrapping

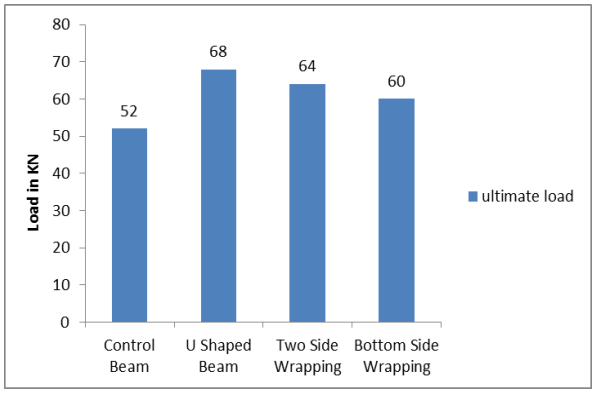

Fig:4 Ultimate Load for different GFRP Wrapping

Effect of GFRP Strengthening on Load Deflection Behaviour:

The load-deflection response on un-strengthened Beam (case-1) and the CFRP strengthened beams (case 2,3,4) are shown in fig 6. As per the obtained results, case 2show increased flexure strength by 16%, case-3 by 12%, case-4 by 8% compared with case-1. The control beam (case-1) without any glass fiber wrapping shows the least flexural strength, and it is very clear that the flexural strength of GFRP beams is more when compared with the control beam and it also shows that an increase in the percentage of glass fiber increases the flexural strength of the Beam.

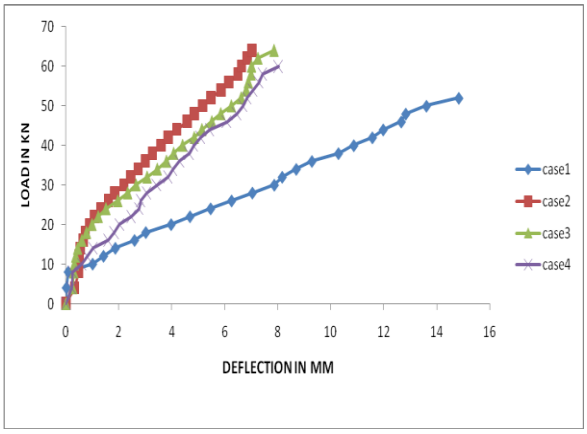

Figure 5: Load Deflection graph of different types of wrapping beams.

VI. CONCLUSIONS

- Retrofitting of structures using glass fibers is an easy technique to be adopted. It helps in reducing the deformation demand and increase the strength and ductility of the structure.
- These materials are of low density, so they can be handled easily and also cost-effective.
- In this experimental study, the mechanical behavior of reinforced concrete beams wrapped using glass fibers is studied.
- The beams were tested for flexural strength, and it was found that the Beam wrapped with three sides shows the maximum strength and is followed by two sides, and the bottom side of GFRP wrapping compared with the control beam.
- From the result, it was found that GFRP wrapping strengthens the beams by delaying the initiation or appearance of cracks.
- It is also found that GFRP wrapping increases the load-carrying capacity of the load.
- Hence it shows that GFRP wrapping is an effective method for retrofitting and repair of beams and structures.

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