

STRENGTHENING OF RCC BEAMS WITH GLASS FIBER REINFORCED POLYMER COMPOSITES

* S MALLESH, **G ANUSHA, ***KASI REKHA

*M.Tech student, Dept of CIVIL, AVN Institute of Engineering and Technology, Hyderabad, TS, India.

** Assistant Professor, Dept of CIVIL, AVN Institute of Engineering and Technology, Hyderabad, TS, India.

*** Associate Professor & HOD, Dept of CIVIL, AVN Institute of Engineering and Technology, Hyderabad, TS, India.

ABSTRACT:

The present study is based on the experimental investigation of glass fibre reinforced polymer (GFRP) strengthened reinforced concrete beams. The behaviour of control and GFRP strengthened beams under static loading is studied. The experimental method of investigation helps in evaluating the performance of RC beam with GFRP composites with various patterns. To investigate the efficiency of a shear reinforcement of RC beam using GFRP composites externally with epoxy resin adhesive and compare for the better performance. It determines the increase in shear strength, stiffness, load carrying capacity and ductility by the application of GFRP composites. The strengthening scheme should be cost-effective. The validated experimental methods are then used for studying the efficacy and effectiveness of various strengthening schemes using epoxy impregnated GFRP fabric where the number of layers, orientation and distribution of fibres are considered as parameters. In all GFRP strengthened beams, mode of failure changed from shear to flexural failure and showed great improvement in the ductile behaviour. It was observed that the beam strengthened with GFRP shows an increase in shear strength, stiffness, load carrying capacity and ductility by 38.41% and 13.47% respectively in comparison to control beam. Based on the experimental studies, the schemes which provide an optimum improvement in performance for the strengthening of the beams are identified.

Keywords: GFRP, FRP, RC beam, Control Beam.

1. INTRODUCTION

Today, Glass Fiber Reinforced Polymer (GFRP) merchandise are being

made use of global for the retrofitting and moreover repair provider of lacking and additionally antique frameworks in conjunction with bridges in addition to houses. Throughout the years the ones structures have really persevered excessive stamina and furthermore tightness due to antagonistic environmental issues together with humidity, deep sea in addition to alkali services. Advanced coarse composite products which embody GFRP can take away the hassle of corrosion further too significantly enhance the durability and tightness of the inner extra suitable with GFRP bars. When it includes Reinforced Concrete (RC) moderate beams, on the floor bolstered with GFRP plates and substances in addition to exposed to negative ecological troubles, but the bond in some of the GFRP plate and furthermore floor vicinity of the RC beam of slight extensively influences the stamina of externally strengthened RC beam of lights. Therefore it's far crucial to investigate the overall motion of the RC moderate beams on the ground bolstered with GFRP plates in addition to cloth and moreover uncovered to specific

environmental problems. The present day generation markets have prolonged immensely inside the very last couple of a few years and appear set for extremely good further growth. This has in reality been notably because of the excessive particular tightness in addition to strength of those materials. Nonetheless, first rate residential or business commercial enterprise corporation houses which incorporates exhaustion resistance, home customizing and moreover producing flexibility also are of charge particularly applications. GFRP systems in aerospace and various notable structural packages are usually based mostly on some form of cycling loading, i.e. Exhaustion. Busy, fatigue is normally approximated as a sinusoid ally differing loads or stress and tension, certified with the useful beneficial aid of the loads percentage, frequency and furthermore maximum wonderful pressure. This form of packing may be labeled common exhaustion (SF). However, real-existence packing histories commonly entail vibrating hundreds that could propagate in structural elements as cyclic effects. This phenomenon is referred to as effect tiredness (IF). IF is of

maximum essential relevance to the structural integrity of things and frameworks because of its volatile impact on average everyday universal overall performance, that could display up after a mainly handful of low amplitude cycles. The outdoors bonding of excessive-energy Fiber Reinforced Plastics (FRP) to architectural concrete human beings has simply drastically acquired enchantment in contemporary-day-day years, in particular in rehab jobs and in recent times develops framework. Comprehensive experimental investigations finished inside the past have proven that this fortifying method has several advantages over the traditional ones, particularly because of its rust resistance, immoderate stiffness-to-weight ratio, boosted resilience and versatility in its utilization over metal plates. Using Fiber Reinforced Polymer (FRP) products in civil centers for the restore and moreover strengthening of stronger concrete frameworks further to furthermore for modern day constructing has in reality ended up being common workout. One of the most dependable approaches for enhancing the flexural

durability of deteriorated RC participants is to externally bond FibreReinforced Polymer (FRP) plates or sheets. FRP composite materials have professional a chronic growth of use in structural conditioning and fixing programs anywhere in the worldwide inside the very last years. GFRP may be produced with better electricity and extra modulus of elasticity than steel, consequently improving the flexural, shear energy, similarly to deflection of architectural player. Moreover, the corrosion resistance function offers more benefit on the use of FRP in greater appropriate concrete wherein it can be used for structures subjected to lousy situation. The utilization of FRP as manual may be very new and furthermore restricted to recovery employer systems. The essential purpose is because of the truth the absence of revel in handling this cloth and fee of the usage of it. Fiber Reinforced Polymer (FRP) compounds are extensively made use of for strengthening concrete frameworks considering they've got masses of blessings over conventional reinforcing techniques. Much have a have a examine has been finished during the

last decade into the overall favored general overall performance of concrete beams stronger in shear with at the ground bound FRP compounds. Previous experimental studies have in truth examined FRP compounds art work in growing the shear capability of Reinforced Concrete (RC) beam of lighting fixtures. In spite of infinite fascinating research, the shear conduct of RC mild beams reinforced with FRP isn't well recognized. The majority of tests has clearly been completed on virtually supported moderate beams without metal braces strengthened with complete detail cover, U-wrap or complete defensive of the phase with Glass Fiber Reinforced polymer (GFRP) sheet.

Main Objective:

- To decide the effectiveness of the out of doors Glass Fiber-Reinforced Polymer (GFRP) overlaying technique in Reinforcing of Reinforced Concrete (RC) Beam Of Light.
- To have a take a look at the right load sporting functionality of the specimens in improving by using way of manner of Glass Fiber-Reinforced Polymer (GFRP) defensive approach.
- To determine the effectiveness of the Glass Fiber-Reinforced Polymer (GFRP) substances with regard to use of the stamina and additionally deformation capability of the FRP fabric.
- Analysis of the results received from the Un-supply a lift to RC beam of slight further to Enhance RC beams with one-of-a-type combos of wrapped Glass Fiber-Reinforced Polymer (GFRP).

2. RELATED STUDY

1. N. Pannirselvam. (2008), Introduced one test to examine a structural performance yeah bolstered steel as for externally bonded extra troops. Final tally

seventeen signals evidence relating three distinct hot - rolled percentages, tie width but instead tie stuff seem to have been evaluated. That whole possibilities such as analyze seem to have been longitudinal reinforcement margin, forms of fiber optics strengthen polyurethane (GFRP) composites, texture sure fiber glass perpetuate thermoplastic (GFRP) epoxy composites but also fiberglass adjustments. Positive three separate loading frames must have been accepted e. G. Measuring. Researchers noted 8.5.57% of about 40% advancement sure maximum stress such as 3 mm fiber reaffirm polyurethane (GFRP) template but instead 8.5.57% in . 57% continue to increase sure maximum strength for five mm in thickness fiber glass perpetuate polyelectrolyte (GFRP) blanket.

2. Nader A. Siddiqui, (2009) explored it and efficacy of various nutrient polypropylene (frap) systems just that deflection as well as cleave intensification after all solid concrete (arc) frames. For with this objective, give fiber reinforced (arc) steel have been spell out two, apiece group consisting 2.5 steel. It and samples were tested of that first bunch have been planned to just be sluggish along deformation and robust such as cleave, and whilst samples collected yeah second category seem to be crafted in just art. Art

direction opposite? In every bunch, out the thirty steel tubular, somebody incident light must have been chosen to take as little more than a based on things and indeed the second two frames have been enhanced utilizing two very different coal fiber reinforced (carp) reinforcing strategies. Together all emitters sure two had been assessed poorly parallel packing. That whole rebuttal anyway regulate as well as reinforced steel tubular seem to be especially in contrast as well as efficacy of various strategies had been judged. It really was noticed the said frustration team connecting sure carps polyethylene (carp) cloth as well as the hex completion.

3. Sheriff H. Al-Tersely. (2013), Analyzed a capacity of reinforced concrete cinderblock (arc) steel shored up throughout strain. Exploratory program seemed to be done to either 9 radiographers sure 3 different wants to set, as-built steel tubular (unstrengthen), frames reinforced as for longitudinal coal nylon polyethylene (carp) neoprene sleeves, or frames intensified as for likely to be able cellulose bras polypropylene (carp) encloses. The primary criteria evaluated seemed to be concrete, soot nylon thermoplastic (carp) layer but also encloses directions (900 & 450). The outcomes of both the experiments conducted noted so here unreinforced comes

from a different folds increased its strength properties sure steel tubular markedly and also that compelled soot nutrient polyethylene (carp) setup seems to be more beneficial since upward and parts.

4. Firm J et al, (2015) All these report offers experimental and analytical explorations the about structural fire behavior of reinforced (arc) emitters together these intensified as well as the carbon fiber polyurethane (carp) epoxy composites. The primary unbiased would have been to analyze it and effect of different smoke alarms as well as to reassess it and effectiveness yeah one's being used in floor slabs yeah constructions. Outcome indicates it when the reconstruction scheme has been left uncovered there in compromised size and shape of both the wire, this same dioxide jute polypropylene (carp) linoleum abutment defrosted just after 950 maximum. Even before fire departments fabrics seemed to be implemented within affected size and shape of such signals, that whole intensification process offal ever since with both 60–89 30 s (25 micrometers thickness) as well as 137-167 sacs (40 mm). Organizational outcomes that whole efficacy of both the retooling processes inside its capacity to keep its structural stability thru a wiring control system but even though the brittle fracture yeah dioxide dispersion

polypropylene (carp) block inside this steel tubular will have did occur and indeed the fireproofing of an emissions dispersion polyethylene (carp) must have been enlarged complete two - thirds sacs.

3. METHODOLOGY AND MATERIALS:

Concrete is a product made up of concrete and also water incorporated with sand, crushed rock, smashed rock, or various other inert products such as broadened slag or vermiculite. A solid stone-like mass is created from chain reaction of the concrete and also water. The concrete paste can be quickly formed right into any type of type or shoveled to create a smooth surface area. Setting beginnings instantly after blending, however safety measures are taken, typically by covering, to stay clear of fast loss of dampness given that the existence of water is needed to proceed the chain reaction as well as enhance the stamina. Excessive of water, nevertheless, creates a concrete that is extra permeable and also weak. The top quality of the paste created by the concrete as well as water mainly establishes the personality of the concrete.

Concrete:

Concrete is a product, usually in powered kind, which can be made right into a paste

generally by the enhancement of water as well as, when formed or put, will certainly establish right into a strong mass. Various natural substances utilized for a sticking, or attachment products are called concretes, however these are categorized as adhesives, as well as the term concrete alone indicates a building product. One of the most commonly use the building and construction concretes is Portland concrete. It is bluish-gray powered gotten by carefully grinding the clinker made by highly heating up an intimate mix of calcareous as well as argillaceous minerals.

Great Aggregate:

Great aggregate/sand is a build-up of grains of mineral issue originated from fragmentation of rocks. It is differentiated from crushed rock just by the dimension of the grains or bits, however stands out from clays which have natural product. Sand is utilized for making mortar as well as concrete and also for brightening as well as sandblasting. Sands including a little clay are utilized for making mold and mildews in factories. Clear sands are used for filtering system water. Right here, the great aggregate/sand is travelling through 4.75 mm screen as well as having a certain gravity of 2.64. The rating area of great accumulation is

area III according to Indian Standard specs IS: 383- 1970.

Coarse Aggregate:

Rugged accumulations are the smashed rock is made use of for making concrete. The industrial rock is quarried, squashed, and also rated. Much of the smashed rock utilized is granite, sedimentary rock, as well as catch rock. The rugged accumulations of 2 qualities are utilized one preserved on 10 mm dimension filter as well as an additional quality included accumulations maintained on 20 mm dimension screen. The optimum dimension of crude accumulation was 20 mm and also is having details gravity of 2.88 grading verifying to IS: 383-1970.

Reinforcing Steel:

High-Yield Strength Deformed (HYSD) bars validating to IS 1786:1985. The supports made use of were 20 mm and also 10 mm size is utilized for the longitudinal support and also the braces are 8 mm size. The return stamina of steel supports made use of in this speculative program is figured out by carrying out the common tensile examination on the 3 samplings of each bar. The evidence anxiety or return toughness of the samplings are balanced and also displayed in Table 3.5.

The modulus of flexibility of steel bars was 2×10 MPa.

For all the thirteen enhanced concrete T-beams, the exact same setup for shear support is made. The stress support includes 2 varieties of 20 mm ϕ as well as 1 variety of 10 mm ϕ HYSD bars. 3 bars of 8 mm ϕ steel bars are likewise supplied as hang up bars.

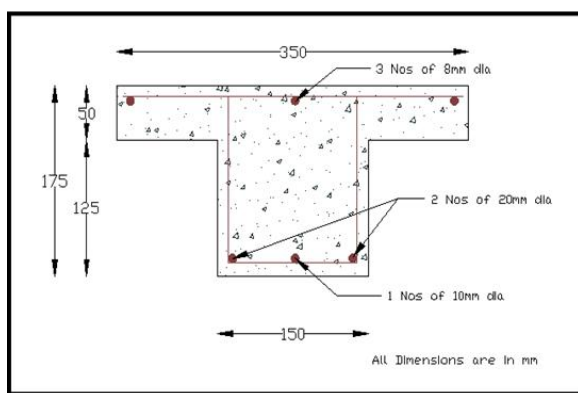


Fig.3.1. Detailing of Reinforcement

4. EXPERIMENTAL ANALYSIS:

Constant fiber strengthened products with polymeric matrix (FRP) can be taken into consideration as composite, heterogeneous, as well as anisotropic products with a common straight flexible practices as much as failing. Generally, Glass and also Carbon fibers are utilized as strengthening product for FRP. Epoxy is made use of as the binding product in between fiber layers. For this research study, one sort of FRP sheet was utilized throughout the examinations i.e., a

bidirectional FRP with the fiber oriented in both longitudinal as well as transverse instructions, as a result of the versatile nature and also simplicity of dealing with as well as application, the FRP sheets are utilized for shear conditioning. Throughout this research, E-glass was utilized produced by Owens Corning.



Fig.4.1. Experimental setup.

All the loosened fragments of concrete surface area near the bottom sides of the beam of light were carved out by utilizing a sculpt. After that the needed area of concrete surface area was made harsh making use of a rugged sand paper appearance as well as cleansed with an air blower to get rid of all dust as well as debris bits. When the surface area was prepared to the necessary requirement, the epoxy material was blended in conformity with supplier's directions. The blending is accomplished in a plastic container (100 components by weight of

Araldite LY 556 to 10 components by weight of Hardener HY 951) as well as was proceeded till the blend remained in attire. After their consistent blending, the materials are reduced according to the dimension after that the epoxy material is put on the concrete surface area. After their consistent blending, the materials are reduced according to the dimension after that the epoxy material is related to the concrete surface area. After that the GFRP sheet is positioned on top of epoxy material layer as well as the material is pressed via the roving of the material with the roller. Air bubbles allured at the epoxy/concrete or epoxy/fabric user interface are gotten rid of. After that the 2nd layer of the epoxy material was used as well as GFRP sheet was after that put on top of epoxy material layer and also the material was pressed via the roving of the material with the roller and also the above procedure was duplicated. The composite laminate was connected beginning at one end as well as using adequate stress to extract any type of excess epoxy from the sides of the laminate. Throughout solidifying of the epoxy, a consistent stress is used on the composite material surface area in order to squeeze out the excess epoxy material and also to guarantee great call in between the epoxy, the concrete as well as the textile. This procedure

is accomplished at space temperature level. Concrete light beams reinforced with glass fiber material are healed for minimum of one week at area temperature level prior to screening.



Fig.4.2. Application of epoxy and hardener on the beam



Fig.4.3. Fixing of GFRP sheets on the beam.

The loading frame must be capable of carrying the expected test loads without significant distortion. Ease of access to the middle third for crack observations,

deflection readings and possibly strain measurements is an important consideration, as is safety when failure occurs. The specimen is placed over the two steel rollers bearing leaving 150mm from the ends of the beam. The remaining 1000mm is divided into three equal parts of 333mm as shown in the figure 3-10. Load is applied by hydraulic jack of capacity 500kN. Lines are marked on the beam to be tested at $L/3$, $L/2$, & $2L/3$ locations from the left support ($L=1300\text{mm}$), three dial gauges are used for recording the deflection of the beams. One dial gauge is placed just below the centre of the beam, i.e. at $L/2$ distance and the remaining two dial gauges are placed just below the point loads, i.e. at $L/3$ and $2L/3$ to measure the deflections.

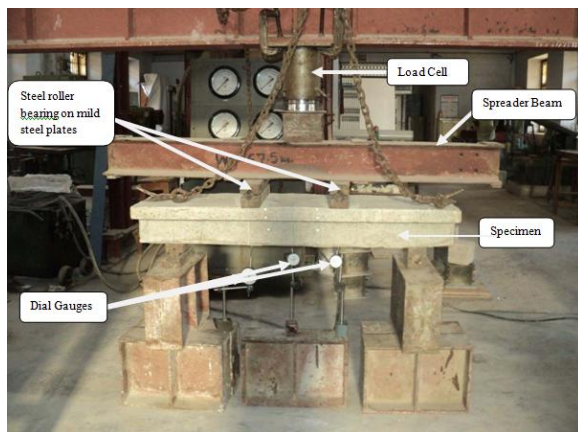


Fig.4.4. Experimental Setup for testing of beams

5. CONCLUSION:

In this speculative examination the shear behavior of RC T-beams reinforced by GFRP sheets are researched. The examination results highlighted in the here and now research study revealed that the exterior conditioning with GFRP compounds can be made use of to enhance the shear ability of RC T- beam of lights, yet the effectiveness differs relying on the examination variables such as fiber positionings, covering systems, variety of layers as well as anchorage system. Based upon the speculative as well as academic outcomes, the adhering to verdicts are attracted:

On the surface bound GFRP support can be utilized to improve the shear capability of RC T-beams. The examination results validate that the reinforcing method of FRP system can raise the shear ability of RC T-beams. The preliminary splits in the strengthened beam of lights are created at a greater lots contrasted to the ones in the control beam of light. Reinforcing of on the internet with GFRP is most susceptible to deboning with early failing. The beam of light reinforced with a U-wrap setup is extra efficient than the side-wrap arrangement. Amongst all the GFRP strip setups (i.e. upright strips, strips inclined at 45° as well as strips inclined at $+45^\circ$ in one instructions as well as $+135^\circ$ in

one more instructions making an "X- form"), the X-shape is extra reliable than the others.

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