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EXPERIMENTAL STUDY ON REHABILITATION OF RCC BEAM USING FRP

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Abstract: This study presents the flexural behavior of rectangular concrete beams strengthened with surface treated glass fiber reinforced polymer (GFRP), Grooved bars and Sand, reinforcing bars. Beams cast with standard mixture of M30 grade concrete, with a reinforcement ratios of 0.73%, and compared therewith of typical steel strengthened beams. entirely 9 rectangular beams of size a 500mmx100mm x100mm were solid. The flexural study was carried underneath static single point loading. The experimental prediction was centered on observation of final load capability, cracks propagation and crack widths and failure modes of beams. The results indicate that each variety of GFRP reinforcements are at par with the standard steel reinforcements.
Keywords – Glass Fiber Reinforced Polymer, Reinforcement, Cracks, Concrete Beam.

1. INTRODUCTION

The maintenance, rehabilitation of structural members, is one in every of the foremost necessary issues in engineering science. An outsized range of structures created within the past victimization the older style codes area unit structurally unsafe in step with the new style codes. Since replacement of such deficient components of structures incurs a large quantity of public cash and time, strengthening has become the suitable manner of rising their load carrying capability. A serious issue relating to the use of FRP in civil applications is the lack of design codes and specifications. For nearly a decade now, researchers from all country have been collaborating their efforts in hope of developing such documents to provide guidance for engineers designing FRP structures. These are being measured as a replacement to the traditional steel in concrete structures because of continued thrust within the worth of FRP materials. Numerous aspects of FRP materials reciprocally with tenet for assortment of chemical compound adhesives for concrete are planned. This section provides getting down to the strengthening of concrete (RC), pre-stressed concrete and steel members victimization outwardly secure plate or fibre strengthened chemical compound (FRP) composites sheets and plates by reviewing the foremost vital investigations reported within the literature.

2. LITERATURE REVIEW

a. Ashutosh Sharma et al. (2015) Reinforced concrete (RC) structures affected by corrosion of steel bars are often repaired and rehabilitated by wrapping fibre reinforced polymer (FRP) sheets. Most commonly available FRP materials are glass and carbon fibre composites. This paper uses ultrasonic guided waves as a non-destructive tool to monitor the initiation and progression of corrosion in reinforcing bars in concrete after repairing with bonded FRP sheets.
b. A. Ghobarah et al. (2001) An innovative and practical technique for the seismic rehabilitation of beam-column joints using fiber reinforced polymers (FRP) is presented. The procedure is to upgrade the shear capacity of the joint and thus allow the ductile flexural hinge to form in the beam. An experimental study is conducted in order to evaluate the performance of a full-scale reinforced concrete external beam-column joint from a moment resisting frame designed to earlier code then repaired using the proposed technique. The beam-column joint is tested under cyclic loading applied at the free end of the beam and axial column load. The suggested repair procedure was applied to the tested specimen. The composite laminate system proved to be effective in upgrading the shear capacity of the non-ductile beam-column joint.
c. Aditya Singh Rajputa et al. (2018) An experimental study was conducted to examine the effects of corrosion for seismic performance of reinforced concrete (RC) columns confirming to current seismic guidelines. Six real size specimens were cast and tested under this study. Three columns were corroded up to 10% and 15% of degrees of corrosion, while the remaining three columns were left un-corroded. Column specimens were corroded by using a pre-calibrated accelerated corrosion protocol. After completion of corrosion exposure, specimens were tested under quasi-static lateral cyclic loading. An appropriate axial load was applied to the column before the commencement of simulated seismic testing. Key indicators of seismic performance were recorded and computed to characterize seismic response of all the RC columns.

d. Abdallah Mohamed Maher et al. (2021) Rehabilitation and strengthening of previous structures victimization advanced materials could be a modern analysis within the field of Structural Engineering. Throughout past twenty years, abundant analysis has been distributed on shear and flexural strengthening of concrete beams victimization differing kinds of fibre bolstered polymers and adhesives. Strengthening of previous structures is important to get associate degree expected life time.

e. Ayesha Siddika et al. (2019) Fiber-reinforced compound (FRP) composites square measure extensively employed in advanced concrete technology given their superiority over ancient steel reinforcements. These materials possess high strength capability and corrosion resistance and may be used because the main reinforcements together with adhesives and anchorages to strengthen concrete (RC) beam members. RC beams square measure designed to supply resistance against flexure, shear, torsion, fatigue, impact, and blast loading. The strength and malleability of RC beams may be improved via FRP strengthening techniques with a mix of fibers.

2.1 MATERIALS USED FOR CASTING OF SPECIMEN:

A. Cement

Ordinary Portland cement (OPC) of fifty three grade confirming to IS: 12269-1987 was used for the casting of specimens.

B. Fine Aggregate

Manufactured sand was used for the study. It is crushed aggregates created from exhausting granite stone that is cubically formed with grounded edges, washed and stratified with consistency to be used as a substitute of river sand.

C. Coarse Aggregate

Coarse aggregate combination is used 2 varieties, 20mm and 12mm. We used mixed aggregate.

D. Reinforcing Steel

TMT steel bars of 415 grade of 8 mm diameter were used as reinforcement for the beam specimen.

E. Concrete

The concrete combine as per common design procedure. The mix used was M30.The mix proportion was 1:0.75:1.5 and a w/c ratio of 0.45 were adopted.

F. FRP (Fiber Reinforced Polymer)

FRP used was a material created by combining optical fibre sheet and epoxy glue to convey a replacement combination of properties. Fiber sheet utilized in this experimental study was E-Glass, Bi directional woven mat.

G. Epoxy

The epoxy resins are typically 2 half systems, an organic compound and a hardener. The ratio of mixing of resin part A and hardener part B was by weight and Hardener by weight. The ratio of mix proportion of epoxy and hardener is for example (1:1), (2:1).

Property	GFRP	CFRP	AFRP	STEEL
Density (gm/cm3)	1.50–2.10	1.25–2.50	1.25–1.45	7.85
Tensile Strength (MPa)	600–3920	483–4580	1720–3620	483-690
Young’s Modulus (GPa)	37–784	35–86	41–175	200
Elongation (%)	0.5–1.8	1.2–5.0	1.4–4.4	6.0-12.0
Coefficient of Linear Expansion (10–6/C)	–9.0–0.0	6.0–10.0	–6.0–2.0	11.7

Table No : 1 : Comparison between properties of FRP and steel

3. MATERIAL INFORMATION :

3.1. Glass Fiber Reinforced Polymer (GFRP) :

1. Fiberglass is especially created by combination of silica sand, limestone, folic acid and alternative minor ingredients.
2. The mixture is heated to soften at concerning 1260°C and therefore the liquid glass is then allowed to flow through the small perforations in a very platinum plate forming filaments.
3. The glass filaments are cooled and assembled. The fibers area unit force to extend their directional strength.
4. Glass-produced fibers square measure the predominant reinforcing of strengthened compound composites to their non-conductor properties, low susceptibleness to wet and high mechanical properties. Glass is usually thought of to be a extremely impact-resistant fiber.
5. Good however weighs over carbon or aramid. covering material has characteristics further as high sturdiness, uniform and well-distributed, smart vertical performance, fast fertilization, smart adhesion to the mold, straight forward removal of bulges and high strength, less loss of resistance in wet places and used in the manufacture of cars, equipment and cooling towers.

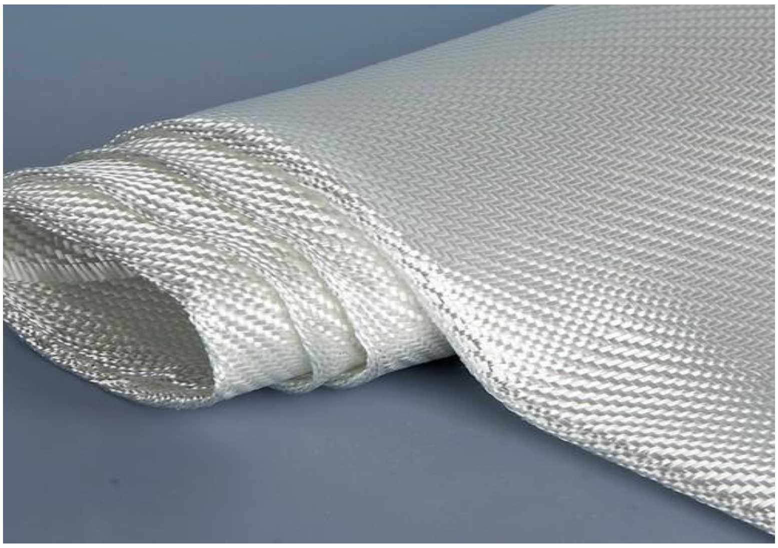


Fig. no. 1: GFRP Sheet

3.2 PROPERTIES OF EPOXY

Property	Epoxy
Density (gm/cm3)	1.2–1.4
Tensile Strength (MPa)	55–130
Young's Modulus (GPa)	2.75–4.10
Poisson's ratio	0.38–0.40
Saturation %	0.08–0.15
Coefficient of Thermal Expansion (10–6/C)	45–65

Table no : 2 : Properties of epoxy

3.3 Advantages of FRP

1. **Low weight:** The FRP is far less dense and so lighter than the equivalent volume of steel.
2. **Mechanical strength:** FRP will offer a most material stiffness to density magnitude relation of 3.5 to 5 times that of steel. FRP is thus stiff for its weight, it'll out-perform the other materials.
3. **Formability:** the fabric will take up irregularities within the form of the concrete surface. It are usually wrought to almost any desired type.
4. **Joints:** Laps and joints don't seem to be needed.
5. **Low maintenance:** Once FRP is put in, it needs minimal maintenance.

3.4 Disadvantages of FRP

1. A specific concern for bridges over roads is that the risk of side reinforcement being hit by over- height vehicles.
2. A perceived disadvantage of mistreatment FRP for strengthening is that the comparatively high price of the materials.
3. However, comparisons ought to be created on the idea of the whole strengthening exercise; in sure cases the prices will be but that of plate bonding.
4. A disadvantage within the eyes of the many shoppers are the shortage of expertise of the techniques and fitly qualified employees to hold out the work.
5. Finally, a big disadvantage is that the lack of accepted style standards.

3.5 Application of FRP in construction :

There area unit 3 broad divisions into that applications of FRP in technology are often classified:

1. Applications for new construction
2. Repair and rehabilitation applications
3. Architectural applications.

4. METHODOLOGY:

1. **Market survey**

   ↓

2. **Quantity calculation**

   ↓

3. **Materials and casting process**

   ↓

4. **Experimental set up**

   ↓

5. **Casting of beam**

   ↓

6. **GFRP applying process**

   ↓

7. **Strengthening of beam**

4.4.1 Design Mix Proportions :

Description	Cement	Sand	Aggregate	Water
Mix Proportion (by Weight) M 30	1	0.75	1.5	0.45
Quantities of Materials For 9 No. of beam Casting	30 Kg	25 Kg	80 Kg	30 Lit.

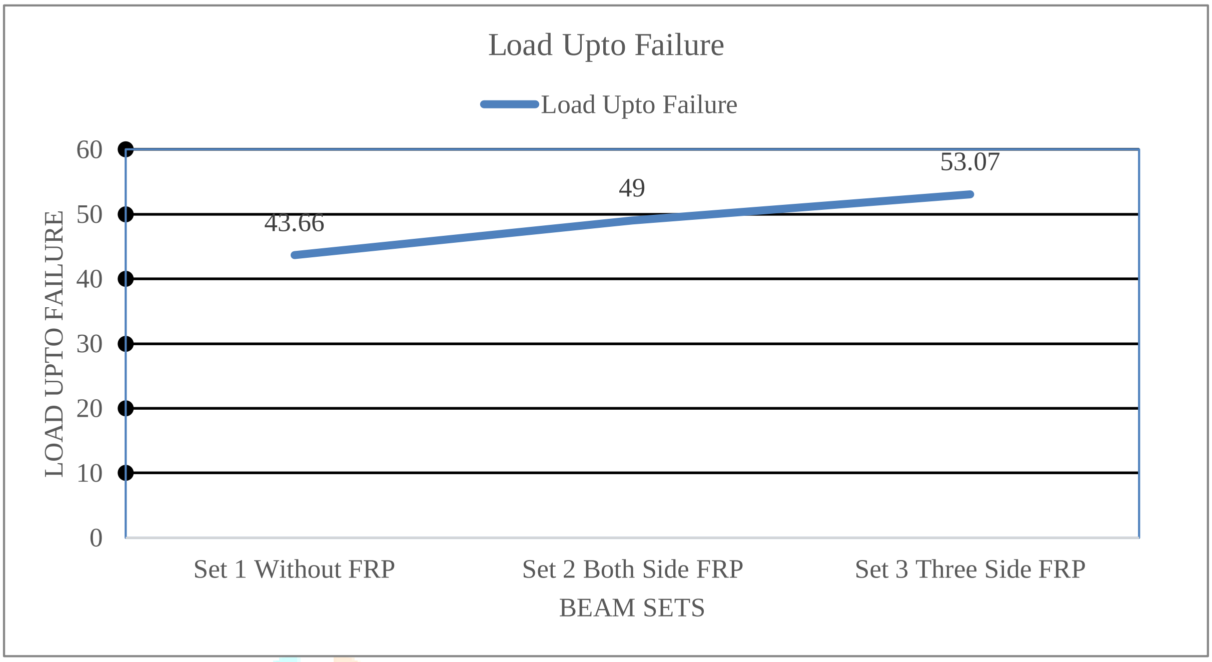
Table no: 3 : Design Mix Proportion of M30

5. RESULTS AND DISCUSSION

Fibres can increase the Flexural strength of concrete in a passive way eg : confining effect upto a certain range of fibre content.

Sr No	Beam Set I (Without FRP Normal Beam) (KN)	Beam Set II (With FRP Both Side Wrapping) (KN)	Beam Set III (With FRP Three Side Wrapping) (KN)
1	39.55	48.39	50.86
2	46.02	48.48	53.19
3	45.42	50.13	55.17
Average of each set of beams (KN)			
4	43.66	49	53.07

Table No : 4 : Beam Testing Results



GRAPH SHOWING AVERAGE OF BEAM TESTING RESULTS ALL SETS OF GLASS FIBERS.

5.1 Crack Pattern :

Since all the strengthened and unstrengthen beams, hence large number of flexural cracks developed in the tension zone and these cracks propagates during the increase in loading. The beam curvature and deflection will increase and also the collapse by yielding of steel and crushing of concrete in compression zone. Within the case of strong beams, cracks weren't visible to the GFRP wrapping. Cracking sound could be heard during loading. During loading of specimen, then firstly the rupture of FRP was observed at the centre followed by FRP deboning. Deboning occurred at the two and three sides as well as on bottom side of the beam. Ultimate load capacity was reached and failure occurs.

Fig. No : 2 : Crack pattern Set 1

Fig. No : 3 : Crack pattern Set 2

Fig. No : 4 : Crack pattern Set 3

6 CONCLUSION

- The double sheet of glass fiber wrapped beams can carry 48% extra load than the normal beams.
- The three sheet of glass fiber wrapped beams can carry 55% extra load than the normal beams.
- The deflection of double sheet of glass fiber wrapped beams at a certain load is lesser than that of normal beams.
- The deflection of three sheet of glass fiber wrapped beams at a certain load is lesser than that of double sheet of glass fiber wrapped beams.
- FRP debonding, failure by FRP rupture are the important mode of failures of FRP.
- There remains substantial reserve capacity of beam even after the yielding of steel.

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