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STRUCTURAL RETROFITTING OF REINFORCED CONCRETE BEAM BY USING CARBON FIBRE REINFORCED POLYMER (CFRP) SHEET

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Abstract: Rehabilitation and strengthening of old systems using advanced materials is a contemporary study within the field of Structural Engineering. It is important to modify, repair, rehabilate or rebuild an existing structure to achieve the expected life span. Life span of Reinforced Concrete (RC) structure can be reduced for no. of reasons, such as corrosion of concrete & development of surface cracks due to chemical agents, improper design and sudden unexpected external loads that also lead to the failure of the structure.The advanced properties of polymer composite materials such as extreme corrosion resistance, high strength, excessive hardness, extremely good performance and good resistance to chemical attack etc., have encouraged researchers and practicing engineers to apply the polymer composites to the rehabilitation of structures. This project shows an experimental study on retrofitted RCC beam using CFRP sheet .The main objective of study is to investigate the behavior of RCC beam after Retrofitting by CFRP sheets.

***Index Terms* - RCC (Reinforced Cement Concrete) Beam, Retrofitting, CFRP (Carbon Fiber Reinforced Polymer) sheet, FRC material (Fiber Reinforced Composite Material, epoxy.**

I. INTRODUCTION

Rapid growth in production industries has given rise to the need for improved materials in terms of strength, hardness, density, and cost reduction with better stability. Composite materials have emerged as one of the materials processing such superiority in properties serving their capacity in a variety of applications. The use of natural or synthetic fibres inside the fabrication of composite materials has found extensive applications in various fields including construction, mechanical, vehicle, aerospace, biomedical, and marine.

Research studies over the past two decades have presented composites as an alternative to many conventional materials as the structural, mechanical, and tribological properties of fibre-reinforced composite (FRC) material have been greatly enhanced. Although composite materials were successful in increasing the durability of the material, there is currently a serious concern about the accumulation of plastic waste in the environment. This concern has compelled researchers around the world to develop environmentally friendly materials associated with cleaner manufacturing processes. Several different composite recycling processes also have been developed to deal with the thousands of tons of composite waste generated in a year.

Natural fibres are specifically classified as fibres that are plant-based, animal-based, and mineral-based. Since the asbestos content material with the mineral-based fibres is risky to human health, those are not well-explored fibres with respect to research into fibre-reinforced composite materials, at the same time as plant-based fibres offer promising characteristics which include low cost, biodegradable nature, availability, and good physical and mechanical properties.

II. CFRP SHEET

Carbon fiber reinforced polymer (CFRP) is a combination of extremely thin carbon fibers of 5-10μm in diameter, embedded in polyester resin. In CFRP the reinforcement material is carbon fiber which provides the strength and stiffness and commonly used polymer resin for the matrix-like epoxy, which bonds the reinforcement in an organized way. Carbon fiber is an anisotropic material in nature manufactured at 1300°c. The major advantage of fiber includes low density, low conductivity, high fatigue strength, high elastic modulus (200-800 GPA), good creep level resisting chemical influences, and do not absorb water.

CFRP is most commonly used in industrial masonry structures for the Retrofitting of old structures that have been already damaged due to earthquakes, chemical reactions, environmental effects, etc. Since Carbon fiber Reinforced polymers (CFRPs) are one the stiffest and lightest composite materials so they are far superior to other conventional materials in many areas of applications. Norazman et al investigated the purpose of using CFRP to improve the tensile strength of reinforced concrete, and replace steel, totally and he concluded that the main Advantage of using CFRP as reinforcement is to avoid rusting and corrosion of reinforcement. Currently, CFRP Is being used for structural repair for structures damaged due to aging and extreme condition. Because of these benefits, carbon fiber finds great application in many industries such as aerospace, automotive, military, and recreational applications.

III. MATERIAL USED

No. of element	Material
1.	Cement
2.	Sand
3.	Water
4.	Coarse Aggregate
5.	Steel
6.	Carbon Fiber Reinforced Polymer
7.	Epoxy

IV. TEST ON MATERIALS

IV.1 .CEMENT

A grade of 53 ultratech cement satisfying all the requirements of IS 8112:1989 will be utilized. It will be tested for its physical properties as per Indian standard specifications.

Sr. no	Characteristics	As per IS code 8112:1989
1.	Standard consistency (%)	30%
2.	Fineness test (gm/m2)	2.13gm
3.	Initial setting time	45 min
4.	Final setting time	60 min

IV.2. SAND

Sand used in this study was locally available with fitness modulus 3.126gm has been used.

IV.3.WATER

We use normal tap water to mix concrete which has neutral ph.

IV.4.COARSE AGGREGATE

Maximum size of aggregates of 20mm will be used and grading zone of aggregates was zone II as per IS specifications.

Sr. no	Characteristics	As per IS code
1.	Elongation test	23.3%
2.	Flakiness index	17.25%
3.	Sieve analysis	3.219 gm

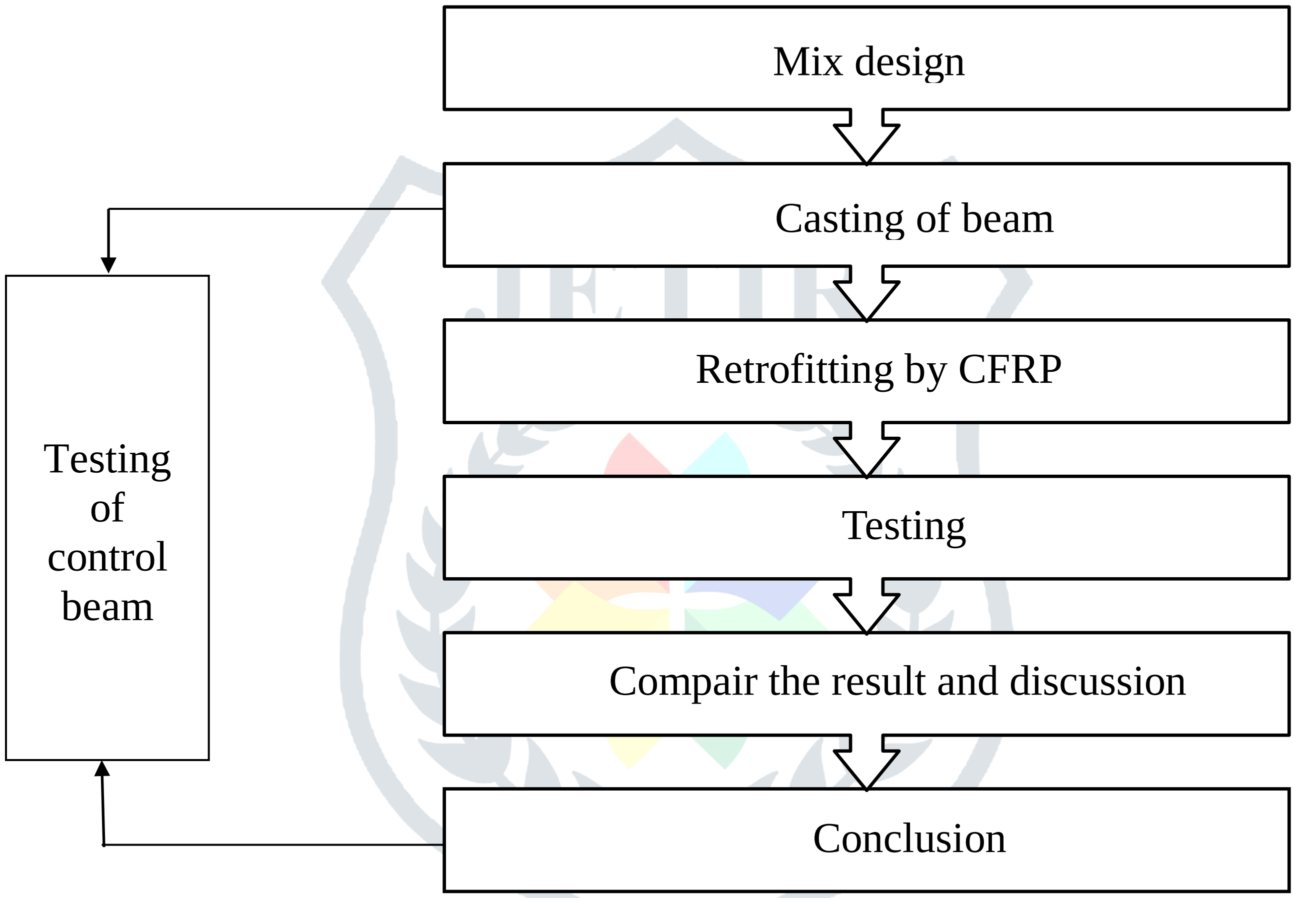
IV.5.CARBON FIBRE REINFORCED POLYMER

CFRP is having high strength and durability, and one more thing it is easy to install. It is commonly used whenever high strength and rigidity are needed. Carbon fiber sheets of different thicknesses will be used as a retrofitting material for the beams.

IV.6.EPOXY

Epoxy resin with hardener was used as a bond purpose between the concrete surface and carbon fiber sheet. The epoxy resin primer is mixed as per the guidance of the manufacturer's instructions. And the mixing is carried out in a plastic container having a base hardener ratio (Base: Hardener =3.33Kg: 1Kg) i.e., a hardener with 30% of epoxy resin. After the uniform mixing, epoxy resin is applied to the concrete surface of RC Beams.

V. METHODOLOGY



V.1.MIX DESIGN:

- Rate analysis for single R.C.C beam : 1:1:2
- As per IS code: 10262
- Grade of concrete M25
- Wet vol. Of concrete = 0.15 X 0.3 X 1
  = 0.045 m^3
- Dry vol. Of concrete = 52/100 X 0.045 +0.045
  = 0.0684 m^3
- Quantity of cement = (dry vol./1+1+2) X 1
  = (0.0684/1+1+2) X 1
  = 0.0171m^3

Quantity in kg = (0.0684/4) X 1440
= 24.624 kg

No. Of bags (cement) = 0.0171/ 0.0347
= 0.49≈0.5 bag

Quantity of sand = (0.0684/1+1+2) X 1
= 0.0171m^3

Quantity in kg = (0.0684/4) X 1450
= 24.795 kg

Quantity of aggregate	=	(0.0684/1+1+2) X 2
	=	0.0342m^3
Quantity in kg	=	(0.0684 X 2/4) X 1500
	=	51.3 kg
Quantity of water	=	as per IS code 456
Water /cement ratio	=	0.50
Water/ cement	=	0.50/1
Water	=	0.50 X cement in kg
	=	0.50 X 24.624
	=	12.312kg ≈ 12.312 Liters.

Percentage of steel used = as per is code 456:2000

Cross section area	=	L X B
	=	(0.15* 0.3)
	=	0.045m2
Cross sectional area of 1 bar	=	3.14*d2/ 4
	=	3.14* 0.010^2 /4
	=	0.000785m2
Cross sectional area of	=	0.000785*4
4 no's of bars	=	0.000314m2
Percentages of steel	=	(0.000314/ 0.045)* 100
	=	0.6%

V.2.CASTING OF BEAM:

Six beams were cast while three beams are non-retrofitted and the other three are retrofitted beams. All the samples had the same dimensions and were similar in shape i.e. rectangular having dimensions 1000mm in length and 300mm X 150mm in cross-section. To design the beam, the design mix ratio was used. Shows rectangular reinforcement cage with 10mm diameter and 8mm diameter of 4 bars for stirrups as shear reinforcement with c/c spacing 150mm. First, three beams were tested in single-point loading for failure. The rest three beams were tested in single-point loading until cracks appeared on them.

V.3.RETROFITTING OF CFRP

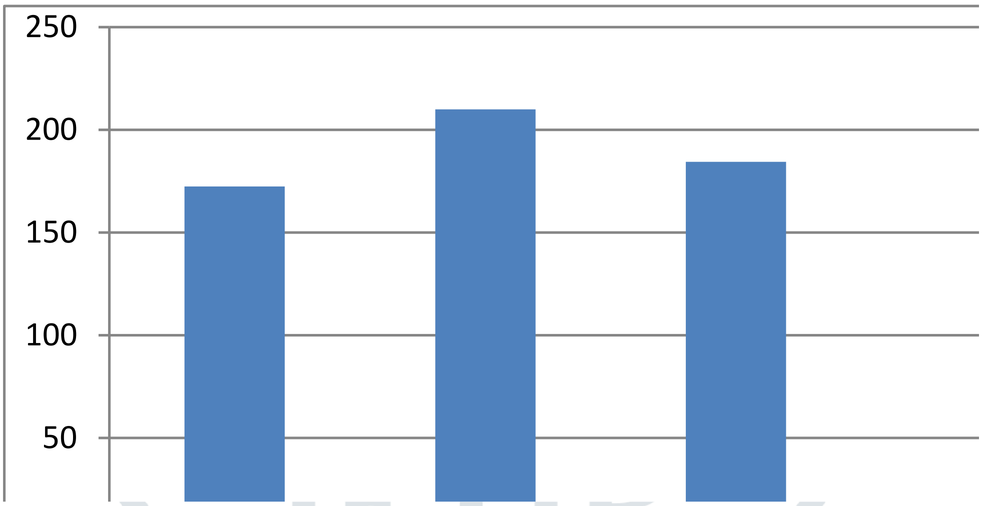
The beam we fix after 28 days. The beam is wrapped on all four sides with a CFRP sheet using a complete wrapping technique. Before epoxy primer was applied, the beam surfaces were clean with water and roughened to a better bond between the concrete surface or CFRP sheet. And mixing is done in a plastic tray with a hardener or epoxy ratio of 10:1. I.e. 10% of hardener is used. As per the guidance of manufacturer instructions. After mixing, epoxy raisin was applied to the solid surface of the RC beam. After that, the CFRP sheet was applied to the beam, air bubbles are formed there. Then we removed the air bubbles by using the roller brush. This retrofitting is done at room temperature. Move the retrofitted beam to a resting position at room temperature for 2 days before testing.

V.4.TESTING OF BEAM

The controlled and retrofitted beams were tested under the triaxial load to ascertain the ultimate load-carrying capacity .the distance from both the end of the beam is 100mm, roller support on provided side's side. The support conditions for the tested sample are the same as shown in fig. consists of a beam supported on the two steel rollers bearing 100mm from the ends of the beam. The remaining portion of 800mm was divided into three equal parts of 266mm a. Until the appearance of the first crack was recorded on the UTM machine, the deflection of the beam was noted. Then the factor load was recorded as the load at which load on automatic UTM. The load-deflection graph was obtained. The deflection curve of a beam in triaxial loading is analysed.

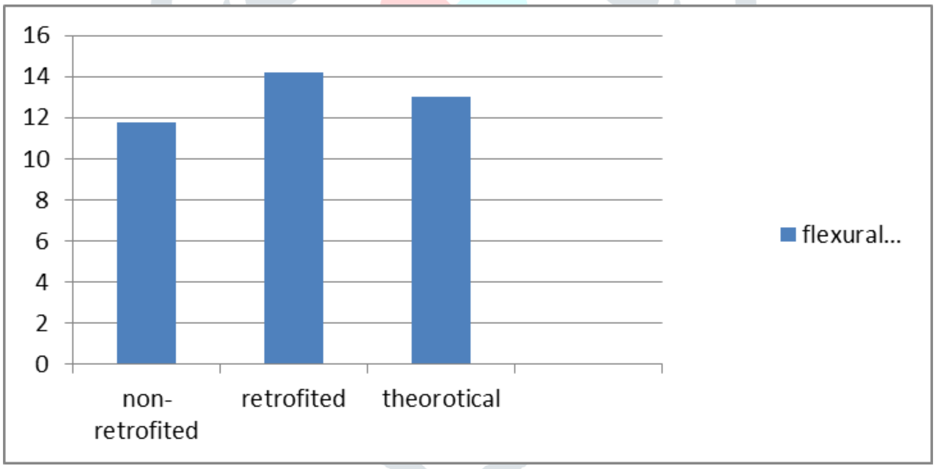
V.5. COMPARISON OF RESULT AND DISCUSSION

From the present experimental work we can found the load baring capacity of conventional beam and Retrofitted Beam, Flexural strength and deflection in both beams. The fully wrapping techniques used for strengthening of the beam, initially the cracks were not visible. As the increase the loading increase the propagation of the crack but due to wrapping of CFRP sheet around the beam leads less cracks formation. The result show in given graph due to experimental work performs on beam in laboratory.



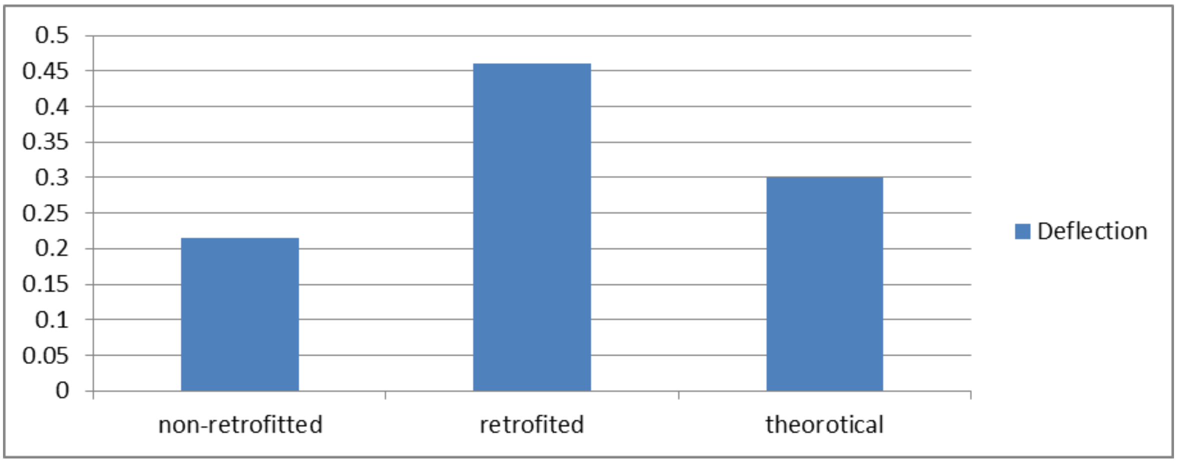
Graph. No. 1: Load caring capacity of conventional or non –conventional Beam

Flexural Strength:
Flexural strength is measure of the tensile strength of concrete structure. It is maximum bending stress that can be applied on structure before yields. We can measure theoretically and perform the experimental test on the both beam.

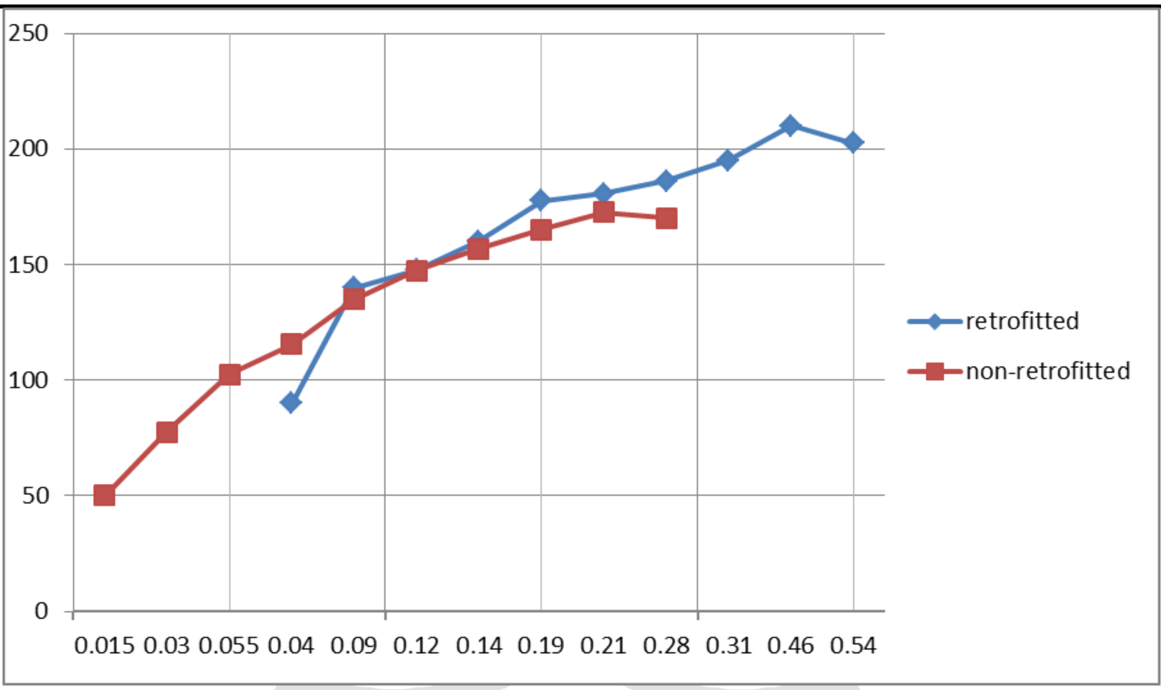


Graph no. 2: Comparison of flexural strength of Conventional & Retrofitted beam

Deflection:
Deflection, in the structure its means the movement of a beam or node from its original position. It happens due to the forces and loads being applied to the structure.



Graph no. 3: Deflection in mm



Graph no. 4 comparisons of Deflection between Non –retrofitted and retrofitted beam.

V.6.CONCLUSION

In the study the behavior of RC concrete beam Retrofitted with CFRP sheet after applying load in connectional and retrofitted beam.

The following conclusions are obtained from the study:

i. The maximum load-carrying capacity increased by this study is 210kN. This results in 20% increase when compared with non-retrofitted.

ii. The crack formation was reduced in the CFRP sheet retrofitted beam compared to the non-retrofitted beam.

iii. Increase the thickness of the CFRP sheet this gives more effective results for concrete repair and reinforcement.

iv. The study shows the main failure if mixing ratio and proper application of chemical (epoxy and hardener) affects the load-bearing load bearing capacity and the efficiency flexural reinforcement of the beam.

Based on this studies should be performed to investigate the b of CFRP retrofitted beam and non – retrofitted beam. Also analyse the beam using STAAD pro and numerical work should be done for comparing behaviour of retrofitted beam.

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