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Behaviour of Simply Supported Concrete Beam using CFRP (Carbon Fiber Reinforced Polymer) - A Review

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Abstract: ***The main objective of this paper is to study the behavior of beam with use of Carbon Fiber Reinforced Polymer (CFRP) composite, Because of current scenario the steel prices are increasing day by day and transportation and installation and required skilled labours is costly and the main drawback of use of steel in construction industry is the corrosion & changes in weather conditions the expansion and contraction of steel, if we don't use steel in construction of small G+1 & G+2 houses the main problem of corrosion is solve and it increases the life span of structure. Because without steel the concrete is act like hard rock or a single element so the steel is not there in concrete so the cracks produced by expansion and contraction and deterioration of concrete by corrosion of steel these problems are solved and not use steel the maintenance cost are also less, so for replacement of steel we use Carbon Fibre Reinforced Polymer.***
Keywords: Carbon Fibre Reinforced polymer, Reinforced concrete, Retrofitting, Strengthening, Flexural strength.

I. INTRODUCTION

Carbon fiber is developed by the controlled oxidation process, in which carbonisation and graphitisation of carbon-rich organic harbingers which are already in fiber form. The fibers are also be made from pitch or cellulose. Two types of carbon fibers are High strength fibers, and High modulus fibers.

CFRP wrapping technique is best techniques to improve the strength of the structure in this process the existing structure not disturbed. FRP (fiber reinforced polymer) is a composite material generally consisting of different type's carbon fiber reinforced polymer (CFRP). CFRP is used in construction industry for shear strengthening many structural members like beam, column, and slab. [1]

Reinforced concrete is composite material in which low ductility and tensile strength are frustrated by the formation of reinforcement having higher ductility and tensile strength. By earthquake structure is damaged and whole structure is damaged and whole structure Ex. Bridge and chimney silo not economical to reconstruct so we need repairing and retrofitting of structure. By various method CFRP wrapping is one of them retrofitting is increase the strength of existing structure. and no need of demolition the structure is usable for 5 to 10 years and increase life span of structure. Retrofitting is the process of adding new technology. [2]

Two types of CFRP products is used Forca sheets manufactured by Forca japan and Carbodur sheet manufactured by Sika, Canada. [3]

Retrofitting is amelioration of existing structure to make them more resistible against earthquake and other natural calamities FRP is largely used in construction industry for strengthening of R.C.C structures from past 15 years in India but it is new in India not everyone is aware of this product. [4]

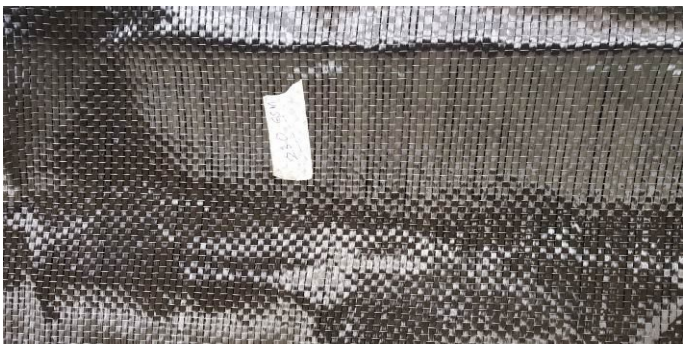


Fig-1 Carbon Fiber

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A. Advantages of Carbon Fiber

1) Carbon fibres provide special benefits when used with concrete structure to increase the flexural capacity.
2) Carbon fiber having High modulus of elasticity depend on fibre type usually in India 230gsm and 430gsm carbon fiber are largely used in construction industry.
3) Carbon fiber having excellent fatigue properties.
4) Carbon Fiber having excellent resistance to all types of chemical attack.
5) Carbon fiber are water resistant and not corrode when contact with water.
6) Carbon fiber are freezing and thawing and de-icing salt resistant.
7) Carbon fiber are minimum coefficient against thermal expansion approximately 50 times lower as compare to steel.
8) It is used in column for axial load enhancement.

B. Process of CFRP wrapping

1) Preparation of surface
2) Application of resin primer for setting min 6hrs.
3) Mixing of saturant part a (epoxy) and part b (hardener) with low speed mixer.
4) Spreading of resin with brush spread equally on all surface.
5) Wrapping and resin impregnation and rolling remove air voids.
6) Sand pasting for plaster bonding.

II. LITERATURE REVIEW

Srudhira et al. (2019) In this paper author shows the comparison of CFRP wrapped beams with the conventional R.C.C beam was done M25 grade of concrete was used and cast 4 beams of size 1.5×0.38×0.23m the shear behavior of CFRP wrapped R.C.C beam through the load verses deflection response and cracking pattern compared with conventional beam. And author concluded that the performance of CFRP wrapped beam was better than as compared to conventional beam. [1]

Shafi Ullah Miakhil et al. (2020) in this paper author elaborates FRP material and techniques using for retrofitting of R/C beams in the building. In this author also review on the strengthening of R/C haunched Beams using CFRP and GFRP strips and it observed that the U-wrapping of R/C beam using CFRP laminates gives better performance in both shear and flexure after complete wrapping process. [2]

Khaled Soudki et al. (2015) in this study 11 R.C.C beam casted of size 2.4×0.25×0.15 m and lightly reinforced with 0.6% of steel and two types of CFRP products used sheet and strips for experiment. 3 beams is placed at room temperature and 8 beams subjected to 300 wetting and drying cycles with 3% Nacl exposure. for checking load carrying capacity of beams tested on four point bending, and various non-destructive tests performed to determine chloride diffusion and reinforcing bar mass loss, at seven locations half-cell tests performed author observed that the change in environment does not affect the strengthened beam and yield stress and strain of tension steel reinforcing bar is 460 MPA and 0.2% is obtained from laboratory results. [3]

Anumol Raju et al. (2013) This experiment was performed to investigate the behavior of beams after retrofitting using various natural and synthetic fibers such as carbon, glass, coir, steel, polypropylene M20 grade of concrete is used and 30 beams where casted of size 1×0.15×0.15m 5 conventional beam and 25 beams where retrofitted with various fibers author observed that the initial cracks developed in the strengthened beam at very higher load and ultimate load carrying capacity is increased by 125% as compared to conventional beams. [4]

R. Balamuralikrishnan et al. (2009) This experiment explores the flexural behavior of CFRP strengthened R/C beam for flexural strength 10 beam where casted of size 3.2×0.25×0.15m out of 8 beams wrapped with CFRP one and two layer and check for monotonic and cyclic loads. With the help of ANSYS software model created and by this author predicted moment curvature relationship and load displacement response and compare experimental and numerical (ANSYS) results author observed that strengthened beams flexural strength and flexural stiffness is increased. [5]

S.D. Vanjara et al. (2015) In this study static structure analysis on beam element with the help FEA software ANSYS is done the beam model is created of size 3×0.25×0.15m volume and area of reinforcement is 0.15×3m for concrete solid 65 element is used and for CFRP shell 81 element is used and beam bottom wrapped with two layer of CFRP and check displacement of the beam for different loading conditions 24KN load is applied at 2L/7, 40KN load is applied at 2L/6 and 60 KN load is applied at 2L/4 in Y-direction and compare the load deflection curve by this analysis author observed that the CFRP wrapped beam strength is increased by 50%. [6]

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Julio F. Davalos et al. (2012) in this paper author suggest repairing methodology and FRP design done on the basis of ACI codes to the 1000 concrete T-beam bridges situated in Pennsylvania. Various Non-destructive tests are carried out for finding defect ultrasonic pulse velocity and rebound hammer test for beam concrete and for carbonation test on deck concrete cores and finite element model is created and it was calibrated by truck loading by AASHTO on the basis of analysis design is suggested. [7]

Abhijit Mukherjee et al. (2004) In this experiment beam column joint cast with proper bond of reinforcements and different typed of FPR sheets and FRP strips are applied on it and column check for axial force and beam check for cyclic load and compare both results control specimen and strengthened specimen plot load verses deflection curve author observed that the beam column joint strengthened with carbon composite material is having increase in strength and it is useful for seismic retrofitting as well as repairing of R.C.C joints. [8]

Abhijit Mukherjee et al. (2008) The experimental work is carried out to find the performance of R.C.C beams externally prestressed with fiber composite material the beam casted of size is 1.8×0.18×0.09m for tension reinforcement 12mm diameter bar is used for shear links 6mm diameter mild steel bar is used. beam is retrofitted with use of carbon fiber reinforced composite laminates and tested for four point bend test and results is calculated in terms of flexural strength, deflections, cracking behavior and failure modes author observed that flexural performance of retrofitted beam is better than fresh R.C beam and load carrying capacity of retrofitted beam is also increasing and deflection decreases as compared to fresh beam. [9]

Tom Norris et al. (2013) In this paper analytical and experimental results of CFRP strengthened beam is compared and for analytical method ACI equation is modified and the contribution of the CFRP is determined by considering its strength and fiber orientation. In experimental work 19 concrete beam casted of size 2.44×0.203×0.127m and with this 13 beam are tested for flexural strength and stirrups are closely spaced load verses deflection curve is plotted. Author observed that use of CFRP sheets on web and tension face and CFRP placed perpendicular to cracks the strength and stiffness was increased. [10]

Reza Saiedi et al. (2015) In this experiment 3, 13 year old precast concrete T-beam is used in this 2 prestressed with CFRP rod and 1 prestressed with steel prestressing strands tested with sustainable load and exposed to low temperature at -27ºC for 163 days and compare the results of normal temperature and low temperature shows prestressing strain decreases when temperature decreases. Author observed that in prestressed CFRP beams 19% of strength is reduced and failure pattern changes flexural to concrete to CFRP bond failure. [11]

T. Liu1 et al. (2017) The purpose of this paper is to show impact behavior of beams without use of stirrups in this experiment static and impact load test is carried out 11 beams are casted without stirrups and wrapped with CFRP. Author working on the effect of varying impact energy and impact velocity on dynamic behaviour and cracking patterns, time histories of dynamic forces, deflection, acceleration, CFRP strain various analysis are done author observed that CFRP retrofit can increase the impact resistance of R/C beam and decrease the damage percentage and also reduce the deflection percentage. [12]

Feifei Jin et al. (2019) In this paper 5 beams where casted 4 are wrapped with transverse prestressed unbounded carbon fiber reinforced polymer straps and aged for 320 days to find external concrete strains, internal steel shear link strain, strap strains, shear crack patterns and compared with unstrengthened beam. By use of CFRP straps reduce the proportion of the shear deflection and mohor's circle analysis is done. Analysis shows that long term tensile behavior in shear span administer growth of shear deformation. [13]

III.CONCLUSIONS

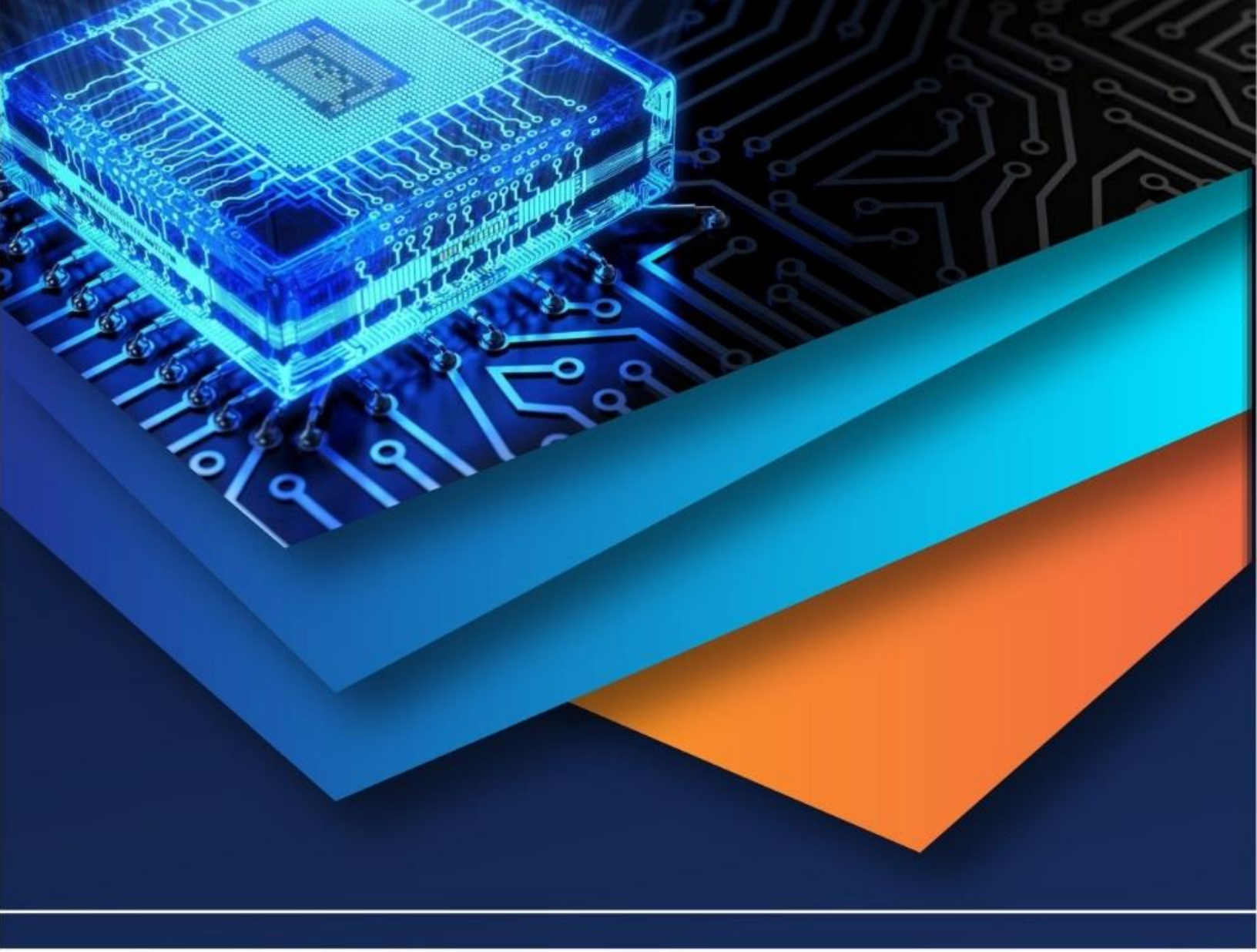
A. The load verses deflection behavior of CFRP wrapped beam are better performed when compared to the conventional beam.
B. The ultimate load carrying capacity of CFRP wrapped beam are larger than the conventional beam.
C. Because of its high strength CFRP wrapping should be useful for the structural members.
D. U-wrapping of R.C beam using CFRP laminate gives better performance in both shear and flexure after complete wrapping technique.
E. Long term effectiveness CFRP wrapped beam against corrosive environment was observed.
F. Beams strengthened with CFRP exhibit increased flexural strength, enhanced flexural stiffness and composite action until failure.
G. Carbon composite material is used for seismic retrofitting as well as rehabilitation of R.C.C joints.
H. CFRP wrapping can enhance the impact resistance of R.C beams and reduce their deflection and decrease the damage percentage.

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