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Analysis of RCC Beam Using GFRP Wrapped with Cellular Stirrups

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ABSTRACT

Many of the current worldwide reinforced concrete structures urgently need rehabilitation, repair or reconstruction as a consequence of various factors, including corrosion, lack of detail, failure to bind between column beam joints, increases in service loads, and so on. FRP composite has been agreed as a successful substitute for repairing and increasing RCC structural strength.As a composite of fibres-reinforced polymer (FRP), RCC structures increase in strength due to their exceptional properties such as high strength to weight, corrosion and fire resistance, increased fatigue resistance and energy absorption capabilities. This paper is intended for the testing of damaged reinforced concrete beams remedied by the addition of GFP overlays to beams. Analytically and experimentally examined the ultimate load carrying capacity and deflection capacity of the RCC beam and wrapped GFRP beam. The investigation was done with ANSYS software.

Keyword: RCC Beam, GFRP, Cellular and Stirrups.

1. INTRODUCTION

Almost all engineering structures, ranging from residential buildings, industrial buildings to power stations and bridges, face degradation or deterioration throughout their lifetime. These deteriorations are mainly caused by environmental effects such as corrosion by steel, gradual loss of strength as an aging process, variation in temperature, freeze-thawing cycles, repeated high-intensity loading, chemicals and saline contact with water. Another main cause of structural deterioration is the addition of earthquakes to these environmental effects. This issue requires the development of successful structural retrofit technologies. Several investigations were made in order to strengthen the structures by retrofitting technology. There are still many drawbacks to the findings from the numerous investigations concerning improvements in fundamental parameters such as strength / stiffness, ductility and resilience of structural components retrofitted with externally bondable FRP composites, albeit very promising. It requires more studies so that FRP composites can be recognized as a possible structural additive in full proof. FRP reparation is an simple way to enhance a structure's strength and design life. This repair method is ideal for the deteriorated concrete structure because of its high strength to weight ratio and corrosion resistance.

1.1 Glass Fibre Reinforced Polymer (GFRP)

The glass enhanced polymer / plastic is a newly produced material for the flexural strengthening of the RC and the masonry framework. The key advantages of this technology include high weight strength, good fatigue properties and fiber-reinforced non-corroding characteristics. The resin matrix attaches the fiber and also links concrete to GFRP. The successful replacement of plates in steel for beam reinforcement with external wrapping has been identified. This increases the strength of the beam and its stability, but the deflection efficiency and ductility are reduced.

1.2 Objectives

The objective is achieved by conducting the following tasks.

- To improve the load carrying capacity of RCC beams by retrofitting with GFRP.
- To study the load deflection behaviour of flexural deficient beams which are retrofitted with GFRP.
- To study the ductility of flexural deficient beams.
- To compare the strength of experimental and analytical results of normal RCC beam and GFRP wrapped RCC beams.

2. METHODOLOGY

Figure 1 shows the methodology of the study.

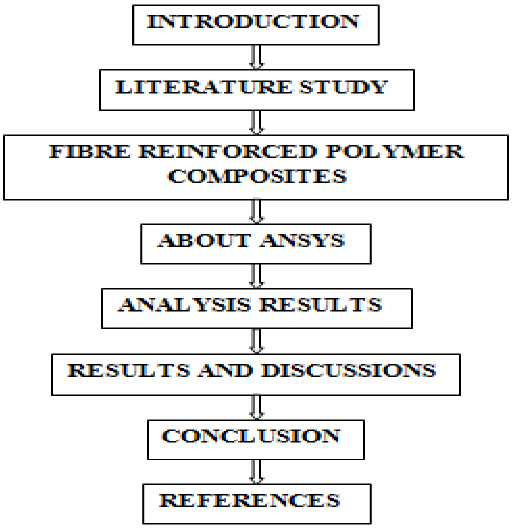


Figure 1 Methodology

3. FIBRE REINFORCED POLYMER COMPOSITES

3.1 Fibre Reinforced Polymer (FRP) In Construction, Types and Uses

Composite fiber enhanced polymer (FRP) is a fiber-reinforced polymer. It constitutes a class of materials which fall within a category known as composites. Composite materials are formed by dispersing one or more material particles in another material, creating an ongoing network around them. FRP composites differ from conventionalconstruction materials such as aluminium and steel. FRP are anisotropic composites, while Steel and Aluminium are isotropic. Their properties are also directional, so the strongest mechanical characteristics are in the direction of the placing of the fiber.

3.1.2 Types of Fibre Reinforced Polymer (FRP)

3.1.2.1 Glass Fibre Reinforced Polymer (GFRP)

Glass fibers are basically formed by combining sand, calcareous, folic and other minor components of silica. The mixture is heated to around 1260 ° C until it melts. The molten glass will then flow into a platinum plate through fine hole. The glass beams are cooled, collected and wounded. The fibers are drawn so that directional strength is increased. The fibers are then woven into various shapes for composite use. Figure 2 shows the Glass fibre reinforced polymer bars.

Figure 2 Glass Fibre Reinforced Polymer Bars

3.1.2.2 Carbon Fibre Reinforced Polymer (CFRP)

Carbon fiber has a 200-800 GPa high elasticity modulus. The highest elongation is 0.3-2.5% where the lower elongation is higher rigidity and vice versa. Carbon fibers are water free and resistant to a wide variety of chemical solutions. They are excellent resistant to fatigue and neither corrode nor crunch or relaxation. Figure 3 shows the carbon fibre reinforced polymer bars.

Figure 3 Carbon Fibre Reinforced Polymer Bars

3.1.2.3 Aramid Fibre Reinforced Polymer (AFRP)

The short aromatic polyamide type is Aramid. Kevlar is a well-known brand of aramid fibers. The fiber modules are 70-200 GPa with a final extension, depending on price, of 1.5 to 5 percent. The strength of Aramid is high and is also used for the helmets and bulletproof clothing. Sensitive to higher temperatures, humidity and ultraviolet radiation, they are not commonly used incivil engineering. Finally, Aramid fibers have relaxation problems and stress corrosion issues. Figure 4 shows the Aramid fibre.

Figure 4 Aramid fibre

3.1.3 Applications of FRP

- Carbon FRPs are used in pretensioned concrete for applications where CFRP is important for its high corrosion resistance and electromagnetic transparency.
- The steps and pathways are fitted with composites for saving weight and resistance to corrosion.
- This is used in hybrid high-performance structures.
- For concrete buildings, the FRP bars are used as internal reinforcement.
- For seismic retrofitting, FRPs are being used.
- In building special structures requiring electric neutrality, fiber-reinforced polymers will be used.

4. ABOUT ANSYS

4.1 Introduction to Ansys

ANSYS is a FEA (Finite Element Analysis) software package. A pre-processor is the software engine used to construct geometry. Then a solution process is used to prepare the desired geometry. In the end, after processor results are given in the program engine (ANSYS Structural Analysis Guide). RCC beams laminated with GFRP are finite element modelled with the aid of FEA software ANSYS. Finite element beam models have been developed in order to simulate structural behavior using the ANSYS system by non-linear reaction and up to failure.

4.2 Finite Element Analysis

Finite element analysis (FEA) is an extremely helpful method to numerically estimate physical structures that are too complex for standard research approaches in the field of civil engineering. Finite Element Analysis or FEA is analysis of a physical phenomenon by a quantitative statistical method called the Finite Element or FEM process. This approach is at the core of mechanical and other fields. This is also a central principle for the development of applications for simulation. These FEMs can be used by engineers to minimize the number of physical samples and to perform simulated research to improve their designs.

4.2.1 FRP laminates

Materials made of two substances are FRP composites. The elements are macroscopically mixed and are not soluble. A part of the reinforcement is the continuous polymer called the matrix, which is incorporated into the second constituent. In the case of fibres, i.e. carbon and glass, the supporting material is typically stronger and more stiffening than the matrix. The FRP composites are orthotropic materials, i.e. not all their characteristics are the same.

5. ANALYSIS RESULTS AND DISCUSSIONS

5.1 Model Creation

The RC beam model is created by merging finite element RCC concrete model 100 mm spacing steel reinforcement & RCC element 100 mm spacing with cellular stirrups model as shown in Figure 4 & 5 for flexural beam. A perfect bond is assumed between the concrete and the steel reinforcement. Figure 5 shows the RCC beam 100mm bar spacing with cellular stirrups

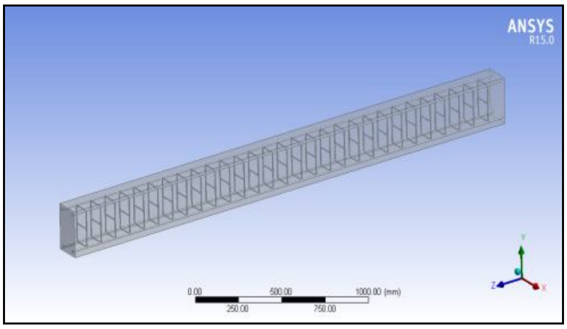


Figure 5RCC beam 100mm bar spacing withcellular stirrups

The RC beam model is created by merging finite element RCC model 100mm spacing cellular stirrups reinforcement with 5mm GFRP laminates model as shown in Figure 6.

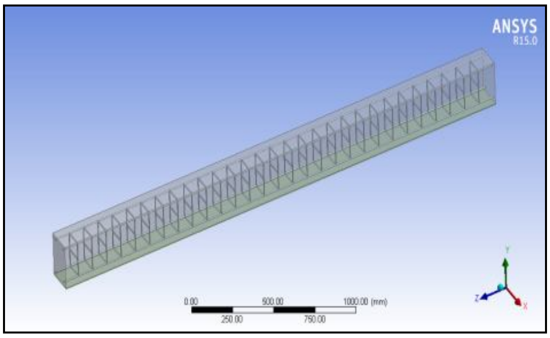


Figure 6RCC beam 100mm bar spacing with cellular stirrups &5mm GFRP laminated

5.2 Deflection

The result of the maximum deformation analyse by finite element model on GFRP beams and conventional reinforced concrete beam are shown in the Figures 7 and Figure 8

5.2.1 First Crack Load Deflection for Different Beams

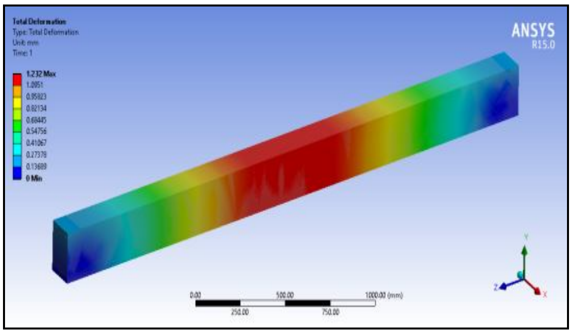


Figure 7 Deflection of RCC beam 100mm spacing with cellular stirrups

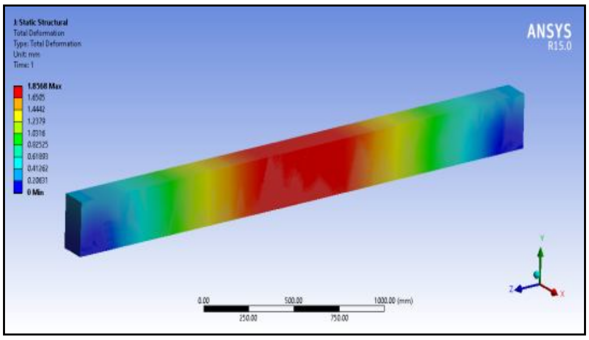


Figure 8 Deflection of RCC beam 100mm spacing with cellular stirrups& 5mm GFRP

5.2.2 Yield Load Deflection for Different Beams

Figure 9 shows the Deflection of RCC beam 100mm spacing with cellular stirrups.

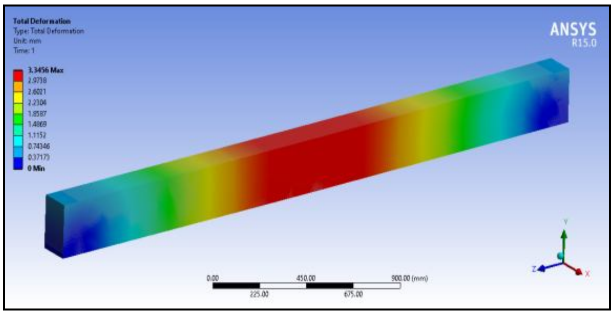


Figure 9 Deflection of RCC beam 100mm spacing with cellular stirrups

Figure 10 shows the Deflection of RCC beam 100mm spacing with cellular stirrups & 5mm GFRP

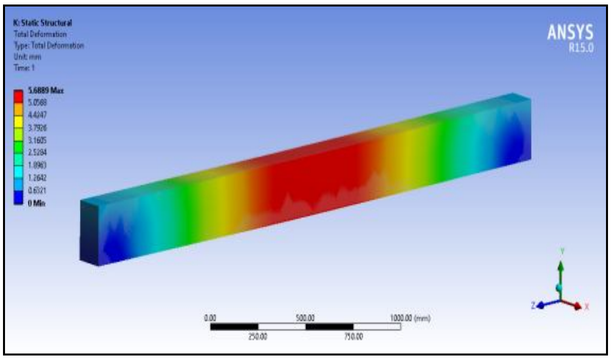


Figure 10 Deflection of RCC beam 100mm spacing with cellular stirrups & 5mm GFRP

5.2.3 Ultimate Load Deflection for Different Beams

Figure 11 shows the Deflection of RCC beam 100mm spacing with cellular stirrups

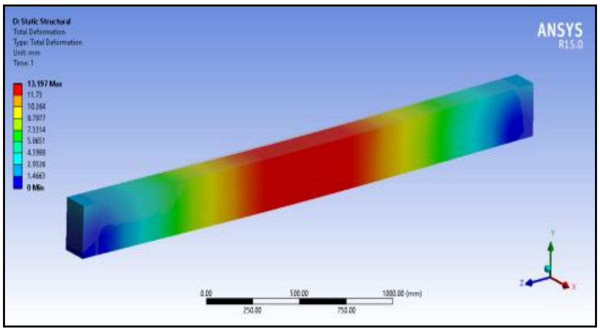


Figure 11 Deflection of RCC beam 100mm spacing with cellular stirrups

Figure 12 shows Deflection of RCC beam 100mm spacing with cellular stirrups& 5mm GFRP

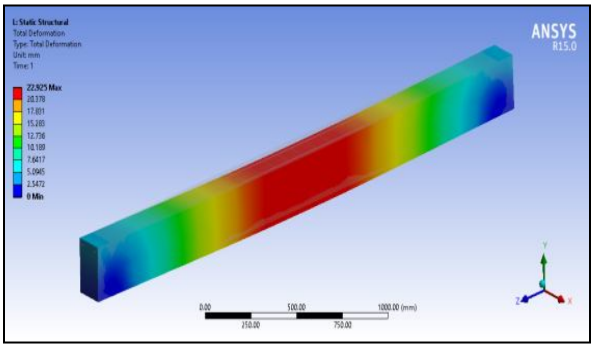


Figure 12 Deflection of RCC beam 100mm spacing with cellular stirrups& 5mm GFRP

5.3 Comparision Of Experimental Vs Analytical Results

5.3.1 First Crack Load Vs Deflection

Table 1 shows the First crack load Vs Deflection.

Table 1: First crack load Vs Deflection

Beam ID	Load	Exp	Analysis	Variations
100CS	20	1.16	1.232	5.84416
100CS5	35	3.1	1.856	40.129

5.3.2 Yield Load Vs Deflection

Table 2 shows the Yield Load Vs Deflection.

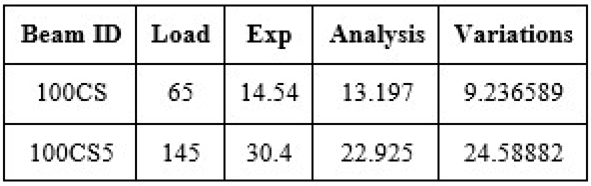
Table 2: Yield Load Vs Deflection

Beam ID	Load	Exp	Analysis	Variations
100CS	35.5	3.65	3.345	8.3561644
100CS5	72.5	6.85	5.688	16.963504

5.3.3 Ultimate Load Vs Deflection

Table 3 shows the Ultimate Load Vs Deflection.

Table 3: Ultimate Load Vs Deflection

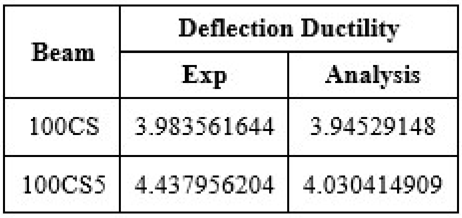


Beam ID	Load	Exp	Analysis	Variations
100CS	65	14.54	13.197	9.236589
100CS5	145	30.4	22.925	24.58882

5.3.4 Deflection Ductility

Table 4 shows the Deflection ductility.

Table 4: Deflection ductility

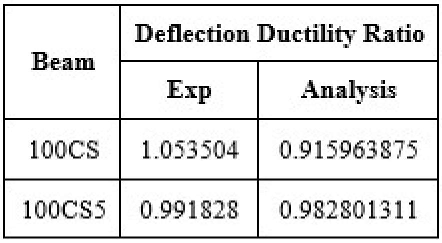


Beam	Deflection Ductility	
	Exp	Analysis
100CS	3.983561644	3.94529148
100CS5	4.437956204	4.030414909

5.3.5 Ductility Ratio

Table 5 shows the ductility ratio.

Table 5: Ductility ratio



Beam	Deflection Ductility Ratio	
	Exp	Analysis
100CS	1.053504	0.915963875
100CS5	0.991828	0.982801311

Figure 13 shows the 100 CS (Normal RCC beam).

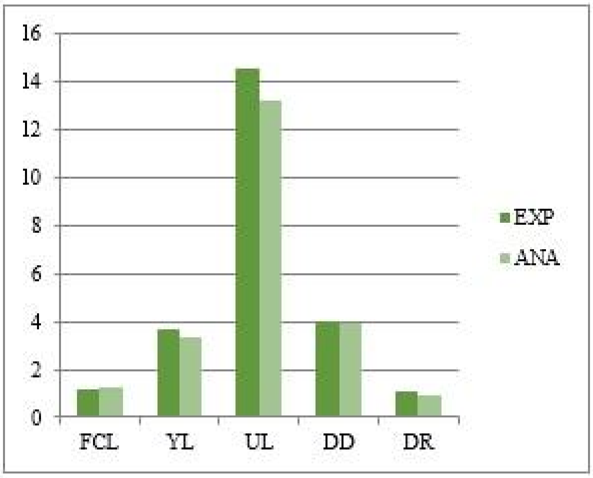


Figure 13100 CS (Normal RCC beam)

The normal RCC beam 100CS exhibit the first crack load, yield load, ultimate Load of 20 kN, 35.5 kN& 65 kN respectively. The deflection level observed in the beam experimentally was 1.16 mm, 3.65 mm &14.54 mm respectively, through non-linear FEA it was 1.232 mm, 3.345 mm & 13.197 mm respectively.
Figure 14 shows the 100CS5 (RCC beam with 5 mm GFRP laminated).

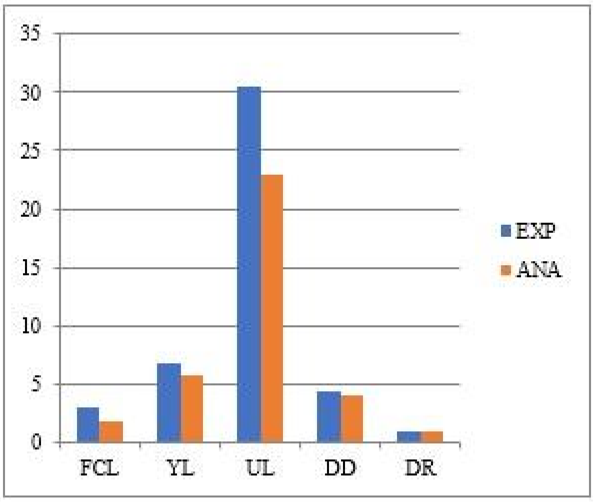


Figure 14 100CS5 (RCC beam with 5 mm GFRP laminated)

The GFRP laminated RCC beam 100CS5 exhibit the first crack load, yield load, ultimate Load of 35 kN, 72.5 kN& 145 kN respectively. The deflection level observed in the beam experimentally was 3.1 mm, 6.85 mm & 30.4 mm respectively, through non-linear FEA it was 1.856 mm, 5.688 mm & 22.925 mm respectively.

6. CONCLUSION

The present experimental and analytical study is made for the comparison of flexural behaviour of control beam and beam wrapped by GFRP. Following conclusions were drawn from the test results:

- The use of GFRP on the surface of the concrete provides greater crack protection and beam deformation characteristics.
- Relative to the control beam, the overall load carrying capacity of the RCC wrapped GFPR has been improved.
- Their cracking, yield, and ultimate strength increased dramatically with reinforced concrete beams strengthened with GFRP sheets.
- For the case of GFRP beams wrapped RCC, initial cracks occur at higher loads.

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