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FEA Analysis of RCC Beam using ANSYS

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Abstract:

The beams are used in various types of industrial and domestic buildings. The flexural strength of beam can be improved using composite material encasings. The objective of current research is to investigate the beam encased with GFRP and CFRP sheets using techniques of Finite Element Method under transverse loading condition. The 3 point bending test is used to evaluate the shear strength of beam. The FEA simulation of beam with encasing is conducted using ANSYS simulation package. From the FEA results, it is evident that use of composite encasings had significantly enhanced the flexural strength of beam. The shear stress is evaluated for RCC beam, CFRP encased beam, GFRP encased beam.

***Key Words**: Flexural strength, RCC, Composite beam*

1. INTRODUCTION

Composite materials encompass more than two materials with resultant property better than constituent material properties. The constituent materials of composites retain its properties like chemical property, mechanical property and physical property. Composite materials offer advantages with respect to higher strength, stiffness with low density and thus increases weight reduction is possible. The fibres are continuous type and discontinuous type. The discontinuous fibres have short aspect ratios and random orientation while continuous fibres have preferred orientation. Continuous-fiber composites are often made into laminates by stacking single sheets of continuous fibers in different orientations to obtain the desired strength and stiffness properties with fiber volumes as high as 60 to 70 percent. Fibres which include glass, aramid and carbon contain fewer surface defects as compared to bulk.

2. LITERATURE REVIEW

N. Attari, et al, (2011) studied the numerical behavior of controlled RC beam strengthened with GFRP, CFRP and hybrid FRP sheets. One control beam and 6 RC strengthened beams were made and tested through four point bending. Different strengthening combinations were carried out by the use of single layer, double layer and triple layer of CFRP, GFRP and hybrid FRP sheets in U shape. Results for ductility factor, strength, stiffness and mode failure were discussed for every strengthening schemes. It was noted that single layered hybrid composite or glass fiber alone improves ductility as compared to other strengthening schemes. [1]

Jiangfeng Dong, et al, (2013) they presented about RC beams strengthened with FRP laminates to investigate the flexural and flexural-shear performance. The FRP laminates includes GFRP and CFRP in U shape and L shape arrangement strips applied to the sides and bottom of the RC beam. In case of flexural strengthening one reference beam and others 6 beams were casted with one and two layers of CFRP. In flexural-shear strengthening 2 beams were casted with one layer of GFRP sheet in U shape arrangement and the other 4 beams casted with two layers of CFRP sheet in L shape. Parameters measured were load deflection behavior, failure modes and cracking behavior. The experimental

research output shows that flexural strengthening arrangement was less effective as compared to the flexural-shear strength. [2]

K. Vijai, et al, (2013) carried the comparison between experimental and analytical investigation on the behavior of RC beams laminated with CFRP. The nonlinear analysis was carried in ANSYS software. The 4 beam specimens were prepared including two beams were control beam of different sizes and the other remaining two beams were strengthened with CFRP at bottom side of the beam or in U shape pattern. Examined parameters were load vs deflection relationship and cracks. The research output shows that with use of laminates increase the load carrying capacity of beam. The load carrying capacity of the beam laminated with GFRP in U shape was found to be high as compared to beam laminated with GFRP only at bottom side. [3]

Rami A. Hawileh, et al, (2014) introduced to strengthened the RC beam with Hybrid FFP system. This paper deals with hybrid GFRP and CFRP sheets bonded externally to the RC beam specimen. The results were obtained through experimental and analytical investigations also comparison made between them. One ordinary reference RC beam and 4 RC beams using different arrangements of CFRP, GFRP and hybrid FRP sheets were made. The data such as load deflection curves, modes of failure, and load vs strain relationship were examined. It was noted that beams laminated with single CFRP sheet have less ductility at failure loads as compared to the GFRP/Hybrid FRP sheet. The conclusion was made that for achieving the strength in structural element and to improved ductility choose the most favourable combination of hybrid sheets. [4]

Shweta S. Shetty, et al, (2015) had performed the analytical analysis on RC beam laminated with GFRP. 3D beam was modelled in ANSYS under two point loading. One reference beam and 3 RC beams with GFRP laminate were modelled and analysed by Ansys software. The analysis based on varying parameters such as different thickness of the laminates and varying width of the beam. Stress intensity variation and load vs deflection relationships were examined. It was concluded that with the increase in width of the beam, deflection of the beam was reduced also the RC beams laminated with GFRP improves load carrying capacity of the beam. [5]

3. OBJECTIVE

The objective of current research is to investigate the beam encased with GFRP and CFRP sheets using techniques of Finite Element Method under transverse loading condition. The 3 point bending test is used to evaluate the shear strength of beam. The FEA simulation of beam with encasing is conducted using ANSYS simulation package.

4. METHODOLOGY

In a "3-point bend test, the sheet or plate's convex side is placed under tension, exposing the outer fibres to the maximum stress and strain. The product will fail if the strain or elongation is greater than the material's limit" [6].

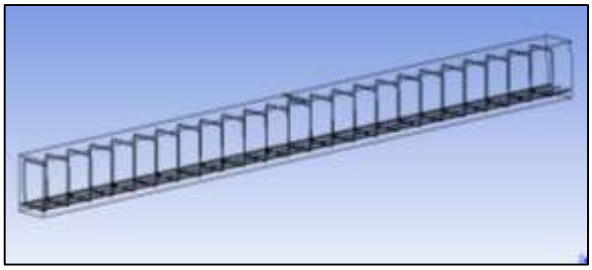

Figure 1: Imported design of beam with rebars

The model of beam is meshed. The meshing of beam is done using fine sizing and high relevance. The inflation for meshing is set to and growth rate is set to 1.2. The model is meshed using hexahedral element type. The meshed model of beam is shown in figure 2 below.

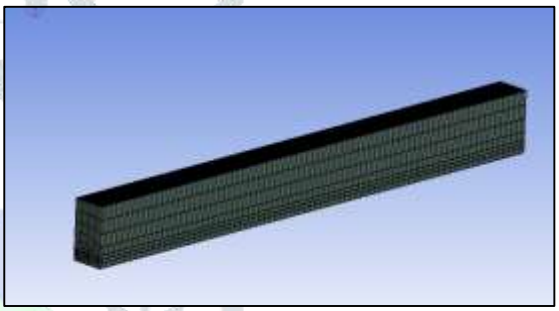

Figure 2: Meshed model of RCC beam

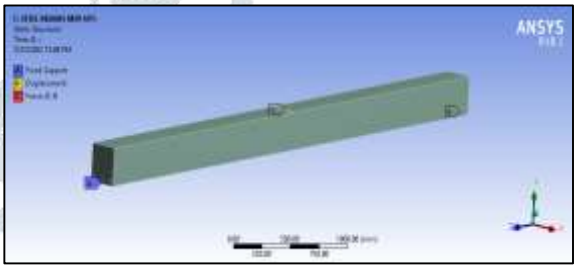

Figure 3: Transient structural load conditions

The applied transient structural boundary conditions are shown in figure 3 above. The edges of the beam are applied with fixed support and displacement roller support as represented in zone A and zone B. The loads are applied on mid-section region of beam and the loads are applied in steps.

5. RESULTS AND DISCUSSION

The transient structural analysis is conducted on RCC beam under varying loads. From the analysis, the deformation is determined for each load steps.

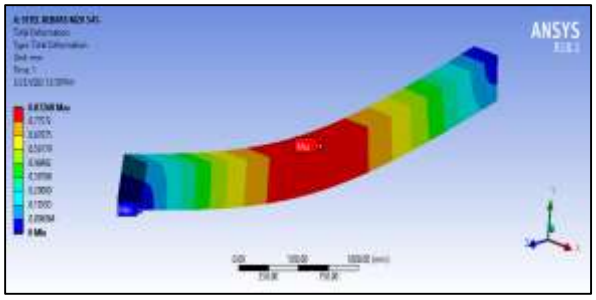

Figure 4: Deflection of RCC beam under 5000N load

Under 1st load i.e. 5000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is .87mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than .193mm.

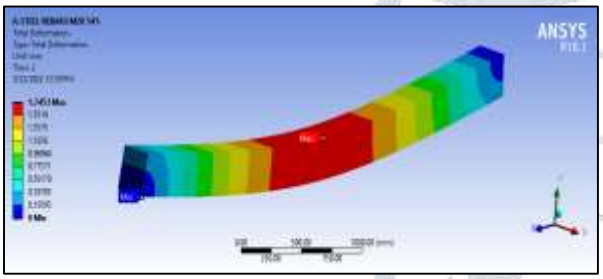

Figure 5: Deflection of RCC beam under 10000N load

Under 2nd load i.e. 10000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is 1.74mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than .387mm.

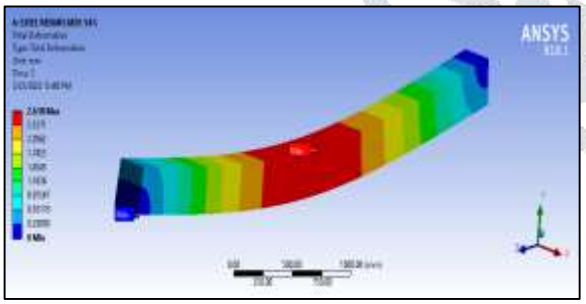

Figure 6: Deflection of RCC beam under 15000N load

Under 3rd load i.e. 15000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is 2.61mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than .581mm.

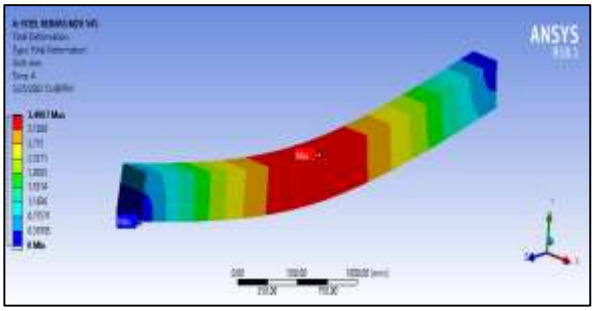

Figure 7: Deflection of RCC beam under 20000N load

Under 4th load i.e. 20000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is 3.49mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than .775mm.

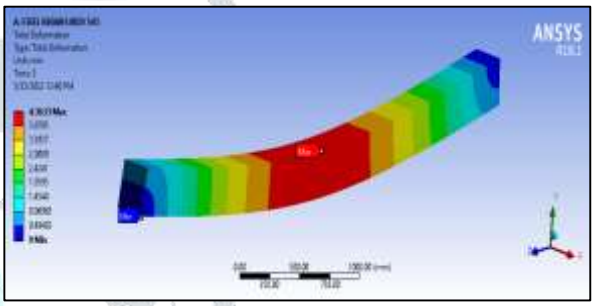

Figure 8: Deflection of RCC beam under 25000N load

Under 5th load i.e. 25000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is 4.36mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than .969mm.

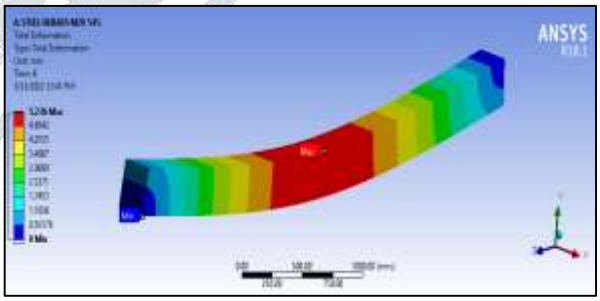

Figure 9: Deflection of RCC beam under 30000N load

Under 6th load i.e. 30000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is 5.23mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than 1.163mm.

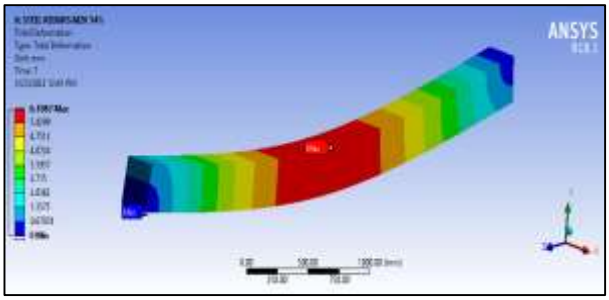

Figure 10: Deflection of RCC beam under 35000N load

Under 7th load i.e. 35000N, the deflection is observed to be maximum at the center region of RCC beam. The deflection at this region is 6.108mm. The deflection is minimal at the support regions as shown in dark and light blue color zone. The deformation at the fixed support region is less than 1.357mm.

6. CONCLUSION

The use of FEA tool enabled to determine the deformation on RCC beam, beam with GFRP encasing and beam with CFRP encasing. The tool enabled to determine the flexural strength of beam under varied loading conditions. From the FEA results, it is evident that use of composite encasings had significantly enhanced the flexural strength of beam. The shear stress is evaluated for RCC beam, CFRP encased beam, GFRP encased beam. The detailed findings are:

1. From the FEA analysis, the load deformation curves are generated for RCC beam, beam with GFRP encasing and beam with CFRP encasing.
2. The GFRP encased beam has lower deformation as compared to RCC beam.
3. The CFRP encased beam has lower deformation as compared to RCC beam.
4. The CFRP encased beam has lower deformation as compared to GFRP encased beam.
5. The flexural deformation of beam reduces with thickness of encasing (both CFRP and GFRP).
6. The deformation of beam is minimum for CFRP encased beam having width of 25mm.
7. The deformation of GFRP encased beam is nearly 20.3% lower than RCC beam.
8. The deformation of CFRP encased beam is nearly 39% lower than RCC beam.
9. The maximum shear stress is obtained for 25mm encasing width of CFRP and lowest shear stress is obtained for 5mm width of encasing.
10. The shear stress of 14.76MPa is observed to be maximum for 25mm CFRP encased beam.

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