Numerical Study on Behavior of Externally Bonded Rc Rectangular-Beam Using FRP Composites

Duraisamy R[1], S. Sundari[2]
[1]Dept of Civil Engineering,
[2]Associate Professor, Dept of Civil Engineering
[1, 2] Government College of Engineering, Salem, Tamilnadu, India.

Abstract- *Fiber-reinforced polymer (FRP) application is a very effective way to repair and strengthen structures that have become structurally weak over their life span. FRP repair systems provide an economically viable alternative to traditional repair systems and materials. In this study experimental investigation on the flexural behavior of RC Rectangle-beams strengthened using fiber reinforced polymer (FRP) sheets are carried out. Reinforced concrete Rectangle beams externally bonded with FRP sheets were tested to failure using a symmetrical two-point static loading system. RC Rectangle-beams was casted for this experimental test. This is weak in flexure. One beam was used as a control beam and another one was strengthened using different configurations of fiber reinforced polymer (FRP) sheets. Experimental data on load, deflection and failure modes are obtained. The effect of different amount and configuration of FRP on ultimate load carrying capacity and failure mode of the beams was investigated. The experimental results show that externally bonded FRP can increase the flexural capacity of the beam significantly. In addition, the results indicated that the most effective configuration was the U-wrap FRP. A series of comparative studies on deflection results from finite element method.*

Keywords- fiber-reinforced polymer, flexural behavior, deflection, finite element method..

I. INTRODUCTION

In this analytical and numerical study of flexural and shear performance of retrofitted or strengthening of beam by fibre reinforced polymer (FRP). Now a day investigator prefer numerical and analytical study to minimize error which can't reduce in experimental study, hence numerical study is more reliable than experimental study and analytical study less time consuming then experimental still having good agreement with experimental study. Almost all the software available in market are work based on finite element method (FEM) such as ANSYS, ATENA 3D and ABAQUS. Analytical study carried out by different author using FEM based software they found ultimate capacity of beam increased noticeably. Analytical investigation of reinforced concrete (RC) beam with FRP were carried out by number of investigator they all studied on different aspect, some of those worked on single layer or double layer of FRP of those worked on different pattern of FRP and then compared stress, strain and deflection with control specimen. For precise result by finite element method use fine mashing and appropriate material property. Bond behaviour between steel-concrete and concrete- FRP sheets/plate must be specify for accurate and realistic results.

STRUCTURAL DETAILS

Span -1000 mm Widh-150 mm Depth -200 mm

II. MATERIALS PROPERTIES

CONCRETE

Element type-solid 65
Modulus of elasticity (N/mm²)-2.783×10^4 Poission ratio-0.3
Density -2400 kg/mm³ Compressive strength-25 Mpa

STEEL PROPERTIES

Density- 7849.047 Kg/m3
Modulus of Elasticity -200000 MPa Poissions Ratio -0.3
Tensile Yield Strength- 415 MPa Tensile Ultimate Strength -485 MPa

FRP SHEET

Element type-solid 45
FRP –link 8
Tensile strength -900 N/mm² Thickness of FRP -1.2mm Poissons ratio (FRP)-0.25

EPOXY RESIN

Viscosity at 25˚c -12000 (cP) Density-1.16 kg/cm³
Modulus of elasticity (N/mm²)-5 Gpa Tensile strength -73 N/mm²
Volume fraction- 60%

III. NUMERICAL SIMULATION

A full 3D finite element analysis has been carried out using finite element software ANSYS. The analysis carryover in beam is subjected to two point loading. The FEA calibration study included modelling a concrete beam with the dimensions and properties corresponds to model. SOLID65 Element was used to model the concrete. This element has eight nodes with three degrees of freedom at each node – translations in the nodal x, y and z directions. This element is capable of plastic deformation, cracking in three orthogonal directions. A schematic of the SOLID 65 element is shown in fig.2 Smeared cracking approach has been used in modelling the concrete in the present study

IV. MODELING OF FRP RECTANGULAR BEAM

Concrete model

Modelling of R.C. beam was done by using key points and with the corresponding element type, real constant and material properties as mentioned above. The sample output of concrete model is shown in below. The image was taken from plot control option and the numbers depicts the key points of that model.

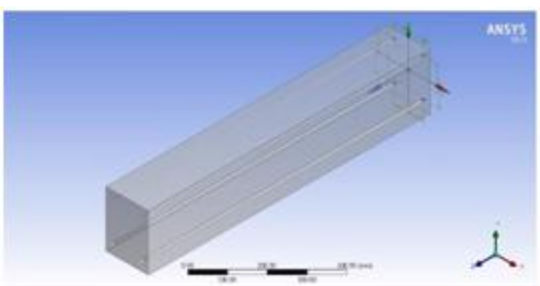

Fig 1 FRP concrete model

FRP wrapped R.C Beam mesh model

Meshing was done by setting mesh attributes under meshing option and then by using mesh tool the beam was meshed and is shown in below.

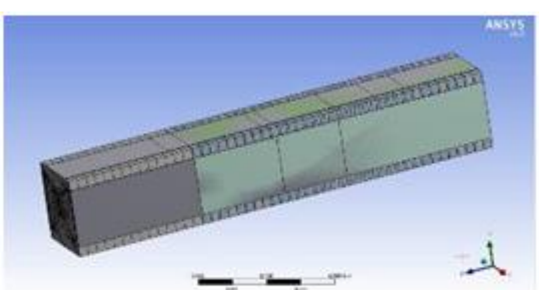

Fig 2 FRP wrapped R.C.Beam model

Modelling of FRP layer

FRP layer was created as volume and are meshed using Solid 65 element which is shown below.

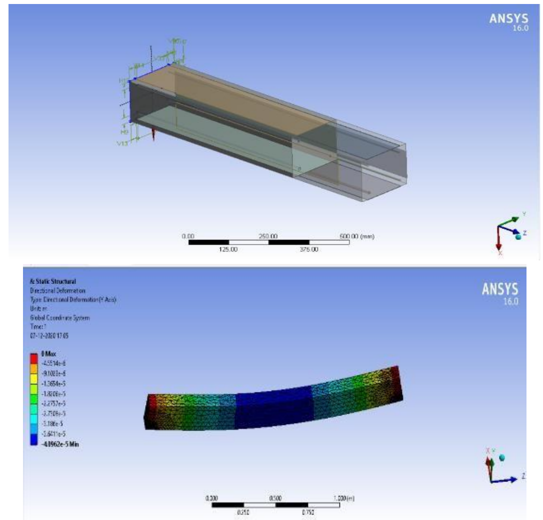

Fig 3 Modelling of FRP layer

Load modelling

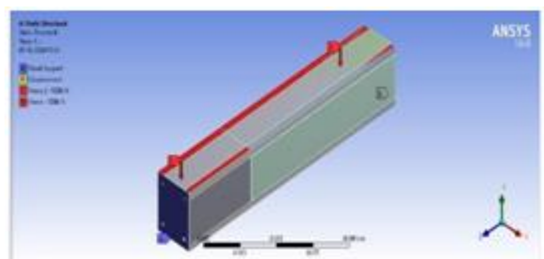

Fig 4 Load modeling

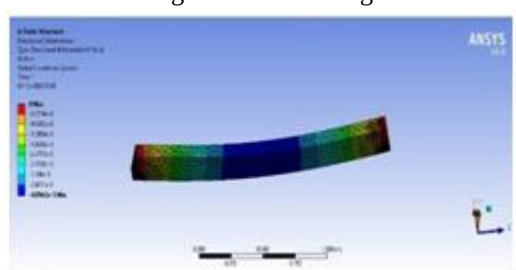

Fig 5 Total strain energy

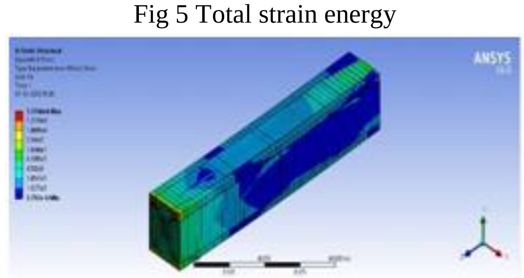

Fig 6 Deflection result for FRP wrapped confined RC Beam

V. RESULT DISCUSSION

The load carrying capacity of FRP Confined R.C Beam has increased stiffness and FRP confinement gives increased ductility characteristics which are clearly depicted in the below comparison graph. The comparison of load deformation characteristics of ANSYS value are shown in below.

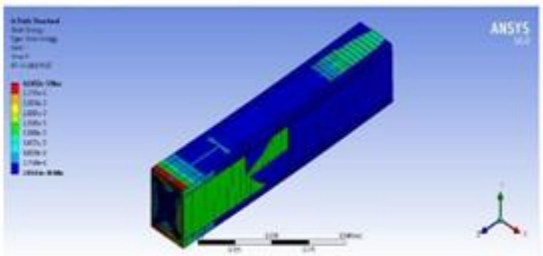

Fig 7 Unconfined RC Beam equilateral stress behaviour

RESULTS CHARTS

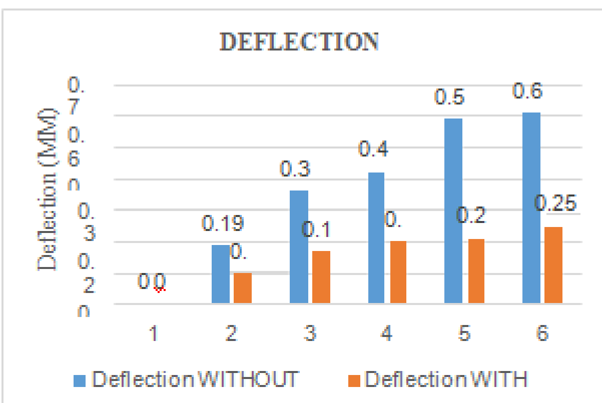

Fig. 7: Comparison of deformation with and without frp .

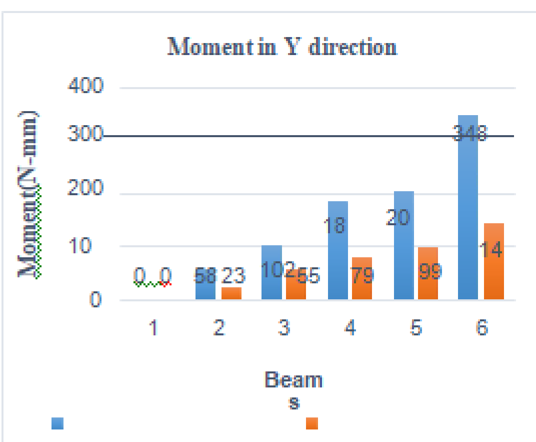

Fig. 8: Comparison of B.M in Y- direction .

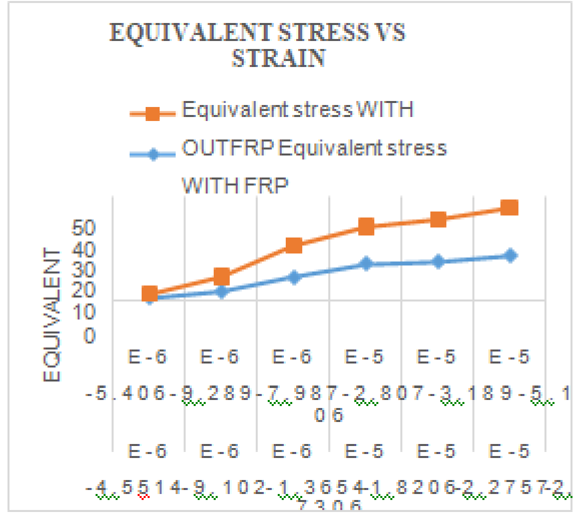

Fig 9 Equivalent stress v/s Equivalent strain for beam

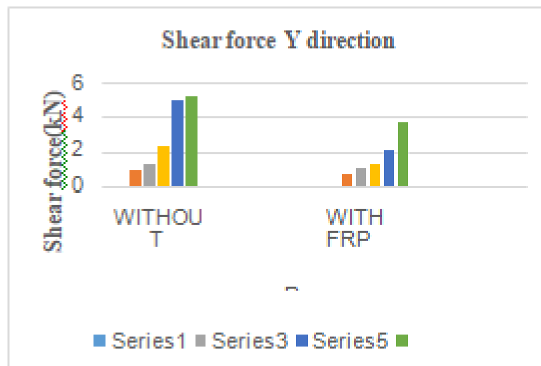

Fig. 10: Comparison of shear force in Y- direction.

VI. CONCLUSION

- According to the analytical FEM value of FRP Wrapped R.C. Beam and Controlled R.C. Beam are 1.374*10^6N/mm^2 and 1.234*10^6N/mm^2.
- The Structural behavior of rectangular concrete beam was analyzed by Finite Element Analysis software ANSYS and the following conclusions are drawn.
- The load carrying capacity of FRP wrapped R.C.Beam dominates over the controlled R.C. Beam. The confinement of FRP strengthen the RC Rectangular Beam and thus increases the strength and stiffness of the Rectangular beam. The FRP confinement enhances stiffness of the RC Beam and shows improved load carrying capacity. The effect of thickness of confinement on strength and stiffness showed much improved deformation characteristics.
- The above conclusions necessitate that ANSYS is capable of predicting FRP confinement characteristics of R.C. Beam.

REFERENCES

[1] Tarek H. Almusallam and Yousef A. Al- Salloum, Ultimate strength prediction of RC beams externally strengthened by composite materials, composite engineering, Feb-2001, Part-B, pp 609-19.

[2] Y.C. Wang, C.H. Chen, Analytical study on reinforced concrete beams strengthened for flexure and shear with composite plates, 2003, Composite Structure, pp 13748.

[3] Sergio F. Bren, Beth M. Macri, Effect of Carbon-Fiber Reinforced Polymer Laminate Configuration on the Behavior of Strengthened Reinforced Concrete Beams, May-June 2004, Journal of Composites for Construction, pp 229-40.

[4] Hsuan-Teh Hu, Fu-Ming Lin and Yih-Yuan Jan, Nonlinear finite element analysis of reinforced concrete beams strengthened by fiber-reinforced plastics, 2004, Composite Structure, pp 271-81.

[5] J. Lundqvist, H. Nordin, B. Täljsten and T. Olofsson, Numerical analysis of concrete beams strengthened with CFRP– a study of anchorage lengths, 2005, International Institute for FRP in Construction.

[6] F.A.Fathelbab, M.S.Ramadan and A. Al- Tantawy, Finite element modelling of strengthened simple beams using FRP techniques: A parametric study, Concrete Research Letters, June-2011, Volume-2, pp 228-40.

[7] A.Vijayakumar, Dr.D.L.Venkatesh babu and R. Jayaprakash, Analytical study on various types of FRP beams by using AVSYS, International Journal of Engineering Research and Applications, Sep-Oct 2012, Volume-2, pp 593-98.

[8] Kaushal Parikh and C.D.Modhera, Application of GFRP on preloaded retrofitted beam for enhancement in flexural strength, International Journal of Civil and Structural Engineering, May-2012, pp 1070- 80.

[9] P.Jayajothi, R Kumutha and K. Vijai, finite element analysis of FRP strengthened RC beams using ANSYS, Asian Journal of Civil Engineering, 2013, Volume-14, pp 631-42.

[10] C.C. Spyrakos, I.G. Raftoyiannis, L. Credali and J. Ussia, Experimental and Analytical Study on Reinforced Concrete Beams in Bending Strengthened with FRP, 2014, The Open Construction and Building Technology Journal, pp 153-63.