Retrofitting of Reinforced Concrete Beams using CFRP Jacketing

M. Leeladhar Reddy, A.V.S Sai Akhil, G. Sri Harsha

Abstract:--- After the completion of the design life of a structure, there is a necessity to repair or upgrade the structure in many ways. This strengthening and improvement of the performance of the deficient structural element is known as retrofitting. The main objective of the retrofit is to strengthen the building to satisfy the requirements of the present design load. In this paper, An RCC structure has been designed and analyzed in E-Tabs. The number of floors in the structure was increased over the top floor of the existing structure and due to increase of the floors in the structure the design loads were increased. Some of the existing columns in the bottom floors were failed and these are retrofitted using CFRP jacketing technique in ANSYS to increase the strength and to meet the current design requirements.

Index Terms: Design Loads, Flexural Stress, Jacketing, Longitudinal Reinforcement, Retrofitting.

I. RESEARCH SIGNIFICANCE

In the recent times, RC structures must be strengthened for various reasons such as to increment the loads, due to damage of structural elements, ageing, corrosion, reduction of stresses, deformation or crack width and deviations in planning or execution in construction. The most used technique to strengthen these types of structures is retrofitting. The main objective of retrofitting is to enhance the performance of deficit structural elements. Retrofitting indicates the addition of new technology or features to older systems.

I. INTRODUCTION

Retrofitting is the process of strengthening the structure or the structural elements using different techniques. It is of two types: Global retrofitting and Local retrofitting. The main target of global retrofitting is to provide seismic resistance. The Seismic waves that reach the earth's surface cause an earthquake[1]. Sudden Seismic forces is the major problem faced in the construction field, so to resist the effect of seismic force on the building addition of shear walls was introduced to the structure. Local retrofitting concentrates on improving the load resistance of the member by using advanced techniques like jacketing to structural members i.e, beam, column, & beam-column joint[2].

Reinforced Concrete Jacketing, Steel jacketing and fibre reinforced polymer jacketing[3] are the advanced techniques available for retrofitting which are used to increase the flexural strength and shear strength of the beam or column. Fibre Reinforced Polymer (FRP) is the composite material that is increasingly used in the construction industry. Usage of FRP materials have been increased in recent years because of their light weight and high strength and resistance to corrosion[4].

In retrofitting FRP jacketing is used because carbon fibre is flexible and made to contact the surface tightly for a high degree of confinement due to its high strength and modulus of elasticity[5]. The main advantage of using FRP wrapping in beams is to increase the ductility, increase in flexure, shear strength and rapid installation [6].

In the present study, the structure is designed and analyzed using different loading conditions. Some of the structural elements were failed, at this stage we have to re-design the structure but the other alternative for this is to identify the failed structural elements and retrofit them with the suitable technique to increase the load carrying capacity of that structural element.

II. STRUCTURE DETAILS

A G+5 structure is designed and analyzed in ETABS as shown in Fig.1. The failure beams are identified and strengthened using a suitable jacketing technique in ANSYS software. The failure load is applied to the same members in ANSYS with CFRP jacketing and results are compared between concrete beam without jacketing and the beam jacketed with CFRP. The purpose of using ANSYS is the ease to simulate engineering materials like reinforced concrete, polymers, metal.

Table 1: Structural Specifications

S. No	Parameters & Elements	Dimension
1	Length of Structure	19m
2	Breadth of Structure	14m
3	Height of the Structure	16m
4	Cross Section of Beam	200mm x 400mm
5	Cross Section of Column	250mm x 450mm

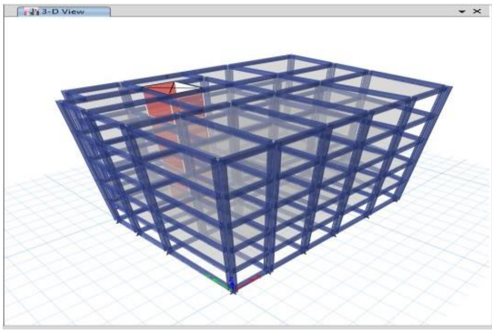

Fig. 1: 3D View of the Building

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M. Leeladhar Reddy, UG Student, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur - 522502, AP, India.
A.V.S Sai Akhil, UG Student, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur - 522502, AP, India.
G. Sri Harsha, Assistant Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur - 522502, AP, India.

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III. MATERIAL SPECIFICATIONS

A. Concrete

Table 2: Concrete Properties

S. No	Properties	Values
1	Density	2548.53Kg/m^3
2	Modules of Elasticity	25000MPa
3	Poissions Ratio	0.2
4	Co-Efficient of Thermal Expansion	0.0000055 1/C
5	Shear Modules	10416.67Mpa
6	Compressive Strength	25MPa

B. Steel

Table 3: Steel Properties

S. No	Properties	Values
1	Density	7849.047Kg/m^3
2	Modulus of Elasticity	200000MPa
3	Poissions Ratio	0.3
4	Co-Efficient of Thermal Expansion	0.0000117 1/C
5	Tensile Yield Strength	415MPa
6	Tensile Ultimate Strength	485MPa

IV. SPECIMEN DETAILS

A. Finite Element Analysis

Finite element analysis can be applied for any type of problems such as stress analysis, magnetic field. The body or the region that has to be analyzed may have any shape i.e. no geometric restriction[7]. The specimen that is to be simulated has been modelled using ANSYS 18.2 workbench. Linear static analysis is the type of analysis done using ANSYS[8]. A concrete beam is modelled and CFRP sheets of thickness 2mm were wrapped around the member on all the sides as shown in fig.2.

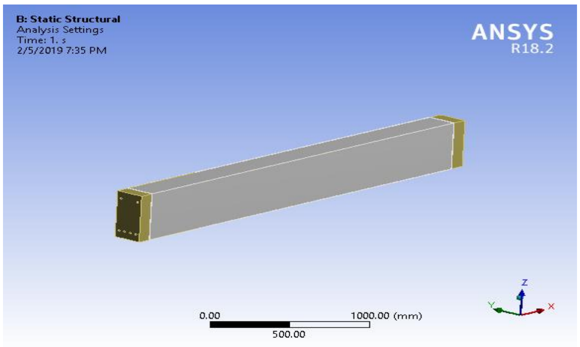

Fig. 2: Beam jacketed with CFRP wrapping

A. Meshing

The objective of Meshing is to create element connectivity data and nodal coordinate data[9]. Meshing is done to get good results; preferably rectangular meshing is recommended. The overall mesh of the volume is shown in fig.3.

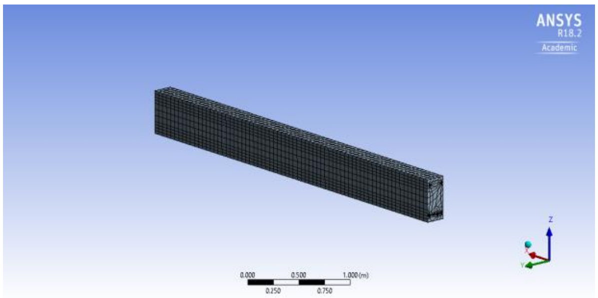

Fig. 3: Meshing of Beam

C. Loading and Boundary conditions

Fixed supports are provided for the beam at both the ends and loads are applied in transverse direction of the model. These loads are obtained from E-TABS by designing the G+5 structure.

V. INTERPRETATION OF RESULTS

The following graphs show a detailed comparison of failed beams with jacketing and without a jacket.

A. Equivalent Stress v/ s Equivalent Strain

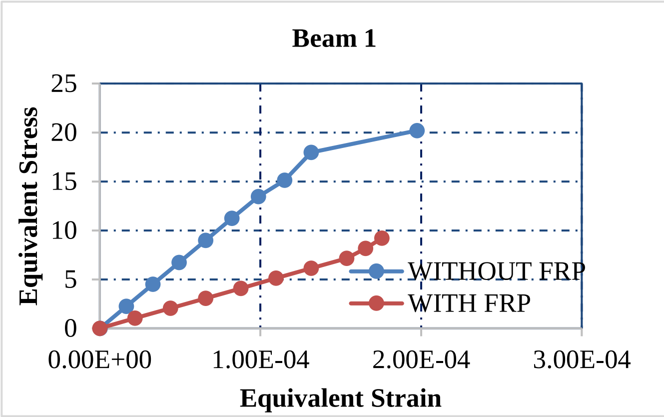

Fig. 4: Equivalent stress v/s Equivalent strain for beam 1

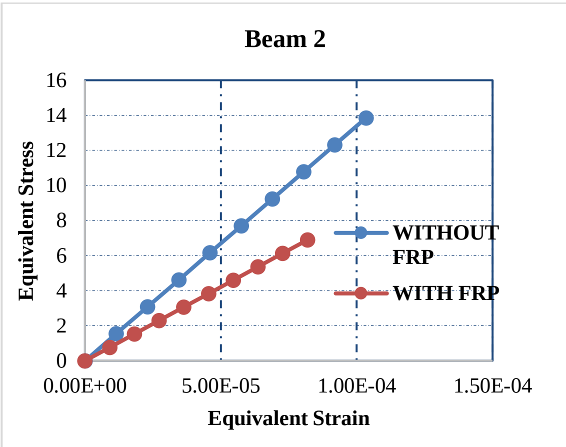

Fig. 5: Equivalent stress v/s Equivalent strain for beam 2

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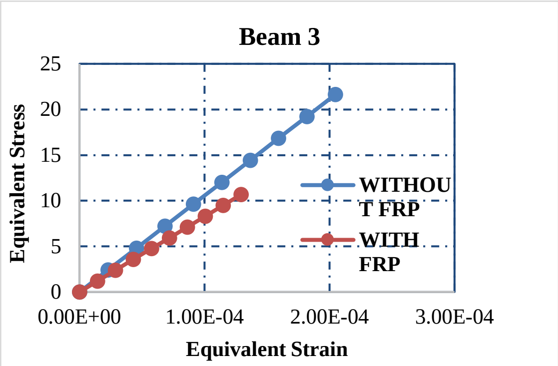

Fig. 6: Equivalent stress v/s Equivalent strain for beam 3

A. Deformation

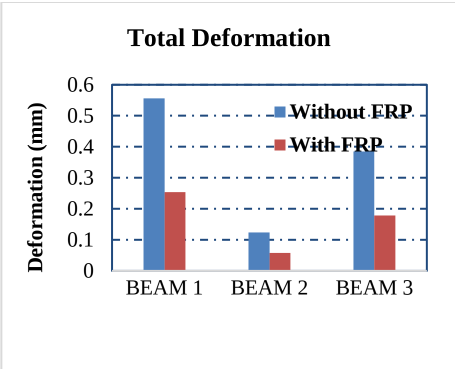

Fig. 7: Comparison of deformation before and after jacketing

C. Shear Force

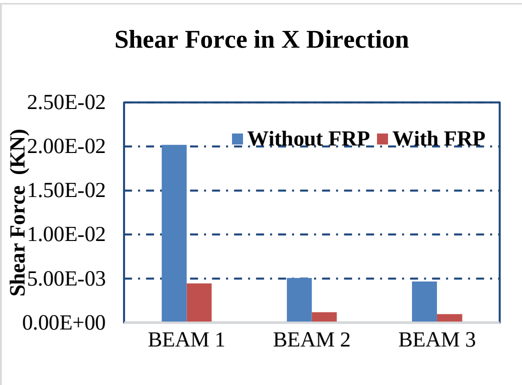

Fig. 8: Comparison of shear force before and after jacketing in X- direction

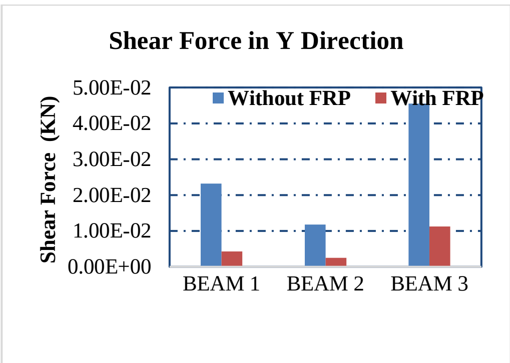

Fig. 9: Comparison of shear force before and after jacketing in Y- direction

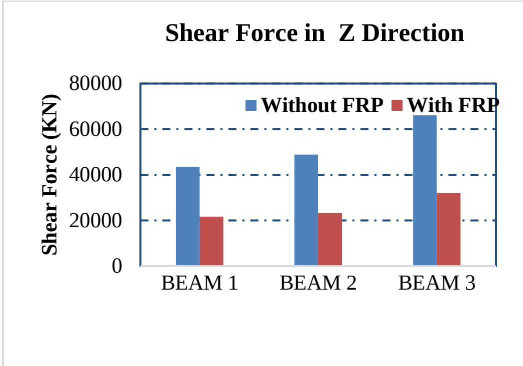

Fig. 10: Comparison of shear force before and after jacketing in Z- direction

D. Bending Moment

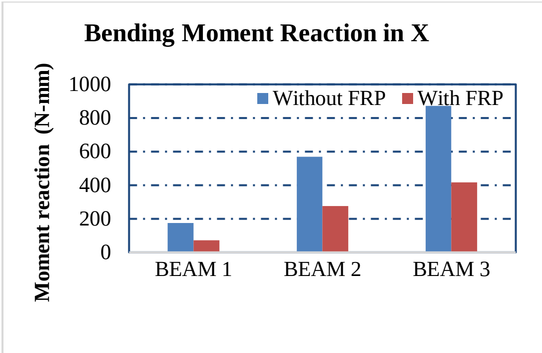

Fig. 11: Comparison of B.M before and after jacketing in X- direction

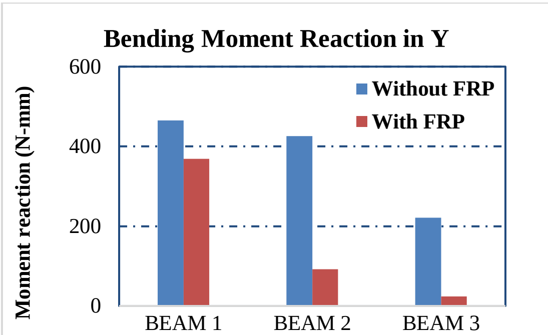

Fig. 12: Comparison of B.M before and after jacketing in Y- direction

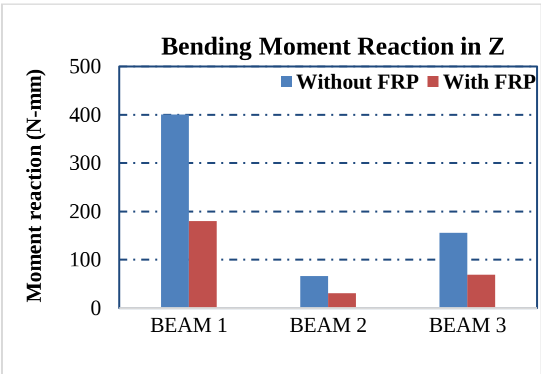

Fig. 13: Comparison of B.M before and after jacketing in Z- direction

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VI. CONCLUSIONS

- Total deformation is reduced by 45.66%, 46.82% and 46.28% for Beam 1, Beam 2 and Beam 3 respectively when CFRP wrapping is introduced.
- Shear force in X-direction is reduced by 22%, 23.48% and 20.61% for Beam 1, Beam 2 and Beam 3 respectively when CFRP wrapping is done.
- Shear force in Y-direction is lowered by 18.52%, 21.58% and 24.78% for Beam 1, Beam 2 and Beam 3 respectively when CFRP wrapping is implemented.
- Shear force in Z-direction is decreased by 49.59%, 47.65% and 48.5% when CFRP wrapping is introduced.
- Bending moment in X-direction is reduced by 41.41%, 48.4% and 47.73% for Beam 1, Beam 2, Beam 3 respectively when CFRP wrapping has done.
- Bending moment in Y-direction is reduced by 79.26%, 21.67% and 10.95% for Beam 1, Beam 2, Beam 3 respectively when CFRP wrapping has implemented.
- Bending moment in Z-direction is reduced by 44.82%, 45.82% and 44.44% for Beam 1, Beam 2, Beam 3 respectively when CFRP wrapping has introduced.
- Comparing with the normal concrete beams the equivalent stress in the beams jacketed with CFRP wrapping are decreased by 45.5%,49.75%, 49.34% for Beam 1, Beam 2 and Beam 3.
- Comparing with the normal concrete beams the equivalent strain in the beams jacketed with CFRP wrapping decreased by 88.89%, 79.16%, 63.11% for Beam 1, Beam 2 and Beam 3.

1. REFERENCES

1. G. S. Harsha and H. Sudarsana Rao, "shear wall analysis & design optimization in high rise buildings," vol. 4, no. 8, pp. 333–341, 2015.
2. N. Gupta, P. Dhiman, and A. Dhiman, "Design and Detailing of RC Jacketing for Concrete Columns," pp. 54–58, 2013.
3. S. S. Raval and U. V. Dave, "Effectiveness of various methods of jacketing for RC beams," *Procedia Eng.*, vol. 51, no. NUiCONE 2012, pp. 230–239, 2013.
4. S. E. Günaslan, A. Karaşin, and M. E. Öncü, "Properties of FRP Materials for Strengthening," vol. 1, no. 9, pp. 656–660, 2014.
5. P. Ranjan and P. Dhiman, "Retrofitting of Columns of an Existing Building by RC, FRP and SFRC Jacketing Techniques," *IOSR J. Mech. Civ. Eng.*, vol. 16, pp. 40–46, 1987.
6. B. J, Concrete Structures Repair, Rehabilitation & Retrofitting, 1st ed. CBS, 2005
7. R. J. W. Robert D. Cook, David s Malkus, Michael E. Plesha, *Concepts and Applications of Finite Element Analysis*, 4th ed. Wiley, 2013.
8. S. S. Dhanush, U. F. Pasha, and N. S. Kumar, "Retrofitting of Existing RC Columns by Reinforced Concrete Jacketing Using ANSYS and ETABS," vol. 7, no. 6, pp. 572–578, 2018.
9. B. D. A. Chandrupatla R. Tirupathi, *Introduction to Finite Elements in Engineering*, 2nd ed. Eastern Economy Edition, 1999.

AUTHORS PROFILE

M. Leeladhar Reddy is doing his Bachelor of Technology in Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India. His research interests include Retrofitting of Structures, Seismic Analysis of RC structures, Concrete materials.

A.V.S. Sai Akhil is doing his Bachelor of Technology in Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India. His research interests include Retrofitting of Structures, Biaxial Coaxial Slabs and Analysis of RC structures, Concrete materials.

Mr G. Sri Harsha is working as Assistant Professor in Department of Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India. He is pursuing a PhD in Koneru Lakshmaiah University and completed a Master of Technology in Structural Engineering from JNTU Anantapur in 2015. His research interests include Structural Dynamics, Earthquake resistant Structures and Concrete Materials. He has published 7 research papers in various international journals and conferences and guided 5 students in masters and 14 students in bachelors. He is a lifetime permanent member of ICI (Indian Concrete Institute), IAENG & ISRD