COMPARATIVE STUDY ON RETEROFITTING OF RCC BEAM AND COLUMN JOINT BY USING FERRO CEMENT, GFRP AND CFRP

Kartik Yadav[1], Bilal Siddiqui[2], Dr. Satyendra Roy[3]

[1]*M.Tech Scholar, Structural Engineering, Babu Banarasi Das University, Lucknow, India*
[2]*Assistant Professor, Department of Civil Engineering, Babu Banarasi Das University, Lucknow, India*
[3]*Head of Department, Department of Civil Engineering, Babu Banarasi Das University, Lucknow, India*

Abstract— The effective implementation of a quality fire safety model of Reinforced Concrete (RC) structures relies on the reliable numerical simulation tools of RC exposed to elevated temperature. To assess the thermal behaviors, models were created for Glass Fibber Reinforced Polymer (GFRP) RC beams exposed to fire loads. The performance of fiber reinforced polymer (FRP) composites at high temperatures is a serious concern that needs investigation before the incorporation of these composites into important engineering structures. This article presents an experimental study on the tensile properties of carbon fiber reinforced polymer (CFRP) sheets, hybrid carbon/glass fiber reinforced polymer (C/GFRP) sheets and hybrid carbon/basalt fiber reinforced polymer (C/BFRP) sheets at different temperatures.

Keywords—Fibre Reinforced Polymer; finite element Analysis; ANSYS; CFRP; modelling.

I. INTRODUCTION

An increasing range of concrete structures have reached the top of their service life, both thanks to deterioration of the concrete and reinforcement caused by environmental issue and also the widespread application of deicing salts, thanks to a rise in applied masses. These deteriorated structures could also be structurally deficient or functionally obsolete, and most are currently in serious want of in-depth rehabilitation or replacement. Strengthening will be used as an economical different to the replacement of those structures and is usually the sole possible answer. Their application in technology structures has been growing speedily in recent years, and is changing into an efficient and promising answer for strengthening deteriorated concrete members. as results of FRPs are quickly and simply applied, their use minimizes traffic disruption and labour prices and result in important savings within the overall value of project. Fiber bolstered Polymers (FRP) sheets or plates are well matched to the present application as a result of their high strength-to-weight quantitative relation, sensible fatigue properties, and glorious resistance to corrosion.

2. LITERATURE REVIEW

Marco et al. (1997) [1] Two CFRP material systems, two concrete surface preparation, two RC cross sections, and number and location of CFRP piles. For two specimens, the presence of applied load (simulating total service load) as well as external prestressing during adhesion of the CFRP reinforcement (reinforcement), were investigated. It is shown that the effect of CFRP strengthening was considerable, but effect of some of the tested variables was modest. Different failure mechanism from ductile to brittle were simulated and verified, adopting mechanical properties of the constituent materials obtained via standard tests or using a simple test for concrete adhesive interface.

Duthinh et al. (2002) [2] Studied strength & ductility of RC beams wrapped with CFRP. Referring to work carried out by Naaman et al. (2001) study was carried out. In the tests seven concrete beams reinforced internally with varying amounts of steel & externally with precured CFRP plates after the concrete had cracked under service loads. Curvature was computed in constant moment region by measuring strains.

Niu et al. (2006) [3] Studied the effect of interface bond properties on the performance of FRP-strengthened reinforced concrete (RC) beams in terms of concrete cracking, interface stress transfer. FRP bonding technology highly depends on bond integrity between concrete & FRP.

Mukherjee & Rai (2015) [4] It is noticed that the flexure performance of the rehabilitated beams was far superior to that of the fresh RC beams. The beams had higher failure loads and lower deflections. They remained in the elastic zone for a much higher applied load. The recovery from the deformation increased with the increase in the prestressing force. As a result, the area under the load-deflection curve was much higher for the highly prestressed beams. However, the ultimate load and the maximum deflection did not go up significantly with higher levels prestress.

Heffernan & Erki (2004) [5] The author investigated fatigue behavior of reinforced concrete beams Post strengthened with CFRP laminates. For these twenty reinforced concrete beams, 150 X 330 X 3000 mm, were casted. The CFRP sheets were cut to 125 X 2650 mm and applied in accordance with the specifications of the manufacturer. The fatigue life of a CFRP strengthened reinforced concrete beam appeared to be at least as long as for an equivalent strength conventionally reinforced concrete beam subjected to the same loads, where that fatigue life is largely dependent on the stress range applied to the steel reinforcement.

Li et al. (2005) [6] The author did Experimental and numerical analyses are performed to predict the loading carrying capacity of reinforced concrete beams strengthened with carbon fiber reinforced plastics (CFRP) composites. Four-point bending test was carried out for rectangular beams in a large testing frame of 2000 KN capacity. Dimensions of the beams were b X h = 120 X 200, length = 2000mm, clear span = 1800mm, which were designed as under reinforced.

Xiong et al. (2004) [7] The test program including six beams was carried out. Two strengthening systems, namely hybrid carbon fiber glass fiber-reinforced polymer strengthening and CF-reinforced polymer strengthening were used. The beams were 125 X 200 mm in cross section and 2,300 mm in length. The process of applying a fiber sheet to concrete involved surface preparation, priming, resin undercoating, fiber sheet application, and resin over coating according to ACI 2000

Silva & biscaia (2007) [8] The degradation of bond between FRP & RC beam. The effects of cycles of salt fog, temperature and moisture as well as immersion in salt water on the bending response of beams externally reinforced with GFRP or CFRP, especially on bond between FRP reinforcement and concrete was considered. Temperature cycles (- 10oC to 10oC) and moisture cycles were associated with failure in the concrete substrate, while salt fog cycles originated failure at the interface concrete–adhesive. Immersion in salt water and salt fog caused considerable degradation of bond between the GFRP strips and concrete.

Benjeddou et al. (2006) [9] The damaged reinforced concrete beams repaired by external bonding of carbon fiber reinforced polymer (CFRP) composite laminates to the tensile face of the beam. Two sets of beams were tested in this study: control beams (without CFRP laminates) and damaged and then repaired beams with different amounts of CFRP laminates by varying different parameters (damage degree, CFRP laminate width, concrete strength class).

P. Parandaman and M. Jayaraman (2014) [10] From the analysis of RC beam retrofitted with different FRP sheets the following conclusions were obtained. When the RC beam is wrapped with carbon fiber reinforced polymer (CFRP), the deflection of the beam is 73% minimized. When wrapped with glass fiber reinforced polymer (GFRP), the deflection of the beam is 65% minimized.

3. METHODOLOGY

FINITE ELEMENT MODELLING

Concrete exhibits a large number of micro cracks, especially, at the interface between closer aggregate and mortar, even before subjected to any load. The presence of these micro cracks has a great effect on the mechanical behavior of concrete, since their propagation during loading contributes to non-linear behavior at low stress levels and causes volume expansive near failure.

Column size- 175 mm x 150 mm, Beam size- 175 mm (D) x 150 mm(B), Strength of concrete fck- 20 N/mm2., Yield strength of steel fy- 415 N/mm2.Column longitudinal steel- 16 mm diameter- 4 nos. Column lateral tie- 8 mm diameter @ 150 mm c/c.. Beam main reinforcement steel- 12 mm diameter- 4 nos. Beam stirrups- 8 mm @ 100 mm c/c. Maximum load on column – Pmax. - 15kN.

W max -15 kN. Column height- 1500 mm, Beam length- 600 mm. RCC beam column joints were designed for analysis based on IS 1893-2002 Criteria for Earthquake Resistant design of structures and detailing based on IS 13920-1993 Edition 1.2 (2002-03) on Indian Standard Code of Practice.

The structural geometry of exterior beam column joint has been modelled for the mentioned dimension and analyzed using ANSYS. The exterior beam column joint has been analyzed without CFRP wrapping.

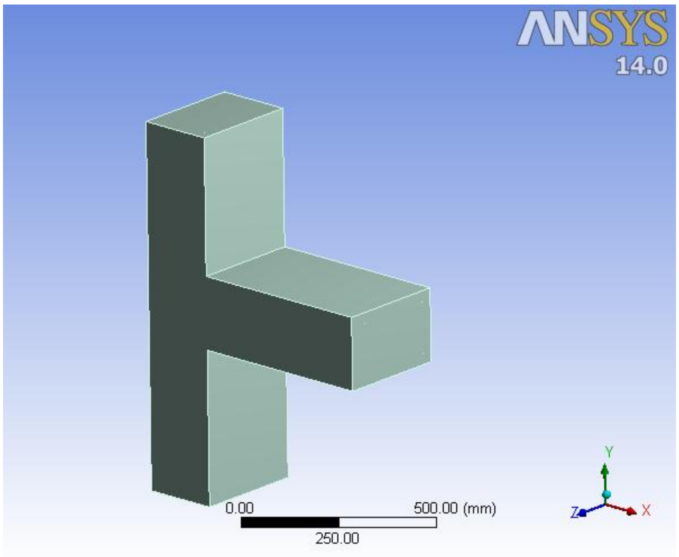


Figure 1. Simple beam column joint

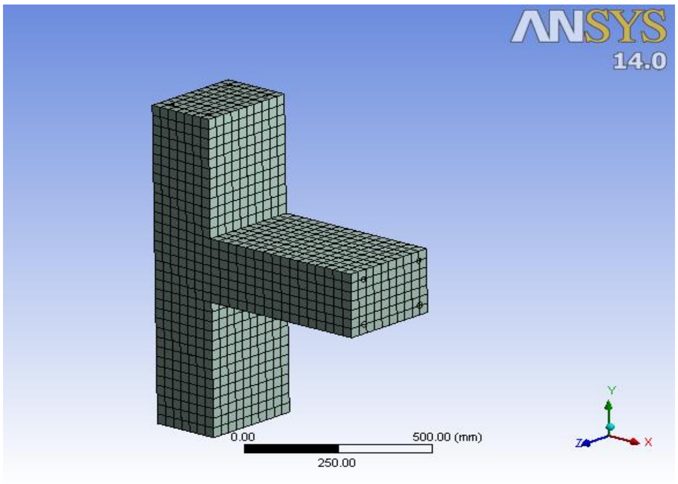


Figure 2. Mesh model for exterior beam column joint without wrapping

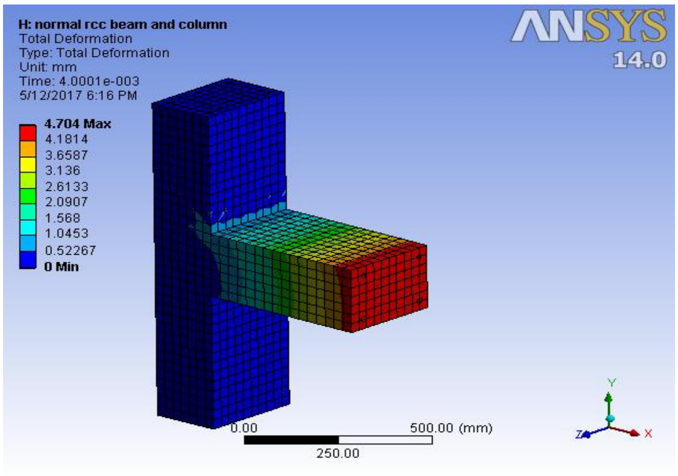


Figure 3. Deflection for concrete exterior beam column joint without CFRP wrapping

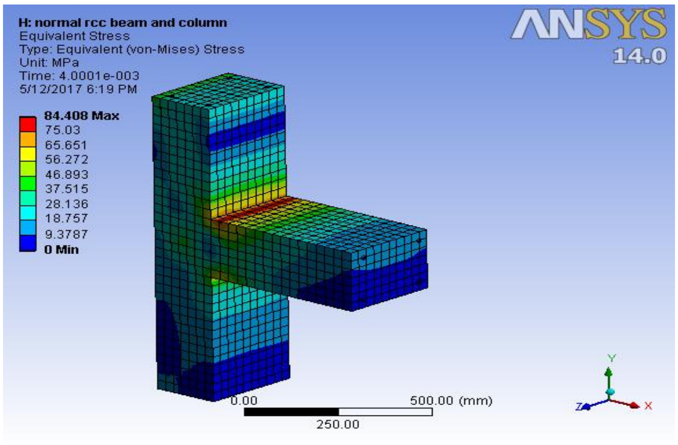


Figure 4. Equivalents stresses for concrete the beam column joint without CFRP wrapping

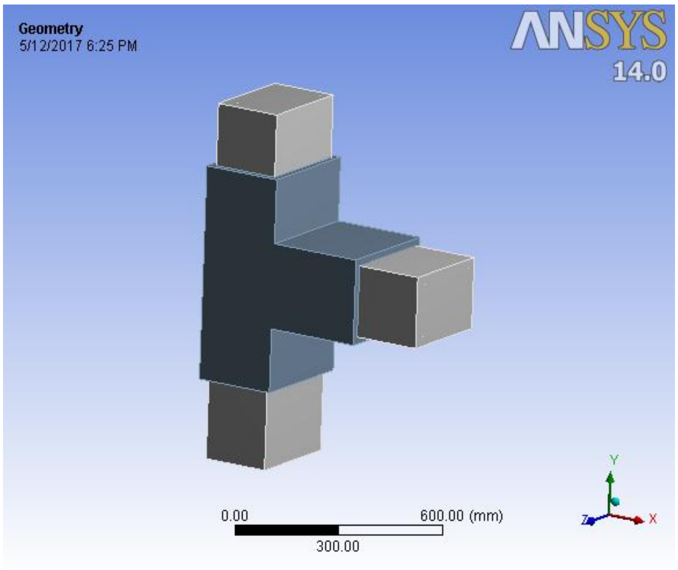


Figure 5 The exterior beam column joint model with ferro

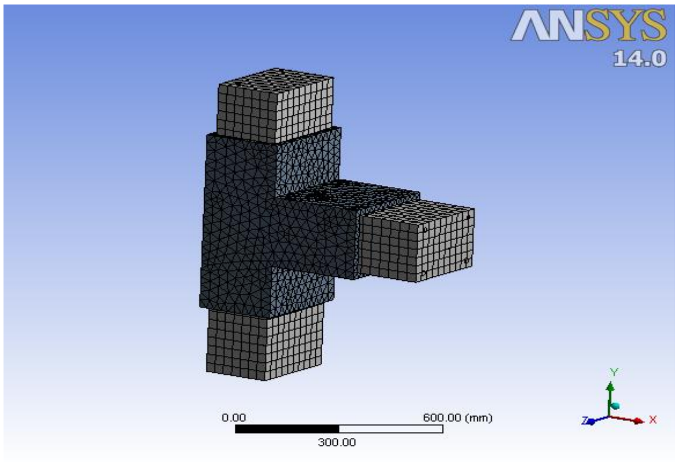


Figure 6. Mesh model for exterior beam column joint with ferro wrapping

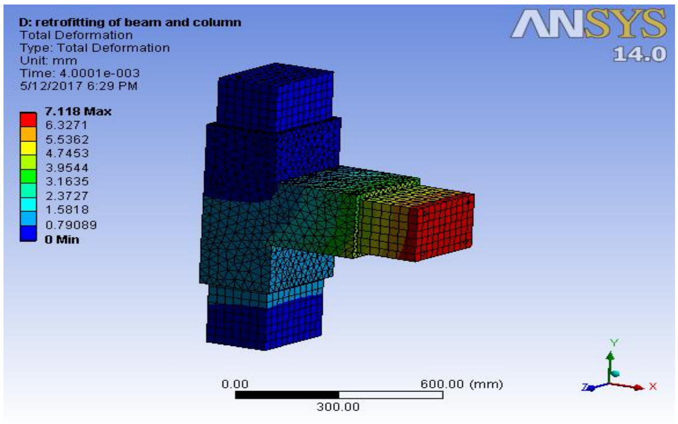


Figure 7. Deflection for exterior beam column joint with ferro wrapping

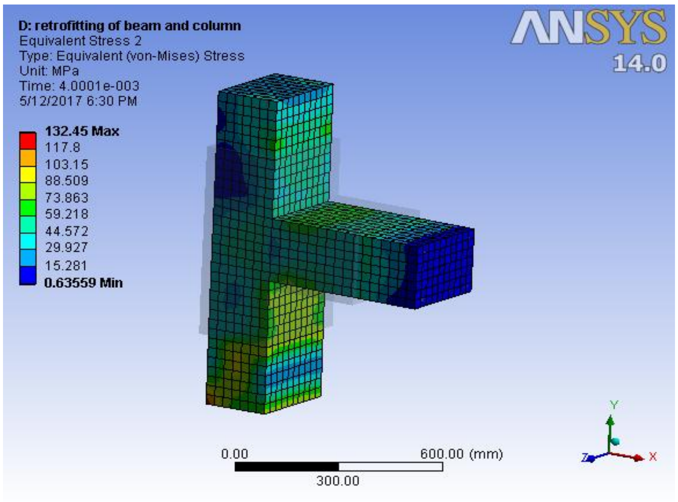


Figure 8. Equivalent stress for concrete the beam column joint with ferro wrapping

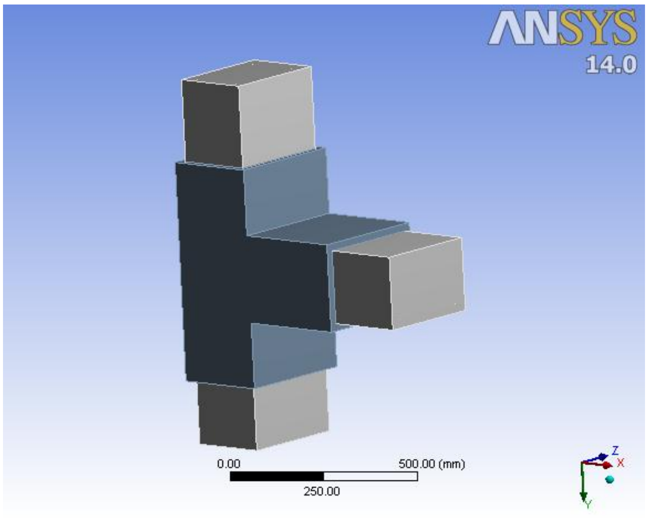


Figure 8. The exterior beam column joint model with GFRP

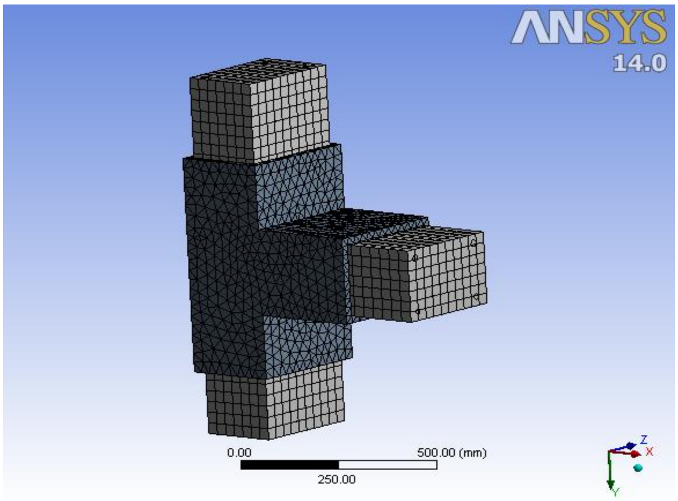


Figure 9. Mesh model for exterior beam column joint with GFRP wrapping

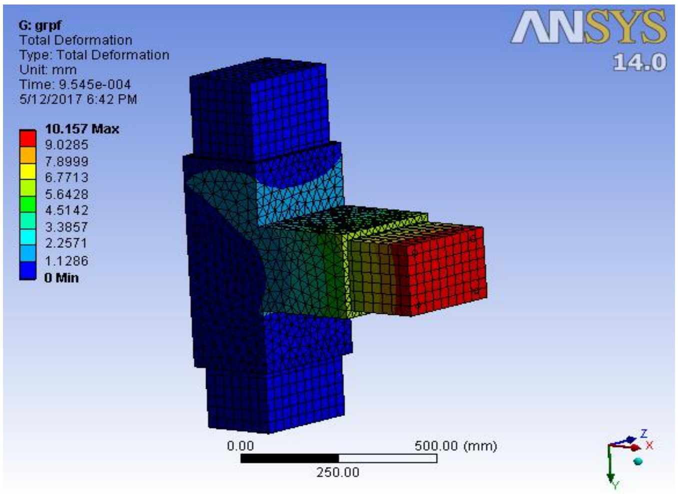


Figure 10. Deflection for exterior beam column joint with GFRP wrapping

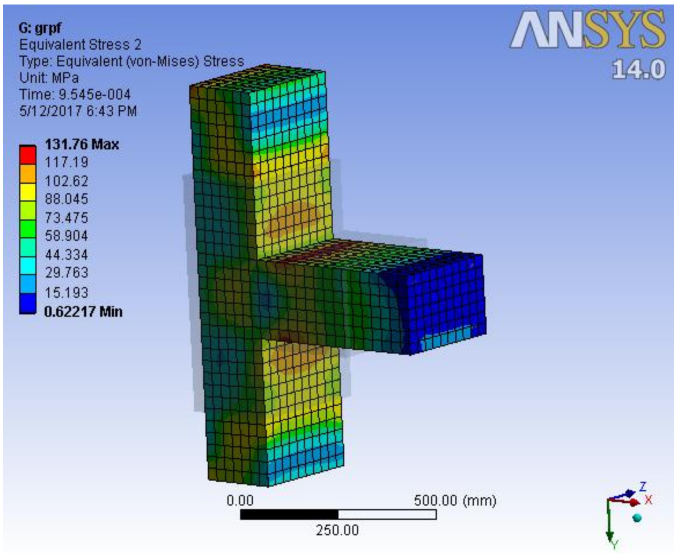


Figure 11. Equivalent stress for concrete the beam column joint with GFRP wrapping

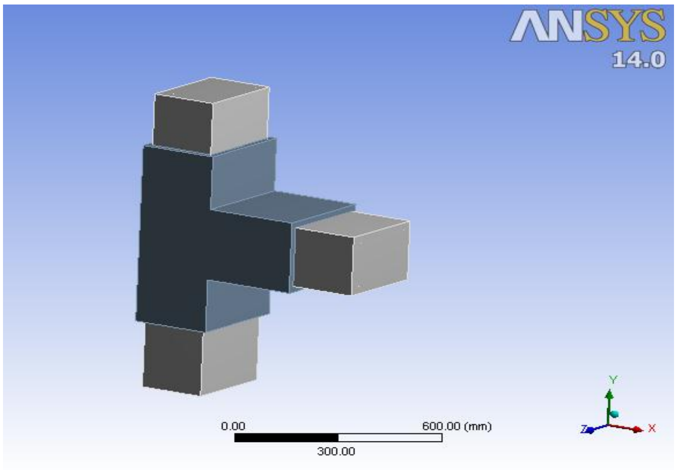


Figure 12. The exterior beam column joint model with CFRP

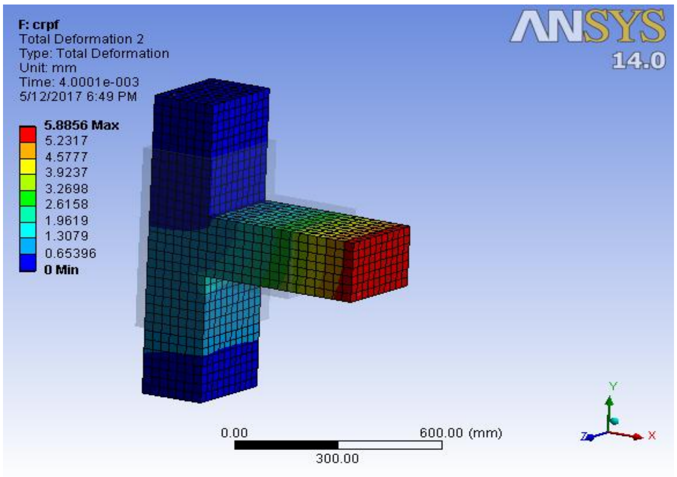


Figure 13. Deflection for exterior beam column joint with CFRP wrapping

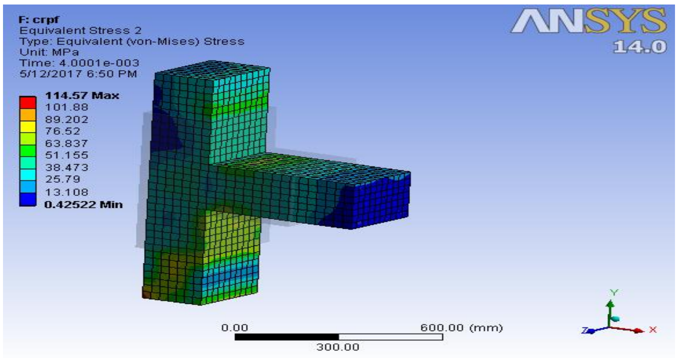
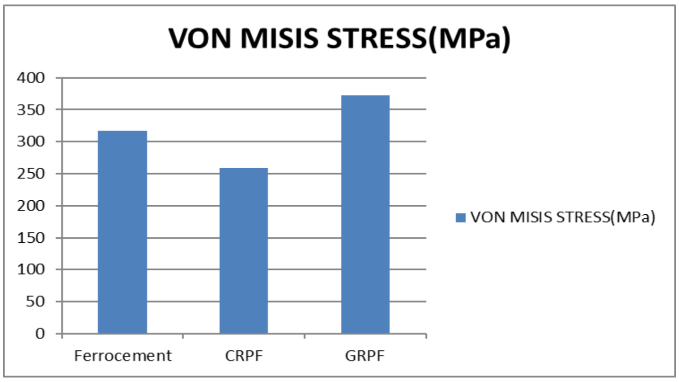


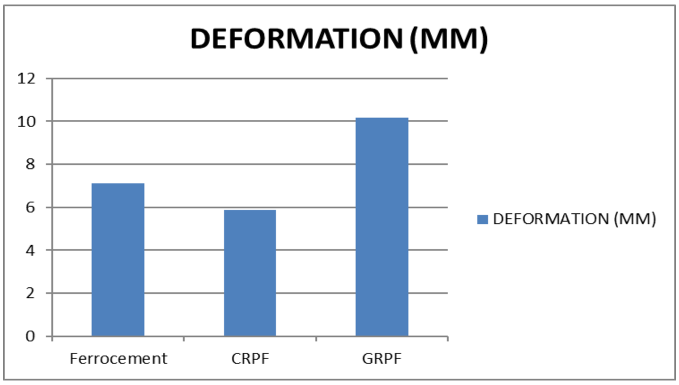
Figure 14. EQUIVALENT STRESS FOR CONCRETE THE BEAM COLUMN JOINT WITH CFRP WRAPPING

4. RESULT AND DISCUSSION

For glass fiber initial deflection is larger than steel due to low value of Young's Modulus. Specimen retrofitted shows reduction in deflection values. Concrete jacketed specimen with 20 mm thick shows 31.25 % reduction in deflection values. ferro with 20 mm thickness shows 55 % reduction in deflection value, while glass fiber retrofitted specimen results in 42 % reduction in deflection compared to the control specimen. In case of 40 mm thick concrete retrofitted specimen shows 38.3 % reduction in deflection value compared to the control specimen. While for CFRP and GFRP retrofitting reduction in deflection values are 60.42 % and 48 % respectively. Loading carrying capacity of retrofitted specimens is higher than control specimens. For control specimen 15 kN is the ultimate load.



Graph 1



Graph 2

For concrete jacketed specimen with 20 mm thickness 8.40 %in the load carrying capacity, for steel retrofitted specimen it is 25% increase and for glass fiber with same thickness results in 33.33 % increase in load value. For retrofitted specimens with 40 mm thick increase in load carrying capacity are 16.7 %, 33.33 % and 50 % higher than control specimen. Stress values in rebar and concrete for retrofitted specimens are higher than control specimens. Because retrofitted specimen carries more load compared to control specimen. 5.

5. CONCLUSION

In this the numerical results of with ferro cement, CFRP wrapping, without CFRP wrapping and GFRP wrapping are interpreted. Their behavior throughout the analysis is studied from the recorded data obtained from the deflection behavior and load carrying capacity using ANSYS. The strengthened and unstrengthen beam column joints are tested for their ultimate strength.

- The load carrying capacity of the retrofitted specimen is 30% more than the unstrengthen specimen.
- The load deformation characteristic also improves to the large extent in case of retrofitted specimen over unstrengthen specimen.

- The ductility of the retrofitted specimen will be more when compared with the normal specimen.
- CFRP retrofitting specimen of the beam column joint shifted the failure of the joint from column portion to the beam portion of joint which will prevent progressive collapse.

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