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Comparative Study on the Behaviour of Steel Reinforced Beam-Column Joint with GFRP Bars

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Abstract: *Beam-column joints are the crucial zones in the moment resisting structure and are designed to achieve the desired strength and durability. In extreme weathering conditions, the steel in the reinforced concrete is more susceptible to corrosion. So, the steel should be provided with the precautionary measure like coating, etc, if used in such conditions. This results in the use of Fibre Reinforced Polymer (FRP) bars as an alternative to steel since it is non-corrodible. Several researches were done by using FRP bars as an alternative to steel. It is identified that the flexural strength of the beam reinforced with FRP bars were reduced compared to the beams with steel bars. To increase the flexural strength, the fibres were added to the beam. And the seismic behaviour of the beam-column joint will be studied. In this study, a journal proposed by Mohammed Hasaballa and Ehab El-Salakawy is validated using FEA Software package and the results were compared. The comparison between these results was proposed. The failure study is undertaken and compared with GFRP and Steel.*

Keywords: Fibre Reinforced Polymer, Beam-column joints, GFRP, Steel

I. INTRODUCTION

Beam-column joints are the critical elements in moment resisting reinforced concrete frame structure which should be designed to provide the sufficient ultimate strength and deformation capacity. Loads are transferred to the beam-column joints and from the beam-column joints through the members. The bending moments and shear forces generated by these loads are significant. And the additional effects on the beam-column joints are produced by the lateral loads from wind and earthquake. Due to the nature of the beam-column joint's behaviour, the design and detailing of such joints are very important in the construction of moment resisting frames. The failure of these joints can be caused by the improper use of their joints. In most cases, these components can contribute to the collapse or partial collapse of reinforced concrete structures. Various structural defects were identified during the design of this structural element. These issues were mainly due to the improper use of smooth reinforcement bars and the lack of transverse reinforcement in joint regions. Since the 1960s, various studies have been conducted on the behaviour of beam-column joints. In 1976, a general design guideline was developed by American Concrete Institute (ACI) - American Society of Civil Engineers (ASCE) for the joints to determine the joint's size, end anchorage and transverse reinforcement.

Beam-Column joint is defined as the portion of the column within which the depth of the beam frames into the column. Beam-column joints are the critical elements in moment resisting reinforced concrete frame structure. Since it is the connection between beam and column, it should have adequate strength and stiffness.The main purpose of this review is to gain more knowledge about different bracings which is to be provided in steel structure thereby to check its lateral stability and to adopt the optimum bracings.

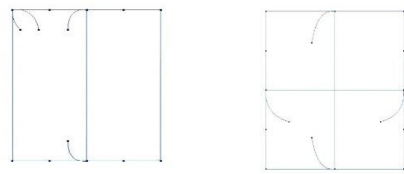
II. OBJECTIVES

The main objectives of the project is to study the literatures, model the beam-column joint using FEA Package software. To study the behaviour of Steel reinforced beam-column joint with Glass Fiber Reinforced Polymer (GFRP) bars by static and dynamic analysis i.e., under monotonic loading and cyclic loading. To analyse the beam-column joint. To interpret the results by comparing with experimental results from literature. To compare the failure of beam-column joint with steel and GFRP bar.

III. VALIDATION FOR GFRP BARS

The beam-column joint is modelled using FEA software package. FEA software package is a finite element analysis environment that provides a simple, consistent interface for creating, submitting, monitoring, and evaluating results from Standard and Explicit simulations. It is divided into modules, where each module defines a logical aspect of the modelling process: for example, defining the geometry, defining material properties, and generating a mesh. The beams and columns were modelled as a solid element. The reinforcement for the beam and column is modelled as a reinforcement element. The stirrups are also modelled as a reinforcement element. The reinforcements were assembled separately.

The material properties are assigned for concrete and GFRP as per the experiment journal proposed by Mohammed Hasaballa and Ehab El-Salakawy.



Beam and Column Reinforcement Details

Reinforcement Details – Beam (350x450 mm)

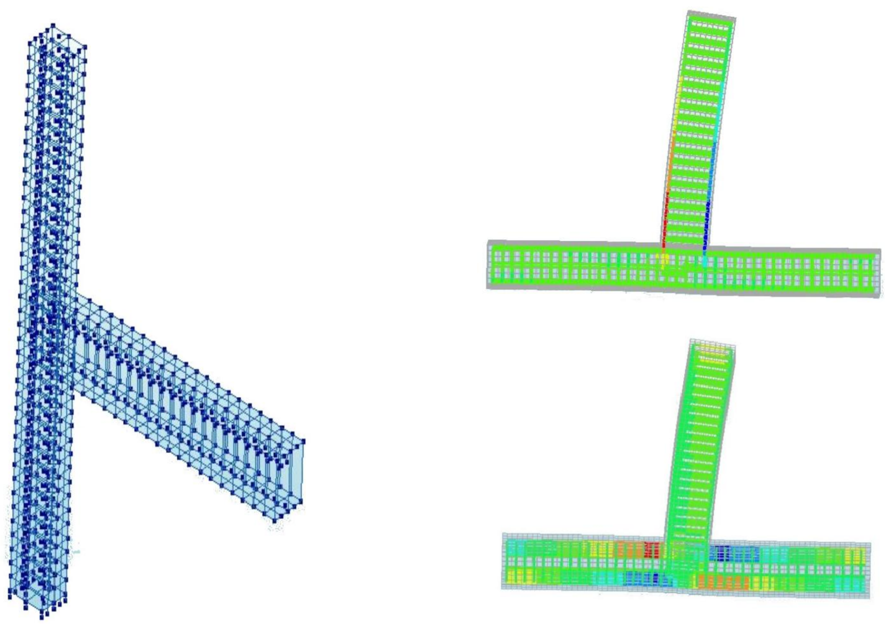
Main Reinforcement – 5 No of 16 mm Día @ top and bottom

Stirrup – 12 mm Día @ 100 mm spacing Column (400x350 mm)

Main Reinforcement – 12 No of 16 mm Día

Stirrup – 12 mm Día @ 90 mm spacing

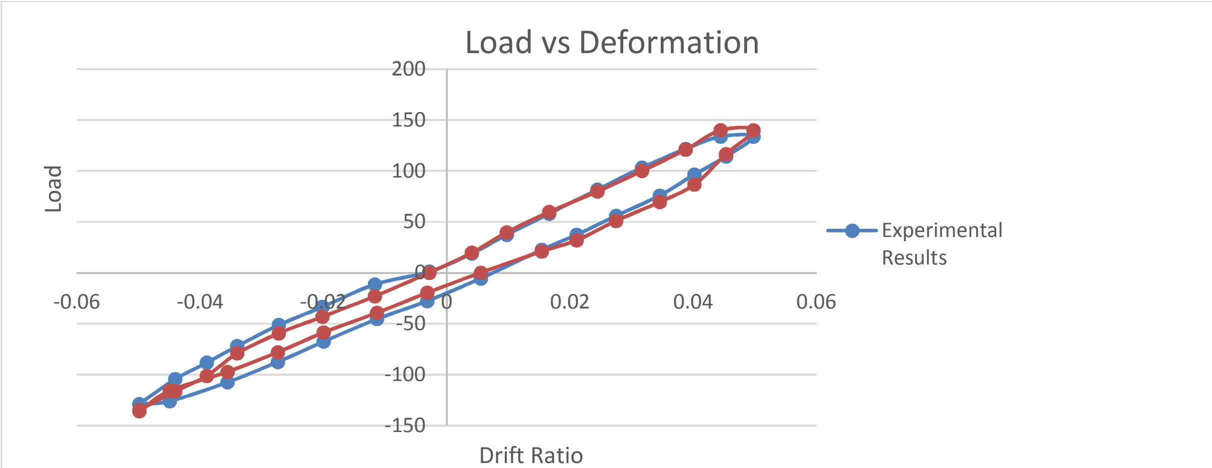
IV. MODELLING AND DEFORMATION



Beam and Column Modelling and Deformation results

V. VALIDATION RESULTS

	EXPERIMENT	FEA SOFTWARE
MAXIMUM LOAD	133.71 kN	140 kN



Graph Results

VI. FAILURE STUDY

Failure Case	Type of Failure	Fails after
Beam column joint with GFRP Bar	Formation of plastic hinge in beam and Shear failure in joint	108.26 mm
Beam Column joint with Steel	Formation of plastic hinge	30.35 mm
Beam with GFRP & Column with Steel	Formation of plastic hinge	50.26 mm
Beam with Steel & Column with GFRP	Formation of plastic hinge in beam and Shear failure in joint	96.61 mm

VII. CONCLUSION

The following conclusions have been drawn based on the results obtained from present study,

1. The concept of using GFRP Bars is one of the advantageous concepts which can be used to strengthen the structures thereby resisting the corrosion.
2. The ultimate load carrying capacity in the positive drift obtained from FEA Software package is increased by 6%, when compared with experimental values.
3. Similarly, the ultimate load carrying capacity in the negative drift is increased by 3.42% when compared with experimental results.
4. The average ultimate load from analytical results is increased by 0.8% when compared with that of experiment.
5. From load-lateral drift response, it is evidenced that the beam-column joints can withstand drift ratio of 6% (deformation up to 105 mm) without any failure.
6. In Comparison to failure models, the hybrid model of column with GFRP Bar and Beam with Steel can be preferred where a model with GFRP is not possible as model with steel fails at smaller deformation than hybrid model.

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