FINITE ELEMENT ANALYSIS OF BEAM COLUMN JOINT WITH GFRP STIRRUPS AND LATERAL TIES IN THE CONFINEMENT ZONE

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***Abstract*— Reinforced beam column joints are an essential part of a structure. The damage occur in these joint will definitely affect the serviceability of the whole structure. GFRP bars can be used as a best suitable replacement for conventional steel as they have a tensile strength twice than that of steel and bond strength is also similar to that of steel. The aim of this project is to study the behaviour of beam column joint with GFRP stirrups and lateral ties in the confinement zone. Total deformation was analysed by FEA modelling in Ansys 15 has compared with a specimen reinforced with GFRP bars as stirrups amd lateral ties in confinement zone.**

Keywords—Beam Column Joint,GFRP,Confinement Zone,Ansys 15

I. INTRODUCTION.

Reinforced concrete beam-column joints are commonly used in structures such as parking garages and road overpasses, which might be exposed to extreme weathering conditions and the application of de-icing salts. The use of the noncorrodible fiber-reinforced polymer (FRP) reinforcing bars in such structures is beneficial to overcome the steel-corrosion problems. However, FRP materials exhibit linear-elastic stress-strain characteristics up to failure, which raises concerns on their performance in beam-column joints in which energy dissipation, through plastic behaviour, is required.

The fiber-reinforced polymer (FRP) reinforcement is currently being used as a viable alternative to steel in new concrete structures especially those in harsh environments. The main driving force behind this effort is the superior performance of FRP in corrosive environments attributable to its noncorrodible nature. However, the FRP materials exhibit linear-elastic stress-strain characteristics up to failure with relatively low modulus of elasticity [40–60 GPa for glass (G) FRP compared to 200 GPa for steel]. Moreover, they have different bond characteristics and relatively low strength under compressive and shear stresses. These mechanical characteristics raise concerns among researchers on the validity of using GFRP in structural members that require the inelastic behaviour (ductility) of reinforcement.

The design philosophy of such joints is on the basis of providing the structure with an adequate ductile mechanism to dissipate the seismic energy. Such a ductile mechanism should be on the basis of a weak beam-strong column concept, while preventing shear damage in the joint zone. It is thought that the large deformation, exhibited by FRP material, may be beneficial in replacing yielding of steel and consequently, allow the FRP reinforced concrete to adequately dissipate the seismic energy.

II. LITERATURE REVIEW

A number of experimental and FEA studies have been conducted for beam column joint over the years. Hamdy M et al (2014) **S**tudied the structural performance of reinforced concrete (RC) exterior beam–column joints rehabilitated using carbon-fiber-reinforced polymer (CFRP).They include the absence of the transverse reinforcement within the joint core, insufficient bond length for the beam main reinforcement and inadequate spliced implanted column on the joint as the defects.Three different strengthening schemes were used to rehabilitate the defected beam–column joints including externally bonded CFRP strips and sheets in addition to near surface mounted (NSM) CFRP strips. The test results showed that the proposed CFRP strengthening configurations represented the best choice for strengthening the first two defects from the viewpoint of the studied failure criteria. Mohammed Mady et al (2015) assess the seismic behaviour of concrete beam-column joints reinforced with glass (G) FRP bars and stirrups. The experimental results showed that the GFRP-reinforced joints can successfully sustain a 4.0% drift ratio without any significant residual deformation. Costas P et al (2014) studied certain load versus imposed displacement response characteristics, maximum lateral load, the stiffness, and the cumulative energy dissipation capacity. The results demonstrated the important role of mechanical anchorages in limiting premature debonding, and they provide important information on the role of various parameters, including: area fraction of FRP; distribution of FRP between the beam and the column; column axial load; internal joint made of steel reinforcement; initial damage; carbon versus glass fibres; sheets versus strips; and effect of transverse beams.Ciro Del Vecchio et al (2016) studied the numerical seismic assessment of RC structural systems designed without proper seismic details in the joint panel and the benefits of the FRP local strengthening. A new modelling strategy has been developed to account for the joint nonlinear behavior and the fiber reinforced polymer (FRP) strengthening in the finite element method (FEM). Several case studies were selected for the model validation. At the subassembly level, the model predictions were compared with recent experimental tests on full-scale beam-column joints with and without FRP strengthening.Mohamed Hasabella et al (2016) studied the shear capacity of beam-column joints reinforced with GFRP bars and stirrups. Six full-scale exterior beam-column joint prototypes (T-shaped) were constructed and tested under simulated seismic load conditions. Test parameters in this study included the concrete strength and the shear stress level in the joint. They found out that the diagonal shear failure in the joint exhibited in some specimens showed the significance of evaluating the shear capacity in the joint.

The GFRP bars have a good corrosion resistance than conventional steel and the mechanical and physical properties are very much higher than that of steel.So they can be used as a best replacement for steel.The cumulative energy dissipation during the seismic analysis is less for the specimens which used GFRP as rebars,so GFRP bars can be used in joints as a replacement for steel.

III. FINITE ELEMENT ANALYSIS

A. Modelling

An exterior beam-column joint is vulnerable for shear failure for beam-column joints designed without transverse reinforcement and hence is identified as the principal cause of collapse of many moment-resisting frame buildings during recent earthquakes. Effective techniques to increase joint shear resistance and ductility is needed in these zones. The finite-element analysis of bare and strengthened beam-column joints first require modeling of the joints with the dimensions and properties corresponding to beam-column joints tested in the experiment. In this section, modeling, including meshing, details of beam-column joints, is presented. The finite-element program ANSYS Workbench Version 15 was used for this purpose. The element details of each material are presented subsequently.

B. Geometry

Using the geometry tools of ANSYS software, beam column joint specimens is modeled as a 3D model. The created geometry and typical steel reinforcement locations for the half-scale beam-column joint shown in fig 1 and meshing of sizing 50 mm.In the finite-element models, 3D spar elements, Link8, were employed to represent the steel reinforcement. Ideally, the actual bond strength between the concrete and steel reinforcement should be considered. However, in this study, a perfect bond between the two materials is assumed. To provide the perfect bond, the link element, representing the steel reinforcing bars, is connected between the nodes of each adjacent concrete solid element; thus, the two materials shared the same nodes.

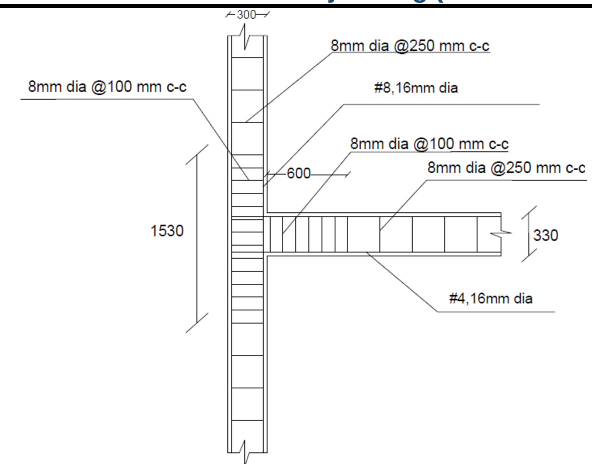

Figure.1.Detailing of the specimen

Geometric Properties of Exterior Joint considered for FEM modelling is given in Table 1. The dimensions of the beam was 1mx0.3mx0.33m and column was 1.75mx0.3mx0.3m. One control specimen and a specimen with GFRP bars in the confinement zone as stirrups and lateral ties in the confinement zone were modelled.

Table 1. Geometric Properties of Exterior Joint considered for FEM modelling

PARAMETER	BEAM VALUE(mm)	COLUMN VALUE(mm)
Width	300	300
Depth	330	300
Span	1.3	1.75
Concrete Cover	25	40
Top Steel	#4,16	#8,16
Bottom Steel	#2,16	-
Transverse Steel Diameter	8	8
Transverse Steel Spacing	250	250
Confinement Zone spacing	150	150
Number of Bars	5	8 Both sides

C.Loading Conditions

The base of the column was fixed and the other end was restrained in 2 directions namely X and Z,the Y direction was made free.On the top face of the column,a pressure was given which is equivalent to 150 KN . Load of 150 KN was applied on the specimens as shown in figure 2.

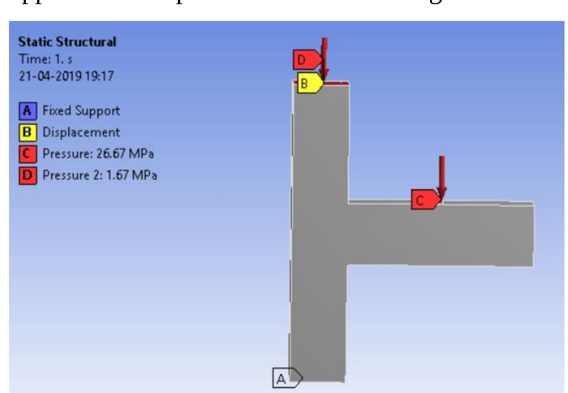

Figure.2.Loading Conditions

D.Meshing

i. To obtain good results from the elements, a square mesh is used. Therefore, the mesh is setup such that square or rectangular elements are created.The meshing option in the modal part of ANSYS 15 was used to mesh the Specimens. This properly sets the width and length of elements in the concrete support and makes it consistent with the elements and nodes in the concrete portions of the model. In the analysis, the specimen was modeled with 132 square concrete elements by using a 50 mm mesh configuration as shown in Figure 3. The following material properties were used for the present FE analysis:-

CONCRETE: Elastic Modulus, Ec c, Ultimate uniaxial compressive strength, fc = 20 Mpa, Ultimate tensile compressive strength, fr =2.77Mpa, Poisson ratio for concrete = 0.2

STEEL: Elastic Modulus, Es =200000 Mpa, Yield stress of longitudinal steel bars, fy = 500 Mpa, Yield stress of transverse steel bars, fy = 380 Mpa, Poisson ratio for steel = 0.3

GFRP: Elastic Modulus, Es =54494 Mpa, Yield stress of longitudinal steel bars, fy = 1318 Mpa, Yield stress of transverse steel bars, fy = 1267 Mpa, Poisson ratio = 0.3

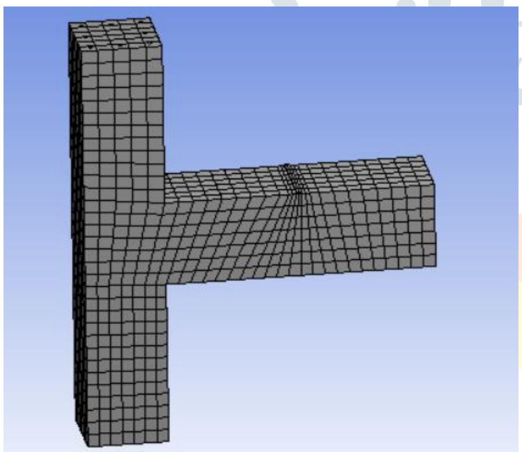

Figure.3.Meshing

IV. ANALYSIS RESULT

The result of FE analysis of control specimen using ANSYS Workbench under the static loading of 10000 N.Figure 4 and 5 shows the total deformation of the control and test specimen.

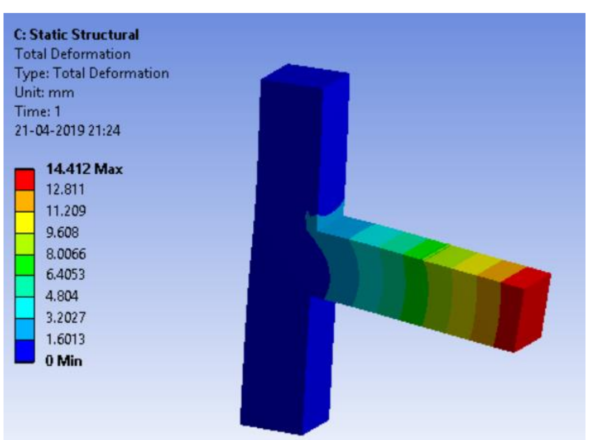

Figure 4.Total deformation for the Control Specimen CG

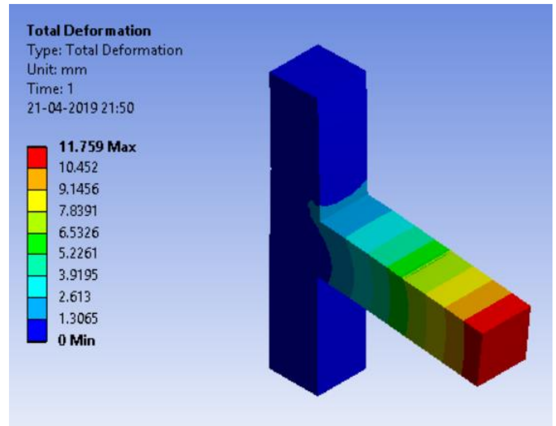

Figure 5.Total Deformation of Specimen SG

The maximum total deformation obtained for control specimen is 14.412 mm while for the specimen with GFRP bars as stirrups and lateral ties in the confinement zone had a maximum total deformation of 11.759 mm.

V. CONCLUSION

Modified reinforcement technique using GFRP bars as stirrups and lateral ties in the confinement zone is a feasible solution for increasing the shear capacity of the cyclically loaded exterior beam-column joints.External beam-column joint reinforcement with GFRP bars in the confinement zone as stirrups and lateral ties,modeled in ANSYS Workbench showed high strength under static applied load. .From the analysis it was found that we can decrease the deformation upto 18.4% when we use GFRP bars in the confinement zone.

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