IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X.
PP 32-37
www.iosrjournals.org

Strengthening Of Exterior Beam Column Joint With Modified Reinforcement Technique

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ABSTRACT : *Modified reinforcement technique using crossed inclined bar at beam column junction is a feasible solution for increasing the shear capacity. The presence of crossed inclined bars introduces an additional mechanism for shear transfer. Exterior beam-column joints with crossed inclined bar modeled in ANSYS workbench showed high strength. From experimental data the analytical result done via ansys workbench concludes that the specimen with diagonal cross bar at joint shows better performance under the static loading and it is a feasible solution for increasing the shear capacity of exterior and interior beam-column joints. Behavior of beam column joint is less efficient when subject to large lateral loads, such as strong wind. One of existing solution is inclusion of high percentages of transverse hoops in the core of joints in order to meet the requirement of strength, stiffness and ductility under static loading. From the analytical study it is observed that the provision of cross diagonal reinforcement increased the ultimate load carrying capacity, stiffness and ductility of joints in the both upward and downward loading conditions. The present study is confined to static load only.*
Keywords *- Comparison of Results, Exterior Joints, Finite-Element Modeling, RC Frame****,*** *Static load.*

I. INTRODUCTION

The shear strength and confinement pressure provided by joint panel stirrups are crucial to preserve joint panels from premature brittle failures; a suitable amount of transverse reinforcement allows the action between the beams and columns to be appropriately transferred. However, the lack of joint panel transverse reinforcement is very common in structural systems designed for gravity load or according to obsolete seismic codes, especially in the Mediterranean area. For this reason, several surveys carried out in the aftermath of major recent earthquakes have shown that beam column joints represent one of the main sources of vulnerability in existing reinforced concrete (RC) constructions. In most of earthquake prone countries, preseismic code designed reinforced concrete (RC) buildings do not comply with the current seismic codes requirements. In Recent earthquakes failure/collapse of moment resisting RC frame buildings in the existing beam column joints, especially exterior ones with inadequate shear strength and ductility is the prime reason. The present study is to study the behavior of beam column joint under static load only with modified reinforcement technique at the beam column junction. Further investigation can be carried out for seismic behavior of beam column joint with modified reinforcement scheme as done for static load.

1.1 Literature Review

Number of works has been reported on experimental studies of composite up gradation for strengthening beam column joint. The literature has been reviewed to get the experimental data for making comparison with analytical model of present study.

S. H. Alsayed, Y. A. Al-Salloum, T. H. Almusallam, and N.A. Siddiqui, in 2010,epoxy-bonded CFRP sheets have been used with different scheme such as control, strengthened, repaired specimens at the joints for the upgrading the shear strength and ductility of exterior beam-column joints. The author compared the results of different scheme through hysteretic loops, load-displacement envelopes, joint shear distortion, ductility, and stiffness degradation and found that CFRP sheets are very effective in improving shear resistance and deformation capacity of the exterior beam-column joints and delaying their stiffness degradation.

K.R.Bindhu and K.P. Jaya studied the seismic performance of exterior beam column joint with non-conventional reinforcement detailing. The specimens were sorted into two groups based on the joint reinforcement detailing. The first group (Group A) comprises of two joint assemblages having joint detailing as per construction code of practice in India (IS 456:2000) with two axial load cases. The second group (Group B) comprises of two specimens having additional cross bracing reinforcements for the joints detailed as per IS 456:2000 with similar axial load cases that in first group. The experimental investigations are validated with the

analytical studies carried out by finite element models using ANSYS. The experimental results and analytical study indicated that additional cross bracing Reinforcements improve the seismic performance.
Suhasini M Kulkarni, Yogesh D Patil concluded that, the important factors affecting the shear capacity of exterior RC beam-column joints are the compressive strength of concrete, aspect ratio of the joints and number of transverse hoops in the core of the joint.

Modified reinforcement technique using crossed inclined bar at beam column junction showed increased shear capacity of the statically loaded exterior beam-column joints. The cross inclined bars is intended for creating an additional mechanism for shear transfer. Exterior beam-column joint modelled in ANSYS Workbench showed high strength for crossed inclined bar arrangement at joint.

II. EXTERIOR JOINTS

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.

Table 2.1: Geometric Properties of Exterior Joint considered for FEM modeling

Parameter	**Value (mm)**	**Parameter**	**Value (mm)**
Beam dimension and details		**Column dimension and details**	
Width	160	Width	160
Depth	350	Depth	300
Span	2000	Clear height	1450
Concrete cover	15	Floor to floor height	1800
Top steel	4-12	Concrete cover	15
Bottom steel	4-12	Longitudinal steel	10-10
Transverse steel diameter	6	Transverse steel diameter	6
Transverse steel spacing	225	Transverse steel spacing	140
Bearing plate dimension		Cross inclined bars at joint Diameter	10
Width	160	Depth	10

2.2 Finite-Element Modeling

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 12 is used for this purpose. The element details of each material are presented subsequently.
Concrete: To model the concrete an eight-node solid element, Solid65, is used. This solid element has eight nodes with three degrees of freedom at each node with translations in the nodal x, y, and z directions. Plastic deformation, cracking in three orthogonal directions and crushing capability can be utilized by the element.
Reinforcing Steel: Discrete modeling is used for reinforcement steel by defining the element between the nodes in the performed meshes. Steel reinforcement in the experimental beam-column joint is constructed with typical Grade 60 (fy-500 MPa) steel reinforcing bars. The steel for the finite-element model was assumed to be an elastic–perfectly plastic material with identical properties in tension and compression. A Link8 element is used to model the steel reinforcement. Two nodes are required for this element. Each node has three degrees of freedom, which are translations in the nodal x, y, and z directions.

2.3 Creation of 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 2 and meshing of sizing 40 mm shown in fig 4. 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.

2.4 Loading Condition

Displacement boundary conditions were needed to constrain the model to get a unique solution. To ensure that the model acts in the same way as the experimental beam-column joint, boundary Conditions are applied at the supports and where loadings exist. To simulate the lateral load conditions, at the top of the column, a 30-mm displacement and an axial constant load of magnitude 4240 N is applied.

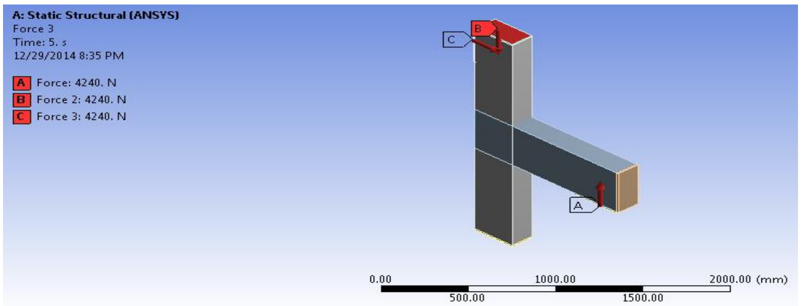

Fig. 2.1: ANSYS Workbench Model for Loading

2.5 Reinforcement Detailing

The reinforcement detailing is done by using ANSYS Workbench v12. The properties are listed in Table 1.

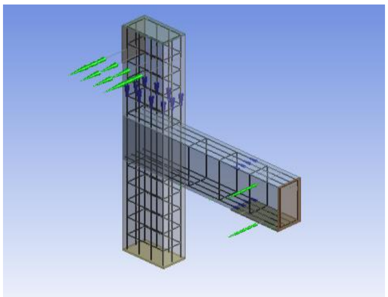

Fig. 2.2: Reinforcement Detailing (ANSYS v12)

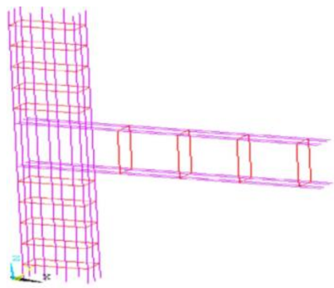

Fig. 2.3Reinforcement Detailing (ANSYS v11)

2.6 Meshing

To obtain good results from the Solid65 element, a square mesh is used. Therefore, the mesh is setup such that square or rectangular elements are created (Fig. 4&5). The volume sweep command of ANSYS v12 is used to mesh the support. 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 4,141 square concrete elements by using a 40 mm mesh configuration.

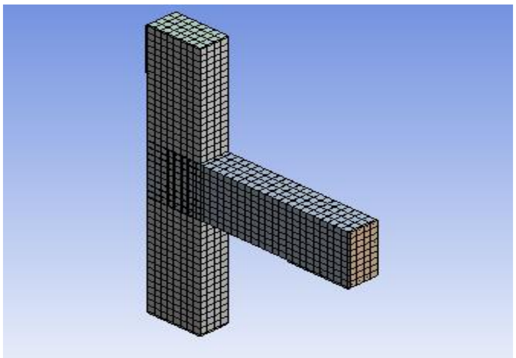

Fig. 2.4 Mesh v12

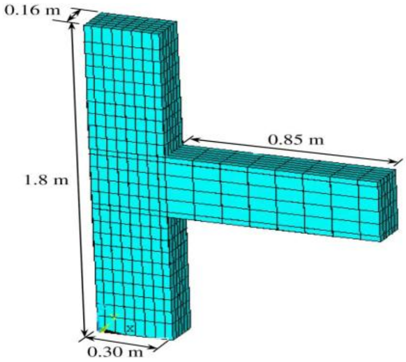

Fig. 2.5: Mesh v11

The following material properties were used for the present FE analysis:-

CONCRETE:
Elastic Modulus, E_c= 4700√f_c, Ultimate uniaxial compressive strength, f_c = 30 Mpa, Ultimate tensile compressive strength, f_r = 0.62√f_c, Poisson ratio for concrete = 0.2
STEEL:
Elastic Modulus, E_s =200000 Mpa, Yield stress of longitudinal steel bars, f_y = 500 Mpa, Yield stress of transverse steel bars, f_y = 380 Mpa, Poisson ratio for steel = 0.3

III. RESULT

3.1 Control Specimen

The result of FE analysis of control specimen using ANSYS Workbench under the static loading of 4240 N. Figure 6 and 7 shows the result of total deformation, maximum principal stress and maximum principal elastic strain respectively.

TABLE 3.1

RESULT	MAXIMUM VALUE
Total deformation	14.173 mm
Maximum principal stress	72.327 Mpa
Maximum principal strain	0.00725 mm/mm

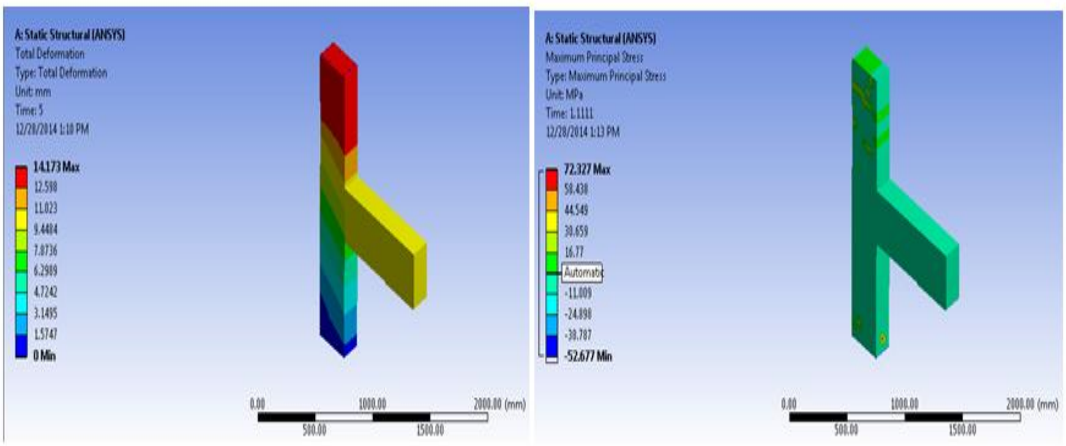

Fig. 3.1: ANSYS Workbench Model for Total Deformation and Maximum Principal Stress

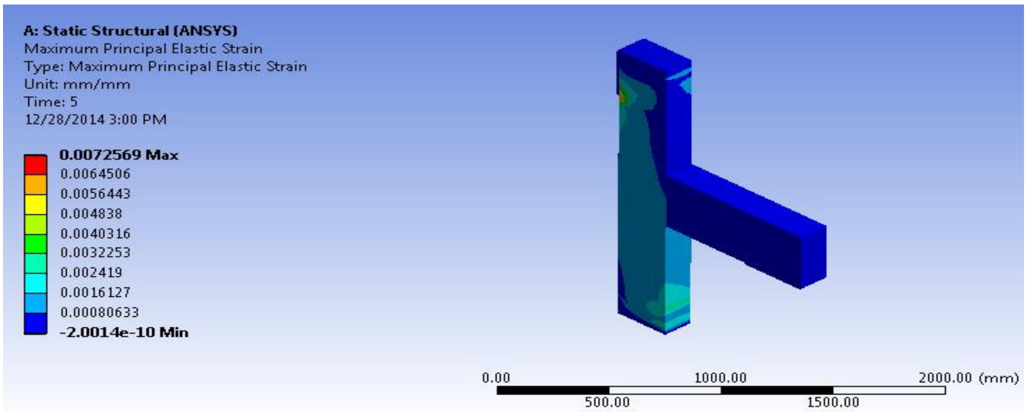

Fig. 3.2 ANSYS Workbench Model for Maximum Principal Elastic Strain

3.2 Strengthen Specimen

Figure 8 shows the reinforcement detailing of strengthen specimen. In this model Modified reinforcement technique using crossed inclined bar10 mm diameter in beam-Column joint is used. Figure 9 shows the deformation of strengthen specimen under the static loading of 4240 N and from the result it is clear that, the deflection in strengthen specimen as compare to control specimen is minimum.

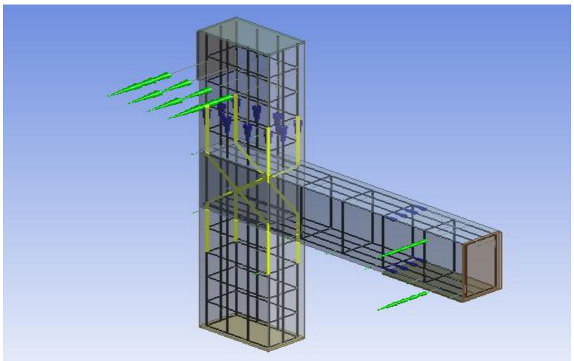
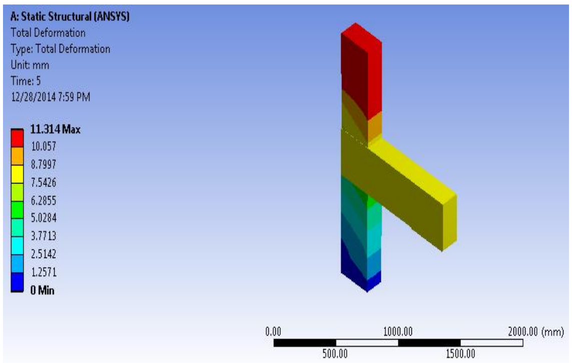

Fig. 3.3 Reinforcement detailing of Exterior joint Fig. 3.4 ANSYS Workbench Model As per IS: 456-2000 Deformation of strengthening Joint

3.3Comparison of FE Results with Test Result

The goal of the comparison of FE analysis results with the experimental test results is to ensure that the present finite-element model and analysis are capable of predicting the response of the beam-column joints. The results were compared through load-displacement behavior.

TABLE 3.2: Comparison of Experimental Test Result with Strengthening Exterior Beam Column Joint

Load (N)	Test result	FE result	Percent difference
4240	16.88 mm	14.172 mm	11

The Exterior joint comprises of specimen having additional cross bracing reinforcements for the joints detailed as per IS 456:2000 with similar axial load cases that in experimental setup. The experimental investigations are validated with the analytical studies carried out by finite element models using ANSYS. The experimental results and analytical study indicate that additional cross bracing reinforcements improves the seismic performance.

Load-Displacement

TABLE 3.3

Load(N)	**Test result**	**Strengthening specimen**	**Percent difference**
4240	16.88 mm	11.314 mm	22

IV. CONCLUSION

Modified reinforcement technique using crossed inclined bars at beam column junction is a feasible solution for increasing the shear capacity of the cyclically loaded exterior beam-column joints. The cross inclined bars aids in creating an additional mechanism for shear transfer. External beam-column joint reinforcement modified with crossed inclined bars modeled in ANSYS Workbench showed high strength under static applied load. From experimental data the analytical result done via ANSYS concludes that the specimen with diagonal cross bar at joint shows better performance under the static loading and it is a feasible solution for increasing the shear capacity of exterior and interior beam-column joints.The reinforcement details of such structures though conform to the general construction code of practice may not adhere to the modern seismic provisions. A beam column joint becomes structurally less efficient when subject to large lateral loads, such as strong wind. One of the solutions to meet the requirement of strength, stiffness and ductility is by providing high percentages of transverse hoops in the core of joints. Another which can be proposed is the modified reinforcement technique as studied in present study in which the provision of cross diagonal reinforcement increased the ultimate load carrying capacity, stiffness and ductility of joints in the both upward and downward loading conditions.

V. RESEARCH SCOPE

- Investigate behavior of other beam column joint i.e. interior and corner joint.
- Study the behavior of beam column joint under dynamic loading.
- Study the variation of stresses in reinforcing bars of column and beam.

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