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# Performance Evaluation of Corner RC Beam-Column Joints with Different Reinforcement Detailing Subjected To Cyclic Loading

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***Abstract: Beam column joint subjected to seismic force will experience large shear forces, diagonal tension and high bond stresses in the reinforcement bars. Hence special attention need to be given for design and construction of beam column joint subjected to seismic loading. Based on the location of joint, beam-column joint are classified as interior, exterior and corner joint. The study mainly focuses on experimental investigation on behaviour of Corner beam-column joints under seismic conditions. Corner beam-column joint of a multistorey reinforced concrete building (G + 4) in Salem Zone falling under the seismic Zone – III has been analyzed and designed using STAAD.pro. The specimens were designed for seismic load according to IS 1893 (Part-I): 2002 and detailed as per IS 13920 : 1993. The test specimen is reduced to one fifth model of beam column joint from prototype specimen. Four specimens are investigated in which one is conventional specimen and other three are specimens with different reinforcement detailing. All the specimens were loaded up to failure under quasi - static cyclic loading, simulating earthquake actions. The beam - column joints are examined in terms of load carrying capacity, load-deflection behavior, stiffness degradation, energy absorption capacity, ductility factor and cracking characteristics. Performance of beam column joint improves by suitably modifying the reinforcement details.***
***Keywords: Corner beam-column joints, Different types of detailing, Stiffness, Ductility, Energy absorption capacity.***

## I. INTRODUCTION

Reinforcement detailing in beam column joints have significant impact on the performance of beam column joint subjected to seismic loading. Performance of beam column joint improves by adopting different detailing practices [1-12]. Cross inclined bars in joint region increased the performance of beam-column joint[1].Under cyclic excitation, three types of failure namely flexural failure of beam, shear failure of beam and shear failure of column occur in a beam column joint[2]. Various techniques like carbon fibre reinforced polymer (CFRP) sheets or plates and ferrocement laminates were also used to strengthen the beam-column joint. Ultimate capacity of specimens has been increased by the application of CFRP and ferrocement laminates[10,11].This paper emphasizes the modification of reinforcement detailing in beam-column joint which considerably increases the performance of beam-column joint.

## II. LITERATURE REVIEW

1) *Bindu K.R et.al* implemented cross inclined bars at the beam column joint subjected to seismic loading. Author made an attempt to improve the confinement of core concrete. Author investigated four exterior beam column joints sub assemblages which is subjected to reverse cyclic loading. Based on the joint reinforcement detailing, author grouped the specimens. Group A consists of 2 joint assemblages with detailing as per ductile detailing code (with two axial load case) and Group-B comprises of two specimens with cross inclined bars as confining reinforcements. The joint with transverse reinforcement recorded poor performance under seismic loading and cross inclined bars as confining reinforcement performs well under seismic loading. Author developed analytical model using finite element software ANSYS and the results were compared.
2) *Lakshmi G.A et.al* experimented the strengthening of beam-column joint using FRP materials. Author investigated three different types of beam-column joints to study flexural failure of beam, shear failure of beam and shear failure of column under cyclic excitation. Author compared the specimens in terms of load carrying capacities. Specimens have been strengthened using suitable FRP. Finite element analysis of specimens are carried out with the help of ANSYS and author numerically simulated each of these cases. The finite element analysis has given the behavior of complex beam- column joints. Retrofitted beam-

column joints designed for the failure of beam in flexure were also analysed using ANSYS. Observations of ANSYS were compared with experimental results and the behaviour was studied.

## III. EXPERIMENTAL PROGRAM

Experimental study focus on Corner beam-column joint of a multistorey reinforced concrete building in Salem Zone falling under the seismic Zone – III. The structure comprises of five storey's and having 1.5 m foundation depth. Four specimens are investigated in which one is conventional specimen and other three are specimens with different detailing.

### A. *Material Properties*

Cement used for the specimen was ordinary Portland cement. The specific gravity of cement was found to be 3.15. The potable water available in our campus was used for mixing and curing of concrete. The fine aggregate used for all the specimens was river sand which was sieved through IS 4.75 mm sieve and its specific gravity was found to be 2.65. The coarse aggregate used in the mixes are hard blue granite stones from quarries around Erode. 12 mm size aggregates were used and its specific gravity was found to be 2.7. HYSD type of reinforcement bars are used for study.

### B. *Mix Design*

Design mix of $M_{30}$ grade was used for casting the beam-column joints and its ratio is 1:1:2.5 with a water cement ratio of 0.4

### C. *Preparation of beam-column specimens*

The dimension of mould for beam region is 450 mm x 170 mm x 120 mm and that for column region is 375 mm x 230 mm x 120 mm. Figure 1 shows the specimen size and different types of detailing systems. The concrete are weighed accurately and mixed by Hand mixing.

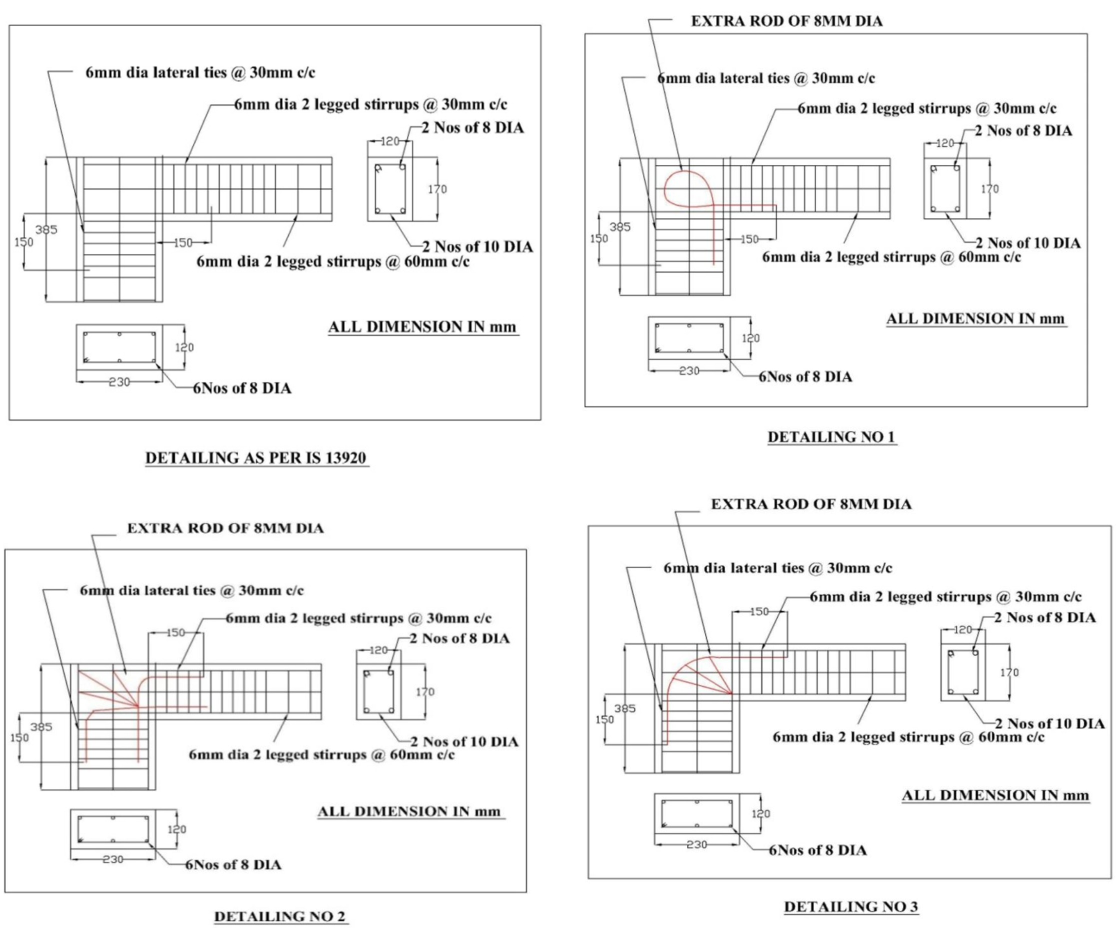


Fig.1 : Different types of detailing system

### *D. Test Setup and Procedure*

Each specimen was tested under forward and reverse cyclic loading. The column was centered accurately using plumb bob to avoid eccentricity. In top of column mild steel plate over 50 tonnes hydraulic jack was fixed. It is used for applying axial load on column. LVDT is used to measure the downward and upward displacements in the beam at a distance of 450 mm from the clear face of column. The axial load represents 0.1 $f_{ck}$ of the static dead load in the Ground floor column of the model. The shear force applied on beam by screw jacks in the order of reversed cycle to the beam ends and the corresponding deflections are measured by LVDT. By changing the screw jack on either side of the beam end, apply positive (downward) and negative (upward) loads. The proving ring was placed between loading point and screw jack and used to measure the applied beam forces. Proving ring capacity of 10 tonnes is used in the testing of specimens.

## IV. RESULTS AND DISCUSSION

Load Carrying Capacity, Load-Deflection Behavior, Failure Patterns, Ductility Factor, Energy Absorption Capacity and Stiffness degradation of the Conventional Specimen and Beam column joints with different types of detailing systems were compared and discussed.

Table 1 : Comparison of Experimental Results

| S.No | Description | Ultimate load (kN) | Cumulative ductility factor | Cumulative energy absorption (kN-mm) | Max stiffness (kN/mm) |
|---|---|---|---|---|---|
| 1 | Conventional | 16.5 | 46.53 | 506.34 | 12.3 |
| 2 | Det. No 1 | 17 | 63.36 | 596.07 | 33.0 |
| 3 | Det. No 2 | 20 | 53.39 | 698.53 | 34.4 |
| 4 | Det. No 3 | 15 | 52.51 | 345.67 | 13.0 |

## V. CONCLUSION

Following conclusions were arrived from the study.

*A.* Among all specimens, detailing no.2 gives the best performance. It gives the higher load carrying capacity of 20 kN (1.2 times greater when compared to the conventional specimen).
*B.* Detailing Number 1 gives more cumulative ductility than other three specimens.
*C.* Results of Energy absorption shows that detailing no.2 of corner beam column joint possess higher value (which is 38% greater than the conventional specimen).
*D.* Mode of failure of three different types of detailing system was observed and detailing no.2 shows the excellent load deflection behavior with less number of cracks. Plastic hinge has been formed at the face of the beam column joint thus giving more desirable behavior under reverse cyclic loading.
*E.* Detailing no.2 possess more stiffness when compared to other specimens.
*F.* In general the behaviour of the corner beam column joint has been much improved by suitably modifying the reinforcement details at the beam column joints.

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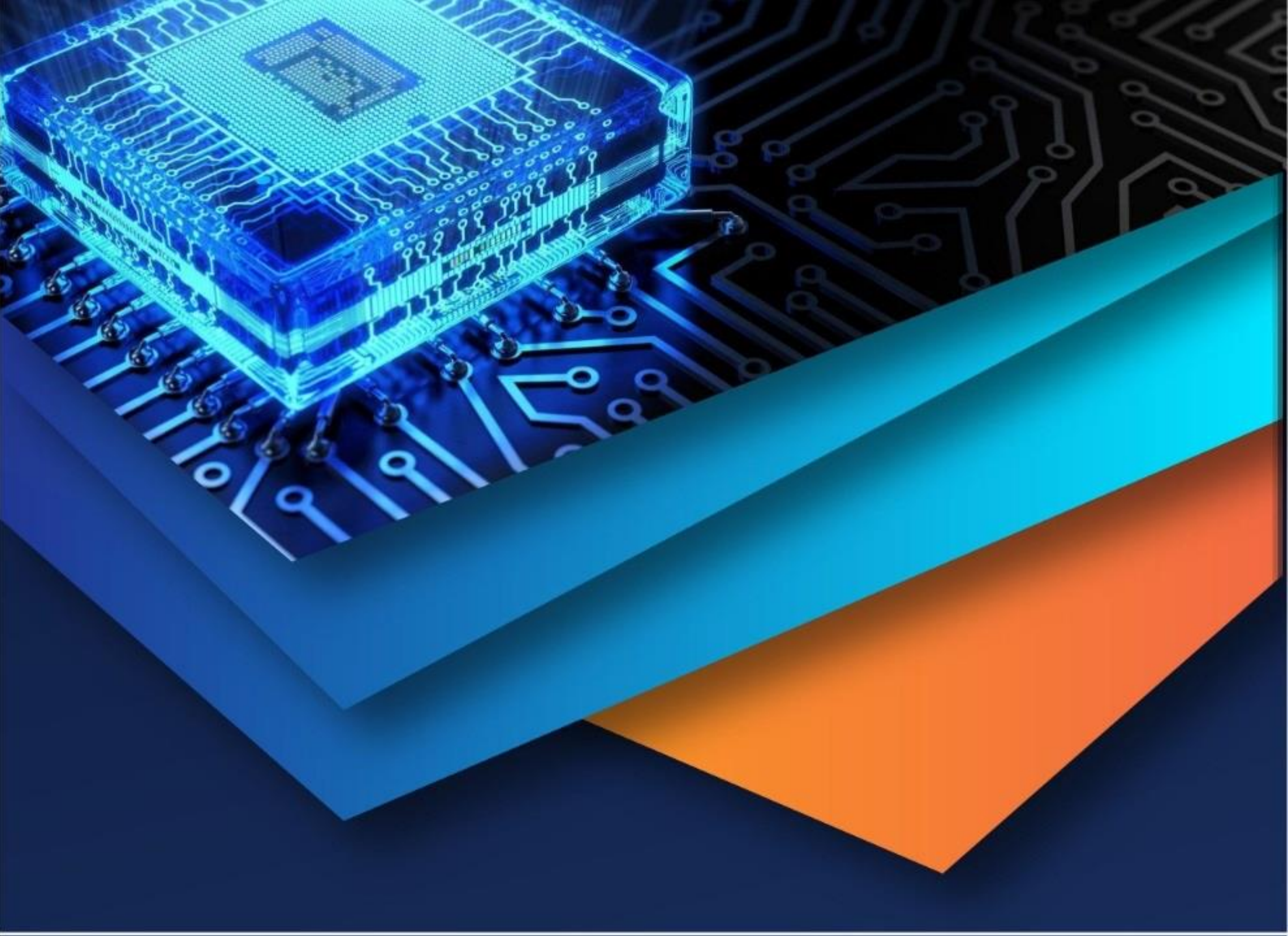


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