Journal of Civil Engineering and Environmental Technology
Print ISSN : 2349-8404; Online ISSN : 2349-879X; Volume 2, Number 9; April – June, 2015 pp 49-53
Krishi Sanskriti Publications
http://www.krishisanskriti.org/jceet.html

Performance of Beam-Column Joint using Non-conventional Reinforcement Technique under Cyclic load

[1]Dr. Suraj. N. Khante[1], Aniket V. Nemade[2]
[1]*Associate Professor Government college of Engineering, Amravati*
[2]*PG Student Government college of Engineering, Amravati*

Abstract : *Performance of Beam-column joint is matter of concern in the modern ductile design of building. Especially under the earthquake loading this is more susceptible to damage. Brittle nature failure is responsible for devastating damages. Since 1970's this area is focused by researchers. But still due to versatile nature of the joints core behaviour, the problem still needs attention. The cyclic forces in beam-column joint during earthquake may cause cracks and failure, when not designed and detailed properly. In the present work, two, one third scale beam column joints' finite element models are analysed using ANSYS11. A refined model of exterior beam column joint is used by representing steel and concrete by different elements in FE model. The first specimen detailed as per guidelines of IS13920:1993(conventional) and second is detailed with additional diagonal cross bracing bars of 10mm diameter at joint and beam reinforcement(non-conventional). Cyclic loading was applied at the beam tip and constant axial load on the column to simulate severe seismic loading. This paper compares the performance of exterior beam-column joint by conventional and non-conventional reinforcement near the joint. Behaviour of these two specimens studied by plotting and calculating, Load-displacement curves, ductility factor, cumulative energy dissipation, stiffness behaviour. The study indicates that non-conventional reinforcement improves the seismic performance.*

Keywords: *Beam-column joint, cyclic loading, ANSYS11, ductility, stiffness, energy dissipation*

1. INTRODUCTION

Beam-column joints are an important part of a reinforced concrete moment resisting frame subjected to earthquake loading and should be designed and detailed properly. Failure of beam-column joints during earthquakes is governed by bond and shear failure mechanism which are brittle in nature which is not an acceptable structural performance especially in seismic conditions. Understanding the joints behavior is essential in exercising proper judgments in the design of joints. Therefore it is important to discuss about the seismic actions on various types of joints and to highlight the critical parameters that affect joint performance with special reference to bond and shear transfer. The anchorage length requirements for beam bars, the provision of transverse reinforcement and the role of stirrups in shear transfer at the joint are the main issue. A study of the usage of additional cross-inclined bars at the joint core shows that the inclined bars introduce an additional new mechanism of shear transfer and diagonal cleavage fracture at joint will be avoided. However, there were only limited experimental and analytical studies for the usage of non-conventional detailing of exterior joints. In spite of the wide accumulation of test data, the influence of cross inclined bars on shear strength of joint has not been mentioned in major international codes. In this work an attempt has been made to improve the confinement of core concrete without congestion of reinforcement in joints. Syed and Shaikh [1] carried out computational analysis in ANSYS11. The specimens designed as per IS13920:1993 with additional diagonal cross bracing bars at joint or beam. The comparison showed better performances of the joint when it is provided with cross bars 8 mm in beam region. Bindhu and Jaya [2] studied the performance of exterior beam column joint with non-conventional reinforcement detailing. They tested four specimens under cyclic load at beam end. The specimens detailed as per IS: 456 with diagonal confining bars had improved ductility, energy absorption capacity and ultimate load carrying capacity. Siddiqui *et al.* [3] carried out experimental investigation of beam column joint using Carbon Fibre Reinforced Polymers. They studied two specimens for cyclic lateral load histories. They found CFRP sheets improves the shear resistance of the joint and increase ductility.

The performance of exterior joint assemblages designed for earthquake loads as per IS 1893:2002 are compared with the specimens having additional cross bracing bars provided in column and beam region confining reinforcements[1].

2. DETAILS OF SPECIMENS

The beam column joints had identical beam and column sizes. The beam and column sizes were 150mm x 100mm and 200mm x 100mm respectively. Figure 1.shows the reinforcement detailing for conventional specimen and Figure 2.Shows the reinforcement detailing for Non-conventional specimen. The cover for the beam and column section was maintained at 20mm.

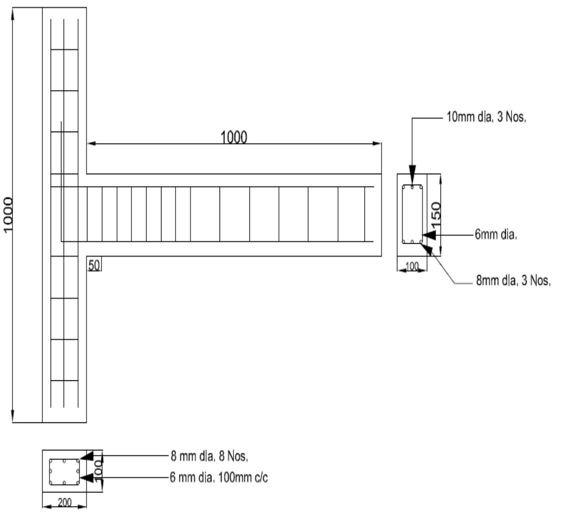

Figure 1. Reinforcement details of specimen as per IS13920:1993guidelines(Conventional) Specimen1.

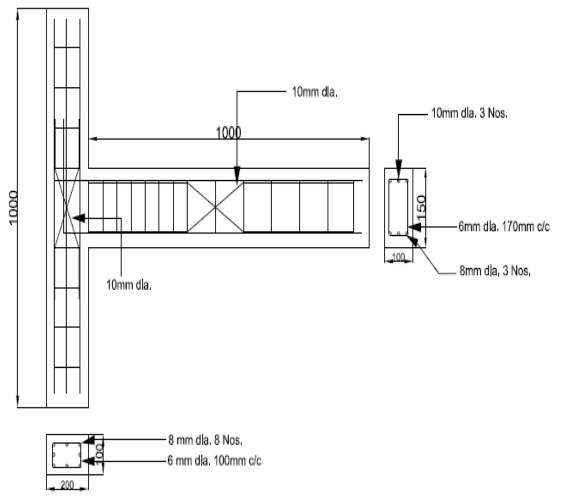

Figure 2. Reinforcement details of specimen provinding cross digional bars in beam and column (Non-Conventional)-Specimen2

3. ANALYTICAL MODELING

The exterior beam-column joint is considered to study joint behavior subjected to cyclic loading. The exterior beam column joint is analyzed using ANSYS11 software. The elements used are solid i.e.concret65 and link i.e.spar8. Concrete65 element was used to model the concrete of eight nodes with three degree of freedom at each node and Spar8 element was used to model steel reinforcement of two nodes with three degree of freedom at each node.

3.1. Real constants

The real constants considered for concrete65 element were volume ratio and orientation angles. But there was no streak reinforcement; the real constants were set to zero. The real constants set for spar8 element are cross-sectional area and initial strain.

3.2. Material Properties

The material properties used in the models are given in Table 1. Grade of concrete and steel used are M25 and Fe415 respectively.

Table 1. Material properties used in model

Material No.	Element type	Material properties	
1	Link-spar8	Linear Isotropic	
		EX	$2.1x10^{11}N/m^2$
		PRXY	0.3
		Bilinear Kinematic	
		Yield stress	$432x10^6N/m^2$
		Tangent Modulus	$847x10^6N/m^2$
2	Solid-concrete65	Linear Isotropic	
		EX	$2.5x10^{10}N/m^2$
		PRXY	0.15
		Concrete	
		Shear transfer coefficient for open crack	0.2
		Shear transfer coefficient for closed crack	0.9
		Uniaxial tensile cracking stress	$2.895x10^6N/m^2$

3.3. Modeling of Exterior Beam-Column Joint

The exterior beam-column joint is modeled in ANSYS11 software using above element and the material properties. Modeling details are shown in Figure 3 to Figure 5.The axial load is applied on column of 110kN and the load on the beam is applied in the interval of 0Hz to 20Hz at a distance of 40mm from the free end in upward and downward direction. The models were analyzed with cyclic loading in the upward and downward direction.

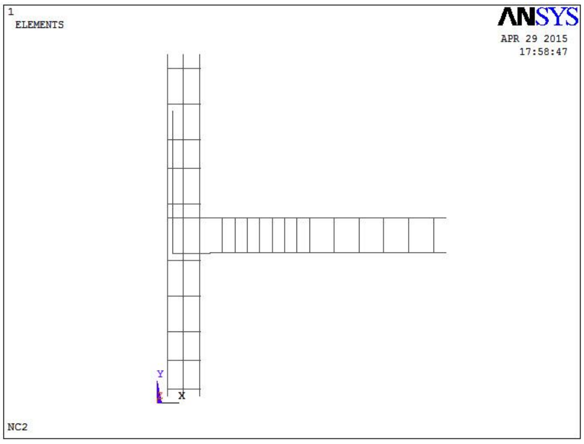

Figure 3. Modeling of reinforcement in ANSYS11 Using IS13920:1993 guidelines (Conventional)-Specimen1.

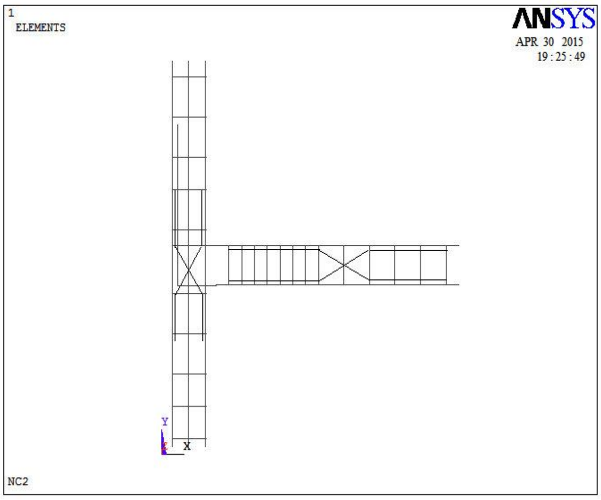

Figure 4. Modeling of reinforcement in ANSYS Using Cross Bars in Beam and Column region (Non-conventional)-Specimen2.

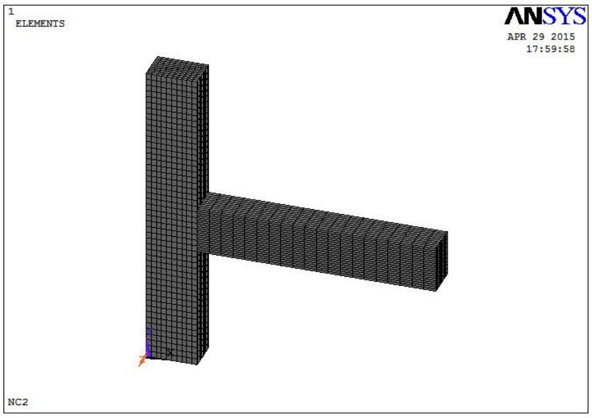

Figure 5. Mesh of concrete.

4. RESULTS AND DISCUSSION

In this section the results of analytical studies are briefly described.

4.1. Hysteretic Curves

The load-displacement hysteresis loops for the specimens are shown in Figure 6 and Figure 7. For Non-conventional specimen, hysteresis loops were observed with large energy dissipation capacity. From Table 2 it can be observed that the ultimate load carrying capacity is higher for Non-conventional specimen than Conventional specimen. In general, specimen with diagonal cross bars in beam and column perform better than conventional specimen.

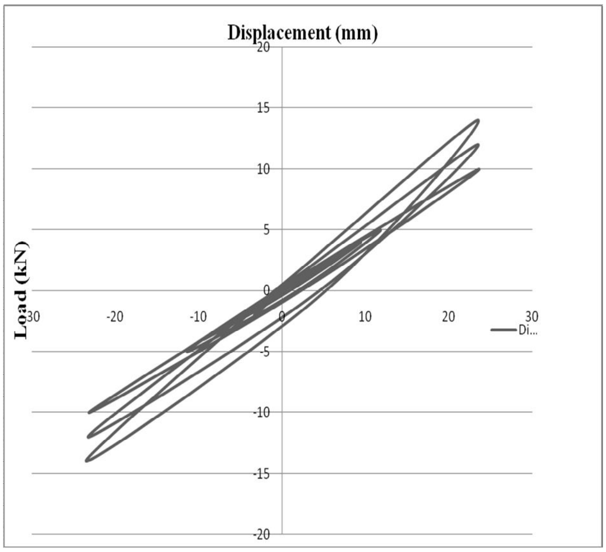

Figure 6. Load-displacement curve for Conventional Specimen1.

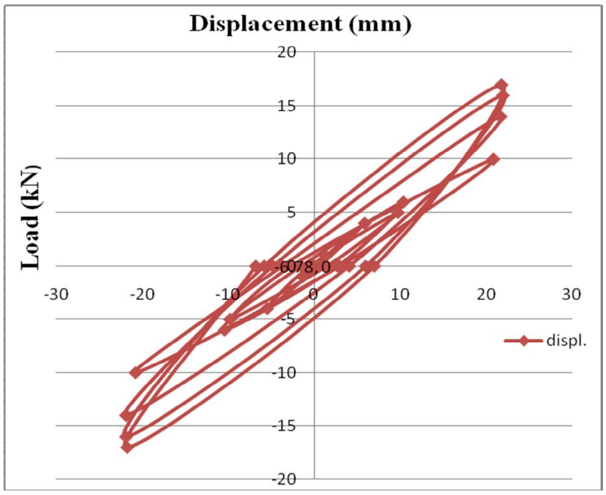

Figure 7. Load-displacement curve for Non-Conventional Specimen2.

Table 2. Yield load and ultimate load of specimens from ANSYS11

Specimen	Yield Load(kN)		Ultimate Load(kN)	
	Downward direction	Upward direction	Downward direction	Upward direction
Conventional	3	3	14	14
Non-conventional	4	4	17	17

4.2. Cumulative Energy Dissipation

The area enclosed by the hysterisis loop in Load-displacement curve at a given cycle represents the energy dissipated by the specimen during that cycle. Comparison of cumulative energy dissipation for the specimens is shown in Figure 8. It is found that the energy dissipation capacity is enhanced by the addtion of diagonal cross bars.

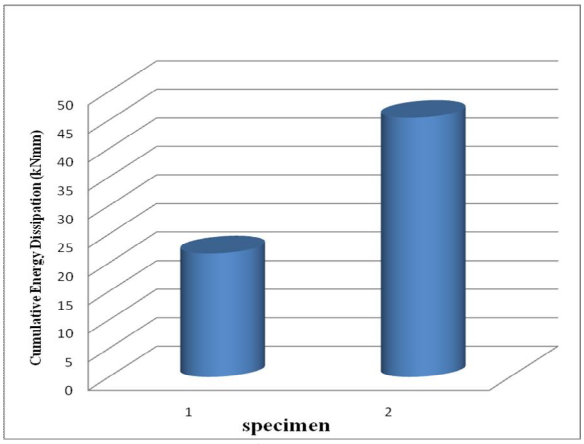

Figure 8. Comparision of cumulative energy dissipation.

4.3. Ductility

Ductility is measured in terms of displacement ductlity factor, which is the ratio of the maximum deformation that structure or an element can undergo without significant loss of initial yielding resistance to the intial yield deformation[2]. The displacement values and the displacement ductlity factor for both the specimens is shown in Table 3. It is observed that the ductility for non-conventional specimen incerases by 11% over conventional specimen. So, the the non-conventional reinforcement at joint region improves the ductility of the joint.

Table 3. Displacements and Displacement ductility factor of specimens

	Displacement(mm)	
	Conventional Specimen	Non-Conventional Specimen
Yield Displacement(mm)		
Download	7.117	6.431
Upward	7.089	6.500
Ultimate Displacement(mm)		
Download	23.481	21.730
Upward	23.496	21.815
Displacement Ductlity Factor		
Displacement ductlity factor		
Download	3.299	3.696
Upward	3.314	3.697
Average Displacement Ductlity Factor	3.307	3.697

4.4. Stiffness Behavior

Siffness gets degraded when the joint is subjected to cyclic loading. During cyclic loading concrete and reinforcement steel bars are subjected to different loading, unloading and reloading paths[3]. Comparison of Stiffness degradation for both the specimen is shown in Figure 9.

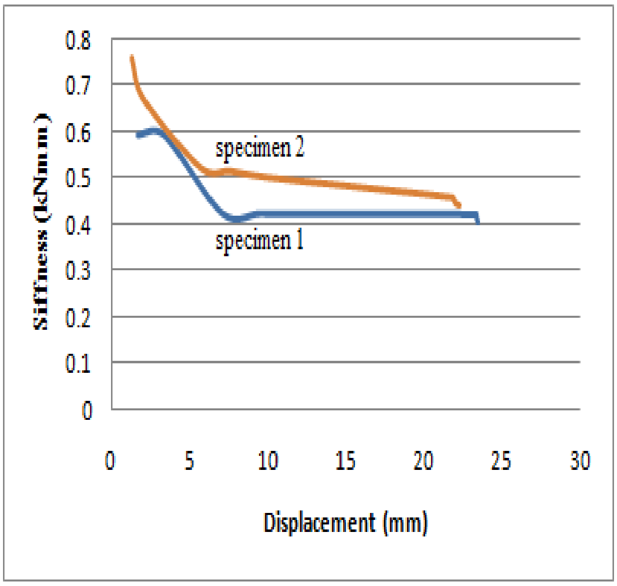

Figure 9. Comparison of stiffness degradation.

5. CONCLUSIONS

In the present study, the performance of exterior beam-column joint with non-conventional reinforcement detailing was studied analytically. The following conclusions are made.

1. Reinforcement providing non-conventionally had improved ductility factor by 11% than conventional reinforcement.
2. Energy dissipation for non-conventional specimen had increases by 52.31% than conventional specimen.
3. Stiffness degradation process is slow in non-conventional specimen proves better performance.
4. It is observed that provision of cross diagonal reinforcement bars increased the ultimate load carrying capacity and ductility of joint in the upward and downward loading condition.

6. REFERENCES

[1] Syed Sohailuddin S. S. and M G Shaikh, "Finite Element Modeling of Reinforced Concrete Beam-column Joint using ANSYS", *in Proceedings International Journal of Structural and Civil Engineering Research*,August2013,Vol.2,pp.3-8

[2] Bindhu K.R. and Jaya K.P., "Strength and Behavior of Exterior beam column joints with diagonal cross bracing bars", *in Proceedings Asian Journal of Civil Engineering (Building and Housing)*, 2010, Vol.11, pp.397-410

[3] Al.Salloum Y.A., Alsayed S.H., Almusallan T.H. and N.A. Siddiqui, "Seismic Behavior of FRP-upgraded exterior RC beam-column joints", *in Proceedings Journal of Concrete Repair, Rehabilitation and Retrofitting II-Alexander et.al*, July2009

[4] Rajagopal S. and Prabavathy S., "Study on seismic performance of exterior beam-column connection with different joint Core details", *in Proceedings Asian Journal of Civil Engineering (BHRC)*, 2013, Vol.14, pp.445-460

[5] IS 13920:1993, Indian Standard Ductile Detailing of Reinforcement Concrete Structure Subjected to seismic Forces-code of practice (Bureau of Indian Standards), New Delhi, India, 1993

[6] ANSYS Library Version 11