A Study of R.C.C. Beam Column Junction Subjected To earthquake loading

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***Abstract*: Beams and columns where intersects are called intersections or junctions. Other types of joints are classified as corner joints, outer joints, and inner joints in beam column joints that apply a quasi-static load to the cantilever tip of the beam. Studies of various parameters found in corner and outer beam column joints, Minimal stress, displacement and changes in rigidity of beam column joints can be analyzed with Ansys software (nonlinear FEM software). An important experimental study is the hysteresis of RC beam-column joints over the last 30 years under the frame load cyclic displacement. Various research studies have focused on the supporting motion of corner and external beam column joints and beam clamp joints. However, some recent experimental studies have addressed beam-column joints of sub-standard RC frames with weak columns, inadequate fixing and insufficient lateral reinforcement of longitudinal beam bars. Behavior of external beam column joints is different from corner beam column joints.**

***Index Terms*: Beam, column, corner, exterior, joint, quasi-static.**

I. INTRODUCTION

The design and details of beam and column joints in reinforced concrete frames are important to ensure the safety of structures in the event of an earthquake. These joints should be designed and refined to maintain the integrity of the joint to develop the ultimate strength and deformation capacity of the connecting beams and columns. Minimizes cracking of joint concrete and prevents bond loss between concrete and longitudinal beam and column reinforcement to prevent excessive deterioration of joint stiffness under earthquake loading. Prevention of brittle shear fracture of joints. We recognize that beam-column joints can be an important reason for RC frame design for a resilient response to severe earthquakes. As a result, the seismic moment of the opposite sign occurs simultaneously on the columns above and below the joint, and beam moment reversal occurs across the joint. Horizontal and vertical shear forces that are several times higher than adjacent beams and columns at the joint. If not designed for, a joint failure can occur.

II. LITERATURE REVIEW

Zhang et al. (1994) presented a reinforced concrete model for nonlinear finite element analysis. They developed a blurred / laminated reinforced concrete model for three-dimensional finite element analysis. The model assumed nonlinear behavior of concrete and reinforced steel assuming compatible deformations of the two materials. The effects of concrete cracking, tensile strengthening and knocking have also been taken into account in the new model. The reinforcement was assumed to be constructed in three orthogonal directions. This makes mesh creation very convenient. Assuming that the rebar is spreading on concrete or a layer is formed on the element, you can adjust the number and position of the layers.

Shannag et al. (2007) reported experimental results as well as FEM results of periodic responses of fiber-reinforced concrete joints. They used two concrete mixes of high performance concrete with a compression strength of 27 Mpa and a compressive strength of 75 Mpa. They used 0, 2 and 4% of brass coated steel fiber and hooked steel fiber. They created a third-scale reinforced concrete inner beam column joint and showed the highest energy dissipation from the reinforced specimen using hooked steel fiber. They also said that the energy dissipated as a result of increased fiber content has increased significantly. They used a non-linear static (extrusion) procedure to model the behavior of the inner beam-column joint under lateral cyclic loading. The experimental results are in good agreement with the applied modeling techniques and assumptions. They have shown that static pushover analysis is a viable tool for predicting the load-deflection and moment curvature response of beam-column joints.

Bindu and Jaya (2008) reported the performance of an external beam column joint with a cross bar under earthquake loading. Four external beam-column joints, 1/3 size, designed for seismic loads in accordance with IS 1893: 2002 and detailed in accordance with IS 13920: 1993, have been constructed. The difference between the specimens of groups 1 and 2 was that the two specimens were bound with diagonal cross-stiffeners at the joints of the two sides. They reported that a cross bar reinforcing reinforcement in the test improves seismic performance. They compared their test results with analytical models developed using the finite element software package ANSYS. Only half of the system is modeled through thickness so that symmetry conditions are used. Solid 65 elements are used for concrete modeling and link elements are used to model reinforcements. The models were analyzed by forging loading in the upward direction and the performance was compared. The load - displacement relation of the finite element model is compared with the experimental curve.

Uzmeri (1977) conducted an empirical study on the behavior of eight reinforced concrete beam-column joints subjected to slow load inversion simulating earthquake loading. The variables are the amount and size of the joint reinforcement and stress strain characteristics of the jointed steel. He reported that the assumption of a rigid beam-column joint could give the wrong result. He suggested that the use of joint reinforcements with flat yielding plateaus may not be desirable for detention. He recommended that the stirrups of the joints should extend above and below beam steel at equal distances from the joints, at least half the distance of the core dimensions, to prevent premature breakage of the beam immediately above or below the beam.

Lee et al. (1977) investigated the behavior of six beam-column joints designed in accordance with ACI-ASCE Commission 352. The test variables were the amount of lateral reinforcement, the magnitude of the axial load of the column and the degree of load. They concluded that cracks were formed on each specimen at the joint and beam portions and larger and more severe at specimens without axial loads. The results also show that the specimens with column axial loads and those with lower stiffness have slightly higher initial stiffness. The shear resistance was also increased by the increase of the transverse stiffener.

Abrams (1987) conducted tests on eight small joints, four medium-sized joints, and six large joints. The specimens were reversed in lateral force to study the scale correlation for nonlinear hysteresis characteristics. He concluded that the stiffness degradation was the highest in small specimens due to weak bonding between the model reinforcement and the mortar. The 1/4 size specimen showed a force - deflection response similar to the force - deflection response of large specimens. He recommended that the minimum usable scale when testing separated reinforced concrete components would be 1/4.

Kitayama et al. (1987) reported the 'seismic design criteria for reinforced concrete inner beam-column joints'. They argued that the ratio of the column width to the diameter of the beam bar should be limited to a function of the beam bar strength and concrete strength. They also described that the design shear stress should be limited to prevent shear compression failure after the bond has deteriorated along the stiffener. Minimal side reinforcement must be placed within the joint to contain the main strut's concrete.

Kumar et al. (1991) conducted an experimental study of external beam-column joints. They tested 23 specimens simulating a typical external beam-column joint under axial compression and uniaxial bending. The effects of column axial loads, concrete grades of beams and columns, and lateral reinforcement of beams and columns were studied. A centrally grooved steel shoe for holding the steel ball was secured to each end of the column to provide ball joints to maintain the position of the ends. A hydraulic jack with a proof ring was used to load the beam end. The lower part of the column was placed through the ball joint of a 50-T hydraulic jack. The top of the column was supported under a steel girder. They reported that the efficiency of the joint increases with the increase in the axial load of the column for the same grade of concrete in the column and columns. However, the tendency was reversed when the concrete grade of the beam was more abundant than the concrete grade of the column.

Hwang and Lee (1999) proposed a method for determining the shear strength of an external beam-column joint for seismic isolation. The so-called strut-and-tie model is based on the strut-and-tie concept and is designed to meet the equilibrium, compatibility and compositional rules of cracked reinforced concrete . They compared the calculated shear strength with the experimental data reported in the previous literature to confirm the accuracy of the proposed procedure.

Kumar et al. (2002) conducted an experimental study to clarify the impact of joint refinement on the seismic performance of lightweight reinforced concrete frames. The variables studied were the rate of joint rotation, axial axial load, cross reinforcement at the joint, and longitudinal reinforcement to the beam. Approximately eight T-beam-column joint subassemblies designed and detailed in accordance with IS 13920-1993 were tested under cyclic loading conditions. They found that using crossover reinforcement at joints reduced joint damage but also reduced ductility and energy loss capabilities. This test result showed that not only increased the strength and ductility but also the damage of the joint area by allowing the existence of the axial load of the column and free joint rotation. They thus concluded that ductility and energy dissipation capacity increased with a decrease in the rate of longitudinal reinforcement.

Pampanin et al. (2002) conducted an experiment to investigate the inherent vulnerability of reinforced concrete beam-column connections designed solely by gravity loads. Experimental tests on six 2/3 scale-beam joints designed solely for gravity loads were performed under simulated seismic loads. They reported serious flaws in the joint panel zone area and the critical role of slip due to the use of smooth bars and improper docking. They observed a specific "concrete wedge" brittle fracture mechanism due to the interaction of shear crack and stress concentration at the hook fixing position of the outer beam-column joint specimen.

Murty et al. (2003) reported an experimental evaluation of the effectiveness of various details of longitudinal beam bar anchoring and transverse joint reinforcement in an outer beam-column joint of an anti-moment frame. Twelve specimens were tested with four arrangements to secure the beam bar, such as Type P, Type Q, Type R, Type S, and three different arrangements of stiffeners in Type I, Type II, and Type 3 joint areas. Among them, Type 2 joint stiffeners were the most effective, providing additional strength to the specimens beyond the cracks and reducing strength degradation. TypeR test specimens (with the longitudinal beam bars fully immobilized) provide the best performance with strength and ductility of the specimen. They concluded that ACI standard hooks, along with hair clip-like transverse reinforcement, among all studied joint reinforcement detailing systems, are the preferred combination due to ease of construction and overall effectiveness.

Liang and Montesinos (2004) presented the results of four RC steel-steel beam subassemblies with large displacement inversion and dynamic analysis of the RCS system under various ground motions. Test specimens are designed for connection based on strong column weak beam philosophy and strain-based capacity design methods. The results of this study show that the RCS frame system works satisfactorily under seismic excitement. The researchers reported that the specimens had excellent strength and stiffness retention and showed excellent energy loss up to about 5.0% displacement level. The joint transformation based capacity design procedure was effective in controlling.

Au et al. (2005) reported new details developed specifically for interthreshold seismic events using additional diagonal lines at the junction. They performed cyclic load tests on six half-scale inner beam-column subassemblies with details of different joints. The results show that the joints with newly proposed details, regardless of the axial load, exhibit better behavior in the low ductility factor range due to the high load carrying capacity, low stiffness and low strength drop I did.

Rajesh Prasad et al. (2005) reported the dynamic response of reinforced concrete connections in gravity design. The researchers carried out six tests on full-scale specimens with reversed cyclic displacements at varying speeds from slow quasi-static loads to high-speed dynamic loads of 20 Hz. They concluded that the maximum joint failure occurred because there was no dorsal fin inside the joint core. Damage patterns and failures of specimens showed a better correlation with residual layer shear stiffness than loss of interlaminar shear strength during repeated cycles.
Asha and Sundararajan (2006) detailed the behavior of external beam column joints in accordance with IS 13920: 1993 under seismic conditions. The main variable was type of restraint in the extended joint area of the column. They used four types of confinement: square rings, square spiral rings, circular rings, and circular spirals. For strain control testing, we used a screw jack to apply the displacement load at the beam jack. The end of the column is secured to the pivot assembly. The loading programming consists of a simple history of the reverse symmetric displacement of increasing amplitude. The specimens were evaluated for load - displacement relationship, ductility, stiffness, load ratio and crack pattern. They reported that external beam-column joints with square spirals in the cavity area were the most effective of all tested specimens.

Uma and Meher Prasad (2006) studied the behavior of beam column joints. They reviewed the hypothesized theory of joint behavior. They proposed that, in seismic design, plastic hinge-like damage is assumed to be formed by beams rather than columns. They found that the factors affecting the joint movement in the joints were related to the axial load of the joints and the amount of horizontal stiffeners. The functional requirements of the joint, which is the area where the beam intersects the column, is to allow the adjacent member to develop and maintain the final capacity. The demand for this finite-size element is always particularly severe under earthquake loads. The joints must have adequate strength and rigidity to withstand the internal forces induced by the frame members. The high internal forces generated in the plastic hinges create a severe bond to the longitudinal bars passing through the joints and impose high shear demands on the joint core.

Alexanders and Tsonos (2007) conducted an experiment to study the cyclic loading behavior of reinforced concrete beam-column joints in modern structures. They tested the seismic performance of four 1/2 external beam-column joints. According to ACI 318R.02 (A1), four subassemblies were designed and fabricated in accordance with Eurocode 2 (E1) and Eurocode 8 (E2) and in accordance with the Greek earthquake code. The subsets received cyclic lateral load history equivalent to severe earthquake damage. They reported that A1 and E2 beam column joints were satisfactorily performed while periodically applying loads so that they could not form plastic hinges on adjacent beams. Joints E1 and G1 do not perform well under counter-rotating loads. They point out that despite the use of a weak girder strong column design philosophy, current design procedures can sometimes severely damage joints.

Jachong and Lafave (2008) prepared a comprehensive database of reinforced concrete beam-column connection test specimens and showed joint failure when subjected to reverse cyclic lateral loading. They collected about 341 experimental subassembly data from around the world. They suggested that the shear shear strength and deformation model are mainly dependent on the compressive strength, stiffener and joint transverse stiffener of the RC joint shear capacity of reversed transverse loads.

Lars (1996, 1997 and 1998) studied the effects of high strength concrete and mixed cocktail fibers (a combination of steel and synthetic fibers). He conducted several tests to cast cylindrical specimens and observe the effect of steel fiber on post-peak behavior of HPC under compressive forces. In the first test, he experimented with compression tests on cylindrical specimens using only steel fibers. In the test, he reported that steel fibers did not improve the fracture behavior of HPC. He conducted several tests to study the effects of various fiber values and morphology. The use of polypropylene fiber improves material workability but does not change the fracture behavior in the region of maximum stress. In the third step he made a mixture of steel fibers and polypropylene fibers. It is called "fiber cocktail" concrete. He reported that after adding 0.2% polypropylene fiber to the concrete mixture, ductility could be improved by a steel fiber value of 1.5 vol%. After adding the synthetic fibers to the steel fiber reinforced concrete, the development of the plateau can be observed even in the region of maximum stress in the stress strain curve.

Eswari et al. (2008) presented a study on the ductility performance of hybrid fiber reinforced concrete. They investigated the effect of fiber content on ductile performance of hybrid fiber reinforced concrete specimens with different fiber volume fractions. Parameters of the survey include rupture factor, final load, working load, final and working load deviation, crack width, energy ductility and deformation ductility. They cast a total of 27 specimens (100 mm x 100 mm x 500 mm) and were tested to study the above variables. They used 0.0 to 2.0% volume ratio of polyolefin and steel fiber. The ductility of hybrid fiber - reinforced concrete specimens was compared with that of ordinary concrete. The researchers reported that the hybrid fiber volume fraction of 2.0% of the 30-70 polyolefin-steel composite significantly improved the ductility performance of reinforced concrete specimens.

Somma (2008) reported the shear strength of fiber-reinforced concrete beam-column joints under earthquake loading. They studied experimental work done by other researchers at beam-column joints with no fiber reinforcement or with beam stiffeners. Based on his research, he proposed a new formula to predict the shear strength of fiber-reinforced concrete beam-column joints. He compared the shear strength values obtained with these formulas to the values obtained from the experimental tests and reported that the proposed expression provided an accurate and uniform prediction of shear resistance as the test results were properly predicted.

III. OVERALL CONCLUSION

According to the results of previous studies, FRCs containing 1.2 to 2.0% volume of iron fibers can be used for partial replacement of fracture stiffeners in beam-column joints. The compressive strength of fiber concrete is slightly higher than the compressive strength of ordinary concrete mix. The static bending tests have shown that good fixation between the steel fibers and the cement matrix results in high ultimate flexural strength, high load carrying capacity and high ductility of the composite. Steel fiber reinforced concrete is superior to ordinary concrete in absorbing impact loads. All experimental work on beam-column joints was performed using steel fibers. Ductility has been reported to be improved by the addition of fiber cocktail or hybrid fibers (a combination of steel and synthetic fibers). After adding synthetic fibers to the steel fiber in the reinforced concrete, it is observed that the stress strain curve becomes even in the region of maximum stress. This test was performed only on cylindrical specimens. Since there is little literature on hybrid fibers in beam column joints, we have proposed a study on the effect of using hybrid fibers in beam column joints: ductility, energy absorption and strength enhancement.

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