"Analysis of Beam-Column Joint subjected to Seismic Lateral Loading" – A Review

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Abstract - *In reinforced concrete structures, portions of columns that are common to beams at their intersections are called Beam-Column Joint. Beam-column joint is an important part of reinforced concrete frames in terms of seismic lateral loading. The two major failure at joints are, joint shear failure and end anchorage failure. As we know that nature of shear failure is brittle so the structural performance can not be accepted especially in seismic conditions. This study presents design as well as detailing of beam-column joint of the structure. From this paper we get a review on the behavior of joints under ACI 352R-02 and IS13920:1993 code. Design and detailing provisions on beam-column joints in IS13920:1993 do not adequately address prevention of anchorage and shear failure during severe earthquake shaking. A careful study and understanding of joint behaviour is essential to arrive at a proper judgement of the design of joints. This paper focus on the seismic action on various type of joints and even on the parameters which affect joints and all component parts will be check for strength and stability.*

Key Words: *Beam-column joint, shear failure, seismic action, moment resisting frame reinforced concrete frames, shear reinforcement.*

1. INTRODUCTION

Earthquake is a violent tremor in the earth's crust, sending out a series of shock waves in all directions from its place of origin. It is the result of a sudden release of energy in the earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquake experienced over a period of time. Analysis of damages incurred in moment resisting RC framed structures subjected to past earthquake show that failure may be due to utilization of concrete not having sufficient resistance, soft storey, beam-column joint failure for weak reinforcements or improper anchorage, column failure causing storey mechanism [5]. An earthquake resistant building is able to accumulate a lot of energy without major failure. It will swing and sway and it might be damaged. But it would not collapse before giving very visible signs. Therefore, people would be able to leave the building before it would collapse. An earthquake resistant building, which has been damaged, could most of the time be repaired.

1.2 Theoretical Development of Beam-Column Joint

Beam-Column Joint is the zone of intersection of beams and columns which enables the adjoining members to develop and sustain their ultimate capacity. The joints should have proper adequate strength and stiffness to resist the internal forces induced by the framing members. Beam-Column joints are the weakest link in RC moment resisting frame. Design and detailing of beam-column joints reinforced concrete frames are critical in assuring the safety of these structures in earthquakes. Such joints should be designed and detailed to Preserve the integrity of the joints sufficiently to develop the ultimate strength and deformation capacities of the connecting beams and columns; Prevent excessive degradation of joint stiffness under seismic loading by minimizing cracking of the joint concrete and by preventing the loss of bond between the concrete and longitudinal beam and column reinforcement; and Prevent brittle shear failure of the joint. As a consequence, seismic moments of opposite signs are develop in columns above and below the joints and at the same time beam moment reversal across the joints.

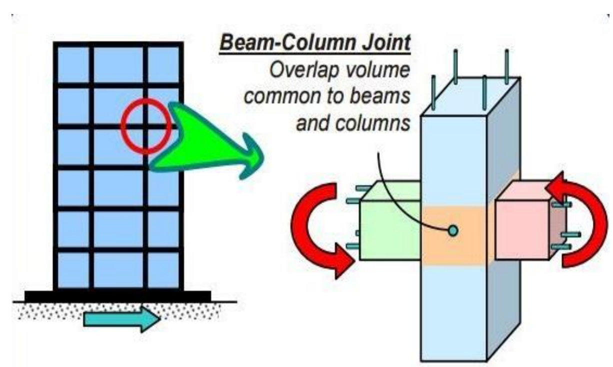

Fig -1: Beam-column joints are critical parts of a building.

Under the action of seismic forces, beam-column connections are subjected too large shear stresses in the joint region. These shear stresses are a result of moments and shear forces of opposite signs on the member ends on either side of the joint core. Typically, high bond stresses are also imposed on reinforcement bars entering into the joint. The axial compression in the column and joint shear stresses result in principal tension and compression stresses that lead to diagonal cracking and or crushing of concrete in the joint core. Figure 2, shows the geometric distortion of the joint. If column cross-section size is insufficient, the concrete in the joint can develop diagonal cracks.

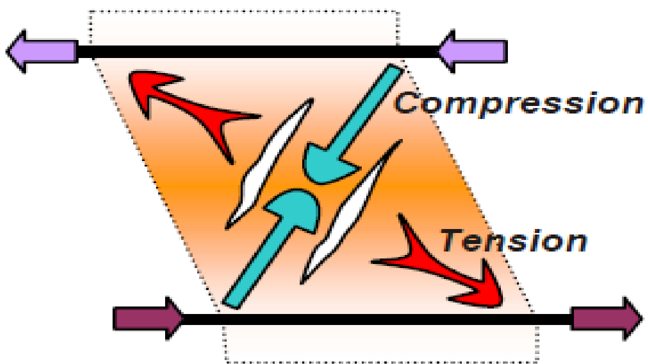

Fig -2: Geometric Distortion of the Joint

The design of Beam-column joint is mainly focused on providing joint shear strength and adequate anchorage within the joint. IS 13920:1993 code of ductile detailing of reinforced concrete structures subjected to seismic forces has given recommendations for the strengthening of the joint [2].

1.3 Types of Beam-Column Joint

On the basis of location of joint in structure, the joints are grouped in three types as follows;

- Interior Joint
- Exterior Joint
- Corner Joint

1.3.1 Interior Joint

When four beams frame into the vertical faces of a column, the joint is called as an Interior Joint.

1.3.2 Exterior Joint

When one beam frames into a vertical face of the column and two other beams frame from perpendicular directions into the joint, then the joint is called as an Exterior Joint.

1.3.3 Corner Joint

When a beam each frames into two adjacent vertical faces of a column, then the joint is called as a Corner Joint.

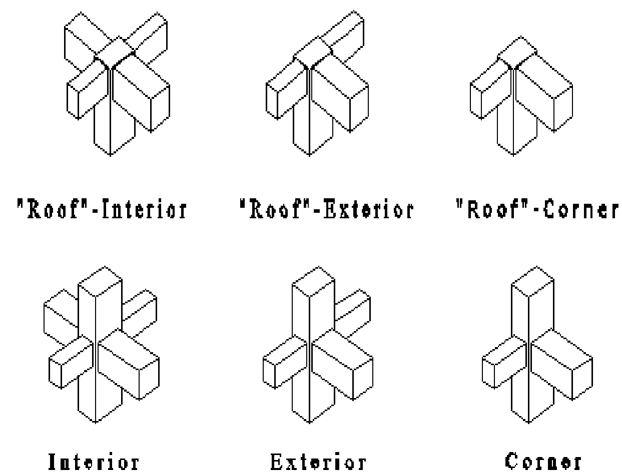

Fig -3: Types of Beam-Column Joints

2. LITERATURE REVIEW

- **Recommendation for design of Beam-Column Joint in RC Structure (1997),** These recommendations are for determining joint proportions and design of the longitudinal and transverse reinforcement at the intersection of beams and columns in cast-in place concrete frame construction. Because of the use of high-strength materials (concrete and steel), smaller member sections, and larger reinforcing bars, special attention to the design and detailing of the joint has become more important.

- **N. Subramanian and D. S. Prakash Rao (2012),** discussed the behaviour and design of two-, three- and four-member beam - column joints in framed structures are; obtuse and acute angle joints are included. Detailing of the joints based on experimental investigations is also explained. The specifications of American, New Zealand and Indian codes of practice are appraised. An equation for calculating the area of joint transverse reinforcement has been proposed for the Indian code, based on recent research.

- **Dr. S. R. Uma (2006),** presented critical review of recommendations of well established codes regarding design and detailing aspects of beam column joints. The codes of practice considered are ACI 318M-02, NZS 3101 (Part 1): 1995 and the Eurocode 8 of EN 1998-1:2003. All three codes aim to satisfy the bond and shear requirements within the joint. It is observed that ACI 318M-02 requires smaller column depth as compared to the other two codes based on the anchorage conditions. NZS 3101:1995 and EN 1998-1:2003 consider the shear stress level to obtain the required stirrup reinforcement whereas ACI 318M-02 provides stirrup reinforcement to retain the axial load capacity of column by confinement. Significant factors influencing the design of Beam- Column Joints are identified and the effect of their variations on design parameters is compared. The variation in the requirements of shear reinforcement is substantial among the three codes.

- **P. Rajaram and G. S. Thirugnanam (2008),** according to them, a two bay five storey reinforcement cement concrete moment resisting frame for a general building has been analysed and designed in STAAD Pro as per IS 1893:2002 code procedures and detailed as IS 13920:1993 recommendations. A beam column joint has been modeled to a scale of 1/5th from the prototype and the model has been subjected to cyclic loading to find its behaviour during earthquake. Non linear analysis is carried out in ANSYS software.

- **S. S. Patil and S. S. Manekari (2013),** studied various parameters for monotonically loaded exterior and corner reinforced concrete beam column joint. The corner as well as exterior beam-column joint is analyzed with varying stiffness of beam-column joint. The behavior of exterior and corner beam-column joint subjected to monotonic loading is different. Various graphs like load vs. displacement (deformations), Maximum stress, Stiffness variations i.e. joint ratios of beam-column joints are plotted.

3. CONCLUSION

The performance of framed structures depends upon the individual structural elements as well as the integrity of the joints. Based on literature studies the interior, exterior and corner beam-column joints were studied. The beam-column joint are weakest member in seismic loading and have confined ductility and a little resistance to snaping. Hence, the design and detailing of joints are critical in seismic conditions.

Large amount of research carried out to perceive the complex mechanisms and safe behaviour of beam-column joints has gone among the codal recommendations. This study shows that there is a enough changes in the codal provisions on beam-column joints and also present a review of design and detailing of beam-column joint of the structure. And its object to satisfy the bond and shear requirements inside the joints.

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