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# Study of Reinforced Concrete Beam-Column Joint

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**ABSTRACT**:The critical area of a reinforced concrete moment-resisting frame is the beam-column joint. It experiences strong forces during violent ground shaking, and its actions have a big impact on how the structure reacts. The assumption of a rigid joint fails to consider the effects of high shear forces developed within the joint. The shear failure is always brittle which is not acceptable structural performance, especially in seismic conditions. the paper presents a review of the postulated theories associated with the behaviour of joints. Understanding joint behaviour is essential in exercising proper judgments in the design of joints. This paper discusses the seismic actions on various types of joints and highlights the critical parameters that affect joint performance with special reference to bond and sheartransfer.

**KEYWORDS:**Beam column joint, moment resistingframe, rigid joint, shear failure, seismic actions, shear transfer

## I. INTRODUCTION

Failure of a beam is common in structures made of reinforced concrete. near the beam-column joint making, the joint is one of the most critical sections of the Sudden change in geometry and complexity of stress distribution at the joint are the reasons for their critical behaviour. In Earlier, the design of joints in reinforced concrete structures tended to focus only on meeting anchorage specifications. In succeeding years, the behaviour of joints was found to be dependent on several factors related to their geometry; amount and detailing of reinforcement, concrete strength, and loading pattern. heavy earthquake damage in a beam-column joint should be avoided

(a) The joint can withstand the force of gravity.
(b) It is difficult to achieve in the joint a large ductility and energy dissipation.
(c) After an earthquake, repairing a joint is challenging.

However, an excessive complication of reinforcement detailing should be equally avoided to ensure good workmanship and construction. In order to avoid an expected structural deformation, joint shear failure and considerable beam bar slippage within a joint should be avoided

## 1.1 SHEAR RESISTING MECHANISMS OF BEAM-COLUMN JOINT

### 1.1.1 Diagonal StrutMechanism

The resultant of the horizontal and vertical Compression stresses and shear stresses acting on the concrete at the beam and column critical sections, the diagonal compression strut is created at joint panel along the main diagonal.

### 1.1.2 TrussMechanism

The tensile stresses in the vertical and horizontal reinforcement, the bond stresses along the external bars of the beam and column, and the uniformly distributed diagonal compression stresses all contribute to the formation of the truss mechanism.

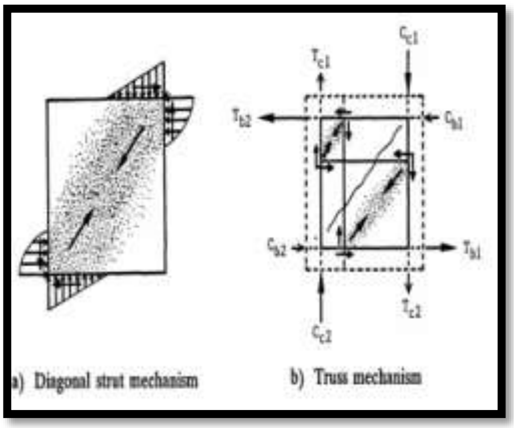

**Fig.1 shear transfer mechanism at joints**

**(Source: Kazuhiro Kitayama and Et al.2010)**

### 1.2 various Types of joints:

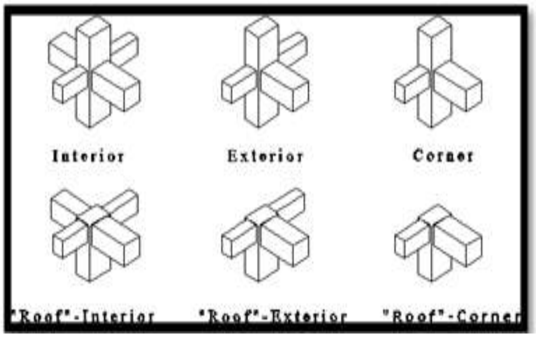

**Fig.2 Typical Beam-Column Connections**
**(Source: Joint ACI-ASCE Committee 352, 2002)**

### 1.3 Performance Criteria

It's necessary the following are some criteria for joints' desired performance**:**

**I.** The strength of the joint should not be less than the maximum demand corresponding to the development of the structural plastic hinge mechanism for the frame. This will reduce the need for maintenance in a somewhat difficult-to-reach area and for joint mechanisms to dissipate energy. As will be seen later, joint mechanisms suffer substantial stiffness and strength degradation under cyclic actions in the inelastic range. The capacity of the column should not be jeopardized bypossiblestrength degradation within the joint. The joint should also be considered an integral part of the column

**II.** The joint reinforcement is necessary to ensure satisfactory performance and should not cause undue construction difficulties

## II. LITERATURE REVIEW

**Laura N. Lowes and Arash Altoontash,2003,** Theyestablished a model to represent the response of reinforced-concrete beam-column joints under reversed-cyclic loading. The proposed model provides a simple representation of the primary inelastic mechanisms that determine joint behavior: Failure of the joint core under shear loading and anchorage failure of the beam column junction contains longitudinal reinforcement. In two-dimensional nonlinear analysis of reinforced concrete structures, the model is implemented as a four-node 12-degree-of-freedom element that is suitable for use with conventional hysteretic beam-column line elements. Constitutive relationships are developed to define the load formation response of the joint model based on material, geometric, and design parameters. A comparison of simulated and observed responses for a series of joint sub assemblages with different design details indicates that the proposed model is appropriate for use in simulating response under earthquake loading.

**Sudhir K. Jain,2006,** presented a critical review of recommendations of well-established codes regarding the design and detailing aspects of beam-column jointsACI 318M-02, NZS 3101: Part 1:1995, and the Eurocode 8 of EN 1998-1:2003 are the codes of practice that are taken into consideration. The bond and shear requirements within the joint are the focus of all three regulations. It is observed that ACI 318M-02 requires a smaller column depth as compared to the other two codes based on the anchorage conditions. The shear stress level is taken into account by NZS 3101:1995 and EN 1998-1:2003 to determine the necessary stirrup reinforcement, whereas ACI 318M-02 offers stirrup reinforcement to maintain the axial load capacity of a column via confinement. The impact of their modifications on design parameters is evaluated, and significant factors impacting the design of beam-column junctions are discovered. The three codes significantly differ in their demands for shear reinforcement.

**Nilanjan Mitra,2007,** developed performance-based design methods that enable the design of a structure to achieve specific performance objectives, typically above 'life safety, under a given level of earthquake loading. Accurate component load and deformation demands must be predicted in order to complete performance-based design; normally, nonlinear analysis is used to ascertain these demands. He concentrated on creating a number of analytical and design tools to aid in the performance-based design of reinforced concrete beam-column joints, a specific structural component. This particular component is chosen for investigation because, even though laboratory and post-earthquake reconnaissance indicate that joint stiffness and strength loss can significantly affect structural reaction, but analysis rarely takes these components' inelastic response into account. Or design Data from prior experimental joint research were compiled, covering a wide variety of geometric, material, and design characteristics. A number of models were created and put to using these data to improve our understanding of the seismic behavior, modelling, and design of reinforced concrete beam-column joints. These include a 1) discrete choice probabilistic failure initiation model, 2) continuum model for joints, 3) strut-and-tie models for joints, and 4) a component-based super-element model for the jointregion.

**P. Rajaram and G.S. Thirugnanam,2008**, a two bay five-story reinforcement cement concrete moment resisting frame for a general building has been analyzed 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 modelled at a scale of 1/5th from the prototype, and the behavior of the joint under cyclic loads has been determined.In ANSYS software, nonlinear analysis is performed.

**Dr.S.R.Uma,2009**, presented a critical review of recommendations of well-established codes regarding the design and detailing aspects of beam-column joints. ACI 318M-02, NZS 3101: Part 1:1995, and the Eurocode 8 of EN 1998-1:2003 are the codes of practice that are taken into consideration. The bond and shear requirements within the joint are the focus of all three regulations. It is observed that ACI 318M-02 requires a smaller column depth as compared to the other two codes based on the anchorage conditions. NZS 3101:1995 and EN 1998-1:2003 both this code considers the shear stress level to get the required stirrup reinforcement whereas ACI 318M-02 provides stirrup reinforcement to retain the axial load capacity of a column by confinement. The impact of their modifications on design parameters is evaluated, and significant factors impacting the design of beam-column junctions are discovered. The three codes significantly differ in their demands for shear reinforcement.

**Kazuhiro Kitayama, Shunsuke Otani, and Hiroyuki Aoyama,2010** a list of the requirements for internal beam-column joints made of reinforced concrete that are earthquake resistant. The protection of the joint to an acceptable deformation level of a frame structure during a strong earthquake is emphasized in the design criteria. For the design against shear, Experimental research was done on the shear-resisting mechanism provided by trusses and concrete compression struts, the function of joint lateral reinforcement, and the impact of transverse beams and slabs. Therequirementfor beam bar bond was discussed based on nonlinear earthquake response analysis.

**Gregoria Kotsovou and Harris Mouzakis,2012,** put forward a method for the seismic design of external beam-column joints by considering the load transferred from the linear elements to the joint is mostly resisted by a diagonal strut mechanism. The work presented is not only to verify the validity of the proposed method but also to identify means for its implementation that will maximize its effectiveness. The effect of the above characteristics on structural behavior is established by testing full-size beam-column joint specimens under cyclic loading the acquired results demonstrate that the suggested strategy yields design solutions that fully satisfy the code performance requirements and are discovered to be consistent with previously published experimental data.

**N. Subramanian and D.S. Prakash Rao,2012,** discussed the behavior and design of two-, three- and four-member beam-column joints in framed structures; obtuse and acute angle joints are included. Detailing the joints based on experimental investigations is also explained. The provisions of American, New Zealand, and Indian codes of practice are evaluated. to calculate the area of joint transverse reinforcement has been proposed for the Indian code.

**S. S. Patil and S.S. Manekari,2013,** studied various parameters for monotonically loaded exterior and corner reinforced concrete beam-column joints. The corner, as well as the exterior beam-column joint, is analyzed with varying stiffness of the beam-column joint. When exposed to monotonic loading, the behavior of exterior and corner beam-column joints differs. Several graphs such as load vs. displacement (deformations), Maximum stress, and Stiffness variations i.e. representation of joint ratio of beam column joint is done.

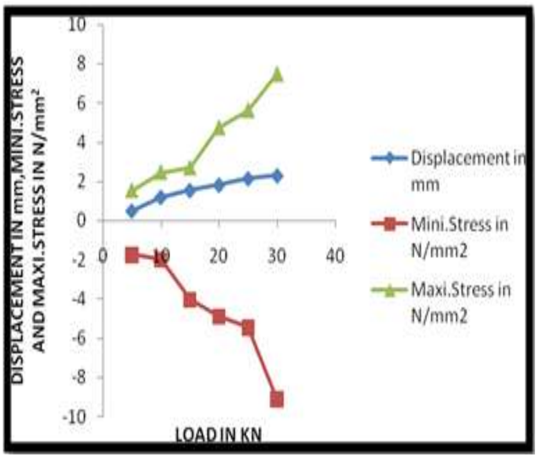

**Fig.3 Load Vs Maximum Deformation, Minimum Stress, Maximum Stress Graph**

**(Source: S. S. Patil and S.S. Manekari,2013)**

**Mehmet Unal and Burcu Burak,2013,** studied the inelastic behavior of beam-column joints, and the factors influencing the seismic behavior of beam-to-column connections. Mr. Mehmet unal and etal believed that the main parameters which influences the connection performance arecolumn-to-beam moment ratio, confinement of the connection zone by the lateral reinforcement and beam framing, anchoring of the longitudinal reinforcement of the beam, and shear stress level in the joint. In addition, material properties, section dimensions, eccentricity between the center lines of beam and column, the axial load acting on the column, and the presence of wide beams or slabs also affect the connection behavior.

**A.K. Kaliluthin, Dr.S. Kothandaraman,2014,** focused on the general behavior with specific structural properties of common types of joints in reinforced concrete moment resisting frames to be aware of the fundamental theory of the joint for better efficiency. A beam-column joint is a very critical zone in reinforced concrete framed structures where the elements intersect in all three directions. The behavior of joints was found to be dependent on several factors related to their geometry; amount and detailing of reinforcement, concrete strength and loadingpattern.

## III. SUMMARY AND CONCLUSION

In a rigid frame, structural joints should be able to withstand forces greater than those of the connecting parts. The joints of RC rigid frames, however, are not designed or developed with the same level of attention as the beams and columns. If the joints are unable to withstand the forces and deformations brought about by the transfer of forces among the parts coming together at the joint, the structural behavior will differ from that expected in the analysis and design.Joint opening in particular needs to be carefully studied because it will cause the joint to break diagonally. Such opening of joints occurs in multistoried structures due to lateral loads. Although the ideas are focused on seismic forces, they are universal in nature and can be used to apply to structures that are exposed to lateral forces.

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