1. INTRODUCTION:

Recent study on beam column joint lead to the revelation that, this particular junction of structural members is one of the most vulnerable, in terms of failure tendency. For a long time now, studies have been conducted to enhance the strength of this particular failure location. Many of these studies showed that a difference incorporated in the detailing of the joint reinforcement enhances the property of the joint. These differences can be in the form of addition of reinforcement, reduction of reinforcement or even as modification of existing reinforcement.

This paper presents a summary of all of the research work that has been carried out in the topic of beam column joint. It also includes studies conducted on different types of concrete and also review on codal provisions.

2. LITERATURE REVIEW:

Bindhu K R (2009)\(^1\) studied the behaviour of columns and exterior joints under seismic type loading. Cross inclined bars were provided as a replacement of ties in the joint region for the joints having transverse reinforcement detailed as per IS 13920 : 1993. The specimens having special confining reinforcement as per IS 13920:1993 showed improved ductility and energy absorption capacity than the specimens detailed as per IS 456:2000 and SP34. The performance of the specimens with non-conventional confinement reinforcement had exhibited higher ultimate strength with minimum cracks.
Kaviarasu (2012) analyzed the behavior of beam column joint under the influence of headed bars. Emulative precast connections were developed. The Ultimate load carrying capacity, displacement, ductility, energy dissipation capacity, strain in reinforcements was considered. In the precast specimens the strain in the column main reinforcement were negligible and the strain in longitudinal reinforcement of the beam was higher for all the specimens tested which indicates beam mode of failure.

Vandhana R K, Bindu K R (2014) studied the RCC interior beam column joint under reversed cyclic loading. Beam column joints are designed based on strong column weak beam behavior. The joint shear strength and stiffness are greatly influenced by the factors like concrete compressive strength, slab transverse reinforcement. The statistical modeling is used to represent their jointy behaviour to decide the shear strength and energy absorption capacity.

Shyh-Jiann Hwang, Hung-Jen Lee et. al. (2005) studied to understand the role of hoops on shear strength of reinforced concrete beam column joint. Nine exterior reinforced concrete beam column sub assemblage were tested carry shear as a tension tie and constrain the width of crack. The joint hoops are found to act as a tension tie as well as to constrain the crack width. The elastic joint hoops are effective in restraining the displacement reversals.

Siva Chidambaram,K.R, Thirugnanam,G.S (2012) conducted a comparative study on behaviour of reinforced beam-column joints with reference to anchorage detailing. The control specimen (CS) constructed and detailed as per IS
13920:1993 codal provisions and externally anchorage specimen (EAS) cast with small projection beyond the column face. The first crack load of the externally anchorage specimen is 45 more than the conventional joints specimen.

Stavroula Pantazopoulou and John Bonacci(1992)\textsuperscript{6} studied the implications of the frequent questions about beam-column joints. The mechanics of beam-column joints loaded frame structure are investigated in this paper. The role of stirrups and axial load on the behaviour of the joints are illustrated clearly. Through persistent debate and careful scrutiny of experiments over the past several decades, recommendations for reliable design of beam-column joints have evolved.

Sergio Malcocer et al(2000)\textsuperscript{7} studied the behaviour of a precast concrete beam column connection. Beam column joints are tested under unidirectional and bidirectional cyclic loading. In one structure continuity was achieved by placing hoops around the extensions of 90-deg hooks of beam bottom reinforcement that protruded from the beam ends to the joint. In the other specimen, hooks were replaced by U-shaped prestressing strands that were lap-spliced to the bottom beam reinforcement that was in turn terminated flush at the beam end. Specimens exhibited a ductile response. Specimen behavior was controlled by joint shear.
Bing Li (2009) investigated the seismic performance of lightly reinforced concrete exterior beam-column joints. Experimental results of four lightly RC exterior beam column joints with and without beam stubs under cyclic loading with constant column axial force applied at the top of the column. Test results showed that when the hooks anchored down in the column increased the tensile stress in the diagonal concrete strut in the joint core.

Mohammad Soleymani Ashtiani et al. (2014) studied the implementation of high-strength self-compacting concrete in beam column joints and assessment of its seismic behavior under reversed cyclic loading. Three interior beam-column subassemblies chosen to vary in concrete type and compressive strength are designed as per New Zealand standard NZ3101:2006. The cracking pattern at different load levels and the mode of failure are also recorded and compared among different specimens.

Sakai and Sheik (1989) studied the variations in confinement in reinforced concrete columns. Main focus on characteristics of materials, characteristics of cross-section, behavior of columns and other mechanical characteristics and design constraint such as structural detailing. A comprehensive review on confinement of reinforced concrete columns has been presented. Based on the review of the previous research, it appears that a re-examination of the ACI code provisions for confinement will be needed.
Mo and Wang (2000) analysed the seismic behavior of RC columns with various Tie configurations. To expedite the fabrication of reinforcement cages of columns, a new configurations of transverse reinforcement with alternate ties for column is proposed. The new configurations of transverse reinforcement with alternate ties provides comparable or improved seismic performance than typical configurations normally used in the construction. Finally, it is further established that current ACI requirements for compression lap splices is adequate when the proposed configuration of transverse reinforcement with alternate ties is used.

Shyh-Jiann Hwang (2004) studied the seismic design and detailing of exterior reinforcement concrete beam-column joints. To investigate the effect of joint hoops on the shear strength of exterior reinforced concrete beam column connections subjected to earthquake loading. The deterioration of beam-column joint under displacement reversals could be effectively restrained by the elastic joint hoops. Lesser amount of hoop reinforcement with wider vertical spacing up to 300 mm could be used without significantly affecting the performance of joints.

A.K. Kaliluthin (2014) produced a review on behavior of reinforced concrete beam-column joint. Deals with the requirement criteria for the desirable performance of joints such as i) The strength of the joint should not be less than the maximum demand ii) The capacity of the column should not be jeopardized by possible strength degradation iii) The joint should also be considered as an integral part of the column. iv) The joint reinforcement necessary to ensure satisfactory performance should not cause undue construction difficulties.
S. R. Uma & Sudhir K. Jain (2006) formulated a codal review on the seismic design of beam-column joints in RC moment resisting frames. It presents critical review of recommendations on well-established codes, regarding design and detailing aspects of beam-column joints. The behavior and expected performance of flexural members of reinforced concrete moment resisting frames can be realized only when the joints are strong enough to sustain the severe forces set up under lateral loads.

Dr. S. R. Uma and Prof. A. Meher Prasad investigated the seismic behavior of Beam Column Joints in Reinforced Concrete moment resisting frames. One of the basic requirements of design is that the columns above and below the joints should have sufficient flexural strength when the adjoining beams develop flexural over strength at their plastic hinges. The mechanisms involved in joint performance with respect to bond and shear transfer are critically reviewed and discussed in detail. A significant amount of ductility can be developed in a structure with well-designed beam-column joints wherein the structural members could perform satisfactorily as per the capacity design principles.

K. R. Bindhu, P. M. Sukumar and K. P. Jaya (2009) compared the behavior of exterior beam-column joint sub-assemblages with transverse reinforcements detailed as per IS 456 and IS 13920. A six-storied RC building in the zone III is analyzed, and one of the exterior beam-column joints at an intermediate storey is designed. All the specimens failed due to the development of tensile cracks at the interface between beam and column. The joint region was free from cracks except for some hairline cracks, and therefore the joints had adequate shear-resisting capacity.
Hung-Jen Lee and Si-Ying Yu (2009) studied the cyclic response of exterior beam column joints with or without eccentricity to evaluate the use of mechanical anchorages in place of hooked bar anchorages. The primary test variables were the anchorage methods of longitudinal beam bars and the eccentricity between the beam and column center lines. The first pair of joint specimens used standard 90-degree hooks for the beam bar anchorage. The next two pairs of joint specimens used screw deformed bars with mechanical anchorage devices in place of hooked bars in the joints. The use of a single mechanical anchorage device in place of the 90-degree hook terminating in the joint resulted in an equivalent or better performance under large inelastic displacement reversals.

Xilin Lu, Tonny H. Urukap, Sen Li and Fangshu Lin (2012) introduced a new design philosophy involving the use of additional diagonal bars within the joint particularly suitable for low to medium seismic effects in earthquake zones. Ten full-scale specimens were tested and the detailing has been shown to be effective in improving the seismic resistance of joints. The results of the experiment showed that adding additional bars is a promising approach in reinforced concrete structures where earthquakes are eminent. In terms of overall cracking observation during the test, the specimens with additional bars compared with the ones without them showed fewer cracks in the column.
Thomas H.-K. Kang, Myoungsu Shin, Nilanjan Mitra, and John F. Bonacci (2009) provide a detailed review for the test data; and, finally, propose design guidelines to supplement ACI 352R-02 and 318-08 on the subject of headed bars anchored in beam-column joints. The tested specimens are categorized into three different groups in terms of failure modes established by the writers as follows: Category I: member flexural hinging followed by modest joint deterioration Category II: member flexural hinging followed by joint failure Category III: joint failure prior to member flexural hinging. A detailed review of previous research on the use of headed bars in reinforced concrete beam column joints subjected to quasi-static reversed cyclic loading is presented.

Nilanjan Mitra (2007) developed a series of analysis and design tools to support the performance-based design of reinforced-concrete beam-column joints. Data from previous experimental investigations of joints, spanning a wide range of geometric, material and design parameters, were assembled. The probabilistic modeling strategy provides a first-hand estimate of the factors responsible for failure initiation within the joint region and also identifies the relative importance of the factors in determination of the failure initiation mechanism in the joint region.

3. CONCLUSION:

The review of the literature shows that the beam column joint requires special attention with respect to its detailing detail. The major source of failure is the lack of capability of the joint to withstand the shear force experienced at the juncture. Towards the goal of improving such a vulnerable character of the joint, many authors suggested new techniques and methods. They tested these techniques with that of the conventional construction of the beam column joint. All of the testing revealed that the new methodologies adopted by the authors have displayed far better performance in comparison to the conventional beam column joint.

These researches performed have given an insight on various methods to improve such a risky zone of failure. Each of these papers also suggest areas and scope for further study and have given suggestions on how to conduct them as well.
IV REFERENCE:

[1] Bindhu K R (2009), Behaviour of columns and exterior joints under seismic type loading, PhD thesis at Anna University


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[17] Hung-Jen Lee and Si-Ying Yu(2009), Cyclic Response of Exterior Beam-Column Joints with different Anchorage Methods, ACI STRUCTURAL JOURNAL

