Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 6, Issue 01, January -2019

BEHAVIOUR OF REINFORCED CONCRETE BEAM-COLUMN JOINT UNDER EARTH-QUAKE (A-REVIEW)

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Abstract — *This review paper is based on the research work of different researchers regarding the behavior of beam-column joint in Reinforced Concrete (RC) structure. Because of its importance during earthquake, experiment conducted by researchers on full-scale specimens of connection between beam and column by considering the effects of axial load, confinement effect and the compression effects on joints during an earthquake. Conclusions drawn from experiments are; the joint shear strength capacity will increase by increasing the axial load on the joint. Also, joint shear strength is more in case of interior joint as compared to exterior joint but still there is not any relation between the increases of axial force to the joint shear strength. Joint capacity increases greatly by providing lateral confinement ratio of up to 0.40%. Compressive strength also helps to enhance the bond strength between concrete and steel and it mainly contributes to increase the shear strength of the connection. The shear strength of the connection is about the square root of the compressive strength of concrete.*

Keywords- *Beam-Column joint, Shear strength, confinement effect.*

I. INTRODUCTION

Masonry In Pakistan, Reinforce Concrete frames (RC) frames is a common type of construction for government offices, colleges, hospitals and residential apartments. In RC structures, joints are mainly referred to as the portion of a column that is common to beam at their intersection. The joints play a very important role in transferring the loads or moments of slab, beam and upper story column to the ground. The load and moments can only be transferred properly if there is a rigid connection between the beam and columns. In reinforced concrete beam there is mainly two type of beam-column joints i-e type I and type II. Type I joints are only design for the gravity loads and the moments from both side of the connection will be in opposite direction, while type II joints are design for lateral forces i.e. earthquake forces, wind forces or the blast effects and the moments on the connection from both sides are in the same direction as shown in Figure 1 and Figure 2.

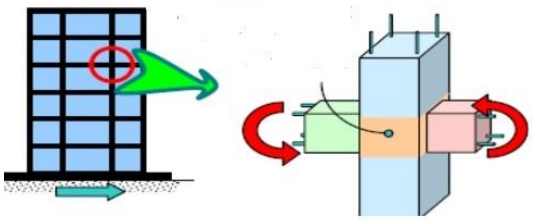

Figure 1 Portion of Beam Column Joint (Type 1)

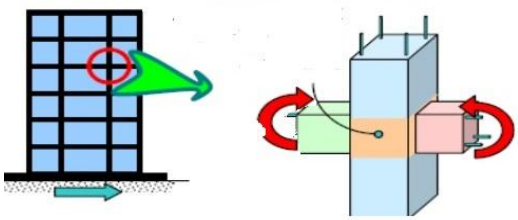

Figure 2 Portion of Beam Column Joint (Type 2)

It is observed form the existing analytical and experimental data that the joints perform well under fixed gravity loading, however, under reverse cyclic loading condition such as an earthquake, high wind and blast loading condition, its behavior becomes more critical. The level of earthquake demand and corresponding performance emphasize a comprehensive study of the behavior of joints. The behavior of joints and shear capacity of the connection under seismic action mainly depends on axial load from column, confinement effects on joint (transverse reinforcement, location of joints), strength of concrete, aspect ratio, effect of joint eccentricity and bond strength between concrete and rebar.

II. Experimental Evaluation

Since last four decades, researchers carried out experimental investigations to predict the behavior of beam-column joint under earthquake loading. Till date experimentally the connections were investigated by applying monotonic and reverse cyclic loadings on beam-column joint specimens. A monotonic loading test usually does not provide adequate information to evaluate seismic behavior, as well as joint shear deformability, ductility, energy dissipation and post-peak behavior. While in cyclic loading the collapse mechanism and ultimate load capacity can be observe in detail. In moment resisting frames under several earthquakes, which is in sprint of research nowadays is very important to evaluate its behavior experimentally. Past research allied with the cyclic loading experimental test is presented here.

2.1 Axial Load Effect

Axial load from the upper column greatly affects the performance of joint in lateral forces. It was observed from the experimental results, that increase in axial load ratio is favorable to energy dissipation capacity of joints with small shear;

no significant effect is observed on the joints with moderate shear; and unfavorable effect is noticed on the joints with high shear which results in premature shear failure, that is, crush of the joint core concrete [1]. Joint shear behavior will increase with the increase in column axial force but with an unknown percentage[2]. From the conclusion of [3], [4], [5], [6] and [7] joint shear strength gets little influenced by column axial load. But there is not any empirical relation which determines the amount of increase in shear capacity by increasing the axial load on column. On the other hand, [8] and [9] claims that high axial load on columns increases joint strength. Ductility of exterior joints was examined by [10] and from there experimental results, changing the axial load on joint from 0% to 17 % of the column axial load capacity, the joint shear strength increases with increases axial loads.

2.2 Confinement Effect on Joints

Confinement of joints mainly refers to the confinement provided by stirrups or it is either confined from the externally provided beams. In both cases, confinement of beam greatly affects the joint shear stress and shear strain. From the experimental results conducted by [11], the beams effectively provide passive confinement to the joint panel and the prevention of expansion of the joint will ultimately help in increasing the capacity. This condition is valid for the case of when the beam member's centerline coincides with the column cross-section centerline but if the beam member's centerline does not coincide with the column cross-section, there is a chance to produce torsion in the joint panel due to joint eccentricity, causing week diagonal strut in the joint. This weakened diagonal concrete strut and truss due to the generated torsion might trigger a reduction in joint shear stiffness.
According to [12], joints shear capacity was improved by providing stirrups as confinement as shown in the schematic diagram shown in Figure 3 and Figure 4 shows the experimental testing of beam-column joint.

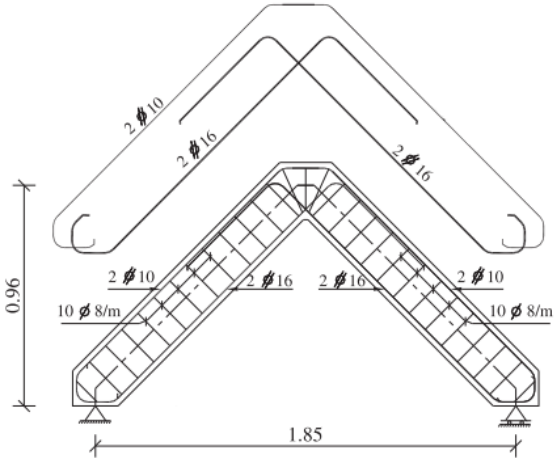

Figure 3 Schematic Diagram of Stirrups provided in joint

Figure 4 Experimental Testing Specimen.

By providing stirrup it increases the cracking and failure loads and also improved the cracking behavior of the joint failure. The reason behind the increase in the cracking behavior is that the stirrups confines the joint concrete and hence reduce the possibility of formation of internal cracks in joint. [13] experimentally investigate that by increasing the lateral reinforcement ratio it will reduce the joint shear deformation and crack width in the joint panel. [14] observed that by using the lateral reinforcing ratio up to 0.40 % stirrup will greatly increase the capacity of the joint.

2.3 Compressive Strength Effect on Joint

The compressive strength of concrete also greatly affects the different parameters in the joint. These parameter includes joint shear strength and bond between joints lateral reinforcement and concrete. High strength concrete has high bond capacity and hence effectively transfer the forces/moments from beam to column. Also, it is experimentally observed that increasing the compressive strength of concrete will ultimately increase the joint shear strength capacity. [15] concluded that by increasing the concrete strength will increase the shear capacity of the joint but with the stiffness degradation of joints. [16] experimentally examine that joint shear strength will increase approximately by a square root of the concrete compressive strength. His experimental results are based on the examination of concrete compressive strength from 4 ksi to 12 ksi.

III. Conclusions

Based on the different experiment conducted by different researcher following conclusion was drawn.

- The joint shear strength capacity will increase by increasing the axial load on the joint from the upper column. But still, there is not any relation between the increase of axial force to the joint shear strength
- By providing max lateral confinement ratio of up to 0.40 %, stirrup will greatly increase the capacity of the joint.
- Joint shear strength is more in case of interior joint as compared to exterior joint.
- Compressive strength mainly contributes to increasing the shear strength and it is about the square root of the compressive strength of concrete. Compressive strength also helps to enhance the bond strength between concrete and steel.
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