IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 4, April 2022

DOI: 10.17148/IARJSET.2022.9471

Analytical Study on Beam to Column Joints Connections Under Different Loading System – State of the Art

Kartik Kumbar[1], R Shanthi Vengadeshwari[2]

Department of Civil Engineering, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India[1]

Associate Professor, Department of Civil Engineering, Dayananda Sagar college of Engineering, Bengaluru, Karnataka, India[2]

Abstract: Beam-column joints are taken into consideration as the vital zones of failure. In realistic condition, extending the beam reinforcement into the column under the soffit and supplying confining reinforcement at ends of beam column joint, will causes clogging of reinforcement. In order to keep away from this clogging we must lessen the improvement period of the bars and growth the spacing of confinement bars such that no failure occurs. RC frame members subjected to lateral loads has long been recognised as being influenced by the show of beam column connection. During earthquakes, the forces in beam column joints can causes stress and, in some cases, failure. In such instances overall performance beam column joints are analysed to conquer from failure in joint phase of contributors and growing the spacing of confining reinforcement without compromising the ductile capacity.

Keywords: Beam, Column, Earthquake, Ductile Capacity, Reinforcement

I. INTRODUCTION

In these RC systems, beam column joints were connecting regions of the building frame, and are accountable for load transfer among them. Therefore, complex forces, including compressive, tensile, and shear forces, act on beam column joints. During the earthquake, beam column joints are subjected to dynamic forces. They represent one of the important regions and must be developed to spend high amounts of power without experiencing significant loss of energy or stiffness. Reinforced details on beam column joints are crucial for enhancing design stiffness. Under dynamic loads, it faced sever stress and failure of bonding rebars with concrete. The collapse of the joint point may simply cause damage to the column loading paths and have an effect on the ductility and power dissipation ability of the body as a whole. Frequent stress may worsen the condition, ultimately in brittle fracture and the development of the bent part of the rod. Due to its apparent severe loss of bond formation and lack of strength, the longitudinal reinforcing bar is pulled out when made flat. At any level, this kind of failure is inexcusable. As a result, proper anchoring of the beam transverse rebar within the joint core is critical.

A) BEAM COLUMN JOINTS

In structures, the stress resisting frames, beam column joints are segment of pillars that are common to all beam at their crossovers. In the case of a Static Load, these connections produced systems are upto fundamental parts with finite strengths and, as a result, limited tension reducing capacity. As a result, while displacements stresses were carried out at some point of earthquakes, such joints might also significantly get broken. Moreover, repairing of broken joints is difficult, and as a consequence harm should be averted with the aid of using enough layout and detailing in advance.

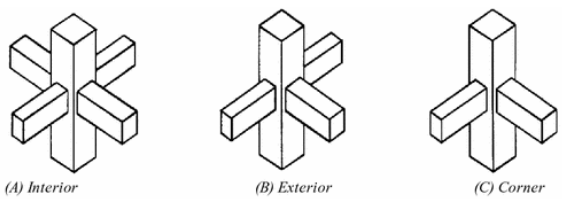


Figure 1: Types of Beam Column Joints's

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

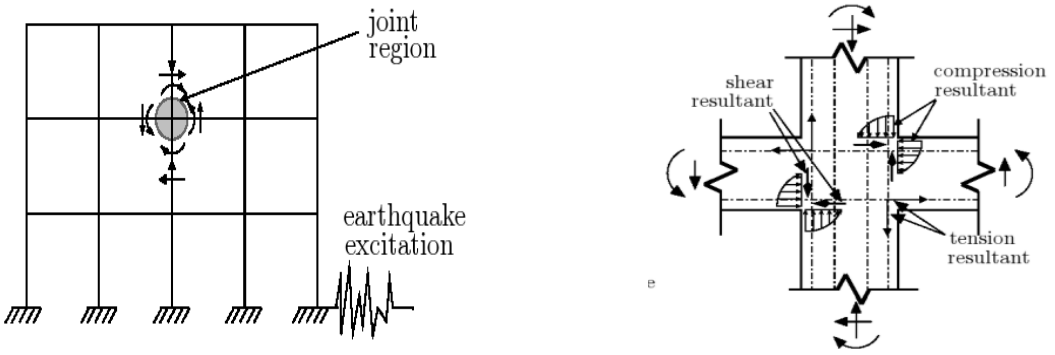
International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 4, April 2022

DOI: 10.17148/IARJSET.2022.9471

B) Behaviour of Beam Column joints Under Seismic Loading

Shear modulus and tension loads are experienced by beam or column in 2D frame joints subjected to earthquake loads. The expected rise in forces in a 2D solid component due to seismic and static loads. Furthermore, while the most recent seismically constructed structures are exposed to moderately severe seismic forces, it is widely predicted that the beams will develop flexural energy on the joint at the very same instant as columns will generate stresses that surpass the movements. Similarly, cracking of beams and columns or lateral buckling of columns in older frameworks could also prevent beams from attaining compromising flexural strength. Fig.2a illustrates the expected forces and their consequences at the joint's perimeter. As seen in Fig.2b the loading might cause significant loading inside the joint core. Furthermore, huge shearing stresses are developed well within joint due to the quick inversion inside the structural elements.



a) Frame with interior joint b) Detail view of joint

Figure 2: Beam Column joints Under Seismic Loading

II. LITERATURE REVIEW

K BINDHU et.al (2009) - *"Performance of Exterior Beam-Column Joints under Seismic type loading"*
The aim of research was to determine how well the outer beam column joint performed overall. The behaviour of joints was researched by analyzing the testing of the required samples, which were all developed to satisfy the stronger column poor beam hypothesis. The development of stress fractures just on joint between columns and beams caused plenty of the samples to failure, ensuring that the stronger column poor beam circumstances were met. With the exception of a hairline splitcracks, the joint zone was devoid of defects, and the joints exhibited adequate shear resistance. Rising overall applied forces upon column enhances stress capacity and toughens the joints. Thus, unfortunately, lowers a joint's load dissipation as well as ductile. The samples using distinct confined reinforcements, as defined by IS13920, exhibited better stress dissipation but those with horizontal reinforcement detailed, as specified by IS456 and SP34. The fractures as in current investigation were centered upon this beam column joint but rather the beams portion for all samples. Like a result, a joint detailed design has been developed in order to displace the plastics hinge as in portion of beams zone [1].

SREEKUMAR K.J et.al (2011) - *"Seismic Resistance of Exterior Beam Column Joint with Diagonal Collar Stirrups"*
In this paper the ductile behaviour of joints determines the seismic structural performance of moment resistant structural systems. The sample with extra beam and transverse neck stirrups has approximately equal lateral load capacities to the IS -13920 sample and is virtually equivalent to a sample without extra beam reinforcing. In addition, the sample with greater tie space at joints yielded negative findings, indicating a loss in load bearing capabilities. The elasticity of the sample with lateral collared stirrups and beam reinforcing was higher than that of the sample required by IS13920 without collared stirrups and higher than that of the sample specified by IS13920 with additional beam reinforcing. The energy-absorbing efficiency of the sample intended with lateral collared stirrups, as well as beam supports, is superior than the sample described in compliance to IS13920 [2].

MINAKSHI V et.al (2015) - *"Performance of RC Beam –Column Joint Connections Subjected to Cyclic Loading"*
Under dynamic loadings, ductile responses such as elasticity, stress, and flexural stresses were used to assess the effectiveness of beam column joints. In addition to shear rebars at the joint and insufficient binding of the lower rebars of beams, the controlled sample showed significant shear losses associated with sliding the lower rod beams. The main beam rods bonding requirements were damaged by the degradation in mixtures at the governing joint, resulting in a substantial drop in strength and compliance with bonding parameters. Flexural crack had found for the duration of second cycle at drift ratio of 1.2 percent with cyclic load of 15.3 kN down for altered specimen. The most load in push axis

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 4, April 2022

DOI: 10.17148/IARJSET.2022.9471

occurred with drift ratio of 5.6 percent had value of 40 kN, pull direction, the max load at a drift ratio of 5.6 perc. had a value of 31.1 kN for altered specimen [3].

R. SIVA C et.al (2015) - "*Seismic behavior of hybrid fiber reinforced cementitious composite beam–column joints*"
In this study, they looked at the dynamic response of externally beam column joint with HPF in the joint. By use of different HPF in assembly improves the lateral stiffness of a joint as well as its pre/post performance. HPF joint samples are compared to traditionally restricted joint samples in terms of overall looping behaviour. The ductility and post yield bending strength of HEC joint samples were about twice as high reduced joint samples. HPF joint samples with extensive scattered splitcracks show a continual reduce of strength. Within the same flexibility value, the damaging index for HPF joint samples was substantially lower than that for traditionally restricted joint samples [4].

REKHA S PATEL et.al (2015) - *"An Experimental Study on Effect of Diameter of Rebar on Exterior Beam Column Joint"*
In this paper, the maximum load bearing capacity enhanced when the dimension of steel rods was reduced, and the maximum bending also reduced. In comparison to sample 2or3, the load bearing capacity of sample1 enhanced and the bending reduced by 10 perc. In comparison to specimens with wide stirrup design, beam column joints with narrower spacing have improved load bearing ability and eventual bending. In comparison to some other samples, the bending moment of sample4 lowered by 15 perc. The link between concrete and steel been improved by using different diameters rods, resulting together in substantially reduced fracture thickness. It is capable to achieve increased elasticity by raising the no. of rods and lowering the dimension of rods. The ductility ratio for sample1 was 25 percent greater than for sample3 & 12 times better than for sample2. Several and densely packed crack were generated via supplying narrower stirrups, halting crack formation [5].

SUDIP CHAPAGAI et.al (2017) - *"Experimental study on size effect of RC beam-column joint with and without hybrid fibres under cyclic loading"*
This study report looked at three different types of samples: Traditional beam-column joints were compared to SF/HF reinforced concrete beam-column joints in terms of shear strength. SF and HF increase a variety of qualities, such as flexibility ratio and energy release, with regard to time of significant, as per research. With comparison to similar Standard samples, the advantage in ductility due to HF/SF increased. When compared to regular samples, HF/SF exhibit a huge increase in shear strength. All fibres used in Hybrid form provide a superior matrix. This possessed the ability to collect fractures as a function of recombination, significantly enhancing qualities. The maximum stress per unit volume of the joint matches the standard sample. HF concrete joints gives a better improvement for max load bearing than SF and traditional samples[6].

HONG YANG et.al (2018) - "*Seismic behavior comparison of reinforced concrete interior beam-column joints based on different loading methods*"
The aim of the experiment was always to determine the seismic behaviour of inner beam column connections when loading was applied to the beam outer edge and column upper edge. After applied load, the loss to the 4 Column edge samples was concentrated with in joint core, having few but bigger longitudinal fractures dispersed throughout the joint, whereas the loss towards the 4 beam edge samples appeared throughout the joint, with compact and tiny crack. The modification in loading approach had a significant impact on horizontal beam rod slip response. The deviated angle of the post component loading to a Column edge was more natural, however the Beam edge worked well in test [7].

JACK P. MOEHLE et.al (2018) - "*Shear Strength of Exterior and Corner Beam-Column Joints without Transverse Reinforcement*"
A study looked at the stiffness of edge beam column joints without transverse reinforcing rods exposed to reversed compressive load to simulate seismic effects. Typical hooks were used to secure horizontal beam reinforcing inside the joint. Reducing overall column lateral load, raising the proportion of beam thickness to pillar depths, plus yielding inside the adjacent horizontal frame all represents a portion shear capacity. Several models were created for different sorts of joints, such as stronger joints and joints with a wider range of imperfections. ACI318 frame simulation parameters are used to create a beam column joint model. joint element size, column's axial force, plus compressive stress was all included in this edition [8].

ROMANBABU M. OINAM et.al (2019) - *"Cyclic performance of steel fiber-reinforced concrete exterior beam-column joints"*
The results of research on beam column joint samples exposed to transverse dynamic loading are presented. The purpose was to evaluate how effective SF reinforced concrete would be decreasing shear stirrups in Flexural members having solid column/poor beam at beam column joints. The slightly bent arrangement for beam rebars with inside beam column

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 4, April 2022

DOI: 10.17148/IARJSET.2022.9471

joints led into shear failure in core even deformation of beam with original rebars forms, according to test results. Even without transverse rods in the beam column joints, all SF model had equilateral stiffness, energy dissipation, or mechanism of breakdown. Moreover, under applied loads, the ultimate stress of SF beam column joints showed better tolerance[9].

MARGHERITA P et.al (2020) - *"Semi-empirical model for shear strength of RC interior beam-column joints subjected to cyclic loads"*
Analysis of outgrowth to RC inner beam column joints of such prototype for strength properties is presented in this paper. The suggested design formula was proven by the 25 samples of beam column joints that have been developed for the shear according to Euro/ACI standard. As the central compression stress of the column rises, the lateral joint reinforcing ratio to longitudinal shear strength reduced, while the concrete shear capacity is better. The shear stirrups have the highest effective stress proportion, that is equivalent about 23 percent. Lateral rods were more efficient that to longitudinal stirrups in adding shear capacity to internal beam column joints[10].

BISWAJIT ROY et.al (2020) - *"Construction joints in substandard beam-column connections subjected to cyclic loading*"
The influence of a structural member connections in multi-story inferior beam column joints were explored in this research. Were 3 test samples containing control and jointed specimens were tested, delivering varying amounts of beam column reinforcement, subjecting it to fatigue tests. As transverse & longitudinal reinforcing, low carbon steel rods were adopted. Damages were mostly seen in beam column joint, the external surface of column, or the beam first at column surface in each of the samples. The maximum movement tolerance of the standard & joint samples are almost similar, with the exception of the sample, who had a 20% fall in breakdown movement relative with sample2. The max ductile and final dampening ratio drop was observed to be 17percent. It was discovered that the maximal variance in energy absorption potential was 12percent[11].

MOHAMMD S. A et.al (2021) - *"Seismic performance of R.C buildings with Beam-Column joints upgraded using FRP laminates"*
The effects and outcomes of CFRP on the dynamic loads on weak building are studied in this research using Non-linear analyses below the base displacement intensity of a chosen earthquake. Due to seismic forces, the vital beam column joints in the original research construction were overloaded well over collapse limit. Even though suggested CFRP technique elevated column shear, it enhanced the research construction project seismic response to the appropriate safety criterion. Improved the stress tolerance of the experimental building beam by 14percent and column by 25persent. Overall inelastic twists were lowered nearly about 20percent for beam & 26percent for column. CFRP technique may greatly enhance the dynamic capability of seismic vulnerable structures and are usually best[12].

JIANXIN ZHANG et.al (2022) - "*Seismic performance of HSS reinforced interior beam-column joints with high-strength steel fiber concrete and enhanced reinforcements*"
To improve the performances of HSS rods, research study assessed the use of high strength steel rods as horizontal reinforcing and high-strength steel fibre concrete in the joints. The elastic behaviour of internal beam column joints with HSS rods was examined using a mixed algorithm that included HSSFC plus X form rods improved bracing. The total effectiveness of HSS in interior joints was investigated using seismic loading to assess the impacts of higher reinforcement. Furthermore, superior binding ability between HSS rods and HSSFC reduced slip of horizontal rebars in beam and bending tensions, resulting in significantly reduced bond slip at beam edges[13].

III. CONCLUSION

The present data was gathered using a complete systematic review of seismic behaviour of Composite beam column joints conducted in the case studies listed following. Seismically weak RC beam column joints erected before the nineties, particularly in developing areas, are exceptionally vulnerable to stress at joint rupture during earthquake events. That is strongly proven, as per observations of beam-column joints post-earthquake survey research. The compaction inside the connecting panel has been reduced due to the growth of longitudinal cracking along to a compression direction. Shear loss occurs soon after strengthening yields, even without reinforced yield, a bond shear condition arises. In these kinds of situations, the total efficiency of beam column joints was investigated in order to avoid failure in the joint region and to increase restricting reinforcement spacing without losing flexural ability.

IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 4, April 2022

DOI: 10.17148/IARJSET.2022.9471

REFERENCES

[1]. K.R. Bindhu et.al (2009) – "*Performance of exterior beam-column joints under seismic type loading*"- ISET Journal of Earthquake Technology, Paper No. 503, Vol.46, No. 2, June 2009, pp. 47–64.
[2]. Sreekumar K.J et.al (2011) - "Seismic Resistance of Exterior Beam Column Joint with Diagonal Collar Stirrups" - International Journal of Civil and Structural Engineering Vol. 2 Issue 1 2011.
[3]. Minakshi Vaghani et.al (2015) – *"Performance of RC beam column connections subjected to cyclic loading"*- IOSR Journal of Mechanical and Civil Engineering Volume 12, Issue 2 Ver. (Mar -Apr. 2015), PP 48-53.
[4]. R. Siva Chidambaram et.al (2015) – *"Seismic behavior of hybrid fiber reinforced cementitious composite beam–* column joints" - Materials and Design 86 (2015) 771–781.
[5]. Rekha S Patel et.al (2015) - *"An Experimental Study on Effect of Diameter of Rebar on Exterior Beam Column Joint"* - Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 7, July 2015 (2015).
[6]. Sudip Chapagai et.al (2017) - "Experimental study on size effect of RC beam-column joint with and without hybrid fibres under cyclic loading" - International Journal of Civil Engineering and Technology (IJCIET).
[7]. Hong Yang et.al (2018) - "Seismic behavior comparison of reinforced concrete interior beam-column joints based on different loading methods"- Engineering Structures 166 (2018) 31–45- doi.org/10.1016/j.engstruct.2018.03.022
[8]. Jack P. Moehle et.al (2018) - "Shear Strength of Exterior and Corner Beam-Column Joints without Transverse Reinforcement" - ACI Structural Journal, V. 115, No. 6, November 2018.
[9]. Romanbabu M. Oinam et.al (2019) - "*Cyclic performance of steel fiber-reinforced concrete exterior beam-column joints*"- Article *in* Earthquakes and Structures · May 2019 DOI: 10.12989/eas.2019.16.5.53
[10]. Margherita P et.al (2020) - *"Semi-empirical model for shear strength of RC interior beam-column joints subjected to cyclic loads*"- Engineering Structures 224 (2020) 111223- doi.org/10.1016/j.engstruct.2020.111223
[11]. Biswajit Roy et.al (2020) – "*Construction joint in substandard beam-column connections subjected to cyclic loading*" - Magazine of Concrete Research-ICE (2020)- doi:10.1680/jmacr.17.00482.
[12]. Mohammd S. A et.al (2021) - "Seismic performance of R.C buildings with Beam-Column joints upgraded using FRP laminates" - Journal of King Saud University – Engineering Sciences 33.
[13]. Jianxin Zhang et.al (2022) – "Seismic performance of HSS reinforced interior beam-column joints with high-strength steel fiber concrete and enhanced reinforcements" - Journal of Building Engineering 48 (2022) 103958.

