Behaviour of Beam-Column Joint on Different Shapes RC Framed Structures: A Review

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Abstract: ***The behavior of reinforce concrete moment resisting frame structures in recent earthquake all over the world has highlighted the consequences of poor performance of beam-column joint. Currently practice demand is "strong column weak beam" behavior so as result for ductile failure. The present review aims at the checking of adequacy of beam-column ratio in building under cyclic loading. The beam-column ratio is gradually increase & failure of column have been noted. Analysis carried by push over analysis. Also, variation of horizontal & vertical irregularity is review.***

Keywords beam column ratio, push over analysis, cyclic loading, seismic analysis

1. Introduction

Reinforced concrete is composite material for structural purpose. Compressive forces are typically carried by the concrete & tensile forces by the steel reinforcement. This takes advantages of properties of both materials. In order for structures to function correctly it is vital that forces can be transferred between the concrete & reinforcement. One mechanism by which this occurs is the bond that forms at the interface between reinforcement & the concrete. This bond mechanism is particularly important in beam-column joint.

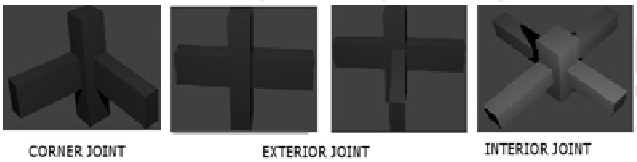

Figure 1: Beam Column Joint

There are three main types of joints i) Corner joint ii) Exterior joint iii) Interior joint.

Reinforced concrete special moment frames are used as part of seismic force-resisting systems in buildings that are designed to resist earthquakes. Beams, columns, and beam-column joints in moment frames are proportioned and detailed to resist flexural, axial, and shearing actions that result as a building sways through multiple displacement cycles during strong earthquake ground shaking. Special proportioning and detailing requirements result in a frame capable of resisting strong earthquake shaking without significant loss of stiffness or strength. These moment-resisting frames are called "Special Moment Frames" because of these additional requirements, which improve the seismic resistance in comparison with less stringently detailed Intermediate and Ordinary Moment Frames. Due to some limitations and disadvantages of other methods nonlinear static analysis, push over analysis is considered as the most suitable method for performance based seismic design because it requires less effort and deals with less amount of data for the analysis purpose. Static analysis is proved to be accurate when the structure is short and regular in plan so that higher modes effect is less significant otherwise dynamic analysis is also to be used along with static method.[2]

2. Review of Literature

T. Paulay and A. Scarpa , (1981) discuss the test was to identify the performance of the joint region when joint shear reinforcement in accordance with proposed New Zealand code1 7 provisions was provided. These design provisions, however, were based on the study of more severely loaded interior beam column joints. The experimental study reported here indicates that the horizontal joint shear reinforcement in commonly used exterior beam-column units of multistorey ductile frames may well be reduced considerably.[1]

Sugano *et. al.*,(1988) conducted experimental programmed on 30-storey RC framed building in Japan and developed design consideration to ensure good collapse mechanism and also observed the ductility of plastic hinges. Basic knowledge on the COF for forming the weak-beam type of plastic mechanisms in steel reinforced concrete frames is presented by Kawano *et. al.* (1998). Dynamic analysis taking ground motion as input in a fishbone shaped model and found that the required COF value that ensures beam hinging responses increases steadily with the increase in ground shaking performed by Nakashima and Sawaizumi (1999). Nakashima (2000) observed increase in ground motion amplitude for ensuring column-elastic response with the increase strength factor of column in steel building. Maximum story drift angle is 1.5 to 2.5 times as large as the maximum overall drift angle, for frames in which column-elastic behavior is ensured.[8]

Hatzigeorgiou (2009) achieve an extensive parametric study on inelastic behavior of reinforced concrete frames under reverse cyclic ground motions and observed the relationship as shown in equation

$$\Sigma M_{n,c} \geq 1.3\ \Sigma M_{n,b}$$

Jain *et. al.*, (2006) affirm that, when a reinforced concrete moment resisting frame is subjected to seismic loads, at beam-column joint, summation of moment of resistances of columns should be greater than or equal to 1.1 times summation of moment of resistance of beams framing into it as in equation

$$\Sigma M_{n,c} \geq 1.1\ \Sigma M_{n,b}$$

In this seismic design concept, it is assumed that beams yielding in flexure will precede possible yielding of columns which is recognised as the favorable failure mode (Anderson and Gupta 1972; Clough and Penzine 1982; Park and Paulay 1975; Lee 1996).

According to design provision of Japan (BCJ 2004) a minimum column over-strength factor (COF) of 1.5 is suggested for cold-formed square tube structures in Japan and in seismic provision of structural steel building (ANSI/AISC 341-05) a COF of 1.0 is considered for steel structures. COF ranging from 1.5 to 2.0 by Countries like New Zealand and Mexico (Dooley & Bracci 2001). Many studies also have been conducted so far by the researchers in designing strong column weak beam frames and search of dominant collapse modes of the frame. Hibino and Ichinose (2005) presented a fish-bone-type steel moment frames for numerical study of the effect of flexural strength ratio of column to beam on the global energy dissipation of beams and columns. The major parameters considered are number of stories, strengths of columns, strengths of beams and ground motion. Findings of the study show that with the increase of the beam to column strength ratio the energy contributing to story mechanism decreases. [2]

Medina and Krawinkler (2005) studied as per the strong column weak beam requirements of current code provisions a family of regular frames to evaluate the strength demands suitable for the seismic design of the columns and indicated that the potential of formation of column plastic hinges is high for the frames designed. Dooley and Bracci (2001) investigated the influence of the COF at the joints in two RC frame structures under seismic excitation using inelastic time-history dynamic analyses. In most of these studies used deterministic approach for specific structures and the probability of undesirable failure mode with risk of failure of the structure remain unknown. Since large uncertainty is associated with the member strength and the earthquake load, the use of probabilistic approach enables the structural safety to be treated in a more rational way. Taking into account these uncertainties, a probabilistic evaluation method (Ono et al. 2000; Zhao et al. 2002) is applied for COF evaluation. Potential storey mechanism is very large which increases as the number of stories increases a multi-storey frame. In another study conducted earlier on storey mechanism of collapse of RC framed structures (Zhao *et. al.* 2007) concluded that all lower storey collapse modes and the upper storey collapse modes with highest failure stories are the frequent occurring failure modes. The least values of COF that ensure probabilistically the entire beam hinging mechanism prior to storey collapse are evaluated.[6]

Xilin Lu (2001) pointed out that ductility of the joint improves with the increase of the ratio of bending moment of column to beam, the plastic hinges are more likely to develop in the beam. Furthermore, the conventional design practice is proven to be accurate by experimenting Group I test specimen frames.

K.R. Bindhu, (2009) investigate that strong-column weak-beam conditions were satisfied because 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. Improves the load carrying capacity and stiffens the joints increases with an increase in the column axial load improves. However, this reduces the energy absorption capacity and ductility of the joint.

Kyung-Suk Choi, Hyung-Joon Kim (2015) According to the analysis results, stiffness and strength of unit modular frames are weakened when a web with access holes is controlled by the shear compared to a web without an access hole. However, there are stable cyclic behavior up to 6% story drift with noticeable reduction in stiffness and strength.

H. Shiohara discussed the key issues of the draft provisions of AIJ Standards with background, test data, theory and analysis with emphasis on why the new concept of joint hinging failure should be necessary. Collapse simulation is made by non-linear time history analysis for moment frames with BC joints failing in joint hinging failure mode, to demonstrate the challenge of simulating strength degradation and severe slip hysteretic relationships inherent to the joint hinging failure. It is concluded that joint hinging failure not only increases of damage to BC joints but also hinders the formation of beam sway mechanisms. As a result, collapse prevention capacity decreases due to accumulation of residual story and resulting collapse due to P-delta effect. The draft equations giving the joint hinging strength of BC joints are also introduced.

3. Conclusion

RC framed buildings with irregular in plan are designed using commercial software modeled using SAP2000. Pushover analysis is done first to study the effect of increase of beam column ratio on ductility and lateral strength of a structure. The effect of increasing moment capacity of column at an expense of extra reinforcement is also observed by obtaining reinforcement ratio as a function of beam column joint. 12 storey building considered with three different type of plan irregularity.

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