REVIEW ON MOMENT CAPACITY OF BEAM-COLUMN JOINT IN REGULAR RC FRAMED BUILDING

Abhay Yadav[1] , Abhishek Kumar[2], Mohd. Afaque Khan[3]

[1]Post Graduate Student, Structural Engineering, Babu Banarasi Das University, Lucknow, Uttar Pradesh, India.
[2]Assistant Professor, Dept. of Civil Engg. Babu Banarasi Das University, Lucknow, Uttar Pradesh, India.
[3]Assistant Professor, Dept. of Civil Engg. Babu Banarasi Das University, Lucknow, Uttar Pradesh, India.

---***---

Abstract - *This paper represent that moment capacity ratio of beam column joint is an important consideration for framed structures. This paper describes that ductility of structures increases with increase of moment capacity ratio and how moment capacity ratio affects the building fragility. The need of this paper is to study the effects of moment capacity ratio on the ductility and strength of structure, and also on the probability of failure of multistoried building.*

Key Words: *Moment capacity ratio, Fragility, Ductility, Lateral strength, Failure probability*

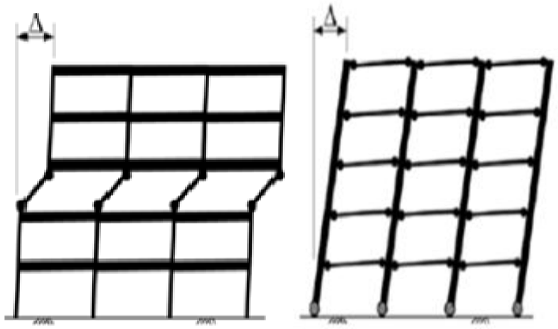
1. INTRODUCTION

Designing a building to behave elastically during an earthquake without any damage will make the project uneconomical. So the earthquake-resistant design philosophy allows damages in some predetermined structural components. One of the most important requirement of the building to withstand any type of earthquake, is not the more force but it can resist the more deformation before collapse. Capacity design procedure sets strength hierarchy first at the member level and then at the structure level. So, it needs adjusting of column strength to be more than the beams framing into it at a joint. Mathematically it can be expressed as :

$$M_c \geq M_b$$

Where M_c and M_b are sum of the moment capacities at the end of column and beam meeting at a joint in a particular direction.

During an earthquake the inertia force induced in the structure causes it to sway laterally. The distribution of damages over the building height and the lateral drift of the structure are related. Weak columns cause the drift and so the damages to concentrate in one or a few stories only (Fig.1a), and if the drift capacity of the columns is exceeded then it is of greater consequence. but, if columns provide a stiff and strong as spine over the building height, drift will be more uniformly distributed thus reducing the occurrences of localized damages.(Fig. 1b).



(a) storey mechanism (b) beam mechanism

Fig 1. Typical diagram showing distribution of damages and storey mechanism

2. LITERATURE REVIEW

Nakashima (2000), observed for steel building that the column over strength factor increases with increase in ground motion amplitude for ensuring column-elastic response. Also for frames in which column-elastic behavior is ensured, the maximum story drift angle is 1.5 to 2.5 times as large as the maximum overall drift angle.

Uma and Jain (2006), found 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

$$\Sigma M_{nc} \geq 1.1\ \Sigma M_{nb}$$

David N. Bilow and Mahmoud Kamara (2007), studied that properly detailed connections or joints allow concrete members to develop full flexural capacity resulting in ductile failure in flexural mode instead of brittle shear failure at the joints. The design of such connections are emphasize adequate reinforcement to confine the concrete in the joints and thereby increase the ductility and shear forces resistance of the joints. And conclude that a column to beam ratio increases the performance of interior joints, and the same effect was not observed in exterior joints.

S.S Patil et.al (2013), studied the behavior for corner and exterior beam column joint, if load increases then the parameters i.e maximum stress, minimum stress and displacement also increases and as the stiffness of the structure changes the displacement, minimum stress, maximum stress changes with respect to loading. The behavior of corner beam column joint is different that of the exterior beam column joint.

Praveen Kumar Parsa (2015), observed that ductility of the structures increases with increases of moment capacity ratio. Also the building designed with lesser MCR values are found to be more fragile compared to the building with higher MCR. He found that with increase of MCR at design axial load upto 1.47 for uniaxial bending in a plane frame improves the ductility at an expense of extra reinforcement, with further increase of MCR there is not much increase in ductility. Increase in strength either at yield or maximum is not very significant with progressive increase in MCR for a seven storey building frame. but for 5 storey and 10 storey frames strength also increase significantly upto MCR 1.7. Since seismic design philosophy aims to achieve good ductility in a structure so we need not have to think for higher strength but for higher ductility. A preferable collapse mechanism can be achieved by increasing MCR.

3. REVIEW OF CODES

American Standard - ACI 318M-02 suggests that, summation of moment capacities of column sections framing into a joint evaluated at the joint faces considering factored axial loads along the direction of lateral forces resulting in the minimum column moment, should be greater than or at least equal to 1.2 times the moment capacities of the beam sections framing into it.

$$\Sigma M_{nc} \geq 1.2\ \Sigma M_{nb}$$

New Zealand Standard - The capacity design philosophy requires that for the design of column under flexure moment of resistance of columns should be more than the moment of resistance of beams framing into a joint considering over strength for beams. This requirement is addressed in American standard with reference to the face of the joint. New Zealand Standard (NZS3101:1995) recommends this aspect with respect to centre of the joint as follows:

$$\Sigma M_{nc} \geq 1.4s\ \Sigma \varphi_0 M_{nb}$$

In equation, φ_0 is over strength factor for beams. The over strength of steel reinforcement is considered as 1.25 and strength reduction factor is taken as 0.85. So the total over strength factor considered for beams is 1.47. The effect of participation of higher modes is taken into account by using dynamic moment magnification factor for enhancing the column moments derived for simply lateral static forces.

European Standard - EN1998-1:2003 recommends the following relation between moment capacities of columns to beams that is to be satisfied at all joints:

$$\Sigma M_{nc} \geq 1.3\ \Sigma M_{nb}$$

In this equation M_{nc} is summation of the minimum moment capacities of the columns considering design axial forces and M_{nb} is summation of the moment capacities of the beams framing into the joint.

Indian Draft Standard - This issue of prevention of anchorage and shear failure in joint region during strong ground motions is not suitably addressed in the design and detailing recommendations for beam-column connections given in Indian standard. In view of these limitations, Jain *et al*. (2006) proposed a provision in draft code IS 13920:1993 for column-beam ratio. According to that, in a moment resisting frame, designed for earthquake forces, at a joint summation of the moment capacities of the columns shall be at least equal to 1.1 times the summation of the moment capacities of the beams along each principal plane of the joint.

$$\Sigma M_{nc} \geq 1.1 \Sigma M_{nb}$$

In the case of a beam-column joint not conforming to above criteria, the columns at the joint shall be considered to be gravity columns only and shall not be taken as part of lateral load resisting system. The design moment of resistances of beam shall be calculated on the basis of principles of mechanics and the limiting strain states as per the IS 456: 2000. Mathematically it can be expressed as in equation,

$$\Sigma M_{nc} \geq 1.3\ \Sigma M_{nb}$$

4. CONCLUSIONS

1. From the various studies mentioned above, it is clear that Moment capacity ratio of column beam joint is certainly an important variable for consideration in overall frame performance.
2. It is observed that MCR effects the ductility and strength of structures.
3. It is evident that ductility of the structures increases with increases of moment capacity ratio. Also the building designed with lesser MCR values are more fragile compared to the building with higher MCR.
4. It is essential to find out the moment capacity ratio suitable for Indian Standard.
5. MCR also effects the probability of failure of multi-storyed building.
6. It is observed that value of MCR is normally varied between 1 to 2.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to all the scholars whose articles are cited and from that a valuable help received for completing this review paper. The authors are also grateful to authours, editters and publisher of those journals and articles from where the literature for this articles has been reviewed and discussed.

REFERENCES

1. Nakashima, "Column-to-beam Strength Ratio required for Ensuring Beam-collapse Mechanisms in Earthquake Responses of Steel Moment Frames", Proceedings of the 12th World Conference on Earthquake Engineering, 2000, pp. 1-8.
2. Uma and Jain, "Seismic Behavior of Beam Column Joints in Reinforced Concrete Moment Resisting Frames", National Information Centre of Earthquake Engineering, Indian Institute of Technology Kanpur-GSDMA Project on buildings codes, Document No.IITKGSDMA.EQ32.V1.0,2006.
3. David N. Below and Mahmoud kamara, "Capacity of Joints to Resist Impact Loads in Concrete Moments – Resisting Frame Buildings" Structural Engineering Research Frontiers @2007 ASCE.
4. S.S. Patil, C.G. Konapure and S.S. Manekari, "A Study of R.C.C Beam Column Junction Subjected To Quasi-Static (Monotonic) Loading", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Vol. 6 Issue 5, 2013, PP. 61-74.
5. Praveen Kumar Parsa, "In A Regular RC Framed Building Moment Capacity Ratio at Beam Column Joint", International journal of Advanced Research in Science and Engineering, Vol. No.4, Issue 07, July 2015, pp. 84-94.
6. IS:13920 -1993, "Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces-Code of practice", Bureau of Indian Standards, New Delhi.
7. NZS 3101: Part 1:1995 "Concrete Structures Standard, Part 1: The Design of Concrete Structures", New Zealand Standard, New Zealand.
8. NZS 3101: Part 2:1995 "Concrete Structures Standard, Part 2: The Design of Concrete Structures", New Zealand Standard, New Zealand.
9. BIS (2000), IS 456, "Indian Standard Plain and reinforced concrete-code of practice" (Fourth revision), Bureau of Indian Standards, New Delhi.
10. ACI 318-02 "Building Code Requirements for Structural Concrete (ACI 318M-02) and Commentary (ACI 318RM-02)", American Concrete Institsute, ACI Committee 318, Farmington Hills.
11. EN 1998-1-3:2003 "Design provisions for Earthquake Resistant Structures-Part 1: General Rules, Seismic Actions and Rules for Building", Brussels.

BIOGRAPHIES

Mr. Abhay Yadav was born in 1993 in Orai (Jalaun). He received his Bachelor of Technology degree in Civil Engineering from Uttar Pradesh Technical University, lucknow, in 2014. He is right now pursuing his Master of Technology in Structural Engineering from Babu Banarasi Das University, Lucknow.
E-mail: yadavabhay21@gmail.com

Mr. Abhishek Kumar was born in 1986 in Patna city. He received his Bachelor of Technology degree in Civil Engineering from school of Engineering (Cochin University of Science and Technology) ,Konchi, Kerala in 2009 ". In 2011 he received his Master's degree in Structural Engineering from MNNIT, Allahbad. He joined Babu Banarasi Das University, Lucknow in 2011 as a faculty where he is now Assistant Professor in Civil Engineering department with a total of 5 years of experience.
E-mail: rajaabhis@gmail.com

Mr. Mohd. Afaque Khan was born in 1982 in Gonda city. He received his Bachelor of Technology degree in Civil Engineering from ZHCET, AMU, Aligarh in 2009. In 2012 he received his Master's degree in Structural Engineering from ZHCET, AMU, Aligarh. He joined Babu Banarasi Das University, Lucknow in 2012 as a faculty. He worked as a Head of Department in Babu Banarsi Das Engineering College and he is now Assistant Professor in Civil Engineering department with a total of 4 years of experience.
E-mail: afaque15amu@gmail.com