Earthquake Resistant Design of Low-rise Open Ground Storey Framed Building: A Review

[1]Shailesh Ghildiyal, [2] Sangeeta Dhyani, [3] Chandra Prakash Gusain
[1] M.Tech Student, Faculty of Technology, UTU, [2]Asst. Prof, Faculty of Technology, UTU. [3] B.Tech Student, D.C.M.T.E, UTU.
[1]Civil Engineering Department
[1] Faculty of Technology, UTU, Uttrakhand, India

Abstract*: Today in the world of concrete we are rapidly constructing multi-storey building for commercial and residential purposes, but providing a proper parking space is major concern especially in metropolitan cities. Hence the trend has been utilize the basement of building for parking purpose for this engineer provides the solution they make the basement of the building open, no infill masonry walls is provided in the basement .they did not consider the stiffness and strength of the masonry wall .But this conservative design is not always right .We see when the earthquake occur the column of the ground storey collapse down and the upper storey inclined towards the ground because the upper stories are more stiffer than the lower storey. This failure is termed as soft storey effect because ground storey is more flexible in comparison of upper stories. Open ground storey is also known as weak stories because it is also weaker in strength in comparison of upper stories .After the BUJH Earthquake in Gujarat, India the failure of upper stories emphasis to consider the strength and stiffness of the infill masonry .Therefore IS Code 1893:2002 suggests that we need not to consider the strength of infill masonry but simply consider a factor 2.5 which is known as the multiplication factor for the neutralization the effect of soft storey. It is in clause 7.10.3 (A) of IS 1893:2002 that the beams and columns of the storey need to be taken 2.5 times more the storey shear and moments calculated under specific loads of the bare frame. Nonetheless, by the expertise of the structural design the value suggested by IS CODE 1893:2002 is not realistic. For the validation of the multiplication factor we prepare a separate model for infill wall and walls without any infill i.e. bare frame, and do the linear and non-linear analysis and compare their results. Linear analysis shows stiffness is constant in both open ground storey and bare frame while nonlinear shows the multiplication factor can be reduced.

Key Words: G+3 building, Open storey, Linear and non-linear analysis, Pushover Analysis, Multiplication Factor.

1. Introduction

Open ground storey are the stories in which no infill masonry wall is provided or it is the building in which lateral stiffness of the open storey is less than 70 per cent of the above storey and lesser than 80 per cent in case if the number of storey more than three**.** These open storey are generally utilize for the purpose of the parking, but the strength of the open storey is lesser than the strength of upper storey which infill by masonry walls ,these open storey creates an effect of soft storey or weak storey. At the time of earthquake first impact of vibration forces are on the ground storey then the forces are transferred to the upper storey. And due to presence of infill wall upper storey act as a unit block and arch action is formed it transferred the load equally and ground storey acts separately and whole load act on the column and ground storey is slightly stiffer than bare frame and fails due to the soft storey mechanism in the ground storey. Therefore it is not always right to ignore the infill strength. Unfortunately no proper guidelines is given in IS Code to design the open ground storey. Bare frame analysis is generally done to ignore the strength. After the BHUJ earthquake IS Code 1893 revised in 2002 and it suggests a multiplication factor other national code also suggests multiplication factor. But there is large difference in the values suggested by the codes .For this it is necessary to validate the value of multiplication factor. There are two methods to analysis or validate the multiplication factor suggested by the Codes, which are linear and non-linear methods. For this two separate models are prepared and linear and non-linear analysis is performed and compares the result obtained**.**

Figure no-1 Open Ground Storey (courtesy –www.telegraphicindia.com)

2. Methodology and Design Philosophy

A). Structural Detailing :Consider a G+3 low rise open ground storey building situated in zone 5.Building is RC framed .All column and beam joints are rigid and it is modelled by using end offset joints .Floor slab thickness is 150 mm and it is able to resist the lateral load. All infill walls are modelled by using equivalent diagonal strut. Grade of steel used Fe 415.
(B) Model Detailing: Two models are prepared on STAAD Pro software.
Case 1: (G+4) storey building in which ground storey is open and other stories are having infill wall with fixed end support.
Case 2: (G+4) storey building in which all storey are open (Bare Frame Building) with fixed end support. [2]

S.no	Particular	Details
1	Type of structure	RCC framed
2	No of storey	4
3	Infill wall external	230 mm
4	Infill wall internal	120 mm
5	Size of column	230*800mm
6	Size of beam	300*600mm
7	Depth of slab	150mm

Table no-1 Detail of building

Now we can analysis the models separately by linear and Non-Linear process.
(A).Linear Analysis: Linear analysis assumes elastic behaviour .There is three approaches also given in IS Code1893:2002 which is explained below.

1. *Equivalent Static Analysis*-Equivalent static analysis also known as seismic coefficient method .In these method horizontal and vertical forces are calculated on the structure and multiplied by their weight, horizontal weight is considered to the horizontal forces and vertical weight is considered to the vertical force. Equivalent static analysis is half dynamic in nature. The horizontal forces and vertical forces are known as the seismic coefficient, generally its value lies in the range of 0 to 1, changing according to type of structure, for example in dams seismic coefficient may be up to 1.5 and for heavy structures like nuclear power plant its value may be 0.6 and for bridges 0.2-0.3.[4]

2. *The Response Spectrum*- In this approach the maximum response of a building is calculated on the basis of single degree freedom in a certain period and damping at the time of ground motion in earthquake. The response v/s undammed natural period is plotted and the result obtain is known in terms of Relative velocity, maximum relative displacement, maximum absolute acceleration.

3. *Time History Method*- In this approach dynamic response is analysis for every increase value of time. For this analysis mathematical model are prepared with the help of computer, and in the mathematical model we can directly put the increased value of time and the result obtained is dynamic response. [1]

On the basis of these approaches base shear time period are calculated, once the base shear time period is calculated one can easily find out the value of multiplication factor. Linear analysis the stiffness of open ground storey and bare frame is approximately same. There non-linear analysis is to be performed to validate the result.

(B) Non-linear analysis: In non-linear analysis pushover analysis is performed. Pushover analysis is a static non-linear procedure using non-linear methodology .in pushover analysis simple gravity load is applied to the structure and roof displacement is measured. We can performed the pushover analysis is STADD PRO. In STADD PRO horizontal load is applied to the structure and the horizontal displacement is measured. Actually the horizontal displacement is the deflection of the structure. STADD PRO generates a pushover curve which shows the graph between strength of the structure and deflection. Nonlinear analysis results shows that the value of multiplication factor 2.5 is too much, it can be reduced up to 1.25.

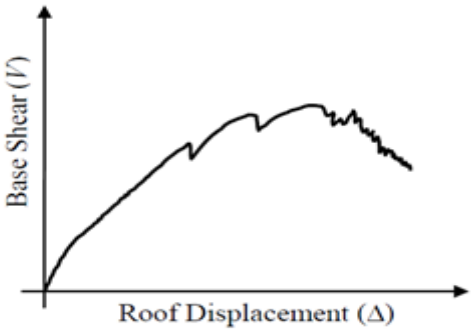

Figure no-2 Pushover curve

3. Conclusion

From the previous work done on the open ground storey we can conclude that the value of multiplication factor can be taken 1.25, and linear analysis shows the stiffness of open ground storey and bare frame are equal, while nonlinear analysis shows that the value of 2.5 is to much higher, and choosing the high value of multiplication factor may create a short storey effect on upper stories. And there is no effect of earthquake zone on multiplication factor it remain same in all zone. [11]

Acknowledgement

From the bottom of my heart I would like to thanks my parents for their kind support and my sincerer thanks to Asst. Prof Sangeeta Dhyani my advisor and guide for encouraging me and for giving me her creative ideas to do the project.

References

[1] IS 1893 (Part I): 2002 — "Criteria for earthquake design of structures – part i: general provisions and buildings (fifth revision)", Bureau of Indian Standards, New Delhi, pg. 25.27.

[2] Piyush Tiwari, P.J.Salunke, N.G. Gore, "Earthquake Resistant Design of Open Ground Storey Building Piyush" , International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 07.

3] Ashish Soni & Dr. Savita Maru, "Performance Based Seismic Design and Pushover Analysis: A -Review", International Journal of Engineering Research- Vol.2. Issue.5, 2014.

[4] M .Hamada, "Earthquake Resistant Design", Civil Engineering-Vol.1, Department of Civil Engineering ,Waseda University ,Japan.

[5] A. Asokan, (2006) Modelling of Masonry Infill Walls for Nonlinear Static Analysis of Buildings under Seismic Loads. M. S. Thesis, Indian Institute of Technology Madras, Chennai.

[6] Snehash Patel, (2012) "Earthquake Resistant Design of Low-Rise Open Ground Storey Framed Building" M. Tech Thesis, National Institute of Technology, Rourkela.

[7] Subramanian, N. (2004), "Discussion on seismic performance of conventional multi-storey building with open ground floors for vehicular parking",The Indian Concrete Journal.

[8] Agrawal, Shrikhande Manish, "Earthquake Resistant Design of Structures".

[9]Chopra A.K,"Dynamics of Structures –Theory and Application to Earthquake engineering".

[10] Piyush Tiwari, P.J.Salunke, N.G.Gore, "Earthquake Resistant Design of Open Ground Storey Building Piyush", International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 07.

[11] Amol Karemore, Shrinivas Rayadu, "Study on Effect of Zone on Magnification Factor for Open Ground Storey Buildings", International Journal of Innovative and Emerging Research in Engineering-Vol.2, Issue 5, 2015.