Seismic Analysis of Building on Sloping Ground Considering Bi-Directional Earthquake

Paresh G. Mistry[1], Hemal J. Shah[2]

[1]ME Structural engineering Student, [2]Assistant Professor
[1]HJD Institute of Technical Education and Research, Kera - Kutch, India.
[2]Applied Mechanics Department, Government Engineering College, Bharuch, India.

***Abstract*—The scarcity of plain ground in hilly regions leads to construct buildings on a sloping ground. One of the biggest challenges of a Structural engineer is to design a seismic resistant building resting on a sloping ground for zone V. Construction of building on a sloping ground it has to face severe earthquakes. Compare to normal buildings, seismic behavior of buildings on a sloping ground are different. Building on a sloping ground has a higher base shear and higher displacement than building resting on a plain ground. In present study, Building on a plain ground, Step back building and Set back with step back building have been considered. Dynamic analysis of building on a plain ground, Set back with step back building and Step back building will be carried out in SAP 2000 software. In present study, Response spectrum analysis and Time History analysis for Bhuj and chamoli earthquakes will be carried out by considering parameters such as Base Shear, Axial force and moments will be studied. Earthquakes Time Histories applied at various angles and most severe analysis will be studied for each cases.**

***Keywords*—Dynamic analysis, Time History, Angle variation, Response of models.**

INTRODUCTION

Earthquake is the most disastrous due to its unpredictability and huge power of devastation. Earthquakes themselves do not kill people; it is due to the destruction of structures. Building structures collapse during severe earthquakes, and cause direct loss of human lives. The scarcity of plain ground in hilly regions leads to construction of buildings on a sloping ground. The buildings constructed in the hilly area are highly asymmetric in plan as well as elevation. Behavior of building on a sloping ground is different from building on a plain ground. The buildings constructed in hilly area are subjected to severe earthquake. In India most of the hilly area is lying in severe earthquake zone. One of the biggest challenges of a Structural engineer is to design a seismic resistant building resting on a sloping ground.

Response Spectrum Analysis method is because, forms of damping-which are reasonable models for many buildings-the response in each natural mode of vibration can be computed independently of the others, and the modal responses can be computed independently of the others, and the modal responses can be combined to determine the total response.

The time history analysis (THA) technique represents the most sophisticated method of dynamic analysis for buildings. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of structure. The method consists a systematic direct integration over a time interval; the equation of motion is solved with the displacements, velocities, and accelerations of the previous step serving as initial functions.

This study is based on Time History analysis and Response Spectrum analysis of buildings in SAP-2000 software. From the above analysis Base Shear, Member Forces and Moments will study. In this study, Building on a plain ground, Step back building and Set back with step back building has been considered.

METHODOLOGY

In this present work building on plain ground, setback with stepback building and stepback building with 10 storey is modeled in SAP-2000 software. The size of beam is 300 mm x 450 mm and the size of column is 450 mm x 450 mm. The slabs are considered as 125 mm thickness. Necessary meshing is given to the slab to transfer slab load to the adjacent beams. The external wall thickness is 230 mm and internal wall thickness is 115 mm. The slabs are loaded with floor finish of 1.5 KN/m^2 and live load of 3 KN/m^2. Terrace water proofing is 1 KN/m^2. Storey height is 3 m. In this case 90% of total seismic mass is covered in 12 modes. Setback with stepback and Stepback building are modeled on 20 degree slope and grade of steel id F_e-415.

In this study following models are prepared in SAP-2000.

1. 10 storey building on plain ground
2. 10 storey Setback with stepback building on sloping ground (20^0)
3. 10 storey Stepback building on sloping ground (20^0)

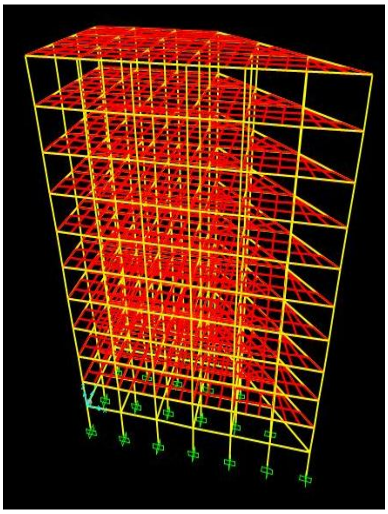

Fig. 1 Building on plain ground

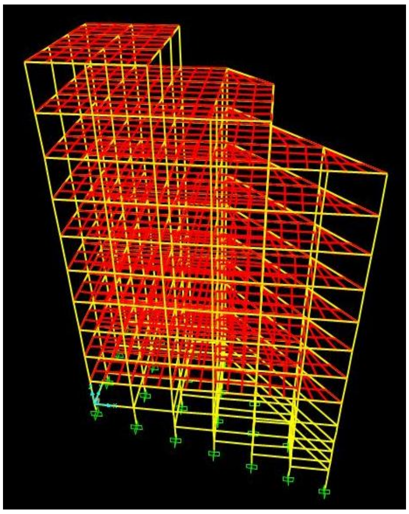

Fig. 2 Setback with stepback building

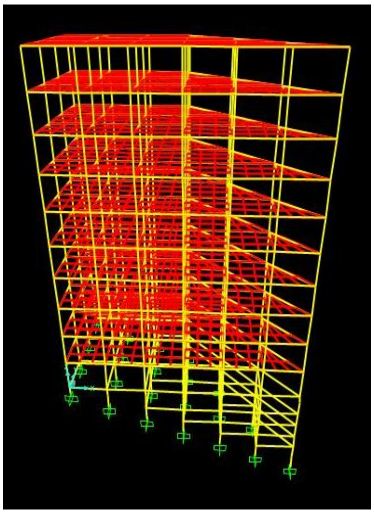

Fig. 3 Stepback building

For response spectrum analysis following data is considered from IS-1893:2002.

1. Zone : V
2. Soil type : Medium (II)
3. Importance factor : 1
4. Response reduction factor : 5

Taking above data response spectrum function is applied on models of Building on plain ground, Setback with stepback building and Stepback building in SAP-2000. Both time history and response spectrum function is applied at 0^0 to 360^0 by taking 10^0 degree increment and most critical angle is studied.

As per IS-1893:2002, the structure shall be designed for the effects due to full design earthquake load in one horizontal direction plus 30 percent of the design earthquake load in the other direction when lateral load resisting elements are not oriented along the orthogonal horizontal direction. Load cases as per clause 6.3.2.2 are also applied on all models.

Necessary data for Time history function is given below:

1. Bhuj Earthquake, 2001
a) Name of time history: Bhuj
b) Magnitude: 7.9
c) Total no of acceleration records: 26706
d) Time step: 0.005 second
e) Duration: 133.55 seconds

2. Chamoli Earthquake, 1999
a) Name of time history: chamoli
b) Magnitude: 6.8
c) Total no of acceleration records: 8705
d) Time step: 0.005 second
e) Duration: 227.95 seconds

RESULT AND DISCUSSION

Analysis has been done on above mentioned models with Bhuj and Chamoli earthquake and Response spectrum for zone-V and results are shown. Base shear for building on plain ground and both sloping ground building are shown in Figure 4 to Figure 6. Axial force and moments for corners base column C1 are shown in Figure 7 to Figure 9.

- For Bhuj earthquake, Base shear is higher for Setback with stepback building, critical angles for base shear are (60^0, 200^0), (220^0, 190^0), (70^0, 20^0) in building on plain ground, setback with stepback building and stepback building respectively.
- For Chamoli earthquake, Base shear is higher for Stepback building, critical angles for base shear are (360^0, 330^0), (220^0, 190^0), (EQX-0.3EQY, 270^0) in building on plain ground, setback with stepback building and stepback building respectively.

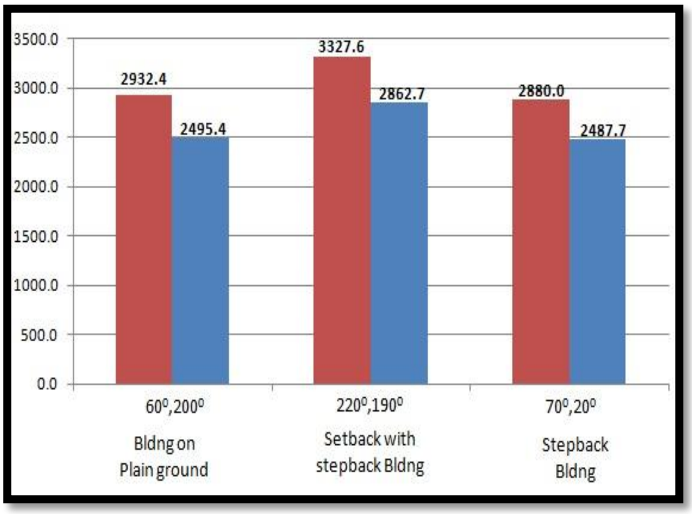

Fig. 4 Comparison of base shear for Bhuj earthquake

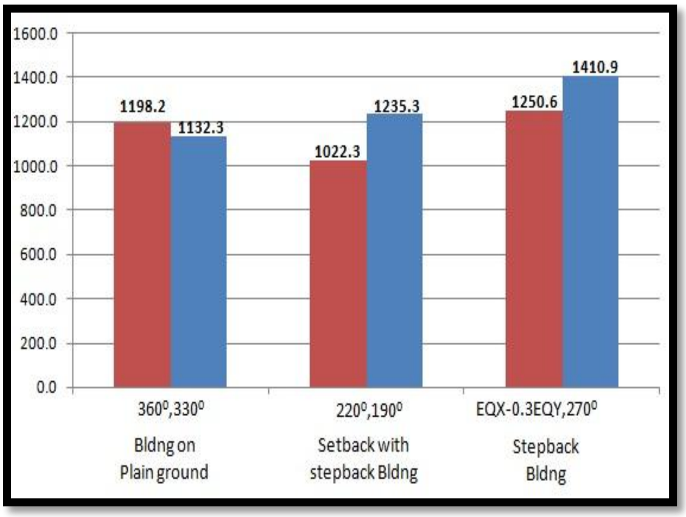

Fig. 5 Comparison of base shear for Chamoli earthquake

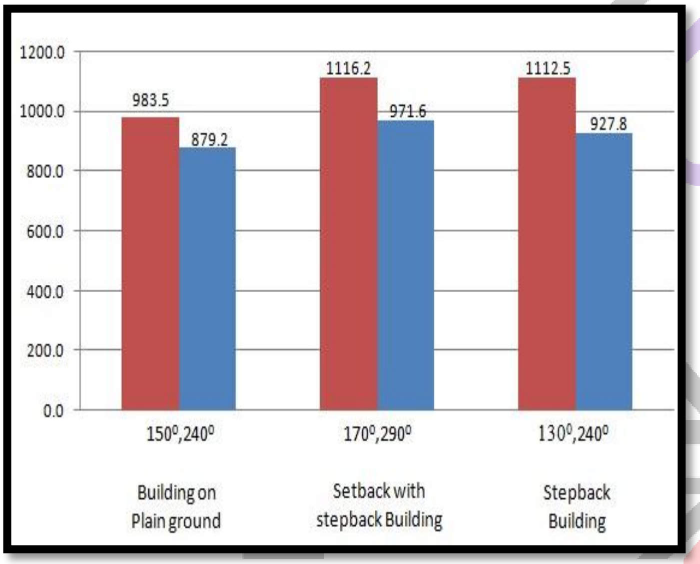

Fig. 6 Comparison of base shear for Response spectrum zone-V

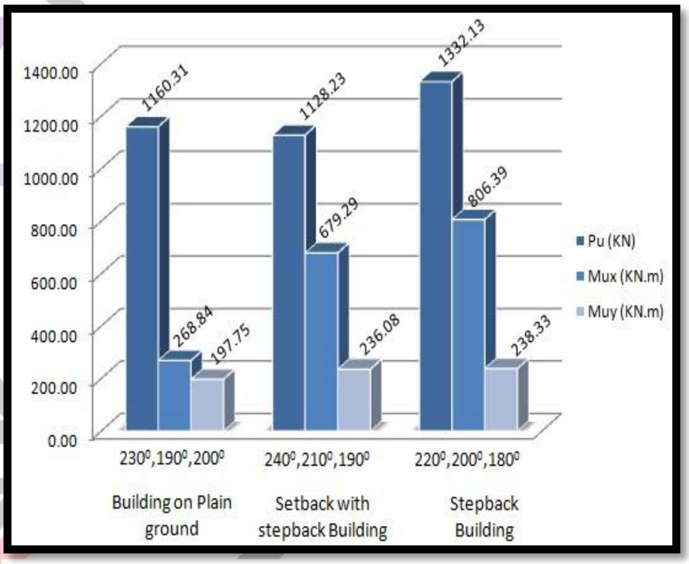

Fig. 7 Comparison of axial force & moments for Bhuj earthquake

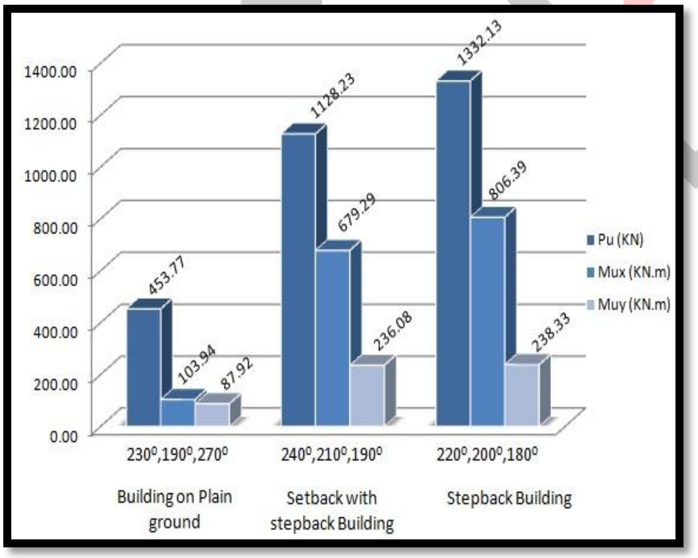

Fig. 6 Comparison of axial force & moments for Chamoli earthquake

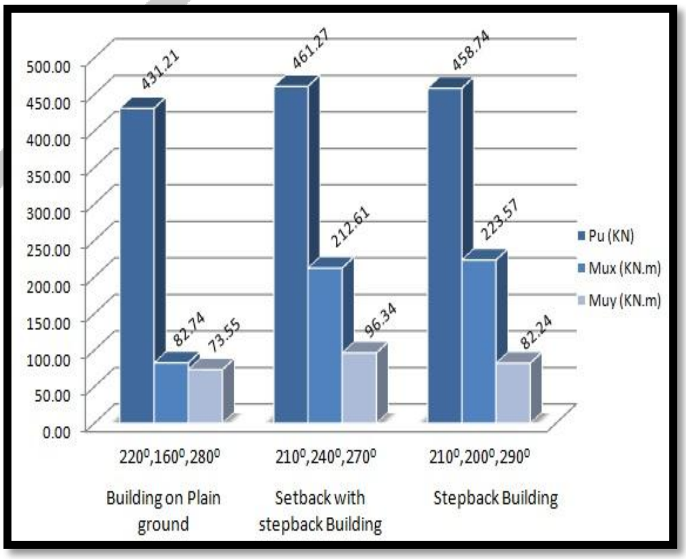

Fig. 7 Comparison of axial force & moments for Response spectrum zone-V

CONCLUSION

[1] The Base shear increases by 20 % if earthquake is applied to some angle compared to right angle.
[2] In Bhuj earthquake time history, Base shear is increase 12 % and 14 % in setback with stepback building compare to building on plain ground and stepback building respectively.
[3] In Chamoli earthquake time history, Base shear is increase 5 % and 18 % in stepback building compare to building on plain ground and setback with stepback building respectively.
[4] In response spectrum analysis, Base shear is increase 12 % in sloping ground building compare to building on plain ground.
[5] In Bhuj earthquake time history, Axial force is almost same in all three types of building but moment increase 66 % and 16 % in stepback building compare to building on plain ground and setback with stepback building respectively.
[6] In Chamoli earthquake time history, Axial force increase 65 % and 16 % and moment increase 87 % and 16 % in stepback building compare to building on plain ground and setback with stepback building respectively.
[7] In response spectrum analysis, Axial force is almost same in all three types of building but moment increase 63 % and 5 % in stepback building compare to building on plain ground and setback with stepback building respectively.
[8] The values of base shear are higher for time history analysis compare to response spectrum analysis.
[9] The values of axial force and moments are higher for time history analysis compare to response spectrum analysis.
[10] In most of cases critical angles are different from 0^0 and 90^0.

It is not possible to decide the angle of application of earthquake which gives peak response because we are getting different angles for various peak responses such as Base shear, Axial force and moments for column. The columns near ground attract higher moments so design should be properly done to resist that much high moment.

REFERENCES

[1] "Seismic Time History Analysis of Building on Sloping Ground Considering Near/Far field Earthquake", International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue: 2014, ISSN: 2278-0181.
[2] "Effect Of Sloping Ground on Structural Performance of RCC Building Under Seismic Load", International Journal Of Science, Engineering And Technology, VOLUME 2 ISSUE 6: 2014 (VER II), ISSN: 2348-4098.
[3] "Investigation of Critical Angle of Seismic Incidence for the Analysis of RCC Frames", Proceedings of 12th IRF International Conference, 2014, Pune, India, ISBN: 978-93-84209-31-5.
[4] "Seismic Performance of Multi-storeyed Building on Sloping Ground", Elixir International Journal, 53 (2012) 11980-11982.
[5] "Design of 3d Rc Frame on Sloping Ground", International Journal of Research in Engineering and Technology (IJRET), Volume: 03, Issue: 2014, eISSN: 2319-1163, pISSN: 2321-7308.
[6] "Seismic Analysis of R.C.C. Building Resting on Sloping Ground", International Journal Of Pure And Applied Research In Engineering And Technology, Volume 3, No.8 (2015): 119-133.
[7] IS – 1893 (Part – 1):2002, Indian Standard Criteria for Earthquake Resistant Design of Structures, Part – 1: General Provisions and Buildings.
[8] CSI, SAP-2000, V-17.2
[9] www.strongmotioncenter.org
[10] Agarwal and Shrikhande, "Earthquake Resistant Design of Structures"; PHI Learning Private Limited; New Delhi; 2010.