Comparative seismic analysis of RCC building resting on flat and sloping ground

K.Y RAKESHA KUMARA[1], NAVEEN KUMAR M[2]

[1]Post graduate student,[2]Professor

[1]Department of civil engineering,

[1]Dr. Ambedkar Institute of Technology, Bengaluru, India.

Abstract - The structures are generally constructed on flat ground; however, due to scarcity of flat grounds the construction activities have been started on sloping grounds. In this project a G+8 multi-storey building resting on flat and sloping ground varying 5°,10° and 15° in zone-4 have been considered for the analysis. A comparison has been made with the building resting on flat ground and sloping ground. The modelling and analysis of the building has been done by using ETABS. The seismic analysis was done by using response spectrum analysis and is carried out as per IS:1893 (Part 1):2002. The results were obtained in the form of Base shear, Storey drift and Time period.

Key words - Sloping ground, Response Spectrum analysis, ETABS, Seismic Analysis.

I.INTRODUCTION

The seismic history of India reveals that the mountainous terrains of the northern and north-eastern areas are mostly where the higher seismic activity and magnitudes occur, in addition to these areas being more susceptible to earthquakes. Seismology is the study of earth vibrations, primarily those caused by earthquakes. The migration of people from hilly regions may be resolved as a result of a lack of resources that may assist them meet their basic needs. The buildings are frequently erected on flat ground. In some areas, the landscape is naturally inclined. Since there isn't enough flat land in an area with hills, construction activities must be carried out on the slopes of hills. When plain areas are formed by earth excavation for construction, the natural beauty of the landscapes is damaged rather than saved money and time. These sloped regions' financial development and quick urbanization have accelerated due to the land improvement. As a result, there has been a noticeable rise in population density, and the ratio of available to required land is currently uneven in the hilly areas. As a result, multi-story structures are increasingly being constructed on hillside slopes. Buildings on slopes act very differently from those on flat ground when it comes to design, being very unpredictable and unbalanced in both the horizontal and vertical axes. The centers of mass and rigidity on various levels do not line up because the mass and stiffness of these structures vary in the vertical and horizontal planes, which causes the structures to twist. In light of the situation, it is essential to consider how these structures would respond during an earthquake in order to increase their seismic resistance and lessen the destruction of life and property. It is crucial to investigate how buildings are impacted by slope variation when there is an earthquake load since hilly slopes change.

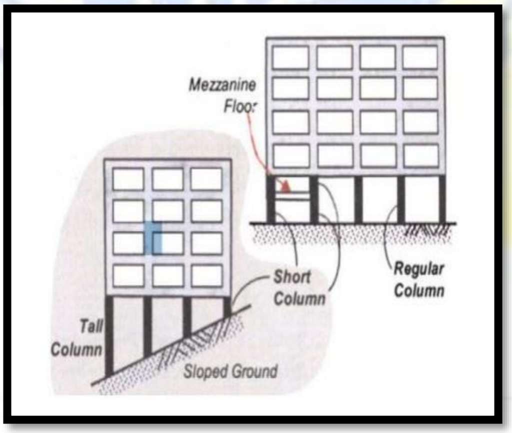

Fig.1 Building Frame with Short and Tall Columns

II.LITERATURE SURVEY

Mojahid Islam and Siddharth Pastariya (2020): A 15-story multistorey building is designed with 5 numbers of 4-meter bays uniformly spaced in both directions, a constant floor height of 3.66 meters, and a bottom floor height of 4.58 meters. Five Step Back cases and five Step Back The tables below include examples of structural configurations and set back scenarios that illustrate buildings resting on both flat and sloping soil. All situations are reviewed and rated in accordance with Indian Standard Code IS 1893 (Part1) against distinct seismic features and constraints for earthquake Zone III in order to research the options for enduring deformation and enduring seismic and structural risks.

The reaction spectrum technique is used in this research study for seismic zone V to examine a variety of conditions. Dynamic analysis was conducted for all the models that contain a structure on level ground, a step-back configuration, and a step-back and setback configuration, and it was done for various load combinations. The characteristics utilized for comparative studies of certain scenarios in tabular and graphical form include maximum nodal displacement, maximum axial force, maximum shear force, maximum bending moment, maximum torsional moment, and base shear.

It has been determined from this study that a 15-story sloping building with both configurations resting on 300 slope is found to be the most efficient as per lowest parametric values out of all the cases with various configurations of Steps back and Step back along with Setback in the plane and sloping terrain with variable slope.

M. Hasan and N. H. M. K. Serker (2019): This paper considers the Step back and Step back Set back frame configurations for a structure with an arbitrary square shape that is 16 meters long and 16 meters wide. Every time, a 10-story building is considered for hill slope angles of 0, 5, 10, 15, 20, 25, 30, 35, and 45 degrees, and ETABS is then run using the response spectrum approach. For this analysis, these cases are taken into account; case 1: Step-back building frame. Case 2: Reverse the building frame's position.
The results of the software study are summarized in respect to base shear, top story displacement, and fundamental time period for all 20 models. For each of the 20 models, the seismic stress in the X- and Y-axis was investigated.

When compared to Step back Setback frames, Stepback frames create higher base shear. In comparison to Stepback Set back frames, Stepback construction frames provide bigger time values in comparison to step back-set back building frames, Stepback building frames provide higher values of top storey displacement and story drift. Additionally, it has been shown that step-set back frames are preferable to step-back frames since they may perform more vulnerable during seismic excitation than other building frame configurations. Additionally, it has been determined that Stepback Set back structures will be more practical, cost-effective, and aesthetically pleasing.

III.METHODOLOGY

Seismic codes vary depending on the country or region. In India, the IS: 1893(part-1):2002 is standard for earthquake-resistant building design and also the primary code book that serves as a framework for calculating seismic design forces. ETABS is a robust and well-liked software for designing and analyzing structures. It provides a complete set of tools for designing and analyzing many different types of structures, such as buildings, bridges, towers, and other civil engineering projects. The different modes of response of a building can be taken into consideration using the response spectrum method. For all constructions other than those that are extremely simple or complicated, this is needed by building code. A structure's response can be described as a synthesis of numerous modes.

Model 1 is lying on the flat ground, is modelled and analyzed in seismic Zone 4.

Model 2 is lying on 5° sloping ground, is modelled and analyzed in seismic Zone 4.

Model 3 is lying on 10° sloping ground, is modelled and analyzed in seismic Zone 4.

Model 4 is lying on 15° sloping ground, is modelled and analyzed in seismic Zone 4.

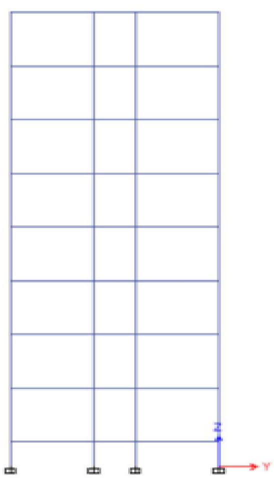

Fig.2 Flat ground

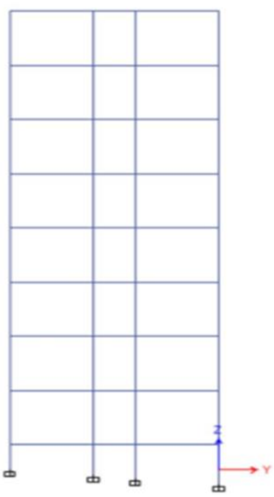

Fig.3 5° sloping ground

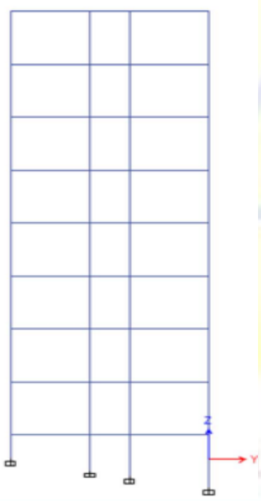

Fig.4 10° sloping ground

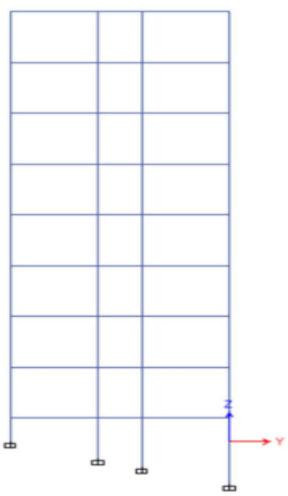

Fig.5 15° sloping ground

Table.1 Parameters considered for analysis

BUILDING DESCRIPTION	
Plan Dimension	24mx10 m
Height of Building	30.3m
Response Reduction Factor [R]	5
Damping Ratio	0.05
Structure Type	OMRF
Importance Factor	1.2
Soil type	Medium (type-II)
Number of Storey	G+8
Height of typical floor	3.2m
Slab size	150mm
Column size	300mm x 750mm
Beam size	300mm x 450mm
Shear wall size	200mm
Typical live load	3 kN/m^2
Roof live load	2 kN/m^2
Floor finish	1.5kN/m^2
Wall load	9.4 kN/m^2

IV.RESULTS AND DISCUSSIONS

(1) Base shear

It is an estimate of the maximum lateral force that the structure might reasonably expect to experience as a result of seismic ground motion. Base shear is maximum at the bottom level for different models such as Model-1, Model-2, Model-3 and Model-4 which is located in zones-4.

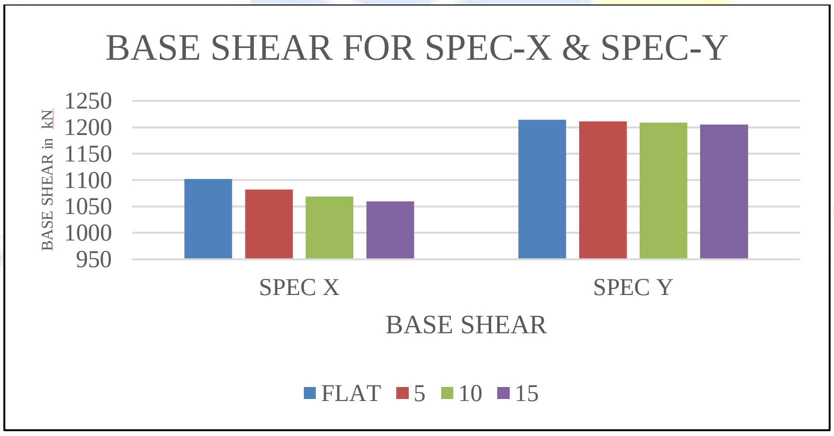

Fig.2 Base Shear for Spec-X and Spec-Y

Fig.2 shows the base shear in the Spec-X and Spec-Y direction of the response spectrum method.The base shear in the Spec-Y direction is more compared to the Spec-X for all the models. Base shear is more in the flat ground than 0.23% for 5˚sloping ground, 0.43% for 10˚sloping ground and 0.76% for 15˚sloping ground. This is because, in flat ground the building experiences the full force of the seismic motion, resulting the higher base shear. In sloping ground, some of the seismic energy is absorbed by slope, which leads to comparatively lower base shear.

(2) Storey drift

One story's position in relation to another is related to it. The design of partitions and curtain walls must take tale drift into consideration. Normally, the story drift ratio around the intermediate level of the building is more critical than at the top. However, the story drift ratio is needed by the code to be tested under earthquake against the limit of 2%. Storey drift for different models such as Model-1, Model-2, Model-3 & Model-4 is plotted which is located in the zones-4.

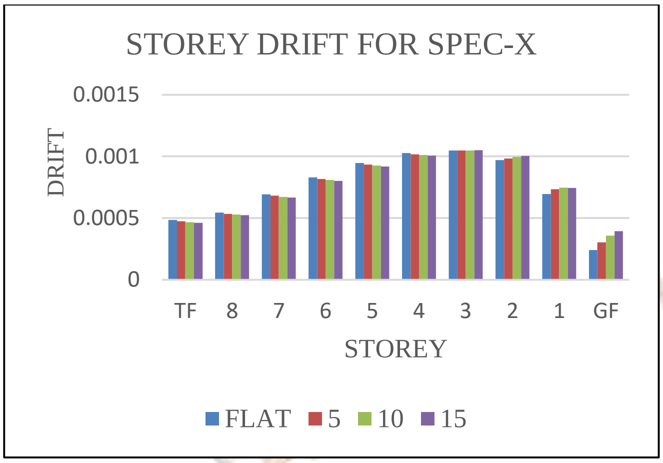

Fig.3 Storey drift in Spec-X direction

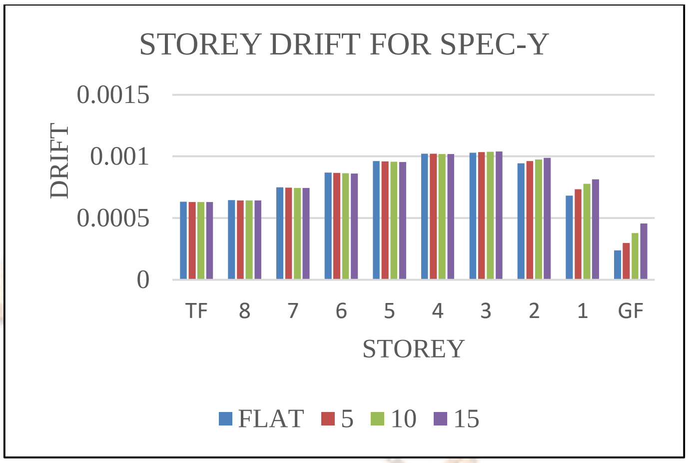

Fig.4 Storey drift in Spec-Y direction

Fig.3 and Fig.4 shows the storey drift for Spec-X and Spec-Y. The storey drift is more efficient in 15° sloping ground by 3.2% than flat ground, 2.17% than 5° sloping ground, 1.08% than 10° sloping ground. This is because the building's foundation is typically more rigid and less deformable in flat ground compared to sloping ground.

(3) Time period

The amount of time required for a building to go through one full oscillation cycle is known as its natural period. It is a built-in characteristic of a building that is governed by its mass (m) and stiffness (K).

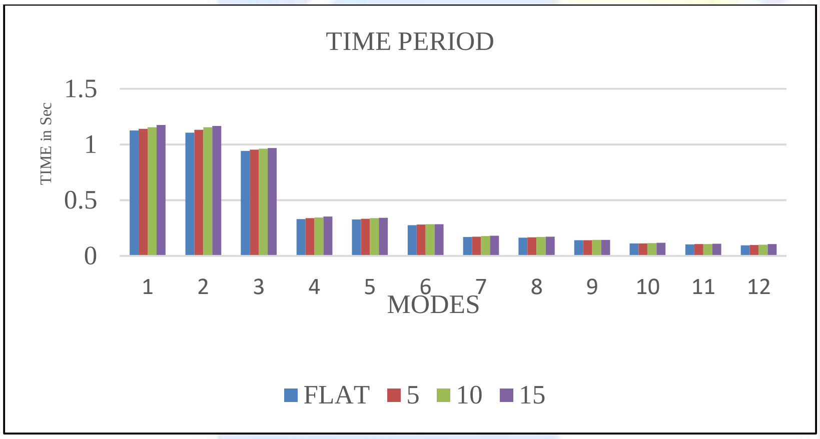

Fig.5 Time period

Fig.5 shows the time period for Model 1, Model 2, Model 3, Model 4. Time period goes on decreasing for higher mode shape number. The time period is more in 15° sloping ground by 4.53% than flat ground,3.06% than 5° sloping ground, 1.73% than 10° sloping ground. This is because the building will be affected by gravitational acceleration when it moves on a sloped surface, which causes it to accelerate more on slope due to the gravity force.

V.CONCLUSIONS

From the above results and discussion, the following conclusions are drawn.

- The short ground level columns take the biggest hit. When it comes to design and detailing, these columns should receive special consideration
- All of the structures have nearly comparable base shear. As the slope angles rise, the base shear value falls. This is because, in flat ground the building experiences the full force of the seismic motion, resulting the higher base shear. In sloping ground, some of the seismic energy is absorbed by slope, which leads to comparatively lower base shear.
- For all building frames, on both flat and sloping terrain, the maximum story drift can be found at the 6th storey. As the ground slope increases from 0° to 15°, the storey drift reduces. This is because the building's foundation is typically more rigid and less deformable in flat ground compared to sloping ground.

- It is evident that as the slope angles rise, the time period increases. This is because the building will be affected by gravitational acceleration when it moves on a sloped surface, which causes it to accelerate more on slope due to the force of gravity.

VI.REFERENCES

[1] Birajdar B. G and Nalwade S. S, - Seismic Analysis of Hill Buildings Resting on Sloping Ground, 13th World 1. Conference on Earthquake Engineering, Vancouver, B.C., Canada, 2004, pp. 1472.
[2] Haider Abdulazeez Ibrahim, Dr N.V.Ramana Rao (2015). "Analysis of reinforced concrete building with different plan shapes resting on sloping ground", International Journal & Magazine of Engineering, Technology, Management and Research, ISSN: 2348-4845, VOL. 2, PP 152-157.
[3] Khadiranaikar RB and Arifmasali (2014). "Seismic performance of buildings resting on sloping ground- A review", IOSR Journal of Mechanical and Civil Engineering, Vol-11, No 3, PP 12-19.
[4] Mojahid Islam and Siddharth Pastariya (2020) "Analysis of building on sloping ground subjected to sesmic forces", International Journal of Advanced Engineering Research and Science (IJAERS), [Vol-7, Issue-1, Jan- 2020] ISSN: 2349-6495(P) | 2456-1908(O).
[5] Tamboli Nikhil Vinod, Ajay Swarup (2017), "Study of Seismic Behavior Of Multi-Storied R.C.C. Buildings Resting On Sloping Ground And Bracing System", International Journal of Advance Research and Innovative Ideas in Education, ISSN: 2395-4396, Vol. 03, Issue 04, pp. 317-324.
[6] Roser J. Robert, Ranjana M. Ghate (2016), "Seismic Analysis of Multistoried RCC Building on Sloping Ground", International Journal for Research in Emerging Science And Technology, ISSN: 2349-7610, Vol. 03, Issue 12, pp. 40-45.
[7] Paresh G. Mistry, Hemal J. Shah (2016), "Seismic Analysis of Building on Sloping Ground Considering Bi-Directional Earthquake", International Journal of Scientific Development and Research (IJSDR), ISSN: 2455-2631, Vol. 01, Issue 04, pp. 59-62.
[8] I.S. 456-2000, Indian standard code of practice for plain and reinforced concrete (fourth revision), Bureau of Indian standards, New Delhi.
[9] I.S. 1893(Part 1)-2002, Criteria for earthquake resistant design of structure, general provision and building, Bureau of Indian standards, New Delhi.