Survey Paper on Building Resting at Sloping Terrain

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Abstract— The paper overviews on idea about work of different researches carried out on building resting on sloping terrains. The result from a previous experiment expressed that the analysis of structure depends on idealization of geometry of structure and its load system. The scope of present work is to analyze behaviour of multi storied building having vertical irregularities which are especially seen in hilly regions. All Analysis were carried out by using finite element software. Previous examination focuses on parameters like story drift, lateral displacement, story shear and axial force in columns, time period variation under both static and dynamic loading. This study summarizes the knowledge in the seismic response of buildings on sloping terrain conditions. It is observed that the seismic behaviour of buildings resting on sloping ground is different from flat ground buildings. Most of the studies agreed that the buildings resting on sloping ground has higher displacement and base shear compared to buildings resting on plain ground. Also, the shorter columns are subjected to heavier forces which undergoes damage when subjected to earthquake. Step back building could seems to be more hazardous during seismic excitation.

Key words: Sloping terrain, seismic force, vertical irregularities step back frames, step back & set back frames

I. INTRODUCTION

The past earthquakes observation shows that, buildings in hilly regions is high affected which leads to collapse. So that, while construction of multi-story buildings in hilly areas which is affected by seismic activity, special care should be taken to making these buildings earthquake resistant.

In sloping terrain areas, the cost of foundation is always requires more as compare to normal terrain. In this situations, it is preferable to build series of supporting steps for columns which can be the cost effective solution as it reduces the excavation cost.

The path of load may changes with the change in geometry of the structure. It may lead to additional demand of torsional, bending and axial forces in addition to lateral forces earthquakes. Hence, such unsymmetrical buildings may require greater attention in the analysis & design because of short and long columns effects which may damage to the building due to heavily induced stresses. When a building is rested on sloped ground, there is many possibilities of having such short and long columns in same structure. Generally the short column is subjected to more earthquake forces which leads to savior damage.

II. TERMINOLOGY

- Vertical geometric irregularity :As per IS 1893:2002 It shall be consider that, where the horizontal dimension of the lateral force resisting system in any story is more than 150 % of that in its adjacent story, then it may know as vertical irregularity in structure.
- Step backs structure: The structure which possess regularly reducing the footprint of each level and located successively back from the ground, such buildings may know as step back structures.
- Setbacks structure: The multi-story building in which various floors are arrange in step wise manner towards hill slope such buildings may know as set back structure.
- Bays: Bays are the division of a building between vertical lines or planes, such as two adjacent supports like columns, including floors or ceiling between them.

III. PROBLEM EXPLORATON

Hilly area in northeast region of India is more is prone to heavy seismic activity. Hilly region buildings are constructed in masonry with cement mortar without conforming to seismic code provision which may lead to unsafe and, resulted in loss of life and property when subjected to earthquake ground motions.

In general, footings should be placed at the same level. However, In case of sloping terrain condition, if the footing shall be constructed at different levels, the distance between the edges of footings shall be maintain such that to prevent unwanted overlapping of stresses in soil and disturbance of pressure bulbs in the soil under the lower footing due to the presence of the upper footing. This problem can be avoided by keeping the difference in footing elevations.

If the slope is present along the length of the structure, then footing may rest down upto certain distance below finished grade. This is uneconomical, as it requires extra excavation and material. So to minimize the excessive cost of excavation, place the footing in stepwise manner so that its depth should be below the finished level and at any point no stresses may overlap each other. Where the isolated footings may be more economical than a continuous spread footing option.

IV. DISCUSSION AND RESULTS

The summary of some literature review referred from different publication are discussed below, which shows the modelling, methodology, mode of analysis and their respective conclusions.

Reference [1] shows, the paper which presents response spectrum analysis of 6-story, 8-story and 10-story building on sloping ground and configured into different unsymmetrical bays. Dynamic analysis has been carried out to evaluate the parameters such as fundamental time period, story displacement and base shear. The models have been analyzed by using ETAB software.

The analysis of all 48 models concluded that, the less values of base shear are obtained in Step back-Set back frames. The rate of increase in top story displacement is proportional to the height of the building. The values of the fundamental time period are seen less than that of the step back frames. Therefore, it is concluded that greater number of bays are observed to be better under seismic conditions.

Reference [2] shows, the sloping effect of the ground on behaviour of medium raised G+5 structure frames in earthquake zone V using STAAD Pro V8i software with five different cases,

1) Regular building which having slope 0o
2) Building having slope of 10o
3) Building having slope of 20o
4) Building having slope of 30o
5) Building having slope of 40o
6) Building having slope of 50o

From the study, it is resulted that, on sloping ground, the displacement of building shows the same behavior as of regular building. The value of displacements gets reduces as the slopes increases.

Reference [3] shows, 10 story is modeled in SAP-2000 software analyzed for both time history and response spectrum function with following models in earthquake zone V.

1) M1: Normal building on plain ground
2) M2: Setback - step back building on sloping ground 20o
3) M3: Step back building on sloping ground 20o

The time history data of Bhuj Earthquake 2001, Chamoli Earthquake, 1999 where has taken for analysis.

For the time history analysis it has been observed that, base shear is increase in M2 compare to M1 and M3. In response spectrum analysis, base shear is increase in sloping ground building compare to building on plain ground. While for both the time history analysis and spectrum analysis shows axial force is same in all three types of building. But the moment value increase M3 as compared to M1 and M2.

Reference [4] shows, the paper describes the building in hill slope for earthquake zone III with three types of configurations such as,

1) Step back
2) Step back-Setback
3) Setback

For the sloping & plain ground, buildings height varies from 15.2m to 52.6m (4 to 15storey). The dynamic analysis where carried for these buildings.

The results where summarized as follows:-

The base shear is maximum in Step back-Setback building & minimum in Setback building.

The storey displacement at top of Step back building is higher as compared to Step back-Setback building resting on sloping ground. Finally it is concluded that Step back-Setback building is more favourable on sloping ground.

Reference [5] shows, the G+6 multistoried building in earthquake zone III resting on ground having slope as 26°, 28°, 30°. The response spectrum analysis is performed using STAAD Pro software for following models,

1) Step back building on sloping ground
2) Step back-setback building on plain ground
3) Step back- setback building on sloping ground

From this study it is concluded that, top story displacement of setback-step back building is less than that of step back building. Use of bottom ties gives effective response of hilly building. It has been observed that, as the slope of ground increases the value of base shear, story displacement at top and time period will decreases considerably. Also, the base shear of building resting on plain ground is less than that of building resting on sloping ground.

V. SCOPE OF WORK

- Analysis can be carried out by considering new irregular plan.
- Comparison of frames by dividing into number of bays.
- Study the effect of long column and short column with change in terrain condition.
- Analysis can be perform by selecting high seismic zone in Maharashtra region.

VI. CONCLUDING REMARKS

It has been observed from the past earthquakes studies, buildings in hilly regions in earthquake prone areas are generally irregular and hence subjected to severe damage when affected by lateral ground movement. Hence, care should be taken while construction of buildings in sloping region to make it earthquake resistant.

The paper present the summary of building configured on sloping ground. The investigation of previous papers is for predicting the seismic response of RC buildings with different configuration on sloping and plain ground condition. This paper is beneficial for the researcher for further studies and to the work in this filed which enables them to choose their way of research work.

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