Study of Seismic Behavior of Multi-Storied R.C.C. Buildings Resting on Sloping Ground

A.H. Shastrakar[1], S.S. Parma[2], R.H. Rikibe[3], R.S. Sakhare[4]
[1, 2, 3, 4] Dept of Civil Engineering
[1, 2, 3, 4] Dr.D.Y.PATIL SOET, Pune, Maharashtra, India

Abstract- *As we know that generally buildings are constructed on flat ground. For mountainous area or for hilly area like Ladakh, Himachal Pradesh all is mountainous areas. For this type of area we choose the construction on sloping ground. And we have to study the seismic behavior for building. For that we take the building on sloping ground having slope between 10-30 degree. We used ETABS 2015 for analysis of 8 storey building. With step back and step back set back configuration are modeled in which slope angle is varied. Models are then analyzed for preliminary design by linear static analysis and Response spectrum analysis according to Indian seismic code and evaluated using Performance based Design approach by Nonlinear Static Pushover analysis.*

Keywords- Building resting on sloping ground, ETABS, step back Building, Set-back Building.

I. INTRODUCTION

The study of earthquakes and the structure of the earth, by both naturally and artificially generated seismic waves. From the seismic history of our country, it is observed that majority of the devastating earthquakes have been occurred in northern and north-eastern states of India. It's very difficult to construct the building on slopping ground for doing this work we have to study about its geographical conditions and earthquake conditions. Disasters like Kedarnath had happened in past which affects the building which are constructed on the sloping ground. R.C. buildings are stronger than the buildings constructed of wood and clay or mud. Here we have to take special care of building resting on slopping ground because it's very difficult to construct it as compare to flat ground. Here are the chances of uneven settlement of foundation in sloping terrain conditions.

While construction, it must be noted that hill buildings are different from those in plains that is they are very irregular and unsymmetrical. During past earthquakes reinforcement concrete frame buildings that have columns of different heights within one storey, suffered more damage in shorter columns as compared to taller columns in the same storey. First example of buildings on sloping ground and building with a mezzanine floor can be seen in Poor behavior of shorter columns is due to the fact that in an earthquake, a tall column and a short column of same cross section move horizontally by same amount. Second example of structural behavior of short column under lateral loading which can be seen from However the short column is stiffer as compared to tall column and it attracts larger earthquake force.

Three major earthquakes of magnitude greater than 8, Kangra (1905) have occurred in this hilly track in the last century. The hilly seismic region of our country ranges from Jammu Kashmir, Himachal Pradesh, North Uttar Pradesh, North Bihar, Sikkim, North Bengal, Assam, Meghalaya, Nagaland, Auranachal Pradesh, Manipur, and Tripura and Mizoram. It is observed from the past earthquakes, buildings in hilly regions have experienced high degree of damage leading of collapsed though they have been designed for safety of the occupants against natural hazards.

A grass-covered hillside makes for a picturesque setting for your dream home, but the process of bringing that picture to life is more complicated than it would be for the average dwelling. Building a house on a sloped lot presents unique challenges that you need to be aware of to ensure the rewards for you are worth the additional costs and longer construction time.

The biggest hurdles boil down to two main factors: the gradient of the slope and whether the lot is upslope or down slope. You can get a rough idea of how challenging a particular site will be to build on by its gradient rating. Less than 10% incline is considered slight and is the easiest to build on, while 11-20% is considered moderate. Anything above 20% is deemed steep. Beyond about 15%, costs begin to increase significantly as the risks become greater and the work becomes more difficult. An upslope plot (where what will be the front of the house rises up to the back) is also more challenging than a down slope plot. These types of plots usually require some amount of cutting or even blasting, plus transporting and disposing of rocks and soil.

II. CASE STUDY

The economic growth and rapid urbanization in hilly region has accelerated the real estate development. Due to this, population density in the hilly region has increased enormously. Therefore there is popular and pressing demand for the construction of multi-stored buildings on hill slope in and around the cities.

It is observed from the past earthquakes, buildings in hilly regions have experienced high degree of demand leading to collapse though they have been designed for safety of the occupants against natural hazards. Hence, while adopting practice of multi-stored buildings in these hilly and seismically active areas, utmost care should be taken, making these buildings earthquake resistant.

In the present study a G+8 building with two different configurations i.e. Step back and step back set back with varying ground slope 0°, 15°, 25°, 30° are considered. To compare the behavior of regular configuration resting on plain ground a G+8 building having plan same as that of respective hill configuration are considered. Lateral load analysis as per the Indian seismic code [4] for the building resting on flat ground and building resting on sloping ground (step back and Step back Setback [5]), is carried out and an effort is made to study the effect of seismic loads on them and thus assess their seismic vulnerability by performing nonlinear Pushover analysis carried out using Etabs analysis package. Slabs are modelled as rigid diaphragms. Default hinge properties available in ETABS Nonlinear as per ATC- 40[6] are assigned to the frame elements. Building has no walls at all stories and is modelled as bare frame. However masses of the walls are included. In addition to wall masses the other load like floor finish and imposed live load is added at each storey. Three distinct analyses are carried out Equivalent Static Analysis, Response Spectrum Analysis, and Nonlinear Pushover Analysis.

III. OBJECTIVES

1. To carry out modeling and seismic behavior of multi storied R.C.C. building resting on sloping ground by using E-TAB software.
2. To calculate the design lateral force on sloping ground building using seismic coefficient method & compare the result of different configuration of structure.
3. To calculate the base shear, fundamental time period & displacement and compared with considered configuration as well as will other configuration.

IV. MODEL DESCRIPTION

4.1 Geometric parameters

In the present study, one building configurations are considered, which include buildings situated on plain ground. Number of storey considered for each type of configurations is 8 storeys. Plan layout is kept same for all configurations of building frame. The columns are taken to be square to avoid the issues like orientation.

4.1.2 Geometric Properties

1. The height and length of building in a particular pattern are in multiple of blocks (in vertical and horizontal direction), the size of block is being maintained at 6m x 5 m x 3.0 m.
2. The height of all floors is 3.0m
3. The depth of footing below ground level is taken as 1.8 m where, the hard stratum is available.
4. The slope of ground is 27 degree with horizontal, which is neither too steep or nor too flat

The dynamic analysis is carried out using response spectrum method to the step back and step back and step back building frames. Three dimensional space frame analysis is carried out for four different configurations of buildings ranging from eight storey resting on sloping ground under the action of seismic load by using E-tab software.

Table no 4.1 Geometrical properties of members for different configurations of building

Building configurations	Number of story	Size of column in mm	Size of beam in mm
Step Back Building	8 storey	300X680	250X500
Step back building with bracing	8 storey	300X680	250X500
Regular building on plain ground	8 storey	300X680	250X500
Step back and set back building	8 storey	300X680	250X500
Bracing	8 storey		180X300

4.1.2 Assumed Preliminary Data Required for Analysis of Frame

1. Types of structure :multi-storey rigid joined plane frame (special RC moment resisting frame)
2. Number of stories: four different configurations of buildings ranging from G+8.
3. Specific weight of R.C.C :25 kN/m^3
4. Materials: Concrete grade is M20 and Steel reinforcement is Fe415

5. Depth of slab is taken as 150 mm thick for all floors.
6. Height of parapet:1.2m
7. Response spectra: As per IS 1893 (Part 1):2002
8. Infill wall: 230 mm thick for all floors

4.2 Methods of Seismic Analysis of Multi-Storied R.C.C. Buildings as per IS 1893 (Part 1):2002

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis is a recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

There are different types of seismic analysis methods. Some of them used in the project are

Equivalent Static Lateral Force Method.
Response Spectrum Method.
Time History Method

V. RESULTS

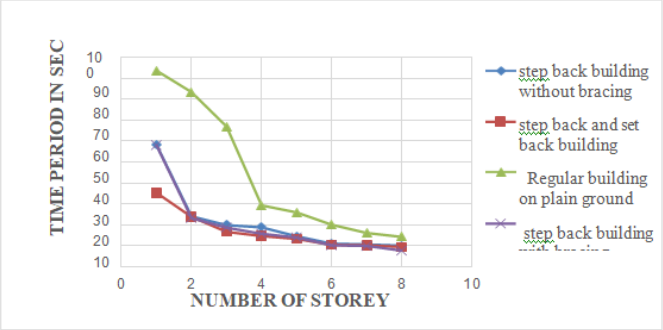
5.1 Analysis of Results of R.C. Frames Building Configurations (2D) for 8 Store By using ETABS.

5.1.2 Result and Discussion about Time Period

Comparison of time period between step back without bracings, step back with bracings, step back and set back without bracing and regular building on plain ground frames of 8 storey building:

5.1 Time Period of Building Configurations for 8 Storey

Storey No	Step back building	Step back and set back building	Regular building on plain ground	Step back building with bracing
1	58.3691	35.3622	93.6740	58.0850
2	24.0672	23.8289	83.3299	23.2337
3	19.8911	16.6523	66.8967	18.6891
4	18.8915	14.6414	29.2978	15.7600
5	14.5592	13.2660	25.9486	13.9853
6	11.0281	10.4300	20.0907	10.2959
7	10.6750	10.2321	16.1443	9.9148
8	10.1213	9.4347	14.2473	7.7033



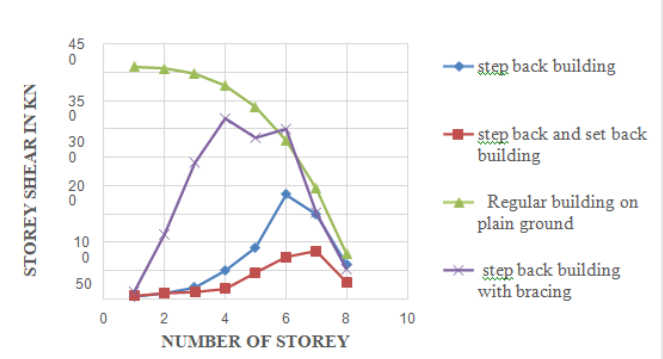
Graph 1 Time period variation with respect to Number of Storey for 8 Storey

Result and Discussion about Storey Shear

Comparison of storey shear between step back without bracings, step back with bracings, step back and set back without bracing and regular building on plain ground frames of 8 storey building:

Table 5.2 Storey Shear of Building Configurations for 8 Storey

Storey No	Step back building	Step back and set back building	Regular building on plain ground	Step back building with bracing
1	4.24	4.99	409.7	12.8
2	9.89	10.27	407.34	113.98
3	19.84	12.32	397.91	240.56
4	50.01	17.63	376.67	318.54
5	90.87	46.43	338.93	284.52
6	183.89	74.2	279.95	300.05
7	149.36	84.75	195.02	152.38
8	60.83	29.53	79.43	52.13



Graph 2 Storey Shear variation with respect to Number of Storey for 8 Storey

VI. CONCLUSIONS

The following conclusions have been drawn based on the results obtained from present study:

1. The concept of using R.C.C bracing is one of the advantageous concepts which can be used to strengthen sloping structures.
2. First storey shear of step back without bracings and step-set building frames are decreased by 20-30 % as compared to step back with bracings frames.
3. Top storey displacement of step back frames with bracings is decreased by 70-80 % as compared to step back frames without bracings and step and set back frames.
4. The performance of step back frames without bracings during seismic excitation can be affected more than other configurations of building frames. Hence, step back building frames without bracings on sloping ground are not desirable. However, it may be adopted by providing bracing system to control displacements.
5. As number of storey increases time period and top storey displacement is increased.

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