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

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Abstract- *The buildings are present in sloping ground are very different from those in plain ground, in sloping ground the buildings are very irregular and unsymmetrical in horizontal and vertical planes. The buildings in sloping ground causes more damage during earthquake, because in sloping ground the structure is constructed with different column heights. In this study 3D analytical model of 8 storied building, 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. Slabs are modeled 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 modeled as bare frame.*

Keywords- Flat Slab, Plain and Sloping Ground, Response Spectrum, ETABS 2015.

I. INTRODUCTION

The earth have various natural calamities in that the earthquake is a common calamity which is harmful as we know that when it occurs it destroys only, in that situation the structures are also affected by this earthquake, as the structures are have to construct by taking it in account. We have to use the different IS code for constructing the structure in earthquake regions.

Earthquake is the major reason for the issue of safety for the construction of multi storey buildings. The buildings which are present now are designed and constructed according to as per older code provisions, are not satisfying. Therefore it is need to construct different types of buildings which have the capacity to resist the forces, like Flat Slab and RC Framed.

Structures which are constructed on slopping ground they are have to construct on the parameters of earthquake because when the earthquake occurs that time it harms most to the structures which are on slopping grounds.

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.

Buildings behaviour in earthquakes depends on various uncertainty factors. These uncertainties originate from different sources, earthquake nature, components behaviour, and the analytical methods. Therefore, the response of the building is dependent on ground motions and an assembly of individual responses of structural and non-structural components in a fully probabilistic framework. Experience in past earthquakes has demonstrated that many common buildings and typical methods of construction lack basic resistance to earthquake forces. In most cases this resistance can be achieved by following simple, inexpensive principles of good building construction practice. Adherence to these simple rules will not prevent all damage in moderate or large earthquakes, but life threatening collapses should be prevented, and damage limited to repairable proportions. These principles fall into several broad categories: (i) plan and layout of the building involving consideration of the location of rooms and walls openings such as doors and windows, the number of stories, etc. At this stage, site and foundation aspects should also be considered. (ii) Lay out and general design of the structural framing system with special attention to furnishing lateral resistance. (iii) Consideration of highly loaded and critical sections with provision of reinforcement as required. Studies have provided a good overview of structural action, mechanism of damage and modes of failure of buildings. From these studies, certain general principles have emerged: (i) Structures should not be brittle or collapse suddenly. Rather, they should be tough, able to deflect or deform a considerable amount. (ii) Resisting elements, such as bracing or shear walls, must be provided evenly throughout the building, in both directions side-to-side, as well as top to bottom. (iii) All elements, such as walls and the roof, should be tied together so as to act as an integrated unit during earthquake shaking, transferring forces across connections and preventing separation. (iv) The building must be well connected to a good foundation and the earth. Wet, soft soils should be avoided, and the foundation must be well tied together, as well as tied to the wall. (v) Care must be taken that all materials used are of good quality, and are protected from rain, sun, insects and other weakening actions, so that their strength lasts. (vi) Unreinforced earth and masonry have no reliable strength in tension, and are brittle in compression. Generally, they must be suitably reinforced by steel or wood.

Categories of Buildings

For categorizing the buildings with the purpose of achieving seismic resistance at economical cost, three parameters turn out to be significant:

(i) Seismic intensity zone where the building is located.
(ii) How important the building.
(iii) How stiff is the foundation soil.

Objectives of Work

The main aim of this work is to study the static, dynamic analysis and performance of flat slab building on plain ground and sloping ground at various slopes under seismic excitation. The objective of study is as follows:

Three dimensional space frame analysis is carried out for flat slab building of 8 storeys resting on plain ground and sloping ground with slope angles 10°, 20° & 30° to horizontal. Analysis is performed under the action of seismic load by using Etabs software. Response spectrum method of analysis is used, the results in terms of base shear, storey drift, frequency, storey acceleration, time period and displacement is obtained, and compared with the configuration in plain ground to the configurations in sloping ground. At the end, a suitable configuration of building to be used in hilly area is suggested.

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.

A combination of these parameters will determine the extent of appropriate seismic strengthening of the building.

Seismic zones in India

In most countries, the macro level seismic zones are defined on the basis of Seismic Intensity Scales. In this guide, we shall refer to seismic zones as defined with reference to MSK Intensity Scale as described.
Zone II: Risk of Minor Damage.
Zone III: Risk of Damage. Zone
IV: Risk of Collapse and Heavy Damage. Zone
V: Risk of Widespread Collapse and Destruction.

Bearing capacity of foundation soil

Three soil types are considered here:

(i) Type I: Rocky or hard soil these soils which have an allowable bearing capacity of more than 10 t/m2.
(ii) Type II: Medium soil these soils, which have allowable bearing capacity less than or equal to 10 t/m2.
(iii) Type III: Soft soil these soils, which are liable to large differential settlement or liquefaction during an earthquake.

Buildings can be constructed on firm and soft soils but it will be dangerous to build them on weak soils. Hence appropriate soil investigations should be carried out to establish the allowable bearing capacity and nature of soil. Weak soils must be avoided or compacted to improve them so as to qualify as firm or soft.

II. MODEL DESCRIPTION

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.

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.

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	300X680	250X500
Step back building with bracing	8	300X680	250X500
Regular building on plain ground	8	300X680	250X500
Step back and set back building	8	300X680	250X500
Bracing	8		180X300

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

Load combinations

Load Combinations are taken as per IS 1893 and are as follows: In the limit state design of reinforced and pre-stressed concrete structures, the following load combinations shall be accounted for:

1. 1.5(DL+LL)
2. 1.2(DL+ZL+EL)
3. 1.2(DL+ZL-EL)
4. 1.5(DL+EL)
5. 1.5(DL-EL)
6. 0.9DL+ 1.5EL
7.0.9DL-1.5E

Combination for two or three component motion when responses from the three earthquake components are to be considered, the responses due to each component may be combined using the assumption that when the maximum response from one component occurs, the responses from the other two components are 30 percent of their maximum. All possible combinations of the three components (ELx, ELy and ELz) including variations in sign (plus or minus) shall be considered, Thus, the response due earthquake force (EL) is the maximum of the following three cases:

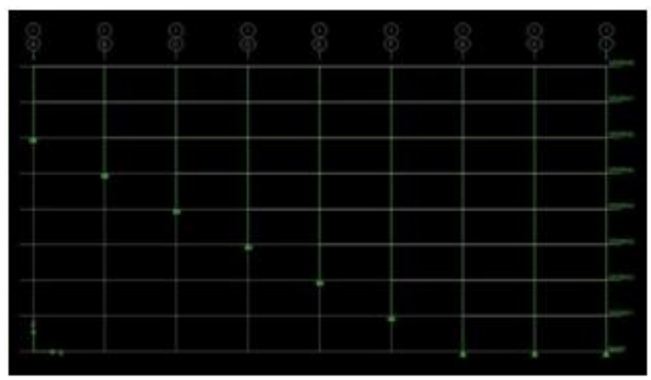
I. ±ELx±0.3ELy±0.3ELz
II. ±ELy±0.3ELx±0.3ELZ
III. ±ELz±0.3ELx±0.3Ely

Where x and y are two orthogonal directions and z is vertical direction.

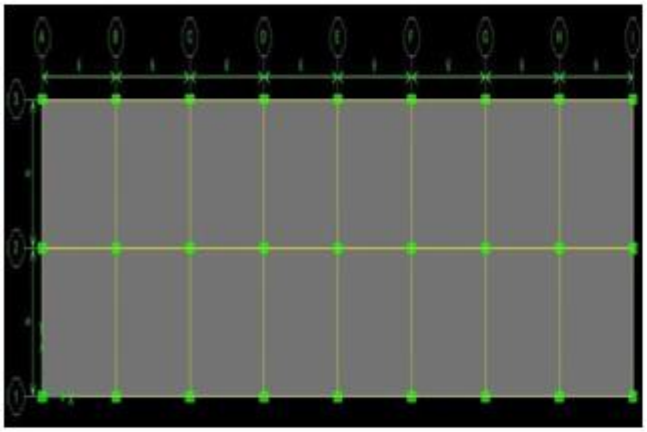
Analysis of Building Configurations (2D) Frames for 8 Storey

In the present study, four groups of multistoried building configurations are considered.

1. Step Back Buildings without Bracings.



2. Top Floor Plan of Step Back Buildings without Bracings for 8 Storeys.



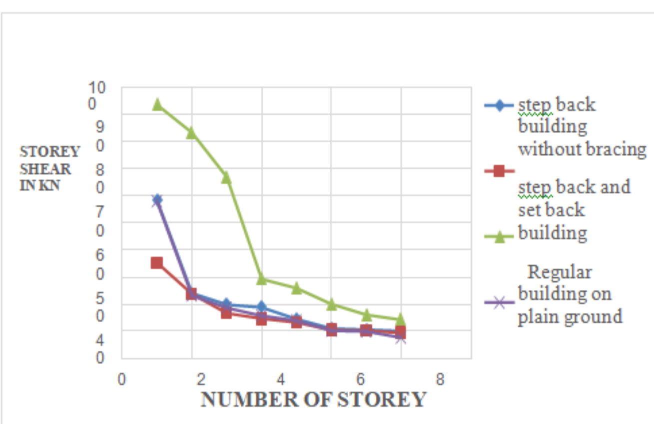
III. RESULTS

Result and Discussion about Time Period

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:

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



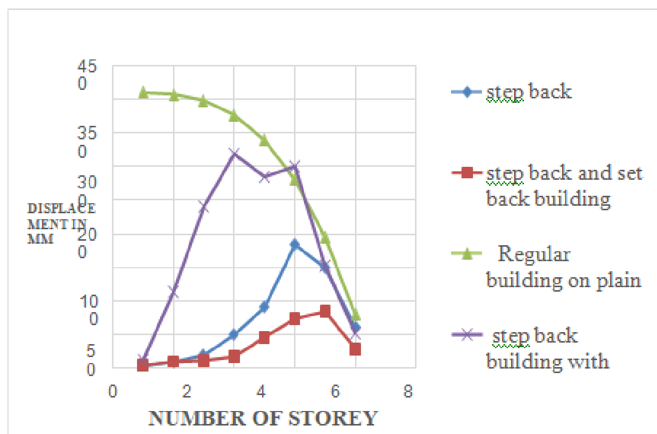
Result Conclusion: From the above table 2 & graph 2 shown that storey shear for first stories step back without bracings and step-set frames are less than step back with bracings frames and regular building on plain ground.

Result and Discussion about Joint Displacement

Comparison of displacement 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.

Time Period of Building Configurations for 8 Storeys

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



Result Conclusion: From the above table 2 & graph 2 shown that storey shear for first stories step back without bracings and step-set frames are less than step back with bracings frames and regular building on plain ground.

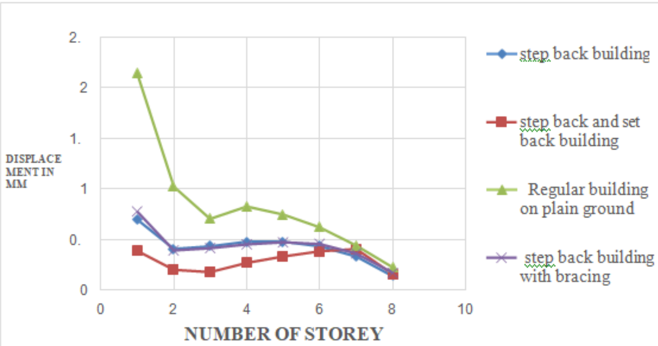
Result and Discussion about Joint Displacement

Comparison of displacement 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:

Displacement of Building Configurations for 8 Storeys

Storey No	Step back building	Step back and set back building	Regular building on plain ground	Step back building with bracing
1	1.0508	1.0289	2.6346	0.7387
2	1.3638	1.1927	4.5020	0.908
3	1.5738	1.0738	6.1034	1.0709
4	1.6276	1.0828	7.5495	1.5221
5	1.7329	1.1860	8.8237	1.9733
6	1.8536	1.3701	9.8656	2.4915
7	2.0586	1.8710	10.6091	3.0284
8	2.654	3.0053	11.0413	3.6036



Result Conclusion: From the above table 3 & graph 3 shown that Displacement for Top stories step back

Without bracings, step-set and regular buildings on plain ground frames are more than step back with bracings frames.

IV. CONCLUSION

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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