Analysis of Unsymmetrical Building Resting on Sloping Ground by Dividing In 2D Frame

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ABSTRACT: When a building is rested on sloped ground, there are many possibilities of having short and long columns in same structure. During earthquake shaking, all columns move horizontally by the same amount along with the floor slab at every different level which may effects damage to the structure. In this study, the building is analyzed in terms of 2-D frames considering different floor heights and number of bays using a structural analysis software tool ETABS. The analysis where carried along both x and y direction. For the comparison of results, various graphs were drawn for bending moment bending moment developed for the frames on plane ground and sloping ground. From these results, we have the summary of the simultaneous effects on short and long columns when present in the structure. Also, the results had been compared for different bay systems on plane and on a sloping ground for the increment of every story in frame. And finally, the structure would be analyzed and designed on sloping ground in seismic zone.

Key Words: 2D portal frame, slope terrain, multi-storey.

I. Introduction

The concrete structures are mostly designed in modern constructions. These monolithic structures behave independently as the design parameters are changed. Buildings constructed on hill slopes are unsymmetrical in nature. The design of such structure may appear to be more complex. These buildings are designed in such a way that its every component must resist two types of loads, i.e. vertical Load due to gravity, and lateral load due to earthquake and wind. The components of horizontal framing system are slab and beams, which transfer vertical load to vertical framing system and in the vertical framing system there are beams and columns, which transfer lateral load to the foundation. Besides the Himalayan region and the Indo-Gangetic plains, even the peninsular India is prone to severe earthquakes as clearly. illustrated by the Konya (1967), the Latur (1993), and the Jabalpur (1997) earthquakes, Sumatra earthquake (2004) Kashmir earthquake (2005).and Nepal earthquake (2015) The Bhuj earthquake is considered to be the largest intra-plate earthquake ever recorded. In case of sloping terrain surface and where hard rock strata present near to ground surface, it is difficult to make surface even for footings. In such cases, footings are placed at minimum depth of 0.5 meters at levelled surface. So, in this experimental case we are going to assume sloping surface where the levels of footing are different, maintaining the depth of footing and height of building same at each level. In this study we compare building on sloping ground with full flat excavation and step excavation.

II. LITERATURE REVIEW

B.G. Birajdar et.al [2] says, the paper on the structure resting on sloping ground in which seismic analysis is carried out on R.C.C. frames for three different configurations as step back building, step back set back building, set back building. The results show that the step back set back buildings were more suitable for sloping ground

Ankesh Sharma et.al [3] says, Response spectrum analysis (RSA) and time history analysis was conducted for each type of irregularity and the results obtained were compared with that of a regular structure. From time history analysis, the story displacements of geometry irregular buildings were more than that in case of regular building for upper stories but decreases as moves downward. This is because of lower stiffness acquired by upper story than the lower stories. Also, the tall structure shows maximum response in a low frequency earthquake because of low natural frequency.

S.D.Uttekar et.al [5] says, the seismic response on sloping ground is quite different as compare to seismic response on plain ground. The conclusions shows short column at ground level are damaged most during earthquake in case of Step back and Step back-Set back buildings, base shear is higher for Step back-Setback building and lower for Step back building, lateral displacement of top story is maximum for Stepback building, on sloping soil Setback- Stepback building is favored.

S.M.Nagargoje et.al [6] says, Analysis of three configurations of buildings is carried on sloping & leveled ground in zone 2. The following conclusions may be drawn from this study. The maximum base shear is induced in Step back-Setback building & least in Setback building on leveled ground. Top storey displacement of Step back building is quite high as compared to Step back-Setback building resting on sloping ground. Stepback-Setback building may be Favored on sloping group.

III. Methodology

The project was divided into different phases. They are as follows: -

Step-1- Consideration of building plan, seismic zone, location, terrain condition for the analysis.
Step-2- Divide the building in the form of simple 2-dimensional frames along both x and y direction independently.
Step-3- Calculation of upcoming vertical and horizontal forces on every member of 2D frame for static analysis of frames first on a plain ground and then on a sloping ground.
Step-4- Comparison of results for different bay systems on plane and on a sloping ground for the increment of every story in frame.
Step-5-Finally the structure is designed to know that every member should pass safely.
Step-6-Validation of results from ETABS by manual calculations.

In the present paper Following types of structures are analyse as lateral load resisting frame. Column sections of size 230mm×600mm, beam sections of size

Fig. 1 General building plan

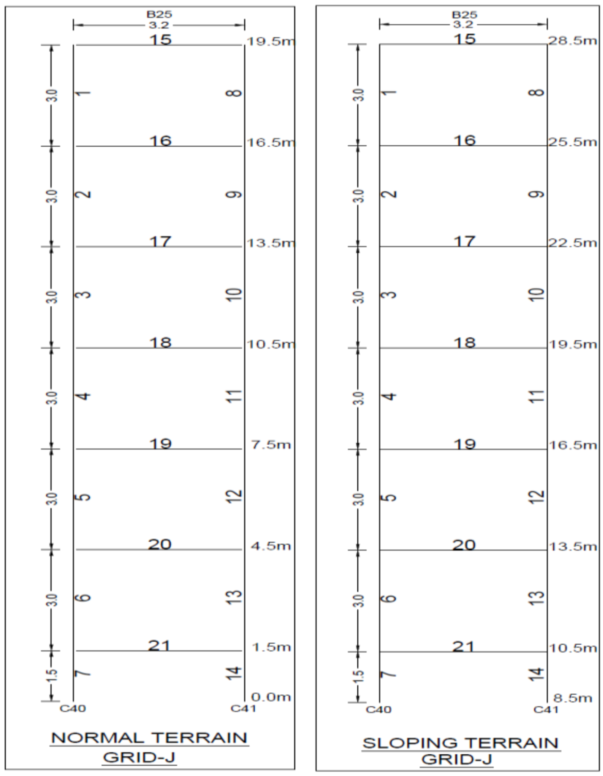
230mm×600mm, 100mm & 115 mm thick RCC slab on all are taken for proposed work. The column height throughout the structure is 3 m. These frames are subjected to dead load, floors finished load 1 KN/m^2, live load 2 KN/m^2 on all floors earthquake loads as per IS 1893:2002.

The damped and undamped frames with different geometrical configurations viz. are taken for the study.
Model-1 building on normal terrain
Model-2 building on sloping terrain
For the seismic analysis of building, the zone factor 'Z' is taken as 0.24 for seismic zone IV, Importance Factor 'I' equal to 1.

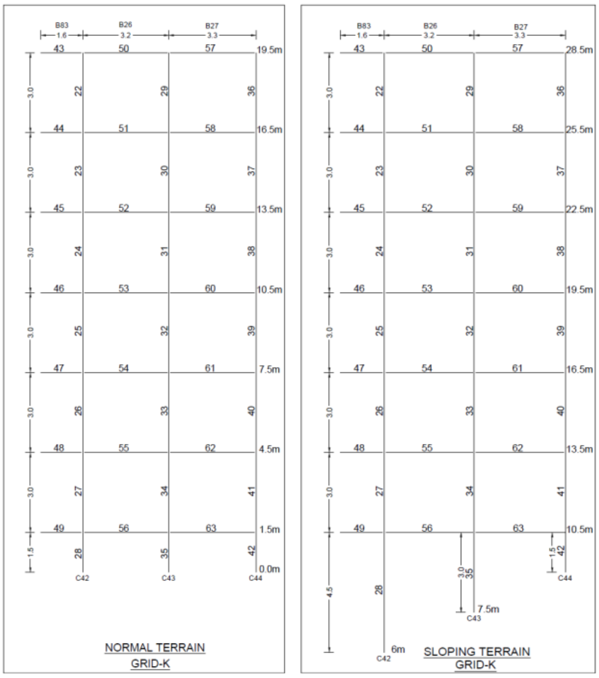
IV. Modeling and Analysis

The G+5 story reinforced concrete building is assumed to be located in seismic zone-IV on medium soil type 2 (as per IS 1893:2002). The frame has six degrees of freedom. Floor diaphragms are considered as semi-rigid for all. As stated earlier the main objective of this dissertation is focused on the behavior of RC frame building on flat and sloping terrain under non-linear response spectra analysis in ETABS software.

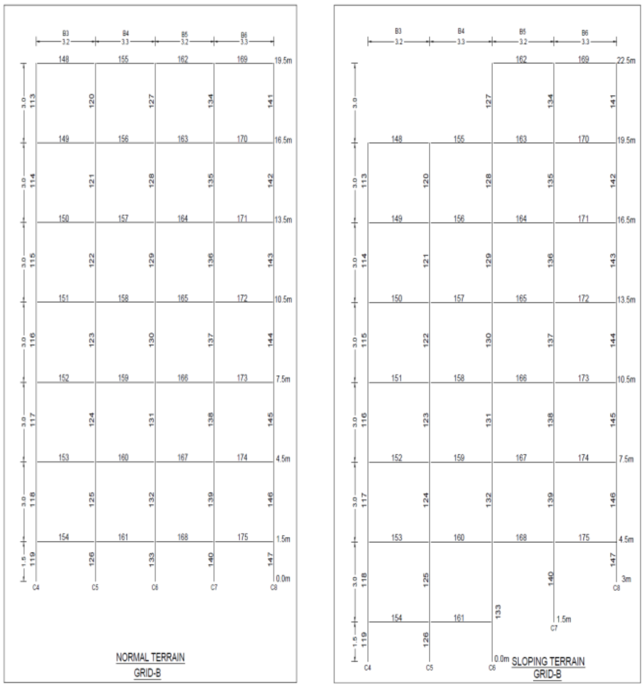
The elevation view of normal and slope terrain model is as shown below



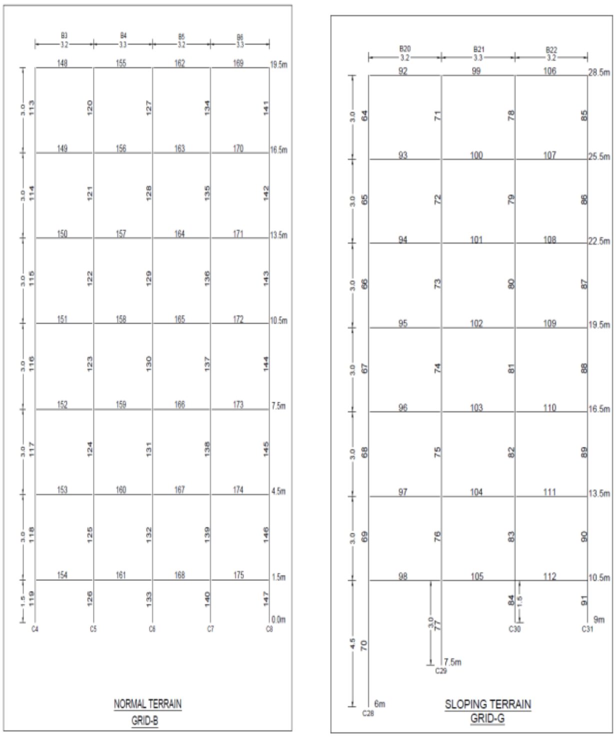
(a) Normal terrain grid-J (b) Slope terrain grid-J
Fig. 2 One bay frame



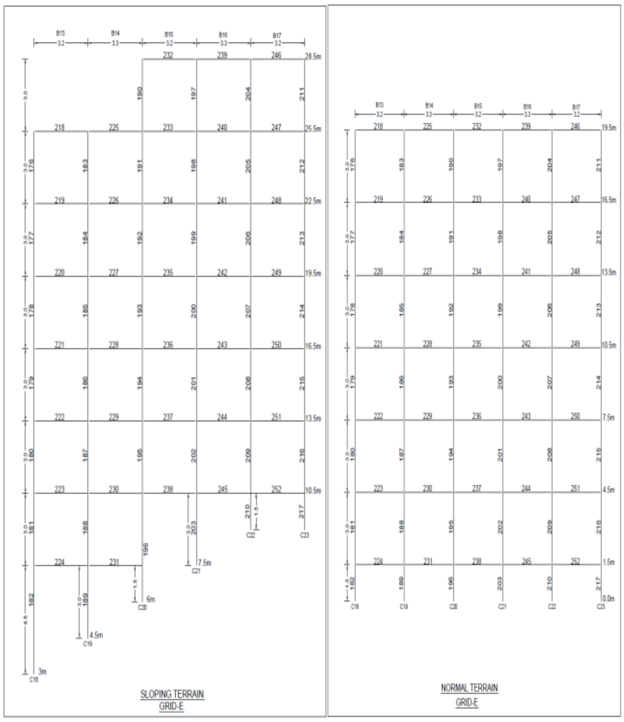
(a) Normal terrain grid-K (b) Slope terrain grid-K
Fig:Two bay Frame



(a) Normal terrain grid-G (b) Slope terrain grid-G
Fig. 4 Three bay frame



5.1(a) Normal terrain grid-B 5.2(b) Slope terrain grid-B
Fig. 5 Four bay frame



6.1 Normal terrain grid-E 6.2Slope terrain grid-E
Fig. 6 Five bay frame

V Results

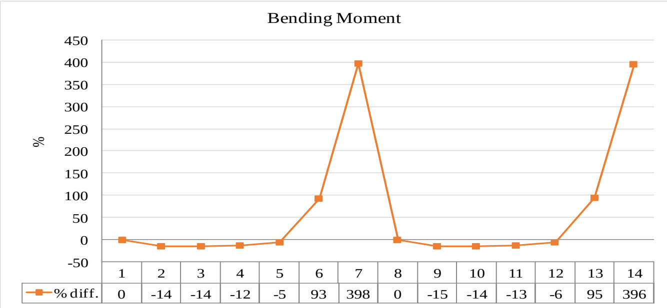


Fig. 7 % difference grid J One bay frame

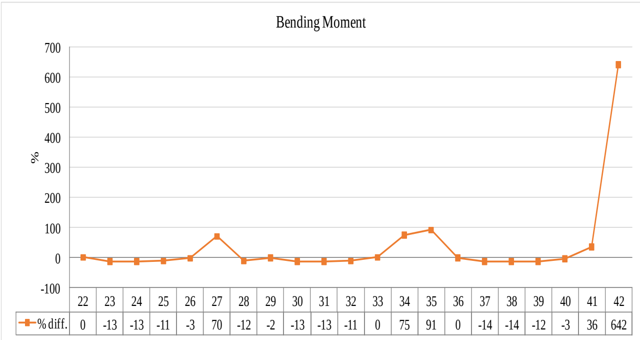


Fig. 8 % difference grid K Two bay frame

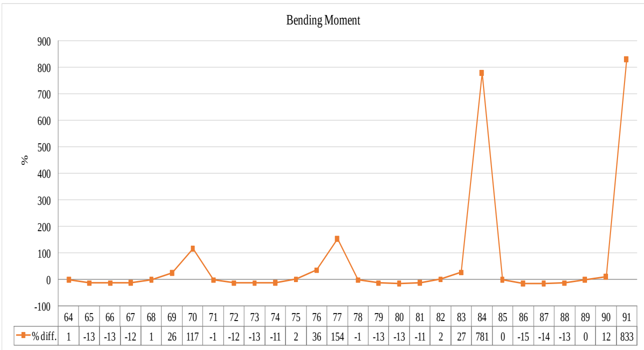


Fig. 9 % difference grid G Three bay frame

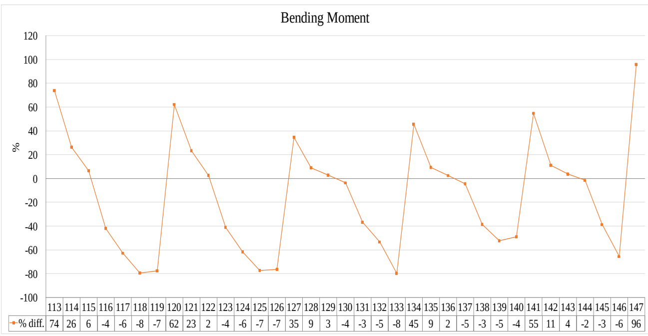


Fig. 10 % difference grid B Four bay frame

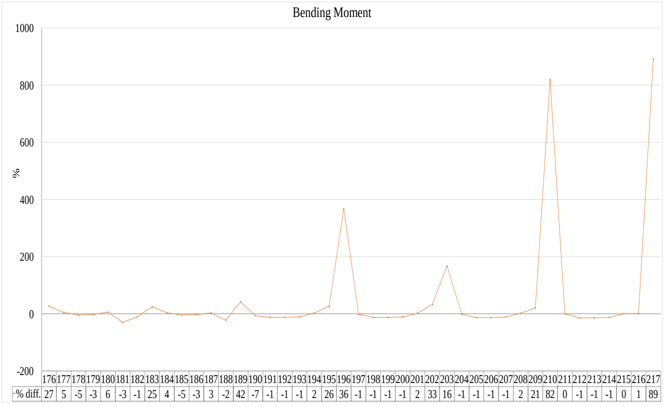


Fig. 11 % difference grid E Five bay frame

VI. Conclusion

In this paper following consideration are concluded in between structure with normal terrain and sloping terrain for bending moment in columns and beams.

On the basis of present study and retained literature the following conclusion can be drawn.

1. It has been observed that bending moment in sloping terrain building is reduces considerable, but tremendously increase at base of building.
2. Seismic Performance of building can be improved by providing step up set back columns, which resist input energy during earthquake.
3. The variation in bending moment between long column and short column is about 22%. This is due to presence of ground-slope is making one side of the building stiffer than the other side, which leads to variation in bending moment due to short column effect.
4. Bending moment is seem to be reduced due to step up columns.
5. The bending moment in column is increase at base of frame due to the long column and short column effect.

VII. SCOPE FOR FUTURE WORK

1. The variation of torsion moments in columns can be compare for study.
2. The variation in shear force in columns and beams can be study.
3. The variation in axial force in columns and beams can be study.
4. Also stiffness of various members can be compare.

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