Analysis of Earth Quake Resistant Multistoried Building on Sloping Ground

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Abstract— The thrust of this work is to investigate the performance of three buildings, The two step back building and step-set back building, resting 70 percent on severe sloping ground i.e.; ranging from 0° to 30°, and 30 percent on plain ground and set back building resting on plain ground. The three buildings are consisting of 15 storey geometrical, vertical and horizontal irregularity, when exposed to different range of Load combination as per the Indian code IS-1893 - 2002. Study of performance of those building will carried out by using two methods, first Equivalent lateral force method (static method), the second is linear time history method by using software program STAAD Pro. The considered buildings for dynamic analysis are a 15 storey RC framed building resting in zone IV.

Key words: Dynamic Analysis, Time History, Angle Variation

I. INTRODUCTION

During an earthquake, failure of structure starts at the points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures; Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building.

The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design become more complicated.

Earthquakes occur within the Earth's crust along faults that suddenly release large amount of energy that have built up over long periods of time. Or can be define an earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth's crust that creates seismic. The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Plate tectonics cause many of the physical features that we see on earth today like volcanoes and earthquakes, but also other geologic features like faults.

The shaking during earthquakes is caused by seismic waves. Seismic waves are generated when rock within the crust breaks, producing a tremendous amount of energy. The energy released moves out in all directions as waves, much like ripples radiating outward when you drop a pebble in a pond .The earth's crust near tectonic plate edges are forced to bend, compress, and stretch due to the internal forces within the earth, causing earthquakes.

Equivalent Static Lateral Force Method is the simplest one and it requires less computational effort and is based on formulae given in the code of practice. The structure is treated as discrete system having concentrated masses at floor levels which include the weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the appropriate amount of imposed load at this floor is also lumped with it. It is also assumed that the structure flexible and will deflect with respect to the position of foundation the lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution of mass and stiffness in a structure, together with its damping characteristics of the ground motion.

The time history analysis technique represents the most sophisticated method of dynamic analysis for buildings. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of structure. The method consists a systematic direct integration over a time interval; the equation of motion is solved with the displacements, velocities, and accelerations of the previous step serving as initial functions.

This study is based on Equivalent Static Lateral Force Method and Time History analysis of buildings in Staad Pro software. From the above analysis Base Shear, Member Forces and Moments will study. In this study, Building on a plain ground, Step back building and Set back with step back building has been considered.

II. METHODOLOGY

In this present work building on plain ground, setback with stepback building and stepback building with plan dimension 30 m x 25 m, 15 number of storey is modeled in Staad Pro. software. The size of beam is 300 mm x 600 mm and the size of external column is 500 mm x 500 mm and internal column 750mm x 750mm. The slabs are considered as 125mm thickness. Necessary meshing is given to the slab to transfer slab load to the adjacent beams. The external wall thickness is 230 mm and internal wall thickness is 115 mm. The slabs are loaded with floor finish of 1.5 KN/m2 and live load of 4 KN/m^2. Terrace water proofing is 1.75 KN/m2. Storey height is 3.2m in all floor except ground floor, and ground floor is considered as 3.2m. In this case 90% of total seismic mass is covered in 12 modes. Setback with stepback and Stepback building are modeled on 0° to 30° degree slope. Grade of steel is taken as Fe-500 and grade of concrete M40.

In this study following models are prepared in Staad Pro.

- 15 storey building on plain ground
- 15 storey step-set back building on sloping ground (0° to 30°)
- 15 storey Step back building on sloping ground (0° to 30°)

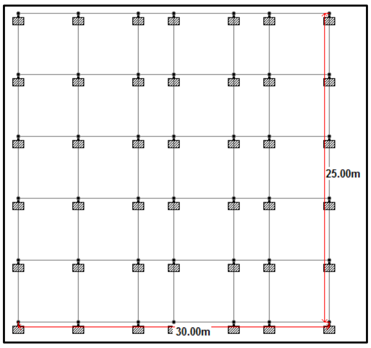

Fig. 1: Plan of Configuration Building

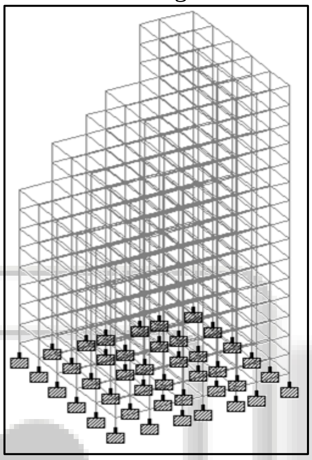

Fig. 2: Isometric view Building on plain ground

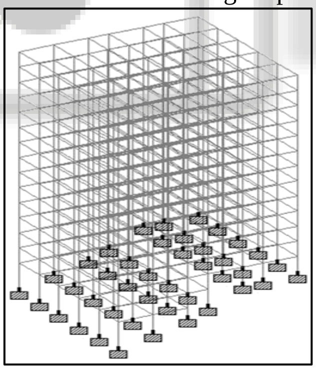

Fig. 3: Isometric view Step-set Back Building

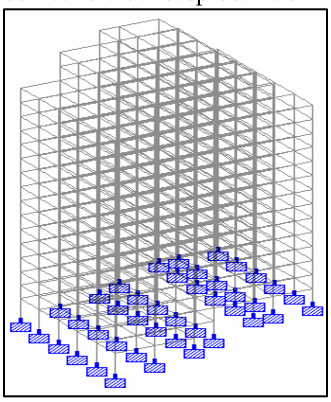

Fig. 4: isometric View Step Back Building

For response spectrum analysis following data is considered from IS-1893:2002.

1) Zone: V
2) Soil type: Medium (II)
3) Importance factor: 1
4) Response reduction factor: 5

Taking above data response spectrum function is applied on models of Building on plain ground, Setback with stepback building and Stepback building in Staad Pro. Both time history and response spectrum function is applied at 0^0 to 360^0.

Necessary data for Time history function is given below:

- Bhuj Earthquake, 2001
  1) Name of time history: Bhuj
  2) Magnitude: 7.9
  3) Total no of acceleration records: 26706
  4) Time step: 0.005 second
  5) Duration: 133.55 seconds

III. Result and Discussion

Dynamic analysis are performed STAAD Pro. The results and discussion are presented for setback building resting on plain ground, the step back building and Step – Set back building for 15 storey RCC framed building resting on severe sloping (0^0 to 30º) with the horizon under high seismic effects by using equivalent static lateral force method and linear time history method. The parameters which are studied by equivalent static lateral force method under six serviceability combination of loads on three buildings, diaphragm displacement, storey drift ,time period ,storey shear and columns forces (including shear force, bending moment, torsion, axial forces) for columns for the seventh floor of each building and discussion results of 10 columns only.

A. Results of Analysis using (Equivalent Static Lateral Force Method)

1) Storey Drift Result

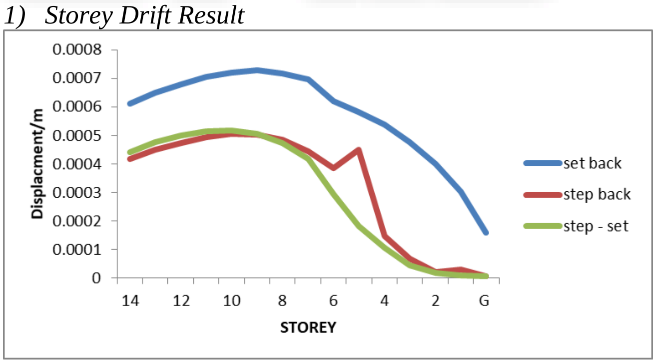

Fig. 5: Variation of Storey Drift under Load of combination 1.2 (DL + LL + ELX)

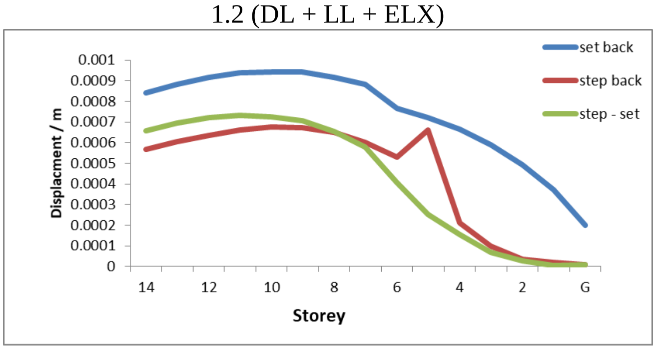

Fig. 6: Variation of Storey Drift for Load of combination (0.9DL+1.5 ELX)

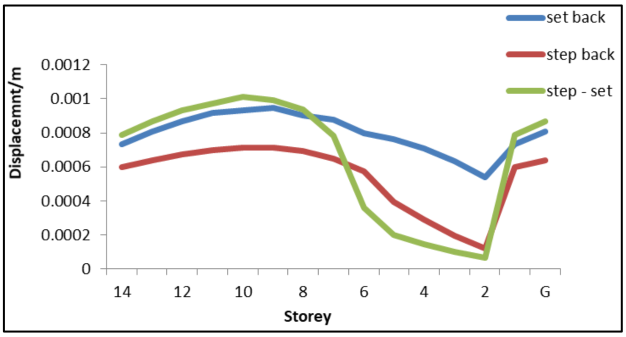

Fig. 7: Variation of Storey Drift in Y Direction under Load of combination 1.2 (DL+LL+ELY)

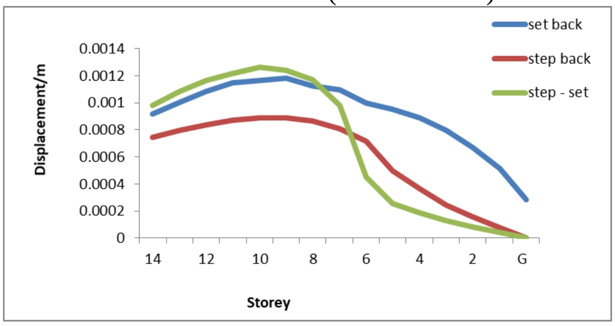

Fig. 8: Variation of Story Drift Storey in Y direction under Combination Load (0.9DL + 1.5 ELY)

Storey Shear

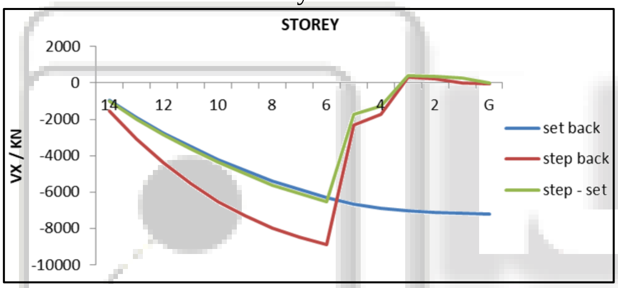

Fig. 9: Variation of Storey Shear under Combination Load 1.2 (DL+LL+ELX)

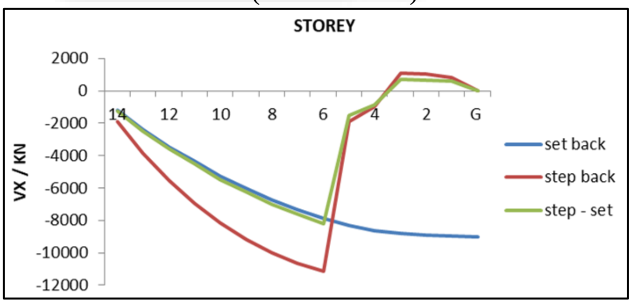

Fig. 10: Variation of Storey Shear under Load of combination (0.9 DL + 1.5 ELX)

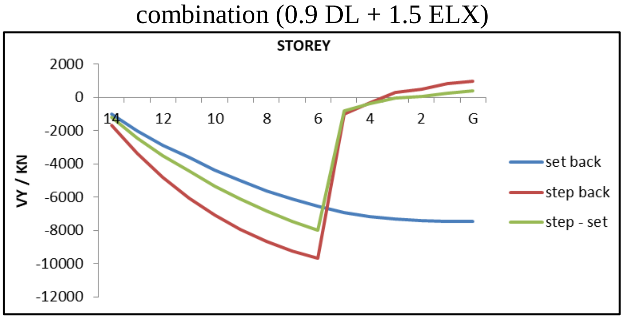

Fig. 11: Variation of Storey Shear under Load of combination 1.2 (DL+LL+ELXY)

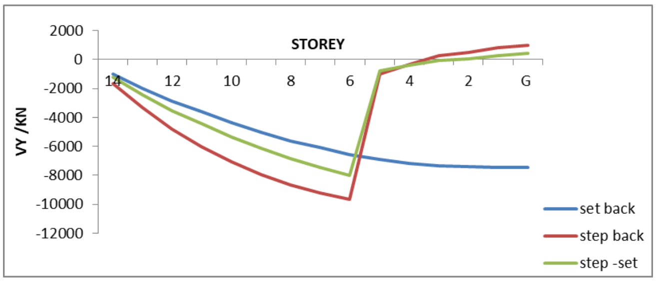

Fig. 12: Variation of Storey Shear for Three Buildings under Load combination (0.9 DL + 1.5 ELY)

IV. Conclusions

– The shear force for column of setback building is more than 51.4% when compared with the step set building under the Load of combination1.2 (DL +LL + ELX) as compared between columns shear force is higher in column c11 of setback building.
– The bending moment for column C3 is more in setback building by 53.53 % when compared with bending moment of step back building. The bending moment for C8 is more in setback building by 89.39% when compared with bending moment of step back building.
– It is observed that the percentage of axial force less in columns are 73.09%, 57.02% & 25.41% respectively of setback building compared to step back building.
– Since the mass is not varying with the increased ground slope, it can be concluded that the stiffness of the building is getting reduced where length of the columns is higher, relative to the other extreme end.
– In Step back buildings and Step back-Set back buildings, it is observed that extreme left column at ground level, which are short, are the worst affected. Special attention should be given to these columns in design and detailing.
– The critical horizontal forces and bending moment in footing increases significantly with increase in ground slope. However critical values of vertical reaction in footing remain almost same for different ground slopes.
– The critical bending moment in the column increases significantly for sloping ground 15 degree compared to plain ground. However critical value of axial Force in column remains almost same for different grounds.

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