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An Assessment Of Set Back And Step Back Building

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***Abstract*- India consists of great arc of mountains which consists of Himalayas in its northern part which was formed by on-going tectonic collision of plates Hill buildings are different from those in plains; they are very irregular and unsymmetrical in horizontal and vertical planes, and torsionally coupled. Hence, they are susceptible to severe damage when affected by earthquake ground motion. Such buildings have mass and stiffness varying along the vertical and horizontal planes, resulting the center of mass and center of rigidity do not coincide on various floors**

***Keywords*- Stiffness, High Rise, Structural stability, Slope, Set back, Step back**

I. INTRODUCTION

Earthquake is the most disastrous and unpredictable phenomenon of nature. When a structure is subjected to seismic forces it does not cause loss to human lives directly but due to the damage cause to the structures that leads to the collapse of the building and hence to the occupants and the property. Mass destruction of the low and high rise buildings in the recent earthquakes leads to the need of investigation especially in a developing country like India.

Structure subjected to seismic/earthquake forces are always vulnerable to damage and if it occurs on a sloped building as on hills which is at some inclination to the ground the chances of damage increases much more due to increased lateral forces on short columns on uphill side and thus leads to the formation of plastic hinges. Structures on slopes differ from those on plains because they are irregular horizontally as well as vertically. Past earthquakes [e.g. Kangra (1905), Bihar- Nepal (1934 & 1980), Assam (1950), Tokachi-Oki-Japan (1968), Uttarkashi-India (1991)], have proved that buildings located near the edge of stretch of hills or sloping ground suffered severe damages. Such buildings have mass and stiffness varying along the vertical and horizontal planes, resulting the center of mass and center of rigidity do not coincide on various floors. This requires torsional analysis; in addition to lateral forces under the action of earthquakes

1. Step Back building and Set Back Building

Set back generally refers to the arrangement of stepping of a building. This is done generally to accommodate the architectural aesthetic as well as to get sunlight behind the structure.

Step back buildings generally refers to the building with stepped lowest level or stepped foundation. This kind of structure are common in the hilly or seashore areas where it is uneconomical to dug the whole cliff.

II. LITERATURE REVIEW

Patel et al. (2014) studied 3D analytical model of eight storied building was analysed using analysis tool ETABS with symmetric and asymmetric model to study the effect of variation of height of column due to sloping ground during earthquake. In this study lateral load analysis as per seismic code was done to study the effect of seismic load and assess the seismic vulnerability by performing pushover analysis. It was observed that vulnerability of buildings on sloping ground increases due to formation of plastic hinges on columns in each base level and on beams at each storey level at performance point. The number of plastic hinges are more in the direction in which building is more asymmetric. Buildings on sloping ground have more storey displacement as compared to that of buildings on flat ground.

Singh et al. (2012) carried out an analytical study using linear and nonlinear time history analysis. They considered 9 story RC frame building (Step back) with 45 degrees to the horizontal located on steep slope. The number of storeys was 3 and 9 and 7 bays along the slope and 3 across the slope. They took 5 set of ground motions i.e., 1999 Chi-Chi, 1979 Imperial Valley, 1994 Northridge , 1971 San Fernando , 1995 Kobe from strong motion database of pacific Earthquake Engineering Research Centre (PEER). They observed that almost all the storey shear is resisted by the short column. The effect of torsional irregularity is represented by the ratio of maximum to average inter storey drifts ($\Delta max/\Delta avg$) in a storey. They observed the step back buildings are subjected to considerable

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amount of torsional effects under cross slope excitations.

III. MODELING DATA

In this chapter comparative study has been carried out on simple frame building, diagrid structural system building, pentagrid structural system building and hexagrid structural system building.

1. Effect of building configuration

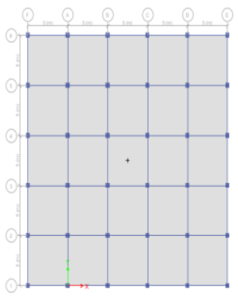
In this part a comparative study has been carried out between two different building configurations that are possible on hilly slopes.A total of 6 models for 3 different storey heights i.e. 8 storey, 10 storey, 12 storey with stepback and stepback-setback configurations on 35° hill slope are analysed and compared for storey displacement, storey drift, base shear and time period.

2. Modeling data

Plan dimension	(25X 25) m
Number of storey	8,10,12
Floor to floor height	3.5m
Structure utility	Residential
Seismic zone	4
Seismic coefficient	0.24
Response reduction factor	3
Importance factor	1
Structure type	C
Analysis method	Dynamic analysis(RSM)
Codes used	• IS 456-2000, • IS 875-2015. • IS1893 Part 1-2016

The design data as follow:

1. For all the types of buildings 230x450 mm concrete sections have been used as beam sections.
2. For all the four types of buildings 500x500 mm concrete section have been used as column sections for interior as well as exterior.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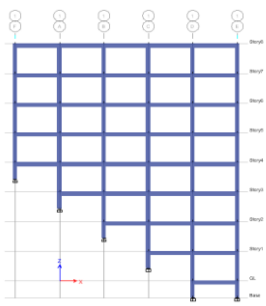
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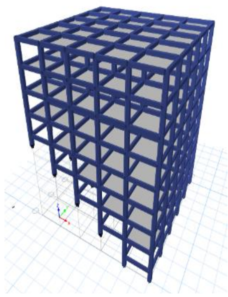
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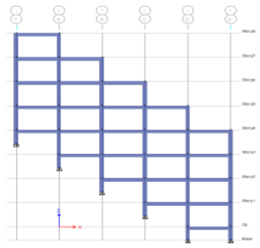
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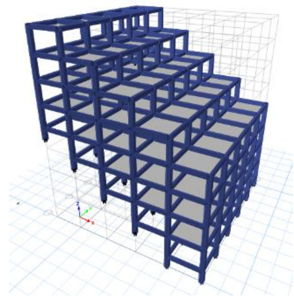
(5)

Figure 1 Floor plan of 35° sloped building
Figure 2 Elevation of 8 storey 35° sloped stepback building
Figure 3 3D view of 8 storey 35° sloped stepback building
Figure 4 Elevation of 8 storey 35° sloped stepback-setback building
Figure 5 3D view of 8 storey 35° sloped stepback-setback building.

IV. RESULTS

All 6 models are analysed against lateral loads i.e earthquake loads and the dynamic analysis is performed by using response spectrum method. Parameters like storey displacement, storey drift, base shear, time period are compared.

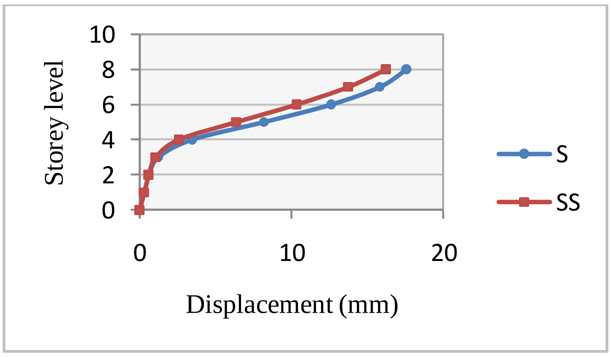

Figure 6 Storey displacement in X direction for 8 storey buildings.

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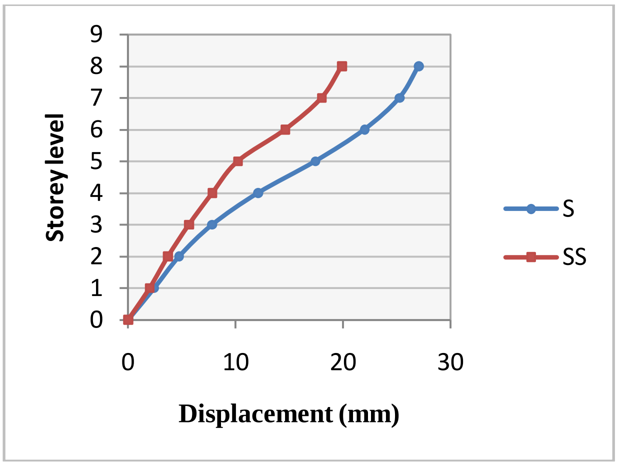

Figure 7 Storey displacement in Y direction for 8 storey buildings.

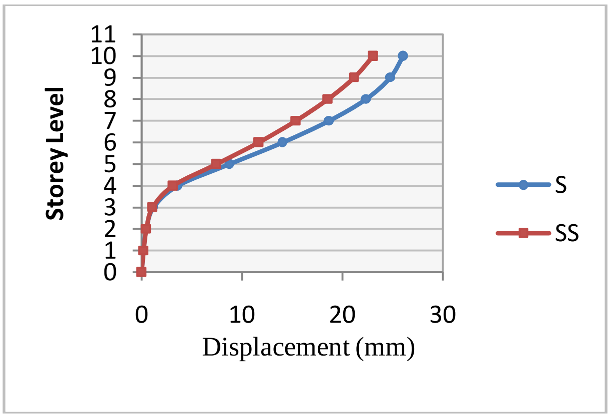

Figure 8 Storey displacement in X direction for 10 storey buildings.

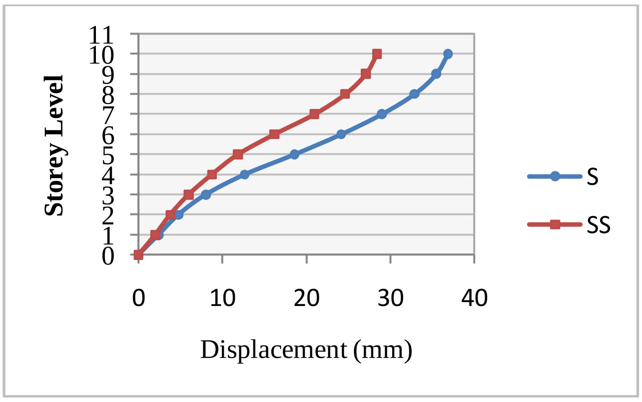

Figure 9 Storey displacement in Y direction for 10 storey buildings.

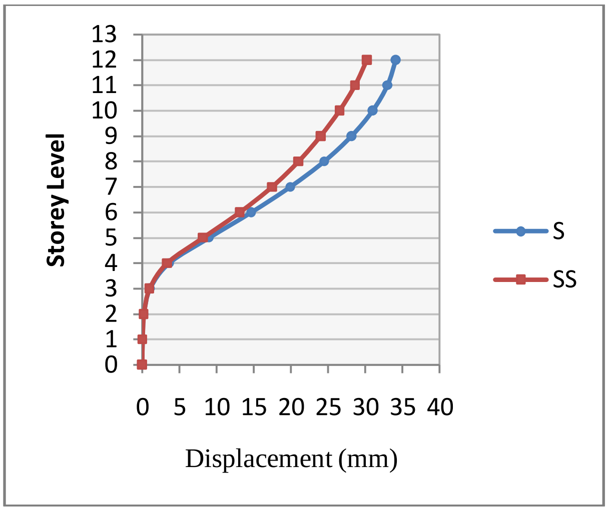

Figure 10 Storey displacement in X direction for 12 storey buildings

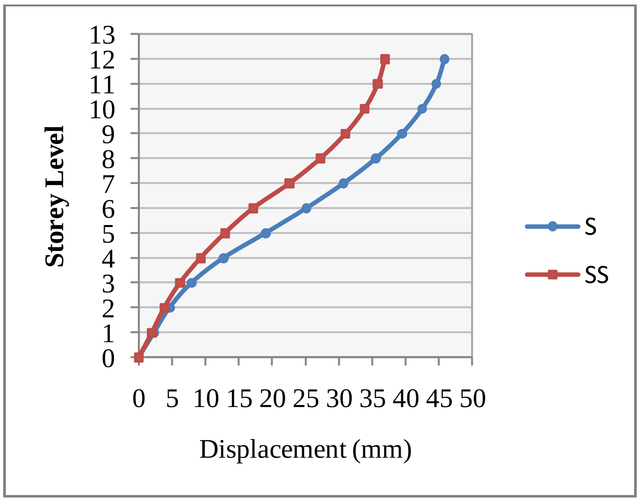

Figure 11 Storey displacement in Y direction for 12 storey buildings.

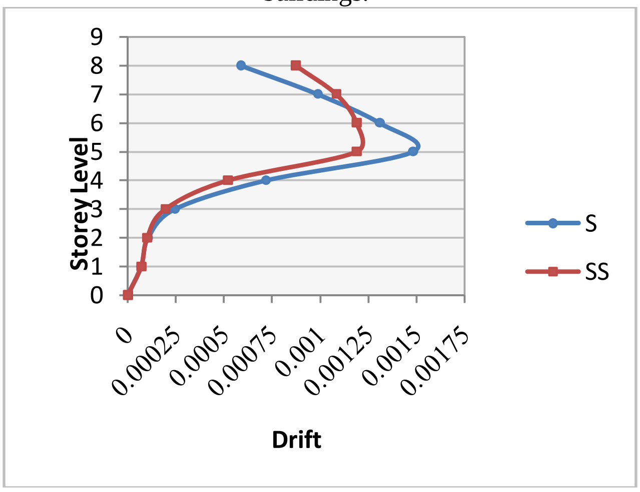

Figure 12 Storey drift in X direction for 8 storey buildings

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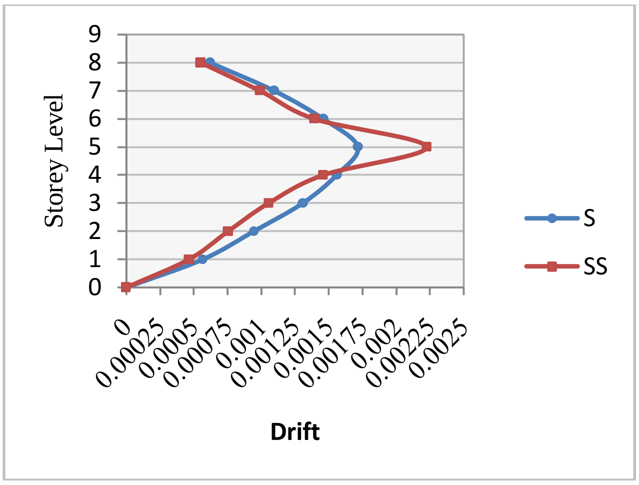

Figure 13 Storey drift in Y direction for 8 storey buildings

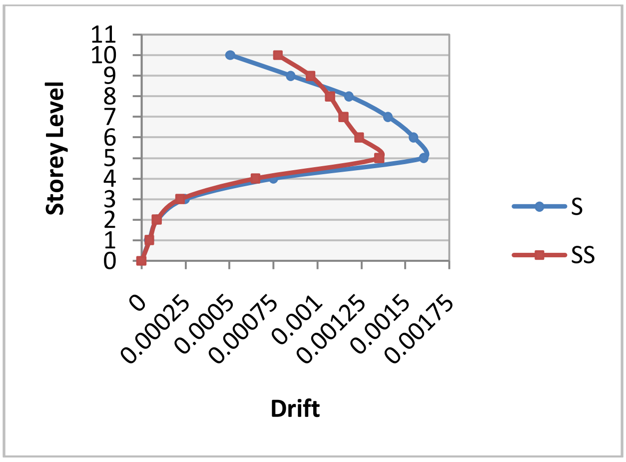

Figure 14 Storey drift in X direction for 10 storey buildings

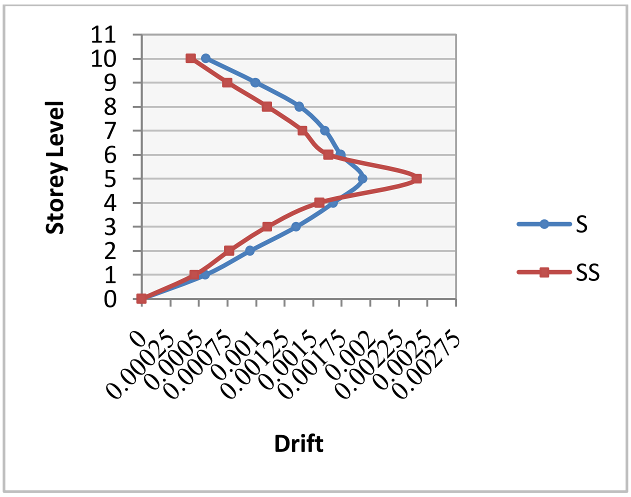

Figure 15 Storey drift in Y direction for 10 storey buildings

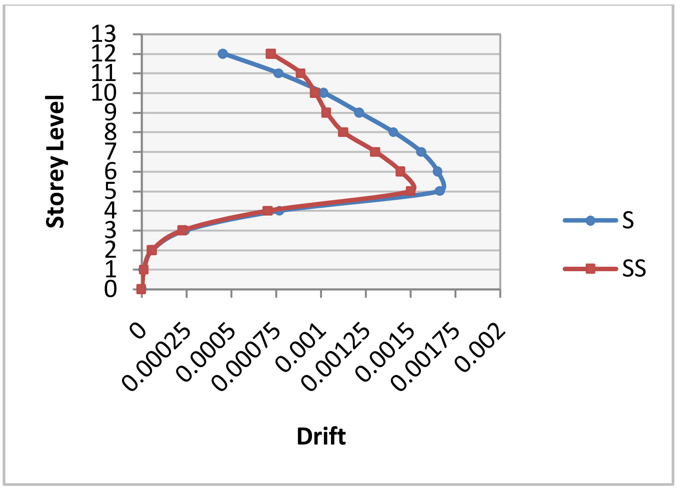

Figure 16 Storey drift in X direction for 12 storey buildings

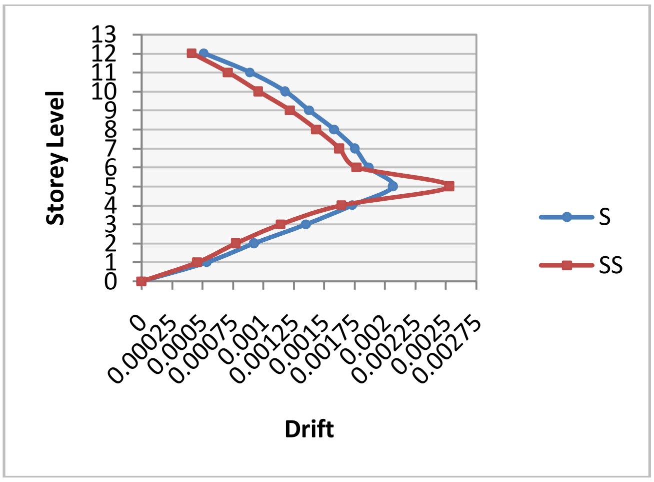

Figure 17 Storey drift in Y direction for 12 storey buildings

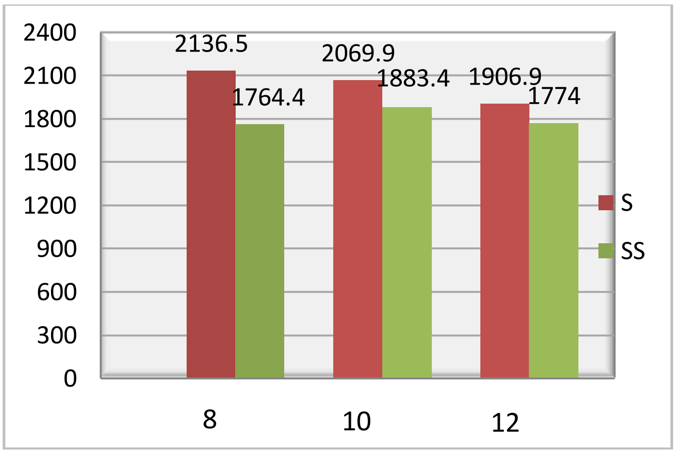

Figure 18 Base shear in X direction for 8, 10, 12 storey 35° sloped stepback and stepback-setback buildings

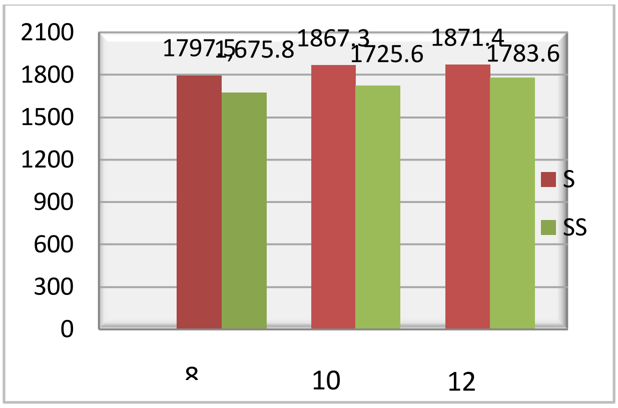

Figure 19 Base shear in Y direction for 8, 10 , 12 storey 35° sloped stepback and stepback-setback buildings

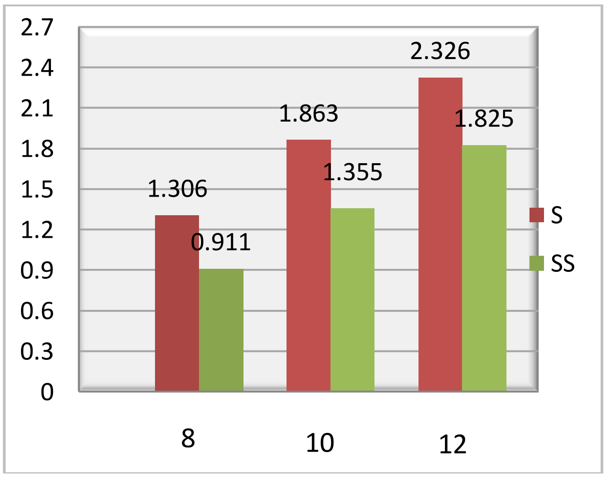

Figure 20 Time period in seconds for 8, 10, 12 storey 35° sloped stepback and stepback-setback buildings

V. CONCLUSION

From above table it is observed that,

1.Story displacement-

i. Maximum storey displacements in X direction for stepback-setback buildings are lesser than those of for stepback buildings and are reduced by 7.63%, 11.47%, 11.31% for 8,10,12 storey buildings respectively.

ii. Maximum storey displacements in Y direction for stepback-setback buildings are lesser than storey displacements for stepback buildings and are reduced by 26.41%, 22.87%, 19.51% for 8,10,12 storey buildings respectively.

2. Storey drift-

i. Maximum storey drifts in X direction for stepback-setback buildings are lesser than the maximum storey drifts for stepback buildings and are reduced by 19.78%, 15.81%, 9.73% for 8, 10, 12 storey buildings respectively. However maximum storey drifts in Y direction for stepback-setback buildings are more as compared to stepback buildings and are increased by 29.64%, 24.45%, 22.54% for 8, 10, 12 storey buildings respectively.

1. Base shear

i. Base shear values in X direction for stepback-setback buildings are lesser than those of for stepback buildings and are reduced by 17.41%, 9.01%, 6.97% for 8, 10, 12 storey buildings respectively.

ii. Base shear in Y direction for stepback-setback buildings are lesser than the base shear for stepback buildings and are reduced by 6.77%, 7.58%, 4.69% for 8, 10, 12 storey buildings respectively.

2. Time period- Time periods for stepback-setback buildings are lesser as compared to stepback buildings and are reduced by 30.245%, 27.265, 21.53% for 8, 10, 12 storey buildings respectively.

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