Analysis and Comparison of Buildings Resting on Sloping Strata in X Plane with varying Number of Storeys

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Abstract— The structures are generally constructed on level ground; however, due to scarcity of level grounds the construction activities have been started on sloping grounds. The present study is on analysis and comparison of bare frame structure. The present project carried out to investigate the analysis and comparison of building on sloping ground with different number of storeys i.e. G+3, G+5, G+7 and G+9 in X plane by using E tabs software and results such as storey force, storey displacement, storey stiffness and time period has been extracted. Then comparison is done for varying number of storeys in X plane and Here, the results shows in X plane that the storey of G+3 building has high stiffness and low displacement, storey force, time period that means it has more strength than other three buildings.
Key words: Comparison of Buildings Resting on Sloping Strata, RCC Buildings on Hilly

I. INTRODUCTION

The term earthquake may be described as some of unstable waves generated either by natural or formatted by humans under the ground. Large strain energy released for the duration of earthquake travels as seismic waves in all directions. The buildings are usually built on flat grounds. Since the ground is leveled the constructed buildings are regular and symmetrical in both horizontal and vertical directions. Hence they tend less damage to the buildings during earthquake because in leveled ground the structures are constructed with same column height. In hilly areas due to lack of flat ground surface the construction of buildings have been started on sloping grounds. The study of earthquake resistant building on slopes becomes popular to prevent the loss of life, property during earthquake ground motion.

The economic growth & 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 & pressing demand for the construction of multi -storey buildings on hill slope in and around the cities. In some parts of world, hilly area is more prone to seismic activity; e.g. northeast region of India. Codal provisions have proved unsafe and, resulted in loss of life and property when subjected to earthquake ground motions. Seismic analysis is the calculation of the response of a structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent. The study of earthquake resistant building on slopes becomes popular to prevent the loss of life, property during earthquake ground motion.

North and northeastern parts of India have large scales of hilly region, which are categorized under seismic zone IV and V. In this region the construction of multistory RC framed buildings on hill slopes has a popular and pressing demand, due to its economic growth and rapid urbanization. This growth in construction activity is adding increase in population density. While construction, it must be noted that Hill buildings are different from those in plains i.e., they are very irregular and unsymmetrical in horizontal and vertical planes, and torsionally coupled. Since there is scarcity of plain ground in hilly areas, it obligates the construction of buildings on slopes.

A. Building Configuration

Three different configurations are considered,

- Step back
- Step back –Set back
- Setback.

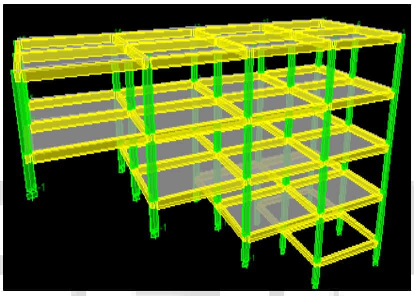

Fig. 1: Step back building

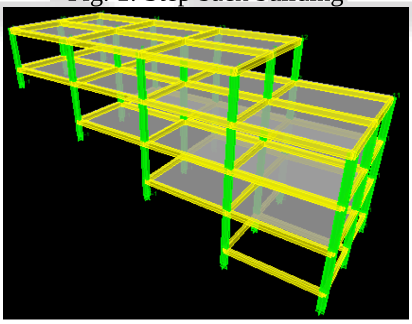

Fig. 2: Step back – Set back building

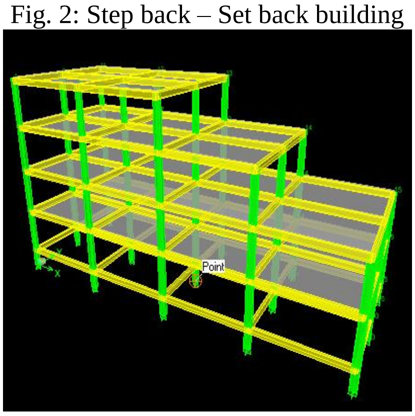

Fig. 3: Set back building

- Set back is nothing but the side of the building looks like having a set backs from one building to another building with some steps.

- Step back buildings will be having their columns in the ground floor. So that the ground storey will be considered as soft storey.
- In the combination of step back and set back building the design and architectural features are combined together and constructed.

II. LITERATURE REVIEW

Shaik Imran et.al (2017) presented by Earthquake Analysis of RCC Buildings on Hilly. Buildings may be considered as asymmetric in plan or in elevation based on the distribution of mass and stiffness along each storey, throughout the height of the buildings. Most of the hilly regions of India are highly seismic. A building on hill slope differs in different way from other buildings. In this study, 3D analytical model of G+9 storied buildings have been generated for symmetric building model.

Manjunath C S et.al (2016) studied on seismic performance of r c buildings on sloping grounds with different types of bracing systems. Structure are highly susceptible to serve damages in earthquake scenario, so choosing an appropriate lateral force resisting bracing systems will have a significant effect on performance of the structure. So this present study is aimed at evaluating and comparing various types of eccentric steel bracings for 12 storey RC frame building resisting on sloping ground configurations. For this 5 types of bracing systems like X-Bracing, Diagonal bracing, K- bracing, V-bracing and inverted V bracing are considered on the outer periphery of the buildings with step back and set back – step back type configurations are modeled and analyzed.

Paresh G. Mistry et.al (2016) investigated by Seismic Analysis of Building on Sloping Ground Considering Bi-Directional Earthquake. The scarcity of plain ground in hilly regions leads to construct buildings on a sloping ground. In present study, Building on a plain ground, Step back building and Set back with step back building have been considered. In present study, Response spectrum analysis and Time History analysis for Bhuj and chamoli earthquakes will be carried out by considering parameters such as Base Shear, Axial force and moments will be studied.

Miss. Pratiksha Thombre et.al (2016) reported by Seismic Analysis of Building Resting on Sloping Ground. The hilly areas in north east India contained seismic activity. Due to hilly areas building are required to be constructed on sloping ground due to lack of plain ground. In this paper we analyzed using Staad Pro comparison between sloping ground, with different slope and plain ground building using Response Spectrum Method as per IS 1893-2000 The dynamic response, Maximum displacement in columns are analyzed with different configurations of sloping ground.

III. OBJECTIVES

The following objectives were taken on the basis of literature review,

- To study the variation of base shear, storey displacement, with respect to variation in number of storeys.
- To study the variation of storey stiffness, and time period, with respect to variation in number of storeys.

IV. MODELING DESCRIPTION

In this paper, a 4 bay by 5 bay building in X plane with varying number of storeys models has been modeled and analysis could be done. The details of models are as follows

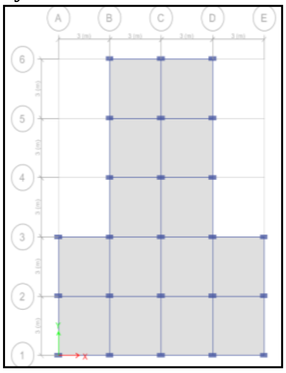

Fig. 4: 2D plan of G+ 3 model

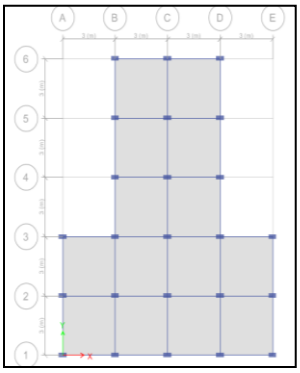

Fig. 5: 2D plan of G+ 5 model

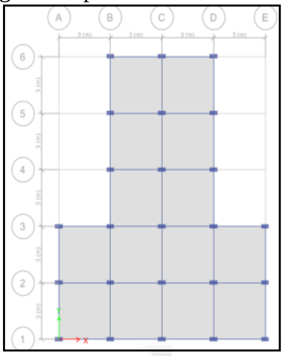

Fig. 6: 2D plan of G+ 7 model

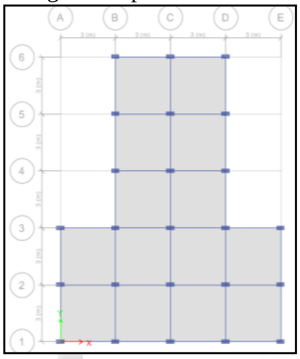

Fig. 7: 2D plan of G+ 9 model

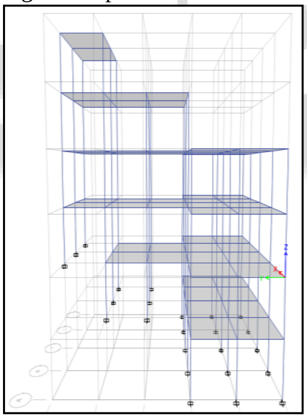

Fig. 8: 3D plan of G+ 3 model

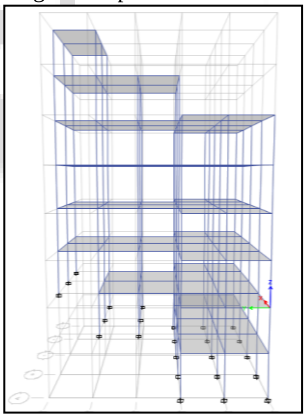

Fig. 9: 3D plan of G+ 5 model

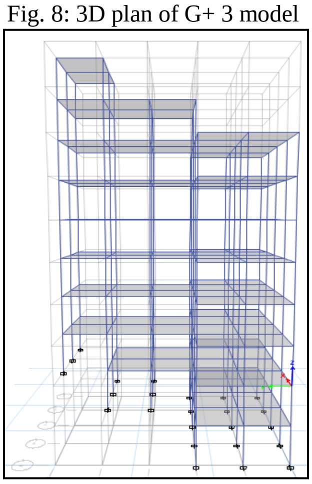

Fig. 10: 3D plan of G+ 7 model

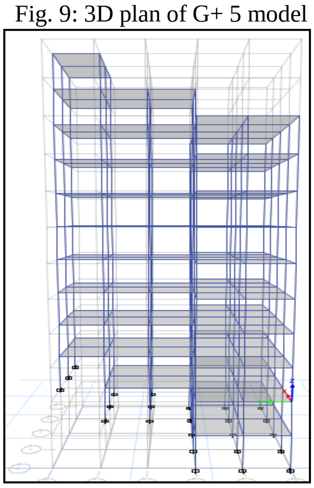

Fig. 11: 3D plan of G+ 9 model

A. *Material Properties*

- Concrete: Grade: M20 (Columns), M20 (Beams, Slabs)

- Reinforcements: HYSD bars of grade Fe415

B. Section Properties

- Beam 230X400 mm
- Column 230X450 mm
- Slab 150 mm thick
- Storey height 3m

C. Load Cases

- Dead load: After assigning the proper sectional properties to various members E-tabs will automatically considers the DL for the analysis.
- Live load: As per IS 875-part2 Slabs have been assigned a Live load of 3kN/m^2.

V. Results and Discussions

A. Comparison of Results with Varying Number of Storeys with Respect To X-Plane.

1) Storey displacement for RSX

Story No	Storey Height (m)	Storey Displacement (mm)			
		G+3	G+5	G+7	G+9
9th	30				5.3
8 th	27				4.9
7 th	24			3.9	4.5
6 th	21			3.7	4.2
5 th	18		2.9	3.5	3.9
4 th	15		2.8	3.2	3.4
TF	12	2.5	2.7	2.8	2.9
SF	9	2.4	2.3	2.3	2.4
FF	6	2.2	1.9	1.8	1.8
GF	3	1.7	1.3	1.2	1.2
Base	0	1.1	0.8	0.7	0.7
BS1	-3	0.6	0.4	0.4	0.4
BS2	-6	0	0	0	0

Table 1: Storey displacement for RSX

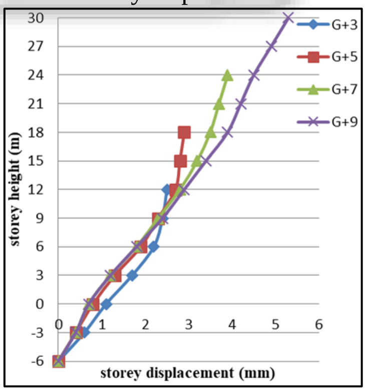

Fig. 12: Storey displacement for RSX

2) Storey displacement for RSY

Storey No	Storey Height (m)	Storey Displacement (mm)			
		G+3	G+5	G+7	G+9
9th	30				8.7
8 th	27				8.5
7 th	24			7.3	8.2
6 th	21			7	7.8
5 th	18		6.2	6.7	7.2
4 th	15		5.8	6.2	6.5
TF	12	6	5.4	5.6	5.7
SF	9	5.4	4.8	4.7	4.7
FF	6	4.5	3.9	3.7	3.7
GF	3	3.4	2.7	2.5	2.5
BASE	0	2.2	1.7	1.5	1.5
BS1	-3	1.1	0.8	0.7	0.7
BS2	-6	0	0	0	0

Table 2: Storey displacement for RSY

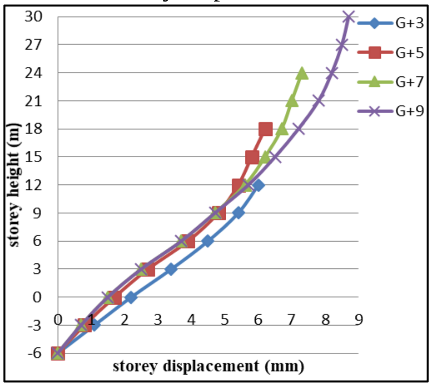

Fig. 13: Storey displacement for RSY

- Discussion: From table we can notice that as the storey height increases the storey displacement values increases simultaneously. It can observe that G+9 building having more displacement than compare to G+7, G+5 and G+3 buildings.

3) Storey stiffness for RSX

Storey No	Storey Height (m)	Storey Stiffness (kN/m)			
		G+3	G+5	G+7	G+9
9th	30				12623.49
8th	27				39968.048
7th	24			16953.175	87888.401
6th	21			49565.367	103993.132
5th	18		22810.493	104758.548	112385.227
4th	15		60289.393	120230.597	118561.258
TF	12	29733.588	121971.054	128434.566	124016.795
SF	9	70976.619	136093.558	134769.115	129397.282
FF	6	169364.504	166768.31	165231.124	160436.969
GF	3	167688.605	165432.045	163052.883	157725.213
Base	0	166741.056	162434.796	159626.216	156880.572
BS1	-3	149403.356	146605.077	145276.056	144299.989

Table 3: Storey stiffness for RSX

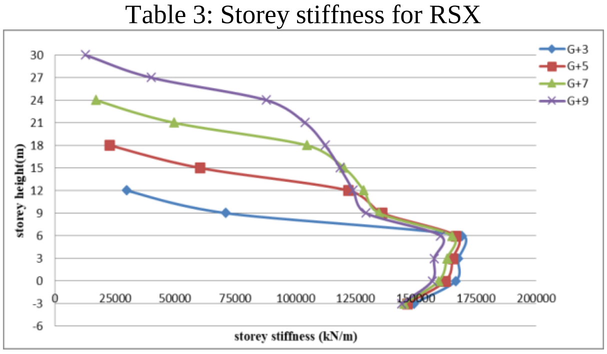

Fig. 14: Storey stiffness for RSX

4) Storey stiffness for RSY

Storey No	Storey Height(m)	Storey Stiffness (kN/m)			
		G+3	G+5	G+7	G+9
9th	30				13606.886
8th	27				35849.511
7th	24			14855.944	63270.579
6th	21			37098.231	66541.432
5th	18		16065.415	67106.960	68016.741
4th	15		38145.428	69637.304	69077.668
TF	12	17132.184	70910.526	70856.881	70083.853
SF	9	39111.800	72698.533	71890.911	71197.783
FF	6	73515.064	73002.682	72327.56	71833.582
GF	3	64555.456	65448.924	65781.015	65773.668
BASE	0	60545.682	60198.960	59952.576	59784.352
BS1	-3	54372.101	53831.911	53543.674	53354.979

Table 4: Storey stiffness for RSY

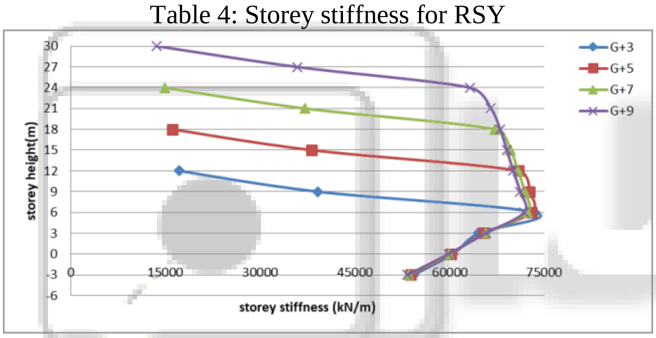

Fig. 15: Storey stiffness for RSY

– Discussion: For table, we conclude that the storey stiffness value increases up to 6m height and then start to decrease till 30m height. Figure it is notice that by comparing G+9 building has least stiffness value than G+7, G+5 and G+3 structures.

5) Storey forces for in RSX direction

X plane						
Storey No	Load Case/ Combo	Location	Storey Force (kN)			
			G+3	G+5	G+7	G+9
FF	RSX Max	Bottom	81.6332	84.8793	84.9028	84.9241

Table 5: Storey forces for in RSX direction

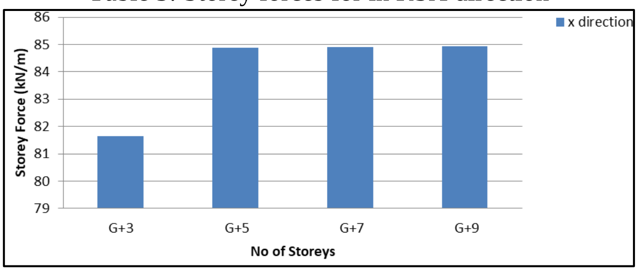

Fig. 16: Storey forces for in RSX direction

– Discussion: for table it can be seen that in X plane as the number of storey increases the storey forces also increases simultaneously.

6) Storey forces in RSY direction

X Direction						
Storey No	Load Case/ Combo	Location	Storey force (kN)			
			G+3	G+5	G+7	G+9
FF	RSY Max	Bottom	81.5799	84.9141	84.8678	84.9298

Table 6: Storey forces in RSY direction

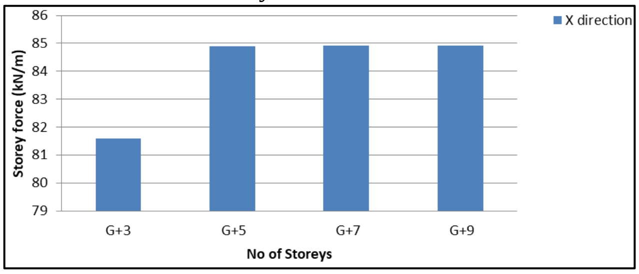

Fig. 17: Storey forces in RSY direction

– Discussion: for table it can be observe that in both Y plane and X plane when the number of storey increases then the storey forces goes on increases simultaneously.

7) Time period for X plane

mode	X direction, period (sec)			
	G+3	G+5	G+7	G+9
1	0.574	0.849	1.135	1.429
2	0.398	0.601	0.814	1.042
3	0.365	0.562	0.767	0.978

Table 7: Time period for X plane

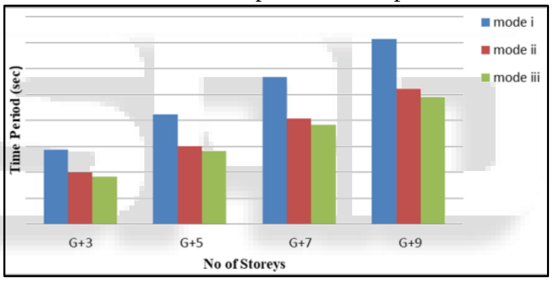

Fig. 18: Time period for X plane

– Discussion: here the time period varies depending upon type of structure. Table it shows G+9 building has more time period as compare to other three building.

VI. Conclusions

For X plane Comparison of G+3, G+5, G+7, G+9 buildings, the building with G+9 floors gave more displacement than other 3 type of buildings in both RSX and RSY directions.

For both RSX and RSY direction, the storey force is high for building G+9 floors as compare to G+3, G+5 and G+7 with respect to both X plane.

For X plane gives the more time period values for G+9 structure when compare to other three buildings.

From X planes, by comparing stiffness values for G+3, G+5, G+7 and G+9 structures, G+3 building has higher value of stiffness than other structures in both RSX and RSY directions.

Finally it is concluded that in present study for sloping ground G+3 floors has more strength due to higher value of stiffness and lower value of displacement.

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