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Analysis and Comparison of Bi Directional Bare Frame Building on Hill Slope

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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 G+9 building on sloping ground in X plane and Y 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 building G+9 in X plane and Y plane.

1. Introduction

In some parts of world, hilly region is more prone to seismic activity; e.g. northeast region of India. The scarcity of plain ground in hilly areas compels construction activity on sloping ground resulting in various important buildings such as reinforced concrete framed hospitals, colleges, hotels and offices resting on hilly slopes. Since, the behavior of buildings during earthquake depends upon the distribution of mass and stiffness in both horizontal and vertical planes of the buildings, both of which vary in case of hilly buildings with irregularity and asymmetry due to step back frame and step back & set back frame configuration. Such construction in seismically prone areas makes them exposed to greater shears and torsion as compared to conventional construction.

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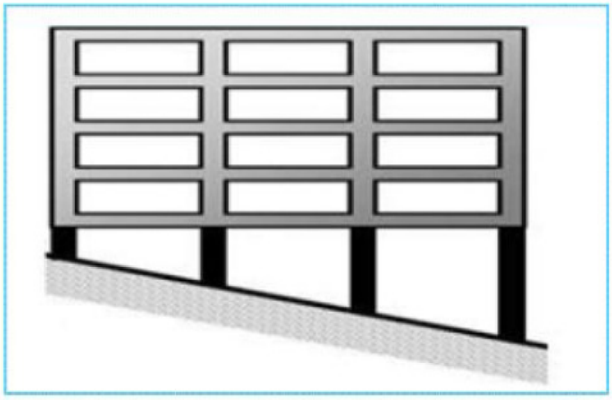
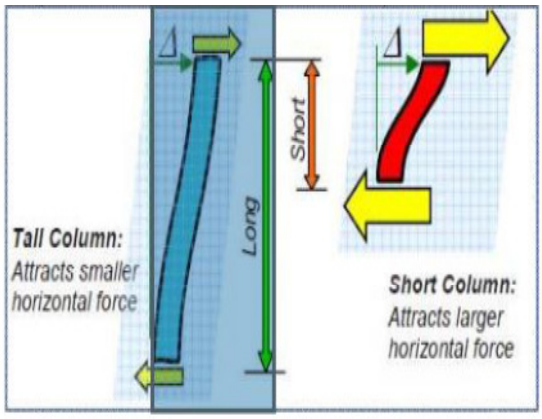


Figure 1: Building frame with short columns



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. During past earthquakes, reinforced concrete frame buildings that have columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey. One example of buildings with short columns in buildings on a sloping ground can be seen in the figure.

Poor behavior of short columns is due to the fact that in an earthquake, a tall column and a short column of same cross section move horizontally by same amount which can be seen from the given figure.

1.1 Building Configuration

Three different configurations are considered,

1) Step back
2) Step back –Set back
3) Setback.

In the present study combination of step back set back building has been considered. In the combination of step back and set back building the design and architectural features are combined together and constructed. The main drawback of such type of construction is the buildings of such nature are more vulnerable to seismic forces and intensity of disasters will be increased.

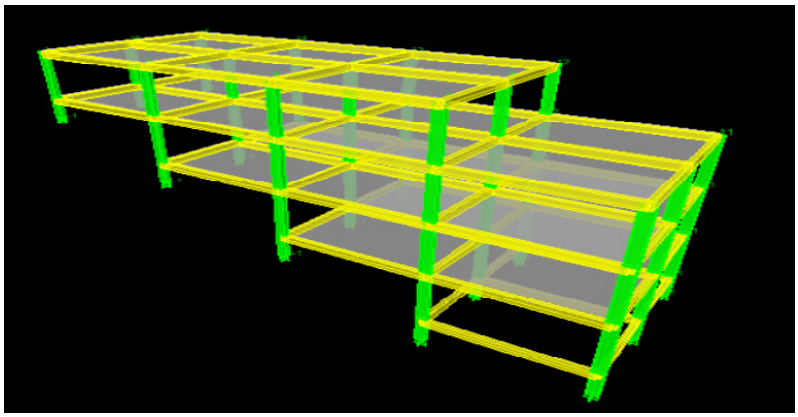


Fig: 2 Step back –Set back

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2.0 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.

Sandeep Goyal (2015) investigated on Dynamic analysis of sloped buildings. The buildings situated in hilly areas are much more prone to seismic environment in comparison to the buildings that are located in flat regions. Structures on slopes differ from other buildings since they are irregular both vertically and horizontally hence torsionally coupled and are susceptible to severe damage when subjected to seismic action. In this study, behavior of two storied sloped frame having step back configuration is analyzed for sinusoidal ground motion with different slope angles.

Narayan Kalsulkar et.al (2015) presented by Seismic Analysis of RCC Building Resting on Sloping Ground with varying Number of Bays and Hill Slopes. In the present study, the response spectrum method is carried out on the type of structure that rests on the sloping ground. Building frames which occurs in hilly regions are narrowed down to two basic formats such as step back frames and step back-set back frames. And dynamic responses have been studied for various building configuration. . [2] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

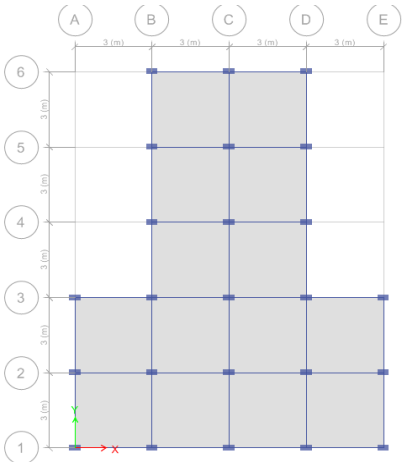
OBJECTIVES

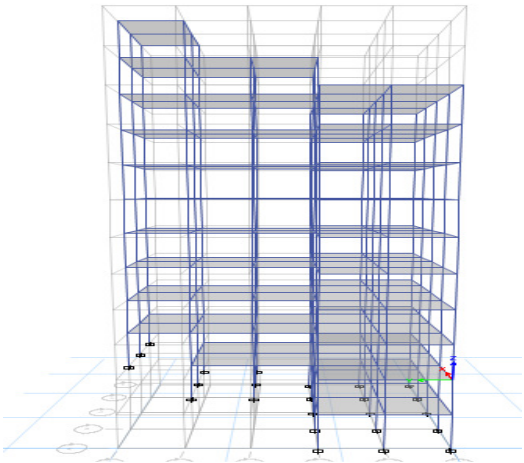
The following objectives were taken on the basis of literature review

- To study the variation of base shear, storey displacement, with respect to X plane and Y plane.
- To study the variation of storey stiffness with respect to X plane and Y plane.

MODELING DESCRIPTION

In this paper, a 4 bay by 5 bay building in X plane and 5 bay by 4 bay building in Y plane models has been modeled and analysis could be done.





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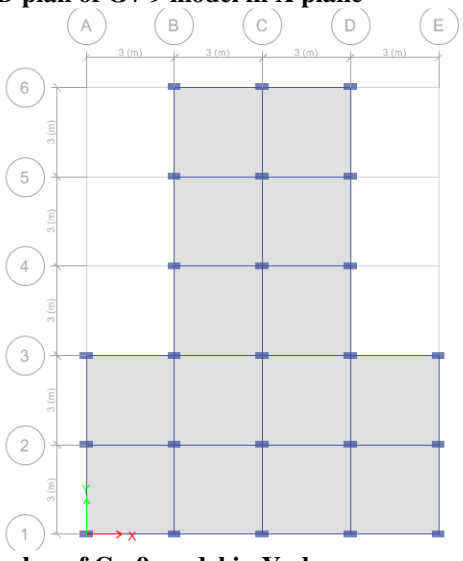
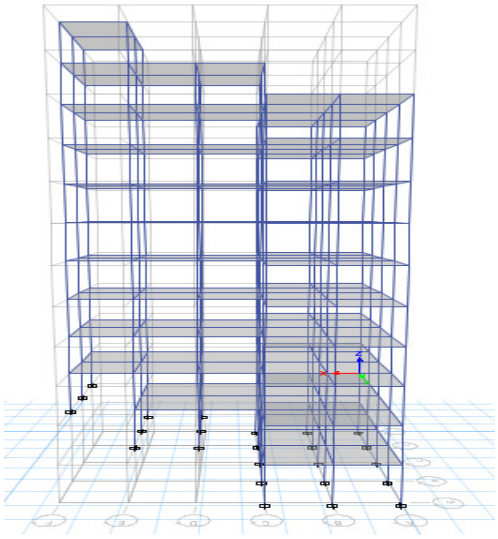
2D plan of G+ 9 model in X plane



3D plan of G+ 9 model in X plane



2D plan of G+ 9 model in Y plane

3D plan of G+ 9 model in Y plane

Material Properties: CONCRETE: Grade: M20 (Columns), M20 (Beams, Slabs) REINFORCEMENTS: HYSD bars of grade Fe415

Section Properties: Beam 230X400 mm, Column 230X450 mm, Slab 150 mm thick, Storey height 3m

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.

RESULTS AND DISCUSSIONS

Comparison of Results for X - Plane and Y – Plane.

Storey displacement for RSX

Storey	Storey Height (m)	Storey Displacement(mm)	
		G+9 (X)	G+9 (Y)
9th	30	5.35	4.25
8th	27	4.95	4.15
7th	24	4.50	3.95
6th	21	4.25	3.70
5th	18	3.9	3.45
4th	15	3.4	3.10
TF	12	2.9	2.65

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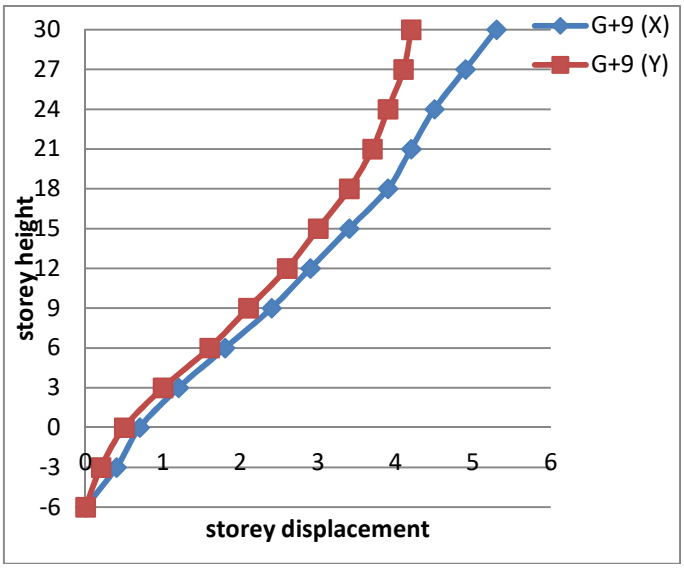
SF	9	2.4	2.15
FF	6	1.8	1.65
GF	3	1.2	1.0
BASE	0	0.7	0.55
BS1	-3	0.4	0.25
BS2	-6	0	0



Discussion: it can notice that the storey displacement increases as the storey height increases. When comparing the X plane and Y plane, the value of storey displacement shows higher in X plane because the number of bays in X plane is more than the Y plane.

Storey displacement for RSY

Storey	Storey Height (m)	Storey Displacement(mm)	
		G+9 (X)	G+9 (Y)
9th	30	8.7	9.2
8th	27	8.5	8.9
7th	24	8.2	8.6
6th	21	7.8	8.2
5th	18	7.2	7.6
4th	15	6.5	6.8
TF	12	5.7	5.9
SF	9	4.7	4.9
FF	6	3.7	3.8
GF	3	2.5	2.6
BASE	0	1.5	1.6
BS1	-3	0.7	0.8
BS2	-6	0	0

Discussion: it can notice that the storey displacement increases as the storey height increases. When comparing the X plane and Y plane, the value of storey displacement shows higher in Y plane because the number of bays in Y plane is more than the X plane.

Storey stiffness for RSX

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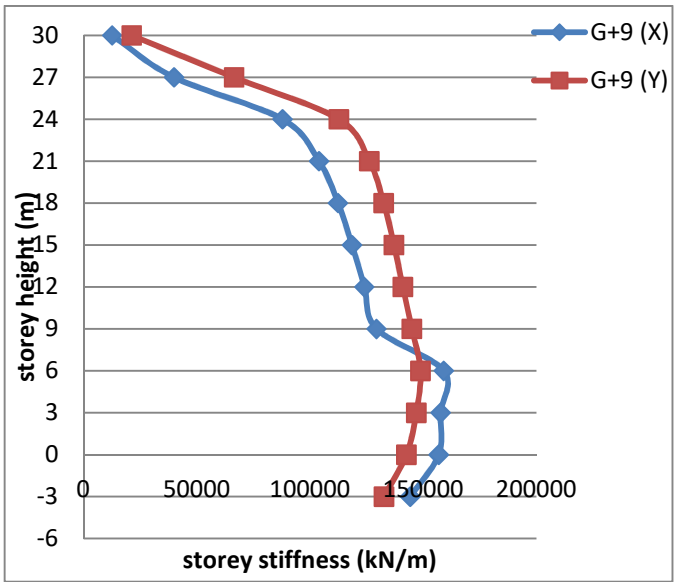
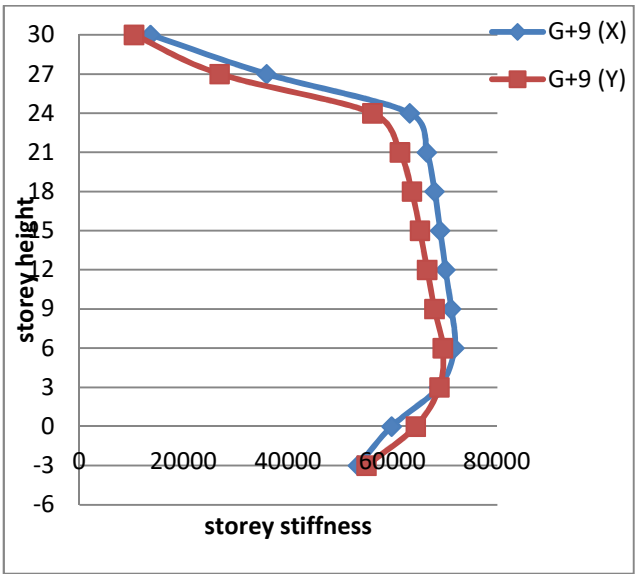
Storey	Storey Height (m)	Storey Stiffness (kN/m)	
		G+9 (X)	G+9 (Y)
9th	30	12623.49	21289.164
8th	27	39968.048	66506.909
7th	24	87888.401	112816.347
6th	21	103993.132	126228.75
5th	18	112385.227	132567.774
4th	15	118561.258	137118.418
TF	12	124016.795	141011.764
SF	9	129397.282	145025.91
FF	6	159102.977	148822.543
GF	3	157725.213	146973.114
BASE	0	156880.572	142614.811
BS1	-3	144299.989	132698.962



Discussion: we can see that the up to the 6m height the value of stiffness increases because of the ground that is irregular, after that it started to decrease up to the top of the building. It can notice that the value of stiffness is more in Y plane than compared to X plane.

Storey stiffness for RSY

Storey	Storey Height (m)	Storey Stiffness (kN/m)	
		G+9 (X)	G+9 (Y)
9th	30	13606.886	10452.75
8th	27	35849.511	26842.331
7th	24	63270.579	56111.033
6th	21	66541.432	61390.193
5th	18	68016.741	63682.167
4th	15	69077.668	65225.279
TF	12	70083.853	66604.499
SF	9	71197.783	68011.08
FF	6	71833.582	69617.15
GF	3	68791.285	68952.671
BASE	0	59784.352	64435.225
BS1	-3	53354.979	54995.343



Discussion: we can see that the up to the 6m height the value of stiffness increases because of the ground that is irregular, after that it started to decrease up to the top of the building. It can notice that the value of stiffness is more in X plane than compared to Y plane.

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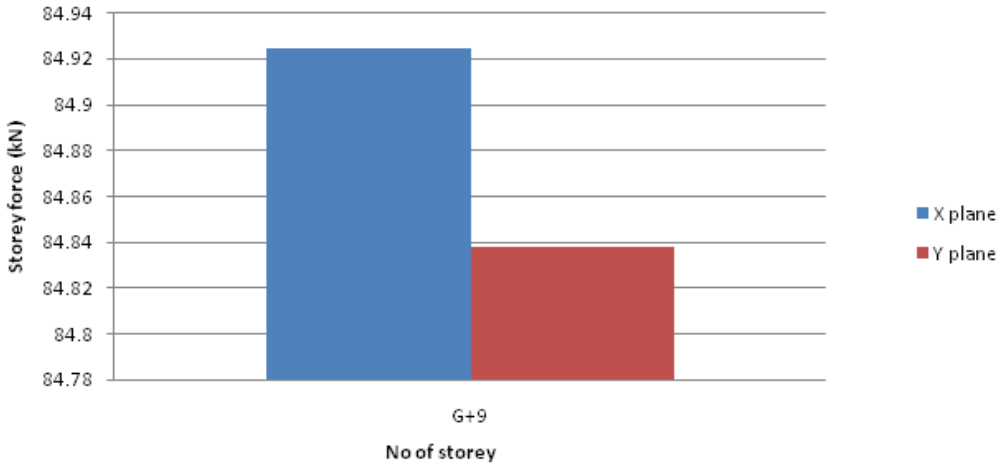
Storey forces in RSX direction

X plane			
storey	**load case/ combo**	**location**	**Storey Force (kN) G+9**
FF	rsx Max	Bottom	84.9241

Y plane			
storey	**load case/ combo**	**location**	**Storey Force (kN) G+9**
FF	rsx Max	Bottom	84.8373



Discussion: it can notice that the value of storey force is more in X plane than compare to Y plane. More the storey force value more is the flexibility of building.

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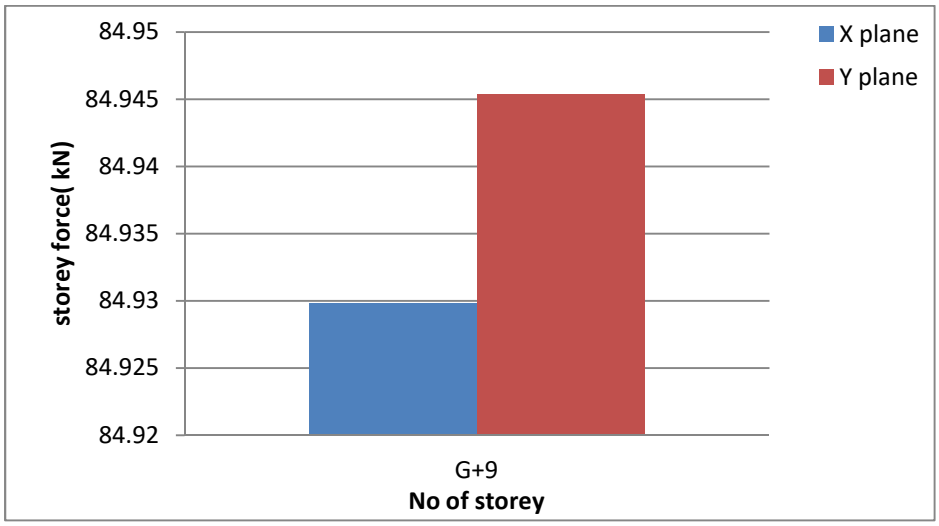
Storey forces in RSY direction

X plane			
storey	**load case/ combo**	**location**	**Storey Force (kN) G+9**
FF	rsy Max	Bottom	84.9298

Y plane			
storey	**load case/ combo**	**location**	**Storey Force (kN) G+9**
FF	rsy Max	Bottom	84.9454



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Discussion: it can notice that the value of storey force is more in Y plane than compare to X plane. More the storey force value more is the flexibility of building.

CONCLUSIONS

1. In RSX direction, by comparing the X plane and Y plane displacement, the X plane displacement is more i.e. 20.75% more than Y plane and similarly in RSY direction, the Y plane values of displacement is more i.e. 5.43% more than X plane.
2. In RSY direction, the stiffness values for X plane is high 40.74% than Y plane. Similarly the value of stiffness for Y plane in RSX direction is more i.e. 23.18% than X plane.
3. For RSX direction storey force is high in X plane than compare to Y plane and for RSY direction storey force is high in Y plane than the X plane.

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