Research Paper Engineering

Siesmic Analysis of Multi-Storey RC Buildings in Different Terrain Conditions

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ABSTRACT

Due to rapid growth of urbanization it becomes necessary to build the structures in different terrain conditions viz plane and sloping grounds by considering the seismic aspects of that respective zone. From past earthquake history, it is observed that if the structures are not properly structurally analysed and constructed with required quality then it may lead to greater destruction and loss to human life. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry. In this research the G+15 Storey building structure of size 15mx15m assumed to be located in seismic zone II, as per Indian standard code. Linear static and linear dynamic (response spectrum method) analysis has been performed using ETABS software for two building models and the dynamic response quantities such as fundamental time period, base shear, storey displacement and inter-storey drift were obtained for all the models.

KEYWORDS Storey Displacement, Storey Shear, Fundamental Natural Time Period, Storey Drift

Introduction: Analysis of building resting on a hill is different from analysis of building on normal (i.e. plane) ground. Since the column of hill buildings rest at different levels on sloping grounds in hilly areas. The short column of hill buildings attracts more force and undergoes extensive damage if it is not properly designed for earthquake force. Also, buildings on hills have mass and stiffness varying along the vertical/ horizontal plane resulting in the centre of mass and centre of rigidity that do not coincide at various floor levels. Due to this, this irregular buildings experience torsion, in addition to bending and shear, during earthquake ground motion. Hence, these buildings which are irregular and unsymmetrical in nature require greater attention during the analysis and design stages. During past earthquakes, reinforced concrete (RC) frame building constructed on hilly regions that had columns of different heights within a storey suffered more damage in shorter column in taller ones. In the past, attempts had been made to study the seismic analysis of buildings either resting on normal ground or resting on sloping ground. But in the present work, analytical study has been carried out to investigate the seismic behavior of two building models resting on normal and sloping ground in seismic zone II. The results obtained in this study are presented and discussed in this paper.

In the multi story buildings damages due to earthquake are usually at the weak points. This weakness is due to strength, variation in stiffness etc[1]. Earthquake is generated by sudden release of energy in earth's crust that creates seismic waves. It has the capability for causing damages, by the natural hazards. In nature, earthquake forces are accidental and uncertain natural hazards. An Engineer requires the tools for analyzing structures under the effects of these types of forces [7]. The lateral load such as earthquake is to classified as live horizontal force acting on the structure depending on the building's geographic location, height, shape and structural material [3].

Case Study Details:

Dimension of beam	300 mm x 500mm
Dimension of column	900mm x 1200mm
Thickness of Slab	150mm
Thickness of outside wall	230mm
Thickness of inner wall	150mm
Height of each storey	3.2m
Live Load	3kN/m^2
Floor Finish	1kN/m^2
Grade of reinforcing steel	Fe415
Grade of concrete	M 25
Density of concrete	25 kN/m^3
Density of infill	20kN/m^3
Seismic Zone	II
Importance factor	1
Zone factor	0.16
Damping ratio	5%

Results and Discussion:

1. Base shear: It can be seen from results given in table that base shear depends upon seismic zone, terrain nature, base condition and building height. Buildings resting on sloping grounds have higher base shear than building resting on normal ground. This is obviously due to lower time period for building resting on sloping ground. But, in the case of buildings with fixed base condition, the base shear for buildings resting on normal ground up to 4 storey height is higher than building resting on normal ground is lower than building resting on sloping ground. Plot of building height vs base shear for zone II are shown in figure.

Table No - 1

	Base Shear in X Direction		Base Shear in Y Direction	
Storey level	Normal Ground	Sloping Ground	Normal Ground	Sloping Ground
15	93.58	106.56	82.01	91.51
14	212.1	232.96	188.38	208.13
13	287.64	309.65	257.5	284.03
12	336.21	359.19	303.24	334
11	371.5	394.55	338.66	369.22
10	398.54	422.06	368.09	395.79
9	419.92	451.6	392.28	421.21
8	441.53	489.23	414.99	451.72
7	468.15	531.91	439.79	487.57
6	499.24	576.07	466.23	526.83
5	533.61	616.68	494.09	565.89
4	571.59	643.08	525.59	595.89
3	608.87	174.18	558.38	60.09
2	634.97	136.27	582.49	35.64
1	643.65	64.22	590.74	19.93

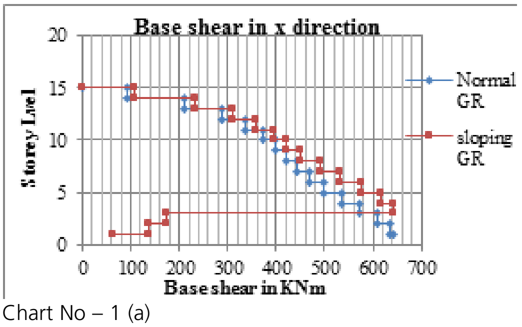


Chart No – 1 (a)

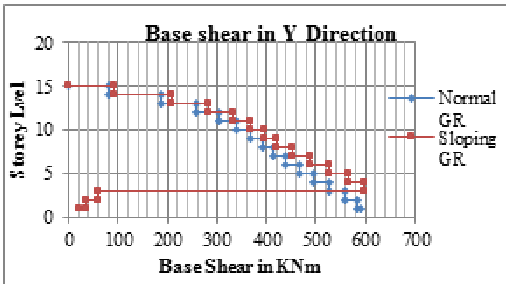


Chart No – 1 (b)

2. Time period: It can be seen from the results that the time period depends upon the terrain nature, building height and does not depend upon seismic zone. I t can also be seen that time period for normal ground is more than sloping for their respective mode. This increase in time period decreases lateral inertia force developed in the building due to earthquake significantly.

Table No -2

No of Modes	Time Period (Sec)	
	Normal Ground	Sloping Ground
1	2.4722	2.0031
2	2.2846	1.8072
3	1.7622	1.4353

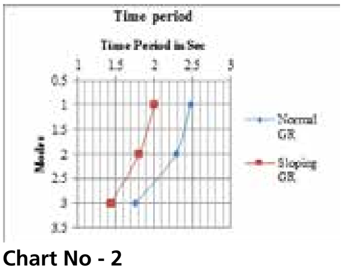


Chart No - 2

3. Storey displacement: It can be seen from the results that the displacement increases with increase in floor level of building. It can also be seen that the storey displacement is more in normal ground as compare to sloping ground.

Table No -3

	Storey Displacement in X Direction		Storey Displacement in Y Direction	
Storey level	Normal Ground	Sloping Ground	Normal Ground	Sloping Ground
15	19.99641	15.70784	20.42947	18.83643
14	19.16919	14.80914	19.78286	18.06883
13	18.24778	13.80949	19.01322	17.15705
12	17.20031	12.67526	18.08452	16.06003
11	16.01545	11.39992	16.98651	14.77181
10	14.69312	9.990848	15.72129	13.30039
9	13.23931	8.465389	14.29656	11.66004
8	11.66427	6.852111	12.72281	9.870793
7	9.983325	5.195727	11.01358	7.963289
6	8.220153	3.565327	9.188496	5.988964
5	6.411944	2.076723	7.278932	4.055301
4	4.616252	0.927579	5.336747	2.393859
3	2.920011	0.291953	3.448251	1.240306
2	1.451191	0.049369	1.755688	0.503983
1	0.392951	0.025124	0.487539	0.110712

Chart No –3 (a)

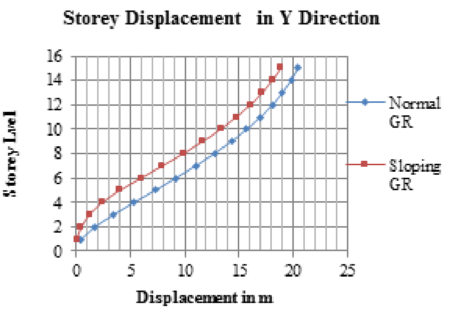


Chart No –3 (b)

4. Inter-storey Drift: Drift is the lateral displacement of a storey. Storey drift is the drift of one level of a multistory building relative to the level below. Inter storey drift is the difference between the roof and floor displacement of any given storey as building sways during the earthquake, normalized by the storey height. The greater the drift, the greater likelihood of damage. As a result shows the storey drift in sloping ground is less than that of normal ground.

Table No -4

	Storey Drift in X Direction		Storey Drift in Y Direction	
Storey level	Normal Ground	Sloping Ground	Normal Ground	Sloping Ground
15	0.000308	0.000318	0.000254	0.000296
14	0.000346	0.000356	0.000304	0.000353

13	0.00039	0.0004	0.00036	0.000417
12	0.000433	0.000441	0.000413	0.000474
11	0.000471	0.000476	0.000461	0.000523
10	0.000504	0.000503	0.000502	0.000563
9	0.000532	0.000522	0.000538	0.000595
8	0.000554	0.000528	0.000569	0.000619
7	0.00057	0.000515	0.000595	0.00063
6	0.000577	0.000467	0.000612	0.00061
5	0.000567	0.00036	0.000615	0.000522
4	0.000532	0.0002	0.000593	0.000363
3	0.00046	0.000082	0.00053	0.000231
2	0.000331	0.000016	0.000396	0.000123
1	0.000131	0.000008	0.000163	0.000037

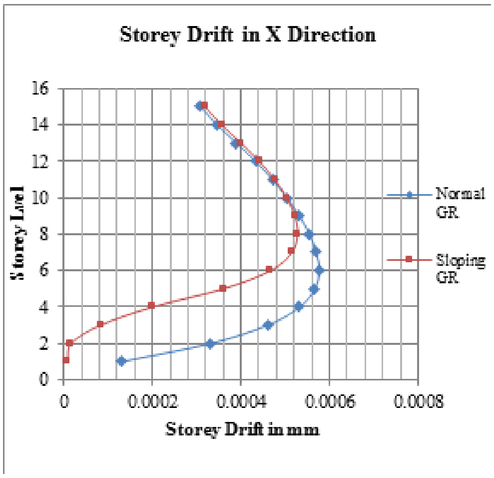
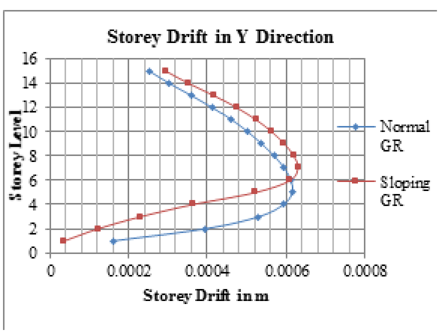


Chart No –4 (a)



No –4 (b)

Conclusion: Based on the seismic analysis carried out in this study, the following conclusions can be drawn. The results as obtained in zone II using ETABS for the static and dynamic analysis are compared for different terrain conditions viz. normal and sloping ground,

- It can be seen from results given in table that base shear in seismic zone II the Buildings resting on sloping grounds have higher base shear than building resting on normal ground. This is obviously due to lower time period for building resting on sloping ground.
- It can be seen from the results that the time period. It can also be seen that time period for normal ground is more than sloping for their respective mode. This increase in time period decreases lateral inertia force developed in the building due to earthquake significantly.
- It can be seen from the results that the displacement increases with increase in floor level of building. It can also be seen that the storey displacement is more in normal ground as compare to sloping ground.
- As a result shows the storey drift in sloping ground is less than that of normal ground. Drift is the lateral displacement of a storey. . The greater the drift, the greater likelihood of damage.

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