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Time History Analysis of the Buildings on Sloping Ground

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ABSTRACT

Lets of Previous studies deals with proper planning and construction practices of multi-storeyed buildings on sloping ground. However, in normal design practice the designers generally ignore the effect of sloping ground on the structural behavior of the building. It is very important to consider earthquake effect and design earthquake resistant buildings from the safety point of view. Shear wall is one of the most commonly used lateral load resisting system in the buildings for its better seismic performance. They provide additional strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building. The seismic analysis of a G+4 storey RCC building on varying slope angles i.e., 7.5^0, 15^0 and 30^0 is studied . The seismic forces are considered as per IS: 1893-2002. Lateral load resisting element, shear wall of 150 mm thick is provided. The analysis is carried out to evaluate the effect of sloping ground on structural forces. The free vibration properties like frequency, Modal mass participation ratio, the base reaction and also axial force, bending moment, shear force in columns.

Keywords : Frequency, Modal Mass Participation Ratio, The Base Reaction.

I. INTRODUCTION

In normal design practice the designers generally ignore the effect of sloping ground on the structural behavior of the building. It is very important to consider earthquake effect and design earthquake resistant buildings from the safety point of view. Earthquake is the most disastrous due to its unpredictability and huge power of devastation. Earthquakes themselves do not kill people, rather the colossal loss of human lives and properties occur due to the destruction of structures. Earthquakes causes serious damage to buildings, such as failure of members in the building and if the intensity of earthquake is high, it leads to collapse of the structure. Hill buildings constructed in masonry with mud mortar or cement mortar without conforming to seismic codal provisions have proved unsafe and resulted in loss of life and property when subjected to earthquake ground motions. In recent years population has been increased drastically and due to which cities and towns started spreading out. The economic growth and 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 and pressing demand for the construction of multistorey buildings on hill slope in and around the cities.

Shear Wall : Shear wall system are one of the most commonly used lateral load resisting system. Shear wall has high in plane stiffness and strength which can be used to simultaneously to resist large horizontal loads and support gravity loads. Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote, "We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls." as said by Mark Fintel, a noted consulting engineer in USA.

Function of Shear Wall : Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them. These other components in the load Comparative Study of Strength of RC Shear Wall at Different Location on Multi 393 path may be other shear walls, floors, foundation walls, slabs or footings. Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive sidesway. When shear walls are stiff enough, they will prevent floor and roof framing members from moving off their supports. Also, buildings that are sufficiently stiff will usually suffer less nonstructural damage.

Modelling of Infill wall without opening as Equivalent Diagonal strut:

The geometric and material properties of equivalent diagonal strut are required for conventional braced frame analysis to determine the increased stiffness of infilled frame. The geometric properties are of effective width and thickness of the strut. The thickness and the material properties of strut are similar to the infill wall. Many investigators have proposed the various approximations for the width of the equivalent diagonal strut. Originally proposed by Polyakov (1956) and subsequently developed by many investigators, the width of strut depends on the length of contact between wall and columns, and between the wall and beams. The propose range of contact length is between one-fourth and one-tenth of the length of panel.

II. METHODS AND MATERIAL

Literature Review

Khadiranaikar and Masali (2014) reviewed literature related to studies on the seismic behaviour of buildings resting on hill slope. It is found that most of the studies agree that the buildings resting on hill slope has higher displacement and base shear compared to buildings resting on plain ground and the short column attracts more forces and undergoes more damage whensubjected to earthquake force. From the study authors concluded that the presence of infill wall and shear wall influences the behaviour of structure by reducing storey displacement and storey drifts considerably, but may increase the base shear, hence special attention should be given in design to reduce base shear. It is also concluded that the greater number of bays are found to be better under seismic condition, as the number of bays increases, time period and top storey displacement decreases in hill slope buildings.

S.M. Nagargoje and K.S. Sable (2012) studied Seismic performance of multi storied building resting on sloping ground. Three dimensional space frame analysis is carried out for three different configurations such as Step back, Step back-Setback, Setback. The seismic analysis of all buildings is carried out by Seismic coefficient method by using IS 1893(part I)-2002. Dynamic response of these buildings, in terms of base shear and top floor displacement is presented and compared within the considered configuration as well as with other configurations. At the end, a suitable configuration of building to be used in hilly area is suggested.

Swathi A.S et al [2015] carried out comparison of seismic performance of soft storey building on sloping grounds and soft storey building retrofitted with shear wall. Five storey building built on a slope of 300 is analyzed to find out the seismic performance. Then the building is retrofitted with shear wall and it is analyzed to find if the seismic performance is been improved. Structural engineering software SAP-2000 is used for analysis with Seismic coefficient method. The Non-linear Static Pushover analysis carried out for analyzing the structure.

Sujit Kumar et al [2014] carried out the seismic analysis of a five storied RC building on varying slope angles i.e. 7.50 and 150 and compared with the building resting on the flat ground. The effect of sloping ground on the seismic performance of building during earthquake is studied by linear static analysis by using the structural analysis software STAAD Pro. v8i. The author discussed briefly the performance of hill buildings and structural behavior of short column subjected to lateral load.

3. Objectives

1. To study seismic performance of building resting on sloping ground without shear wall.
2. To study seismic performance of building resting on sloping ground with shear wall at different location.

III. DESCRIPTION OF BUILDING

Model consists of G+ 4-storey RCC building having four bays in X-direction and six bays in Y-direction; each bay is having width of 3.5m. The story height for each floor and plinth height is kept as 3m and 1.5m respectively.Size of beam in longitudinal and transverse direction is taken as 0.30 x 0.5m. The column of size 0.45m x 0.45m and also slab of thickness 0.120m is taken. Parapet wall of height 1m is considered. Thickness of the shear wall is taken as 0.150m. The modelsare analyzed on sloping ground (slope 200 and 300with horizontal). The frames on sloping ground under consideration for present study is as shown in Fig. 1 and Fig. 2. The concrete of grade M20 and steel of grade Fe 415 is used.

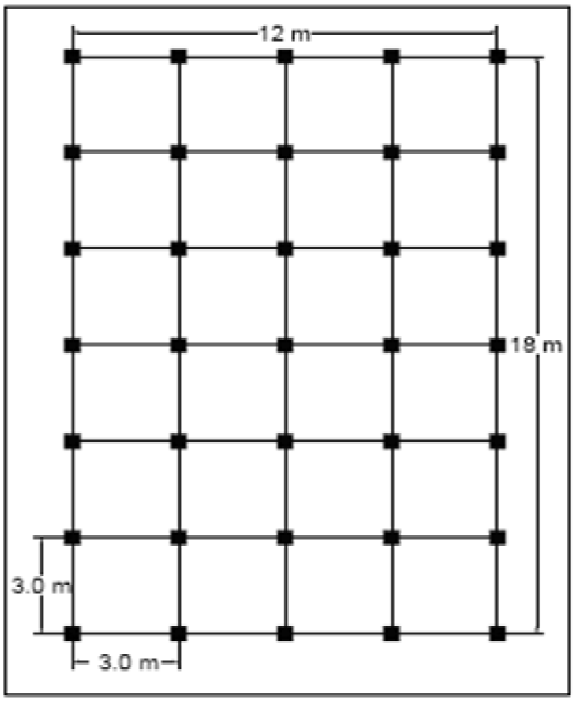

Figure 1. Plan of the building showing column positions

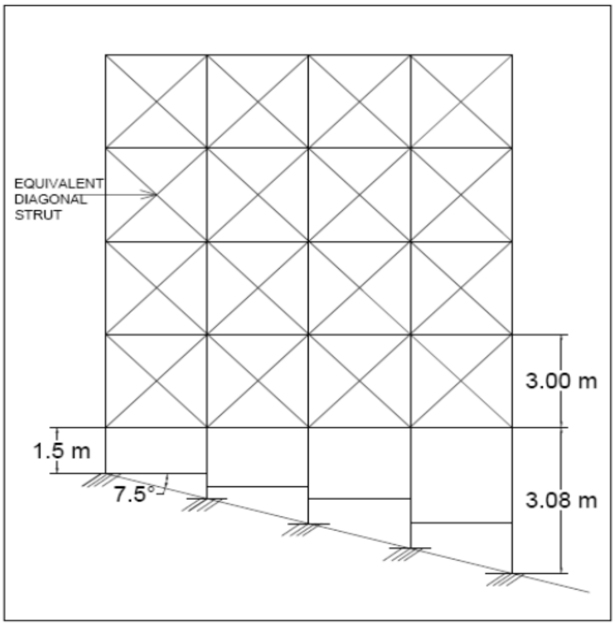

Figure 2. Elevations of building on 7.50 sloping ground

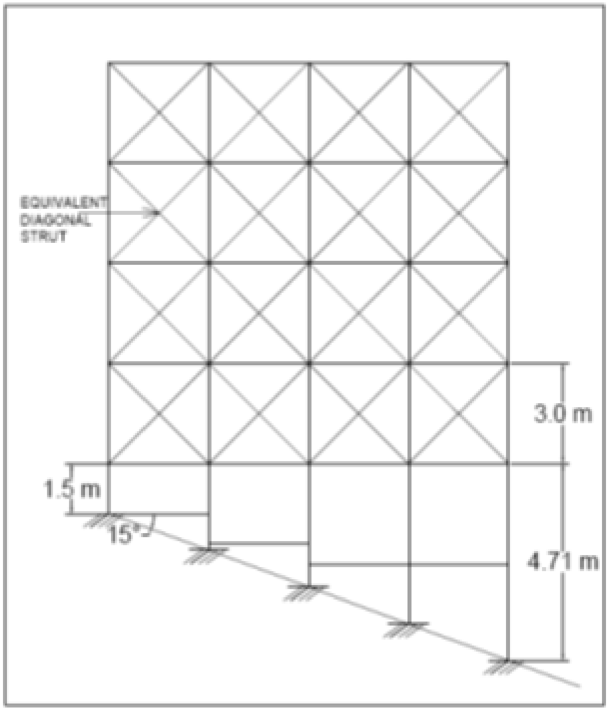

Figure 3. Elevations of building on 150 sloping ground

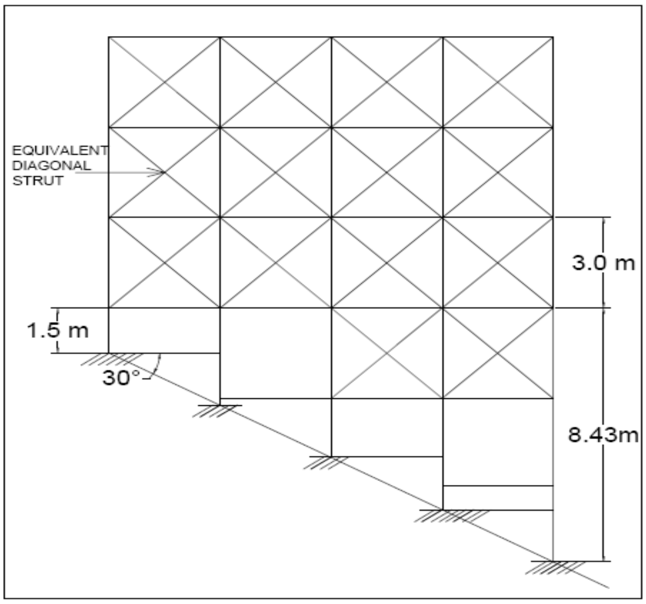

Figure 4. Elevations of building on 300 sloping ground

Loads

1) Dead load:

Super imposed dead load (Floor finishes or water Proofing) for all floors =1.875kN/m2.

External wall load (230mm thick) =13.8 kN/m.

Internal wall load (115 mm thick) =6.9 kN/m.

Parapet load= 2.3 kN/m.
2) Live Load:
Live load on floor = 4 kN/m2
Live load on roof =1.5kN/m2

3) Earthquake load: Imperial Valley earthquake , Kern earthquake, Parkfield earthquake is applied in X-Direction .

IV. METHOD OF ANALYSIS

Dynamic Analysis of the building is done by using finite element software SAP-2000. 3D analysis has been carried out by Time History method for this study. Dynamic response of these buildings, in terms of base shear, fundamental time period, modal mass participation ratio and compared within the considered configuration of shear wall as well as with model without shear wall on sloping ground and at the end, efficient position of shear wall configuration to be used is suggested. Damping considered for all modes of vibration was five percent.

V. RESULTS AND DISCUSSION

VI. MODAL MASS PARTICIPATION RATIO

Mode	Slope	NS		SSSW		LSSW2C		LSSW4C	
		X	Y	X	Y	X	Y	X	Y
1	7.5^0	0.83	0	0	0.85	0.8	0	0.77	0
	15^0	0	0.73	0	0.87	0.82	0	0.79	0
	30^0	0.82	0	0	0.84	0.79	0	0.76	0
2	7.5^0	0	0.72	0.77	0	0	0.8	0	0.78
	15^0	0.85	0	0.78	0	0	0.83	0	0.79
	30^0	0	0.73	0.75	0	0	0.80	0	0.76
3	7.5^0	0	0.14	0	0.002645	0	0.009743	0	0.001799
	15^0	0	0.14	0	0.002506	0	0.004339	0	0.009965
	30^0	0	0.12	0	0.001742	0	0.005302	0	0.00532
4	7.5^0	0.08562	0	0	0.07857	0.09134	0	0.09186	0
	15^0	0	0.05646	0	0.06994	0.08823	0	0.09411	0
	30^0	0.0854	0	0	0.0812	0.0913	0	0.0932	0

						6		4	
5	7.5^0	0	0.06623	0.09339	0	0	0.08626	0	0.08835
	15^0	0	0.0786	0.09647	0	0	0.08161	0	0.09024
	30^0	0.0854	0	0	0.0812	0.09136	0	0.09324	0
6	7.5^0	0	0.01031	0	0.000347	0	0.001046	0	0.000149
	15^0	0	0.01159	0	0.0004904	0	0.0007728	0	0.000733
	30^0	0.0854	0	0	0.0812	0.09136	0	0.09324	0
7	7.5^0	0.02283	0	0	0.02144	0.02642	0	0.02694	0
	15^0	0	0.01306	0	0.0174	0.02187	0	0.01619	0
	30^0	0.02342	0	0	0.02392	0.02789	0	0.02934	0
8	7.5^0	0	0.01788	0.02641	0	0	0.02577	0	0.0267
	15^0	0.01691	0	0.01208	0	0	0.02271	0.01001	0
	30^0	0	0.01898	0.02863	0	0	0.02865	0	0.03202
9	7.5^0	0	0.001981	0	0.000025	0	0.0001617	0	0.000004
	15^0	0.001235	0	0.01356	0	0.00100	0	0	0.02769
	30^0	0	0.002136	0.00157	0	0	0.0001722	0.00068	0
10	7.5^0	0.000675	0	0.00051	0	0.00024	0	0.00027	0
	15^0	0	0.00189	0	0.0001156	0	0.000164	0	0.000414
	30^0	0.000963	0	0	0.0000256		0	0	0
11	7.5^0	0	0.00147	0	0.001611	0	0.001263	0	0.000895
	15^0	0	0.001246	0	0.0002286	0	0.0004125	0	0.000352
	30^0	0	0.001262	0	0.0009597	0	0.001137	0	0.000900
12	7.5^0	0.007901	0	0.00509	0	0.00699	0	0.00582	0
	15^0	0.001791	0	0.00276	0	0.00193	0	0.00199	0
	30^0	0.007089	0	0.00388	0	0.00530	0	0.00365	0

VII. CONCLUSION

When shear wall is provided at two corners of building for 7.5^0 , 15^0 and 30^0 first mode is dominating as it more contributes in first mode only and with same slopes of building vibration in second mode is dominating as it contributes more in this mode only but in y-direction. Overall observation from the modal mass participation is that the mode contributes in the modal mass participation up to higher modes as the building is unsymmetrical.

VIII. REFERENCES

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