ANALYSIS OF 2D FRAME(G+10) BUILDING ON SLOPING GROUND

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Abstract

In hilly areas buildings are built on sloping grounds. When the hilly areas come under the seismic zones, these buildings are highly vulnerable to earthquakes. This is due to the fact that the columns in the ground storey are of different heights in such a way that column in one end is a short column and column in other end is a long column. Dynamic characteristics of hill buildings are somewhat different than the buildings on flat ground. Torsional effect of such buildings is damaged for having the difference stiffness and mass along horizontal and vertical plane during ground motion .Short columns of RC frame buildings damage because of attracting more forces during earthquake. The work is focused to analyze 2-D frame of (G+10)building on plane and on sloping ground at 45degrees ,65 degrees using ETABS software when seismic loads are incorporated.

Keywords: sloping ground, Earthquake forces

1.INTRODUCTION

North and north eastern parts of India have large scales of hilly terrain, which are categorized under seismic zone IV and V. In this region the construction of multistorey 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 to tremendous 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 plane ground in hilly areas, it obligates the construction of buildings on slopes.

Dynamic characteristics of hill buildings are significantly different from the buildings resting on flat topography, as these are irregular and unsymmetrical in both horizontal and vertical directions. The irregular variation of stiffness and mass in vertical as well as horizontal directions, results in centre of mass and centre of stiffness of a storey not coinciding with each other and not being on a vertical line for different floors. When subjected to lateral loads, these buildings are generally subjected to significant torsion response. Further, due to site conditions, buildings on hill slope are characterized by unequal column heights within a storey, which results in drastic variation in stiffness of columns of the same storey. The short, stiff columns on uphill side attract much higher lateral forces and are prone to damage.

- Three dimensional space frame analysis is carried out for two different configurations of buildings of 10 storeys resting on sloping and plane ground under the action of seismic load in ETABS software.
- Dynamic response of the buildings, in terms of base shear, fundamental time period and displacement is presented, and compared with the buildings having different sloping values. At the end, a suitable configuration of building to be used in hilly area is suggested. The effects of the supporting foundation medium on the motion of structure gives soil structure interaction, but this may not be considered in the seismic analysis for structures supported on rock or rock like materials.

1.1 METHODOLOGY

1. Review of existing literatures by different researchers.
2. Selection of existing multistorey RC building.
3. Modeling of the selected structure.
4. Performing dynamic analysis on selected building model and the analysis results are plotted in form of graphs.
5. Column is modeled as fixed to the base.
6.The effect of soil structure interaction is ignored.

7. A 2 dimensional frame subjected to concentrated loads with un-equal supporting columns. In ETABS , analysis of G+10 multistoried building on sloping ground is carried out for storey displacement, storey shear and base shear using response spectrum method.

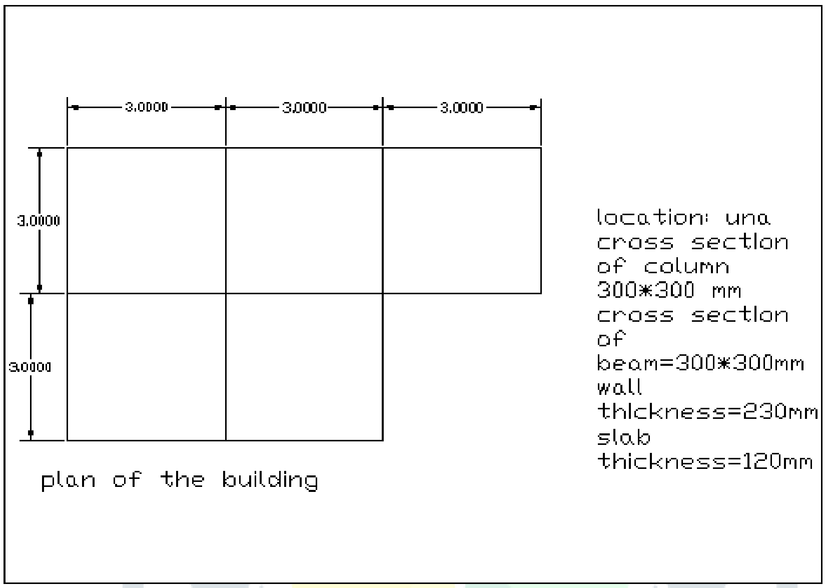


Figure 1. Plan of the building

1.2 BUILDING CONFIGURATION

In the present study, two groups of building (i.e.Configurations) are considered, and these two are resting on sloping ground with varying slopes of 30, 45, 60 degree with horizontal, which is neither too steep or nor too flat. The height and length of building in a particular pattern are in multiple of blocks (in vertical and horizontal direction), the size of block is being maintained at 9 m x 6m x 3.0 m. The depth of footing below ground level is taken as 1.75 m where, the hard stratum is available. The building chosen for the study is presented in figure 1.5 is present in zone no-5 in Himachal Pradesh.

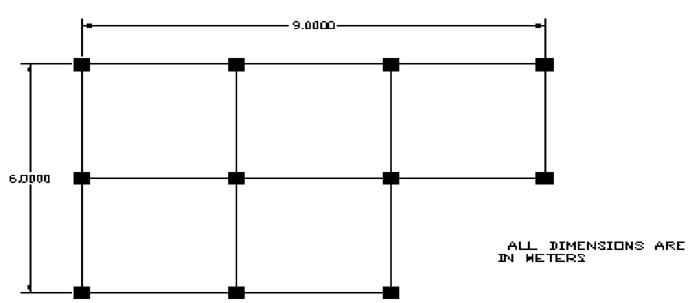


Figure 2 Grid line marking of building plan

LOADINGS

Live load	4 kN/m²
Floor finish	1.5 kN/m²
Wall weight	13.8 kN/m
	6.9 kN/m on roof
Seismic loading:	IS 1893
Zone factor	0.36 (zone V)
Soil type	medium
Importance factor ,I	1.5
Response reduction, R	3

II. LITERATURE REVIEW

Patel et al. (2014) studied 3D analytical model of eight storied buildings on sloping ground .They concluded that more number of bays are better as this increases the time period and therefore it reduces top storey displacement.
Halkude et al. (2013) studied the dynamic characteristics of the building i.e., base shear, top storey displacement and natural time period with respect to variation in number of stories and number of bays along the slope.

Sreerama and Ramancharla (2013) observed that by varying slope angles of 0, 15°, 30°, 45°, 60° and found that short column attract more forces due to the increased stiffness. The base reaction for the shorter column increases as the slope angle increases. Time period of the building decreases as the slope angle increases and short column resist almost all the storey shear as the long columns are flexible and cannot resist the loads.

III. METHODOLOGY

To study and evaluate the behavior of reinforce concrete buildings resting on the sloping ground. Here, a dynamic analysis of a RC- building with fixed base is done considering different types of frames using ETABS.

1. STRUCTURAL MODELLING SPECIFICATIONS

Live Load	3kN/m^2
Density of RCC considered:	25kN/m^3
Thickness of slab	150-200mm
Depth of beam	450mm
Width of beam	300mm
Dimension of column	900x600mm
Density of infill	20kN/m^3
Thickness of outside wall	20mm
Thickness of inner partition wall	15mm
Height of each floor	3.0m
Earthquake Zone	V
Time period in X-direction	1.10sec
Time period in Y-direction	0.9sec
Damping Ratio	5%
Importance factor	1.5

Type of structure	OMRF
Response reduction Factor	3

OMRF=Ordinary Moment Resisting Frame

2. MODELLING DETAILS

A (G+10) building with ordinary moment resisting frames in two orthogonal directions, was selected for the study. The building had a one brick thick exterior infill wall along the periphery.

The material and sectional properties in the analysis of different building frames are shown in Table 1 confirming to IS 456:2000.

Table 1 Material and Sectional Properties

Sl.No.	Model Parameters	Details
1	Column	900 x 600mm
2	Beam	450x 300 mm
3	Slab	150 mm thick
4	Wall thickness	230 mm thick
5	Unit weight of masonry	25 kN/m^3
6	Support conditions	Fixed support
7	Ground slope	45°
8	Grade of concrete	M25
9	Grade of steel	Fe415

Dead loads and live loads are compared as per IS 875 (part 1):1987 and IS 875(part 2):1987 respectively and are shown in table no 2.

Table 2 Loading parameters

Sl.No	Parameters	Details
1	Roof finish	1.50 kN/m^2
2	Floor finish	0.75 kN/m^2
3	Roof live load	2 kN/m^2
4	Floor live load	4 kN/m^2

3. PROCEDURE FOR STRUCTURAL MODELLING

Step 1 After the software is opened, a pop-up window appears with 'Model Initialization ' as shown in figure 4., here the units, steel section database, steel design code and concrete design code are to be selected .

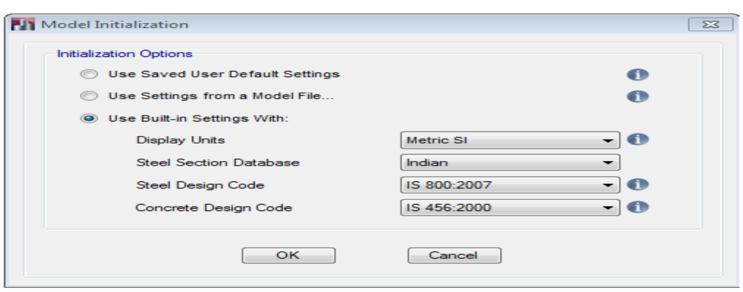
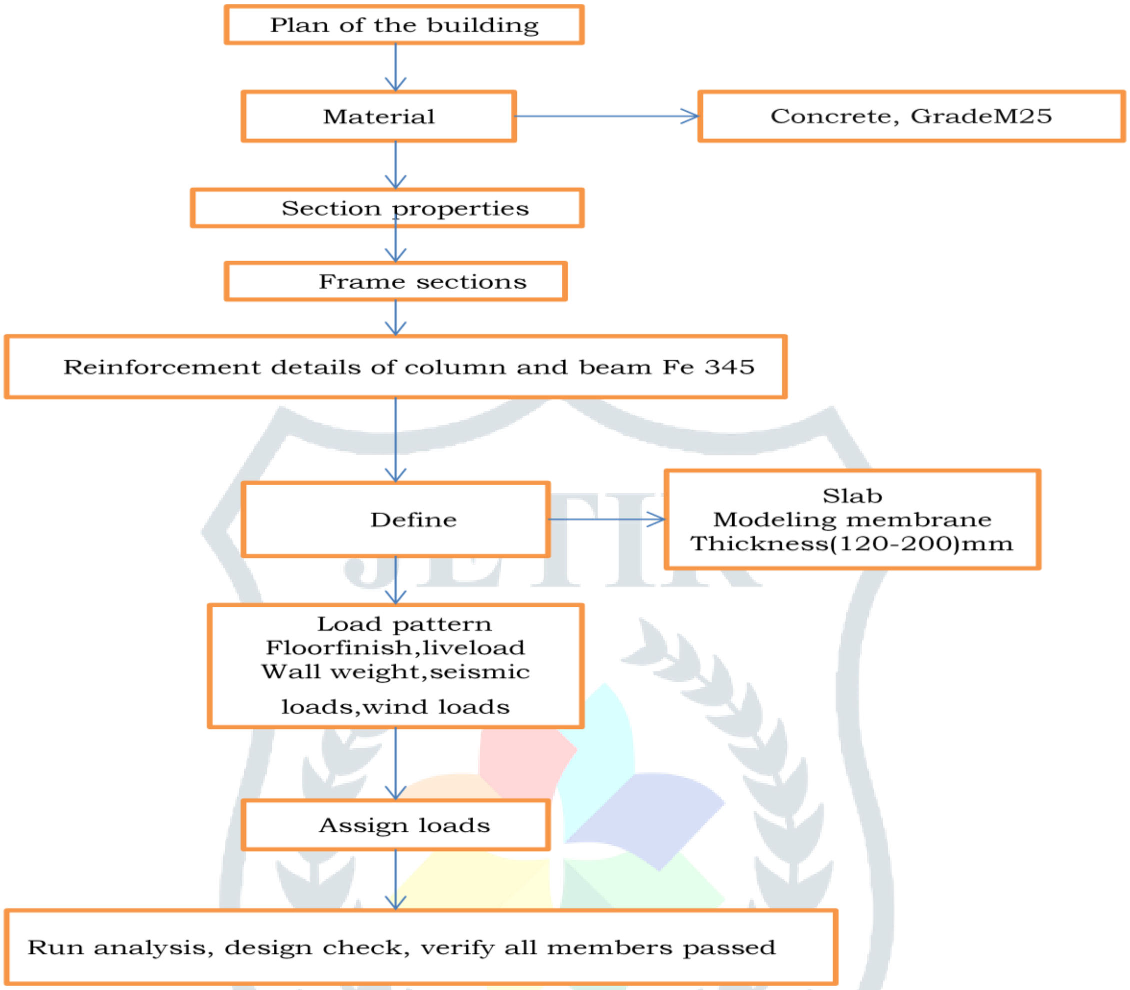


Figure 3 Initialization options

Then the next following steps are mentioned in form of flowchart



Deformed Shapes of Bare frames:

The deformed shapes of bare frame of (G+10) building is shown in figure 5 Maximum displacement is seen for highest point of the building and its goes on decreasing as the storey number decreases.

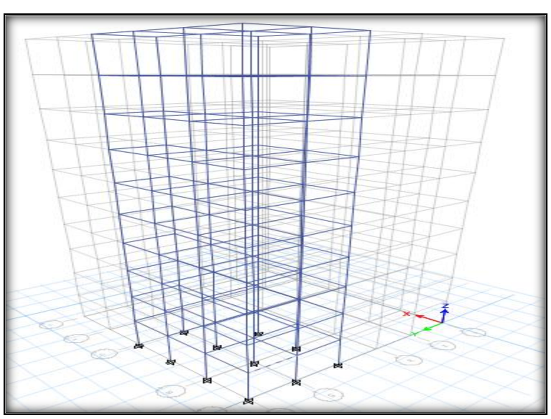


Figure 4 Modeled structure

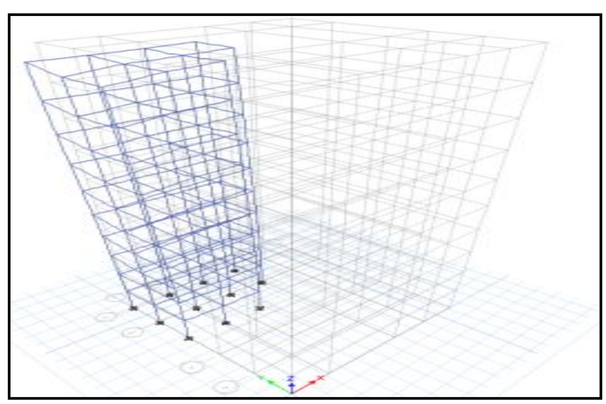


Figure 5 Deformed structure

Parametric Study:

The parameters which are considered are:

1)Maximum displacement

Figure 7 represents the displacement values of the building obtained from the response spectrum analysis increase as the storey increases. 45 degree sloped frame experiences more storey displacement than 65 degree sloped frame due to the low value of stiffness of short column.

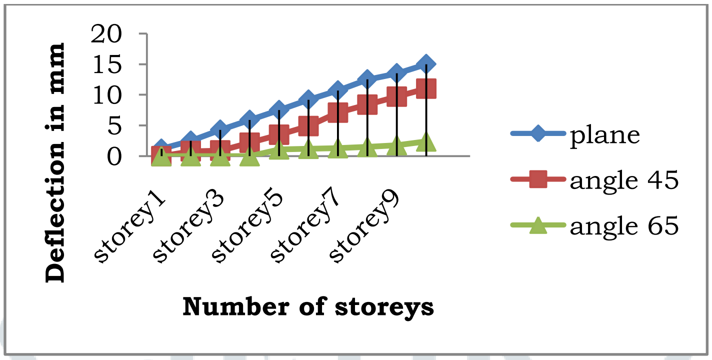


Figure 6 Displacement of structure at each storey

2)Storey shear: The figure 8 shows that the storey shear variation for the building on the plane ground.

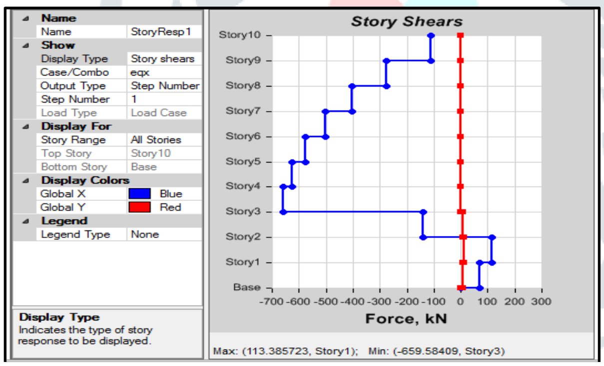


Figure 7 For plane ground

The figure 8 shows the storey shear for 45 degree slope ground the maximum value occurs at base and minimum value at 429 kN from storey 1 to storey 3and it goes on decreasing up to storey 10.

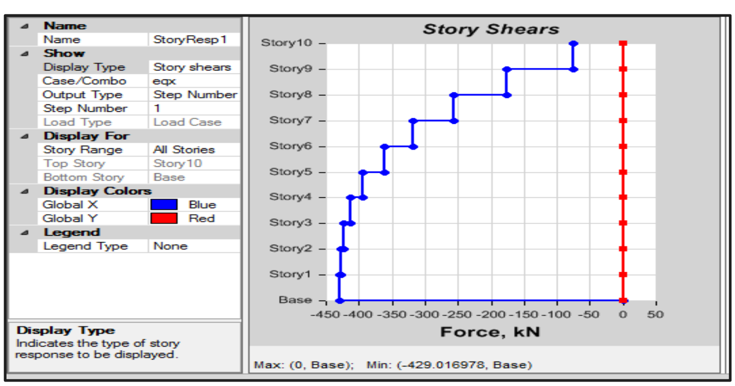


Figure 8 For 45 degree sloped ground

The figure 10 shows the storey shear value for 65 degree slope ground the maximum value occur at storey 3 and minimum value as 300kN from storey 3 to storey 6 its goes on decreasing up to storey 10.

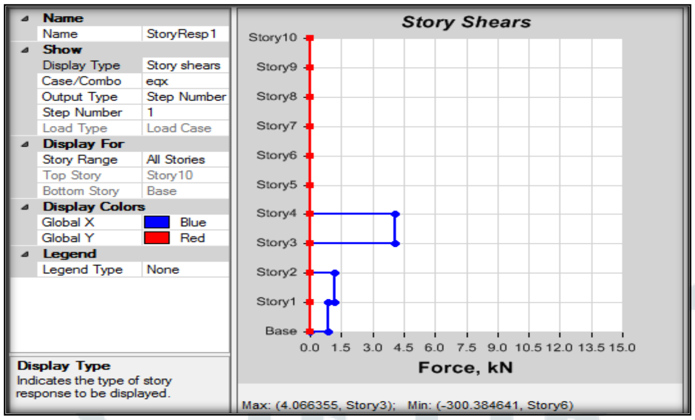


Figure 9 For 65 degree sloped ground

IV.RESULTS AND DISCUSSIONS

- On plane ground, storey deflection is more than on sloping ground.
- Deflection values are less on sloping ground because of short column stiffness. Due to low stiffness of the short columns, this variation arises.

Lateral stiffness $k=12EI/L^3$

Lateral stiffness is inversely proportional to length. If length of column decreases, stiffness value increases which reduces storey deflection.

- The base shear distribution on the ground storey of the building is such that the short column attracts almost 75% of the shear force which may lead to plastic hinge formation.
- It is observed that base shear increases with increase in number of storey. But as the slope increases, the base shear decreases.(from lower angle to higher angle)
- On plane ground, Maximum base shear is 113.38kN

V.CONCLUSIONS

1)According to results of Response Spectrum Analysis, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases. It is observed

that base shear decreases from lower angle to higher angle.
2) On plane ground, storey deflection is more than on sloping ground.

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