

Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground

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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. There are two types of configuration of building on sloping ground, the one is step back and the other is step back setback. In this study, G+ 10 storeys RCC building and the ground slope varying from 10⁰ to 30⁰ have been considered for the analysis. A comparison has been made with the building resting on level ground. The modelling and analysis of the building has been done by using structure analysis tool ETAB 2015, to study the effect of varying height of the column in bottom storey at different position during the earthquake. The seismic analysis was done by the response spectrum analyses have been carried out as per IS:1893 (part 1): 2002. The results were obtained in the form of top storey displacement, Storey Acceleration, Base shear and Mode period. It is observed that short column is affected more during the earthquake.

KEYWORDS: ETABS, Sloping ground, Step-back building, Response spectrum analysis.

I. INTRODUCTION

The term earthquake may be used to describe any quite unstable waves which can be either natural or initiated by humans that generate unstable waves. Earthquakes are caused normally by rupture of geologic faults. Associate in nursing earthquake unharness of energy within the layer that creates unstable waves results Associate in nursing earthquake. The frequency, sort and magnitude of earthquakes fully fledged over a amount of your time outline the seismicity (seismic activity) of that space. The observations from a seismometer are wont to measure earthquake. Earthquakes larger than some five are principally reportable on the size of moment magnitude. Those smaller than magnitude five, that are additional in variety, as reportable by the national geophysical science observatories are principally measured on the native magnitude scale, that is additionally referred to as the scale.

At present time the methods of seismic evaluation for the seismic damage or earthquake damaged structures are not yet fully developed. The buildings which do not fulfil the requirements of seismic design, may suffer extensive damage or collapse if shaken by a severe ground motion or earthquake.

Earthquake is the major reason for the issue of safety for the construction of multi storey buildings. The buildings which are present now are designed and constructed according to as per older code provisions, are not satisfying. Therefore it is need to construct different types of buildings which have the capacity to resist the forces, like Flat Slab and R.C Framed structure buildings are more suitable for now a day, because of increased in population and the land value.

Buildings are present in hilly areas are very different from those in plain ground; in hilly areas they are very irregular and unsymmetrical. Hence, they tend to severe damage to the structure when affected by earthquake, because in hilly areas the structure is constructed with different column heights, the short column will affects more damage then the long column during earth quake. The recent earthquake at Utharkhand- India (2015) it has been seen that buildings located near the edges have undergone severe damages. Hence, the structures should be designed on the basis of strength and stiffness criteria.

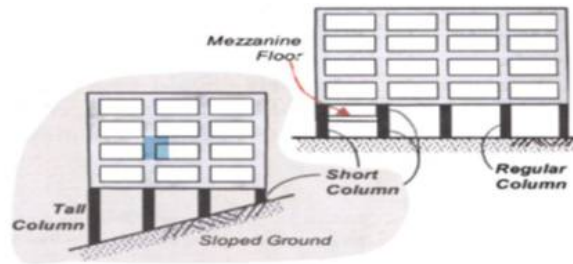


Fig.1.1 Building Frame with Short Columns

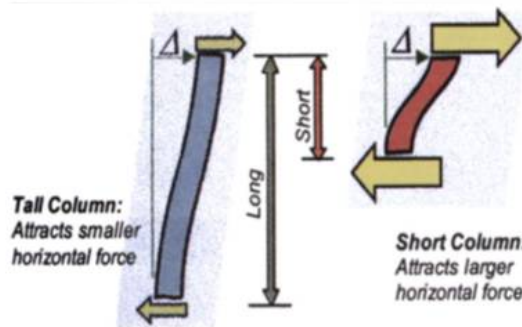


Fig.1.2 Structural Behaviour of Short Column under Later Load

II. HISTORICAL REVIEW

Nagargoje and Sable 2 (2012) Studied unstable performance of buildings on hill slope. They applied 3D house frame analysis to check dynamic response of the buildings, in terms of base shear and prime floor displacement. A constant quantity study was applied on thirty six buildings with 3 configurations as step back, step back set back and set back buildings settled in unstable zone III. B.G.Biradar and S.S.Nalawade (2004) studied unstable performance of hill buildings by considering story level up to eleven, but during this paper the study is applied by considering construction level starting from four to fifteen (15.2 m to 52.6m). They found that the construction displacement of step back buildings is sort of high as compared to step back –set back buildings,. They discovered that the bottom shear elicited in step back set back buildings is higher within they vary of sixty and 260% than set back building. They urged step back set back buildings could also be favoured on sloping ground.

Prashant D and JagadishKori G 5 (2013) Studied seismic response of 1 method slope RC frame building with soft structure. During this paper study is concentrated on the behaviour of buildings set on sloping ground with and while not infill wall, the influence of infill wall on buildings set on sloping ground is given. Non linear static pushover analysis is dispensed on ten structurebuildings that embrace clean frame while not infill wall and alternative model with infill wall together with a soft structure building on sloping ground. All buildings include five bays on slope direction set at a slope of twenty seven degree with the horizontal, set in seismic zone III. Building frame system thought-about is SMRF. They determined that the period of clean frame model is found to be one.975 sec that is nearly 96-135% over alternative models with presence of infill wall. Therefore they conclude, this higher price of natural amount in clean frame compared to infill frame ultimately leads to underestimate of style base shear in clean frame model on sloping ground. The abrupt changes within the slope profile indicates stiffness irregularity, they determined that the displacement in clean frame model is found to be a lot of thanks to reduced stiffness compared to alternative models with infill wall. They found that the bottom shear of infill models is nearly 250% a lot of compared to reveal frame. It's over that the formation of plastic hinges is a lot of in clean frame model and soft structure building compared to completely in filled fames. During this paper study is focused on variation of stiffness as a result of presence of infill wall and soft structure on sloping ground.

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JitendraBabu et al 7 (2012) carried out pushover analysis of various symmetric and asymmetric structures constructed on plain as well as sloping ground subjected to various kinds of loads. They considered various structures in plan symmetry and also asymmetry with different in bay sizes in mutual direction. On sloping ground they considered a 4 storey building in which they have taken one storey above ground level which is situated at a slope of 30 degree with the horizontal. They found that the short column lies in the severity level beyond collapse prevention (CP) from pushover analysis, they obtained displacement and base shear for asymmetric sloping ground as 104X10⁻³ m and 2.77 x 10³ kN respectively. Based on results they developed pushover curves with displacement on X-axis and Base shear on Y-axis and have given comparison between various cases they considered. They observed that the Base shear resisted for maximum displacement up to failure limit by symmetric structure is 70% and by asymmetric sloped building is 24% more than base shear resisted by asymmetric building on plain ground. They conclude that the structure with vertical irregularity is more critical than a structure with plain irregularity.

III. OBJECTIVES

The objective of study is as follows:

- To study the effectiveness of configuration of building frames such as step back frames.
- To study the variation of base shear with respect to variation in hill slope angle for different configurations of building frames.
- To study the variation of mode period with respect to variation in hill slope angle for different configurations of building frames.
- To study the variation of storey displacement with respect to variation in hill slope angle for different configurations of building frames.
- To study the variation of storey acceleration with respect to variation in hill slope angle for different configurations of building frames.
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IV. MODELING DESCRIPTION

4.1.1 Geometric parameters

In the present study, one building configurations are considered, which include buildings situated on plain ground. Number of storey considered for each type of configurations is 10 storeys. Plan layout is kept same for all configurations of building frame. The columns are taken to be square to avoid the issues like orientation.

4.1.2 Geometric Properties

Floorheight	:3.1m
SpacinginXdirection	:7.0m
SpacinginYdirection	:5m
BeamSizes	:300X500mm
Columnsizes	:600X600mm
SlabThickness	:150mm
Number of bays in x- direction	: 7 bays
Number of bays in y- direction	: 4 bays
Number of stories	: G+10

4.1.3 Material Properties

Concrete Grade	: M30
Compressive strength of Concrete	: 30000 KN/m ³

Steel: Fe500

Charctersticks strength of reinforcing steel $f_y = 50000 \text{ KN/m}^3$
Density of concrete = 25000KN/m³

4.1.4 Gravity Loads

(i) Dead load:

Self-Weight: Self weight is calculated by the software based on material constants and section properties provided

Super imposed dead load (water Proofing's or Floor finishes)=1 KN/m²

(ii) Live Load:

Live load on Slab = 3 Kn/m³

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4.1.5 Lateral loads

Response Spectrum Method:

The response spectrum analysis is carried out using the spectra for medium soil as per IS 1893 (Part 1) 2002 for seismic zone V, medium soil and 5% damping.

The spectral acceleration coefficient (Sa/g) values are calculated as follows.

For medium soil sites,

$$Sa/g = 1 + 15T, (0.00 \leq T \leq 0.10), (T = \text{time period in seconds})$$

$$= 2.50, (0.10 \leq T \leq 0.55)$$

$$= 1.36/T, (0.55 \leq T \leq 4.00)$$

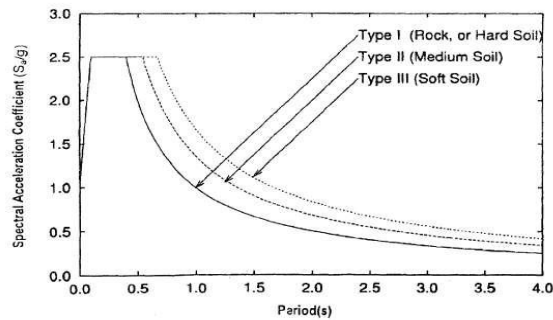
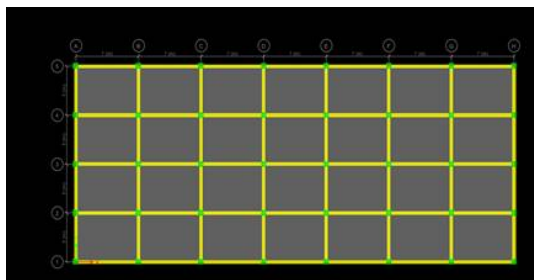


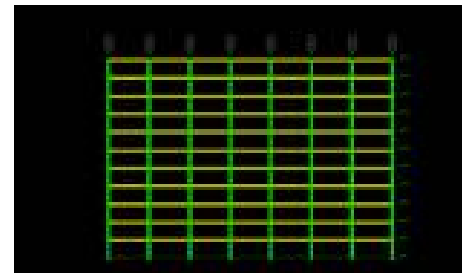
FIGURE 4.1: RESPONSE SPECTRA FOR ROCK AND SOIL SITES FOR 5% DAMPING AS PER IS1893 (PART1):2002 (FIG.2 OF CODE)

4.2 Models considered for the study

Model 1: Building model on plain ground



(a)



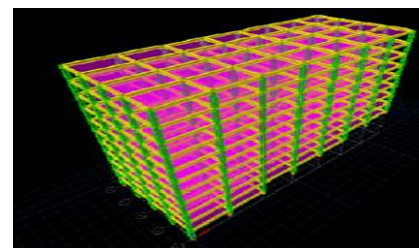
(b)

Fig 4.2.1 (a) plan of a model, (b) elevation of mode on flat ground

Model 2: Building model on 10° sloping ground



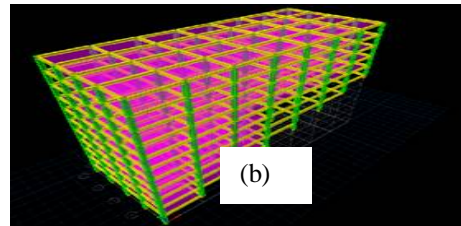
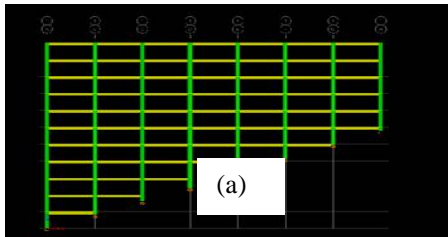
(a)



(b)

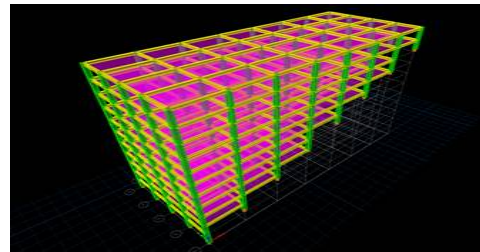
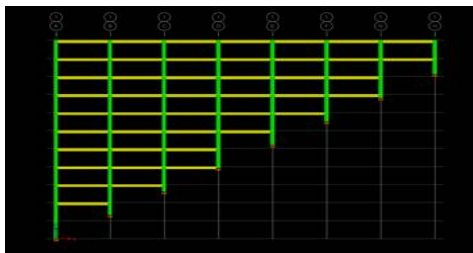
Fig 4.2.1 (a) elevation of a model, (b) plan of 3d model

Model 3: Building model on 20° sloping ground



of a mc

Model



(a) Fig 4.2.1 (a) elevation of a model, (b) plan of 3d model (b)

V. RESULT AND DISCUSSION

5.1 Mode Period

Table 5.1 Comparison of Mode Period for different Models

Model	Mode period(sec)		
	Mode 1	Mode 2	Mode 3
Model 1	1.744	1.612	1.476
Model 2	1.258	1.441	1.058
Model 3	1.135	0.867	0.737
Model 4	0.599	0.375	0.270

Fig 5.1 comparison of Mode Period for different Models

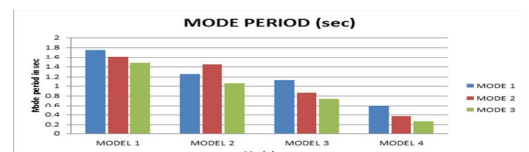


Fig 5.1 comparison of Mode Period for different Models

Table 5.2 Comparison of Base shear for different Models

Model	Base shear in KN	
	X-direction	Y-direction
Model 1	3158.890	3383.09
Model 2	2911.412	2795.066
Model 3	3161.907	2414.386
Model 4	2178.99	1724.39

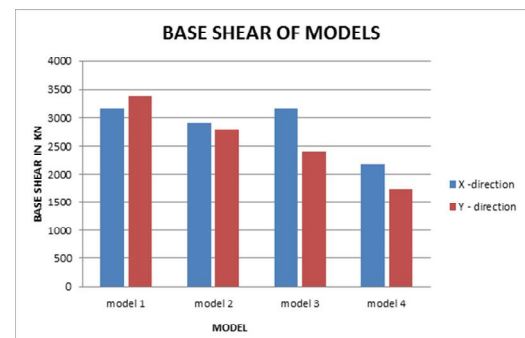


Fig 5.2 Comparison of Base Shear for different Models

5.3 Story Displacement

TABLE 5.4.1 Story displacement of Model 1

TABLE: Story Displacements		
Story	RX	RY
	mm	mm
Story11	41.4	38.3
Story10	40.2	37.1
Story9	38.2	35.2
Story8	35.5	32.7
Story7	32.2	29.7
Story6	28.3	26
Story5	23.8	21.9
Story4	18.8	17.4
Story3	13.4	12.4
Story2	7.8	7.3
Story1	2.7	2.5

Fig 5.3 Story displacement for Model 1

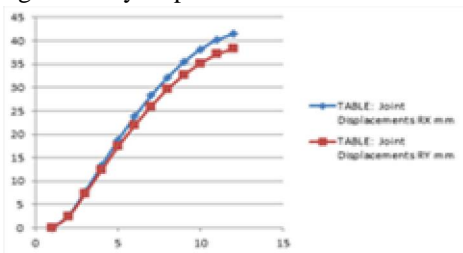


TABLE 5.4.3 Story displacement of Model 3

TABLE: Joint Displacements		
Story	RX	RY
	mm	mm
Story11	22.4	37.7
Story10	20.1	35.7
Story9	16.8	32.6
Story8	12.4	28.4
Story7	7.7	23.2
Story6	3.8	17.5
Story5	1.6	12
Story4	1.1	7.3
Story3	0.9	3.4
Story2	0.4	0.9
Story1	0.04152	0.1
Base	0	0

TABLE 5.4.2 Story displacement of Model 2

TABLE: Storey Displacements		
Story	RX	RY
	mm	mm
Story11	30.5	40.2
Story10	29.1	38.6
Story9	26.8	36.1
Story8	23.6	32.8
Story7	19.7	28.6
Story6	15.2	23.7
Story5	10.2	18.1
Story4	5.3	12.3
Story3	1.9	6.7
Story2	0.7	2.5
Story1	0.2	0.4
Base	0	0

Fig 5.4 Storey displacement for Model 2

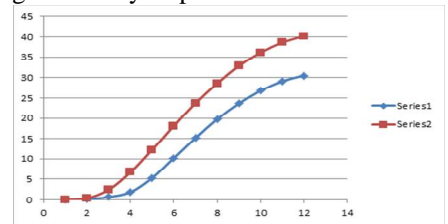


TABLE 5.4.4 Storey displacement of Model 4

TABLE: Joint Displacements		
Story	RX	RY
	mm	mm
Story11	7.5	21.5
Story10	5.5	18.4
Story9	3.7	14.1
Story8	2.5	9.7
Story7	1.9	6.5
Story6	1.5	4.3
Story5	1	2.3
Story4	0.3	0.7
Story3	0.2	0.3
Story2	0.2	0.3
Story1	0.1	0.1

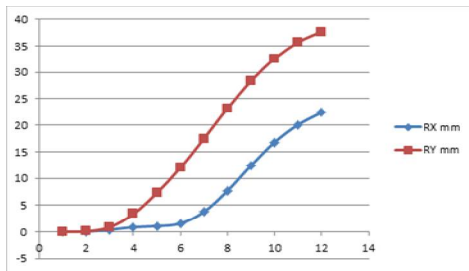


Fig 5.2.3 Storey displacement for Model 3

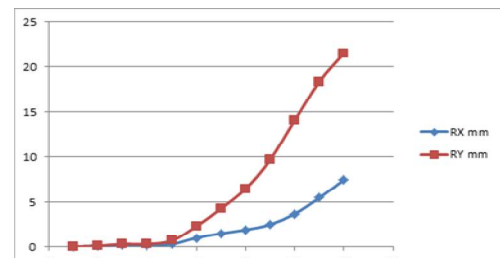


Fig 5.2.4 Storey displacement for Model 4

5.4 Storey Acceleration

TABLE 5.5.1 Storey Acceleration of Model 1

TABLE: Storey Accelerations		
Story	RX	RY
	m/sec ²	m/sec ²
Story11	0.9259	0.9515
Story10	0.7121	0.7479
Story9	0.6171	0.6492
Story8	0.603	0.6304
Story7	0.5977	0.6212
Story6	0.6536	0.6727
Story5	0.6891	0.7072
Story4	0.6804	0.6952
Story3	0.6732	0.6849
Story2	0.5466	0.5596
Story1	0.2373	0.2472
Base	0	0

TABLE 5.5.2 Storey Acceleration of Model 2

TABLE: Storey Accelerations		
Story	RX	RY
	m/sec ²	m/sec ²
Story11	1.4544	1.6209
Story10	1.1117	1.2835
Story9	1.1016	1.1514
Story8	0.9314	1.1344
Story7	0.9606	1.1181
Story6	1.009	1.0799
Story5	1.216	0.9367
Story4	1.2694	0.8272
Story3	0.787	0.6497
Story2	0.2356	0.2845
Story1	0.0202	0.0313
Base	0	0

TABLE 5.5.3 Storey Acceleration of Model 3

TABLE: Storey Accelerations		
Story	RX	RY
	m/sec ²	m/sec ²
Story11	0.9259	0.9515
Story10	0.7121	0.7479
Story9	0.6171	0.6492
Story8	0.603	0.6304
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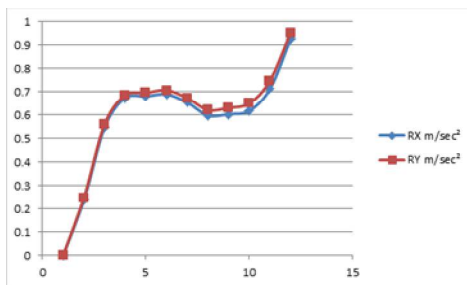


Fig 5.2.1 Storey Acceleration for Model 1

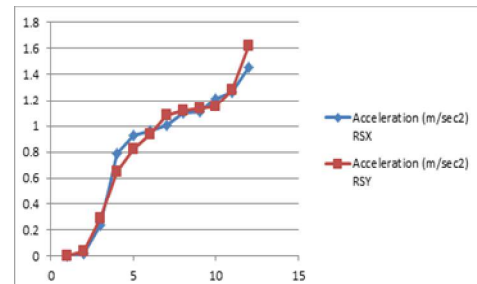


Fig 5.2.2 Storey Acceleration for Model 2

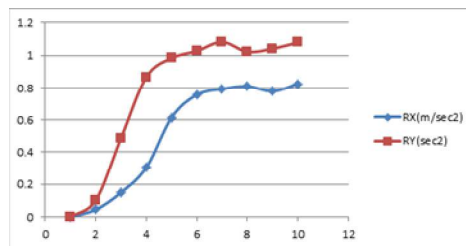


Fig 5.2.3 Storey Acceleration for Model 3

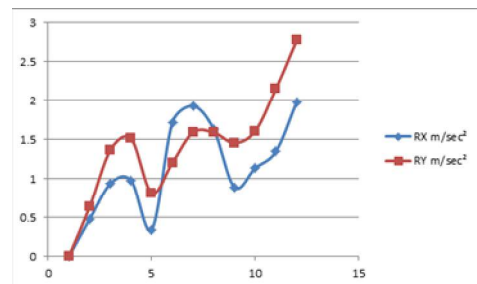


Fig 5.2.4 Storey Acceleration for Model 4

VI.CONCLUSION

Following conclusions can be made from the analysis

1. The sloping ground buildings possess relatively more maximum displacement and shear forces which may give to critical situations than the flat ground.
2. Base shear is maximum at 20° slope compared to other models.
3. Base shear is maximum in X-direction compared to Y-direction for sloping ground building.
4. From the analysis, Mode Period is decrease with increase in slope angle.
5. Mode period is directly proportion to the mass of the structure, the mass of the structure increases, the mode period also increases.
6. From the analysis, Storey displacement is decrease with increase in slope angle.
7. Displacement is maximum at the top story when compared with bottom storeys in all other models along x and y-direction..
8. From the analysis, Storey Acceleration is decrease with increase in slope angle.

Acceleration is maximum in storey-11 when compared to storey-1 in all other models along x and y-direction

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