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Seismic Analysis of RCC Structural Building Resting on Sloping Ground with different Building Heights

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ABSTRACT -
In present project work to study various seismic responses of RC framed regular structure on flat ground compared with RC framed structure on sloping ground. In highly vulnerable earthquakes thrash frequently at different parts of the world causing demolition of life and all kind of structures so it is important to study different structures at different locations in India. In this project we taken RC framed structure of G + 11 storey on two different ground condition and also with two different zone of zone III and zone IV. And the performance is observed when building above sloping ground is compared with building above the flat ground. All building models are analyzed on ETABS 2016 software to study the graphs which differentiate between the displacement, storey drift, lateral load and base shear RC framed structure above the sloping ground and building above the flat ground by using response spectrum method.
Key Words: *RC framed structure, Flat ground, sloping ground, zones, response spectrum method*

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I. INTRODUCTION

In India most part come under hilly area which is highly seismic. In hilly areas structures are generally built on sloping ground. When the hilly areas come under the different seismic zones, these buildings are highly endangered to the earthquakes. A building is resting on hilly slope region it is different from the buildings located at plane or flat surfaces. The buildings are situated in hilly areas are much more vulnerable to seismic environment. The various seismic zones buildings are steps back towards the hill slope and at the same time buildings may have plane ground also. Analysis of hilly slope buildings is somewhat different than the flat ground level buildings, since the column of such building rests at different levels on the slope.

Most cities that are lying in severe earthquake zones, building structures resting on hill slopes are more susceptible to the impact of an earthquake. Such structures may fail if they are not designed considering dynamic characteristics affecting for structures on hill slopes.

Economic development of hill areas in the last century has led to the reconsideration of building style, optimum use of construction material and method of construction. Due to scarcity of the plain land on hills, houses built on steep slopes, pose special structural and construction problems. RC framed structures constructed on hill slopes show different structural behaviour than on the plain ground. Because of steep slopes, buildings are constructed generally in step-back configuration. At the location of setbacks, an increase in the stress concentration has also been reported, when the building is subjected to seismic forces. Recent earthquakes, struck in hill regions viz., Nepal (2015), Sikkim (2011), Kashmir (2005), Uttarkashi (1990) and Bihar-Nepal (1988) have shown major casualties caused by design flaws and failures in RC as well as masonry structures.

Although, the researches carried out in past have provided a better view of structural behaviour of hill buildings but the performance of the hill building in different configurations has not been studied thoroughly. Also, IS 1893 (1984) and IS 1893 (Part 1): 2002; recommend that buildings with geometrical irregularity and or having irregular distribution of mass and stiffness should be analysed by modal analysis and torsional shear should be accounted separately, but fails to capture the true response of the structure. Thus, in order to get the realistic behaviour of hill buildings subjected to seismic load, a three-dimensional modelling of structure is required, considering real structural behaviour of beams/columns, rigid slabs, infill masonry walls and RC shear walls, etc. Also, to incorporate the inelastic behaviours of hill buildings, linear and non-linear dynamic analysis should be carried out. In the present study three-dimensional modelling of two different configurations of hill buildings has been undertaken and the effect of plan aspect ratio has been parametrically studied by varying plan dimensions and height of the models. Results have been discussed in terms of static and dynamic properties of buildings such as shear forces induced in the columns at foundation level, fundamental time period, maximum top storey displacements, storey drifts and storey shear in buildings and compared with in the considered configurations of hill building.

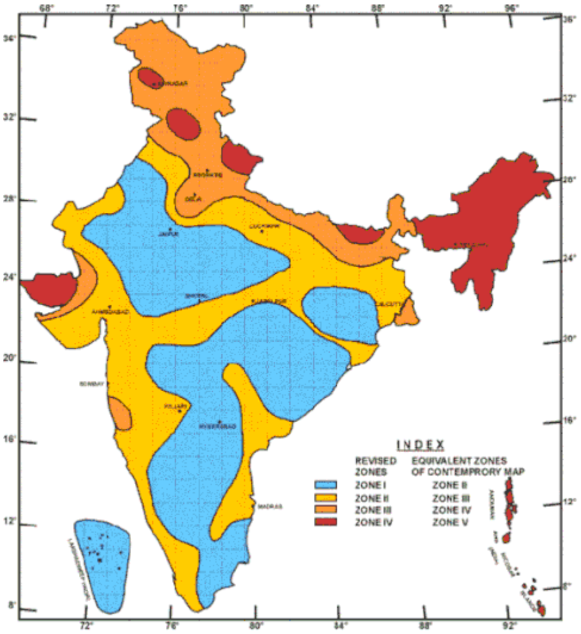

Fig.1 seismic zone

With the help of the past seismic history, Bureau of Indian Standards has grouped the country into four seismic zones namely,

Zone II: Low intensity zone-It covers about 40.93% area of the country. It consists of major parts of peninsular region and Karnataka Plateau.

Zone III: Moderate intensity zone-It covers about 30.79% area of the country. It consists of Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Odisha, Andhra Pradesh, Tamil Nadu and Karnataka.

Zone IV: Severe intensity zone-It covers about17.49% area of the country. It consists of parts of Jammu and Kashmir, Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar, West Bengal, parts of Gujarat, small portions of Maharashtra near the coast and Rajasthan.

Zone V: Very severe intensity zone-It covers 10.79% area of the country. It consists of the entire north-eastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands.

II. LITERATURE REVIEW:

Birajdar and Nalawade (2004) studied unstable behaviour of buildings resting on hill slopes. They analysed twenty-four RC building frames with 3 completely different configurations as Step back building, Step back building located at a slope of twenty-seven degree with the Horizontal. They studied the unstable response of buildings with variable storey starting from four to eleven (15.75m to 40.25m), carries with it 3 bays on slope direction and one bay across slope, settled in unstable zone III.

Rayyan-Ul Hassan and H.S.Vidyadhara (2013) studied the impact of earthquake on six totally different models resting on plain and sloping ground that are clean frame model, building with initial soft floor and different floors with brick infill wall and building with initial soft storey and different storeys with brick infill and additionally supplied with shear wall at corners. The numbers of bays in horizontal direction were unbroken four with twelve numbers of stories and every one building were set in seismic zone V.

Ravikumar C. M et al. (2012) studied seismic performance of RC buildings within which they contemplate vertically irregular buildings resting on plain ground and buildings resting on slopes for which 2 kinds of configurations were thought of particularly buildings resting on diagonal ground in X-direction and buildings resting on diagonal ground in Y-direction. The amount of bays in X-direction and Y-direction were unbroken five and four severally, with three levels and set in severe zone V. The performance of those buildings was studied by linear analysis mistreatment code IS 1893 (part-1) 2002 on sloping ground area unit additional susceptible to earthquake than the buildings resting on plain ground.

Sunilsinghrawat (2015) In his study, the analysis of G+3 and G+4 buildings on varying slope angles i.e.,0°,7.5°,15°,22.5° and 30° has been conducted. Both type of building configurations (step back and step back setback) has been considered. The seismic forces are considered as per IS: 1893- 2002. The buildings are considered in seismic zone IV and damping ratio 5%. Seismic analysis has been done using Linear Static, Linear Dynamic method. 3D analytical model of buildings have been generated and analyzed using structural analysis tool "STAAD Pro 2007" to study the effect of varying height of columns in ground storey due to sloping ground. The response parameters base shear, top storey displacement, shear in bottom storey column, time period are critically analyzed to quantify the effects of various sloping ground. It is found that column on the higher side of slope i.e., short columns are subjected to large shear force than longer columns on lower side. The step back setback buildings performed better than step back buildings under earthquake forces. The base shear and top storey displacement in step back setback buildings is much lower than the setback buildings on the sloping ground.

III. OBJECTIVES:

1. To study the seismic behaviour of the differently configured structures on hill slope.
2. To compare the seismic behaviour of hill structures with regular structures on flat ground
3. To explore modifications in hill structures to avoid stiffness
4. To compare base shear, deflection, lateral load and story drift of sloping ground building to flat ground building.

Type of frame	Special moment resisting RC frame SMRF) fixed at the base
Seismic zones	III , IV
Number of storey	G+10,G+5 storey
Floor height	3 m
Depth of Slab	150 mm
Size of beam	(300 × 400) mm
Size of column	(400 × 400) mm
Spacing between frames in x-direction	3 m
Spacing between frames in y-direction	3 m
Materials	M 25 concrete, Fe 500 steel and
Infill	Masonry
Thickness of external infill walls	230 mm
Thickness of external infill walls	115 mm
Density of concrete	25KN/m3
Density of infill	20 KN/m3

Table 1- Description of model

Type of soil	Medium soil
Seismic zone	As per IS (1893-2002)
Seismic zone factor, Z	For zone III,IV: 0.16,0.24
Importance Factor, I	1.2,1.2
Response spectrum analysis	Linear dynamic analysis
Plinth height above ground level	3 m
Type of the building	SMRF(Special moment resisting RC frame)

Table 2 – Parameters of model

- **Materials used:**

1) Concrete

I Concrete with following properties is considered for study.
Characteristic compressive strength (fck) = 25 MPa
Poisons Ratio = 0.2
Density = 25KN/m3
Modulus of Elasticity (E) = 5000 x √ fck= 25000 Mpa

2) Steel
II Steel with following properties is considered for study.
Yield Stress (fy) = 500 MPa
Modulus of Elasticity (E) = 2x105MPa

3) Masonry infill
III Clay burnt brick, Class A, confined unreinforced masonry
Compressive strength of Brick, FM= 10 MPa
Modulus of Elasticity of masonry (Ei) = 550 x FM= 5500 MPa
Poisons Ratio = 0.15

CONDITION I) when height of structure is G+20

1)Displacement graph,
Slope 45

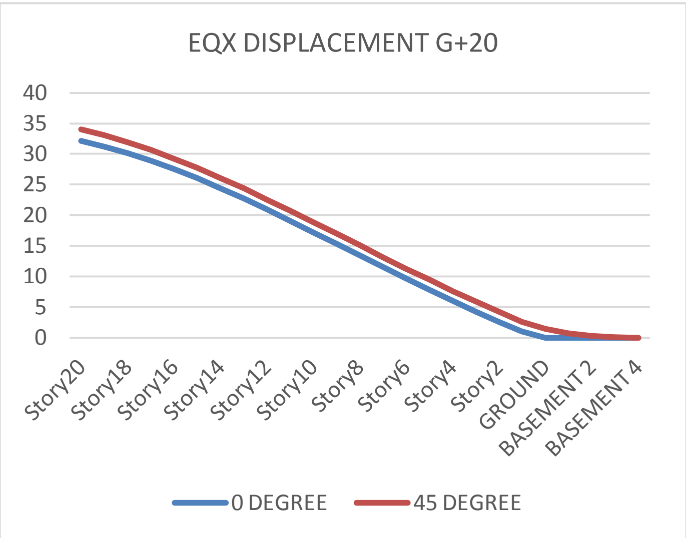

Figure 2 – Displacement of EQX

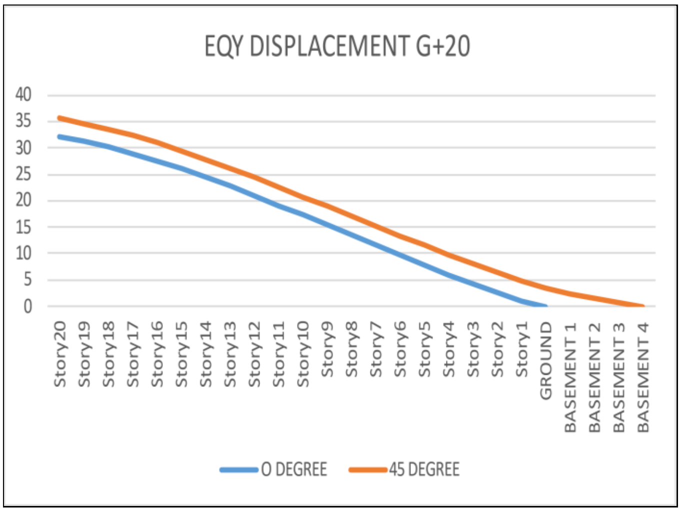

Figure 3– Displacement of EQY

2) Lateral load graph-
Slope 45°

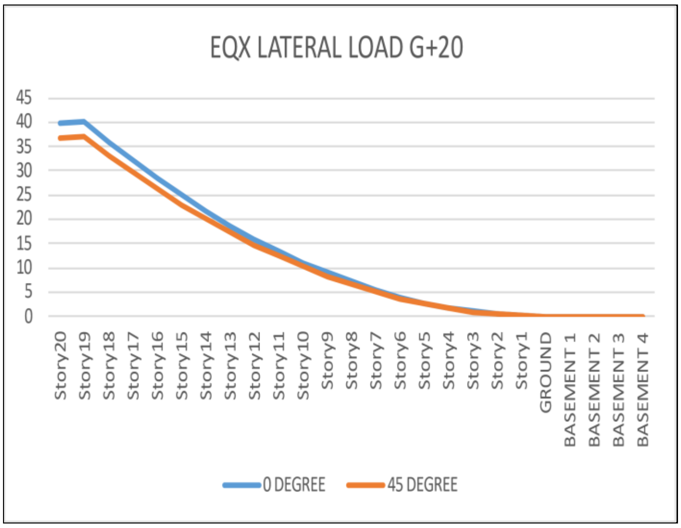

Figure 4 – Lateral loads of EQX

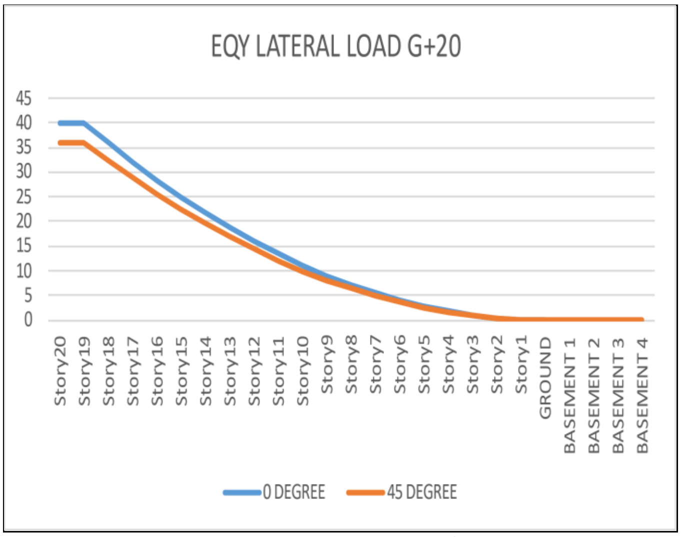

Figure 5 – Lateral Loads of EQY

3) Storey Drift graph-
Slope 45°

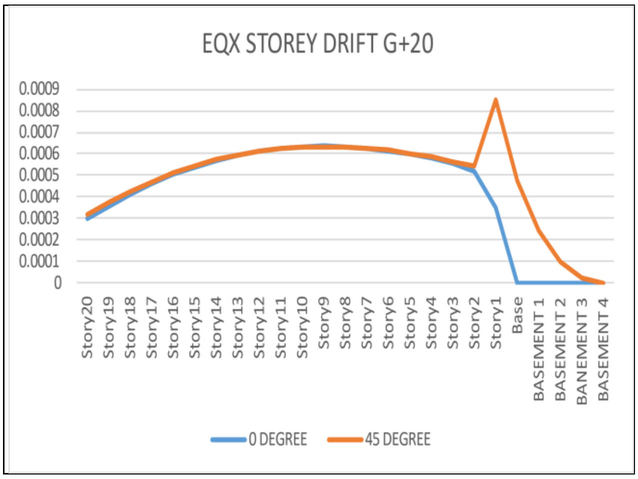

Figure 6- Story drift of EQX

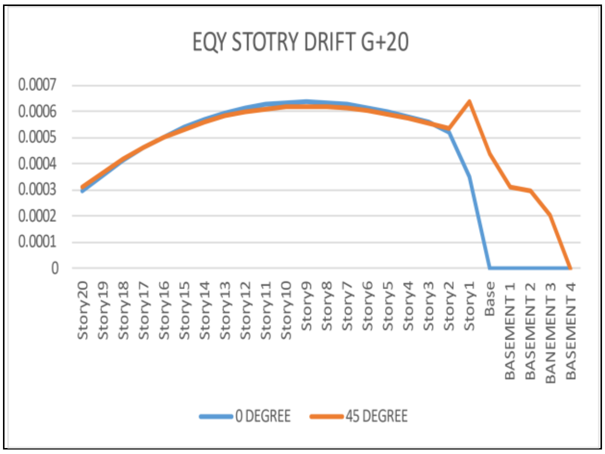

Figure 7- Story drift of EQY

4) Base Shear Result-

SLOPE	EQX	EQY
0 DEGREE	313.4989	313.4989
45 DEGREE	289.7604	282.254

CONDITION II) when height of structure is G+25
1) Displacement graph-
Slope 45°

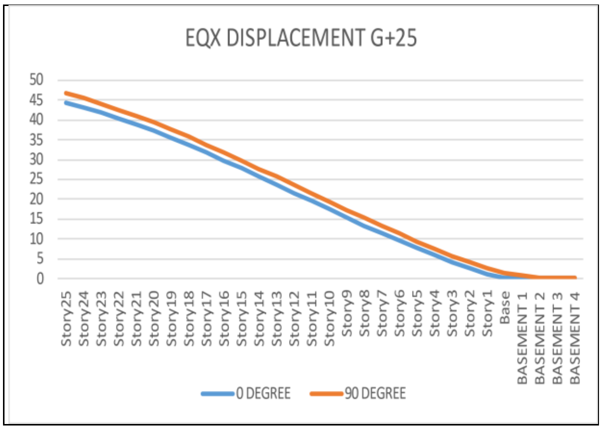

Figure 8 – Displacement of EQX

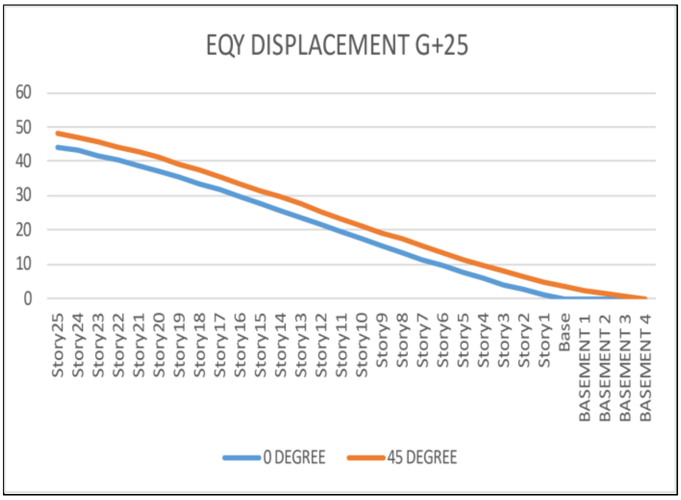

Figure 9 – Displacement of EQY

2) Lateral load graph-
Slope 45°

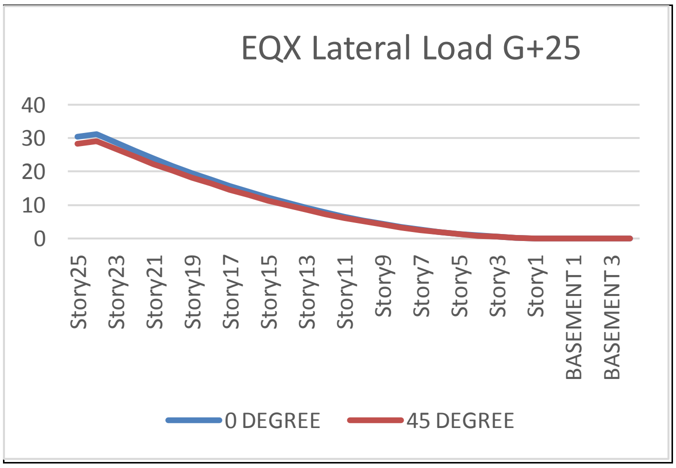

Figure 10 – Lateral loads of EQX

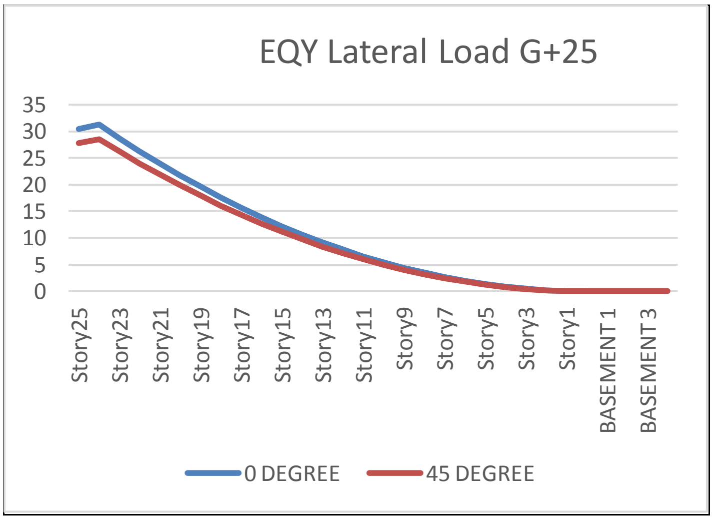

Figure 11 – Lateral loads of EQY

2)Storey Drift graph-
Slope 45°

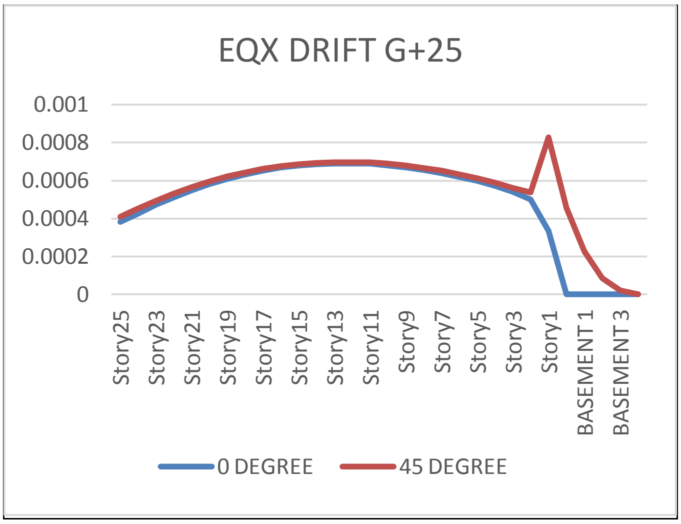

Figure 12- Story drift of EQX

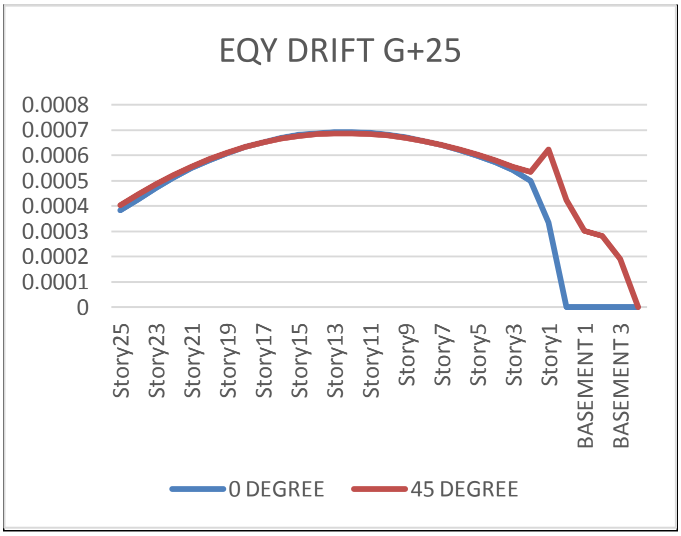

Figure 13- Story drift of EQY

4) Base Shear Result-

SLOPE	**EQX**	**EQY**
0 DEGREE	296.1338	296.1338
45 DEGREE	275.6577	270.8459

Table No.3 Base shear result

IV. CONCLUSION:

- The present study discusses the comparison between behaviour of sloping ground building and flat ground building under seismic load conditions.
- All the models are geometrically modelled and analyzed by using response spectrum method.
- For both sloping ground building and flat ground building we compares factors like height G+25 with G+20 floor with sloping 45°angle.
- As the slope of ground increases displacement, lateral load and story drift are also increase and base shear is decreases.
- As the height of structure increases displacement, lateral load and story drift are also increase and base shear is decreases.

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