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"ANALYZING THE SEISMIC BEHAVIOR OF A REINFORCED CONCRETE (RCC) BUILDING ON SLOPING GROUND WITH VARYING ZONES INVOLVES SEVERAL CRITICAL CONSIDERATIONS."

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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 ETABS2016 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.

Keywords:
RC framed structure, Flat ground, sloping ground, zones, response spectrum method

1. Introduction

In India most part come under hilly area which is highly seismic. In hilly areas structures are generally built on slopingground. When the hilly areas come under the different seismic zones, these buildings are highly endangered to theearthquakes. 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 zonesbuildings are steps back towards the hill slope and at the same time buildings may have plane ground also. Analysis ofhilly slope buildings is somewhat different than the flat ground level buildings, since the column of such building restsatdifferentlevelsonthe slope.

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

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 andconstruction 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 instep-back configuration.At the location of setbacks, an increase in thestress 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 theperformance of the hill building in different configurations has not been studied thoroughly. Also, IS 1893 (1984) andIS 1893 (Part 1): 2002; recommend that buildings with geometrical irregularity and or having irregular distribution ofmass and stiffness should be analysed

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by modal analysis and torsional shear should be accounted separately, but fails tocapture the true response of the structure. Thus, in order to get the realistic behaviour of hill buildings subjected to seismic load, a three-dimensional modeling 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 behaviors' of hill buildings, linear and non-linear dynamic analysis should be carried out. In the present study three-dimensionalmodelling of two different configurations of hill buildings has been undertaken and the effect of plan aspect ratio hasbeen 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 column sat foundation level, fundamental time period, maximum top storey displacements, storey drifts and storey shear in buildings and compared within the considered configurations of hill buildings.

1.1 Seismic zones

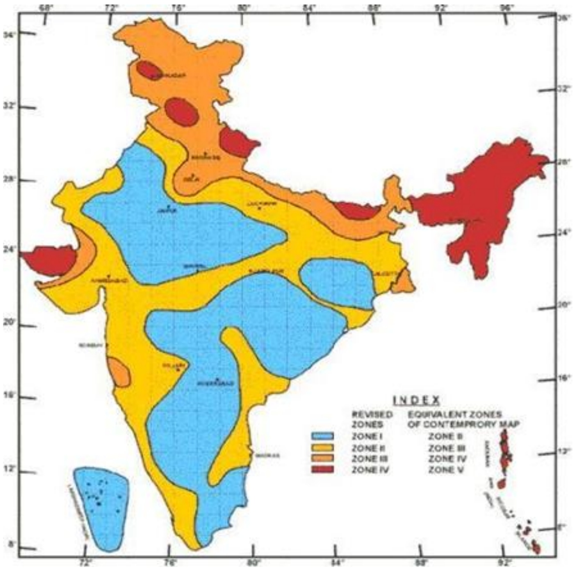

Fig.1seismic zone

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

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, WestBengal,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 andAndaman &NicobarIslands.

1.2 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.

2. Literature

[1] Birajdar B.Gand Nalwade S.S 2004, pp.1472 Results from seismic analyses performed on 24 RC buildings with three different configurations like, Step back building, Step back Set back building and Set back building are presented. 3 –D analysis including torsional effect has been carried out by using response spectrum method. The dynamic response properties i.e. fundamental time period, top storey displacement and, the base shear action induced in columns have been studied with reference to the suitability of a building configuration on sloping ground. It is observed that Step back Set back buildings are found to be more suitable on sloping ground.

[2] Rayyan- Hasan Siddiqui and H. S. Vidyadhara (IJERT), 2013 Earthquakes in different parts of the world demonstrated the disastrous consequences and vulnerability of inadequate structures. Many reinforced concrete (RC) framed structures located in zones of high seismicity in India are constructed without considering the seismic codal provisions. The vulnerability of inadequately designed structures represents seismic risk to occupants. The main cause of failure of multi-storey multi-bay reinforced concrete frames during seismic motion is the soft storey sway mechanism or column sway mechanism. The seismic inertia forces generated at its floor levels are transferred through the various beams and columns to the ground.

[3]Ravikumar C M and Babu Narayan KS, Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings, Architecture Research, 2012 Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. The present paper made an attempt to study two kinds of irregularities in the building models namely plan irregularity with geometric and diaphragm discontinuity and vertical irregularity with setback and sloping ground. These irregularities are created as per clause 7.1 of IS 1893 (part1)2002 code. In Oder to identify the most vulnerable building among the models considered, the various analytical approaches are performed to identify the seismic demands in both linear and nonlinear way. It is also examined the effect of three different lateral load patterns on the performance of various irregular buildings in pushover analysis. This study creates awareness about seismic vulnerability concept on practicing engineers.

[5]Achin Jain and Dr.Rakesh Patel (2017) The research paper investigates the seismic behaviour of multi storey buildings on sloping ground considering soil-structure interaction. The analysis of a G+4 storey RCC building on varying slope angles i.e., 00, 100, 150, 200, 250 and 300 is studied and compared with the same on the flat ground. This analyse different soil condition. It has been observed that the footing columns of shorter height attract more forces, because of a considerable increase in their stiffness, which in turn increases the horizontal force (i.e. shear) and bending moment significantly. Thus, the section of these columns should be designed for modified forces due to the effect of sloping ground. The present study emphasizes the need for proper analysis of structure resting on sloping ground for different soil conditions like Soft Clay, Hard Clay, Dense Sand and Rock. Overall displacement of the structure with respect to different sloping ground configurations is analysed and time period is also analysed

3. Methodology

Analysis of step-back buildings resting on the sloped terrain is done using ETABS2016.Seismic parameters like maximum story displacement, story drift, lateral load and base shear are calculated.

1. Open new project.
2. Set the units and code of practice.
3. Create the model.
4. Define and assign member properties.
5. Define and assign support conditions.

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6. Define and assign loads with load combinations.
7. Analyze the model.
8. Check the model.
9. Run the model.
10. Generate output results.

3.1 Zone wise analysis of structure:

3.1.1 Description and parameters of model:-

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

Table1-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

3.2 Materials used: -

Concrete-

Concrete with following properties is considered for study

Characteristic compressive strength (fck)=25MPa
Poisons Ratio =0 .2
Density=25KN/m3
Modulus of Elasticity (E)=5000x√ fck=25000Mpa

Steel-

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

Masonry infill-

Clay burnt brick, Class A,
Confined unreinforced masonry Compressive strength of Brick,
FM= 10 MPa
Modulus of Elasticity of masonry (Ei) =550 x FM=5500MPa
PoisonsRatio= 0.15

Graphs and Results:-

Condition No.1

1) Slope: 0° and 15° Zone:III.

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a) Displacement Graph-

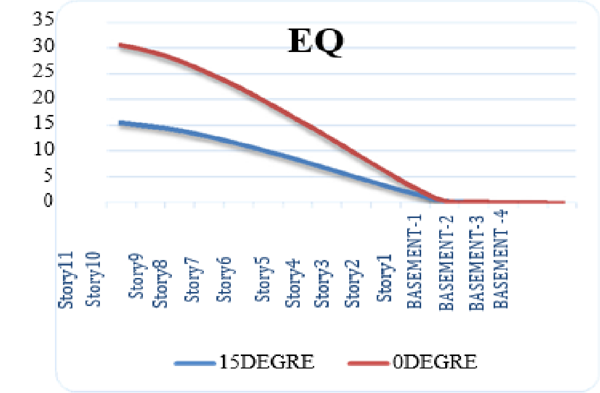

Figure 2–Displacement of EQX

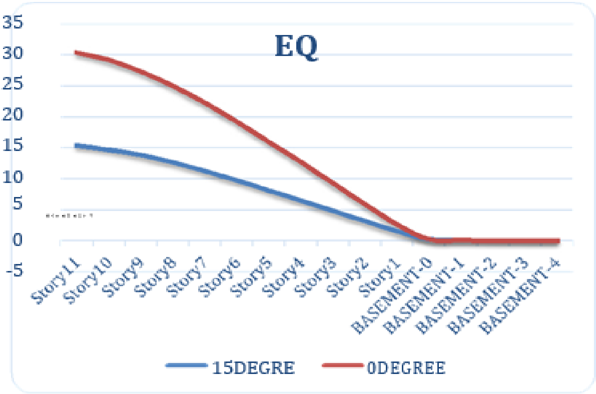

Figure 3 –Displacement of EQY

b) Lateral loads graph:

a) Lateral loads graph:

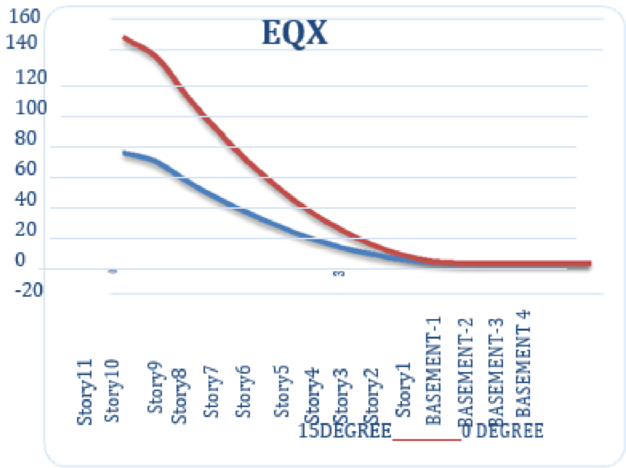

Figure 4 – Lateral loads of EQX

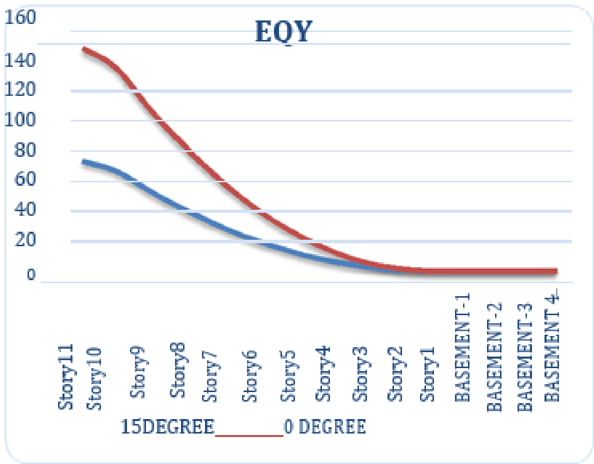

Figure5- Lateral loads of EQY

b) Storey Drift graph-

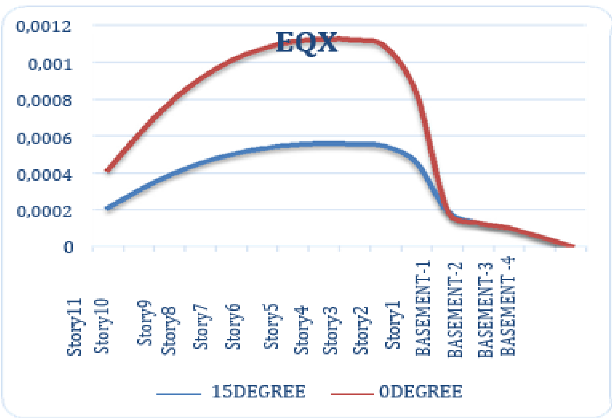

Figure 6-storey drift of EQX

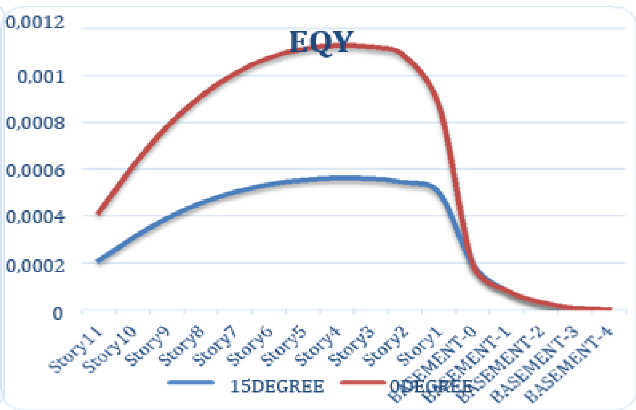

Figure 7-storey drift of EQY

Table3–Base shear Result:

15 °	EQX	328.7766	KN
15 °	EQY	329.6412	KN
0 °	EQX	339.791	KN
0 °	EQY	339.791	KN

Condition No.2

2) Slope: 0° and 30° Zone: IV.

a) Displacement graph-

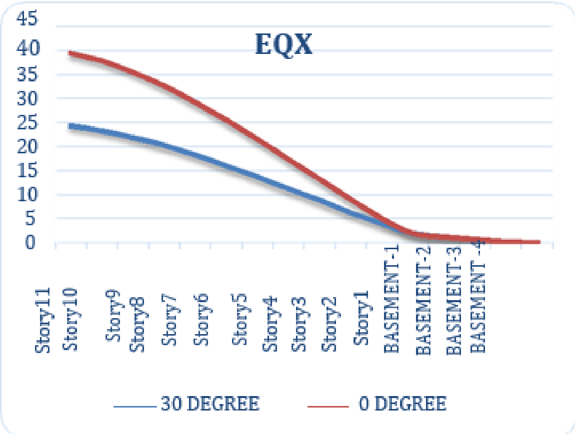

Figure8-displacement of EQX

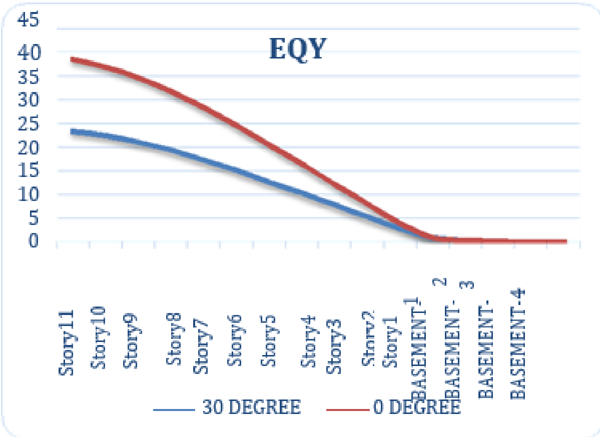

Figure 9-displacement of EQY

b) Lateral load Graph:-

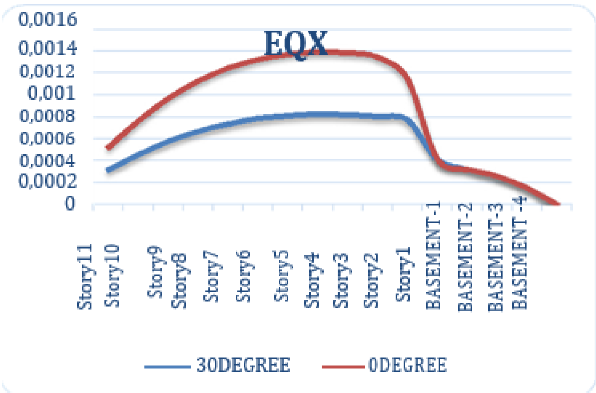

Figure10-lateral loads of EQX

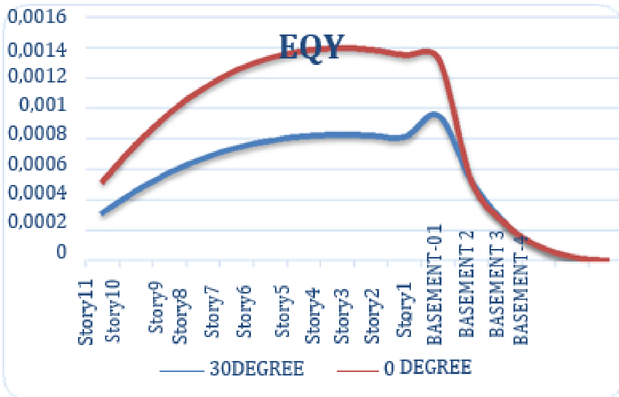

Figure11-lateral loads of EQY

4. 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 modeled and analyzed by using response spectrum method.
- For both sloping ground building and flat ground building we compares factors like zone III with zone V,5 story with10 story,sloping15°angle with 30°angle.
- As the slope of ground increases displacement, lateral load and story drift are also increase and base shear is decreases.

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