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SEISMIC ANALYSIS OF RC BUILDING LOCATED IN HILL SLOPE AREA

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ABSTRACT

The buildings on the hills are more susceptible to shear and twisting because of the irregularity and imbalance of the structures. As a result, there is a mismatch between the rigidity and mass center. Observing the impact on an RC structure resting on a hillside is the goal of the current research. Three slopes make up the foundation of the building under consideration. Forces from earthquakes are applied to the models of buildings under consideration. On the analyzed structure models, a nonlinear static pushover analysis is conducted. The performance of the building during seismic excitations is examined in this research through the seismic analysis of an RC building situated in a hilly region.

Keywords – Earthquake Force, Nonlinear Static, Pushover, RC Structure, Seismic Analysis

1. INTRODUCTION

Most buildings in big cities are built on hill slopes with an uneven arrangement of foundation at various elevations since flat land is rare in these areas. extreme weather conditions, cities Buildings in seismically active areas are more vulnerable to earthquake damage if they are perched on hillside slopes. These structures could collapse if dynamic factors that effect structures on hill slopes are not taken into account while designing them. In the vertical and horizontal axes, the stiffness and mass vary erratically. Due to this irregularity, the middle of a storey stiffness and mass do not overlap, and its middle also does not lie on a perpendicular line for floors that are not the same. Such structures exhibit a substantial torsional reaction when subjected to lateral masses. Due to site conditions, buildings on a hillside are divided into several categories based on the height of their columns, which distinguishes the rigidity of the columns of the same floor. The rigid, short columns draw greater forces, which causes more harm [2].

According to India's geographical data, an estimated 54% of the country's area is earthquake-prone. Asia is being pushed towards by the Indian subcontinent at a pace of around 47 millimeters per year. The most damaging of all natural disasters is an earthquake. Because it affects such a vast region, its effects are the most traumatic. Earthquakes are caused by a huge quantity of elastic energy being released, which causes a quick and brief motion of the earth. In general, earthquakes result in a significant loss of life and property and disrupt a number of important services, including water supply, sewage systems, electricity, and communication. Typically highly uneven and asymmetrical structures may be seen in mountainous areas. The heart of the bulk of buildings on the hills are distorted and asymmetrical due to the hillside structures. resulting in severe shear and torsion, and their centers of stiffness do not coincide. There are three typical building arrangements used in hilly areas: step back, setback, and step back-setback. The current study examines how a building responds to seismic loads. The building's configurations under consideration are subjected to a non-linear static pushover analysis, and the results in terms of displacement at the performance point are then contrasted within those configurations [1].

The previous century's economic growth in hilly locations has necessitated a rethinking of building design, material selection, and construction technique. Because plain ground is scarce on hills, residences erected on steep slopes present unique structural and construction issues. Construction of RC framed buildings on steep slopes demonstrates structural behaviour that differs from that of the plain ground. Buildings are typically erected in a step-back design due to steep slopes, however a combination of step-back and setback building configuration is also frequent. These structures' asymmetrical design and the eccentricity brought on by the different alignments of the centre of mass and stiffness at each floor result in the formation of torsional moments.

These are the main objective of the study:

- To investigate the seismic response of RC structure resting on various ground slope.
- To investigate the impact of structure with flexible base and bracings.

2. Modelling

2.1. Building description

Analyses are being done on a nine story RC frame skyscraper. At street level, the structure has 3 above ground levels and 6 below. On hard rock, the structure is located in seismic Zone-III. In the study of all constructions, 300x600 mm columns and 270x400 mm beams are taken into account. In all models, the slab thickness is taken to be 150 mm on all levels. The distance between floor levels is 3 m, and the exterior and internal infill thicknesses are expected to be 25 mm and 15 mm, respectively. The moderate seismic zone (III), zone factor 0.16, importance factor 1.0, 5% damping, and response reduction factor 3.0 are the parameters employed in the seismic study.

2.2. Material Properties and assumptions

Grade of Concrete- M25

Grade of Concrete -25 N/mm2

Modulus of Elasticity of concrete- 2.5E10 N/mm2

Grade of Steel -Fe 415

Yield Strength of steel -415 N/mm2

Minimum Tensile Stress of steel -415 N/mm2

The analysis was conducted on the following presumptions:

- It is assumed that the substance is uniform, elastic, and isotropic in nature.
- Concrete's Poisson's ratio is assumed to be 0.3, and its elastic modulus is estimated to be 25000 N/mm 2.
- The steel utilised has a yield stress of 500 N/mm 2.
- In all of the simulated setups, a rigid-frame diaphragm with three DOFs per floor is used.
- There are six degrees of freedom (DOF) per node of the beam element at each nodal location in the frame, three translational and three rotational.
- According to IS 1893 (Part 1): 2016, the impact of unintentional eccentricity and torsion is taken into account.

2.3. Computer modeling of structures

To explore the realistic behaviour of buildings lying on slopes vulnerable to seismic reaction, building structures have been studied using the programme SAP 2000 V14.0.0. There has been a numerical investigation, and the outcomes are in strong agreement with the experimental values. The joints are regarded as stiff. A building's foundation is seen as a fixed and adaptable support. The physical characteristics of structural components are taken into account by various models. For all of the model buildings, the seismic parameters used in the non-linear static analysis follow IS 1893 (Part 1): 2002 [1]. Zone III has building models that are perched on hillside.

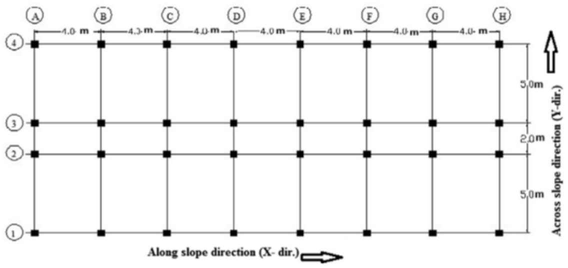

Figure 1– plan view

3. ANALYSIS

3.1. General

Non-linear static analysis was performed on several building configurations in the section before. In order to evaluate the seismic performance of structures, a parametric analysis was done. The studies' findings are addressed in terms displacement at the performance point in this part, and they are contrasted across various building configurations that were taken into consideration.

3.2 Variations in the ground's slope

The ground slope of the buildings in this category are different from one another. A 12°, 24°, and 36° slope is maintained on the ground. In terms of base force and displacement, the impact of raising the ground slope is shown. Table displays the findings from the analysis

3.3 Displacement at performance point

With an increase in ground slope from 12, 24, and 36, both structures with fixed bases and those with flexible bases see a drop in displacement value as a result of the restriction of columns.Because of soil damping, the values of displacement obtained for structures with flexible bases are substantially larger than those obtained for structures with fixed bases. The dampening provided by the earth causes a very significant increase in the building's responsiveness in terms of displacement when the fixed basis of the foundation is replaced with a flexible base.

3.4. Static pushover curve

A static pushover curve that displays the capacity curve and demand curve for the building is produced following modelling the buildings and non-linear static pushover analysis in SAP 2000. The "performance point" is the location where these two curves cross. The curve also provides values for different parameters such as base force, displacement, spectral acceleration, spectral displacement, etc. at the structure's performance point.

4. Results and discussions

4.1 structure resting on various ground slope with fixed support

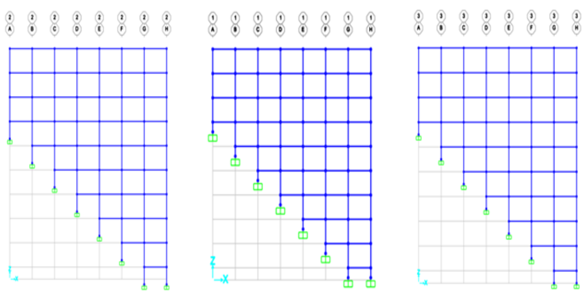

Figure 2 - Ground slope @ 12° 24°, and 36°

Storey level	12° (mm)	24°(mm)	36°(mm)
1	8.54	4.3	3.1
2	15.6	13.23	10.05
3	23.25	18.67	13.83
4	29.45	22.36	19.59
5	37.6	35.23	25.4
6	46.23	42.24	31.82
7	52.21	48.29	38.94
8	66.53	58.39	48.47
9	74.7	65.2	54.74

Table 1 - Maximum Storey displacement for fixed base

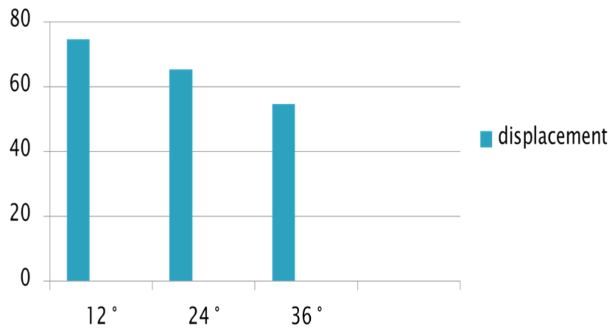

Figure 3- Variation of displacement values for an increase in ground slope for a structure with a constant foundation.

4.2 Structure with flexible base on various ground slope

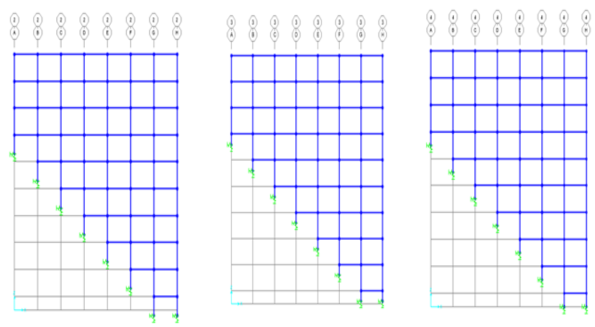

Figure 4 - Ground slope @ 12° 24°, and 36°

Storey level	12° (mm)	24°(mm)	36°(mm)
1	17.7	13.6	11.5
2	27.45	19.90	15.26
3	37.90	25.40	18.34
4	52.06	34.14	27.11
5	58.23	50.02	37.7
6	66.67	60.59	55.30
7	77.64	68.43	62.34
8	88.34	80.23	75.85
9	93.23	89.6	86.2

Table 2 - Maximum Storey displacement for flexible base without bracings

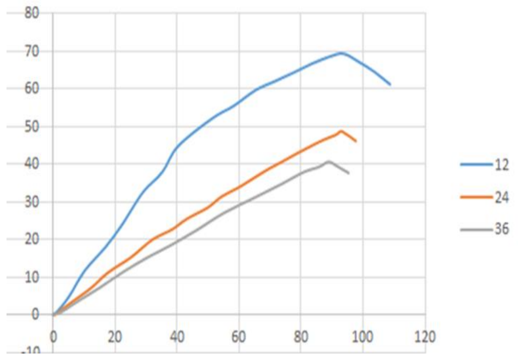

Figure 5- Push over curve

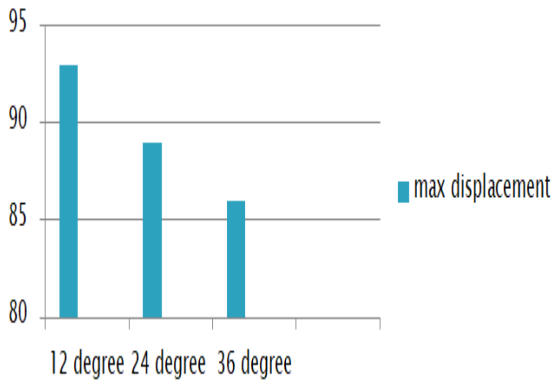

Figure 6- Changes in displacement values for an increase in ground slope for a structure with a flexible foundation without bracings.

4.3 Structure with flexible base with bracings on various ground slope

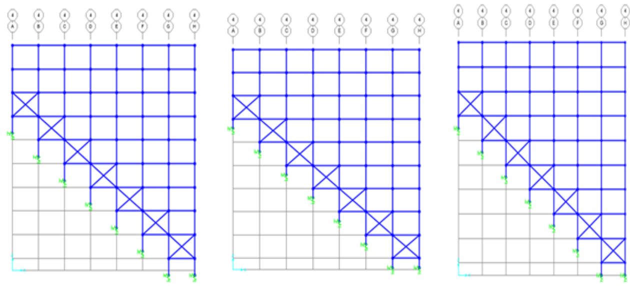

Figure 7 - Ground slope @ 12° 24°, and 36°

Storey level	12° (mm)	24°(mm)	36°(mm)
1	24.6	16.1	12.32
2	32.1	26.5	17.3
3	42.4	34.9	31.8
4	53.2	45.2	40.2
5	60.8	48.9	45.7
6	69.3	59.1	54.5
7	75.4	62.5	58.8
8	84.3	69.3	65.4
9	88.03	86.45	83.21

Table 3 - Maximum Storey displacement for flexible base with bracings

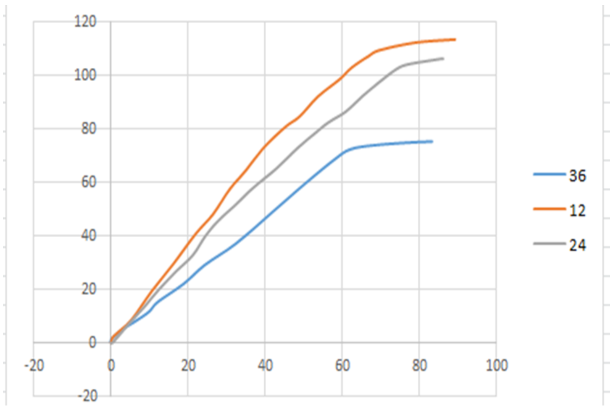

Figure 8- Push over curve

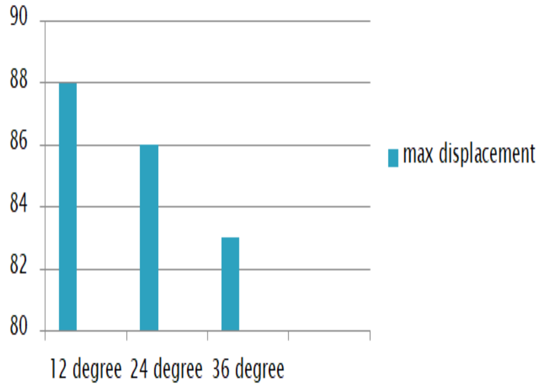

Figure 9- Changes in displacement values for an increase in ground slope for a structure with a flexible foundation with bracings.

4.4 Comparison

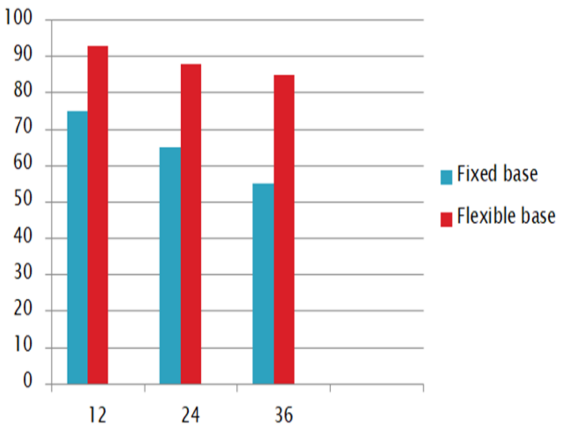

Figure 10 – comparison between fixed and flexible base

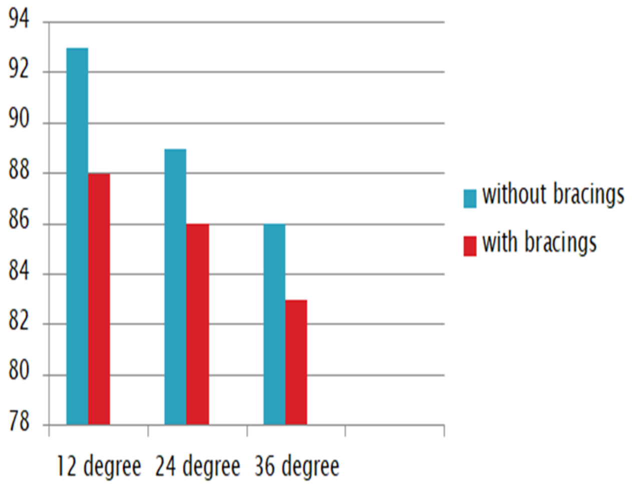

Figure 11 – comparison between flexible base with bracings and without bracings

The maximum displacement of the building will typically be further reduced if the flexible foundation is further braced, such as with a combination of a braced frame and shear wall. This is due to the bracing system giving the structure extra lateral stiffness, which lowers overall lateral displacement during an earthquake.

5. CONCLUSION

This research involves the seismic analysis of an RC building situated in a mountainous environment. The major findings and conclusions from the few analytical studies conducted for the current study are presented in this part.

- The value of displacement reduces with increasing ground slope.
- When compared to a fixed support, a flexible base has a higher displacement value.
- When compared to flexible bases with braces, the displacement value for flexible bases without braces is higher.

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[2] Jammula, D. and Konda, R. (2021). “Seismic analysis of G + 9 framed structures made of reinforced concrete resting on hill slopes” , *Materials Today: Proceedings , 484 , 1-12*