Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, October : 2023

DESIGN AND ANALYSIS OF MULTI STOREY BUILDING ON SLOPING GROUND AND FLAT GROUND BY USING ETABS

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Abstract: Multi-storey high-rises are being built in hilly terrain in developing countries like India because of the scarcity of flat land caused by urbanisation and industrialization. Hilly topography results in buildings that are not perfectly rectangular and are often asymmetrical in both the vertical and horizontal dimensions. Moreover, earthquake damage to such structures is more likely to occur in steep terrain. The purpose of this investigation is to compare the behaviour of various building types when placed on level and sloping surfaces. Hilly terrain necessitates a slightly different layout for buildings than would be used on level terrain. Torsionally linked and exceedingly irregular in plan, hilltop buildings are more likely to be destroyed in an earthquake than their lowland counterparts.

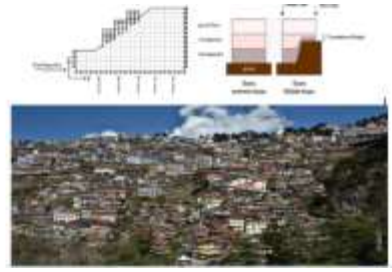
This investigation of the behavior of irregular multistorey buildings in zone V compares these structures to their more conventional flat-ground counterparts and analyzes the effects of 50- and 100-degree slopes. Hillside construction is contrasted with flat-ground construction. These models are developed with the help of the structural analysis software ETABS. The data is analyzed using a response spectrum analysis. This job involves the estimation, tabulation, and analysis of displacements, moments, storey shear, and storey drifts.

KEY WORDS: irregularity, sloping ground, sloping angles 5^0 10^0, ETABS software, Response spectrum analysis.

I. INTRODUCTION

Seismic stress is the most horrific and fleeting force of nature. Loss of life and property during earthquakes is not caused by the tremors themselves, but by the collapse of nearby structures. While earthquakes can cause damage to any building, the risk is especially high for those situated on slopes or other areas with an inclination away from the ground. The larger horizontal powers on the difficult side's shorter parts account for this. Slopes make it difficult to forecast either the horizontal or vertical placement of a building, making them less reliable than fields.

Extensive destruction was brought about by the earthquakes that hit Sikkim (2011), Doda (2013), and Nepal (2015). Multi-storey RC limited structures are necessary because of the area's fast urbanization, rising prosperity, and therefore high population density. Since level property is in short supply, locals have become creative by building on hillsides. Work on display shows the results of a test conducted using Response range inquiry in supplementary analysis and outline programming on a 10-storey, restricted building that is inclined between 120 and 140 degrees with respect to the ground and is exposed to sinusoidal ground movement.



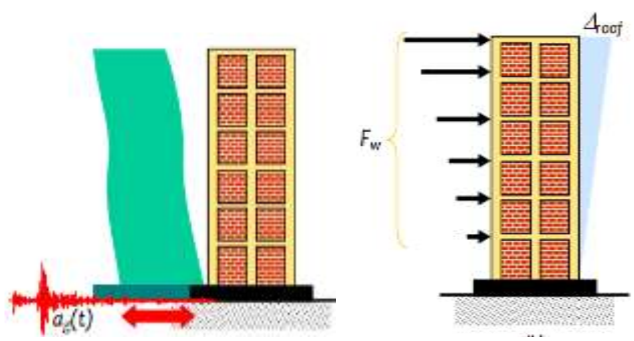
Buildings on sloping ground

Dynamic actions on buildings-wind and earthquake

Buildings are subject to dynamic forces from wind and earthquakes. There is no overlap between wind design and earthquake design. Wind design, in which the building is subjected to a pressure on its exposed surface area, is an example of force-type loading, which is at the foundation of the initiative philosophy of structural design. However, in earthquake design, the building is prone to random ground motion at its base (Figure 1.1), which generates inertia forces and stresses throughout the structure. This is an example of a displacement load. In the case of a force-type loading, like that imposed by wind pressure, the demand on the building is force (i.e., the vertical axis), whereas in the case of a displacement-type loading, like that imposed by earthquake shaking, the demand is displacement (i.e., the horizontal axis).

The wind's effect on the building is composed of a non-zero mean force and a small but non-negligible oscillation component. Therefore, the building may experience issues in strong winds.

Minor changes in the stress field, with stresses only reversing with a change in wind direction after a considerable amount of time has passed. However, the earthquake ground motion is cyclic with regard to the center of the building. This results in the stresses in the building going through many complete reversals within the brief duration of the earthquake.



Effects of earthquake ground movement at the building's foundation and wind pressure on its exposed areas are different due to the building's design.

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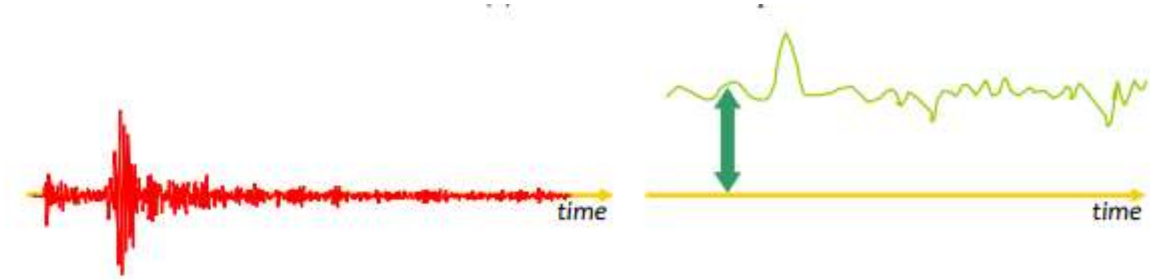


Differences in the mean velocities of earthquake ground motion and wind and cyclone pressure over time, as well as the oscillatory nature of these two variables, inform the design process.

ETABS Software

The revolutionary new ETABS is unparalleled in the realms of structural analysis and building design. In addition to its 40 years of development, the most recent version of ETABS offers users state-of-the-art 3D object-based modeling and visualization tools, lightning-fast linear and nonlinear analytical power, advanced and comprehensive design capabilities for a wide variety of materials, and insightful graphic displays, reports, and schematic drawings that make it easy to read and comprehend analysis and design results.

ETABS is an all-inclusive design environment for engineers, covering every step of the process from brainstorming through documentation. Simple drawing commands have made it possible to rapidly generate floor plans and elevations, making model creation a snap. Either a CAD file or a CAD design can be imported into ETABS and used as a starting point for a new model. In order to quickly analyze increasingly big and complex models, the cutting-edge SAP Fire 64-bit solver supports nonlinear modeling techniques including construction sequencing and temporal effects (for example, creep and shrinkage).

This includes designing steel and concrete frames (with automated optimization), composite beams and columns, steel joists, and concrete and masonry shear walls, and checking the capability of steel connections and base plates. Models can be rendered photo-realistically, and the resulting image can be projected onto the structure itself. Produce detailed and individualized reports for all analytical and design output, as well as conceptual construction drawings such as frame plans, schedules, details, and cross-sections for concrete and steel buildings.

Objective of the study

Following are some of the project's primary goals:

- The seismic behaviour of multi-storey buildings will be analysed in accordance with IS 1893:2002.
- To emphasise the sharp contrast between the horizontal ground and the slanted structures at 50 and 100 degrees.
- With the goal of learning more about how Zone V structures constructed to IS 1893:2002 handle earthquakes.
- The study's goal is to compare the effects of 50-degree and 100-degree slopes on the torsion, bending moment, and drift of stories inside a building.
- Study of the ETABS structure by use of spectral response analysis.

II LITERATURE REVIEW

P. Manjunath and Yogeendra R. Holebsgilu

A 10-storey, 3D model with four bayous running in the Y axis and six straights running in the X axis is depicted in this test. Slope angles range from 0 degrees to 30 degrees. ETABS 2015 software is used to deconstruct the model and make plans for it in seismic zone V with a variety of soil types. They reasoned that by increasing the base incline and soil stiffness, construction efficiency would increase and seismic weight would drop.

Patel et al. (2014)

ETabs with symmetric and asymmetric model were used to examine the impact of column height fluctuation due to sloping terrain and the effect of concrete shear wall at various sites during earthquake. To examine the effects of seismic load and to assess seismic susceptibility via pushover analysis, lateral load analysis was carried out in line with seismic code in the present study. Buildings on sloping ground are more likely to sustain damage if plastic hinges aren't installed on columns at the foundation and on beams at the performance point of each floor. There is a greater concentration of plastic hinges in the building's most asymmetrical orientation. The storey displacement of buildings on sloping ground is greater than that of buildings on level ground or with a shear wall. The presence of the shear wall significantly reduces the base shear and lateral displacement.

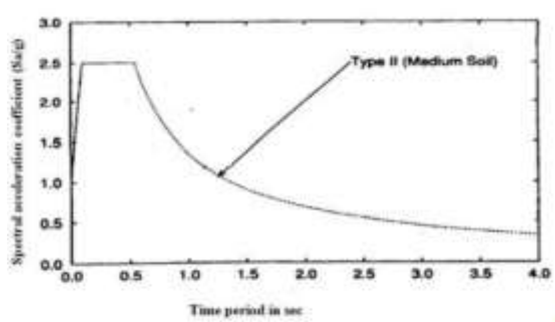
Sandip Doijad and Surekha Bhalchandra (2015)

This study examined the seismic performance of RC buildings with a variety of Shear divider designs on both flat and inclined surfaces. The G+8 narrative's RCC was one potential source for their investigational vehicle. The slopes of 9 degrees, 18 degrees, and 27 degrees are considered in this analysis of slanted and level surfaces. The analysis was performed in SAP2000, and it was found to be suitable for use on medium soil in Zone II.

III METHODOLOGY

Response spectrum method

An idealized one-degree-of-freedom system's maximum reaction to periodic and damping-dependent earthquake ground motions. IS 1893-2002 (part1) serves as the framework for our analysis. Type of soil and seismic zone factor according to IS 1893-2002 (part1). The usual response spectra for the soil type in question are used in the analysis by the ETABS 2013 program. In the following diagram, time is plotted against the spectral acceleration coefficient (Sa/g) to show the usual spectrum of response for a medium soil type.



Spectral response at 5% dampening for a medium soil type

This approach allows for the multiple modes of response of the building to be taken into account in the frequency domain. This is required by many jurisdictions for all but the smallest and most complex structures. The "harmonic" in a vibrating string is a collection of many different forms (modes), and a computer analysis can be used to determine the modes that contribute to a structure's response. Using the modal frequency and modal mass from the design spectrum, we can determine the total response of the structure by summing the responses of the individual modes. This can be done by calculating the sum of the X, Y, and Z forces acting on the structure. Some common instances of such combined methods are as follows:

- Peak values are summed to produce the absolute value
- SRSS is the square root of the sum of the squares.
- CQC, or full quadratic combination, is an enhanced version of SRSS for modes that are close together.

The loss of phase information during the process of generating the response spectra means that the result of a response spectrum analysis performed on a ground motion's response spectra is typically different from the result calculated from a linear dynamic analysis performed on that ground motion alone.

Complex analyses, such as non-linear static analysis or dynamic analysis, are typically necessary when buildings become too irregular, too tall, or too important to the community in the event of a disaster for the reaction spectrum technique to be adequate.

IVMODELING OF BUILDING

This research examines the performance of G+10 multi-storey buildings in Seismic Zone V. The ETABS 3D model of the multi-storey building is complete.

Basic parameters considered for the analysis are

1. Utility of building : Residential building
2. Number of stories : G+10
3. Shape of building : Rectangular
4. Slopes of the building : 5^0, 10^0
5. Geometric details
   a. Ground floor : 3.3m
   b. floor to floor height : 3m
6. Material details
   a. Concrete Grade : M30 (COLUMNS AND BEAMS)
   b. All Steel Grades : HYSD reinforcement of Grade Fe500
   c. Bearing Capacity of Soil : 200 KN/m^2
7. Type Of Construction : R.C.C FRAMED structure
8. Column : 0.5m X 0.5m
9. Beams : 0.35m X 0.35m
10. Slab : 0.150m

Models in ETABS

Building on Flat Ground

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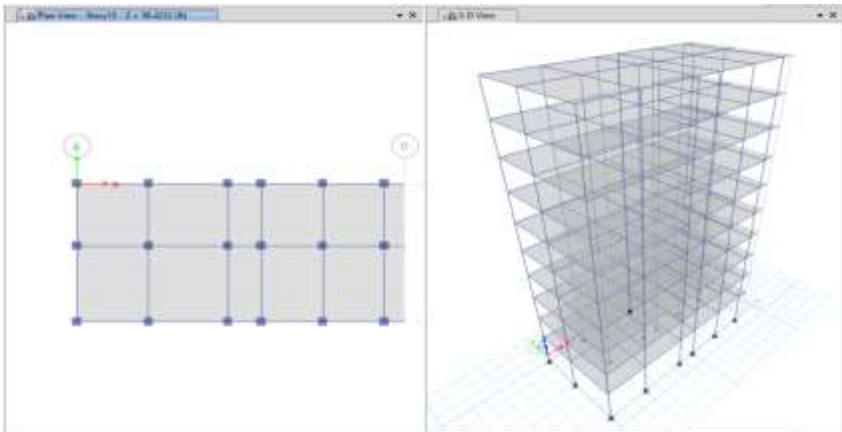
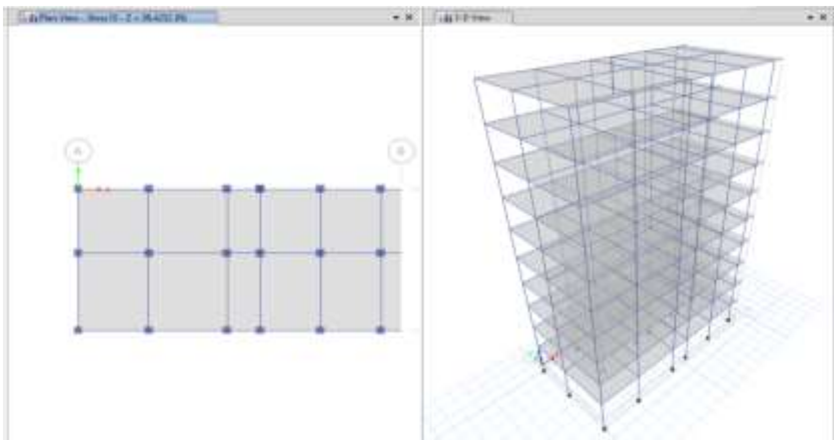
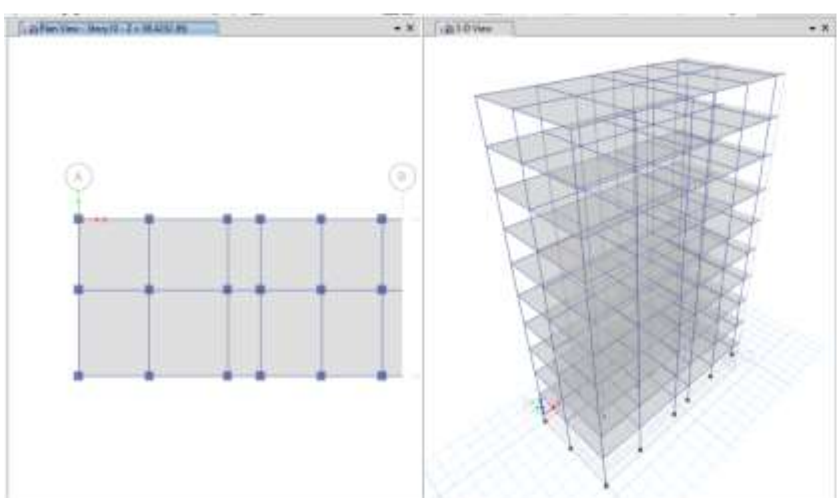


Creating a Structure on a Ground with a Slope of 5^0

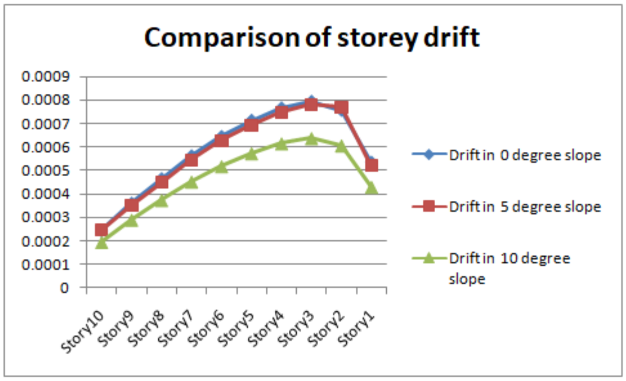


Constructing on a Slope of 10^0



RESULTS AND ANALYSIS

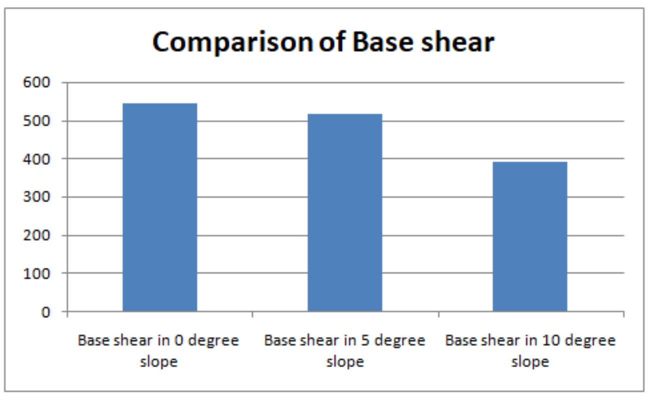
Variation of Drift



Comparison of storey drift

In the preceding graph, the intensity of the drift value is decreasing from the top storey to the bottom storey in zone V seismic condition due to the change of storey drift due to 0, 5, and 10 degrees slope in the case of RSA X loading.

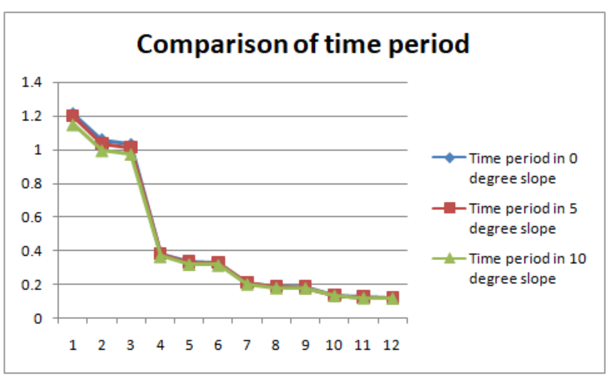
Base shear



Comparison of Base shear

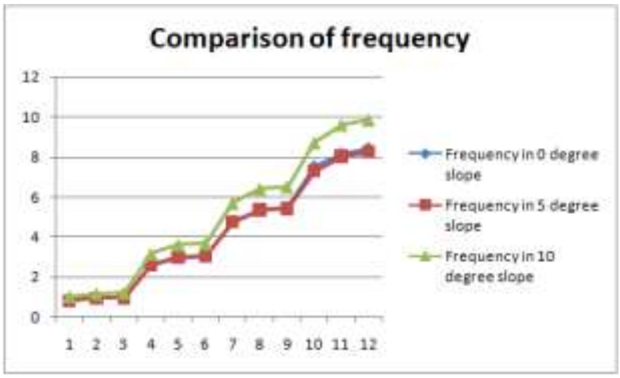
The above graph is a plot of the base shear for RSA X loading, and it can be seen that the strength of the base shear is decreasing as the slope is provided to the building. The 10 degree approach produces fewer values.

Time period



Comparison of time period

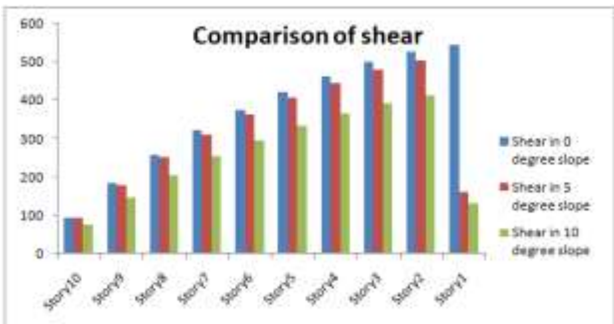
The comparison of time period values are shown in the above graph from this it was observed that the intensity of time period values are decreasing from 1st mode to 12th mode for all the models the intensity of time period is obtained as almost same.



Comparison of frequency

The comparison of frequency for the building models made with different slopes are shown in the above graph from this graph it was observed that the intensity of frequency increases from the mode 1 to mode 12

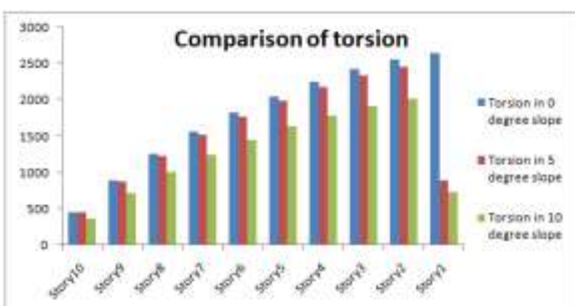
Shear force



Comparison of shear

The comparison of shear variation due to the effect of slope for RSA X is shown in the above plot from this graph it was concluded that by using sloping condition we can decrease the shear values from top to bottom storey of the building optimum value of shear is shown in storey 1 with 20 degree slope condition.

Building Torsion



Comparison of torsion

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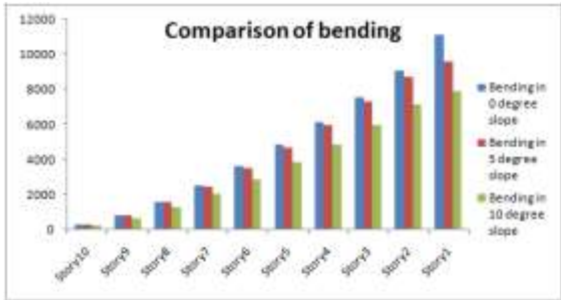
Variation of Bending moment



Comparison of bending

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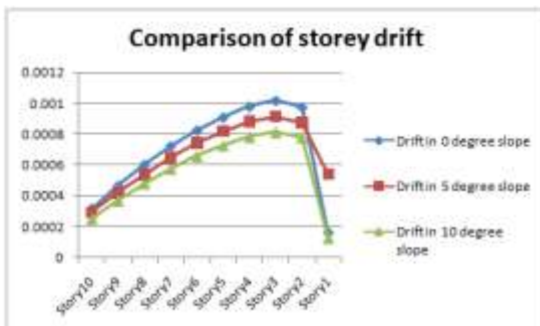
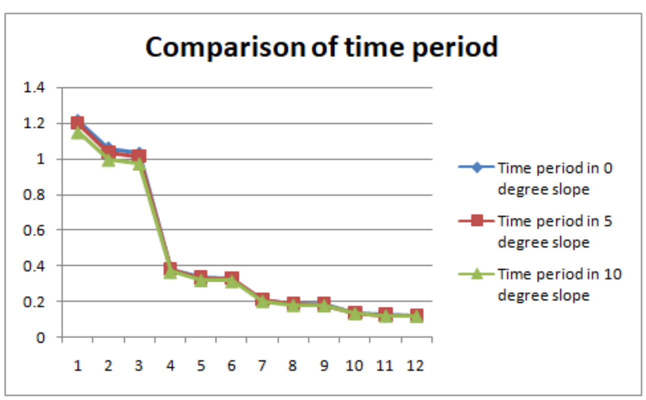
RSA Y Results
Drift



Comparison of storey drift

From the preceding graph depicting the change in storey drift owing to RSA Y loading at 0, 5, and 10 degrees, it can be deduced that the intensity of the drift value decreases from the top storey to the bottom storey in zone V seismic condition as the slope value increases.

Time period



Comparison of time period

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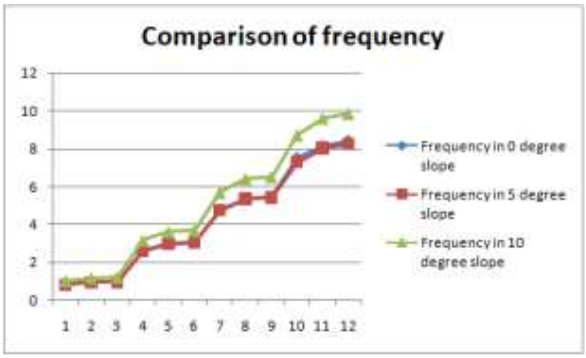
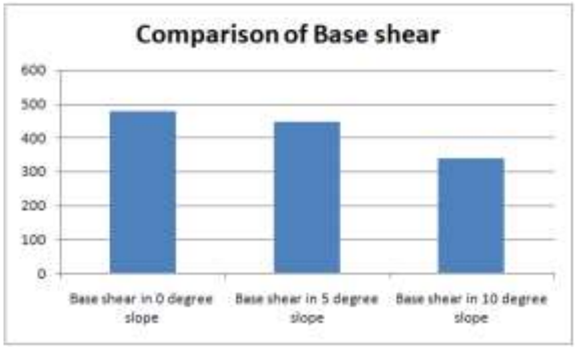


Comparison of frequency

The comparison of frequency for the building models made with different slopes are shown in the above graph from this graph it was observed that the intensity of frequency increases from the mode 1 to mode 12

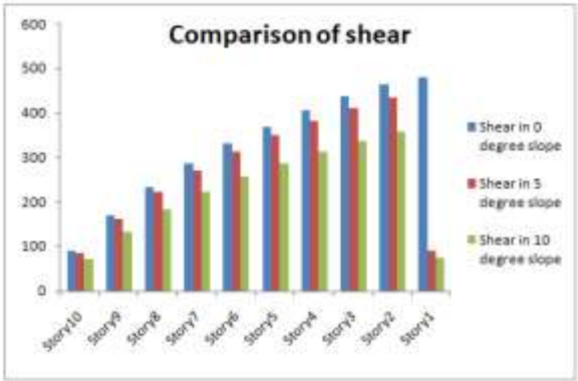
Base shear



Comparison of Base shear

The base shear plot was shown in the above graph for RSA Y loading from this graph it was observed that by providing the slope to the building the intensity of base shear is reducing. Less values are obtained for the 10 degree model.

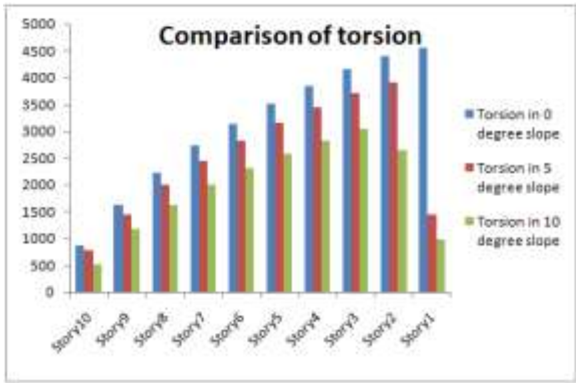
Shear force



Comparison of shear

The comparison of shear variation due to the effect of slope for RSA Y is shown in the above plot from this graph it was concluded that by using sloping condition we can decrease the shear values from top to bottom storey of the building optimum value of shear is shown in storey 1 with 20 degree slope condition.

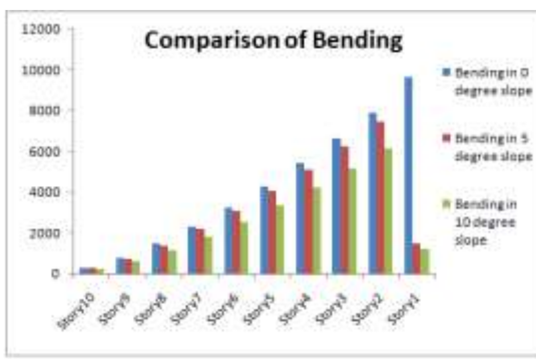
Building torsion (T)



Comparison of torsion

The comparison of torsion variation due to the effect of slope for RSA X is shown in the above plot from this graph it was concluded that by using sloping condition we can decrease the torsion values from top to bottom storey of the building optimum value of shear is shown in storey 1 with 20 degree slope condition.

Bending moment



Comparison of bending

The comparison of bending variation due to the effect of slope for RSA Y is shown in the above plot from this graph it was concluded that by using sloping condition we can decrease the bending values from top to bottom storey of the building optimum value of shear is shown in storey 1 with 20 degree slope condition.

VI CONCLUSIONS

The following findings emerged from the aforementioned investigation:

Drift values in both the X and Y directions are highest on flat land in Zone V. This confirmed that buildings with steeper rooflines are safer in the event of an earthquake.

Lateral loads (Gravity loads) are observed to be lower for sloping buildings compared to buildings on flat ground. Buildings on sloping terrain are found to have lower lateral load ratings due to the presence of setbacks.

Higher values were found for shear force, bending moment, and building torsion in the flat slop building compared to the sloping building. By donating slope, you're helping make the buildings more secure.

Setback buildings on level ground are more stable and less susceptible to damage from lateral load action than similar buildings in other layouts on sloping land.

Less action forces are attracted to set-step back buildings on sloping terrain compared to step back buildings, although setback buildings may still be chosen if the expense of leveling the area is within reasonable bounds.

Looking at the graphs, we can also deduce that buildings on sloping terrain are less vulnerable to earthquake damage than those on level ground.

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