REVIEW PAPER ON SEISMIC ANALYSIS OF MULTISTORY BUILDING FRAME ON SLOPING GROUND

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Abstract – *Due to the current situation's increasing population, city expansion, and lack of level ground, the majority of buildings are frequently built on sloping terrain. When a building is located on a sloping site, the distribution of mass and stiffness in both the horizontal and vertical planes changes. These structures, which are often torsional coupled and positioned on steep hillsides in seismically active regions, are vulnerable to significant damage from ground motion during an earthquake. ETABS 16 software is utilized for model analysis. Models are analyzed on both level and sloping surfaces. The model is first put through a seismic analysis process that involves assigning different load scenarios and combinations. Storey drift, storey shear, overturning moment, and maximum storey displacement are among the study's conclusions that need to be in contrast. A graph was made based on the results of the data analysis. According to Part 1 of IS code 1893:2002, all loads are applied.*

Key Words: Seismic Analysis, ETABS 16, Sloping ground, Response spectrum method, step back frames, step back and set back frames, step back with bracings

1. INTRODUCTION

The structural irregularity in steep areas, seismic forces operate more severely there. Additionally, research has shown that hilly regions are more vulnerable to seismic activity. For instance, the north-eastern states of India. The way that mass and stiffness are distributed throughout the building's horizontal and vertical planes affects how the structure behaves during an earthquake. Both of these characteristics vary irregularly and asymmetrically in hilly regions. Such structures are more vulnerable to shear and torsion in seismically active areas. Plains buildings are not the same as hill buildings. In both the horizontal and vertical axes, they are incredibly asymmetrical and uneven. As a result, they are vulnerable to serious harm from ground motion caused by earthquakes. The idealization of the structure's shape and the loading on it determine the methodology and precision of the analytical results. With a multi-story building resting on a sloping ground, the current work seeks to provide an analytical method for determining the displacements, storey drifts, natural frequency, time period, and foundation shear.

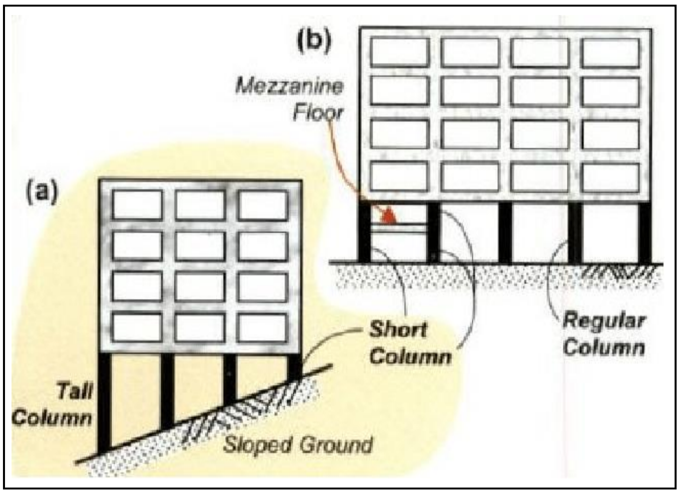

Fig.1. Building Frame with short Column

2. OBJECTIVE OF STUDY

I. To research how variously configured sloping ground buildings behave seismically.

II. To investigate the relationship between changes in the angle of the hillside and variations in the number of storeys for various building frame layouts.

III. To compare the results of story Drift, shear force bending moment, and building torsion of regular and irregular with 10-degree and 20-degree slope ground structure with flat ground models developed with ETABS software.

IV. To examine a multistory RC building's seismic performance with various bracing configurations like X, inverted V, V, diagonals, and Using Nonlinear Static Pushover analysis, K bracings technique and time history, a non-linear dynamic Analytical process.

V. To study the variation of top storey displacement with respect to variation in number of bays, hill slope angle, storey height for different configurations of building frames.

3. LITERATURE REVIEW

1. **Likhitharadhya Y R[1] , Praveen J V[2] , Sanjith J[3] , Ranjith A[4](2016**) ; Studied **"Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground"** [1]. The ground slope, which varies from 100 to 300 meters, and the G+ 10-story RCC building were taken into consideration for the analysis in this study. Compared to flat ground, sloping ground buildings have a comparatively higher maximum displacement and shear forces, which can lead to dangerous circumstances. In sloping ground buildings, base shear is greater in the X direction than in the Y direction. The research shows that the Mode Period decreases as the slope angle increases. The analysis shows that as the slope angle increases, storey displacement decreases. In all other models, displacement is greatest at the top story in relation to the bottom storeys in both the x and y directions. The analysis shows that as the slope angle increases, storey acceleration decreases. In all other models, the highest acceleration occurs in storey-11 relative to storey-1 along the x and y directions.

2. **Shagun Puri[1], Prof.Harpal Singh[2], Er.Mandeep Kaur[3]**; focused on the **"Seismic Analysis of Multistory Building Frame Resting On Plane And Sloping Ground"** [2]. The maximum storey displacement in the 15-degree model is greater because displacement rises with height but decreases with sloping angle declines. The G+5 structure, which is positioned at a 15-degree angle, is suffering higher values of storey drift, storey shear, and overturning moment because the shorter column's length is more stiff than the longer column's, which causes it to attract greater pressures and withstand more earthquake loads. When compared to a long column, it is noted that the shorter column has larger values of axial forces and bending moments for the following reasons: The shorter columns attract greater earthquake forces than the longer ones because the shorter columns are more rigid than the longer ones.

3. **Anvesh Jujjuvarapu[1] , G. Manideep[2] ;** Studied **"Effect of Shear Walls on Seismic Analysis of a Multi – Storeyed Building Resting on Sloping Ground"** [3]. It has been noted that the building's Base Shear when it is resting on sloping land is lower than when it is flat ground as a result of its column weight being reduced. Adding shear walls is seen to enhance the values of base shear and storey shear because of the a growth in their own weights. Shear walls are used to lessen storey displacements and drifts because to the a rise in their rigidity. When compared to the Time History Method, it is noted that there is a significant rise in the displacements. Those figures in the Response Spectrum and Equivalent Static Methods. This study demonstrates that base shear derived through the use of Time History and the Response Spectrum Method. Method's value exceeds that of the Comparable Static Method

4. **The topic of study for Satishkumar Guttedar1, Sujeet Patil2, and others was "Seismic Analysis of RCC Multi-Storey Building with Effect of Bracing Resting on Sloped Ground"** [4]. The able bounds specified by the corresponding codes. Wstorey displacement and storey drift values for each building under consideration for the study are within the allow hen compared to the Step-back-Set-back building that is situated on sloping terrain, the Step-back building has a relatively large top storey displacement and storey drift. More than any other building frame arrangement, the performance of step-back building frames without bracings during seismic excitation may be impacted; nevertheless, it may be adopted by offering a bracing mechanism to manage displacement. The addition of braces to the structure alters the building's seismic response.

5. **Mohd. Arif Lahori[1] , Sagar Jamle[2]**; Studied "Investigation of **Seismic Parameters of R.C. Building on Sloping Ground**" [5]. Case 1 appears to have the highest storey drift, measuring 0.2483 cm, and the most transverse direction drift, measuring 0.2485 cm. Out of all the five examples, case 5, which is the step back set back 30 degree model, has been found to be the most cost-effective part for sloping ground. Time and involvement factors appear to be primarily operating in cases 1 and 2.

6. **Seismic Behavior of Multi-Storied RCMRF Buildings Resting on Sloping Ground was** investigated by **D.J. Misal and M.A. Bagade** [6].They examined the actions of generally uneven and torsional linked, hill slopes in earthquake-prone areas are hence vulnerable to damage from ground motion caused by earthquakes. The mass and rigidity of these structures vary along the vertical and because horizontal planes cause the center of mass and center of stiffness to differ on different levels, torsional analysis is necessary in addition to lateral force calculations when there is an earthquake. Buildings with dual systems are constructed using bracing frames or shear walls, following IS1893(Part-1)-2002, and these are made to withstand the overall lateral force of the design in relation to their lateral stiffness. Step-set building frames are less than step-back frames with bracings, and storey shear for first floors is step back without bracings.

7. **Swati Bhore, Chetan Pise, Shriganesh Kadam** ; focused on the **"Seismic Performance of Multi-Storey RCC building Resting on Sloping Ground"** [7]. The analysis of the RCC building's sloping ground is the study's goal. Step back building performance during seismic excitation can be concluded from a study of four building configurations, which could prove more prone to pregnancy than other building layouts. In contrast to other configurations, comparative investigations revealed that least in Step back-Setback and Setback building. Less base shear occurs when building on sloping terrain than when building on level terrain. Step-back-setback construction could be more advantageous on sloping terrain.

8. **Ajit C. Suryawanshi[1], V. M. Bogar**; carried out **"Seismic Analysis of Building Resting on Sloping Ground with Soil Structure Interaction"** [8] .Comparing SSI building models to traditional fixed base models, there is a greater story displacement. Additionally, it rises in soft soil. Maximum story displacement is achieved in hard, medium, and soft soil with or without SSI while using a structure model with a 30° slope. In comparison to fixed base buildings, story displacement and story drifts are greatest in the case of buildings with soil structural interaction.

9. **Rayyan-Ul-Hasan Siddiqui[1], H. S. Vidyadhar[2]**; focused on the "**Seismic Analysis of Earthquake Resistant Multi Bay Multi Storeyed 3D - RC Frame"** [9] .The analysis of the paper Compared to other buildings, sloping ground buildings have comparatively higher maximum displacements and shear forces that could result in dangerous circumstances. Structures on a level surface. Although the provision of internal and external shear walls generally reduces member forces and support reactions, it may also result in increased forces that must be taken into consideration during design, such as shear force and torsion moment in columns and beams. When an earthquake occurs, the behavior of frames is significantly impacted by infill panels. Generally speaking, infill panels raise the structure's rigidity.

10. **Satish Rathod, Narayan Kalsulkar** Studied "**Seismic Evaluation of an RCC Structure Located on a Sloping Terrain with Different Bay Counts and Hill Elevations"**[10]. Since there are structural irregularities in steep areas, seismic forces act more severely there. Additionally, research has shown that hilly regions are more vulnerable to seismic activity. Two building configurations—step-back frames and step-back-set-back frames—are taken into consideration in this study.

4. CONCLUSIONS

- It has been determined after reading and analyzing a number of research publications that:

1. Buildings with a step back and set back may be preferred on sloping terrain, according to several researchers.
2. It is concluded that as the number of bays, time period, and top story rise, the more bays are found to be better under seismic conditions. Relocation in structures on a hillside declines.
3. The chosen model is examined, designed with every variant, and individually made to meet every structural parameter.
4. Storey drift and displacement, as discussed in the preceding chapter, illustrate the proper nature of structural movement.
5. Compared to full length columns, shorter columns will bend more.
6. It is useful to prevent large joint displacements encountered in bare frames by providing both an external and an internal shear wall.
7. When soil structure interaction is present, story displacement and story drifts are more than when fixed foundation buildings are included.
8. According to the analysis, storey displacement decreases as the slope angle increases.

5. REFERENCES

1. The article "Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground" published in June 2016 by Likitharadhya Y R1, Praveen J V2, Sanjith J3, and Ranjith A4

2. Shahu Puri1, Prof. Harpal Singh2, Er. Mandeep Kaur3, "Seismic Analysis of Multistory Building Frame Operating on Plane and Sloping Terrain" Access Volume: 08, Issue: 09, September 2021 from www.irjet.net.

3. Anvesh Jujjuvarapu1 Manideep2, "Shear Walls' Implications for a Multi-Storey Structure's Seismic Evaluation on a Slope," Volume 6, Issue 2.

4. Satishkumar Guttedar[1], Sujeet Patil[2] ; "Seismic Analysis of RCC Multi-Storey Building with Effect of Bracing Resting on Sloped Ground" Volume: 07 Issue: 09 Sep 2020 www.irjet.net

5. "Investigation of Seismic Parameters of R.C. Building on Sloping Ground," Mohd. Arif Lahori[1], Sagar Jamle[2]; Vol. 5, Issue 8, Aug. 2018

6. D.J.Misal[1] , M.A.Bagade[2] ; "Seismic Behavior of Multi-Storied RCMRF Buildings Resting on Sloping Ground" Vol. 2, No.1, March 2016

7. Swati Bhore, Chetan Pise, Shriganesh Kadam ; "Seismic Performance of Multi-Storey RCC building Resting on Sloping Ground" ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

8. Ajit C. Suryawanshi[1], Bogar2, "Soil Structure Interaction and Seismic Analysis of a Building Resting on a Sloping Ground," e-ISSN: 2395-0056, Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

9. Rayyan-Ul-Hasan Siddiqui and H. S. Vidyadhara (October 2013) Seismic Analysis of Earthquake Resistant Multi Bay Multi Storeyed 3D - RC Frame International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 10

10. Satish Rathod, Narayan Kalsulkar "Seismic Evaluation of an RCC Structure Located on a Sloping Terrain with Different Bay Counts and Hill Elevations"