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Analysis and Design of G+10 Storey Building under Different Sloping Condition

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ABSTRACT

Structures are typically built on level ground; however, due to a lack of level ground, construction operations have begun on sloping terrain. The step back and step back setback are two different types of construction configurations on sloping terrain. For the purposes of this study, a G+ 10 storey RCC structure with a ground slope of 20 and 44 degrees was investigated. The building has been compared to one that is standing on flat ground. The structure analysis programmed ETAB 2018 was used for modeling and analysis of the building. To use the time history and response spectrum approach to assess a structure on sloping terrain with or without a shear wall. On the basis of the results from both analyses, a comparison of different response parameters is made. Designing and optimizing various structural elements under the current conditions by comparing the analysis of the identical structure on level ground with the structure on sloping land. The seismic study was carried out using response spectrum analyses and time history in accordance with IS: 1893(part 1) 2016. Top storey displacement, storey shear, and storey drift were used to get the results.

INTRODUCTION

Seismic analysis is a branch of structural analysis that involves calculating a structure's response to dynamic excitation. It is a subset of the structural design, earthquake engineering, or structural assessment and retrofit process in earthquake-prone areas. During seismic excitation, a structure can "wave" back and forth.. During a strong windstorm, this behavior is also observable. The 'basic mode,' as the name implies, corresponds to the lowest frequency of building response. The structure takes the least amount of energy to vibrate at this frequency. The majority of structures, on the other hand, have greater reaction modes that are only triggered during earthquakes. Nonetheless, in most cases, the first and second modes cause the most damage. For seismic response analysis of structures, various forms of ground motion inputs are necessary. Methods used for seismic response analysis of structures can be classified as (i) time history analysis, (ii) response spectrum method of analysis, and (iii) frequency domain spectral analysis, depending on the available input information.

Time history analysis can be used for both elastic and inelastic response ranges, the other two methods are only useful for elastic responses. However, by employing appropriate approaches, these methods can be expanded to approximation response analysis in the inelastic range. To determine the response of structures across a particular time history of stimulation, several approaches such as Duhamel integration, step-by-step numerical integration, and the Fourier transform approach are employed.

The response spectrum technique of analysis takes earthquake response spectra as input to generate a set of lateral equivalent forces for the structure. which will have the most effect on it due to ground motions A static analysis is used to determine the structure's internal forces. Frequency domain spectrum analysis is performed when the earthquake ground motion is considered as a stationary random process. It returns the power spectral density function (PSDF) of any response quantity of interest using random vibration analysis methods for a given PSDF of ground motion as input. The root mean square response is calculated and predicted using the moments of the PSDF of response. When opposed to high-rise buildings, the likelihood of sway is substantially lower in low-rise structures [1].

LITERATURE REVIEW

Sylviya.B et al. (2018) did a comparative study on the effective arrangement of shear walls at different sites in different seismic zones for an RCC multi-story structure. Four models were developed for the investigation, and storey drift, displacement, and storey shear were observed in all zones, i.e. (Zone II, III, IV and V). Shear walls are most effective when placed at the building's extremities, and storey drift and displacement are highest at zone. [3]

Tarun Magendra et al.(2016). The optimal positioning of shear walls in multi-story structures has been investigated in this research. It has been discovered that shear walls located in the center or at the corners of a building's design, forming a box, indicate that the structure is more stable for characteristics such as storey displacement and storey drift, and that overturning moments are minimal in traditional buildings. [4] A research on the configuration of shear walls that have been exposed to seismic forces stress was conducted by R.S.Mishra (2015). When comparing the core and peripheral positions of shear walls in a structure, it is found that the midway site is most suited. [5]

Jaimin Dodiya et al. (2018) investigated the study of multi-story buildings employing shear walls at various points throughout the structure. Three models have been created, and it has been demonstrated that when shear walls are situated in the opposite directions of the structure, displacement is minimised. [2]

M V Naresh et al. (2019) conducted a research on the static and dynamic analysis of multi-story buildings, concluding that static analysis is insufficient for high-rise structures and emphasising the importance of dynamic analysis to counteract the lateral stresses created during earthquakes. [6]

When Kusuma.S (2020) utilised Etabs to evaluate response spectrum analysis and time history analysis for a multi-story structure, they observed that the response spectrum technique yields more accurate conclusions and higher base shear values.

Bagheri et al. (2012) examined the damage assessment of an irregular building using static and dynamic analysis, and concluded that static analysis caused more displacement than dynamic analysis.[7]

R. Chittiprolu et al. [2014] conducted research on response spectrum analysis and lateral load for structures with and without shear walls. The shear forces and tale drifts of both examples were compared. In an uneven structure, he determined that structures with shear walls are more resistant to lateral stresses than those without shear walls. There is a reduction in storey drift in case of structure with shear wall. [8]

Nagargoje and Sable 2 (2012) investigated the unstable behaviour of structures on a steep slope. They used 3D house frame analysis to assess the structures' dynamic response in terms of primary floor displacement and base shear. In unstable zone III, a constant quantity analysis was conducted on 36 structures with three configurations: step back, step backset back, and set back structures. [9]

B.G.Biradar and S.S.Nalawade (2004) investigated the unstable performance of hill structures at storey levels up to eleven, while in this work, the analysis is applied at construction levels ranging from four to fifteen (15.2 m to 52.6m). They discovered that step back buildings had a higher construction displacement than step back – set back structures. They discovered that the bottom shear created in step back set back structures is sixty to 260% more than in setback structures. On sloping ground, they advised for step back setback buildings to be favored.. [10].

METHODLOGY

Geometric parameters

One building layout is investigated in this study, which includes structures that are positioned on flat land. The number of stories taken into account for each type of setup is ten. All variants of the building frame have the same plan arrangement. To prevent complications like orientation, the columns are assumed to be square.

Software used

ETABS - Extended Three-Dimensional Analysis of Building System

ETABS is a cutting-edge, multi-purpose research and design programme designed specifically for building systems. With its best-integrated systems and skills, even the largest and most complicated building models may be readily sketched. [13]

Etabs-2018 software was used to do a response spectrum analysis and a time history study on a normal building, as illustrated in fig. The response spectrum of the El Centro earthquake was matched using the time domain approach. For each level, the storey displacement, storey drift, storey shear forces, spectral acceleration, and spectral displacement were computed, and the graph was shown. [14]

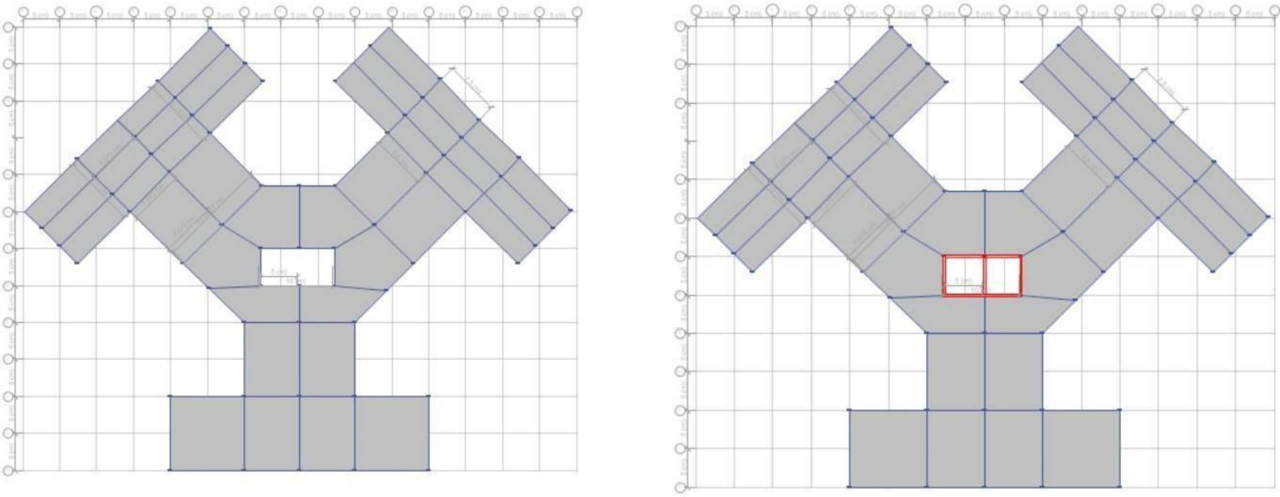
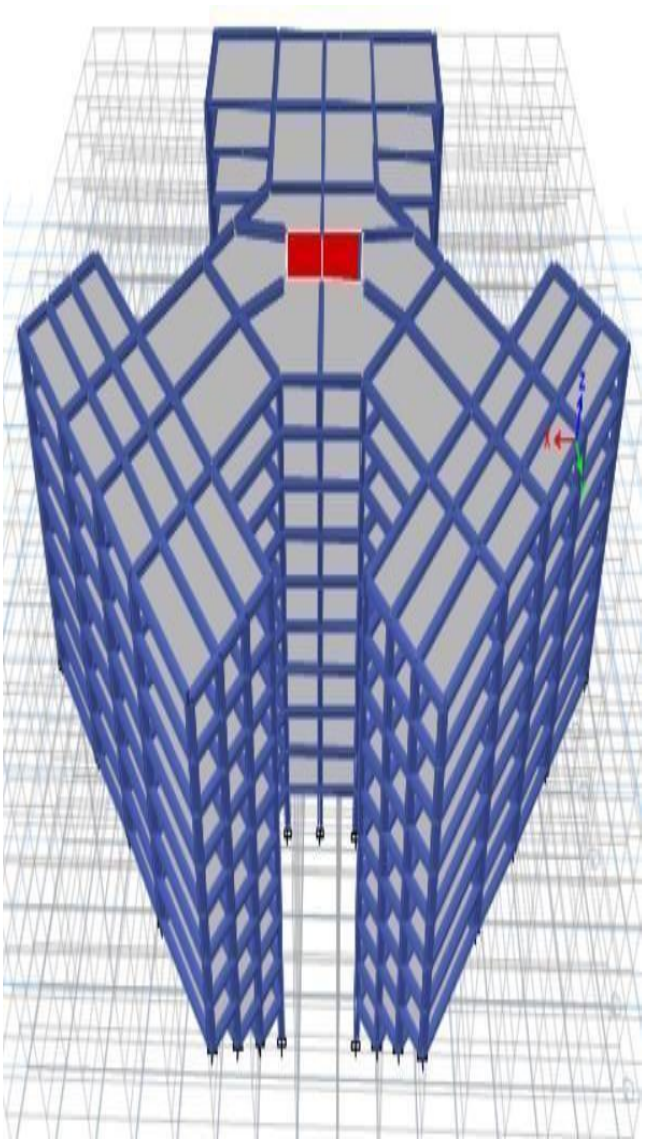


Figure 1 Plan view without and with shear wall



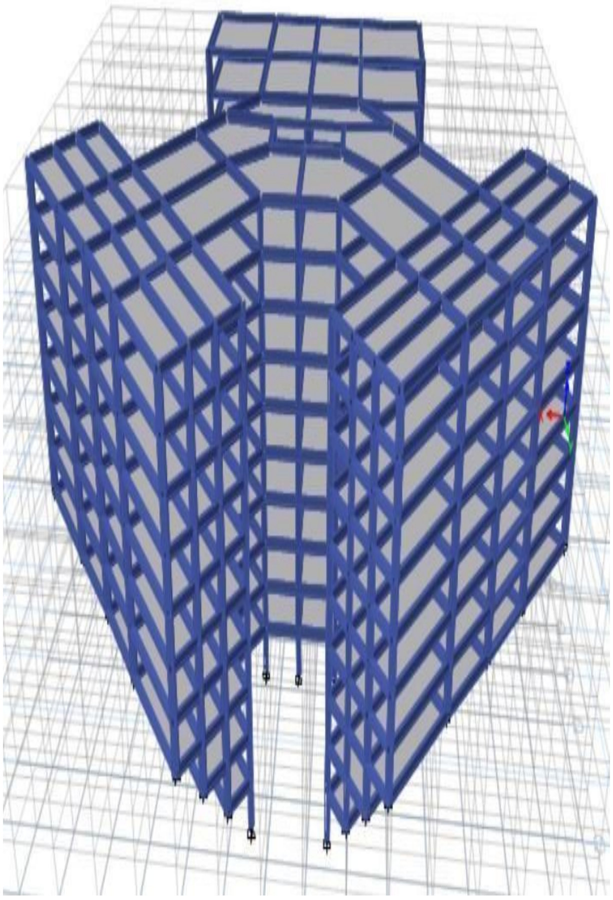


Figure 2 Inclined on 44-degree slope with and without shear wall

RESULTS

Storey displacement

Table 1 Displacement (mm) using response spectrum analysis in X and Y direction with shear wall.

STOREY	RESPONSE SPECTRUM					
	MODEL 1		MODEL 2		MODEL 3	
	X	Y	X	Y	X	Y
10	21.083	48.131	19.446	53.154	20.131	52.521
9	19.957	44.094	18.44	48.517	18.828	47.609
8	18.441	39.545	17.127	43.476	17.299	43.224
7	16.59	34.564	15.475	37.997	15.524	37.963
6	14.473	29.275	13.556	32.215	13.519	32.372
5	12.165	23.822	11.431	26.264	11.334	26.564
4	9.728	18.351	9.158	20.288	9.022	20.674
3	7.217	13.02	6.785	14.444	6.636	14.847
2	4.678	8	4.357	8.902	4.237	9.25
1	2.181	3.523	1.923	3.857	1.899	4.082
BASE	0	0	0	0	0	0

Table 2 Displacement (mm) using time history analysis in X and Y direction with shear wall.

STOREY	TIME HISTORY					
	MODEL 1		MODEL 2		MODEL 3	
	X	Y	X	Y	X	Y
10	20.425	27.791	27.9	33.119	31.034	34.336

9	18.243	24.573	25.647	29.321	28.092	30.531
8	15.899	21.255	23.141	25.429	24.941	26.795
7	13.455	17.888	20.4	21.487	21.719	22.893
6	10.993	14.528	17.452	17.57	18.391	18.98
5	8.597	11.255	14.356	13.765	15.01	15.121
4	6.34	8.166	11.188	10.168	11.638	11.399
3	4.424	5.371	8.039	6.88	8.35	7.914
2	2.692	2.991	5.011	4.01	5.237	4.773
1	1.176	1.173	2.214	1.673	2.398	2.091
BASE	0	0	0	0	0	0

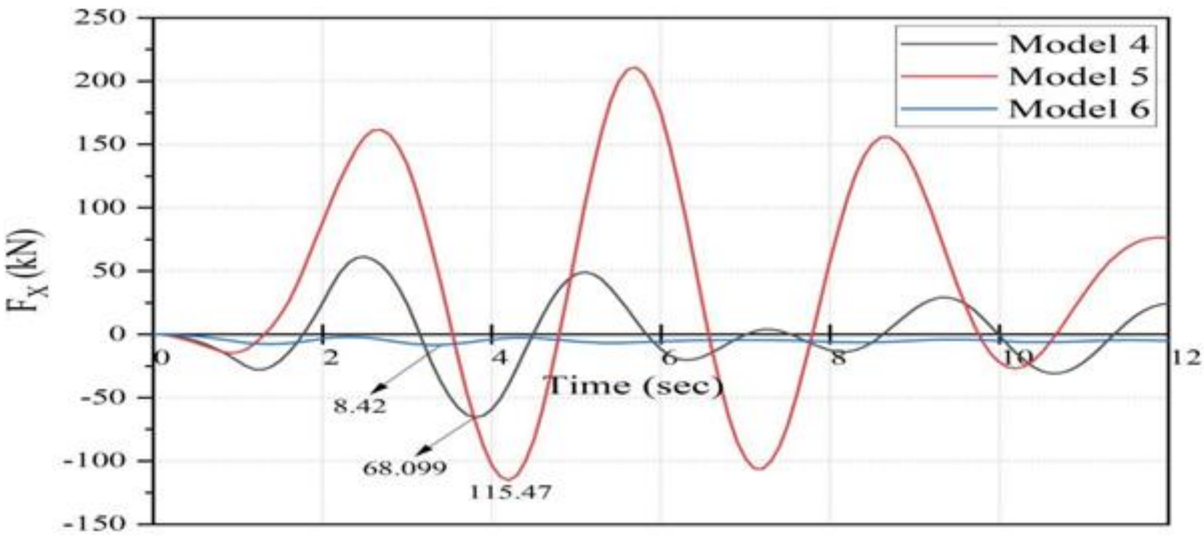


Figure 3 Time history base shear with and without shear wall.

CONCLUSIONS

1) On analysis by time history method of 3D mathematical model following conclusions have been made:-

a) With shear wall

i) The 3D model on 44o sloping ground was found to have maximum displacement in both the direction. Whereas model on flat ground has less displacement in both the direction.

ii) It is observed that maximum storey drift is seen on the 9th storey of 44o sloping ground model. It is also observed that on increasing sloping angle from 0o to 44o slope storey drift increases.

iii) Building model on 44o sloping ground was found to have maximum value of storey shear in both the direction, while on flat ground is least.

b) Without shear wall

i) The 3D model on 20o sloping ground was found to have maximum displacement in Y direction. While model on flat ground have maximum displacement in X direction.

ii) It is observed that maximum storey drift is seen on the 2th storey of 20o sloping ground model.

iii) Building model on 44o sloping ground was found to have maximum value of storey shear in both the direction, while on flat ground is least.

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