Study on Seismic Performance of Buildings Resting on Sloping Grounds with and without Shear Wall

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ABSTRACT

The buildings in hilly areas have to be configured differently due to scarcity of flat ground. In hilly areas buildings are built on sloping grounds. When the hilly areas come under the seismic zones, these buildings are highly vulnerable to earthquakes. The stability of the structure is at risk due to the un-symmetric frame of the building due to different levels of column foundations. This paper deals with the comparison of G+9 residential buildings for seismic performance resting on sloping grounds without and with shear walls retrofitted when subjected on earthquake forces in zone III and in two different types of column foundations. The structures are analyzed by non-linear dynamic analysis (Response Spectrum Analysis- as per IS 1893-2002) using “ETABS 13.0” for a constant sloping ground of 30° with horizontal. With this we can study the performance evaluation of building under the presence of shear wall, storey shear, displacements and storey drifts at each storey were determined and compared. The main aim is to check if the seismic performance of the structure is improved when it is retrofitted with shear wall.

Keywords--- Earthquake, Structure, Frame

I. INTRODUCTION

Shear walls are one of the excellent means of providing earthquake resistant to multi-storied reinforced concrete buildings. In present scenario due to the economic growth and rapid urbanization there is a tremendous development in real estate which resulting in increasing population density even in hilly regions. India has a large coastal line which is covered with mountains and hills. The buildings in these areas are constructed on sloping grounds and these often highly irregular structural configurations are termed as “Hill Buildings”.

The stability of the structures is at risk due to the un-symmetric frame of building due to the different levels of column foundations. The short stiff columns on uphill side attract much higher lateral forces during earthquakes resulting in failure of the structure. It is observed during the past earthquakes, structures in hilly regions experience a high level of damage which leads to collapse of the structure. From pervious case studies it came to a conclusion that there are two main concepts for a better earthquake resistant design of structures and they are

- Introducing a setback-step back configurations, and
- Constructing the structure with shear walls

When shear walls are situated in the advantageous position in a building, they can act very efficient in resisting lateral loads on building. Well-designed shear walls in seismic areas have a very good performance. The main aim of this study is to compare multi-storey residential structures for seismic performance which is resting on sloping grounds without and with shear walls retrofitted when subjected to earthquake forces in zone III and in two different types of soils (soft and hard soils).

II. OBJECTIVE OF STUDY

The main objective of the present study is to evaluate the performance of G+9 residential structure subjected to earthquake forces in zone 3 and in hard and soft soils using response spectrum method. The specific objectives are below.

- Generation of 3D building model for both elastic and inelastic method of analysis.
- Determination of deflections and storey drifts at each storey using Response Spectrum Method.
- Determining the performance level of structure without shear wall.
- To study the performance evaluation of structures under the presence of shear wall and compare it to the structures without shear wall.

III. STRUCTURAL MODELLING, METHODOLOGY AND ANALYSIS

Following are the different types of models

- A G+9 structure with shear wall at centre position and without shear wall in zone 3 and in hard soil medium.
• A G+9 structure with shear wall at centre position and without shear wall in zone 3 and in soft soil medium. 3D models are created for all the considered building structures and material properties, frame sections, load cases are defined and assigned. Gravity analysis and linear static analysis is carried out as per IS 456-2000 and IS 1893-2002. The response spectrum analysis is carried out by using ETABS 2015 software.

Description of the building
The data of modeled building is as follows:
Plan dimensions - 30x39m
Structure - OMRF
Number of storey - G+9
Floor height - 3m
Bottom floor height - 1.8m
Type of building - Residential
Soil strata - hard and soft

Material Properties
Grade of concrete - M10
Grade of steel - Fe 415
Density of concrete - 25kN/m3
Density of brick - 20kN/m3
Modulus of elasticity of concrete - 25x10^7 KN/mm^2
Modulus of elasticity of steel - 2x10^7 N/mm^2

Member Properties
Thickness of slab - 150 mm
Floor beam size - 230x400 mm
Plinth beam size - 230x200 mm
Tie beam size - 230mmx40mm
Column size for normal building - 250x250 mm
Column size for columns below base level - 350x350 mm

External wall thickness - 250 mm
Internal wall thickness - 115 mm
Shear wall thickness - 300 mm
Clear cover - 40 mm

Load Intensities
Floor finish - 1.0kN/m^2
Live load - 2kN/m^2

Seismic Zone Intensities
Seismic zone - III

Ground slope - 30°
IV. RESULTS AND DISCUSSIONS

Figure 3.2: typical plan and 3D view of the structure without shear wall

Figure 4.1: maximum storey displacement for hard soil in zone 3

Figure 4.2: maximum storey drift for hard soil in zone 3

Figure 4.3: maximum storey shear for hard soil in zone 3

Figure 4.4: maximum storey displacement for soft soil in zone 3

Figure 4.5: maximum storey drift for soft soil in zone 3
Comparison of maximum storey displacements, storey drifts and storey shear were done for the structures without shear wall and structures with shear wall at centre position.

There is a considerable decrease in the storey displacement and storey drift for structures with shear wall when compared to the structures without shear wall and a considerable increase in the storey shear for structures with shear wall when compared to the structures without shear wall.

In zone 3 for hard type of soil medium the maximum storey displacement is reduced by 28.35% and for soft type of soil medium the maximum storey displacement is reduced by 29.02%.

In zone 3 for hard type of soil medium the maximum storey drift is reduced by 29.75% and for soft type of soil medium the maximum storey drift is reduced by 25.14%.

In zone 3 for hard type of soil medium the maximum storey shear is increased by 24.87% and for soft type of soil medium the maximum storey shear is increased by 21.8%.

Therefore it is concluded that when the structure is constructed with shear wall the storey displacement and storey drift decreases and the storey shear increases resulting in the better performance of the structure.

V. CONCLUSIONS

The following conclusions are drawn based on the present study.

- The models resting on sloping grounds are found to be the most vulnerable among all the other configurations due to shortening of column length which results in reduction of stiffness.
- Use of bottom ties gives effective response of structures resting on hilly regions.
- The presence of shear wall influences the overall behaviour of the structures when subjected to lateral forces. Lateral displacements and storey drifts are considerably reduced while contribution of shear wall is taken into account.
- The performance of structures without shear wall, during seismic excitation could prove more vulnerable than structures with shear wall.
- Structure with shear wall significantly reduces the lateral displacements when compared to structures without shear wall.
- The storey drift of shear wall structures is less as compared to structures without shear wall thus the overall response of the building decreases.
- The story shear of shear wall structures is high when compared to structures without shear wall which indicates that stiffness of building has increased.

VI. REFERENCES
