Seismic Performance of the Building Resting on Sloping Ground with Shear Wall

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***Abstract*- Buildings resting on sloping ground are different from those buildings which are resting on plain ground. The buildings which are located in hilly areas in earthquake prone regions are generally irregular, unsymmetrical, and torsionally coupled and hence, susceptible to severe damage when affected by earthquake ground motion. Therefore it is very important to consider earthquake effect and design earthquake resistant buildings from the safety point of view. Shear wall is one of the most commonly used lateral load resisting system in the buildings for its better seismic performance. Shear walls are the ideal choice to resist lateral loads in multistoried Reinforced Concrete buildings. They provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building. Hence in the present study, an attempt is made to study the seismic performance of building resting on sloping ground with and without shear wall by linear Time History Analysis in Structural Engineering Software SAP2000.**

Keywords: Seismic Performance, Shear wall, Critical column, Linear time History Analysis.

I. INTRODUCTION:

The economic growth and rapid urbanization in hilly region has accelerated the real estate development. Due to this, population density in the hilly region has increased enormously. Therefore; there is popular and pressing demand for the construction of multi-storey buildings on hill slope in and around the cities. The adobe burnt brick, stone masonry and dressed stone masonry buildings are generally made over level ground in hilly regions. Since level land in hilly regions is very limited, there is a pressing demand to construct buildings on hill slope. Hence construction of multi-storey Reinforced Concrete Frame buildings on hill slope is the only feasible choice to accommodate increasing demand of residential and commercial activities. The buildings situated on hill slopes in earthquake prone areas are generally irregular, torsionally coupled and hence, susceptible to severe damage when affected by earthquake ground motion. Such buildings have mass and stiffness varying along the vertical and horizontal planes, resulting the center of mass and center of rigidity do not coincide on various floors, hence they demand torsional analysis, in addition to lateral forces under the action of earthquakes. These unsymmetrical buildings require great attention in the analysis and design. Analysis of hill buildings is somewhat different than the buildings on leveled ground, since the column of hill building rests at different levels on the slope. The shorter column attracts more forces and undergoes damage, when subjected to earthquakes.

Shear Wall: Shear wall system are one of the most commonly used lateral load resisting system. Shear wall has high in plane stiffness and strength which can be used to simultaneously to resist large horizontal loads and support gravity loads. Well designed and detailed reinforced concrete shear wall in a building can provide the required lateral stiffness and strength, as well as ductility, for resisting seismic loads. RC walls with boundary elements have substantially higher bending strength and horizontal shear force carrying capacity. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight forward and therefore easily implemented at site. The shear walls must possess the ability to dissipate energy imparted to it by earthquakes through hysteretic behaviour. For the buildings on hill slope, the height of columns below plinth level is not same which affects the performance of building during earthquake. Hence to improve the seismic performance of building shear walls play very important role. So there is need to study the shape and positioning of shear walls on seismic performance of building situated on hill slope.

Khadiranaikar and Masali [2] reviewed literature related to studies on the seismic behaviour of buildings resting on hill slope. It is found that most of the studies agree that the buildings resting on hill slope has higher displacement and base shear compared to buildings resting on plain ground and the short column attracts more forces and undergoes more damage when subjected to earthquake force. From the study authors concluded that the presence of infill wall and shear wall influences the behaviour of structure by reducing storey displacement and storey drifts considerably, but may increase the base shear, hence special attention should be given in design to reduce base shear. It is also concluded that the greater number of bays are found to be better under seismic condition, as the number of bays increases, time period and top storey displacement decreases in hill slope buildings.

S.M. Nagargoje and K.S.[3] Sable studied Seismic performance of multi storied building resting on sloping ground. Three dimensional space frame analysis is carried out for three different configurations such as Step back, Step back-Setback, Setback. The seismic analysis of all buildings is carried out by Seismic coefficient method by using IS 1893(part I)-2002. Dynamic response of these buildings, in terms of base shear and top floor displacement is presented and compared within the considered configuration as well as with other configurations. At the end, a suitable configuration of building to be used in hilly area is suggested.

B.G. Birajdar, S.S. Nalawade [4] carried out Seismic Analysis of Buildings Resting on Sloping Ground. 3-D analysis including torsional effect has been carried out by using response spectrum method. The dynamic response properties i.e. fundamental time period, top storey displacement and, the base shear action induced in columns have been studied with reference to the suitability of a building configuration on sloping ground. It is observed that Step back-Set back buildings are found to be more suitable on sloping ground.

Robert Tremblay and Laure Poncet [5] studied the Seismic Performance of Concentrically Braced Steel Frames in Multistory Buildings with Mass Irregularity. A reference regular structure was also considered for comparison. The design of each structure was performed according to the proposed 2005 National Building Code of Canada NBCC provisions using two analysis methods: The equivalent static force procedure and the response spectrum analysis method. Although severe, the mass irregularity conditions considered in this study were found to have a limited negative impact on the seismic performance of the structures designed with the static analysis method.

II. OBJECTIVE:

1. To study the seismic performance of building resting on sloping ground without shear wall.
2. To study the seismic performance of building resting on sloping ground with shear wall at all corners and only at the 2 corners of the long column.

III. DESCRIPTION OF THE BUILDING:

Model consists of G+4 storey RCC building having four bays in X-direction and six bays in Y-direction; each bay is having width of 3.5m. The story height for each floor and plinth height is kept as 3m and 1.5m respectively. Size of beam in longitudinal and transverse direction is taken as 0.30 x 0.5m. The column of size 0.45m x 0.45m and also slab of thickness 0.120m is taken. Parapet wall of height 1m is considered. Thickness of the shear wall is taken as 0.150m. The models are analyzed on sloping ground (slope 20^0 and $30^0$with horizontal). The frames on sloping ground under consideration for present study is as shown in Fig. 2 and Fig. 3. The concrete of grade M_{20} and steel of grade Fe 415 is used.

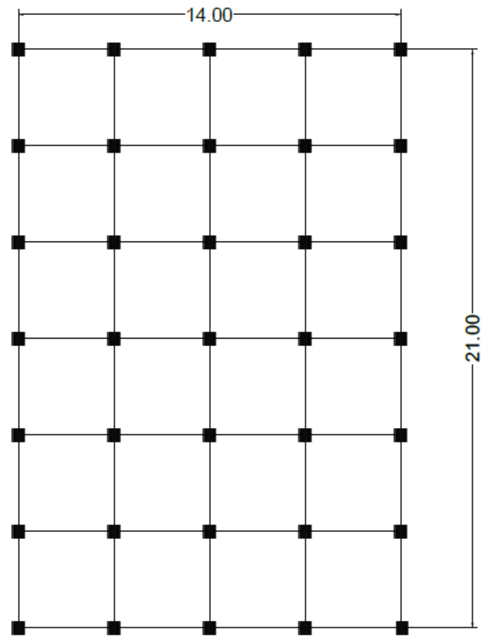

Fig. 1. Plan of building showing column positions

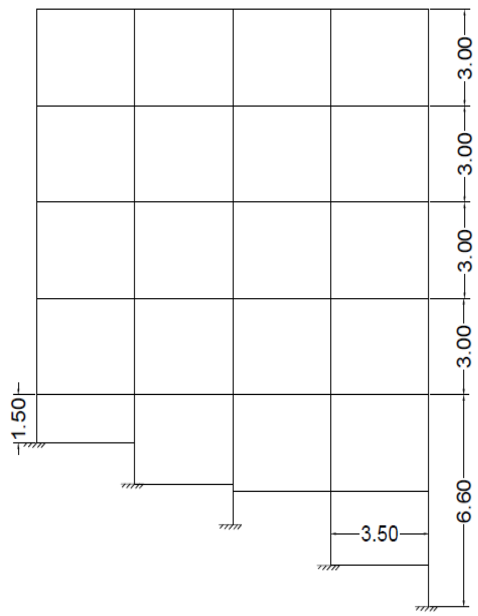

Fig. 2. Building frame on 20^0 slope

IV. LOADS:

A. Dead load:

Super imposed dead load (Floor finishes or water Proofing) for all floors =1.875 kN/m2.

External wall load (230mm thick) =13.8 kN/m.

Internal wall load (115 mm thick) =6.9 kN/m.

Parapet load= 2.3 kN/m.

B. Live Load:

Live load on floor = 4 kN/m^2

Live load on roof =1.5kN/m^2

C. Earthquake load: Imperial Valley Earthquake record is applied in X-Direction.

V. METHOD OF ANALYSIS:

Dynamic Analysis of the building is done by using finite element software SAP-2000. 3D analysis has been carried out by Time History method for this study. Dynamic response of these buildings, in terms of base shear, fundamental time period, storey Drift is presented, and compared within the considered configuration of shear wall as well as with model without shear wall on sloping ground and at the end, efficient position of shear wall configuration to be used is suggested. Damping considered for all modes of vibration was five percent.

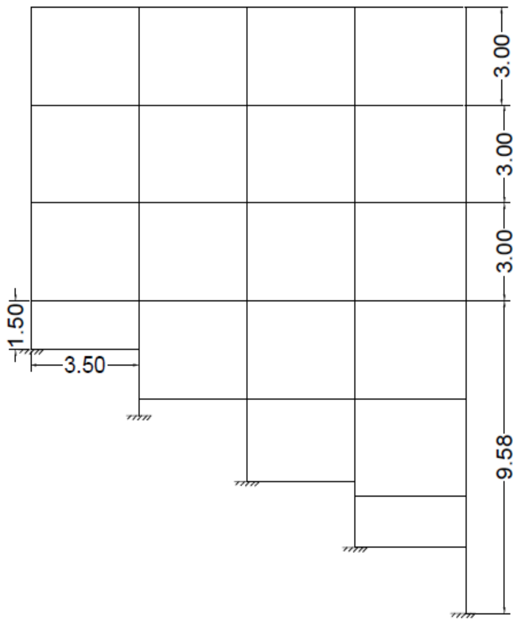

Fig. 3. Building frame on 30^0 slope

VI. RESULTS AND DISCUSSION:

Different cases for shear wall positioning are as follows

Case-1: without shear wall

Case-2: with shear wall at all the four corners

Case-3: with shear wall at two corners of long column

A. Fundamental Time Period:

Fundamental time period of the building is reduced after provision of shear wall as shown in graph below.

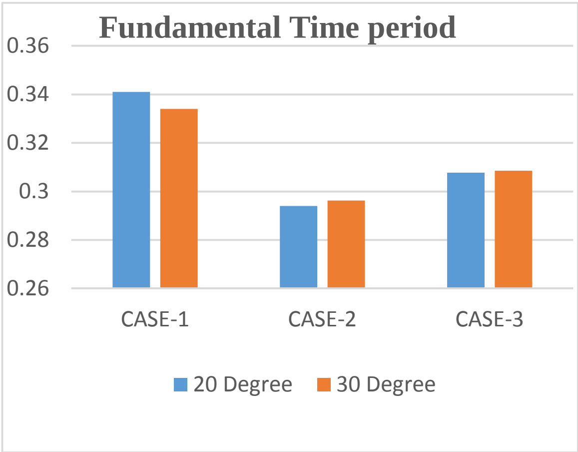

Fig. 4. Graph showing the fundamental time period in sec.

B. Base Shear:

Base shear of the building is increased after provision of shear wall.

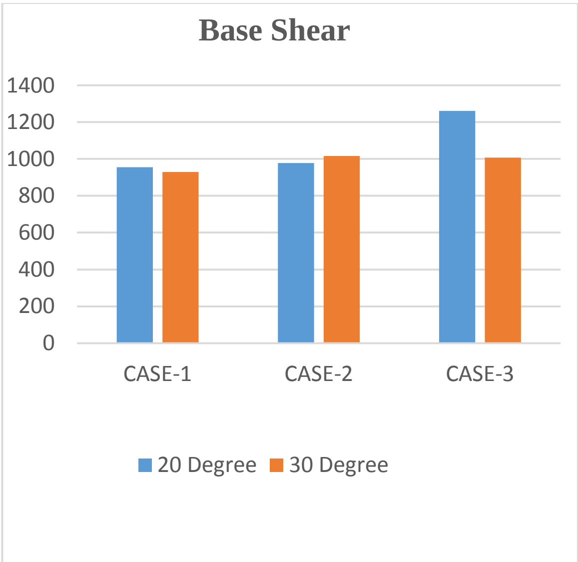

Fig. 5. Graph showing the Base shear in kN

C. Storey Drift:

Storey Drift of the bottom storey is increased with the shear wall inclusion as well as slope of the ground as shown in graph below.

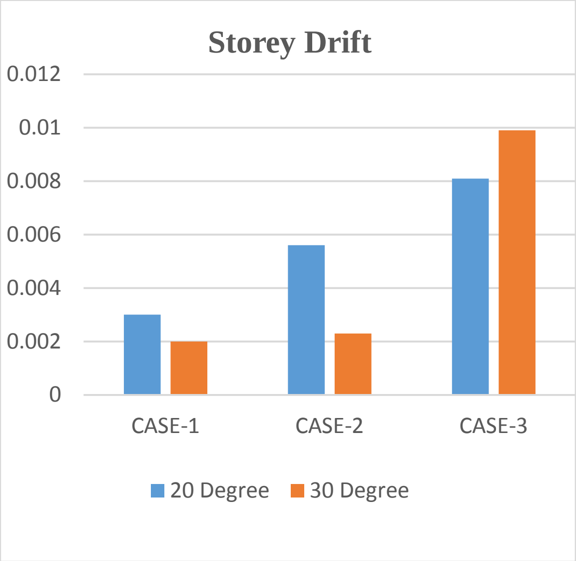

Fig. 6. Graph showing the storey drift.

VII. CONCLUSIONS:

Base shear of the building is increases with the incorporation of shear wall. Storey drift of the bottom storey of the building is increases by providing shear wall and also it is in permissible limit. Fundamental time period is reduced by provision of shear wall. There is significant improvement observed in seismic performance of building on sloping ground by incorporation of shear wall. Since fundamental time period reduces considerably. The shear wall at all the four corners proves to be better for resisting lateral forces during earthquake when compared with the shear wall at the two corners of long column.

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