Study and Dynamic Analysis of Sloped Building

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***Abstract* - Buildings constructed on slopes are different from those in plains. they will be irregular and unsymmetrical in horizontal and vertical planes, and torsion ally coupled. Hence, they are vulnerable to severe damage when suffering from earthquake ground motion. We cannot avoid the longer-term earthquakes but the preparedness and safe building construction practices for earthquakes can certainly reduce the extent of injury and loss of both property and life. this is often thanks to the very fact that the columns within the ground storey are of various heights in such how that column in one end may be a short column and column in other end may be a long column. Dynamic characteristics of hill buildings are somewhat different than the buildings on flat ground. Torsional effect of such buildings is broken for having the difference stiffness and mass along horizontal and vertical plane during ground motion. Short columns of RC frame buildings damage due to attracting more forces during earthquake. The work is concentrated to research 2-D frame of (G+9) building on plane and on sloping ground at 45degrees ,65 degrees using ETABS software when seismic loads are incorporated.**

***Index Terms* - Multistorey building, hill slope angle, seismic response, sloping ground, response spectrum, optimum case, setback case, step-back setback case.**

1.INTRODUCTION

Seismic history of India shows that the zones of upper seismic activity and better magnitudes are mostly presents in hilly terrains of northern and north-eastern regions. As well these places are more likely attracts peoples from plains for various purposes varying from adventure, tourism, religious and also for resolving problem of habitat to decrease in habitable land in the urban areas. These all purposes may cause resolve the matter of migration of peoples from hilly regions to lack of resources which can provide aids to comply their basic needs.

Building structures subjected to seismic forces are always more prone to collapse and if this phenomenon occurs on a sloping ground building structures as on hills which lies at some inclination angle to the ground, chances of damage suddenly increase much more due to increase in lateral forces like seismic and wind on short column on upward hill side and on the short column side more number of plastic hinges forms. Building structures built on slopey terrain differs from those which are on plains because sloping structures have irregularity in horizontally also as vertically.

Dynamic characteristics of hill buildings are significantly different from the buildings resting on flat topography, as these are irregular and unsymmetrical.

In both horizontal and vertical directions. The irregular variation of stiffness and mass in vertical also as horizontal directions, results in centre of mass and centre of stiffness of a storey not coinciding with each other and not being on a vertical line for various floors. When subjected to lateral loads, these buildings are generally subjected to significant torsion response. Further, because of site conditions, buildings on hill slope are characterized by unequal column heights within a storey, which finishes up in drastic variation in stiffness of columns of an equivalent storey. The short, stiff columns on uphill side attract much higher lateral forces and are vulnerable to damage.

Three-dimensional space frame analysis is two different configurations of buildings of 10 storeys resting on sloping and plane ground under the action of seismic load in ETABS software.

Dynamic response of the buildings, in terms of base shear, fundamental period of time and displacement is presented, and compared with the buildings having different sloping values. At the end, an appropriate configuration of building to be utilized in hilly area is usually recommended. The effects of the supporting foundation medium on the motion of structure gives soil structure interaction, but this might not be considered within the seismic analysis for structures supported on rock or rock like materials.

1.1. RELEVENCE OF WORK

Due to difference in the ground condition of building structures in plains to the sloping terrain of horizontal as well as vertical plains situations. Sloping ground building structures have more predictable to severe damage due to worse effect of earthquake ground motion. The approach & the accuracy of analytical results depend upon the characteristics of geometry of the structure & the loading on the structure.

The present work aims at providing an analytical approach for finding out the displacements, storey drifts, fundamental time period, base shear for a multistory building structures resting on a sloping ground terrain subjected to earthquake load. Response spectrum analysis (RSA) based on the IS (1893:2002) PART 1 codal provisions is to be performed on the FINITE ELEMENT model using suitable FINITE ELEMENT ANALYSIS platform. Using the displacement characteristics various structural outputs such as time period, storey drift, base shear is to be computed.

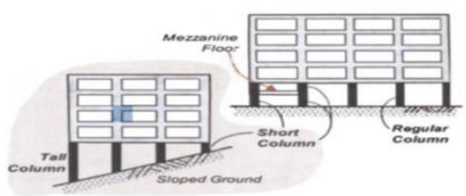
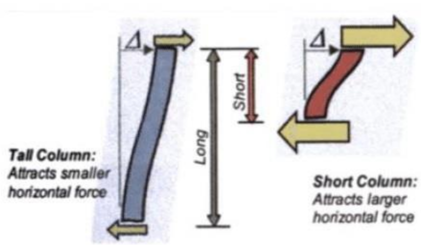


Fig.1.1 Building Frame with Short Columns



1.2. RESEARCH SIGNIFICANCE

There is great amount of mountains in INDIA which consists of Himalayas region in the northen part which is formed by the collision of tectonic plates. In this particular sloping region population density were 62159 per square km as per census of 2011. Hence there is great requirement in the study of earthquake safety and designing criteria of the building structures on the sloping terrain.

The response and severity of damage depends on the frequency of the earthquake because it affects the building structure performance when it is subjected to ground motion. In this research work analytical study is done on different multy storey building of different configuration like STEP BACK, SET BACK – STEP BACK & SET BACK.

Earthquake Magnitude Scale		
Magnitude	Earthquake Effect	Estimated number each year
2.5 or Less	Usually not felt,but can be recorded by seismograph	900,000
2.5 to 5.4	Often felt,but only causes minor damage	30,000
5.5 to 6.0	Slight damage to building and other structure	500
6.1 to 6.9	May causes a lot of damage in very populated areas	100
7.0 to 7.9	Major earthquake serious damage	20
8.0 or Greater	Great earthquake can totally destroy communities the epicenter	One every 5 to 10 year

1.3 OBJECTIVE AND SCOPE OF PROJECT

The purpose of this research work is to study numerically the seismic behavior of sloping ground building structures subjected to earthquake vibration causing sinusoidal ground motion and seismic excitations.

The aim of this thesis is summarized as follows:

Three dimensional (3-D) RC space frame analysis has been done on three various configuration of building structures which are varying height from 12.75 m to 24.25 m height (4 to 8 storey) situated on sloping and flat terrain under the effect of earthquake loads.

Due to dynamic characteristics and sesmic analysis like base shear, natural period of time and top storey sway of the building structures is presented.
By structural analysis tool STAAD PRO(v8i) a linear time history analytical study is performed as per spectra of IS 1893 (PART 1) :2002 for a troublesome soil condition and 5% critical damping.
In the present study, the dynamic characteristics of a G+8 storied RC framed step back set back building on a hill and flat slope is investigated by varying the slope angles. Modelling analysis is performed using STAAD.Pro(v8i).

2.LITERATURE REVIEW

2.1 OVERVIEW

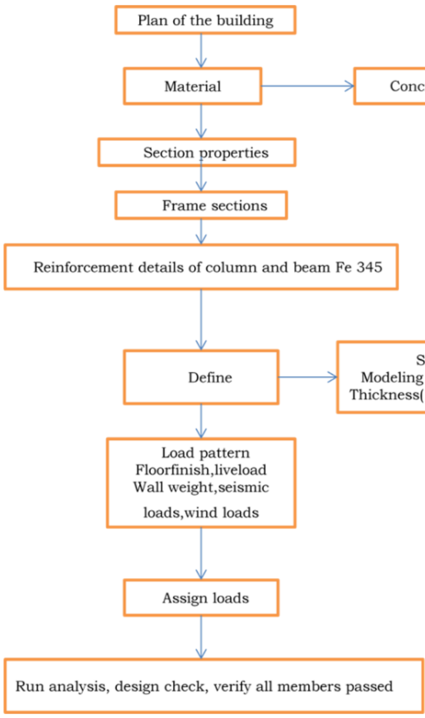
RAVIKUMAR AL. (2012) studied mainly two types of irregularities in building structures model 1) plan irregularity i.e., horizontal discontinuity in configuration 2) elevation irregularity with set back and sloping ground terrain. To identify the seismic behavior, push over analysis was carried out by taking different lateral load condition in all three directions, respectively. All the structures considered were three storied with different plan and elevation irregularities pattern. Due to lesser amount of forces generated on plan irregular models give more deformation. The execution of all models lies in between life safety criteria and collapse prevention expect for models resting on sloping ground. Thus, it can be concluded that structures resting on sloping terrain are more prone to damage rather than structures resting on flat ground even with horizontal irregularities.
Halkude et al. (2013) studied the dynamic characteristics of the building i.e., base shear, top storey displacement and natural time period with respect to variation in number of stories and number of bays along the slope.
Prashant and Jagadish (2013) studied the seismic response of one-way slope RC building with a soft storey. They have focused their work to the buildings with infill wall and without infill wall i.e., bare frame. They carried out pushover analysis in a 10 storey building which include bare frame with and without infill wall. The buildings were situated at an inclination of 27 degrees to the horizontal and having 5 bays along the slope. Frame system considered was specially moment resisting frame (SMRF).
RAMANCHRLA AND SREERAMA (2013) observed about recently earthquakes like BiharNepal, Shilong plateau collision and the Kangra earthquake was cause of more than 3,75,000 people death and over 1 lac of the building structure got damaged and collapsed. Seismic features of the building structures resting on plain ground differs to buildings rested on hilly terrain sloping ground in the plan as well as elevation difference in the building configuration. Due to this irregular behavior the centroid (C.G) and the stiffness center do not match with each other corresponding torsion effect generated due to eccentricity. The mass and stiffness of the beam element differs with in the building storey causes increment in the base shear forces on column on uphill side and prone to damages. They analyze five G+3 building structure of different slope angle 00 ,150 ,300 ,450 ,600 which were designed and analyzed using IS-456 and SAP-2000. They conclude that shorter column attracts more amounts of lateral forces due to increment in the stiffness. As the slope angle increases base shear on the shorter column increases and forces value decreases as the slope angle increases for the other columns.

METHODOLOGY

1. 1.Review of existing literatures by different researchers.
2. 2.Selection of existing multistorey RC building.
3. Modeling of the chosen structure.
4. Performing dynamic analysis on selected building model and therefore the analysis results are plotted in sort of graphs.
5. Column is modeled as fixed to the bottom.
6. The effect of soil structure interaction is ignored.

7. A 2-dimensional frame subjected to concentrated loads with un-equal supporting columns. In ETABS, analysis of (G+9) multistoried building on sloping ground is carried out for storey displacement, storey shear and base shear using response spectrum method.

Then the next following steps are mentioned in form of flowchart:



To study and evaluate the behavior of reinforce concrete buildings resting on the sloping ground. Here, a dynamic analysis of a RC- building with fixed base is done considering different types of frames using ETABS.

1.STRUCTURAL MODELING SPECIFICATIONS

Live Load	3kN/m^2
Density of RCC considered:	25kN/m^3
Thickness of slab	150-200mm
Depth of beam	450mm
Width of beam	300mm
Dimension of column	900x600mm
Density of infill	20kN/m^3
Thickness of outside wall	20mm
Thickness of inner partition wall	15mm
Height of each floor	3.0m
Earthquake Zone	V
Time period in X-direction	1.10sec
Time period in Y-direction	0.9sec
Damping Ratio	5%
Importance factor	1.5

OMRF=Ordinary Moment Resisting Frame

2.MODELING DETAILS

A (G+9) building with ordinary moment resisting frames in two orthogonal directions, was selected for the study. The building had a one brick thick exterior infill wall along the periphery.

The material and sectional properties in the analysis of different building frames are shown in Table 1 confirming to IS 456:2000.

Sl.No	Model Parameters	Details
1	Column	1200x1200
2	Beam	450x 300 mm
3	Slab	150 mm thick
4	Wall thickness	230 mm thick
5	Unit weight of masonry	25 kN/m^3
6	Support conditions	Fixed support
7	Ground slope	45°
8	Grade of concrete	M25
9	Grade of steel	Fe415

Table No.1

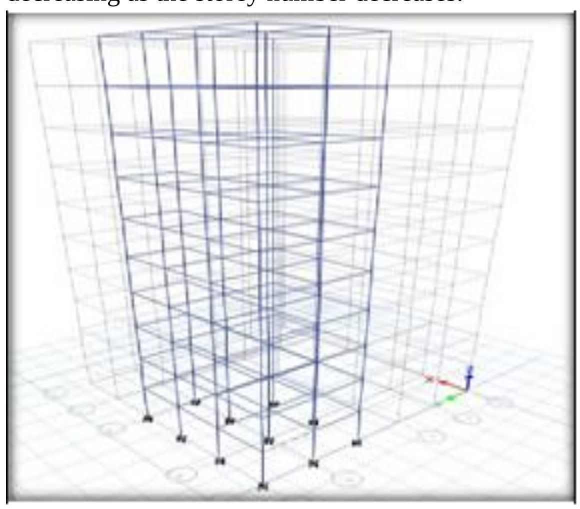
Dead loads and live loads are compared as per IS 875 (part 1):1987 and IS 875(part 2):1987 respectively and are shown in Table no 2.

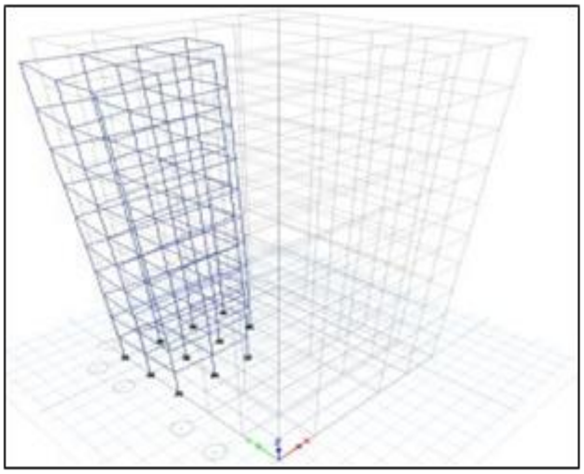
SL. No	Parameters	Details
1	Roof finish	1.50 kN/m^2
2	Floor finish	0.75 kN/m^2
3	Roof live load	2 kN/m^2
4	Floor live load	4 kN/m^2

Table No.2

Deformed Shapes of Bar frames:

The deformed shapes of bare frame of (G+10) building is shown in figure 5 Maximum displacement is seen for highest point of the building and it goes on decreasing as the storey number decreases.

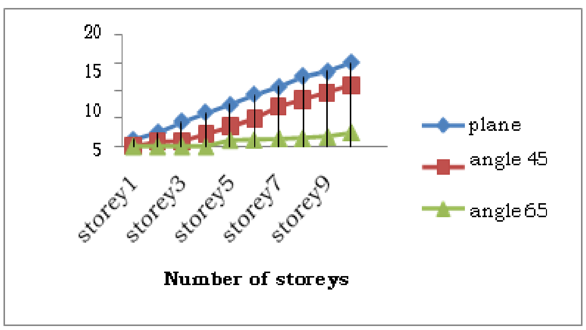




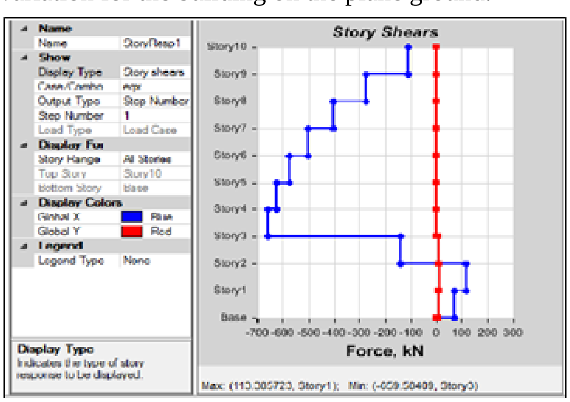
Parametric Study:

The parameters which are considered are:

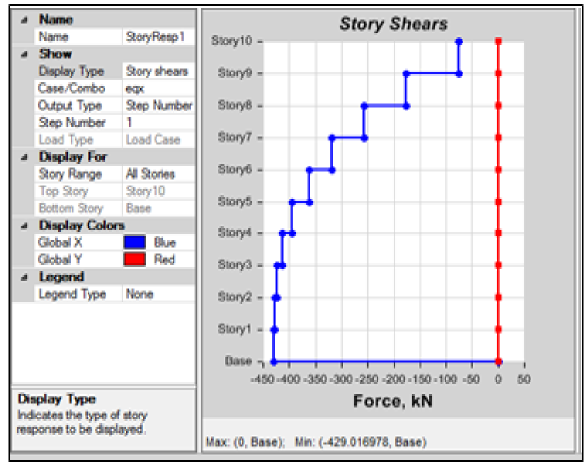
The displacement values of the building obtained from the response spectrum analysis increase as the storey increases. 45-degree sloped frame experiences more storey displacement than 65 degree sloped frame due to the low value of stiffness of short column.



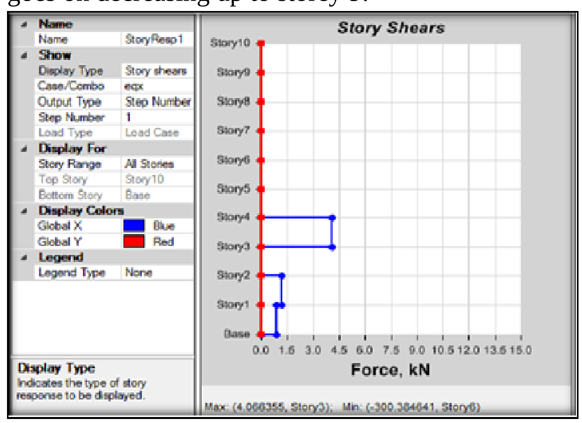
Storey shear: This Figure Show that the storey shear variation for the building on the plane ground.



This figure shows the storey shear for 45 degree slope ground the maximum value occurs at base and minimum value at 440 kN from storey 1 to storey 3and it goes on decreasing up to storey 9



This figure shows the storey shear value for 65 degree slope ground the maximum value occur at storey 3 and minimum value as 310kN from storey 3 to storey 6 its goes on decreasing up to storey 9.



CONCLUSIONS

1. According to results of Response Spectrum Analysis, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases. It is observed that base shear decreases from lower angle to higher angle.
2. On plane ground, storey deflection is quite on sloping ground.
3. Supported on the seismic analysis of three different configurations of building structures, the subsequent conclusions are often drawn.
    a. The performance of step back building configuration during earthquake excitations could prove more vulnerable than other configuration like Step Back Set Back and Set Back building structures.

   b. In step back set back building configuration torsion moment due to accidental generates in lesser amount compare to step back building configuration. Hence Step Back Set Back Building Structures are found to be less high strung than Step Back building against seismic ground motions.
   c. In step back and step back set back building structures it is observed that extreme left column at ground level, which is less and shorter, worst affected so much attention is required for these columns in design and detailing.
   d. Although the Set Back configuration resting on plain ground attracts low base shear action compared to step back set back configuration overall economic cost involved to level the inclined ground and other related issue with this is often got to study intimately.
4. Buildings resting on sloping ground have less base shear compared to buildings on Plain ground.

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