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Seismic Analysis of Step Back Structure on Sloped Ground

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Abstract: ***This project focuses on the analytical investigation of a step back structure on slope ground with three different inclinations (10^0,30^0and45^0). The inclination is achieved in two different phases, in first phase three different inclinations are obtained by maintaining the height of the building constant and in second phase width of the structure was maintained constant. The modelling and analysis were completed using STAAD-Pro. The seismic analysis was carried out by two different methods: Seismic coefficient method and response spectrum method. From the analysis, it was observed that for any inclination ground story short column in the middle of the structure carries more load compared to the long length column. Increasing the angle of fixed height the column forces and stiffness of the structure decrease with increase in the angle whereas for fixed width structures it was increasing.***

Keywords: Step Back Frames, Step Back & Set Back Frames, Static Analysis, Response Spectrum Analysis, Hill Slope Angle.

I. INTRODUCTION

In recent years, it has become a common practice in growing cities located in mountainous regions to undertake the construction of buildings of considerable height and large base areas on slope terrains(ex.: north-east regions of India like Meghalaya, Arunachal Pradesh, Sikkim and etc...). These are mainly in seismic zones of iv and v. In these areas are the occurrence of earthquakes are also more, considering recent major earthquake in Sikkim the seismic tremor of the significance of 6.9 and Doda the seismic magnitude of degree 4.9, the past earthquake Uttarkashi earthquake in 1991, Assam earthquake in 1950, Bihar and Nepal earthquakes in the year of 1934 and 1980. In this work, rc seismic analysis (1- 3 floors) analysis has been carried out and studied changes in structural behaviour due to gradient examination. Numerous surveys have been conducted around the world in recent decades to investigate the seismic performance of buildings on the slopes of the hills. Due to economic growth and rapid urbanization, there is a popular and convincing construction of multiple-story buildings on hill demand.

II. CONFIGURATION OF BUILDINGS ON HILL SLOPES

The resettlement of the choline colony's palace by other residents of the desiguales column and the mismopiso, which causes irregularities in the direction of rigidezendireccionestransversales. Cutting if someten a lateral cargas in the cross direction, including constructions with rectangular configurations that simulate once a twist, means banging to the lateral rigidez of the lateral bastidores varies arriba and cuudiabajo. The plant of the estuary buildings is very much different, and the buildings are on the ground and are replaced by the center of gravity and center of mass with the level of the suelo. The width of one of the two constructions in which a symmetrical configuration is located is not alien to a torsión, but other columns and the dado cuesta arriba of a pisatoman the part of the mayor part of the cizalladura of the piso, which is generally mucho Other Person able to take home and in the company of a courteous fracaso. Eight type of extrutural configuration that deals with crops in plant buildings that are in slope and sloping slopes.

III. RESPONSE SPECTRUM ANALYSIS

Keeping in mind to perform the analysis and design of a structure to be worked in a specific area, the actual time history record is required. However, it is unrealistic to have such records in every single area. Promote, the seismic investigation of structures can't be completed basically in view of the pinnacle estimation of the ground speeding up as the reaction of the structure rely on the recurrence substance of ground movement and its own dynamic properties.

To conquer the above challenges, earthquake reaction range is the most prevalent device in the seismic examination of structures. There are computational focal points in utilizing the reaction range strategy for seismic examination for the expectation of removals and part drives in basic frameworks. The strategy includes the figuring of just the greatest estimations of the removals and part constrains in every method of vibration utilizing smooth plan spectra that are normal of a few seismic tremor movements.

IV. STRUCTURE RESTING ON SLOPE GROUND

Shahrooz and Moehle et al (1990) studied the effects of setbacks on the earthquake response of multi-storeyed buildings. In an effort to improve design methods for setback structures, an experimental and analytical study was undertaken. In the experimental study, a six-storey moment-resisting reinforced concrete space frame with 50% setback in one direction at mid height was selected. The analytical study focused on the test structure. The displacement profiles were relatively smooth over the height. Relatively large inter-storey drifts at the tower-base junction were accompanied by a moderate increase in damage at that level. Overall, the predominance of the fundamental mode on the global translational response in the direction parallel to the setback was clear from the displacement and inertia force profiles. The distribution of lateral forces was almost always similar to the distribution specified by the UBC code; no significant peculiarities in dynamic response were detected. To investigate further, an analytical study was also carried out on six generic reinforced concrete setback frames.

Birajdar and Nalawadeet al.(2004) studied on seismic performance of buildings resting on the inclined ground. They performed tests on twenty four RC frames with three fully totally different classifications as Step back building, Step back set back building and Set back building situated at a slope of twenty seven degrees with the Horizontal. Throughout this study, the unstable response of buildings with variable construction levels from four to eleven (15.75m to 40.25m), contains one bay across the slope and three bays on a slope, set in unstable zone III.

The 3d analysis was disbursed that has torsion result by exploitation Response spectrum methodology. From the analysis, it's observed that there is a linear increase of displacement and a basic fundamental measure of prime construction as a result of the peak of the structure varies ascending.

By scrutiny, the results they observed that the increase in prime construction displacement and basic fundamental measure as a result of the peak of step back building can increase is kind of step back set back structure. From their analysis, it's observed that the shear force inside the column towards the extreme left is predominantly higher as compared to the remainder of the columns, simply just in case of step back structure it's in between 55-250% quite step back set back structure.

Thus they conclude the acute left column at ground level that ar short ar the worst affected and set back structure having plenty of stiffness throughout unstable excitation than the opposite type of classification as a result of it's observed in step back structure, the uneven distribution of shear force inside the many frames suggests the development of torsional moment as a results of static and accidental eccentricity. Devesh P. Soni and Republic of India B. Mistry, A. D. Patel (2006): Qualitative review of the unstable response of vertically irregular building frames. This study summarizes progressive information inside the unstable response of vertically irregular building frames. Criteria method vertical irregularity as per this building codes are mentioned.

He discovered most of the studies agree on the rise in drift demand within the tower portion of occurrence structures and on the rise in seismic demand for buildings with discontinuous distribution in mass, stiffness, and strength. The most important seismic demand is found for the combined stiffness and strength irregularity.

Karavasiliset. al. (2008) distributed a study on the inflexible seismic response of plane steel moment resisting frames with setbacks. A family of a hundred and twenty such frames, designed in keeping with the ecu seismic and structural codes, is subjected to associate degree ensemble of thirty standard earthquake ground motions scaled to totally different| completely different intensities so as to drive the structures to different limit states. The author all over that the amount of inflexible deformation and geometrical configuration play a very important role in the peak wise distribution of deformation demands.

The maximum deformation demands square measure focused within the “tower” for a tower like structures and within the neighborhood of the setbacks for different geometrical configurations.

Athanassiadou (2008) self-addressed seismic performance of multi-storey ferroconcrete (R/C) frame buildings irregular in elevation. 2 ten-storey 2-dimensional plane frames with two and 4 giant setbacks within the higher floors severally, similarly as a 3rd one, regular in elevation, are designed to the provisions of the 2004 monetary unit code eight (EC8).
All frames are subjected to each inflexible static pushover analysis and inflexible dynamic time-history analysis for elite input motions. It's all over that the impact of plasticity category on the value of the building is negligible. Seismic performance of irregular frames square measure equally satisfactory (and not inferior) to it of the regular ones even for motions doubly as sturdy because of the style earthquake. Also, standard pushover analysis looks to be underestimating the response quantities within the higher floors of the irregular frames.
This conclusion relies on the multi-mode elastic analysis and evaluates the seismic style provisions of monetary unit code EC-8 in keeping with that the look provision given within the European customary for occurrence building aren't inferior to it for normal buildings.

As per this reference the setback building and regular building designed as per EC-8performs equally smart once subjected to unstable loadings. Ravi Kumar (2012) cantered on the study of the unstable performance of irregular configurations of RC buildings within which they studied vertical irregularities of buildings like geometric irregularity and buildings resting on sloping that 2 varieties of configurations were thought of as buildings resting on a sloping ground in X-direction and buildings resting on a sloping ground in Y-direction.

All buildings comprise five bays in X-direction and four bays in Y-direction with three story settled in severe zone V. The performance of those buildings was studied by linear analysis victimisation code IS 1893 (part-1) 2002 and nonlinear analysis victimisation ATC forty. They ascertained that the vulnerability of sloping ground buildings was found to be exceptional that attracts giant force to deform moderately.

Base shear of building on hill slope was found to be 6019.2 km, that was around 25-55% quite alternative buildings and additionally, displacement was found to be eighty three.4 millimetre that was moderately beyond alternative buildings. They found that the performance goal wasn't achieved of sloping ground buildings in X-direction and in Y-directions, this was achieved once collapse purpose.

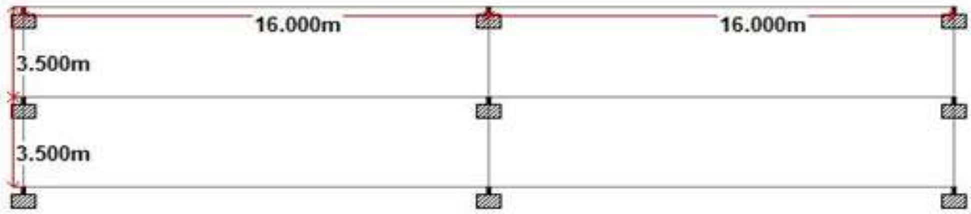
Thus they conclude that the buildings resting on sloping ground square measure additional liable to an earthquake than the buildings resting on the plain ground. Singh et al. (2012) studied the unstable behaviour of buildings settled on slopes. AN analytical study is administrated on buildings thought of, by victimisation linear and nonlinear time history analysis.

They thought of nine construction buildings, that embrace step back building at a slope of forty five degrees with the horizontal, an RC frame settled on steep slope /vertical cut that wasn't thought of in previous studies, within which foundations square measure provided at 2 levels, at base downhill, and at the road level, to match the behaviour, they thought of buildings resting on the flat ground with three and nine story's.

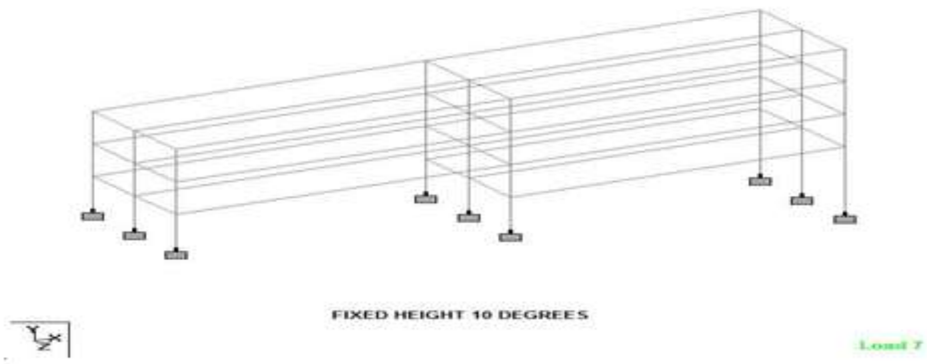
V. MODELING

FIXED HEIGHT OF 10^0 INCLINATION

1. Arrange in X-direction 2 bay each of 16 m length and in Z-direction 2 bay each of 3.5 m length. The total height of the structure is 15m every story height 3m base 6m.
2. The column dimension on ground level 600×850mm for the short length column (3m) at the right of the structure and the long length columns (6m) on ground level.
3. The column dimension 550×750mm for all middle columns.
4. The column dimension 450×650mm for left side 3 columns.
5. The beam dimension 300×750mm for all beams.

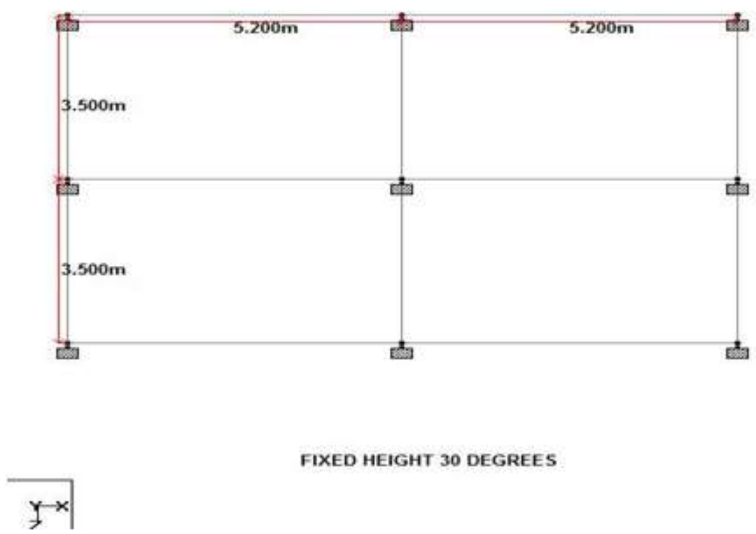


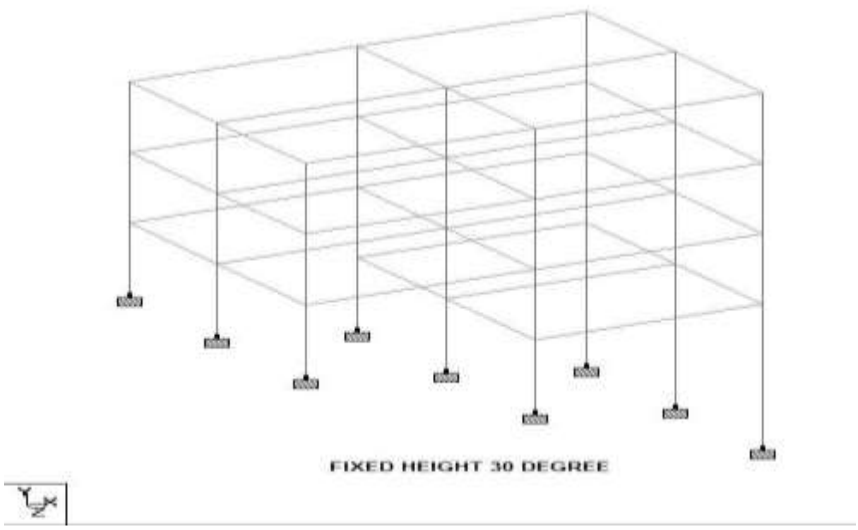
Fixed Height 10 Degrees



FIXED HEIGHT OF 30^0 INCLINATION

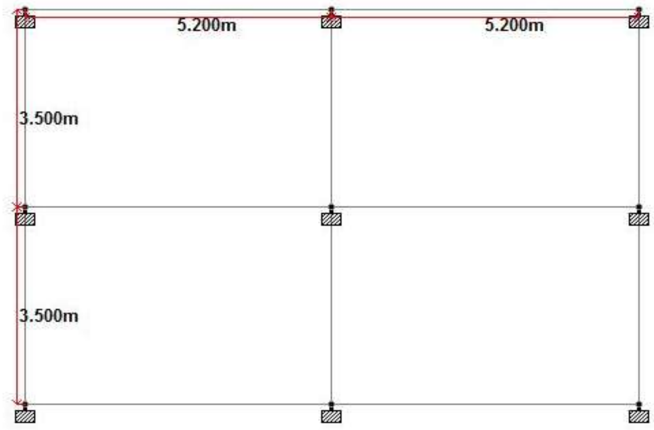
1 .Arrange in X-Dir. 2bay each of 5.2 m length and in Z-Dir. 2 straight each of 3.5 m length. The total height of the structure is 15m every story height 3m base 6m.
2. The column dimension on ground level 400×600mm for long length sections (6m).
3. The column dimension on ground level 350×500mm for short length section (3m).
4. The column dimension 300×450mm for all sections.
5. The beam dimension 300x450 mm for all beams.





FIXED HEIGHT OF 30^0 INCLINATION

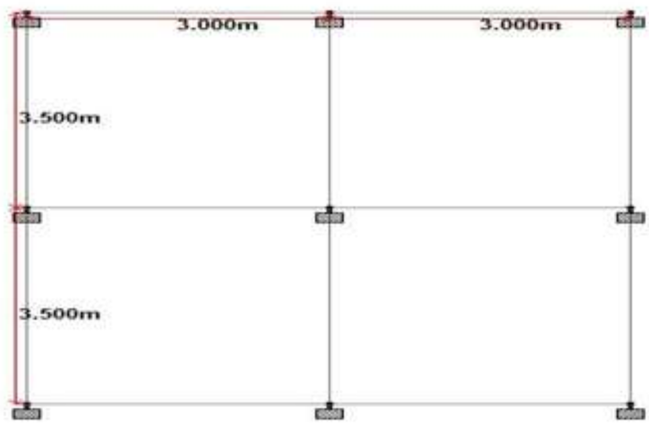
Arrange in X-Dir. 2bay each of 5.2 m length and in Z-Dir. 2 straight each of 3.5 m length. The total height of the structure is 15m every story height 3m base 6m.
The column dimension on ground level 400×600mm for long length sections (6m).
The column dimension on ground level 350×500mm for short length section (3m).
The column dimension 300×450mm for all sections.
The beam dimension 300x450 mm for all beams.



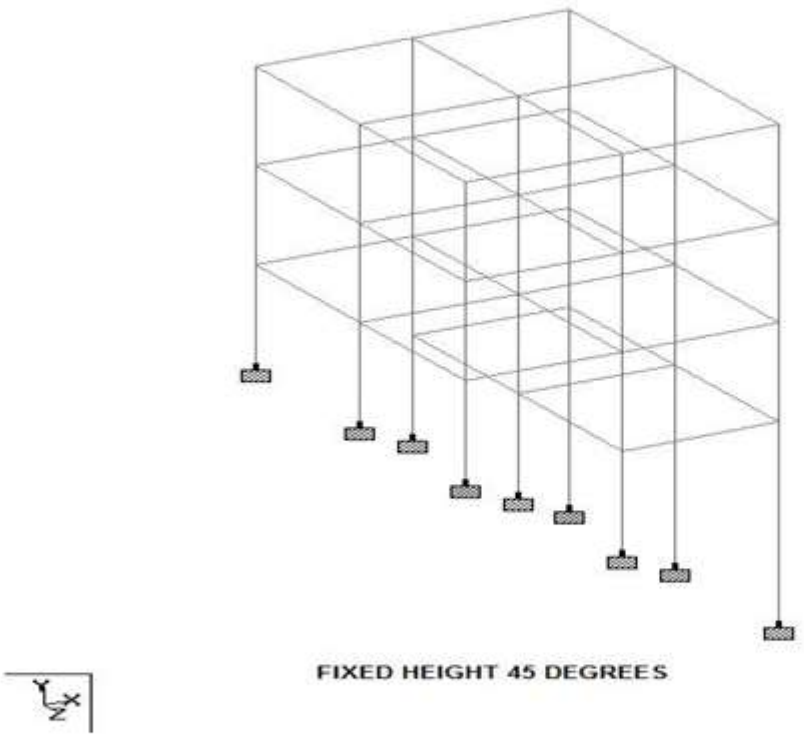
FIXED HEIGHT 30 DEGREES

FIXED HEIGHT OF 45^0 INCLINATION

Arrange in X-direction 2bay each of 3 m length and in Z-dir. 2 narrows each of
3.5 m length. The total height of the structure is 15m every story height 3m base 6m.
The column dimension on ground level 400×600mm of long length columns (6m).
The column dimension on middle row columns 350×500mm.
The column dimension 300×450mm for staying all columns.
The beam dimension 300 x 450 mm for all beams.



FIXED HEIGHT 45 DEGREES



VI. FIXED HEIGHT AND FIXED WIDTH RESULTS

Model Fixed Height	Building height in (m)	Maximum on top Story drift (model displacement) in (mm)	Base shear (seismc coefficient) (V_b) in kN	Maximum column forces from seismic coefficient method in (kN)	Maximum column forces from response spectrum in (kN)	Peak storey shear value (Response spectrum)
AT 10 degrees	15	15	863	4168.06	3168.03	1058
At 30 degrees	15	10.358	318	1541.67	1416.02	261
At 45 degrees	15	5.977	226	1020.34	980.13	169.83

Fig: Fixed Height Results of Base Shear

RESPONCE SPECTRUM ANALYSIS

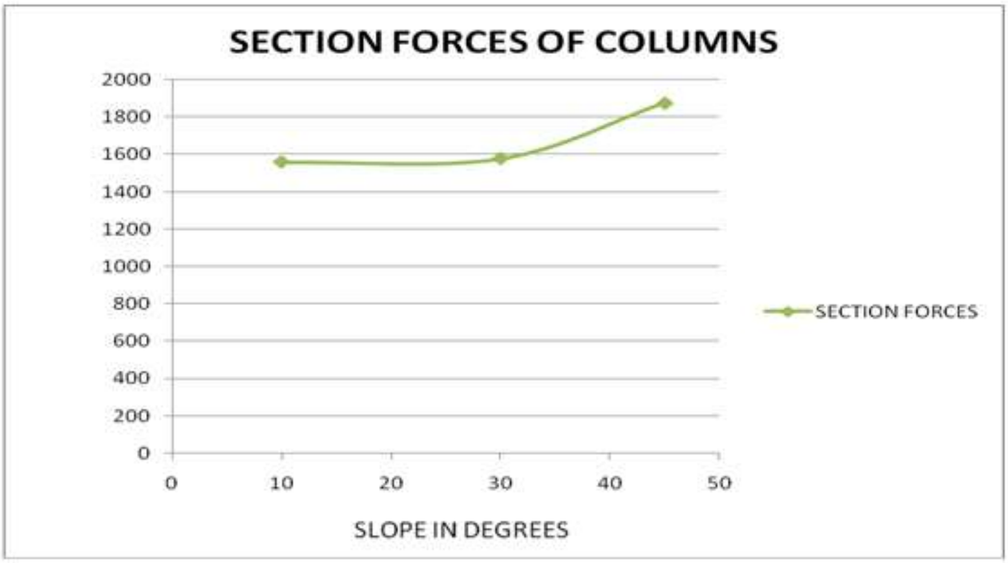
Response spectrum analysis is done as per IS 1893:2002 the minimum values model mass partition factor should consider as more than 90 percentage total seismic mass and the ratio between the design base shear and fundamental base shear value is equal to one

RESULTS AND ANALYSIS OF BASE SHEAR FOR DIFFERENT TYPES OF STRUCUTRES (10^0, 30^0AND 45^0)

BASE SHEAR RESULTS OF FIXED WIDTH	
X-AXIS in Degrees	Y-AXIS in kN
10	326
30	322
45	406

Fig: Base Shear Results of Fixed Width

Fig: Base Shear Results of Fixed Width



VII. CONCLUSIONS

1. From the results it was concluded the short length column at ground level will take more force when compared to the long length columns and the opposite long length column was also taking more force (which was less than short column force) compare to remaining columns.
2. While increasing inclination of the structure the for fixed height the column forces are decreasing and for the fixed width it was increasing while increasing the angle and the story drift was increasing while increasing.

3. For fixed height, the value of base shear was decreasing while increasing the angle of inclination of the structure.
4. For fixed width, the value of base shear was increasing while increasing the angle of inclination of the structure.
5. For fixed width the value of peak story shear was increasing from response spectrum analysis results it was observed that for fixed height case the value of peak story shear was decreasing while increasing the inclination.
6. From response spectrum results it was observed that for fixed height model load participation ratio value increasing for fixed width case the model load participation ration is decreasing.

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