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Analysis of multi store symmetrical building in zone-ii on flat and sloping ground up to failure by using etabs

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Abstract
Buildings may be considered as asymmetric in plan or in elevation based on the distribution of mass and stiffness along each storey, throughout the height of the buildings. Most of the hilly regions of India are highly seismic. A building on hill slope differs in different way from other buildings. In this study, 3D analytical model of four and nine storied buildings have been generated for symmetric and asymmetric building models and analyzed using structural analysis tool "ETABS". To study the effect of varying height of columns in ground storey due to sloping ground, the plan layout is kept similar for both buildings on plane and sloping ground. The analytical model of the building includes all important components that influence the mass, strength, stiffness and deformability of the structure. To study the effect of infill during earthquake, seismic analysis zone –II using both linear dynamics (response spectrum method) as well as nonlinear static procedure (pushover) has been performed

Previous studies emphasize for proper planning and construction practices of multistoried buildings on sloping ground. However, in normal design practice the designers generally ignore the effect of sloping ground on the structural behavior of the building. The seismic analysis of a G+9 storey RCC building on varying slope angles i.e., 7.50 and 150 is studied and compared with the same on the flat ground. The seismic forces are considered as per IS: 1893-2002. The structural analysis software ETABS is used to study the effect of sloping ground on building performance during earthquake. Seismic analysis has been done using Linear Static method. The analysis is carried out to evaluate the effect of sloping ground on structural forces. The horizontal reaction, bending moment in footings and axial force, bending moment in columns are critically analyzed to quantify the effects of various sloping ground. It has been observed that the footing columns of shorter height attract more forces, because of a considerable increase in their stiffness, which in turn increases the horizontal force (i.e. shear) and bending moment significantly. Thus, the section of these columns should be designed for modified forces due to the effect of sloping ground. The present study emphasizes the need for proper designing of structure resting on sloping ground.

In this Study, a multi- storey reinforced concrete building has been modelled and performed by using software ETABS with different plan shapes regular (Rectangular shaped) and each shape has three different configurations like (setback building, step back building and set-step back building) and plane dimension (40 x 40) m with nine stores resting on plan and on sloping ground (26.57o) with fixed length of short columns support for each models, the models have been conducted and analyzed in the ETABS pro program by using equivalent linear static method and response spectrum method for comparing and investigating the changes in structural behavior and the irregularity effect in plan and elevation on sloping ground. The result of the analysis for displacement and storey drift have been studied and compared with reference to the serviceability and the time period, storey shear, storey moment and storey torsion, have been studied and compared for different configurations structure models and it was presenting in graphical and tabular form.

Keywords: Sloping ground, Seismic forces, RCC Building, Structural analysis, ETABS

Introduction
Multistoried R.C. framed buildings are getting popular in hilly areas because of increase in land cost and under unavoidable circumstances due to shortage of land in urban areas. Thus, many of them are constructed on hilly slopes. Setback multistoried buildings are frequent over level grounds whereas step back buildings are quite common on hilly slopes. Combinations of step back and setback buildings are also common on hilly slopes. At the location of setback stress concentration is expected when the building is subjected to earthquake excitation. These are generally not symmetrical due to setback and/or step back and result into severe torsion under an earthquake excitation.

Current building code suggests detailed dynamic analysis for these types of buildings.

Buildings in hilly areas are irregular and asymmetric and therefore are subjected to severe torsion in addition to lateral forces under the action of earthquake forces. Many buildings on hill slopes are supported by columns of different heights. The shorter columns attract more forces as the stiffness of the short columns is more and undergo damage when subjected to earthquakes. Buildings in hilly areas are subjected to lateral earth pressure at various levels in addition to other normal loads as specified on building on level grounds. Building loads transmitted at the foundation level to a slope create problem of slope instability and may result into collapse of the building. The soil profile is non uniform on the hilly slopes and result into total collapse of the building. The bearing capacity, cohesion, angle of internal friction, etc. may be different at different levels. It may result into unequal settlement of foundations and local failure of the slope.

Simplified approaches for the seismic evaluation of structures, which account for the inelastic behavior, generally use the results of static collapse analysis to define the global inelastic Performance of the structure. Currently, for this purpose, the nonlinear static procedure (NSP) which is described in FEMA-273/356 and ATC-40 (Applied Technology Council, 1996) documents are used. Seismic demands are computed by nonlinear static analysis of the structure subjected to monotonically increasing lateral forces with an invariant height-wise distribution until a predetermined target displacement is reached.

Nonlinear static (pushover) analysis can provide an insight into the structural aspects, which control performance during severe earthquakes. The analysis provides data on the strength and ductility of the structure, which cannot be obtained by elastic analysis. By pushover analysis, the base shear versus top displacement curve of the structure, usually called capacity curve, is obtained. To evaluate whether a structure is adequate to sustain a certain level of seismic loads, its capacity has to be compared with the requirements corresponding to a scenario event.

In pushover analyses, both the force distribution and target displacement are based on very restrictive assumptions, i.e. at time-independent displacement shape. Thus, it is in principle inaccurate for structures where higher mode effects are significant, and it may not detect the structural weaknesses that may be generated when the structures dynamic characteristics change after the formation of the first local plastic mechanism. One practical possibility to partly overcome the limitations imposed by pushover analysis is to assume two or three different displacements shapes (local patterns).

Earthquake is the most disastrous due to its unpredictability and huge power of devastation. Earthquakes themselves do not kill people, rather the colossal loss of human lives and properties occur due to the destruction of structures. Building structures collapse during severe earthquakes, and cause direct loss of human lives. Numerous research works have been directed worldwide in last few decades to investigate the cause of failure of different types of buildings under severe seismic excitations. Massive destruction of high-rise as well as lowrise buildings in recent devastating earthquake proves that in developing counties like India, such investigation is the need of the hour. Hence, seismic behavior of asymmetric building structures has become a topic of worldwide active research. Many Investigations have been conducted on elastic and inelastic seismic behavior of asymmetric systems to find out the cause of seismic vulnerability of such structures. The purpose of the paper is to perform linear static analysis of medium height RC buildings and investigate the changes in structural behavior due to consideration of sloping ground.

An important feature in building configuration is its regularity and symmetry in the plane and elevation. Buildings on hill slope are highly irregular and asymmetric in plan and elevation. One of the major contributors to structural damage during strong earthquake is the discontinuities and irregularities in the load path or load transfer.

The lateral load such as earthquake is to be classified as live horizontal force acting on the structure depending on the building's geographic location, height, shape and structural materials. A building with an irregular configuration may be designed to meet all code requirements but it will not perform well as compared to a building with a regular configuration

Studied that the practical system deliberately introduces flexibility to the sloping ground storey of structures was described. The system utilizes Teflon sliders to carry a portion of the superstructure. Energy dissipation is provided by the ground story ductile column s and by the Teflon sliders. Utilizing this concept the seismic response characteristics of a multistory frame are analyzed an discussed. The results show that it is possible to provide safely to the superstructure while maintaining the stability of the ground storey.

Investigated analysis and the design of multi- storied RCC buildings for seismicity. Reinforced concrete multi-storied buildings re very complex to model as structural systems for analysis. Usually, they are modeled as two-dimensional or three- dimensional frame, systems are in to plane and slope with different angles 510, and 15. Analyze multistoried buildings in the country for seismic forces and comparing the axial force, shear force, moment, nodal displacement, stress in beam and support reaction compared to current version of the IS: 1893 – 2002 to the last version IS: 1893-1984.

Presented the results from seismic analyses performed on 24 RC buildings with three different co figurations like, Step back building; Step back Set back building and Set back building are presented. 3 –D analysis including tensional 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.

Studied experimental pushover an alysis was carried out with a study the performance e of framed buildings u nder future expected earthquakes. Sloping ground are consider the three framed buildings with 5, 8 and 12 stories respectively were analyzed. The results obtained in these three buildings and compare the axial force, bending moment, nodal displacement, base shear and s haws that properly designed frames will perform well under seismic codes. Some of the conclusions made by the authors are the pushover analysis is a relatively simple way to explore the linear and non linear behavior of Buildings.

Studied the Analysis of earthquake resistant building using Site Response spectra method. According to the Indian standard for Earthquake resistant design (IS: 1893), the seismic force depends on the zone factor (Z) and the average response acceleration coefficient (Sa/g) of the soil types at twenty meter depth with suitable modification depending upon the depth of foundation in plane and sloping ground. In the their studied an attempt has been made to generate response spectra using site specific soil parameters for some sites in seismic zone III and IV, study the variation of top storey displacement with respect to different sloping angle i. e. Arunachal Pradesh and Meghalaya are the generated response spectra is used to analyze some structures using commercial software ETABS.

2. Methods of analysis of structure

A software ETABS has been used to study the changes of the Structural Behaviour for different shapes of R.C Building on plan and on sloping ground under the lateral load effect such as earthquake load, According to IS 1893:2002, Both the equivalent lateral force procedure (static method) and response spectrum analysis procedure (dynamic method) lead directly to lateral forces in the direction of the ground motion component. The main differences between the two methods are in the magnitude and distribution of the lateral load over the height of the building.

Most building codes prescribe the method of analysis based on whether the building is regular or irregular. Almost all the codes suggest the use of static analysis for symmetric and selected class of regular buildings. For buildings with irregular configurations, the codes suggest the use of dynamic analysis procedures such as response spectrum method or time history analysis. Seismic codes gives different methods to carry out lateral load analysis, while carrying out this analysis infill walls present in the structure are normally considered as non structural elements and their present in the structure are normally considered as non structural elements and their presence is usually ignored while analysis and design. However even though they are considered as non-structural elements, they tend to interact with the frame when the structures are subjected to lateral loads.

In the present study lateral load analysis as per the seismic code for the bare structure and in filled structure is carried out and an effort is made to study the effect of seismic loads on them and thus assess their seismic vulnerability by performing pushover analysis. The analysis is carried out using Etabs analysis package.

This present work deals with study of behavior of sloping ground building frames considering different inclination (7.5o, 15o) under earthquake forces. The comparison of sloping ground and plane ground building under seismic forces is done. Here G+ 4 storey is taken and same live load is applied in three the buildings for its behavior and comparison. The framed buildings are subjected to vibrations because of earthquake and therefore seismic analysis is essential for these building frames. The fixed base system is analyzed by employing in three building frames in seismic zone II by means of ETABS Software. The response of three the building frames is studied for useful interpretation of results.

2.1 Steps for comparison

Comparisons of results in terms of horizontal reaction, bending moments, axial force. Following steps are adopted in this study

Step-1: Selection of building geometry and Seismic zone: The behavior of three the models is studied for seismic zone II of India as per IS code 1893 (Part 1):2002 for which zone factor (Z) is 0.24.

Step-2: Formation of load combination

Types of Primary Loads and Load Combinations: The structural systems are subjected to Primary Load Cases as per IS 875:1987 and IS 1893:2002.Six primary load case and thirteen load combinations used for analysis.

Step-3: Modeling of building frames using ETABS Software

Step-4: Analysis of three the building frames are done under seismic zone II for each load combination.

Step-5: Comparative study of results in terms of bending moments and horizontal force in footings, axial force and bending moment in columns.

The seismic analysis should be carried out for the buildings that have lack of resistance to earthquake forces. Seismic analysis will consider dynamic effects hence the exact analysis sometimes become complex. However for simple regular structures equivalent linear static analysis is sufficient one. This type of analysis will be carried out for regular and low rise buildings and this method will give good results for this type of buildings. Dynamic analysis will be carried out for the building as specified by code IS 1893-2002 (part1). Dynamic analysis will be carried out either by Response spectrum method or site specific Time history method. Following methods are adopted to carry out the analysis procedure.

3. About the structure

Two configurations: Rectangular shaped and for each configuration, a shapes have been modeled:

3.1 Basic data for buildings model

- Plan Dimension: (4x 40) m
- Height of each story: (3) m & one store is 5 m
- Number of stores: G+ 9 stores
- Length of each bay (in X-direction): (4) m
- Length of each bay (in Y-direction): (4) m
- Dimension of Column: (450 X 300) mm
- Dimension of Beam: (230 X300) mm
- Slab Thickness: (150) mm
- Walls Thickness: (230) mm thick brick masonry wall
- Grade of the concrete: M 25, M30
- Grade of the steel: Fe415
- Type of Soil: Type II, Medium Soil
- Seismic Zone: II
- Building Frame Systems: Ordinary RC moment-resisting
- Live Load on Typical Floor: (2.0) KN/m2
- Wind speed: (44) m/s
- Support: Fixed

3.2 Loads and factores calculation

Calculating the loads and factors values which are using in the ETABS:

A. Live Load: Live load for the Residential building in each storey = (2) kN/m2 as per IS: 875 (part 2) – 1987.

B. Dead loads: Dead loads which include Slabs, beams, columns, Floor finish and Wall Load are taken as prescribed by the IS: 875 -1987 (Part-1) Code of Practice Design Loads (other than earthquake) for Buildings and structure.

C. Seismic Loading: In the present work the building is located in Hyderabad which comes under -zone-II, Response reduction factor- 3, Importance factor- 1, Soil Type- medium, using the IS 1893 (Part-1) -2002 the following are the various values for the building considered

3.3 analyzing

A software ETABS v 9.7.4 program had been used for Modelling a multi- storey RC Buildings with different plan shapes (Rectangular), and each shape has three different configurations (setback building, step back building and step-set back building. And the Analysis Result for (time period, Base shear, displacement, storey drifts, storey shear force, storey Bending moment and storey torsion) have studied and compared.

4. Result and discussion

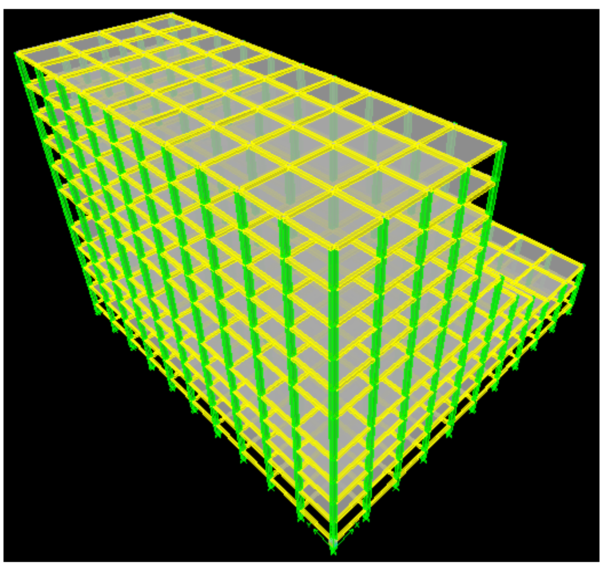

Fig 1: PLAN view

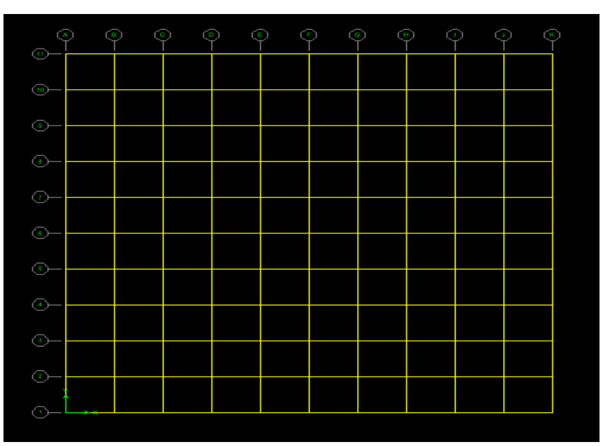

Fig 2: PLAN view

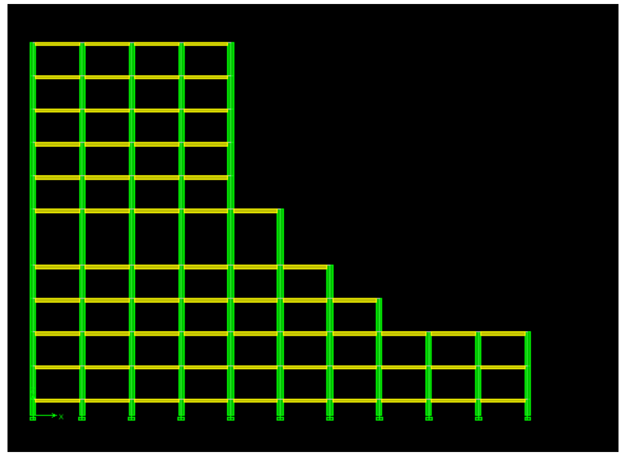

Fig 3: 3D Elevation

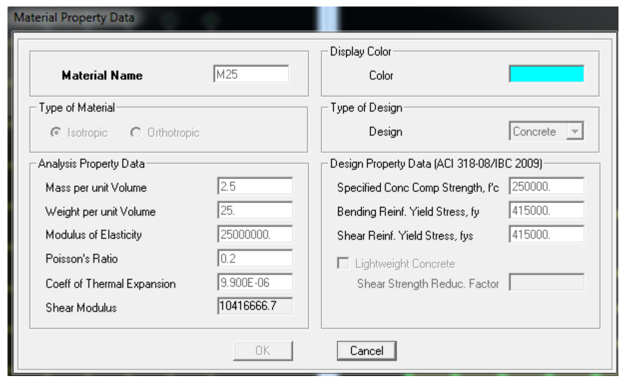

Fig 4: Building properties

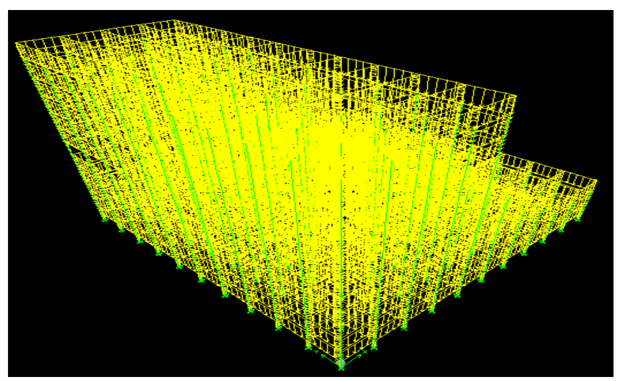

Fig 5: Dead Load

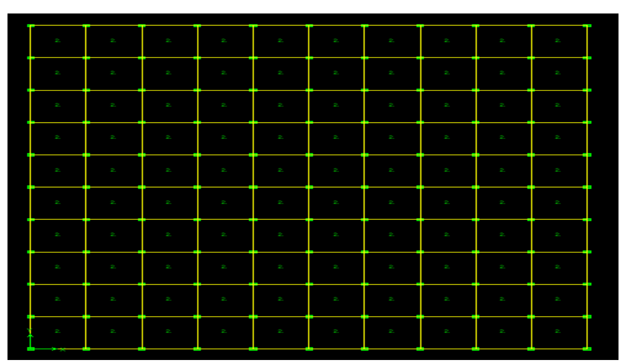

Fig 6: Live load

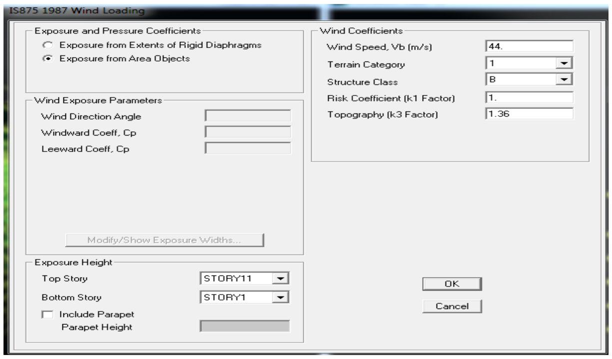

Fig 7: Wind load

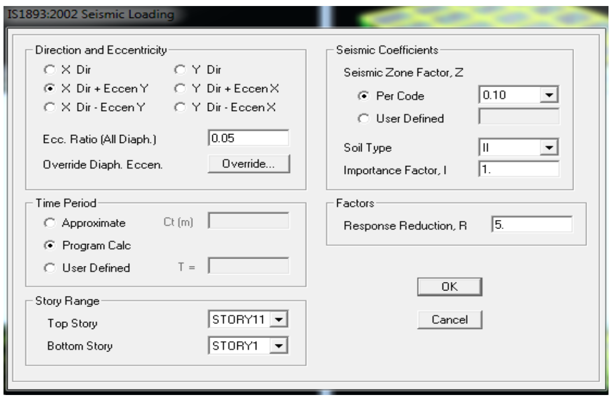

Fig 8: Earth Quake Load

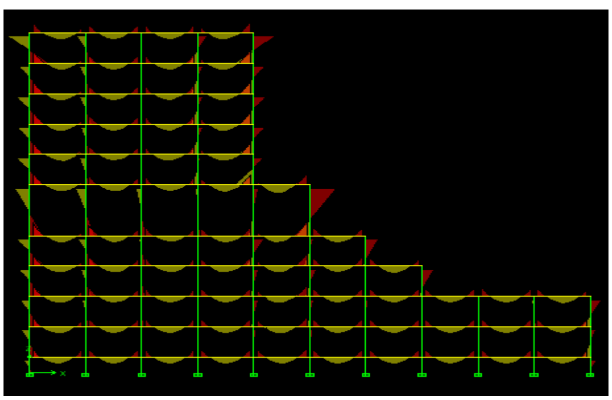

Fig 9: Bending Moment for Beams

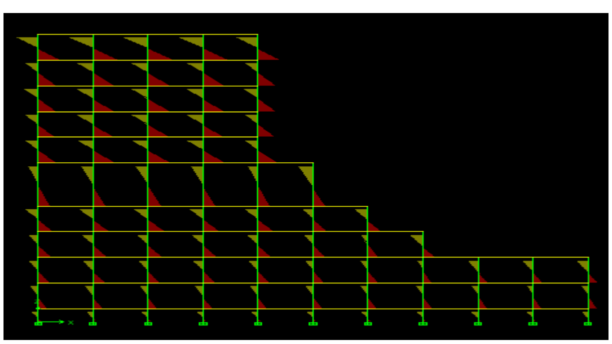

Fig 10: Bending Moment for Columns

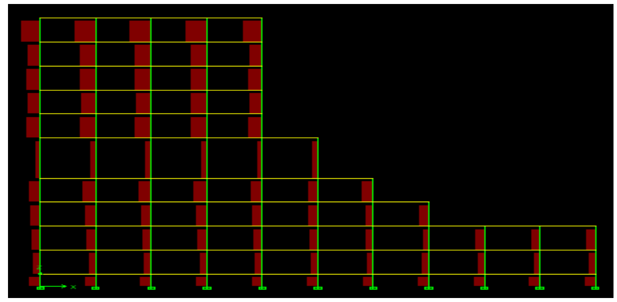

Fig 11: Shear Force for Columns

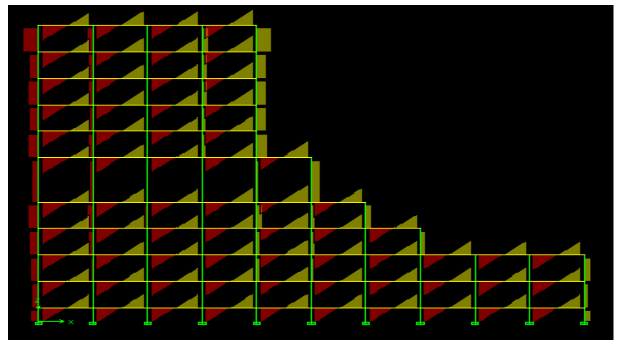

Fig 12: Shear Force for Beams

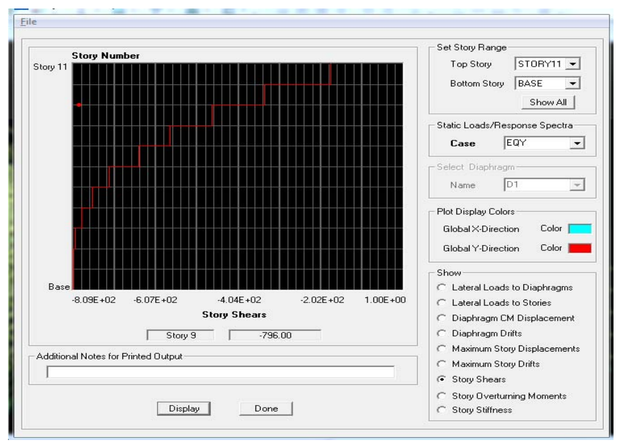

Fig 11: Story Shear along Y- Direction

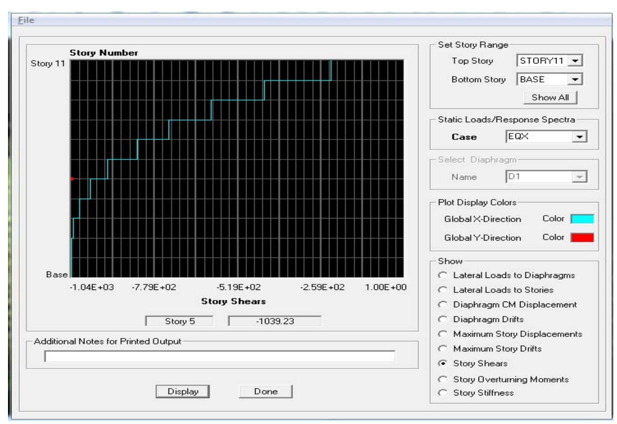

Fig 12: Story Shear along X- Direction.

5. Conclusion
The following conclusions from this study are:
1. The performance of irregular plan shaped building with vertical irregularity could prove more vulnerable than the regular plan shaped building with vertical irregularity.
2. On plan ground, setback building attract less action forces as comparing with other configurations on sloping ground which make it more stable and it would not suffer more damages due to the lateral load action.
3. On sloping ground set-step back building attract less action forces as comparing with step back building but if the cutting cost of sloping ground is with acceptable limits then setback building may be preferred.
4. In step back building, the development of storey shear and moment and torsion were more than other configuration which found to be more vulnerable.
5. The effect of overall building torsion in step back and set-step back building was more than the setback building, as the building gets more unsymmetrical on sloping ground.

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