Earthquake Analysis of RCC Buildings on Hilly

Shaik Imran[1], P.Rajesh[2]
[1, 2] Department of Civil Engineering
[1, 2] ST.MARY'S GROUP OF INSTITUTIONS, Chebrolu(V&M) , GUNTUR (Dist)

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 G+9 storied buildings have been generated for symmetric building model and analyzed using structural analysis tool "Staad Pro Vi8". 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 . The seismic forces are considered as per IS: 1893-2002. The structural analysis software Staad Pro Vi8 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.

Keywords**—** Sloping ground, Seismic forces, RCC Building, Structural analysis, Staad Pro etc.

I. INTRODUCTION

General

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 stepback buildings are quite common on hilly slopes. Combinations of stepback 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 stepback 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.

SEISMIC BEHAVIOUR OF BUILDINGS ON SLOPES IN INDIA

North and northeastern parts of India have large scales of hilly region, which are categorized under seismic zone IV and V. In this region the construction of multistory RC framed buildings on hill slopes has a popular and pressing demand, due to its economic growth and rapid urbanization. This growth in construction activity is adding increase in population density. While construction, it must be noted that Hill buildings are different from those in plains i.e., they are very irregular and unsymmetrical in horizontal and vertical planes, and torsionally coupled. Since there is scarcity of plain ground in hilly areas, it obligates the construction of buildings on slopes. During past earthquakes, reinforced concrete (RC) frame buildings that have columns of different heights within one storey, suffered more damage in the shorter columns as compared to taller columns in the same storey. One example of buildings with short columns in buildings on a sloping ground can be seen in the figure (1) given

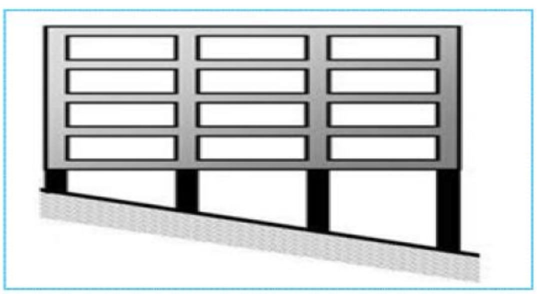


Figure 1: Building frame with short columns

Poor behavior of short columns is due to the fact that in an earthquake, a tall column and a short column of same cross section move ho rizontally by same amou nt which can be seen from the giv en figure (2) below.

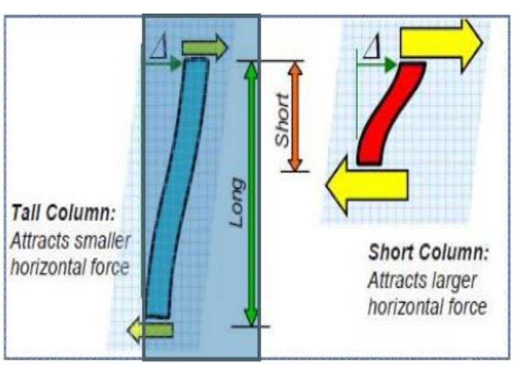


Figure 2: Structural behavior of short column under lateral load

CONFIGURATION OF BUILDINGS ON HILL SLOPES

Buildings constructed in hilly areas have peculiar structural configurations. Successive floors of such buildings step back towards the hill slope and sometimes, the buildings also set back, as shown in the Figure 2.1.

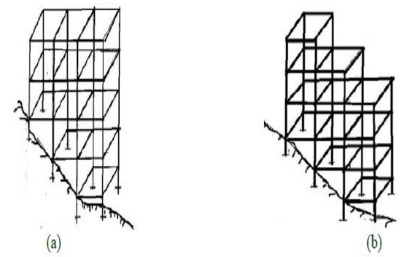


Figure 2.1. Hill building configurations: (a) Step back building; (b)Set back and Step back building

Another common type of structural configuration that is found on hills where buildings are located on steep slopes/vertical cuts, is shown in Figure 2.2. In this case, the foundations of the building are provided at two levels (Figure 2.2): (i) at the base downhill, and (ii) at the road level.

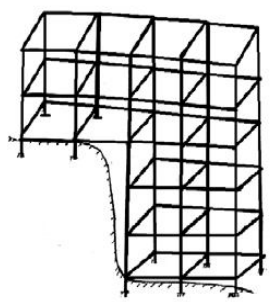
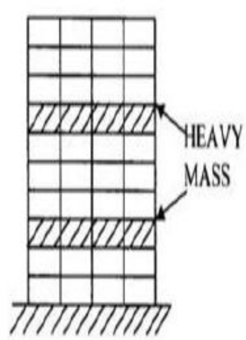


Figure 2.2. Building configurations at vertical cuts/steep slopes



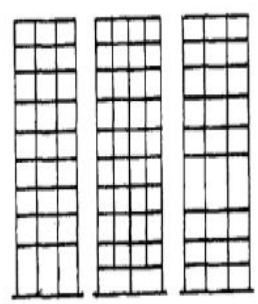


Fig -1: Mass irregularity **Fig -2**: Stiffness irregularity

Objectives of the Study

The present thesis work is aimed at evaluating hypothetical existing RC framed building with the following objectives:

1. Generation of 3D building model for both elastic and inelastic method of analyses.
2. Determination of deflections and storey drifts at each storey using Response Spectrum method and Pushover analysis.
3. Determination of performance level of building using Pushover analysis.
4. To study on the influence of masonry infill on the overall behavior of structure when subjected to lateral seismic forces.
5. To study the effect of vertical irregularity on the fundamental natural period of the building and its effect on performance of the structure during earthquake for different building models selected.
6. To find out the damage distribution in the structure due to earthquake loading.

Scope of the Study

The scope of the present study pertaining to building and loading, modeling and analysis method, and different parametric studies are as follows:

Building and Loading The study is carried out by considering a RC framed residential building resting on isolated footing. Seismic force is applied considering parabolic load pattern.

Modeling and Analysis Method

3D modeling for analyses using Staad Pro Vi8 Nonlinear The building models are pushed along positive orthogonal directions and the building is analyzed by Response Spectrum method as well as Pushover analysis. Parametric Studies The effects of masonry infill on the overall behavior of the structure when subjected forces are examined.
Staad Pro Vi8. Software is used in modeling of building frames. Staad Pro Vi8 stands for Structural analysis and design Program and it is general purpose software for performing the analysis and design of a wide variety of structures. The basic activities which are to be carried out to achieve this goal:

a. Geometry of the structure
b. Providing material and member properties
c. Applying loads and support conditions

A software Staad Pro Vi8 program 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.

Summary

In this chapter, importance of detailed analysis of building located in hilly areas are discussed along with the advantage and advantages of non linear analysis method. Also the scope and objective of the present study are discussed. Based on the objective of the present study, research papers were collected and studied. The review of research papers is discussed in the next chapter

II. LITERATURE REVIEW

Mohammed Azam (2013) presented a study on seismic performance evaluation of multistoried RC framed buildings with shear wall. A comparison of structural behavior in terms of strength, stiffness and damping characteristics is done. The provision of shear wall has significant influence on lateral strength in taller buildings while it has less influence on lateral stiffness in taller buildings. The provision of shear wall has significant influence on lateral stiffness in buildings of shorter height while it has less influence on lateral strength. The influence of shear walls is significant in terms of the damping characteristics and period at the performance point for tall buildings. Provision of shear walls symmetrically in the outermost moment-resisting frames and preferably interconnected in mutually perpendicular direction forming the core will have better seismic performance in terms of strength and stiffness.

P.P Chandurkar and P.S. Pajgade (2013) are investigated Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.

N. Janardhan reddy (2015) in his work seismic analysis of multistoried building with shear walls using ETABS reveals that provision of shear wall generally results in reducing the displacement because the shear wall increases the stiffness of the building and sustains the lateral forces. The better performance is observed and displacement is reduced in both x and y directions and shows better performances with respect to displacements when analysis is done by response spectrum method.

Agrawal and Charkha (2012) are investigation reveals that the significant effects on deflection in orthogonal direction by the shifting the shear wall location. Placing Shear wall away from centre of gravity resulted in increase in most of the members forces.

Greeshma and Jaya (2006) are investigated the proper connection detailing of shear wall to the diaphragm. The shear wall and diaphragm connection with hook deflects more when compared to the other two configurations. Hence, the shear wall- diaphragm connection with hook was more efficient under dynamic lateral loadings.

Mayuri D. Bhagwat (2014) In the work dynamic analysis of G+12 multistoried practiced RCC building considering for Koyna and Bhuj earthquake is carried out by time history analysis and response spectrum analysis and seismic responses of such building are comparatively studied and modeled with the help of ETABS software. Two time histories have been used to develop different acceptable criteria (base shear, storey displacement, storey drifts).

Mohit Sharma (2014) was studied a G+30 storied regular building. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS-1893-2002-Part-1for the zones-2 and 3.

A S Patil and P D Kumbhar (2013) This study shows similar variations pattern in Seismic responses such as base shear and storey displacements with intensities V to X. From the study it is recommended that analysis of multistoried RCC building using Time History method becomes necessary to ensure safety against earthquake force.

Misam Abidi, Mangulkar Madhuri. N (2012) presented an assessment to understand the behavior of Reinforced Concrete framed structures by pushover analysis and the Comparative study was done for different models in terms of base shear, displacement, performance point. The inelastic behavior of the example structures are examined by carrying out displacement controlled pushover analysis.

Bozdogan K.B.,Deierlein et.al,(2010)discussed in detail the modeling issues, nonlinear behavior and analysis of the frame –shear wall structural system. An approximate method which is based on the continuum approach and one dimensional finite element method to be used for lateral static and dynamic analysis of wall-frame buildings are presented.

Kasliwal Sagar K. has investigated that the present work two multi storey building both are sixteen storeys have been modeled using software package ETABS and SAP2000 for earthquake ZONE - V in India. The paper also deals with the Dynamic linear Response spectra method and static non-linear pushover method .The analysis is carried on multi-storey shear wall building with variation in number and position of shear wall. The author has concluded that the shear walls are one of the most effective building elements which resist the lateral forces during earthquake. The shear wall in proper position can minimize effect and damages due to earthquake and winds.

M.Ashraf examines the significance of shear wall in high rise buildings and found that increase on grids opposite to the changing position of shear wall away from the centroid of the building.

III. METHODOLOGY

Code-based procedure for seismic analysis

Main features of seismic method of analysis according to IS1893 (Part 1): 2002 are described as follows

- Equivalent Static Analysis (Linear Static)
- Response Spectrum Analysis (Linear Dynamic)
- Time History Analysis (Nonlinear Dynamic)
- Pushover Analysis (Nonlinear Static)

Equivalent static analysis

All design against earthquake effects must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings and begins with an estimate of peak earthquake load calculated as a function of the parameters given in the code.

Response spectrum analysis

It is a dynamic method of analysis. In the calculation of structural response the structure should be so represented by means of an analytical or computational model that reasonable and rational results can be obtained by its behavior, when response spectrum method is used with modal analysis procedure. At least 3 modes of response of the structure should be considered except in those cases where it can be shown qualitatively that either third mode or the second mode produces negligible response.

The major advantages of modal response spectrum analysis (RSA), compared with the more complex time-history analysis are as follows.

(1) The size of the problem is reduced to finding only the maximum response of a limited number of modes of the structure, rather than calculating the entire time history of responses during the earthquake. This makes the problem much more tractable in terms both of processing time and (equally significant) size of computer output.
(2) Examination of the mode shapes and periods of a structure gives the designer a good feel for its dynamic response.
(3) The use of smoothed envelope spectra makes the analysis independent of the characteristics of a particular earthquake record.
(4) RSA can very often be useful as a preliminary analysis, to check the reasonableness of results produced by linear and non-linear time-history analysis.

Time-history analysis

In this analysis dynamic response of the building will be calculated at each time intervals. This analysis can be carried out by taking recorded ground motion data from past earthquake database. A linear time-history analysis of this type overcomes all the disadvantages of Response spectrum analysis, provided non-linear behavior is not involved. The method involves significantly greater computational effort than the corresponding Response spectrum analysis and at least three representative earthquake motions must be considered to allow for the uncertainty in precise frequency content of the design motions at a site.

Push over analysis:

This is a performance based analysis and has aim in controlling the structural damage. In this analysis several built in hinge properties are included from FEMA 356 for concrete members. This analysis will be carried out by using nonlinear software ETABS 2013. This software is able to predict the displacement level and corresponding base shear where first yield of structure occurs. The main objective to perform this analysis is to find displacement vs. base shear graph. Pushover analysis is a simplified, static, nonlinear analysis under a predefined pattern of permanent vertical loads and gradually increasing lateral loads.

For the present dynamic analysis, response spectrum analysis method is used in the FE based software ETABS. . This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002(part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABSv9.7.4 software.

LOADS CONSIDERED:

Loads on a structure are generally two types.

1. Gravity loads and
2. Lateral loads

Gravity loads:

Gravity loads are the vertical forces that act on a structure. The weight of the structure, human occupancy and snow are all types of loads that need to have a complete load path to the ground.

DEAD LOADS:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m^3 and 25 kN/m^3 respectively.

IMPOSED LOADS:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m^3 and 25 kN/m^3 respectively.
Live loads are taken as 2kN/m.

Lateral loads:

Lateral loads are the horizontal forces that are act on a structure. Wind loads and earthquake loads are the main lateral loads act on structures.

WIND LOADS

Basic wind speed zones in India are classified as six zones as per IS 875 part -3-1987.

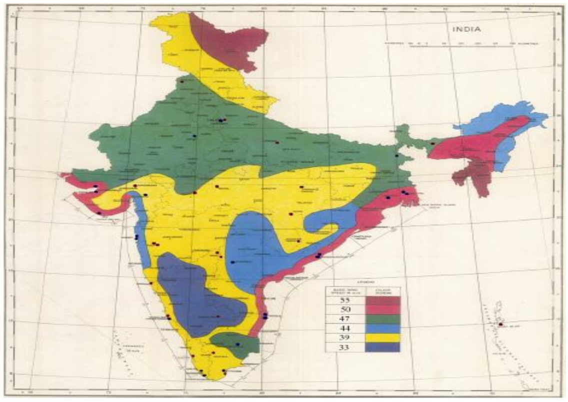


Figure - Basic wind speed zone map in India

Table –Zone wise basic wind speeds in m/s

Zone	**Basic wind speed (m/sec)**
I	33
II	39
III	44
IV	47
V	50
VI	55

Design Wind Speed (V,)

The basic wind speed (V,) for any site shall be obtained from and shall be modified to include the following effects to get design wind velocity at any height (V,) for the chosen structure:

a) Risk level;
b) Terrain roughness, height and size of structure; and
c) Local topography.

It can be mathematically expressed as follows:

Where:

$V = V_b \text{ X } k_l \text{ X } k_2 \text{X } k_3$

V_b = design wind speed at any height z in m/s;

k_l = probability factor (risk coefficient)

k_2= terrain, height and structure size factor

k_3 = topography factor

Risk Coefficient (kI Factor): Gives basic wind speeds for terrain Category 2 as applicable at10 m above ground level based on 50 years mean return period. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used.

Terrain, Height and Structure Size Factor (k2, Factor): Terrain - Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration.

Topography (k3 Factor) - The basic wind speed Vb takes account of the general level of site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges which can significantly affect wind speed in their vicinity.

WIND PRESSURES AND FORCES ON BUILDINGS/STRUCTURES:

The wind load on a building shall be calculated for:

a) The building as a whole,
b) Individual structural elements as roofs and walls, and
c) Individual cladding units including glazing and their fixings.

Pressure Coefficients - The pressure coefficients are always given for a particular surface or part of the surface of a building. The wind load acting normal to a surface is obtained by multiplying the area of that surface or its appropriate portion by the pressure coefficient (C,) and the design wind pressure at the height of the surface from the ground. The average values of these pressure coefficients for some building shapes Average values of pressure coefficients are given for critical wind directions in one or more quadrants. In order to determine the maximum wind load on the building, the total load should be calculated for each of the critical directions shown from all quadrants. Where considerable variation of pressure occurs over a surface, it has been subdivided and mean pressure coefficients given for each of its several parts. Then the wind load, F, acting in a direction normal to the individual structural element or Cladding unit is:

$F= (Cpe – Cpi) \, A \, Pd$

Where,

Cpe = external pressure coefficient,

Cpi = internal pressure- coefficient,

A = surface area of structural or cladding unit, and

Pd = design wind pressure element

Wind loads are applied on the structure as per IS 875-1987.i.e wind load in x-direction WLx and wind load in y-direction WLy.

SEISMIC LOADS:

Design Lateral Force

The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels.

Earthquake loads are applied as per IS 1893-2002 in earthquake x-direction, y-direction Positive x-direction, negative x-direction, positive y-direction and negative y-direction. And load combinations are considered as per IS 1893-2002.

Design Seismic Base Shear

The total design lateral force or design seismic base shear (Vb) along any principal direction shall be determined by the following expression:

$V_b = A_h W$

Where,

A_h = horizontal acceleration spectrum

W = seismic weight of all the floor

Fundamental Natural Period

The approximate fundamental natural period of vibration (T,), in seconds, of a moment-resisting frame building without brick in the panels may be estimated by the empirical expression:

$T_a = 0.075 h^{0.75}$ for RC frame building

$T_a = 0.085 h^{0.75}$ for steel frame building Where,

h = Height of building, in m. This excludes the basement storeys, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected. The approximate fundamental natural period of vibration (T,), in seconds, of all other buildings, including moment-resisting frame buildings with brick lintel panels, may be estimated by the empirical Expression:

$T = .09H/\sqrt{D}$

Where,

H= Height of building

D= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

Distribution of Design Force

Vertical Distribution of Base Shear to Different Floor Level

The design base shear (V) shall be distributed along the height of the building as per the following expression:

Q_i=Design lateral force at floor i,

W_i= Seismic weight of floor i,

h_i=Height of floor i measured from base, and

n=Number of storeys in the building is the number of levels at which the masses are located.

In case of building whose floor diaphragms cannot be treated as infinitely rigid in their own plane, the lateral shear at each floor shall be distributed to the vertical elements resisting the lateral forces, considering the in-plane flexibility of the diagram.

Figure - Seismic zone map of India

In India seismic zones are divided into four zones, i.e Zone – II, Zone – III, Zone – IV and Zone - V. Zone – II is low earthquake prone area, Zone – III is moderate zone, Zone – IV is high earthquake prone area and Zone – V is the highest earthquake intensity zone.

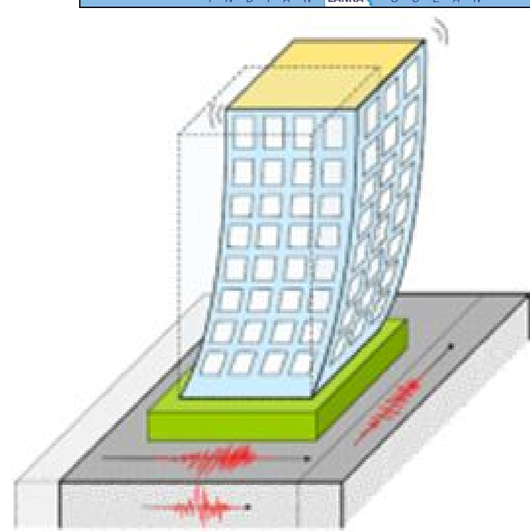


Figure –Behavior of building under earth quake

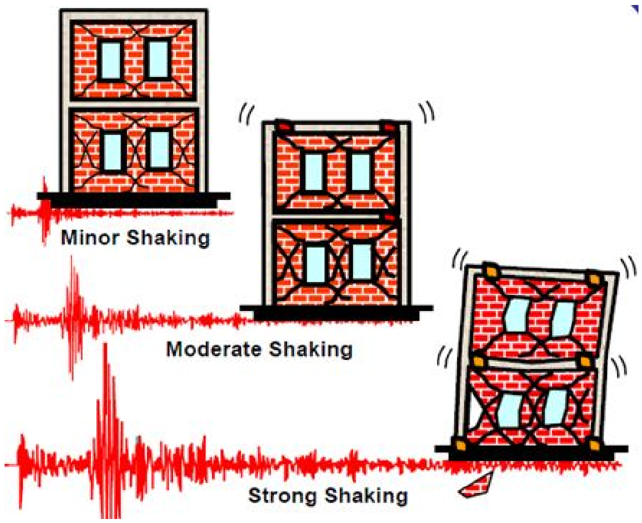


Figure –performance objectives under different intensities of earthquake

Loads:

Wall load calculation:

Thickness of wall = 0.23m

Height of wall = height of floor – depth of beam

= 3-0.5

=2.5m

Density of wall = 20 kN/m^3

Wight of wall on each floor = 0.23X2.5X20

= 11.5 kN/m

Assumed wall load = 12 kN/m

Live load : 2 kN/m

Wind load

In x-direction (according IS: 875-1987)

In y-direction (according IS: 875-1987)

Earth quake loads

In x-direction (EQx) (according IS1893-2002)

In y-direction (EQy) (according IS1893-2002)

Load combinations:

1.5 (DL + LL)

1.2 (DL + LL ± EQ_X)

1.2 (DL + LL ± EQ_Y)

1.5 (DL ± EQ_X)

1.5 (DL± EQ_Y)

0.9 DL ± 1.5 EQ_X

0.9 DL ± 1.5 EQ_Y

Dead load factor is taken as 1 load case details in Staad Pro Vi8

In the present analysis default load combinations are used by the software according to IS1893-2002.

ANALYSIS AND RESULT IS STAAD PRO Vi8

STAAD PRO Vi8

Structural Design Software for Structural Analysis Professionals:

STAAD PRO Vi8 is the present day leading design software in the market. Many design company's use this software for their project design purpose. The innovative and revolutionary new **STAAD PRO Vi8** is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest **STAAD PRO Vi8** offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results. From the start of design conception through the production of schematic drawings, **STAAD PRO Vi8** integrates every aspect of the engineering design process. Creation of models has never been easier **-** intuitive drawing commands allow for the rapid generation of floor and elevation framing. CAD drawings can be converted directly into **STAAD PRO Vi8** models or used as templates onto which **STAAD PRO Vi8** objects may be overlaid. The state-of-the-art **STAAD PRO Vi8** Fire 64-bit solver allows extremely large and complex models to be rapidly analyzed, and supports nonlinear modeling techniques such as construction sequencing and time effects (e.g., creep and shrinkage). Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures.

STAAD PRO Vi8 is the structural engineer's software choice for steel, concrete, timber, aluminum and cold-formed steel structure design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles, aquatic structures and much more.

Structural Software can Offer the following.

- State-of-the art 2D/3D graphical environment with standard MS Windows functionality.
- Full range of structural analysis including static, P-delta, pushover, response spectrum, time history, cable (linear and non-linear), buckling and steel, concrete and timber design.
- Concurrent engineering-based user environment for model development, analysis, design, visualization, and verification.
- Object-oriented intuitive 2D/3D CAD model generation.
- Supports truss and beam members, plates, solids, linear and non-linear cables, and curvilinear beams.
- Advanced automatic load generation facilities for wind, area, floor, and moving loads.
- Customizable
- Structural templates for creating a model.
- Toggle display of loads, supports, properties, joints, members, etc.
- Isometric and perspective views with 3D shapes.
- Joint, member/element, mesh generation with flexible user-controlled numbering scheme.
- Rectangular and cylindrical coordinate systems with mix and match capabilities.

Advantages of STAAD PRO Vi8 structural analysis software:

We revolutionized the concurrent use of spreadsheets, a 3D CAD graphical modeler, and a text-based input language editor. With over 40 step-by-step movie tutorials and hundreds of examples and verification problems, even a novice user can become productive in a matter of days.
STAAD PRO Vi8 is a solution for all types of structures and includes tools designed to aid specific structural engineering tasks. For example, for the bridge engineer, **STAAD PRO Vi8**.beava incorporates a powerful influence surface generator to assist in locating vehicles for maximum effects.
STAAD PRO Vi8 software is mainly made for modeling, analysis and design of buildings.

Various advantages in the **STAAD PRO Vi8** are listed below.

1. Fundamental to **STAAD PRO Vi8** modeling is the generalization that multi-story buildings typically consist of identical or similar floor plans that repeat in the vertical direction.
2. **STAAD PRO Vi8** has feature known as similar story. By which similar storeys can be edited and modeled simultaneously. Due to which building is modeled very speedily.
3. Basic or advanced systems under static or dynamic conditions may be evaluated using **STAAD PRO Vi8**
4. **STAAD PRO Vi8** can perform various seismic coefficients, Response Spectrum, Static Non-linear, Time History, Construction sequence and many more analysis with good graphics
5. Once modeling is complete, **STAAD PRO Vi8** automatically generates and assigns code-based loading conditions for gravity, seismic, wind, and thermal forces. Users may specify an unlimited number of load cases and combinations.
6. **STAAD PRO Vi8** can do optimization of steel section.
7. **STAAD PRO Vi8** has a facility to design composite beam and composite deck.

Procedure for modeling of building using STAAD PRO Vi8 :

1. Open **STAAD PRO Vi8** and select grid only.
2. Define storey data like storey height, storey number and spacing in x and y directions.
3. Define code preference from option menu.
4. Define material properties of concrete and steel from the define menu.
5. Define section properties from frame section in define menu for columns, beams etc.
6. Define slab section from define menu.
7. Give supports conditions
8. Create areas for slabs.
9. From define menu, define static load cases like dead load, live load, wind load in x and y direction and earthquake loads in x and y directions according to the IS-Code preferences.
10. Assign loads.
11. Draw shear wall at core/edges.
12. Specify structure auto line constraint.
13. Specify response spectrum analysis.
14. Select analysis option and run analysis.

IV. METHODS OF ANALYSIS OF STRUCTURE

A software E **STAAD PRO Vi8** TABS v 9.7.4 program 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 **STAAD PRO Vi8** . Software. The response of three the building frames is studied for useful interpretation of results.

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 **STAAD PRO Vi8** . 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.

ABOUT THE STRUCTURE:

BASIC DATA FOR BUILDINGS MODEL:

- Plan Dimension : 40m X40m
- Height of each storey : (3) m
- Number of storeys : G+9 storey's
- Length of each bay(in X-direction) : 40 m
- Length of each bay(in Y-direction) : 40 m
- Dimension of Column : (600 X 600) mm
- Dimension of Beam : (230 X 500) 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

Characteristic cube strength of concrete (fck) – 25 N/mm2
Density of concrete (γck) – 24 kN/m3
Poisson's ratio – 0.3
Steel:
Steel – Fe500
Yield strength (fy) – 500 N/mm2
Density of steel (γfy) – 78.5 kN/m3
Poisson's ratio – 0.2
Brick masonry
Density of brick masonry = 20 kN/m3

4.4.3 Earthquake Data:

Frame: Ordinary moment Resisting Frame
Locations: ZONE - II,
ZONE - III,
ZONE - IV,
ZONE - V
Importance Factor (I): 1
Damping: 5 percent
Type of Soil: Medium (Type 2)
Seismic zone factor (z)
ZONE - II – 0.10
ZONE - III – 0.16
ZONE - IV – 0.24
ZONE - V – 0.36

Loading Data:

Wall load : 12kN/m
Live load : 2 kN/m
Wind load:
In x-direction (WLx) (according IS: 875-1987)
In y-direction (WLy) (according IS: 875-1987)
Earth quake loads:

In x-direction (EQx) (according IS1893-2002)
In y-direction (EQy) (according IS1893-2002)

In the present analysis default load combinations are used.
Depth of Slab - 125mm
Thickness of Shear wall - 230mm
Thickness of wall – 230mm
Clear cover for beams – 25mm
Clear cover for columns – 40mm

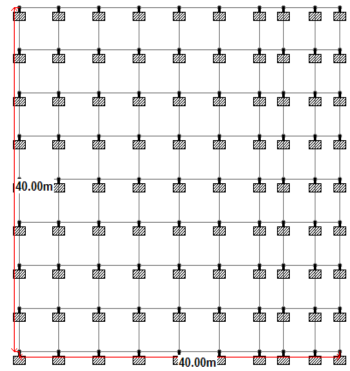


Fig: Plan of sloped building

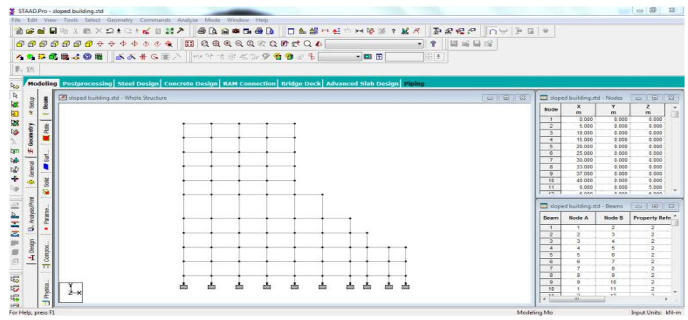


Fig: Elevation of sloped building

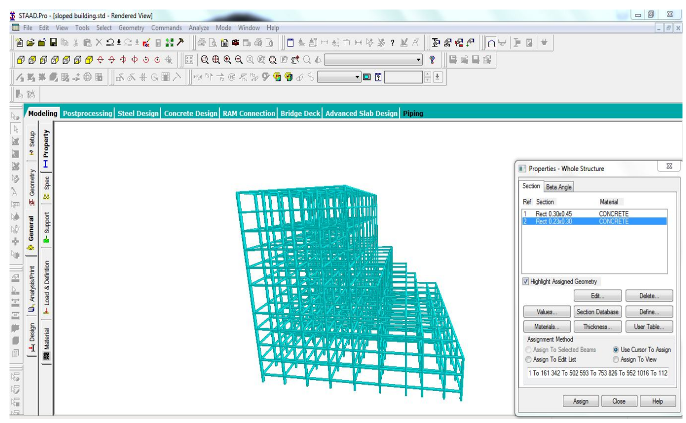


Fig:3D view sloped building

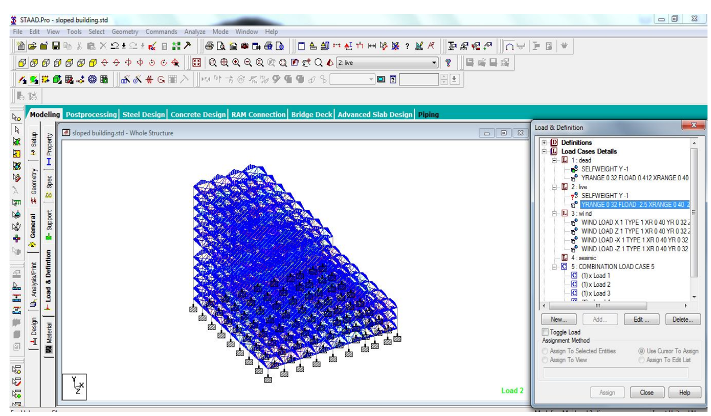


Fig: live load of sloped building

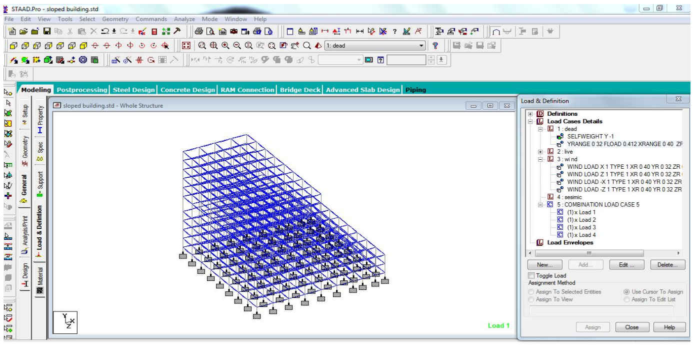


Fig:Dead load of sloped building

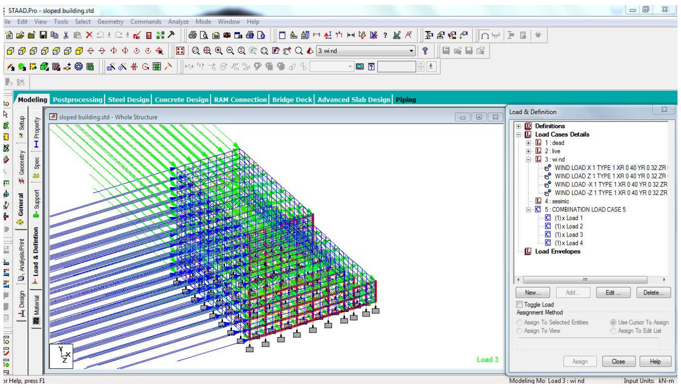


Fig: Wind load X-direction

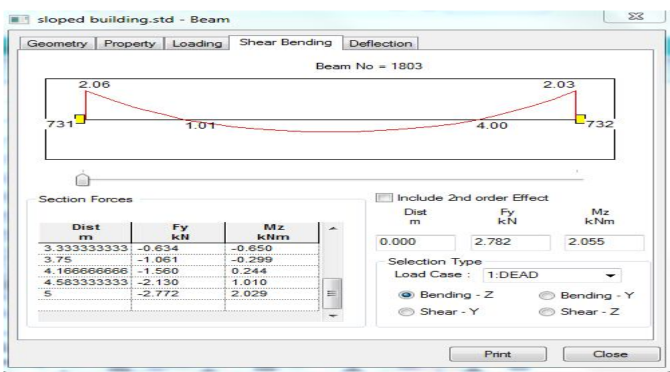


Fig: Beam Share force bending moment diagram

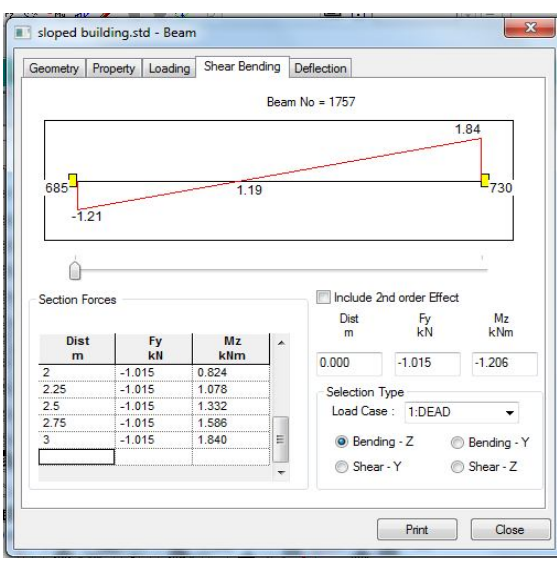


Fig: Column Share force bending moment diagram

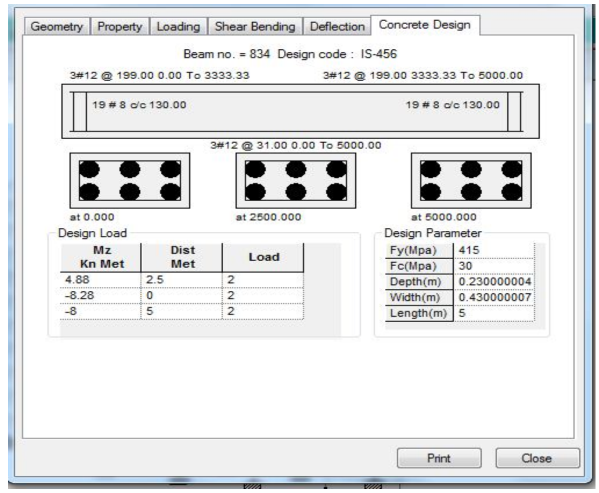


Fig: Beam Concrete Detailing

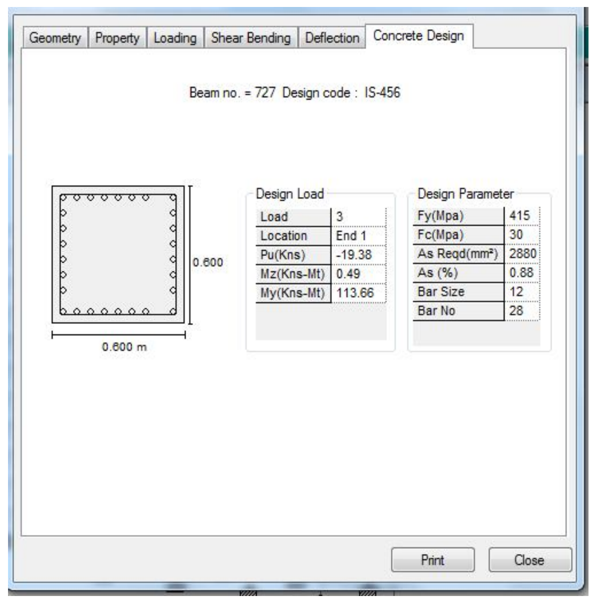


Fig: column detailing

V. 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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