# DESIGN AND ANALYSIS OF REGULAR AND VERTICAL GENETIC IRREGULAR BUILDING BY USING E-TABS

**GANTA RAMYA SREE**
M. Tech Structural Engineering,
PACE Institute of Technology and Science
Vallur, Ongole

**Mr. G. GANESH NAIDU**
Associate Professor, M. Tech (Ph. D)
PACE Institute of Technology and Sciences
Vallur, Ongole

## ABSTRACT

*To study building behavior of multi-story structures always depends on its strength, durability, stiffness and adequacy of the regular configuration of the structure. Methods: The analysis always depends on the forces and importance on the cost of analyzing the structure. Creating the 3D building model for both linear and non-linear dynamic method of analyses Understanding the seismic behavior of Setback buildings and Co-relating the seismic behavior of the Setback building with that of a building without Setback finally comparing the regular building behavior of building with a setback at top most 5 stories to that of the building with a setback at each floor level. Study the influence of vertical irregularity in the building when compare to regular building. Findings: The present study is limited to reinforced concrete framed structure designed for setback and regular building of loads (DL, LL & EL). The behavior of 20-Storied buildings with and without setbacks was studied. The buildings were analyzed using Time History Analysis and Response Spectrum Method and. Novelty: The effect of Setback is studied considering the parameters such as Time Period, storey drifts, Displacements, Storey Shears, Bending Moments and Shear Forces and correlated with the building without a setback.*

***Keywords:*** *3D building, E-tabs, multi-story structures*

## 1.0 INTRODUCTION

## BACKGROUND AND MOTIVATION

In multi-storeyed surrounded structures, harm from quake ground movement for the most part starts at areas of basic shortcomings show in the parallel load opposing edges. This conduct of multi-story encircled structures amid solid tremor movements relies upon the dispersion of mass, firmness, and quality in both the flat and vertical planes of structures. Now and again, these shortcomings might be made by discontinuities in firmness, quality or mass between neighboring stories. Such discontinuities between stories are frequently connected with sudden varieties in the edge geometry along the tallness. There are numerous cases of disappointment of structures in past quakes because of such vertical discontinuities. Auxiliary architects have created trust in the outline of structures in which the appropriations of mass, solidness and quality are pretty much uniform. Be that as it may, there is a less certainty about the plan of structures having unpredictable geometrical setups.

A typical sort of vertical geometrical abnormality in building structures emerges is the nearness of difficulties, i.e. the nearness of sudden decrease of the horizontal measurement of the working at particular levels of the height. This building classification is known as 'difficulty building'. This building structure is winding up progressively prominent in current multi-story building development for the most part in view of its useful and tasteful design. Specifically, such a mishap shape accommodates satisfactory sunshine and ventilation for the lower stories in a urban territory with firmly dispersed tall structures. This sort of building structure additionally gives for consistence building bye-law confinements identified with 'floor zone proportion' (hone in India). Figs 1.1 to 1.2 show run of the mill cases of mishap structures. Difficulty structures are portrayed by stunned sudden diminishments in floor zone along the stature of the working, with subsequent drops in mass, quality and firmness. Stature savvy changes in firmness and mass render the dynamic qualities of these structures unique in relation to the 'general' building. It has been accounted for in the writing (Athanassiadou, 2008) that higher mode interest is noteworthy in these structures. Additionally, the between story floats for misfortune building are relied upon to be more in the upper floors and less in the lower floors, contrasted with normal structures without difficulty.

**Statement of the Project:**

Salient Features:

The design data shall be as follows.

1. Utility of Buildings : Residential Building
2. No of Storey : G+20
3. Shape of the Building : Square
4. Types of Walls : Brick Wall
5. Geometric Details
   a. Ground Floor : 3.3m
   b. Floor-To-Floor Height : 3.0m
6. Material Details
   a. Concrete Grade : M20 (COLUMNS AND BEAMS)
   b. All Steel Grades : HYSD reinforcement of Grade Fe415
   c. Bearing Capacity of Soil : 200 KN/m$^2$
7. Type Of Construction : R.C.C FRAMED structure

**SCOPE OF THE STUDY**

The present examination is constrained to fortified cement (RC) multi-storeyed building outlines with mishaps. Difficulty structures up to 20 stories with various degrees of abnormality are considered. The structures are accepted to have mishap just one way.

The arrangement asymmetry emerging out of the vertical geometric abnormality entirely demands an explanation from for three-dimensional investigation legitimately for torsion impacts. This isn't considered in the present examination, which is restricted to investigation of plane misfortune outlines. Albeit distinctive story numbers (up to 20 stories), cove numbers (up to 10 straights) and anomaly are viewed as, the inlet width is confined, to 6m and story stature to 3m.

It will be suitable to consider versatile load design in powerful examination with a specific end goal to incorporate the impact of dynamic basic yielding. Be that as it may, for the present investigation just settled load dissemination shapes are intended to use in powerful examination, with a specific end goal to keep the methodology computationally straightforward and appealing for outline office condition. Soil structure communication impacts are not considered.

**2.0 LITERATURE REVIEW**

**Hema Venkata Sekhar [1]** Presents building conduct amid tremors dependably relies upon its quality, strength, firmness and sufficiency of the general setup of the structure. Techniques: The examination dependably relies upon the powers and significance on the cost of breaking down the structure. Making the 3D building model for both direct and non-straight powerful strategy for investigations Understanding the seismic conduct of Setback structures and Co-relating the seismic conduct of the Setback working with that of a working without Setback at long last contrasting the seismic conduct of building and a mishap at each two levels to that of the working with a difficulty at each floor level. Age of all powers because of unequal dispersion of mass will be distinguished by basic difficulty proportion along the area of the arrangement and furthermore in the vertical stature of the building. • The perfect evaluations of essential trouble extents are RA and RH. The above assessment adjusts to the criteria given in measures for sporadic structures are considered. • At last, we complete up from the results erratic structures are to be treated with proper arrangement and should be trailed by all IS code obtainments given the rules. • It can in like manner be contemplated that adjustment of shudder codes geometric level oddities seem, by all accounts, to be imperative to decide more preventive ordinates or apply more exact illustrative technique to recognize the seismic execution of trouble building. Particularly for structures with essential trouble extents expect a basic part.

**Milind V. Mohod, Nikita A. Karwa[2]** A typical sort of vertical geometrical abnormality in building structures emerges from sudden lessening of the sidelong measurement of the working at particular levels of the rise. This building classification is known as the misfortune building. Different specialists have examined the conduct of difficulty structures by considering distinctive methodologies, which rotate for the most part around geometric, mass, solidness and diverse techniques for seismic investigation. Yet, the estimation of basic difficulty proportion for which the structure is less inclined to tremor powers has not been accounted for. Subsequently, a need has ascended to think about and determine a few upgrades in codal arrangements for understanding the conduct of mishap structures. Reference structure comes about were received for approval of results got from every one of these models, which helped us to achieve the coveted yield of the undertaking. Nodal dislodging and story float criteria was considered for finding out the ideal estimation of basic misfortune proportions

**S. R. Uma[3]** The conduct of fortified solid minute opposing casing structures in late seismic tremors everywhere throughout the world has featured the results of poor execution of bar segment joints. Vast measure of research completed to comprehend the unpredictable systems and safe conduct of pillar segment joints has gone into code suggestions. This paper presents basic survey of suggestions of entrenched codes in regards to plan and itemizing parts of bar segment joints. Noteworthy variables impacting the plan of pillar segment joints are recognized and the impact of their minor departure from outline parameters is looked at. The variety in the prerequisites of shear fortification is generous among the three codes.

**Devesh P. Soni and Bharat B. Mistry [4]**

This examination abridges best in class information in the seismic reaction of vertically unpredictable building outlines. Criteria characterizing vertical anomaly according to the present construction laws have been talked about. A survey of concentrates on the seismic conduct of vertically sporadic structures alongside their discoveries has been introduced. It is watched that construction laws give criteria to group the vertically unpredictable structures and recommend dynamic examination to touch base at plan sidelong powers. The greater part of the examinations concur on the expansion in float request in the pinnacle bit of set-back structures and on the expansion in seismic interest for structures with broken disseminations in mass, firmness, and quality. The biggest seismic request is found for the joined solidness and-quality anomaly.

## 3.0 DESIGN OF STRUCTURAL ELEMENTS

In the design specifications safety factors to be considered for the design because of this most of the structures tend to be adequately protected against vertical shaking. In general building structures are not susceptible particularly to the vertical ground motions. But it effects to be considered in mind in the design of RCC structural members like RCC columns, steel column connections and beams. Acceleration in the vertical direction also considered in structures with the large span and also stability of structures also is considered in the overall stability analysis of structures. When the building structure is designed for considering only the vertical ground motions in general this design is not safe. This not satisfies the horizontal ground shaking. In generally the forces generated due to Horizontal ground motions of earth is taken as important for the design of the structures. Therefore it is important that the structure is designed to resist the forces acting horizontally due to earthquake. When the building structure is resist on soil surface. The ground surface is displaced or move due to earthquake the structure base is also moves with it but roof has tendency to stay with its original position. Since the roofs and foundations are connected with the columns and walls. During the designing of the building according to the codes the lateral force is considered in two orthogonal horizontal directions of the structure. Many of the building structure have irregularities in both the plan and elevation. Buildings consisting of asymmetrical distribution of strength, stiffness and mass suffer severe damage during earthquakes.

**Design of Structural Elements**

The design of any structure is categorized into the following two main types:

i. Functional design
ii. Structural design

**Stages in structural design:**

The process of structural design involves the following stages:

i. Structural planning
ii. Action of forces and computation of loads
iii. Method of analysis
iv. Member design
v. Detailing, drawing and preparation of schedules

**BEAM**

There are three types of reinforced concrete beams

i. Single reinforced beams
ii. Double reinforced beams
iii. Flanged beams

## 4.0 MODELING AND METHODS OF ANALYSIS OF STRUCTURE

### PROJECT STATEMENT

In the present study, analysis of G+20 multi-story building in most severs zone for wind and earth quake forces is carried out.3D model is prepared for G+20 multi-story building is in ETABS. Building has a typical size of

Basic parameters considered for the analysis are

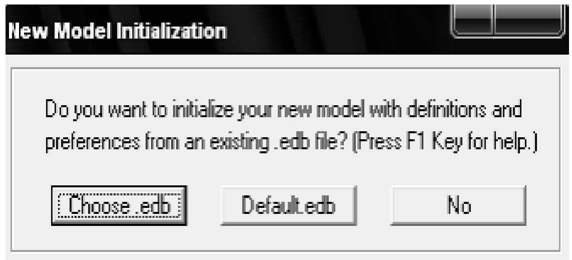
1. Utility of building : Residential building
2. Number of stories : G+20
3. Shape of building : Square
4. Type of walls : Brick wall
5. Geometric details
   a. Ground floor : 3.3m
   b. floor to floor height : 3.0m
6. Material details
   a. Concrete Grade :M20 (COLUMNS AND BEAMS)
   b. All Steel Grades : HYSD reinforcement of Grade Fe415
   c. Bearing Capacity of Soil : 200 KN/$m^2$
7. Type Of Construction : R.C.C FRAMED structure

### MODELING OF G+20 BY USING ETABS:

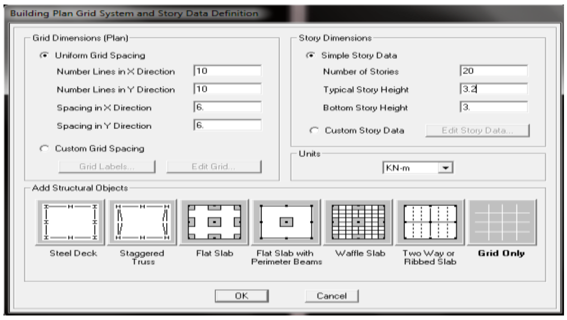
### MODELING STEPS IN ETABS:

1) Open ETABS program.
2) Check the units of the model in the drop-down box in the lower right-hand corner of the ETABS window click the drop-down box to set units to KN-m.

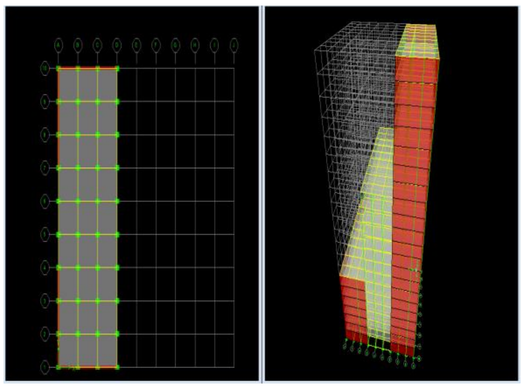

Click the File menu > New model command




The next form of Building Plan Grid System and Story Data Definition will be displayed after you select NO button.



Set the grid line and spacing between two grid lines. Set the story height data using Edit Story Data command



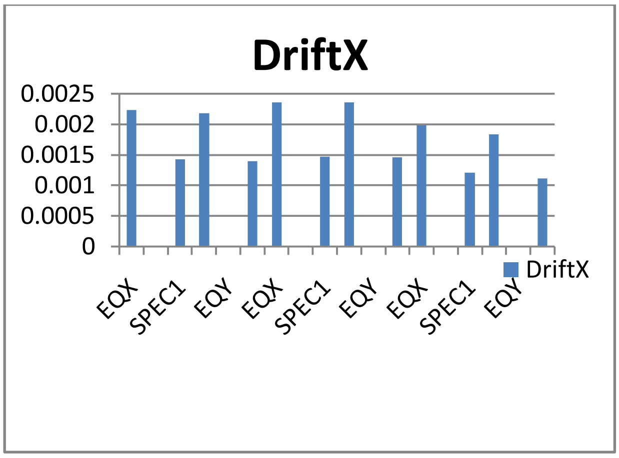
Mass source is defined from Define > mass source command

## 5.0 RESULTS AND ANALYSIS

**For general building Story drift**

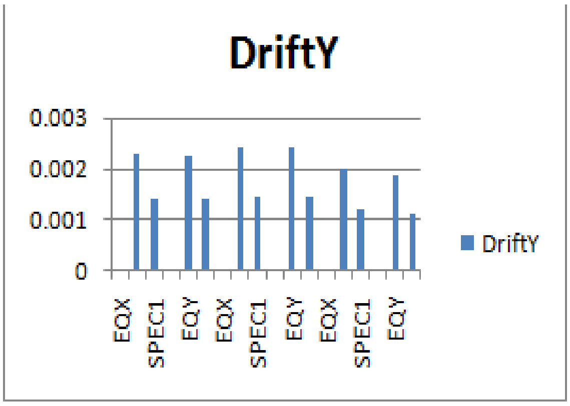
**For driftx**

| Story | Item | Load | DriftX |
|---|---|---|---|
| STORY21 | Max Drift X | EQX | 0.002237 |
| STORY21 | Max Drift X | EQY | 0 |
| STORY21 | Max Drift X | SPEC1 | 0.001425 |
| STORY20 | Max Drift X | EQX | 0.002188 |
| STORY20 | Max Drift X | EQY | 0 |
| STORY20 | Max Drift X | SPEC1 | 0.001395 |
| STORY14 | Max Drift X | EQX | 0.002366 |
| STORY14 | Max Drift X | EQY | 0 |
| STORY14 | Max Drift X | SPEC1 | 0.001466 |
| STORY13 | Max Drift X | EQX | 0.002366 |
| STORY13 | Max Drift X | EQY | 0 |
| STORY13 | Max Drift X | SPEC1 | 0.001455 |
| STORY7 | Max Drift X | EQX | 0.001986 |
| STORY7 | Max Drift X | EQY | 0 |
| STORY7 | Max Drift X | SPEC1 | 0.001204 |
| STORY6 | Max Drift X | EQX | 0.001838 |
| STORY6 | Max Drift X | EQY | 0 |
| STORY6 | Max Drift X | SPEC1 | 0.001117 |



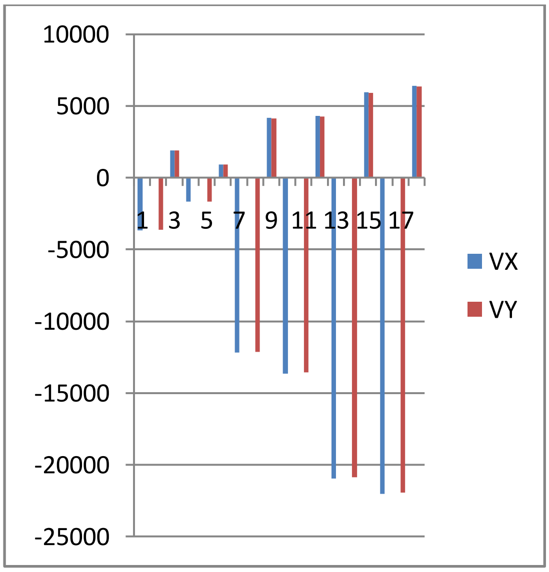

**For drifty**

| Story | Item | Load | DriftY |
|---|---|---|---|
| STORY21 | Max Drift Y | EQX | 0 |
| STORY21 | Max Drift Y | EQY | 0.00229 |
| STORY21 | Max Drift Y | SPEC1 | 0.001435 |
| STORY20 | Max Drift Y | EQX | 0 |
| STORY20 | Max Drift Y | EQY | 0.002244 |
| STORY20 | Max Drift Y | SPEC1 | 0.001407 |
| STORY14 | Max Drift Y | EQX | 0 |
| STORY14 | Max Drift Y | EQY | 0.002414 |
| STORY14 | Max Drift Y | SPEC1 | 0.001475 |
| STORY13 | Max Drift Y | EQX | 0 |
| STORY13 | Max Drift Y | EQY | 0.002412 |
| STORY13 | Max Drift Y | SPEC1 | 0.001464 |
| STORY7 | Max Drift Y | EQX | 0 |
| STORY7 | Max Drift Y | EQY | 0.002017 |
| STORY7 | Max Drift Y | SPEC1 | 0.001208 |
| STORY6 | Max Drift Y | EQX | 0 |
| STORY6 | Max Drift Y | EQY | 0.001866 |
| STORY6 | Max Drift Y | SPEC1 | 0.001121 |



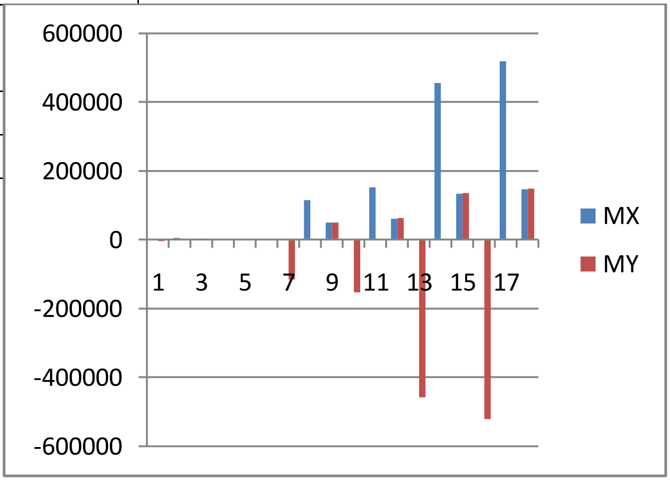
**Story shear for VX and VY**

| Story | Load | Loc | VX | VY |
|---|---|---|---|---|
| STORY21 | EQX | Top | -3665.67 | 0 |
| STORY21 | EQY | Top | 0 | -3643.47 |
| STORY21 | SPEC1 | Top | 1897.67 | 1893.11 |
| STORY20 | EQX | Top | -1663.42 | 0 |
| STORY20 | EQY | Top | 0 | -1653.01 |
| STORY20 | SPEC1 | Top | 924.78 | 923.19 |
| STORY14 | EQX | Top | -12180.4 | 0 |
| STORY14 | EQY | Top | 0 | -12115.9 |
| STORY14 | SPEC1 | Top | 4170.6 | 4137.67 |
| STORY13 | EQX | Top | -13624.3 | 0 |
| STORY13 | EQY | Top | 0 | -13554.3 |
| STORY13 | SPEC1 | Top | 4287 | 4246.65 |
| STORY7 | EQX | Top | -20958.3 | 0 |
| STORY7 | EQY | Top | 0 | -20869.7 |
| STORY7 | SPEC1 | Top | 5951.19 | 5902.02 |
| STORY6 | EQX | Top | -22012.7 | 0 |
| STORY6 | EQY | Top | 0 | -21922.9 |
| STORY6 | SPEC1 | Top | 6383.04 | 6337.95 |



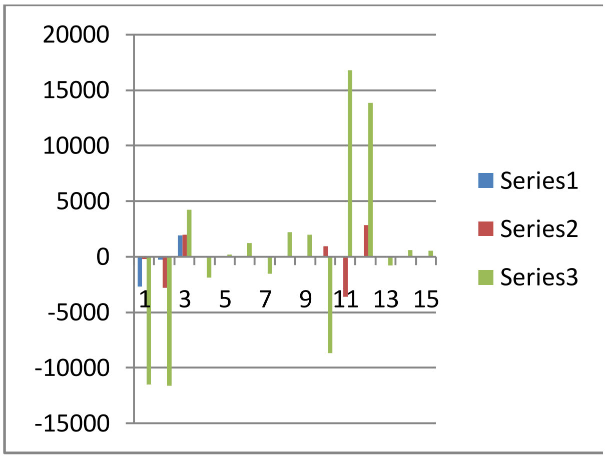

**For MX and MY:**

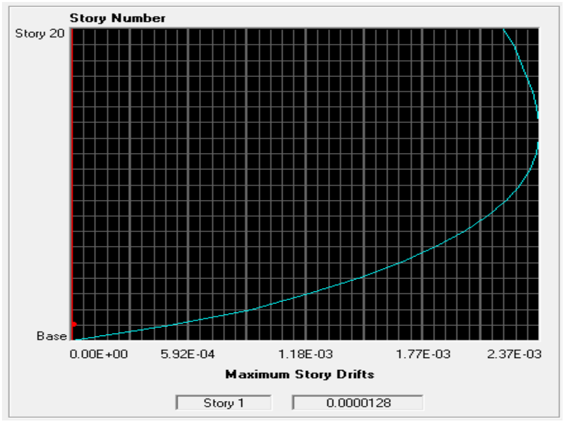
| Story | Load | Loc | MX | MY |
|---|---|---|---|---|
| STORY21 | EQX | Top | 0 | -5314.27 |
| STORY21 | EQY | Top | 5283.017 | 0 |
| STORY21 | SPEC1 | Top | 2769.581 | 2774.329 |
| STORY20 | EQX | Top | 0 | 0 |
| STORY20 | EQY | Top | 0 | 0 |
| STORY20 | SPEC1 | Top | 0 | 0 |
| STORY14 | EQX | Top | 0 | -115799 |
| STORY14 | EQY | Top | 115150.3 | 0 |
| STORY14 | SPEC1 | Top | 48992.22 | 49208.32 |
| STORY13 | EQX | Top | 0 | -152664 |
| STORY13 | EQY | Top | 151822.1 | 0 |
| STORY13 | SPEC1 | Top | 61085.33 | 61400.06 |
| STORY7 | EQX | Top | 0 | -457772 |
| STORY7 | EQY | Top | 455497.4 | 0 |
| STORY7 | SPEC1 | Top | 133017.7 | 134399.4 |
| STORY6 | EQX | Top | 0 | -520970 |
| STORY6 | EQY | Top | 518430.5 | 0 |
| STORY6 | SPEC1 | Top | 145970.5 | 147574.9 |



**Support reactions for FX, FY and FZ**

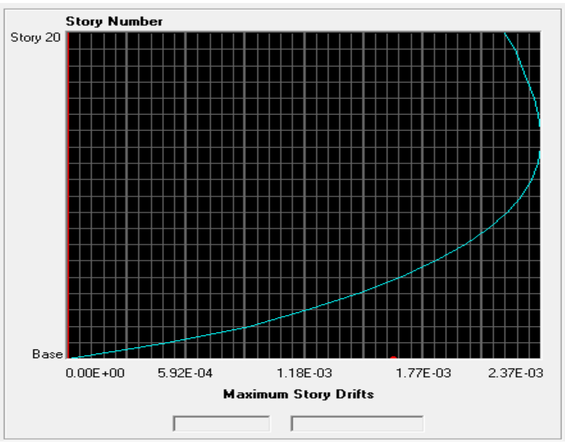
| Story | Point | Load | FX | FY | FZ |
|---|---|---|---|---|---|
| BASE | 1 | EQX | -2693.64 | -231.25 | -11477.8 |
| BASE | 1 | EQY | -236.45 | -2799.68 | -11579.4 |
| BASE | 1 | SPEC1 | 1942.57 | 1970.85 | 4216.85 |
| BASE | 2 | EQX | -26.44 | 3.15 | -1884.85 |
| BASE | 2 | EQY | 1.72 | -23.27 | 190.95 |
| BASE | 2 | SPEC1 | 18.11 | 17.78 | 1222.5 |
| BASE | 3 | EQX | -20.48 | 2.5 | -1510.44 |
| BASE | 3 | EQY | -1.04 | -22.78 | 2210.53 |
| BASE | 3 | SPEC1 | 10.82 | 17.15 | 1970.88 |
| BASE | 4 | EQX | -36.89 | 944.92 | -8683.72 |
| BASE | 4 | EQY | -4.57 | -3606.41 | 16767.62 |
| BASE | 4 | SPEC1 | 10.54 | 2868.77 | 13830.14 |
| BASE | 5 | EQX | -20.18 | 0.37 | -755.3 |
| BASE | 5 | EQY | -0.39 | -18.65 | 624.99 |
| BASE | 5 | SPEC1 | 6.41 | 12.89 | 558.99 |

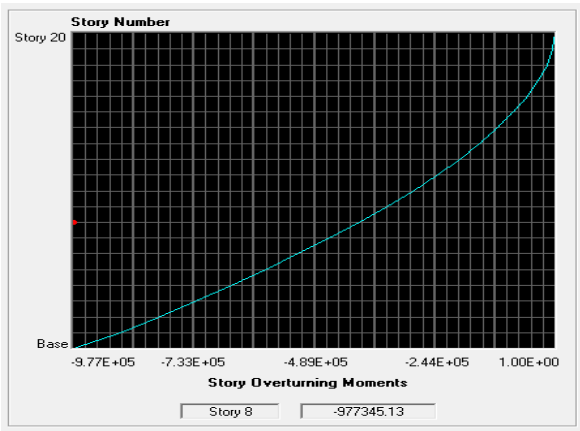



Story overturning moments:

Maximum story drifts




**For setback building**

Story shear

## 6.0 CONCLUSIONS

Based on the work presented in this thesis following point-wise conclusions can be drawn:

1. Period of setback buildings are found to be always less than that of similar regular building. Fundamental period of setback buildings are found to be varying with irregularity even if the height remain constant. The change in period due to the setback irregularity is not consistent with any of these parameters used in literature or design codes to define irregularity.
2. The code (IS 1893:2002) empirical formula gives the lower-bound of the fundamental periods obtained from Modal Analysis and Raleigh Method. Therefore, it can be concluded that the code (IS 1893:2002) always gives conservative estimates of the fundamental periods of setback buildings with 6 to 20 storeys. It can also be seen that Raleigh Method underestimates the fundamental periods of setback buildings slightly which is also conservative for the selected buildings. However the degree of conservativeness in setback building is not proportionate to that of regular buildings.
3. It is found that the fundamental period in a framed building is not a function of building height only. This study shows that buildings with same overall height may have different fundamental periods with a considerable variation which is not addressed in the code empirical equations.
4. A detailed literature review on setback buildings conclude that the displacement demand is dependent on the geometrical configuration of frame and concentrated in the neighbourhood of the setbacks for setback structures. 147 The higher modes significantly contribute to the response quantities of setback structure. Also conventional pushover analysis seems to be underestimating the response quantities in the upper floors of the irregular frames.
5. As the shape of the triangular load pattern and first mode shape are similar for mid-rise regular buildings and close for high-rise and setback buildings, the resulting pushover curves are found to be similar for almost all the building studied here.
6. FEMA 356 suggests that pushover analyses with uniform and triangular load pattern will bind all the solutions related to base shear versus roof displacement of regular buildings. Results presented here support this statement for regular buildings. However, this is not true for setback buildings especially for high-rise buildings with higher irregularity (S3-type).
7. Mass proportional uniform load pattern found to be suitable for carrying out pushover analysis of Setback buildings as the capacity curve obtained using this load pattern closely matches the response envelop obtained from nonlinear dynamic analyses.
8. Upper bound pushover analysis severely underestimates base shear capacities of setback as well as regular building frames.

## REFERENCES

1. *Kumar J L, Wright E W. Eathquake response of steel-framed multistory*

*buildings with setbacks. Earthquake Engrg. and Struct. Dynamics, 1977 December; 5(1), 15-39.*

2. *Jhaveri D P. Earthquake forces in tall buildings with setbacks. Thesis of Doctor of Philosophy presented to the University of Michigan, Ann Arbor, 1967.*
3. *Kannan A E, Powell G H. DRAIN-2D: A general purpose computer program for dynamic analysis of inelastic plane structures. Report No. UCB/ EERC-73/6, Earthquake Engg. Res. Ctr., Univ. of California, Berkeley, Calif., April 13, 1973.*
4. *Korkut, K. Research on the seismic behavior of structures with mass concentrations or with variable width. Bauingenieur. 1984; 59, 235- 241.*
5. *Pekau O A, Green R. . "Inelastic structures with setbacks." Proc, Fifth World Conf. on Earthquake Engrg, 2, Rome, Italy, 1974, 1744- 1747.*
6. *Shahrooz B M, Moehle J P. Evaluation of seismic performance of reinforced concrete frame. J. Struct. Engrg, ASCE. 1989; 116(5), 1402-1421.*
7. *Shahrooz B M, Moehle J P. Experimental study of seismic response of R.C. setback buildings. Report No. UCB/EERC- 87/16, Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, Calif., 1987, Oct. 19.*
8. *Suzuki Z ed. (1971). General report on the Takachi-Oki earthquake of 1968. Keigsku Publishing Co., Tokyo, Japan, 1971.*
9. *Wood S L. Experiments to study the earthquake response of reinforced concrete frames with setbacks. Thesis submitted to the University of Illinois, at Urbana, 111, in partial fulfillment of the requirements for the degree of Doctor of Philosophy 1986.*