

# Dynamic Analysis of Rcc Building Frame with Mass and Stiffness Irregularities for Various Plan Geometry

Mr. Mohite Onkar Deepak<sup>1</sup>, Dr. Tapkire.P. P<sup>2</sup>

<sup>1</sup>PG Students, Civil Engineering Department, Punyasholk Ahilyabai Holkar University, Solapur

<sup>2</sup>Assistant Professor, Civil Engineering Department, Punyasholk Ahilyabai Holkar University, Solapur

**Abstract**—It is very essential to identify the behavior and damages of buildings, which initiate at locations of the structural weak planes present in the building systems, due to various shape of building i.e., Rectangular, L-Shape and T-Shape building. The contribution of lateral load resisting system, number of stories, type and different type of analysis method has to be properly assessed and evaluated in order to avoid torsional effect and collapse of the structure.

The behaviors of building during earthquake depends critically on its overall shape, size and geometry. Buildings with irregular geometry respond differently against seismic action. Plan geometry is the parameter which decides its performance against different loading conditions. The effects of irregularity (plan and shape) on structure have been carried out by using structural analysis software ETABS 2018.

The aim of present study is to compare seismic performance of Equivalent Static Method, Response Spectrum Method using medium soil. The G+15, G+20 and G+25 story structures situated in earthquake zones III. All frames are designed under same gravity loading. Response spectrum method is used for seismic analysis. ETABS software is used and the results are compared. The results were obtained in the form of Earthquake Displacement, Story Force, Base Shear and Modal Mass Participations.

**Index Terms**—: ETABS, Earthquake Load, Torsion, Response Spectrum, Modal Mass Participation.

## I. INTRODUCTION

General

The behavior of a building during an earthquake depends on several factors, stiffness, adequate lateral strength and ductility, simple and regular configurations. The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage

compared to irregular configurations. Most recent earthquakes have shown that the irregular distribution of mass, stiffness and strengths may cause serious damage in structural systems. The area of vertically irregular type of building is now having a lot of interest in seismic research field. Many structures are designed with vertical irregularity for architectural views. Structural design of buildings for seismic loads is primarily concerned with structural safety during major ground motions. Regular structures have uniformly distributed mass, stiffness, strength and structural form. When one or more of these properties is non-uniformly distributed, either individually or in combination with other properties in any direction, the structure is referred to as being irregular.

During an earthquake, failure of structure starts off-evolved at factors of weak spot. This weak point arises due to discontinuity in mass, stiffness and geometry of structure. The systems having this discontinuity are termed as irregular systems. Irregular structures contribute a massive portion of city infrastructure. Vertical irregularities are one of the essential motives of failures of systems during earthquakes. Asymmetry in structures makes Dynamic analysis of the seismic behaviors very complicated. Seismic demand in peripheral elements is enhanced. Uniformity in load distribution gets disturbed. Torsional behaviors of asymmetric building is one of the most frequent causes of structural damage and failure during strong ground motions Torsion responses in structures arise from two sources: Eccentricity in the mass and stiffness distributions, causing a torsion response coupled with translation response; Torsion arising from accidental causes, including uncertainties in the masses and stiffness, the differences in coupling of the structural foundation with the supporting earth or rock beneath it.

Dynamic analysis damage surveys and analyses conducted on modes of failure of building structures during past severe earthquakes concluded that most vulnerable building structures are those, which are symmetrical and asymmetric in nature. Asymmetric-plan buildings, namely buildings with in-plan asymmetric mass and strength distributions, are

systems characterized by a coupled torsional-translational seismic response. For many asymmetrical structures, excessive torsion is the main reason of the poor seismic performance. Torsion effects increase lateral deflections on the weak direction of the structure and decrease on the strong direction.

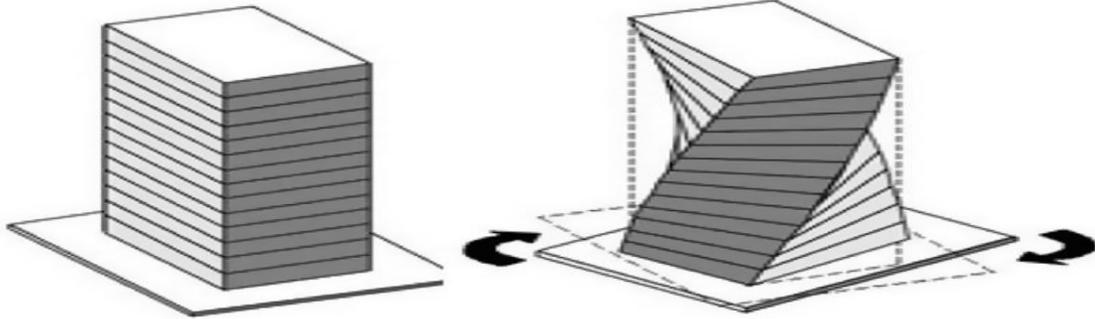


Figure 1.1. Twisting of Structures

For many asymmetrical structures, excessive torsion is the main reason of the poor seismic performance. Torsion effects increase lateral deflections on the weak direction of the structure and decrease on the strong direction. Concrete walls, slab holes, overhangs, column clouds, etc. may cause eccentricity between center of mass and center of rigidity. Modern codes deal with torsion by placing restrictions on the design of buildings with irregular layouts and also through the introduction of an accidental eccentricity that must be considered in design.

## II. METHODOLOGY

### Introductions

Multi-Storied Reinforced concrete building, moment resisting space frame have been analyzed using professional software. Model of Multistoried building frame with different shape of building i.e. rectangular shape, L-shape and T-shape is analyzed by response spectrum Method. The plan dimensions of buildings are shown in table below. The plan view of building, elevation of different frame.

This method is applicable for those structures where modes other than the fundamental one affect significantly the response of the structure. In this method the response of multi degree of freedom system is expressed as the superposition of modal response, each modal response being determined from the spectral analysis of single degree of freedom

system, which is then combined to compare the total response. Modal analysis of the response history of structure to specified ground motion; however, the method is usually used in conjunction with a response spectrum.

### Problem Formations

- 1) It is proposed to study the response of building (as per IS 13920: 2016)
- 2) The seismic parameters like Base Shear, Maximum Bending Moment, Story Drift, will be evaluated.
- 3) An attempt will be made on appropriate provision of lateral load resisting system i.e. vertical irregularity use for lateral load.
- 4) The effectiveness of lateral load system on different vertical shapes of buildings i.e. Rectangular Shape, L-Shape and T-Shape.
- 5) The feasible structural configuration for economical housing tall buildings will be suggested.

## III. RESULTS AND DISCUSSIONS

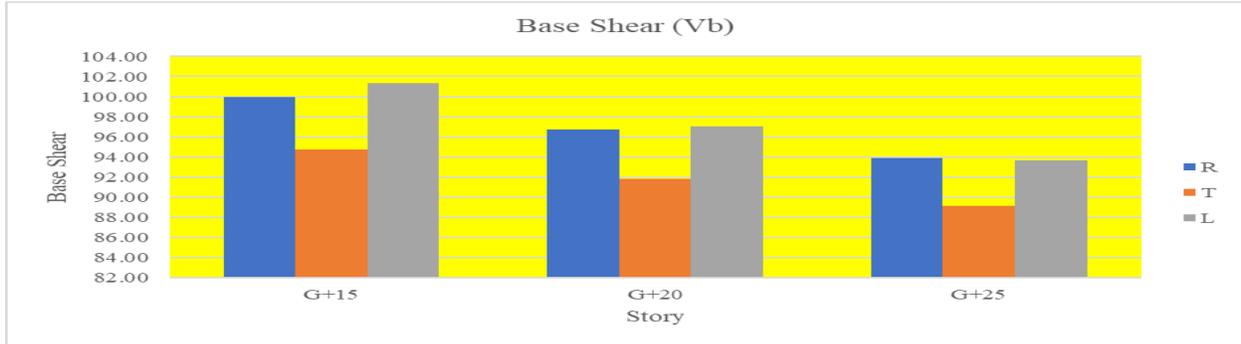
In this chapter, Analysis of RCC Building G+15, G+20 and G+25 Story with different shape of building i.e. rectangular shape, L-shape and T-shape of building. The structures are analyses for earthquake zone III with medium soil and Results Compare. It has been made on different structural parameters viz. Base

Shear, Max. Bending Moment, and Story Drift etc. and results are concluded.

Variation of Base Shear for Different Building

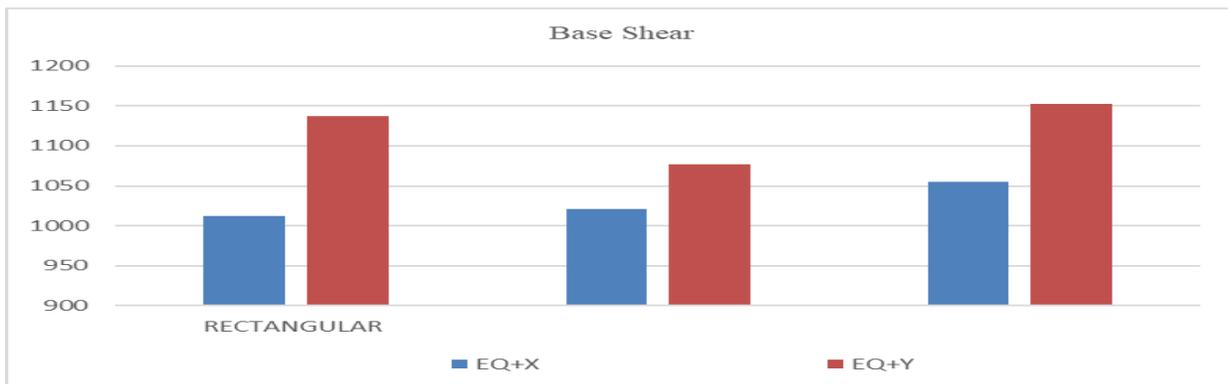
Base shear is an estimate of the maximum expected lateral force that will occur at the base of the structure due to the seismic ground motion. During the analysis,

the codes required for the use of the equivalent static force procedure and a dynamic lateral force procedure. Hence, the base shear obtained or calculated from the dynamic analysis should be reduced to a certain percentage of the base shear results that is determined from the static force procedure.

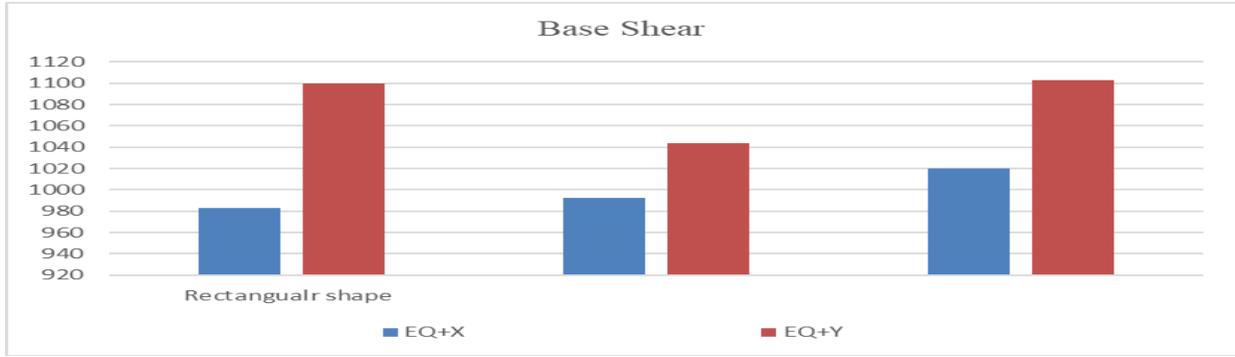


Graph 1.1 Base Shear Vs. Different Story Height I.e. G+15, G+20 and G+25 Story

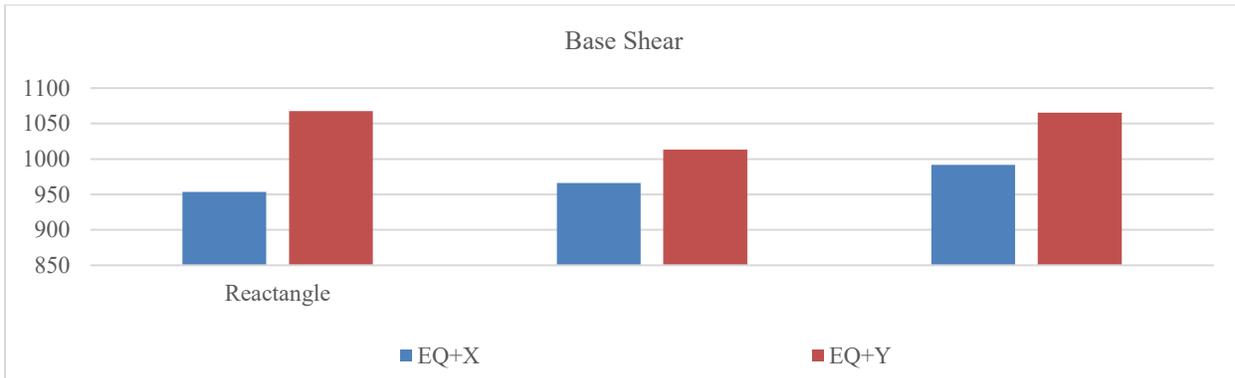
1. Analysis of RCC Rectangular shape building with G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. Base shear increases in G+15 story Building as compare to G+20 & G+25 story Building i.e. 3.3% and 6.49% etc.
2. Also, in L- shape building with G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. Base shear increases in G+15 story Building as compare to G+20 & G+25 story Building i.e. 3.169% and 6.27% etc.
3. Similarly, in T- shape building with G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. Base shear increases in G+15 story Building as compare to G+20 & G+25 story Building i.e. 4.46% and 8.19% etc.
4. Analysis and comparisons of RCC different shape of building i.e. G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. In G+15 story rectangular shape of building base shear is increased 5.56% as compare to L-shape building & similarly in T-shape of building base shear is decreased 1.37 % etc.
5. In G+20 story rectangular shape of building base shear is increased 5.34% as compare to L-shape building & similarly in T-shape of building base shear is decreased 0.32 % etc.
6. Also, in G+25 story rectangular shape of building base shear is increased 5.34% as compare to L-shape building & similarly in T-shape of building base shear is decreased 0.32 % etc.



Graph 1.2 Base shear for G+15 vs. Different Shape of Building Plan



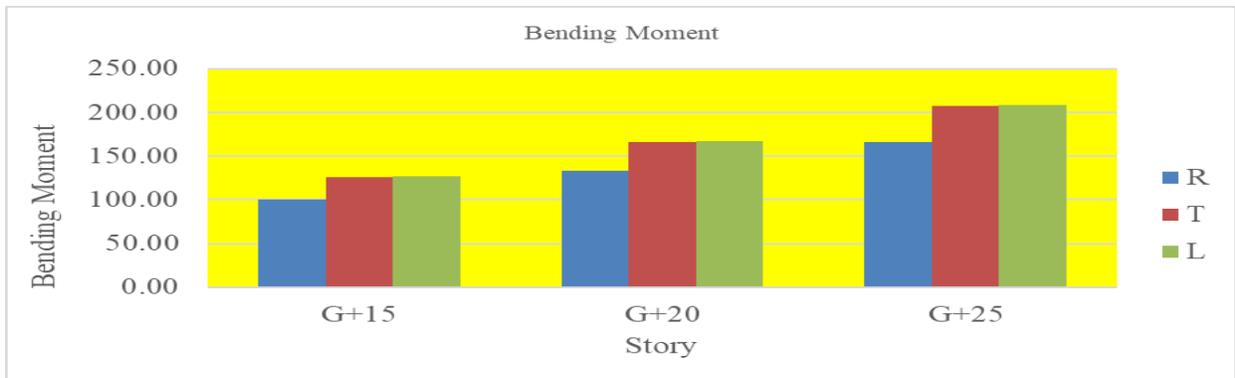
Graph 1.3 Base shear for G+20 vs. Different Shape of Building Plan



Graph 1.4 Base shear for G+25 vs. Different Shape of Building Plan

Variation of Bending Moment for Different Building  
 A bending moment (M) is the internal resistance of a structure to bending. It is caused by external forces acting on a structural member, such as a beam or

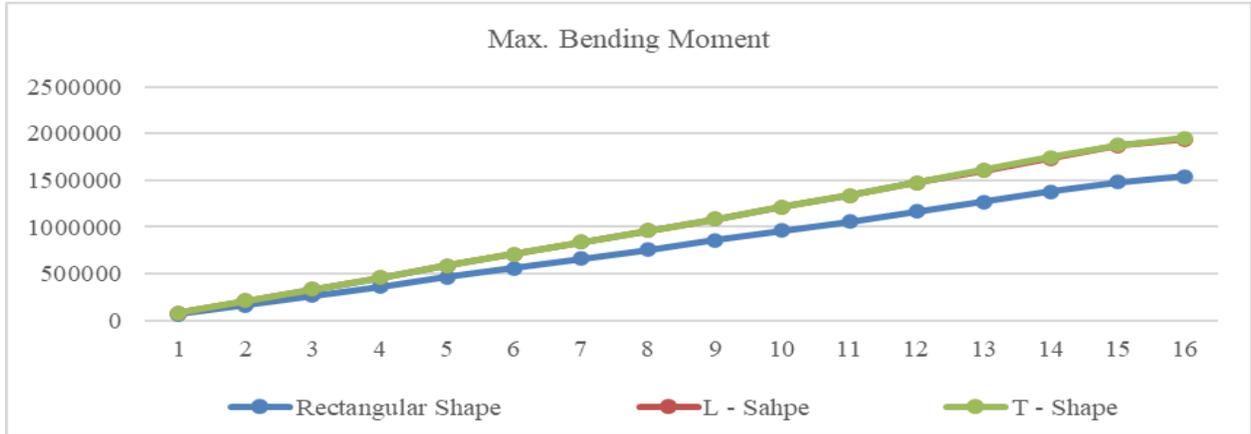
column, which create tension on one side and compression on the other. The bending moment is typically measured in force multiplied by distance (e.g., Newton-meters [N-m]).



Graph 1.5 Max. Bending Moment Vs. Different Story Height I.e. G+15, G+20 and G+25 Story

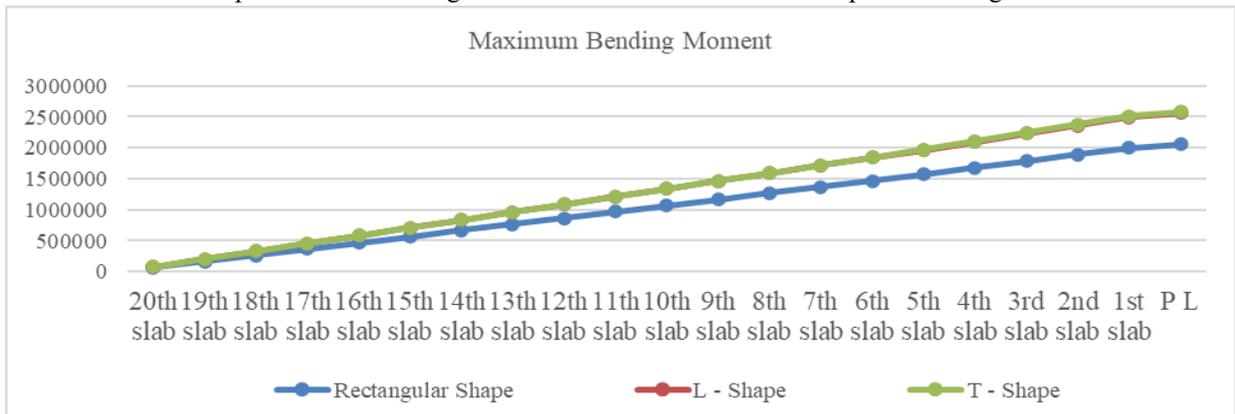
1. Analysis of RCC Rectangular shape building with G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. Maximum bending moment increases in G+25 story Building as compare to G+15 & G+20 story Building i.e. 33.39% and 65.93% etc.
2. Similarly, in L- shape building with G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. Maximum bending moment increases in G+25 story Building as compare to G+15 & G+20 story Building i.e. 32.26% and 64.53% etc.

3. Also, in T- shape building with G+15 story, G+20 Story and G+25 story in medium soil condition at zone III. Maximum bending moment increases in G+25 story Building as compare to G+15 & G+20 story Building i.e. 32.23% and 64.45% etc.



Graph 5.6 Max. Bending Moment for G+15 vs. Different Shape of Building Plan

Graph 1.7 Max. Bending Moment for G+20 vs. Different Shape of Building Plan



Graph 1.8 Max. Bending Moment for G+25 vs. Different Shape of Building Plan Results of Variations of Story Drift for Different Building

#### IV. CONCLUSION

In the present study, Relative Analysis of RCC Building G+15, G+20 and G+25 Story with different shape of building i. e. rectangular shape, L-shape and T-shape of building. The structures are analyses for earthquake zone III with medium soil and Results Compare. It has been made on different structural parameters viz. Base Shear, Story Shear, Max. Bending Moment, Max. Story Force and Story Drift etc. Grounded on the analysis results following conclusions are drawn.

- A. Variation of Base Shear for different Shapes and different stories.
  1. Base Shear Decreases with Height – Generally, as building height increases (G+15 to G+25), the base shear values tend to decrease. This happens because taller buildings have a higher natural period, which reduces the seismic forces acting at the base.
  2. Variation Among Categories (R, T, L) – If the graph shows different categories (e.g., R, T, L), their differences suggest that structural configuration or material properties impact how

seismic forces are distributed. Some structures may absorb or dissipate seismic forces more effectively.

3. Higher Base Shear for Shorter Buildings – The G+15 structure likely has the highest base shear because shorter buildings tend to be stiffer, leading to greater seismic force attraction. This is a common trend in earthquake engineering.
  4. Structural Stability Considerations – A well-balanced decrease in base shear values with height suggests that the structural design effectively manages lateral forces, possibly through damping systems or flexible structural elements.
- B. Variation of Story Drift for different Shapes and different stories.
- a. Story Drift Increases with Height – As the building height increases from G+15 to G+25, the story drift values also increase for all series. This trend is expected since taller buildings tend to experience greater lateral displacement under lateral forces like wind and earthquakes. Variation Among Series – The three series (Series1, Series2, and Series3) exhibit different drift behaviors.
    2. Series1 consistently shows the lowest drift values, indicating it might represent a stiffer structural configuration.
    3. Series2 and Series3 have higher drift values, with Series3 having the maximum drift at G+25, suggesting these configurations may allow more lateral movement.
    4. Significant Increase at G+25 – The drift differences become more pronounced at G+25, indicating that taller structures need better lateral load resistance strategies, such as bracing, shear walls, or damping mechanisms, to control excessive drift.
    5. Design Considerations – Higher drift values at greater heights emphasize the need for structural stability measures. If the drift values exceed permissible limits, modifications in design (e.g., increased stiffness, better load distribution) may be required to ensure safety and serviceability.
- C. Variation of Bending Moment for different Shapes and different stories.
1. Bending Moment Increases with Height – As the

building height increases from G+15 to G+25, the maximum bending moment values also increase. This is expected because taller buildings experience greater bending due to increased lateral forces and moments acting over a longer lever arm.

2. Category Comparison (R, T, L) – The "T" and "L" categories show higher bending moments compared to "R" at each height level. This suggests that these structural configurations (T and L) might experience more flexural stress due to their design or load distribution.
3. Greater Difference at Higher Heights – The difference in bending moments among the three categories becomes more noticeable as height increases, indicating that structural variations play a more significant role in taller buildings.
4. Design Implications – Since bending moments are crucial for designing beams and columns, higher values at G+25 suggest the need for stronger reinforcement or optimized material selection to prevent failure under extreme conditions.

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