Comparative Study of Seismic Analysis of Multi Storey Regular and Irregular Structure

S. J. Pardeshi[1], Prof .N. G. Gore[2], Prof. P. J. Salunke[3]
[1, 2, 3] Department of Civil Engineering
[1, 2, 3] MGM's College of Engineering & Technology, Maharashtra, India

Abstract- *This study, 3D analytical model of G+15 storied buildings have been generated for regular and irregular building models are analyzed using structural analysis tool ETABS software. Mass and stiffness are two basic parameters to evaluate the dynamic response of a structural system. Multi-storied buildings are behaved differently depending upon the various parameters like mass-stiffness distribution, foundation types and soil conditions. This paper is concerned with the effects of various vertical irregularities on the seismic response of a structure. The objective of the project is to carry out Response spectrum analysis of regular and irregular RC building frames and Time history Analysis of regular RC building frames and comparison of the results of analysis of irregular with regular structure is done.*

Keywords- Regular and Irregular structures; Response spectrum analysis; Time history Analysis; Mass; Stiffness

I. INTRODUCTION

Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. The dynamic loads include wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loading. Structural symmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to increased lateral deflections, increased member forces and ultimately the buildings collapse. The structural analyses of G+15 storey reinforced concrete regular and irregular buildings are done with the help of Etabs software. In the present study, The Response spectrum analysis (RSA) of regular and irregular RC building frames compare the results and Time history Analysis (THA) compare with Response spectrum analysis of regular building.

Structural Irregularity:

It is defined by location at the resistant elements, walls, columns, joints with non-structural elements, floor systems, wall openings and geometric arrangement. When irregular features are included in buildings, a considerably higher level of engineering effort is required may not be as good as one with simple architectural features. An observation of structural damage due to strong earthquake shows the class of building. So the structure can be classified on the basis of irregularity.

1. Regular
2. Moderately irregular
3. Strongly irregular

Decisions made at the planning stage on building configuration are more important since the wide range of structural damages observed educative past earthquake across the world is very educative in identifying structural configurations that are desirable versus those which must be avoided. So the irregular structure needs a more careful structural analysis to reach a suitable earthquake system. An earthquake a building should possess four main attributes namely simple and regular configuration and adequate lateral Strength, stiffness and ductility. Current earthquake codes define structural configuration as either regular or irregular in terms of size and shape of the building. A building shall be considered as irregular for the purposes of this standard, if at least one of the conditions is applicable as per IS 1893(part1):2002

II. ANALYSIS METHODS

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner.

There are different types of earthquake analysis methods. Some of them used in the project are:

- ❖ Response Spectrum Analysis
- ❖ Time History Analysis

a. Response Spectrum Analysis

A response spectrum is simply a plot of the peak or steady – state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, that are forced into motion by the same base vibration or shock. The RSM plays an important role in practical analysis of multi-storey buildings for earthquake motions. The maximum response of the building is estimated directly from the elastic or inelastic design

spectrum characterizing the design earthquake for the site and considering the performance criteria for the building. The resulting estimates of maximum forces and deformations provide a basis for preliminary design of buildings. Furthermore, most building code specifications for earthquake forces are based on simplifications of the response spectrum method of analysis. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure.
Following are the types of combination methods:

- Absolute - peak values are added together
- Square root of the sum of the squares (SRSS)
- Complete Quadratic Combination (CQC)

b. Time history analysis

This technique involves the stepwise solution in the time domain of the multi degree-of-freedom equations of motion which represent the actual response of a building. It is the most sophisticated analysis method available to a structural engineer. Its solution is a direct function of the earthquake ground motion selected as an input parameter for a specific building. This analysis technique is usually limited to checking the suitability of assumptions made during the design of important structures rather than a method of assigning lateral forces themselves.

III. PROBLEMS

Regular plan of the structure and irregular plan of the structures are shown in fig. The structure is assumed to be located in seismic zone V on a site with medium soil and Special Moment Resisting Frame. These buildings have approximately the same plan area of about 540m^2.

Dimension of beam	300 mm x 650mm
column size for 1 to 5 storey	300mm x 1200mm
column size for 6 to 10 storey	300mm x 1125mm
column size for 11 to 15 storey	300mm x 1050mm
Slab Thickness	150mm
Height of building	56m
Seismic Intensity	Very sever
Importance factor	1
Zone factor	0.36

a) Plan irregular structures

Typical floor plan and 3D view of regular and irregular buildings:

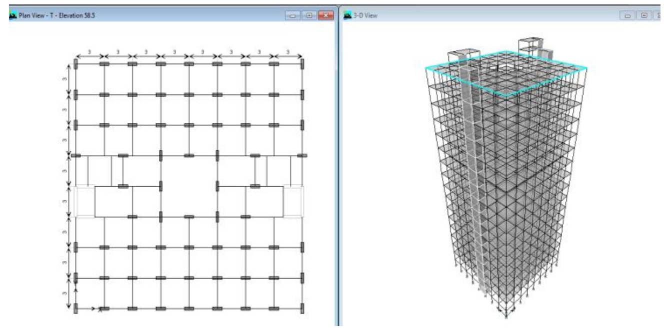

Figure 1: Regular shape

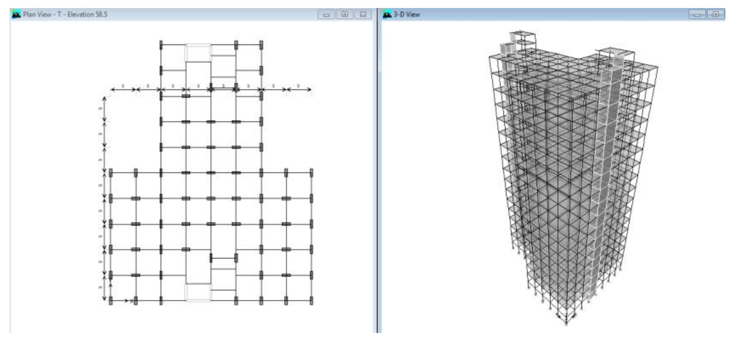

Figure 2: Irregular T shape

b) Mass irregular structure

The structure is modeled as same as that of regular structure except the loading due to swimming pool is provide in the seventh and thirtieth floor.

Height of swimming pool considered- 1.8m
Loading due to swimming pool - 20 kN/m^2

c) Stiffness irregular structure

The structure is same as that of regular structure but the ground storey has a height of 4.5 m. Stiffness of each column= $12EI/L^3 < 0.7$

Hence as per IS 1893 part 1 the structure is stiffness irregular

Load Combinations:

The gravity loads and earthquake loads will be taken for analysis. As per IS 1893 (Part I): 2002 Clause no. 6.3.1.2, the following Earthquake load cases have to be considered for analysis.

1.5(DL + LL) 0.9DL ± 1.5EQ 1.2(DL+LL±EQ)
1.5(DL ± WL) 0.9DL ± 1.5 WL 1.2(DL+LL±WL)
1.5(DL ± EQ)

IV. RESULTS

Response Structure analysis was performed on regular and various irregular buildings using Etabs. The storey shear forces, storey drift, displacement and base shear were calculated for each floor and graph was plotted for each structure.

i. Comparison of Regular and Plan Irregular structure:

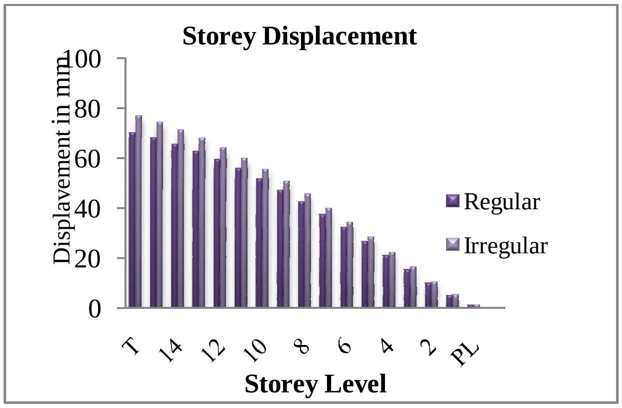

Chart 1: Storey displacement in Y direction

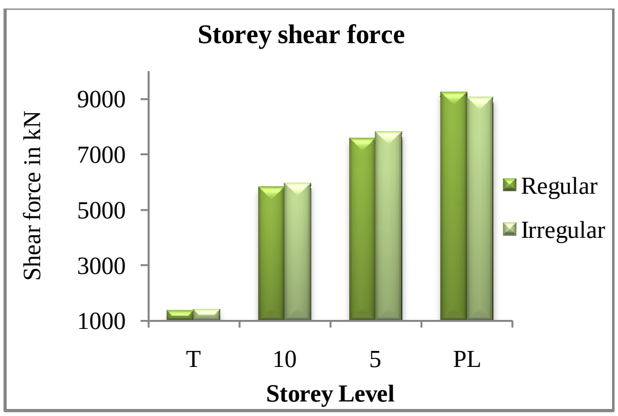

Chart 2: Storey shear force in Y direction

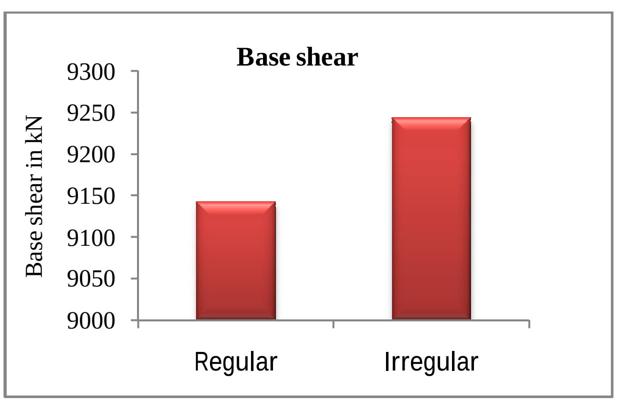

Chart 3: Base shear in X direction

ii. Comparison of Regular structure and Mass Irregular structure:

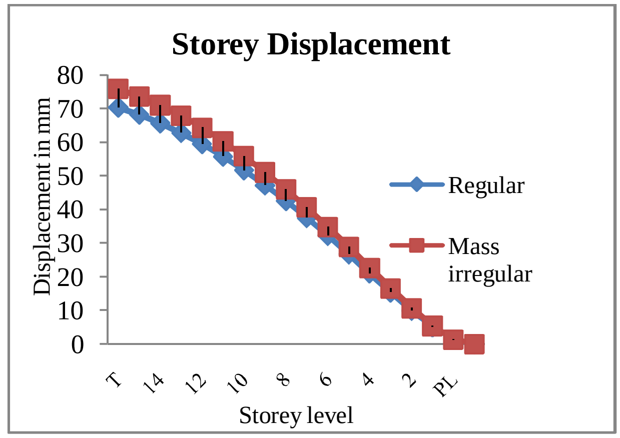

Chart 4: Displacement in Y direction

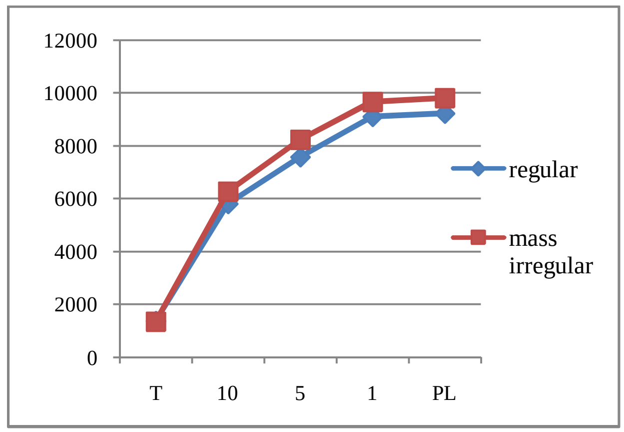

Chart 5: Storey shear force in Y direction

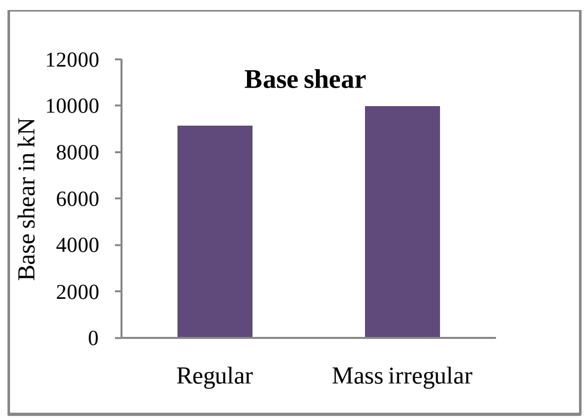

Chart 6: Base shear

The storey shear force is maximum in ground storey and it decreases as we move up in the structure. Mass irregular storey shear force is more in lower storey as compared to regular structure. The mass irregular storey shear force becomes less than that in regular.

iii. Comparison of Regular structure and stiffness Irregular structure:

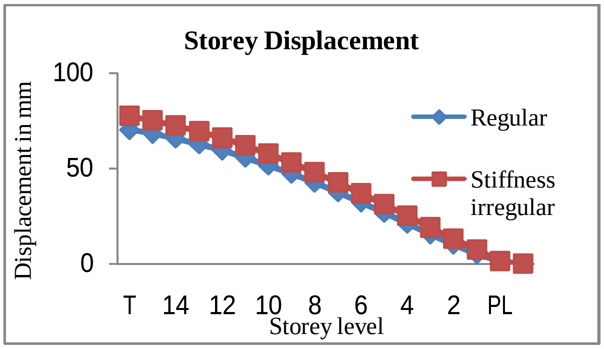

Chart 7: Displacement in Y direction

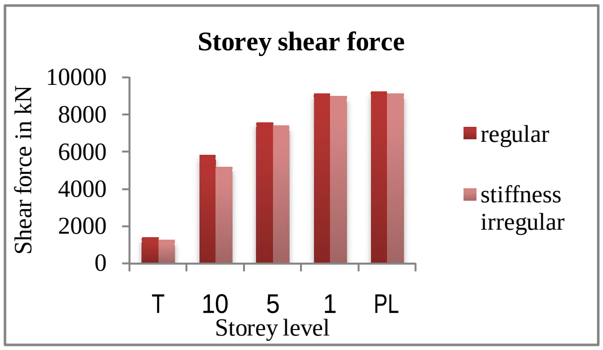

Chart 8: Storey shear force in Y direction

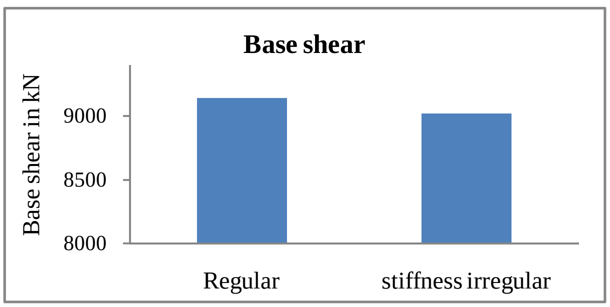

Chart 9: Base shear

The Stiffness Irregular structure has a ground storey height of 4.5m. This makes the building less stiff than regular structure. Hence the storey shear force is more in regular structure as compared to stiffness irregular structure.

iv. Comparison of response spectrum analysis and time history analysis of regular building:

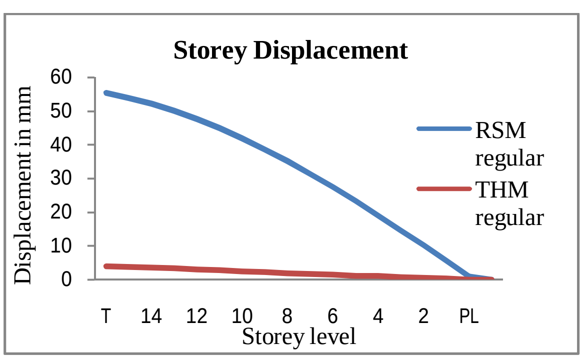

Chart 10: Storey displacement

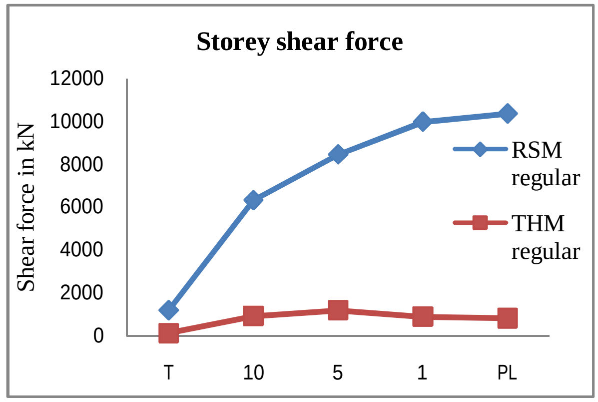

Chart 11: Storey shear force

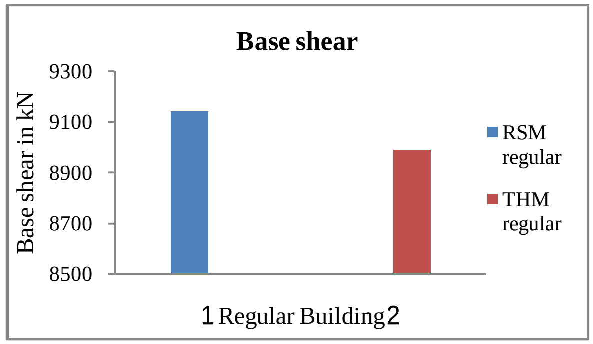

Chart 12: Base shear

V. CONCLUSION

1. Large displacement was observed in the T shape building. It indicates that building with severe irregularity shows maximum displacement and storey drift.
2. It was found that mass irregular building frames experience larger base shear than similar regular building frames.
3. The stiffness irregular building experienced lesser base shear and has larger inter storey drifts.
4. The structure has significant impact on the seismic response of structure in terms of displacement, story drift, storey shear
5. The storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.
6. The values obtained by response spectrum analysis of base shear and storey displacements are higher than time history analysis.

REFERENCES

[1] Dr. Savita Maru,‘Dynamic Analysis of Multistoried Regular Building’, H.O.D. Professor Department of CIVIL, U.E.C, Ujjain, Madhya Pradesh, India, Issue 1 Ver. II (Jan. 2014), PP 37-42

[2] Madhusudan G. Kalibhat,'seismic performance of r.c. frames with vertical stiffness irregularity from pushover analysis', Assistant Professor, Department of Civil Engineering, Manipal Institute of Technology, Manipal, India, e-ISSN: 2278-1684

[3] Ambar Gupta, M.Tech Student, 'Seismic Behavior of Buildings Having Vertical Irregularities' Civil Engineering, Alpine Institute of Technology, Ujjain, M.P., India

[4] Krushna B. Avhad, 'Seismic Analysis of High-Rise Open Ground Storey Framed Building' (IJRTE) ISSN: 2277-3878, Volume-3 Issue-4, September 2014

[5] Shrinath Shet, P.G Student,'Seismic Performance of RC Frames with Vertical Stiffness Irregularity from Pushover Analysis' Department of Civil Engineering, Manipal Institute of Technology, Manipal, India

[6] T. Mahdi, 'Plan irregular RC frames: comparison of pushover with nonlinear dynamic analysis' Department of Structural Engineering, Iran

[7] Dr. S.K. Dubey, 'Seismic Behavior of Asymmetric RC Buildings' Department of Civil Engineering, MANIT, Bhopal

[8] K.S. Babu Narayan and M.H. Prashanth, 'Seismic Performance Evaluation of RC Buildings with Vertical Irregularity' Department of Civil Engineering, National Institute of Technology Karnataka, Surathkal, Karnataka, India

[9] Mr. S. Mahesh, 'Comparison of analysis and design of regular and irregular configuration of multi-Story building in various seismic zones and various types of soils using ETABS and STAAD' Department of Civil Engineering V R Siddhartha Engineering College, India

[10] IS 1893 (Part - I):2002, "Criteria for Earthquake Resistant Design Of Structures", (Bureau of Indian Standards), New Delhi, India

[11] Bureau of Indian Standards:IS-875,part (1) 1987,Dead loads on Buildings and Structures, New Delhi, India