International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 12 | Dec 2018 www.irjet.net p-ISSN: 2395-0072

Non-linear Time History Analysis of the Horizontal and Vertical Asymmetric Buildings

Md Masihuddin Siddiqui[1], Prof N Murali Krishna[2], Md Nouman[3]

[1]Asst. Professor, C.E.D; Muffakham Jah College of Engineering & Technology, Hyderabad, T.S, India
[2]Professor, C.E.D; CMR College of Engineering; Ibraheempatnam, T.S, India
[3]M.E-Structural Engg., Muffakham Jah College of Engineering & Technology, Hyderabad, T.S, India

---***---

Abstract - *Irregular structures are unavoidable in the field of construction as they constitute a large portion of the modern urban infrastructure. This may lead to building structures with irregular distribution of mass, stiffness and strength along the height of the structure. IS code classifies the structural irregularities into two major divisions, i.e., Plan irregularity and Vertical irregularity. Among these divisions, there are sub-classifications. The present work aims to identify the critical irregularities among different irregularities when they are subjected to real time seismic loading by performing Non-linear Dynamic analysis.*

Key Words: Non-linear Time History analysis, Torsion, Asymmetrical Buildings.

1. INTRODUCTION

Asymmetric building structures are almost unavoidable in modern construction due to various types of functional and architectural requirements. Asymmetry results in significant coupling between the translational and torsional response of the structures and, as a result the induced lateral and torsional forces can exceed the design values and cause widespread damage or failure. Seismic damage surveys and analysis conducted on modes of failures of building structures during past severe earthquakes concluded that most vulnerable building structures are those, which are asymmetric in nature. It is very important to perform the dynamic analysis for the structure subjected to real time seismic loadings. As mentioned in various codes and papers by number of researchers, nonlinear time history analysis (NL-THA) can be regarded as the most accurate method for the seismic evaluation of structures.

II. STRUCTURAL IRREGULARITIES

There are various types of irregularities in the buildings depending upon their location and scope, but mainly, they are divided into two groups - plan irregularity and vertical irregularity. As per IS: 1893 (2016)[5], the irregularities can be classified as follows

Types of Structural Irregularities

Plan irregularity

1) Torsion irregularity
2) Re-entrant corners
3) Floor slabs having excessive cut-outs or openings
4) Out-of-plane offsets in vertical elements
5) Non-parallel lateral force System

Vertical irregularity

1) Stiffness irregularity
2) Mass irregularity
3) Vertical geometric irregularity
4) In-plane discontinuity in vertical elements resisting lateral force
5) Strength Irregularity (Weak Storey)
6) Floating or Stub Columns
7) Irregular Modes of Oscillation in two principal plan directions

III. NON-LINEAR TIME HISTORY ANALYSIS

The purpose of the non-linear time history analysis (NLTHA) is to evaluate the non-linear response of structural system. Time-History analysis is a step-by-step procedure where the loading and the response history are evaluated at successive time increments. During each step the responses (displacements and velocities) are evaluated from the initial conditions existing at the beginning of the step and the loading history in the interval. With this method, the non-linear behavior may be easily considered by changing the structural properties (e.g. stiffness, k) from one step to the next. The NLTHA is perhaps the only procedure which captures the realistic response of the structures when subjected to real earthquake loading. Clearly, these benefits come at the cost of additional analysis effort, associated with incorporating all important elements, modelling their inelastic load-deformation characteristics, and executing incremental inelastic analysis, preferably with a three-dimensional analytical model. For the current study popular earth-quake ground acceleration record namely N-W component of the BHUJ earthquake has been selected. The records are defined for the acceleration points with respect to a time-interval of 0.005 seconds.

IV. CASE STUDY

In the present study, seismic response of 4 models of horizontal irregularities and 4 models of vertical irregularities are evaluated using ETABS 2016[3]. The aim of the present work is to evaluate the seismic response of the horizontal and vertical irregular structures subjected to BHUJ earthquake excitation. The layout of the plan is asymmetric either horizontally or vertically having bay length of 5m in X direction and 4m in Y direction. The models considered are reinforced concrete special moment resisting frame of five stories. All these buildings have been analysed by non- linear dynamic analysis [time history analysis]. The typical storey height is 3m for all models.

Table -1: Assumed Preliminary Data for the Analysis

S.No.	Variable	Data
1	Type of Structure	RC Moment resisting frame
2	Number of Stories	5
3	Typical Storey Height	3m
4	Dead Load	1 kN/m2
5	Live Load	3 kN/m2
6	Grade of Concrete and Steel	M30 and Fe500
7	Size of Beams	300 x 500mm
8	Seismic Zone	IV
9	Importance factor	1
10	Reduction factor	5
11	Type of soil	Medium

The plan configuration consists of Models of five story building:

Model 1(a) to 1(d) – Plan Irregularity Models

Model 1(e) to 1(h) – Vertical Irregularity Models

Horizontal Irregularity Models

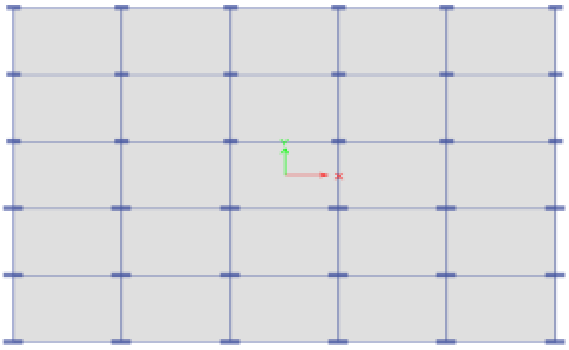

Fig. 1(a): Torsional Irregularity

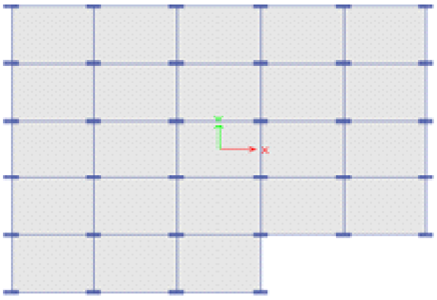

Fig. 1(b): Re-entrant Corners

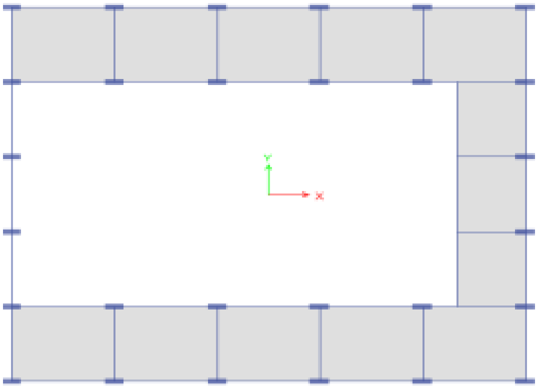

Fig. 1(c): Diaphragm Discontinuity

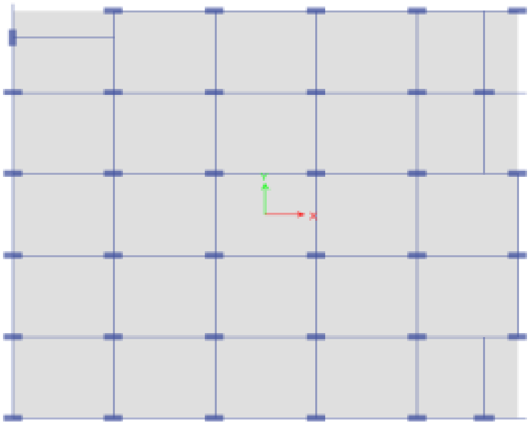

Fig. 1(d): Out of Plane Irregularity

Vertical Irregularity Models

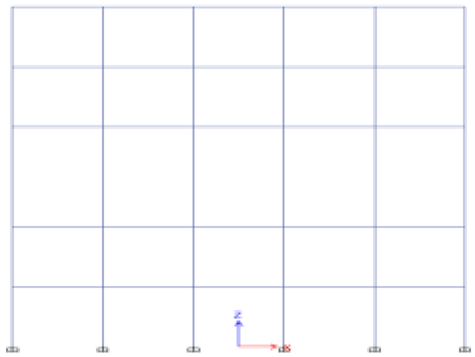

Fig 1(e): Stiffness Irregularity

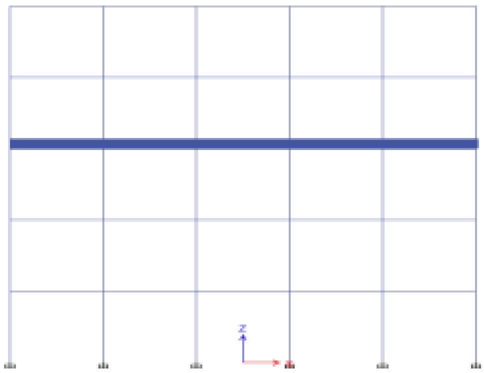

Fig. 1(f) : Mass Irregularity

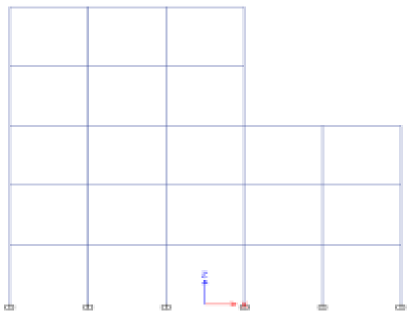

Fig. 1(g): Vertical Geometric Irregularity

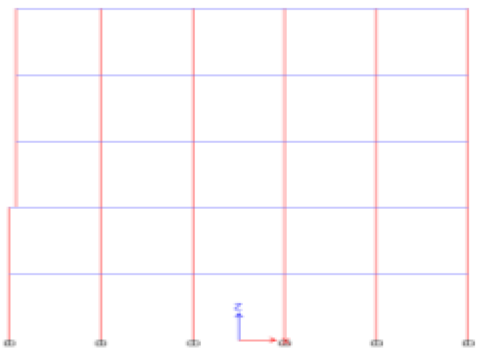

Fig. 1(h): In-Plane Discontinuous Irregularity

The Non-linear Time History Analysis has been performed on the horizontal and vertical irregular models with BHUJ earthquake accelerogram. The following are the results obtained by carrying out the Non-linear Time History Analysis for different models.

V RESULTS

The following table contains the results of the analysis carried out for the models as discussed earlier. The absolute values tabulated are for base torsion (Mz).Torsional variation for non-linear dynamic analysis (Time history analysis) of asymmetrical buildings.

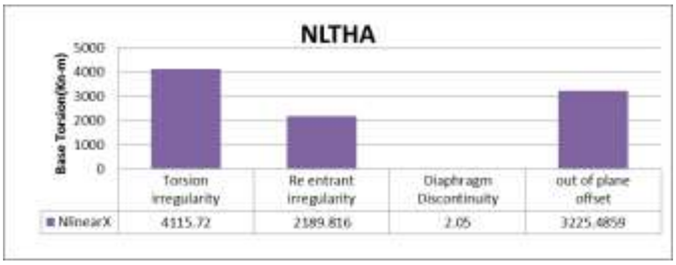

Fig.2: Variation of Base Torsion of Horizontal Irregular Buildings

After performing Non-Linear Time History Analysis (NL-THA) for the above models, Fig.2 shows the variation of maximum Base torsion (MZ) in horizontal irregular buildings. The maximum base torsion was found for Model-1(a) in which torsion irregularity is present.

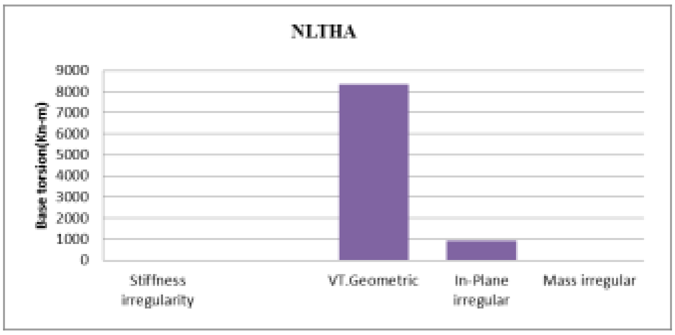

Fig.3: Variation of Base Torsion in Vertical Irregular Buildings.

Similarly performing NL-THA to Models 1(e) to 1(h), Fig. 3 shows the variation of maximum base torsion (MZ) in vertical irregular buildings. The maximum base torsion was found for model-1(f) in which Vertical geometric discontinuity irregularity is present.

VI CONCLUSION

1. It was found that the Base torsion (MZ) was Maximum for model-1(a) in which torsion irregularity is present.
2. The base torsion is maximum for model-(g) in which vertical geometric irregularity is present.
3. Comparing vertical and horizontal irregularities, the maximum base torsion is observed to be in Vertically Geometric Irregular building under similar type of loading conditions.

Hence, Vertically geometrical irregularity is more sensitive for seismic effects.

REFERENCES

[1] ATC-40 (1997). "Seismic evaluation and retrofit of concrete buildings", California Seismic Safety Commission, Vol-1
[2] Earthquake Resistant Design of Structures by Pankaj Agarwal and Manish Shrikhande
[3] ETABS 16.2.1, Structural Analysis Program, Computers and Structures, Inc., Berkeley, CA.

[4] FEMA-273, (1997). "NEHRP/Guidelines for the seismic rehabilitation of buildings". Federal Emergency Management Agency, Washington D.C. Report no. FEMA-273 Vol-1
[5] IS 1893-2016, "Indian Standard Code of Practice for Earthquake Resistant Design of Buildings"
[6] Neha P. Modakwar, Sangita S. Mesh ram, Dinesh W. Gawatre (2013),"Seismic Analysis of Structures with Irregularities", IOSR Journal of Mechanical and Civil Engineering, Volume 3, Issue 2,March- April 2014 pp-63-66.
[7] Varadharajan, V.K, Sehgal and Saini (2011) "Review of different Structural irregularities in buildings" Journal of Structural Engineering Vol. 39(5), Pp. 393-418.

BIOGRAPHY

Muhammed Masihuddin Siddiqui
Academic Qualification: B.E. (Civil Engineering), M.E. (Structural Engineering), Ph.D*
Experience: Working as Asst. Professor at MJCET, Banjara Hills, Hyd.
Research Area: Pursuing Ph.D in the area of Earthquake Engineering.