A Review on Seismic Analysis And Design of Regular And Irregular Configuration Multi-Storey Buildings Using ETABS And STAAD PRO V8i

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Abstract- *The behavior of multi-storied building with regular and irregular plan configuration under earthquake is complex and it varies as wind loads are assumed to act simultaneously with earthquake loads. This paper provides a review study of high rise residential buildings subjected to earthquake and wind loads carried out using ETABS and STAAD PRO V8i, assuming that the material is static and dynamic analysis is performed. These analysis are carried out by considering different seismic zones and for each zone the behavior is assessed by taking three different types of soils namely Hard, Medium and Soft. Different response parameters such as storey drift, displacement, base shear are planned for different areas and different types of soils.*

Keywords- Base Shear, Displacement, Storey drift, ETABS, STAAD PRO V8i.

I. INTRODUCTION

Earthquakes are most unpredictable and devastating of all-natural disasters. Earthquakes have the potential for causing the greatest damages among all the natural hazards. Since earthquake forces are random in nature and unpredictable. They not only cause great destruction in human casualties, but also have a tremendous economic impact on the affected area. The concern about seismic hazards has led to an increasing awareness and demand for structure designed to withstand seismic forces. When a structure is subjected to ground motions in an earthquake, it responds by vibrating. Those ground motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. During an earthquake, the damage in a structure generally initiates at location of the structural weakness present in the building systems. High-Rise RC structures are a special class of structures with their own peculiar characteristics and requirements. These structures are often occupied by a large number of people. Thus, their damage, loss of functionality, or collapse can have very severe and adverse consequences on the life and on the economy of the affected regions. Each high-rise structure represents a significant investment and as such high-rise structure analysis is generally performed using more sophisticated techniques and methodologies. Thus, to understand modern approaches for seismic analysis of high-rise RC structures are valuable to structural engineers and researchers. In the modern era, most of the structures are delineated by irregular in both plan and vertical configurations. Moreover, to analyze or design such irregular structures high level of effort is needed. In other words, damages or loss in those structures with irregular options are over those with regular one. Thus, irregular structures would like careful structural analysis to succeed in an acceptable behavior throughout a devastating earthquake. In most of the situations the shape of the plot for the construction of a structure may not be a regular one. Thus, the shape of the structure may be influenced by the plot configurations. Further it will be interesting to study the stability of buildings with different geometry of shape and their behavior against seismic and other forces. No any structural engineer can design 100% earthquake proof structure, only its resistance to earthquake can be increased. Proper design or maintenance to be given depends on the zone in which structure is situated. It is necessary to check or think right from the planning stage to the completion of the structure to avoid failure of structure or to overcome loss of property.

1.1 Classification of Irregularity: The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of the building. When such buildings are constructed in high seismic zones, the analysis and design become more complicated.
There are two types of irregularities;

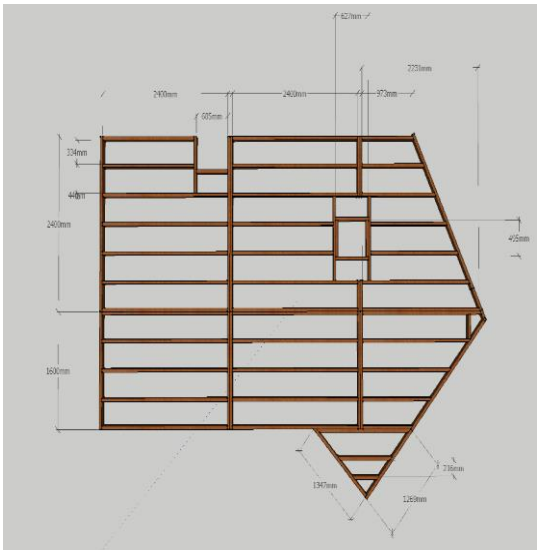
1. Plan Irregularity
2. Vertical Irregularity

There are again various types plan irregularities such as,

A) Torsional Irregularity
B) Re-entrant Corners
C) Floor slabs having excessive cut-off and opening

D) Out-of-plane Offsets in vertical elements
E) Nonparallel lateral force system

1) Plan Irregularities: Asymmetric or plan irregular structures are those in which seismic response is not only translational but also tensional, and is a result of stiffness and/or mass eccentricity in the structure. Asymmetry may in fact exist in a nominally symmetric structure because of uncertainty in the evaluation of center of mass and stiffness, inaccuracy in the measurement of the dimensions of structural elements.



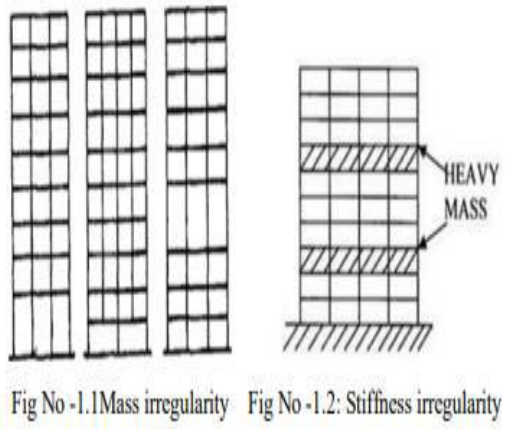


Fig No -1.1Mass irregularity Fig No -1.2: Stiffness irregularity

Fig. 1.1.1 Plan Irregularities

2) Vertical Irregularity: Vertical irregularity is further classified into six types as stiffness irregularity, mass irregularity, vertical geometric irregularity, strength irregularity-weak storey, floating or stub column and irregular modes of oscillation in two principal plan direction.

Fig. 1.1.2 Vertical Irregularity

A) Torsion Irregularity: To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Tensional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure.

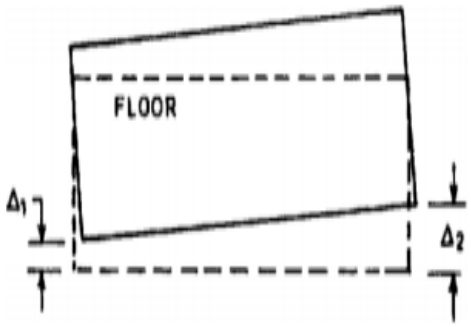


Fig No -1.3: Torsion irregularity [IS 1893:2002]

Fig. 1.1.3 Torsion Irregularity

B) Re-entrant Corners: Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 % of its plan dimension in the given direction.

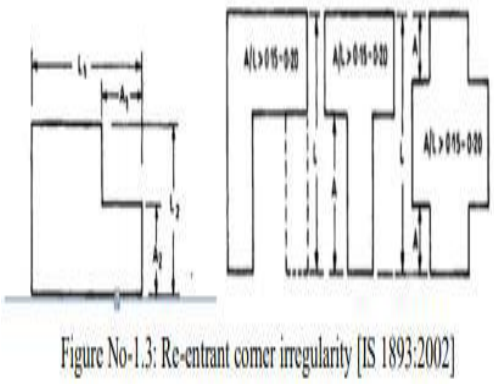


Fig. 1.1.4 Re-entrant Irregularity

1.2 Structural System: Building with structural systems are usually designed to cope up with vertical gravity loads and lateral forces caused by wind and earthquake load. The structural system which is used to resist the lateral force is known as lateral load resisting system. Different structural system used for lateral resisting load systems are classified into

- Braced frame structural system
- Rigid frame structural system
- Shear wall-frame system (Dual system)
- Shear wall system
- Core and outrigger structural system
- Infilled frame structural system
- Flat plate and flat slab structural system
- Tube structural system
- Coupled wall system
- Hybrid structural system

1.3 Concept of Regular and Irregular Configuration: To perform well in an earth quake a building should possess four main attributes namely simple and regular configuration and adequate lateral Strength, stiffness and ductility. Buildings having simple regular geometry and uniformly distributed mass and stiffness in plan as well as elevation, suffer much less damage than buildings with irregular configuration. A building shall be considered as irregular for the purposes of this standard, if at least one of the conditions are applicable as per IS 1893(part1):2002

1.4 The Procedures for the Earthquake Analysis of the Structures:

1. Linear Static Procedure
2. Linear Dynamic Procedure
3. Response Spectrum method
4. Time history method
5. Nonlinear Static Procedure (Pushover analysis)

As per IS-1893:2002, Methods Adopted are

1. Equivalent Static Lateral Force (or) Seismic Coefficient Method
2. Response Spectrum Method
3. Time history method

1.4.1 Linear Static Procedure:

The linear static procedure of building is modelled with their linearly elastic stiffness of the building. The equivalent viscous damps the approximate values for the lateral loads to near the yield point. Design earthquake demands for the LSP are represented by static lateral forces whose sum is equal to the pseudo lateral load. When it is applied to the linearly elastic model of the building it will result in design displacement amplitudes approximating maximum displacements that are expected during the design earthquake. To design the earth quake loads to calculate the internal forces will be reasonable approximate of expected during to design earth quake.

1.4.2 Response Spectrum Method:

The representation of the maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. The maximum response plotted against of undamped natural period and for various damping values and can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement. For this purpose response spectrum case of analysis have been performed according to IS 1893 Comparison of analysis and design of regular and irregular configuration of multi Story building.

II. LITERATURE REVIEW

S. Mahesh, Dr. B. Panduranga Rao [1] carried out "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". They found that the behavior of G+11 multi story building of regular and irregular configuration under earthquake is complex and it varies of wind loads are assumed to act simultaneously with earth quake loads. In this paper a residential of G+11 multi story building is studied for earth quake and wind load using ETABS and STAAS PRO V8i .Assuming that material property is linear static and dynamic analysis are performed. These analysis are carried out by considering different seismic zones and for each zone the behavior is assessed by taking three different types of soils namely Hard, Medium and Soft. Different response like story

drift, displacements base shear are plotted for different zones and different types of soils.

M. Seetha, K. E. Viswanathan [2] carried out "Comparison of Multistorey Building with Regular and Irregular Shape in Different Seismic Zones". Most of the Indian lands square measure insecure owing to the vibrations caused by the earthquakes. Also, it's not possible to stop, however the damages to the buildings may be controlled by means that of effective seismic styles. During this study chiefly focuses on deciding the variation in reinforcement share for various seismic zones of Republic of India. During this gravity hundreds as per IS 456: 2000 and once the building is intended for earthquake forces in numerous zones as per IS 1893 (Part 1): 2002 at the side of wind hundreds as per IS 875 (Part 3): 1987 square measure to be thought-about. For this study each regular and irregular geometric building plan square measure to be thought-about with an equivalent space of 5192sq.ft having G+5 storeys square measure analyzed and designed by exploitation structural analysis computer code tool ETABS-2015. This study conjointly includes the determination of displacement, moment, shear and base shear. The value comparison analysis conjointly to be enclosed, as a result of supported the zone alternatives it's varied. Then the results square measure compared with wind hundreds, gravity hundreds in varied seismic zones.

Pritam C. Pawade, Dr. P. P. Saklecha, Milind R. Nikhar [3] performed "Comparison and analysis of regular and irregular configuration of multi-storey building in various seismic zones and various type of soil". Multi-storey RC Structure subjected to most dangerous earthquakes. It was found that main reason for failure of RC building is irregular distributions of mass, stiffness and strength or due to irregular geometrical configurations. In reality, many existing buildings contain irregularity due to functional and aesthetic requirements. However, past earthquake records show the poor seismic performance of this structure. This is due to ignorance of the irregularity aspect in formulating the seismic design methodologies by the seismic codes (IS 1893:2002, etc.). The review of seismic design codes and reported research studies show that the irregularity has been quantified in terms of magnitude ignoring the effect of location of irregularity. The principle objective of this project is to study the structural behavior of multistory RC Structure for different plan configuration such as rectangular building along with L-shape and C- shape and H-shape in accordance with the seismic provisions suggested in IS: 1893-2002 using STAAD Pro V8i. The analysis involves load calculation and analyzing the whole structure on the STAAD Pro V8i version for dynamic analysis i.e. Response Spectrum Analysis & Time History Analysis confirming to Indian Standard Code of Practice. For time history analysis past earthquake ground motion record is taken to study response of all the structures. These analyses are carried out by considering different seismic zones (II, III, IV and V) and for each zone the behavior is assessed by taking hard, medium and soft soil. Post analysis of the structure, different response like maximum storey displacement, maximum storey drift, storey shear and maximum overturning moment are plotted in order to compare the results of the linear and non-linear dynamic analysis.

Vishal N, Ramesh Kannan M, Keerthika L [4] performed "Seismic Analysis of Multi-Storey Irregular Building with Different Structural Systems". Most of the multi-storey buildings are analysed based on an assumption that the structure is subjected to whole load after modelling the entire structure. But in reality, each storey is subjected to some assumed loads to act during construction period itself as they are constructed in stages as storey wise. Sequential analysis in a structure is ignored by many structural engineers while analysing the structure. Because of this ignorance, variation may occur in structural members in the below storey with respect to above storey as the construction proceeds which leads to incorrect distribution of forces in the member. So, analysis has to be done only by sequential application of loads in each storey for the safety of the structure and cost-effectiveness. In order to study the structural behavior of a 20-storey building with vertical setback irregularity has been modelled and analysed by response spectrum method considering with and without Construction Sequence Analysis (CSA) using different structural systems in CSI ETABS V16 as per BIS 1893:2016 (Part 1). Finally, results such as axial force, shear force, bending moment are drawn for the structural members and response such as storey displacement, storey shear and storey drift are plotted and compared for each structural system.

Yogita K. Kalambe, Prof. Sanjay Denge [5] studied "Seismic Analysis of R.C.C. Building With Plan Irregularities"**.** Earthquake never kills people but the defective structures do. The stability and stiffness of any structure is the major issue of concern in any high-rise buildings. Shear walls are structural members which resist lateral forces predominant on moment resisting frame.

V. Ramanjaneyulu, Dharmesh. M, V. Chiranjeevi [6] carried out "Comparative Study On Design Result Of A Multi-Storey Building Using STAAD PRO And ETABS For Regular AND Irregular Plan Comfiguration". STAAD.Pro and ETABS are the present-day leading design softwares in the market. Many design companies use these softwares for their project design purposes. So, this project mainly deals with the comparative analysis of the results obtained from the design of

a regular and a plan irregular (as per IS 1893) multi storey building structure when designed using STAAD.Pro and ETABS softwares separately. The principle objective of this project is the comparative study on design and analysis of multi-storeyed building (G+8) by STAAD.Pro and ETABS softwares. STAAD.Pro is one of the leading softwares for the design of structures. In this project we analyze the G+8 building for finding the shear forces, bending moments, deflections & reinforcement details for the structural components of building (such as Beams, columns & slabs). ETABS is also leading design software in present days used by many structural designers. Here we had also analyzed the same structure using ETABS software for the design.

Mohd. Abdul Aqib Farhan, Jagadeesh Bommisetty [7] performed "Seismic Analysis of Multistoried RCC Buildings Regular and Irregular in Plan". This paper focuses on the study of seismic response of buildings having regular and irregular plan configurations. RC buildings (Regular and Irregular) of height G+6, G+9 & G+14 having re-entrant corners are selected for this study. FEM modelling and analysis was carried out using ETABS software. Response spectrum Analysis is carried out for seismic zones (II to V) specified in IS 1893 (Part I): 2002 with soil types II (medium stiff). Linear Static Dynamic Analysis has been performed to understand the performance characteristics of the irregular structures in comparison with regular RC structures. Further, the response obtained for each structure in different zones and heights are compared. It is observed from the results that the irregular building has maximum displacement compared to regular building maximum story shear is observed in regular building.

Harpal Singh, Akash Aneja [8] carried out "Parametric Study of Multi-Storey RC Building With Plan Irregularity". The parametric study to evaluate irregular structures in plan L-shape, H–shape and U-shape has been carried out. Lateral length ratio is varied for each shape plan configuration and the assessment of each plan is done on the basis lateral length ratio. Buildings are analysed for Dead loads, Live loads, Wind loads and Earthquake load taken as per the relevant Indian Standard codes. Each building is 11 storeys high having 4m X 4m bays, the height of each storey is taken as 3m and bottom storey height taken is 4m, making the total height of the structure 34m. 3D Modelling and analysis of the structure has been carried out using "ETABS" software. Response quantities such as storey shear, internal forces, storey drift, and storey displacement are considered for the assessment. Based on the results, graphs are plotted for design eccentricity, storey shear, internal forces, storey drift, and storey displacement versus lateral length ratios for different shapes; conclusion for the most stable structure is drawn.

R. Arun, K. Suhana, L. Saicharan Reddy [9] performed "Seismic base shear variation between regular and irregular RCC structure in various zones by STAAD.PRO". Multi-storey structures are frequently caused by the earthquake by the scarcity of provision. Earthquake often occurs on zone 4 and zone 5 region due to lack of remedies building cannot be elevated beyond the certain height. This present study was done base shear variation between regular and irregular configuration informs of the various zone such as zone II, zone III, zone IV, & V various soil conditions such as Medium, Soft, Hard respectively. So, such preliminary data were considered to get better performance of buildings as well as two designs were done such as manual design & software design by Staad.pro. Eventually, base shear performance was found for between different zone region and soils respectively. This SLA was assumed out by considering different seismic zones & soils. As per data, ACP was done for Regular & Irregular structure to get a view of the plan.

Abhay Guleria [10] studied "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations". ETABS stands for Extended Three-dimensional Analysis of Building Systems. ETABS is commonly used to analyze: Skyscrapers, parking garages, steel & concrete structures, low- and high-rise buildings, and portal frame structures. The case study in this paper mainly emphasizes on structural behavior of multi-storey building for different plan configurations like rectangular, C, L and I-shape. Modelling of 15- storeys R.C.C. framed building is done on the ETABS software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases.

III. CONCLUSIONS

- From the analysis of ESA and RSA for both regular and irregular plan building, storey displacement and storey drift is maximum for irregular plan building as compared to building having regular plan.
- Base shear is maximum for regular building as compared to irregular building.
- In regular building, there is reduction in displacement and storey drift due to infill action of the lateral stiffness of the frame.
- As plan irregularity increases both displacement and storey drift increases.

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