*International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-7,October 2015*
*ISSN: 2395-3470*
*www.ijseas.com*

# Comparision of both linear static and dynamic analysis of multistoryed buildings with plan irregularities

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***Abstract***

This paper aims towards the static and dynamic analysis of reinforced concrete building with plan irregularity. Four models of G+15 storey building with one regular plan and remaining irregular plan have been taken for the investigation. The analysis of R.C.C. building is carried out with the FE based software ETABS 9.5. Estimation of response such as; lateral forces, base shear, storey drift, storey shear is carried out. The paper also deals with the effect of the variation of the building plan on the structural response building. Dynamic responses under prominent earthquake,related to IS 1893–2002(part1) have been carried out. In dynamic analysis; Response Spectrum method is used.

## 1. INTRODUCTION

Structural design of buildings for seismic loads is primarily concerned with structural safety during major ground motions, but serviceability and the potential for economic loss are also of concern. Seismic loading requires an understanding of the structural performance under large inelastic deformations. Behavior under this loading is fundamentally different from wind or gravity loading, requiring much more detailed analysis to assure acceptable seismic performance beyond the elastic range. Some structural damage can be expected when the building experiences design ground motions because almost all building codes allow inelastic energy dissipation in structural systems. The first step in dynamic analysis is to develop a mathematical model of the building, through which estimates of strength, stiffness, mass, and inelastic member properties are assigned. In general, for a multistorey building it is necessary to take into account contributions from more than one mode.

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
Structural analysis means determination of the general shape and all the specific dimensions of a particular structure so that it will perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life. ETABS was used to create the mathematical model of the Burj Khalifa, designed by Skidmore, Owings and Merrill LLP (SOM). The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. ETABS provides both static and dynamic analysis for wide range of gravity, thermal and lateral loads.

This analysis mainly deals with the study of a rectangular, L, C and I shaped plan using ETABS. A G+15 storeys structure is modelled using ETABS. The height of each storey is taken as 3m, making total height of the structure 45m. Loads considered are taken in accordance with the IS-875(Part1, Part2), IS-1893(2002) code and combinations are acc. to IS-875(Part5). Post analysis of the structure, maximum

shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analysed cases.
According to IS 1893:2002 (Clause 7.1), there are mainly two types of irregularities,

a. Plan Irregularity
b.vertical Irregularity

**1.1 Plan irregularity –**

Plan irregularity also of five types as follows: i.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. Torsional 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.
ii. 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 percent of its plan dimension in the given direction.

iii. Diaphragm Discontinuity - Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffnes of more than 50 percent from one storey to the next.

iv. Out-of-plane offsets - Discontinuities in a lateral force resistance path, such as out-of-plane offsets of vertical elements.

v. Non-parallel Systems - The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements.

**1.2 Vertical Irregularity –**

Plan irregularity also of five types as follows:
i. Stiffness Irregularity –
1. Soft Storey - A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above.
2. Extreme Soft Storey - A extreme soft storey is one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above. For example, buildings on STILTS will fall under this category.

ii. Mass Irregularity - Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. The irregularity need not be considered in case of roofs.

iii. Vertical Geometric Irregularity - Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.

iv. In-Plane Discontinuity in vertical elements resisting lateral force - An in-plane offset of the lateral force resisting elements greater than the length of those elements.

v. Discontinuity in capacity – Weak storey - A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above, the storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction.

**1.3ETABS**

ETABS is the present day leading design software in the market. Many design company's use this software for their project design purpose. The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.
From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid

generation of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. The state-of-the-art SAP Fire 64-bit solver allows extremely large and complex models to be rapidly analyzed, and supports nonlinear modelling techniques such as construction sequencing and time effects (e.g., creep and shrinkage). Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures.

### 1.4MODELLING OF RCC FRAMES

An RCC framed structure is basically an assembly of slabs, beams, columns and foundation inter-connected to each other as a unit. The load transfer mechanism in these structures is from slabs to beams, from beams to columns, and then ultimately from columns to the foundation, which in turn passes the load to the soil. In this structural analysis study, we have adopted four cases by assuming different shapes for the same structure, as explained below.

1. Rectangular Plan
2. L-shape Plan
3. I-shape Plan
4. C-shape Plan

## 2. LITERATURE REVIEW

**[1] Mahesh N. Patil, Yogesh N. Sonawane et al (2015*)***In this paper, the earthquake response of symmetric multistoried building is studied by manual calculation and with the help of ETABS 9.7.1 software. The method includes seismic coefficient method as recommended by IS 1893:2002. The responses obtained by manual analysis as well as by soft computing are compared. This paper provides complete guide line for manual as well as software analysis of seismic coefficient method.

**[2] Mohammed yousuf, P.M. shimpale et al (2013)** The main objective of earthquake engineering is to design and build a structure in such a way that the damage to the structure and its structural component during an earthquake is minimized. This paper aims towards the dynamic analysis of reinforced concrete building with plan irregularity. Four models of G+5 building with one symmetric plan and remaining irregular plan have been taken for the investigation. The analysis of R.C.C. building is carried out with the FE based software ETABS 9.5. Estimation of response such as; lateral forces, base shear, storey drift, storey shear is carried out. Four cross sectional variation in columns section are considered for studying effectiveness in resisting lateral forces. The paper also deals with the effect of the variation of the building plan on the structural response building. Dynamic responses under prominent earthquake, related to IS 1893–2002(part1) have been carried out. In dynamic analysis; Response Spectrum method is used. The CQC (complete quadratic combination) method has also been employed for each model for estimation of dynamic response for 5%, 10%, 15%, and 20% damping and dynamic responses were compared.

**[3] Ni Ni Win, Kyaw Lin HtaT et al (2014)**This paper presents comparative study of static and dynamic analysis of irregular reinforced concrete building due to earthquake. In present study, computer aided analysis of twelve-storied reinforced concrete building is carried out for static and dynamic analysis by using ETABS (Extended Three dimensional Analysis of Building System) software. Load consideration is based on Uniformed Building Code (UBC-1997). The structure is designed in accordance with American Concrete Institute (ACI-318-99) design code. Firstly, the proposed building is analyzed with static. Secondly, dynamic analysis with response spectrum method is used. In this paper, the results of static and dynamic (response spectrum) analysis such as displacement, storey shear, storey moment and storey drift are compared.

**[4] Mr. S.Mahesh, Mr. Dr.B.Panduranga Rao et al (2014)** The behaviour of G+11 multi story building of regular and irregular configuration under earth quake 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 STAAD 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 behaviour 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.

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**[5] Mohammed Rizwan Sultan et al (2015)** The most important objective of this study is to grasp the behaviour of the structure in high seismic zone and also to evaluate Storey overturning moment, Storey Drift, Displacement, Design lateral forces. During this purpose a 15 storey-high building on four totally different shapes like Rectangular, L-shape, H-shape, and C-shape are used as a comparison. The complete models were analysed with the assistance of ETABS 9.7.1 version. In the present study, Comparative Dynamic Analysis for all four cases have been investigated to evaluate the deformation of the structure. Results & Conclusion: The results indicates that, building with severe irregularity produces more deformation than those with less irregularity particularly in high seismic zones. And conjointly the storey overturning moment varies inversely with height of the storey. The storey base shear for regular building is highest compare to irregular shape buildings.

**[6] Divyashree M, Gopi Siddappa et al *(2014*)** Presence of re-entrant corners in buildings is one of the major deficiencies in buildings causing stress concentration and torsion related problems in the event of an earthquake. The present work focuses on the behavior of buildings with irregularities in the form of re-entrant corners and its strengthening. A four storey L - shaped building is analyzed using response spectrum and pushover analysis methods. Subsequently analysis was also carried out on structures strengthened by the introduction of shear walls and bracings. Results of analysis confirmed the improvement in base shear carrying and roof drifts capacity of the frames by the introduction of retrofitting methodologies.

**[7] S Monish, S Karuna *et al (2014)*** In this paper attempt has been made to study two types of plan irregularities namely diaphragm discontinuity and re-entrant corners in the frame structure. These irregularities are created as per clause 7.1 of IS 1893:2002(part1) code. Various irregular models were considered having diaphragm discontinuity and re-entrant corners which were analysed using ETABS to determine the seismic response of the building. The models were analysed using static and dynamic methods, parameters considered being displacement, base shear and fundamental natural period. From the present study the model which is most susceptible to failure under very severe seismic zone is found, modelling and analysis is carried out using ETABS. The section 7 of IS 1893(part1):2002 enlists the irregularity in buildings.

These irregularities are categorised as follows

1. Vertical irregularities referring to sudden change of strength, stiffness, geometry and mass results in irregular distribution of forces or distribution over the height of the building.
2. Plan irregularities which refer to asymmetrical plan shapes(L-,T-,U-,F-) or discontinuities in the horizontal resting elements (diaphragms) such as cut-outs, large openings, re-entrant corners and other abrupt changes resulting in torsion, diaphragm deformations and stress concentration.

**[8] Rakshith Gowda K.R, Bhavani Shankar *et al (2014*)** The present investigation is to study the behavior of multi storyed RC 3-D frame regular building and vertically irregular (stepped) building in which soft storey’s are provided at different level for different load combinations. Reinforced concrete (RC) buildings are analyzed for earth quake loading as per IS 1893 (Part 1):2002 the various load combinations as per IS: 875 (part 5) are used for design of structure. ETABS (9.7.4) is used for modeling and analysis RC buildings. It is necessary to study and to examine various alternative models of reinforced concrete moment resisting frame building with soft storey at different level, the performance of all the building models is observed in high seismic zone V. In the present paper an investigation has been made to study the behavior of RC frames when subjected to static and dynamic earthquake loading. The result of bare frame, frame with infill, and different location of soft storey provided are compared and conclusion are made in view of IS code. It is observed that, providing infill improves earthquake resistant behavior of the structure when compared to soft storey provided.

## 3.CONCLUSION OF THE LITERATURE REVIEW

- Static analysis gives higher values for maximum displacement of the stories in both X and Y direction.
- The base shear value due to RS analysis and static analysis will be significantly increase at higher stories.
- The dynamic RS analysis produces storey shear in both directions while the static analysis only produces storey shear in the direction of loading.
- Base shear values obtained by manual analysis are slightly higher than software analysis.
- Static analysis is not sufficient for high rise buildings and it's necessary to provide dynamic analysis .
- The results of equivalent static analysis are approximately uneconomical because values of displacement are higher than dynamic analysis.
- Building with re-entrant corners experienced more lateral drift and reduction in base shear capacity compared to regular building.
- When compared to irregular configuration the story drift value is more in the regular configuration.
- Story drift is increased as height of building increased.
- Base shear value is more in the zone 5 and that in the soft soil in irregular configuration.
- Irregular shapes are severely affected during earthquakes especially in high seismic zones.
- Base shear is calculated by using IS 1893-2002 method for all four models and illustrate the comparison of base shear using Equivalent static method. The lower base shear is getting in L shape building and the higher base shear is getting in Rectangular shape building.
- The irregular shape building undergo more deformation and hence regular shape building must be preferred.
- Results have been proved that C shape building is more vulnerable compare to all other different shapes.

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