

Effect of Shape and Plan Configuration on Seismic Response of Structure (ZONE II & V)

Veena S Ravi¹, Sreedevi Lekshmi²

¹Student, Department of Civil Engineering, Sree Buddha College of Engineering for Women Ayathil, Pathanamthitta

²Assistant Professor, Civil engineering Department, Sree Buddha College of Engineering for Women Ayathil, Pathanamthitta, Kollam, India

Abstract: Seven models of G+11 storey building with one regular plan and remaining irregular plan (C, E, H, L, T, PLUS shapes) have been taken. The plan area for each structure is same only there is differ in geometry. Elevation is same for all models. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS-1893- 2002-Part-1. Seismic performance of different shape of structures located in severe earthquake zone (V) and minor earthquake zones (II) are evaluated and compare design lateral shear, time period, joint displacement etc. Response spectrum analysis is used for analysis.

Keywords: differ in geometry, irregular plan, earthquake, time period, joint displacement, lateral shear

1. Introduction

The behavior 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 STAAD Pro. V8i.

Earthquakes, caused by movements on the earth surface, result in different levels of ground shaking leading to damage and collapse of buildings and civil infra-structures. The structure should withstand moderate level of earthquake ground motion without structural damage, but possibly with some structural as well as non-structural damage. This limit state may correspond to earthquake intensity equal to the strongest either experienced or forecast at the site. The results are studied for response spectrum method.

The Present work is focused on the study of Seismic demands of different irregular R.C buildings using various analytical techniques for the seismic zone 2nd and 5th zone of India.

- RC buildings are considered.
- Only plan irregularity was studied.
- Column was modeled as fixed to the base.

Main objective of the project is to perform Dynamic analysis and to obtain Seismic performance of different shape of structures located in severe earthquake zone (V) and minor earthquake zone (II) of India and to evaluate base shear, time period, lateral displacement.

2. Related Works

Milind.V.Mohod (2015) In this paper, the seismic response of different shape and plan configuration on of structure in 3rd zones is studied with the help of STAAD.Pro software.

Equivalent static analysis as per IS 1893-2002 method was adopted in order to design buildings and overcome effect of earthquake on it.

Pralobh S. Gaikwad *et al.* (2015) Studies of Dynamic Effect On Unsymmetrical Building (Rcc & Steel). The main objective of earthquake engineers is to design and build a structure in such a way that damage to the structure during the earthquake is minimize. The paper gives the idea of dynamic analysis of Steel and RCC building with unsymmetrical configuration. The analysis is carried on model of G +9 stories of RCC and Steel building with un symmetrical floor plan. The analysis is by carried by using E TABS Software. The parameter such as story drift, story shear and torsion is determined .For dynamic analysis response spectra method or time history method is used. Dynamic analysis should be performed for symmetrical as well as unsymmetrical building .Dynamic analysis is in the form of full nonlinear dynamic time history analysis .If the RCC and Steel building have unsymmetrical configurations, The torsional effect will be produce in both the building and are compared with each other to determine the efficient building under torsion.

Mahesh N. Patil *et al.* (2015) studies of seismic analysis of multistoried building. The effective design and the construction of earthquake resistant structures have much greater importance in all over the world. 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. From the data revealed by the manual as well as software analysis for the structures with seismic coefficient method conclusions are Calculation of seismic weight by both manual analysis as well as software analysis gives exactly same result .There is slight variation in the values of base shear in manual analysis as well as software analysis. And also there is a gradual increase in the value of

lateral forces from bottom floor to top floor in both manual as well as software analysis.

Neha P. Modakwar et al.(2014)The main objective of this study is to understand different irregularity and torsional response due to plan and vertical irregularity and to analyze cross shape and L shape building while earthquake forces acts and to calculate additional shear due to torsion in the columns. This study was initiated to quantify the effect of different degrees of irregularity on Structures designed for earthquake using simplified analysis. The type of irregularity Considered was (a) Horizontal Irregularity-Reentrant corner (b)Vertical Irregularity -Mass Irregularity. The main objective of this study is to understand different irregularity and torsional response due to plan and vertical irregularity and to analyze cross shape and L shape building while earthquake forces acts and to calculate additional shear due to torsion in the columns. Summary of findings include, the Re-entrant corner columns are needed to be stiffened for shear force in the horizontal direction perpendicular to it as significant variation is seen in these forces. Significant variation in moments, especially for the higher floors about axis parallel to earthquake direction, care is needed in design of members near re-entrant corners. From the torsion point of view the re-entrant Corner columns must be strengthen at lower floor levels and top two floor levels and from the analysis it is observed that behavior of torsion is same for all zones.

Mohammed Rizwan Sultan et al. (2015) The main objective of this study is 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 analyzed with the assistance of ETABS 9.7.1 version. Conclusion: building with severe irregularity produces more deformation than those with less irregularity particularly in high seismic zones.

Pavan Kumar (2014) The main objective this paper is to study the seismic analysis of structure for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structure for the seismic analysis and it is located in zone II. The total structure was analyzed by computer with using STAAD.Pro software. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis. Results and Conclusion: the values for displacement in static analysis of OMRF values are more compared to that of dynamic analysis values of same columns. And also observe that the values for bending moment at dynamic analysis values are more as compared to that of static analysis SMRF structure. The static and dynamic analyses of OMRF & SMRF values are observed. Finally it can conclude that the results of static analysis in OMRF & SMRF values are low when comparing to that of dynamic analysis in OMRF & SMRF values. Hence the performance of dynamic analysis

SMRF structure is quiet good in resisting the earthquake forces compared to that of the static analysis OMRF & SMRF.

Mohammed yousuf 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. Building Plan and Details

Seven models of G+11 storey building with one regular plan and remaining irregular plan have been taken. The plan area for each structure is same only there is difference of geometry. The elevation is same for all models.

1. Regular Square Plan
2. E shaped Plan
3. H Shape Plan
4. T shaped Plan
5. L Shape Plan
6. C shaped Plan
7. Plus (+) Shape Plan

4. Analysis of Building

STAAD.Pro.V8i (Structural Analysis and Design) is the most popular structural engineering software product for 3D model generation, analysis and multi-material design. It has an intuitive, user-friendly GUI, visualization tools, powerful analysis and design facilities and seamless integration to several other modeling and design software products.

STAAD.Pro.V8i is used for analyzing the response of structure and to provide a safe design according to code standards. It is originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineers International was bought by Bentley Systems. It is the leading software used for structural analysis in the industry today. It is the professional's choice for steel, concrete, timber, aluminum and cold-formed steel design of virtually any structure including culverts, petrochemical plants, tunnels, bridges, piles and much more.

A. Equivalent Static Analysis.

Equivalent static analysis defines a series of forces acting on a building to represent the effect of ground motion. It assumes that building responds in its fundamental mode, for which the building must be low-rise and must not twist significantly when the ground moves.

B. Response Spectrum Analysis

This allows the user to analyze the structure for seismic loading. For any supplied response spectrum (either acceleration vs. period or displacement vs. period), joint displacements member forces and support reactions may be calculated. Modal responses may be combined using one of the square root of the sum of squares (SRSS), complete quadratic combination (CQC), the ASCE4-98(ASCE), the Ten Percentage (TEN) or the absolute (ABS) methods to obtain the result responses. Results of the response spectrum analysis may be combined with the results of the static analysis to perform subsequent design.

5. Response Spectrum Method by Using STAAD. Pro.

Response spectrum analysis in STAAD. Pro the design lateral shear force at each floor in each mode is computed by using the equation

$$Q_{ik} = A_k \cdot \delta_{ik} \cdot P_k \cdot W_i \text{ Eq.1}$$

the value of A_k and W_i has to be defined by the user. And Q_{ik} and P_k values are calculated by the STAAD.Pro. STAAD.Pro utilizes the following procedure to generate the lateral seismic loads. We have to specify the value for $(Z \cdot I) / 2R$ as factors for input spectrum. Then the program

calculates the time period for number of modes as specified by the user. Then the program calculates S_a/g for each mode utilizing time period and damping for each mode. Then the program calculates design horizontal acceleration spectrum A_k for different modes. Further STAAD.Pro calculates mode participation factor for different modes. Then the peak lateral force at each floor in each mode is calculated. All response quantities for each mode are also calculated. Further the using various combinations (CQC or SRSS or ABS or TEN or CSM) methods as specified by the user the final results are calculated. Advantage of using the dynamic analysis is that even though the base shear by the static and dynamic and dynamic analyses are comparable, there is a considerable difference in the lateral load distribution with building height, the storey moments are significantly effective because of this change in load distribution providing as well as smaller and better design loads which will help us to listen the reinforcement requirement of our structure while designing the reinforcements.

A. Analysis of Building With Response Spectrum Method
 Space frame modal is prepared. For present work response spectrum method as per IS:1893-2002 is carried out for reinforced concrete moment resisting frame having (G+11) storey situated in zone II and V. The floor to floor height of the building is 3.4m. The total height of building is 40m.

6. Comparison of Results

A. Zone II

a. Base Shear Value

TABLE I. DESIGN BASE SHEAR (Kn)

Method	PLUS (+) Shaped	Regular Square Plan	E shaped Plan	C shaped Plan	T shaped Plan	H shaped Plan	L shaped Plan
RSM	688.50	937.07	816.42	795.58	680.71	664.63	593.05

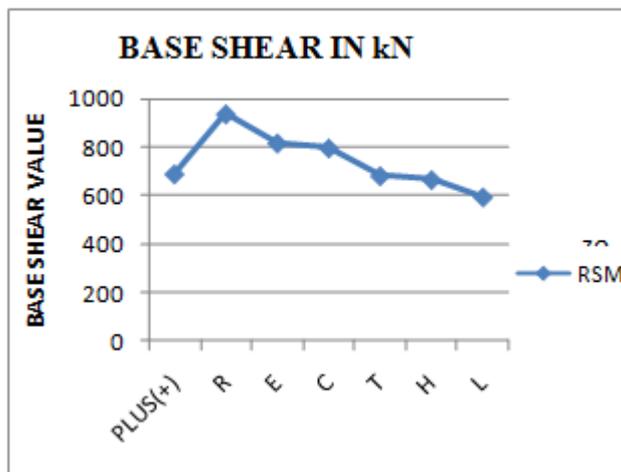


Figure 1: Design base shear in Kn

b. Time period

Table 2: Time Period in sec

Method	PLUS(+) Shaped	Regular Square Plan	E shaped Plan	C shaped Plan	T shaped Plan	H shaped Plan	L shaped Plan
RSM	3.92657	3.74447	3.62401	3.79886	3.59799	3.39656	3.57487

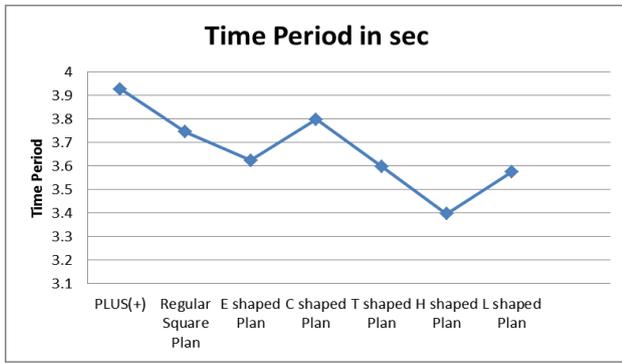


Figure 2: Time period in sec
 PERIOD Vs MODE

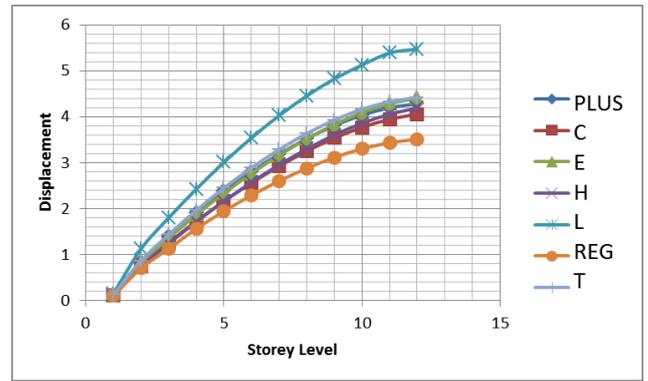


Figure 4: Storey level Vs joint displacement

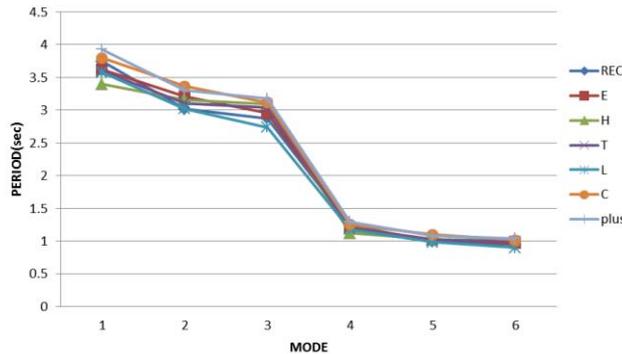


Figure 3: Time Period Corresponding To Different Mode Shapes

Table 3: Design Base Shear (kN)

METHOD	PLUS (+) Shaped	Regular Square Plan	E shaped Plan	C shaped Plan	T shaped Plan	H shaped Plan	L shaped Plan
RSM	2478.60	3373.44	2939.11	2864.11	2450.54	2392.67	2134.98

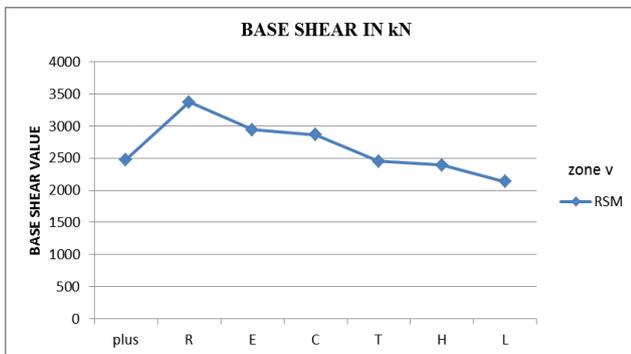


Figure 5: Design base shear in Kn

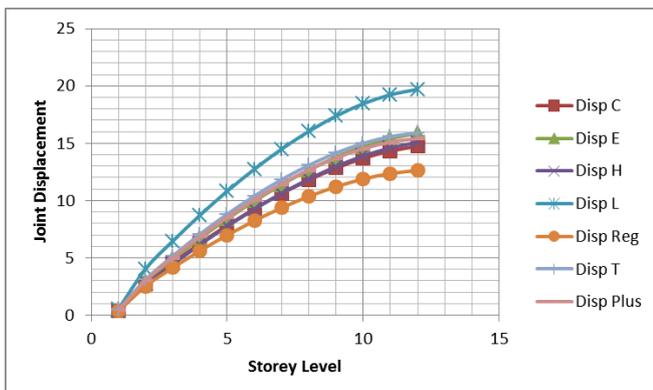


Figure 6: Storey level Vs joint displacement

B. Zone V

a. Base Shear Values

Design base shear value of different shape and plan configuration building in Vth zone and its graphical representation is shown in table.3.and fig respectively.

7. Conclusion

- Response spectrum method allows a clear understanding of the contributions of different modes of vibration. It is also useful for approximate evaluation of seismic reliability of structures.
- Building with regular square plan have the same maximum base shear value compared with other plan shapes and least base shear value for “L” shaped plan configuration in IInd and Vth zone.
- Time period does not depend the zone value.
- Frequency was maximum for “L” shaped and minimum for plus shaped one.
- Maximum displacement for irregular shapes and minimum for regular shapes.
- Regular square building have minimum displacement and “L” shaped have maximum displaced compared to other shapes since it can be avoided.
- Irregular shape building are severely affected undergo more deformation during earthquake especially in high seismic zones.

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