International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019

Study on Effect of Geometry on RC Multistory Building Under Seismic Load

Om Prakash Mahato, M. Anil Kumar

Abstract: ***Seismic forces are irregular in nature and unpredictable hence the static and dynamic investigation of the structures have turned into essential worry of structural Engineer. The main reason for the failure of the building is due to the plan irregularity of the RC multistory building. So, as it's fundamental to detect the seismic response of the structure in high seismic zones to decrease the seismic harms in structures. The main objective of the present study is to obtain the seismic response of the structure i.e. (Displacement, overturning moment ,story drift ,story shear) for G+18 building and to compare these seismic response for the different geometry of the building i.e. (Box-shape, L-shape, T-shape, Tube-shape, H-shape and C-shape) by ETABS 2016 software to conclude the most stable structure among all these shape. Analysis of models were performed by Static and dynamic analysis. And further the comparison in term of displacement between Static and dynamic analysis is performed to evaluate the most economical and best method. The result shows that box shape building is more stable comparing to all other shape of the building and dynamic analysis method is economical and it predict the accurate result then Static method.***

Index Terms: ***Response spectrum analysis, time-history analysis, story drift, overturning moment, story shear, displacement, Etabs.***

I. INTRODUCTION

During strong earthquake motion response of the multistory building depends on the distribution of strength stiffness and weight of the building in both horizontal and vertical planes. Structure engineers have created trust in the plan of structures in which those dispersions are more or less uniform. The structure with regular configuration, uniformly distributed mass and stiffness in plan and in elevation are considered to endure substantially lesser harm than structure with irregular configuration. The structural irregularity is broadly seen in buildings because of architectural and service necessity in the design process, mistakes and adjustment during the development stage and changes in building use all through its service life. These design in the structures leads to the non-uniform distributions in their masses, stiffness and strength due to which the structure are prone to damage during earthquake. Thus, in present investigation an attempt has been made to investigate the seismic response of such structures situated in extreme seismic zone. The proposed G+18 story building of this investigation is situated in seismic zone V.

So, it is expected to think about the impact of seismic response in planning the structures. The fundamental objective of Earthquake resistance design is to avoid building collapse during quake, along these lines, limiting the danger of death or damage to individuals in or around those structures. Since Earthquake forces are irregular in nature and unpredictable, the static and dynamic investigation of the structures have turned into the essential worry of structural Engineer. Load carrying capacity, ductility, stiffness, damping and mass are the principle parameters of the seismic investigation. In this present study horizontal part of ground movement is considered for the dynamic investigation for the fact that the structures are normally considerably stiffer and stronger in response to vertical load than they are in response to horizontal loads.

As per the National building code 2005 of India a building having height more then 15m is called as High-Rise Building. irregular structures might need an extra attention in structural analysis to prevail in an adequate response all through a devasting earthquake. Failure of structure begins from the point of weakness during an earthquake. This weakness emerges because of plan or vertical irregularity of the structure. In order to perform a structure well in the earthquake, the structure ought to have four fundamental characteristics, namely simple and regular configuration, stiffness, adequate lateral strength and ductility.

Current seismic design codes differentiate between the plan and vertical irregularity. As per IS 1893(part 1) structure irregularity is divided into two type namely plan irregularity and vertical irregularity. Vertical irregularity happens due to the significant changes in stiffness, strength, mass or dimension or because of in plane discontinuity in lateral force resisting system (LFRS). The plan irregularity happens because of few reasons, for example when the structure is fundamentally subjected to asymmetrical plan shapes (L-, T-, C-, U) or discontinuities in horizontal resting element (diaphragms) or re-entrant corner or torsion or nonparallel system. As made references to above plan irregularity might be because of diaphragm discontinuity, presence of re-entrant corner etc. in the buildings. diaphragm is defined as a horizontal element that transfer the forces between vertical resistance elements. The diaphragm discontinuity may happen due to the sudden variation in stiffness, including those having removed or open territories greater than 50% of gross enclosed diaphragm area. The re-entrant corners, where the projection of the structure beyond the re-entrant corner are more than 15% of its plan dimension in the provided direction is assumed in the shapes like L, H,T,C shapes. In the present study considering a different shape of the building, here a comparison has been made. Six different shape of the building i.e. (Box-shape, L-shape, T-shape, C-shape,

Revised Manuscript Received on April 09, 2019.

Om prakash mahato, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India – 522502.

M. Anil Kumar, Assistant Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, Andhra Pradesh, India – 522502.

U-shape, Tube-shape) have been considered. Box shape building is symmetry in both axes hence it is a regular shape building while coming to Tube-shape building there is hollow in the middle portion of it and is symmetry along both the axes but there is a diaphragm discontinuity. L-shape, T-shape, building is asymmetrical along both the axes and there is a re-entrant corner irregularity. And even in C and H shape building there is a re-entrant corner irregularity. The material properties of all the shape of the building are likewise same. story shear, max displacement, max. overturning moment and story drift has been taken as the main comparison.

In Jack P.moehle [1984] study, the author tested the four irregular RC building using static method. The structures were discontinuous in the vertical plane by discontinuities in the structural wall at various level. He concluded that the static inelastic analysis gives good measure of strength and displacement under strong Earthquake [1]. In Mohammed Rizwan Sultan [2015] study, the author compared 15 story building on four model of different shape by dynamic analysis to grasp the behavior of the structure. He concluded that building with more irregularity produce more deformation and story base shear is higher for regular building then irregular building and overturning moment varies inversely with height of the story [2]. In K. Upendra Reddy [2017] study, the author performed dynamic analysis for G+12 story building of different plan to obtain the seismic behavior of Multistory building by using ETABS 9.7 software. The building is located in zone V. He studied the effect of the structural displacement, story shear, story drift and overturning moment [3]. In B.Rajesh et.al [2015], the author investigated dynamic analysis for G+15 story building for the four different shape of the building out of which one is regular and remaining are irregular to evaluate the seismic response. It also deals with the effect of variation of building plan or structural response of buildings [4]. In Mohammed Yousuf [2013] study, the author performed the response spectrum method for the analysis of G+5 story building of four different shape out of which one is regular shape and remaining of them are irregular in shape to grasp the seismic behavior. The CQC (complete Quadratic Combination) has been applied for all model to evaluate dynamic response for 5%,10%,15% and 20% damping and dynamic response were compared [5]. In Tejaswini M L [2018] study, the author performed the static and dynamic analysis for the Highrise building for zone 2 and zone 3. The result of the analysis is used for all lateral stability check for zone 2 and zone 3[6].

II. RESEARCH SIGNIFICANCE

At present every country is having their own building code of practice. In order to reduce the damage these building codes give design requirement and construction aspect of structures, but these codes are insufficient for the building having special characteristics like Building with irregular configurations having different shapes, vertical irregularities etc.

In the present study seismic response for the six different shape of the building is compared with both static and dynamic method to find out the most stable structure among all other cases.

III. METHOD OF ANALYSIS OF STRUCTURE

A. Equivalent static method

The response of the buildings is assumed in a linearly elastic manner as this method follow linear static procedure. It is one of the process to estimate the seismic load. As it does not consider all the parameter that are significance of the foundation condition thus high-rise structure are not considered for the design by static method. This method is only suitable for the design and analysis of small structure. This method considers only one mode for each direction. Tall structures are required more than two modes and mass weight of every story design earthquake resistant loads. Static method has a drawback as it uses only one mode of vibration of building. As per the IS 1893:2002 (part 1), analysis is carried out. The total base shear or design lateral force along X and Y direction is provided in terms of seismic weight of the structure and design horizontal seismic coefficient. There are several factors on which design horizontal coefficient depends namely, importance of the structure, fundamental natural time period, Response reduction factor, zone factor etc.

B. Response Spectrum method

Response-spectrum analysis is the linear dynamic method which estimates the contribution from each natural mode of vibration to demonstrate the possible maximum response of essentially elastic structure. This method gives the knowledge into dynamic behavior by estimating pseudo-spectral acceleration, displacement or velocity as a function of structural period for a given time period and level of damping. The software takes care of the Eigen value issue of the model and estimate the fundamental natural period values. Thus, the total seismic loads are created and its dispersion along the height of the building corresponding to the mass and stiffness distribution. The modeling and analysis are performed by ETABS 2016. For each mode shape, from design spectrum responses are studied, with the assistance of parameters, for example modal frequency and modal participation mass ratio and after that they are combined to give an assessment of the total response of the structure.

C. Time history Analysis

Time-history analysis provides for linear or nonlinear assessment of dynamic structural response under loading which may fluctuate as indicated by the specified time function. In response spectrum method, values are taken from IS 1893 (part 1) but in Time-history analysis values are taken from past earthquake data and the load that is used for the analysis is as per IS code. In the present study of time-history analysis data are taken from the ELCENTRO earthquake. The time history data gives structure response under different loading cases to the predetermined time function. Recorded ground movements are haphazardly chosen from closely resembling magnitude, soil condition and distance, these are the three fundamental parameters in time history age

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

IV. MODELLING OF BUILDING

In this study, the analysis of six different G+18 Building of different plan is carried out with both static and dynamic analysis to find out the stable among all other cases. The Analysis is carried out through ETABS 2016 software as it more user friendly and versatile program. The details of the seismic and other various parameter are mentioned in the below Tables.

A. Seismic parameter

Table I: Seismic parameter

Soil Type	II
Importance Factor	1
Seismic Zone	V
Zone factor	0.36
Response reduction factor	5

B. Load details

Table II: Load details

Property	Intensity of load (KN/m)
Live Load @Floor	4
Live Load @Roof	2
Wall Load	15.3
Parapet wall Load	3.6
Mortar screening on slab and tiles placing	0.53

C. Plan details

The structure is 32m in X-direction and 28m in Y-direction. Model consist of number of bays in G+18 story building each bay were having width of 4m. Geometry of the model and material properties are discussed in Table 2.

Table III: Plan details

Number of Stories	19
Support condition	Fixed
Story height	3m
Concrete Grade	35MPa
Steel Grade	Fe500
Size of columns	650×650
Size of beam	450×450
Height of Parapet wall	1.2m
Parapet Wall Thickness	150mm
Wall Thickness	300mm
Slab Thickness	150mm

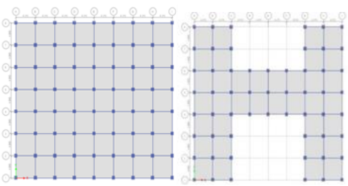

Fig. a) Box Shape Fig. b) H-shape

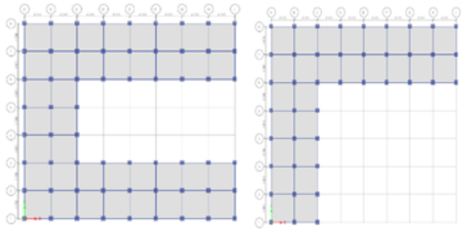

Fig. c) C-shape fig. d) L-shape

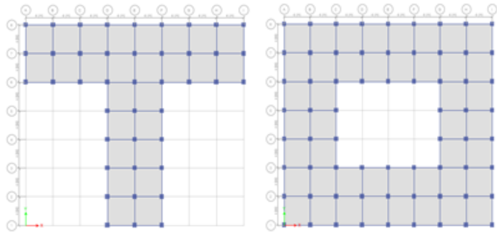

Fig. e) T- shape fig. f) Tube-shape

V. RESULT AND DISCUSSION

The graph plotted between the story number and story shear shows that story shear decreases with increase in story number for all the cases and shear story is maximum for Box shape building and minimum for T-shape building in X-direction as shown in the fig.1

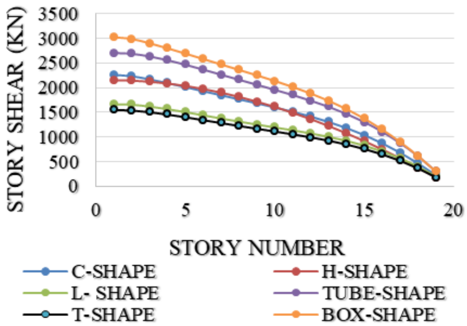

Fig. 1: story shear in x-direction by Response spectrum method.

The graph plotted between the story number and story shear shows that story shear decreases with increase in story number for all the cases and shear story is maximum for Box shape building and minimum for L-shape building in Y-directionas shown in fig. 2

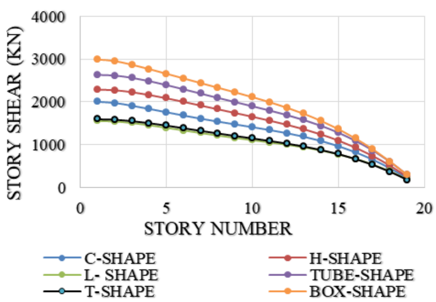

Fig. 2: story shear in Y-direction by Response spectrum method.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The graph plotted between the story number and story displacement shows that the maximum story displacement occurs in T-shape building and minimum displacement occur in box-shape in X-direction. The maximum permissible limit for displacement is H/450=57000/450=126.66mm. The maximum displacement among all the case are 31.277<126.66. Hence it is safe in X-direction as shown in the fig.3

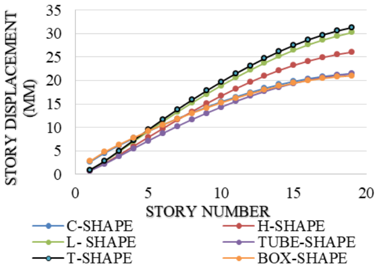

Fig. 3: maximum displacement in x-direction by Response spectrum method

The graph plotted between the story number and story displacement shows that the maximum story displacement occur in L-shape building in and minimum story displacement occur in Box-shape in Y-direction. The maximum permissible limit for displacement is H/450=57000/450=126.66mm. The maximum displacement among all the case are 43.075<126.66. Hence it is safe in Y-direction as shown in Fig.4

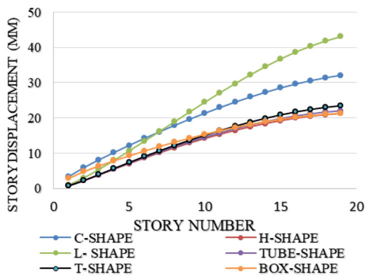

Fig. 4: maximum displacement in Y-direction by Response spectrum method

It has been found that overturning moment varies oppositely with the height of the story. The maximum overturning moment occur in Box-shape building comparing to other shape of the building. As the height increases the overturning moment also decreases in all the cases in X-direction as shown in the fig.5

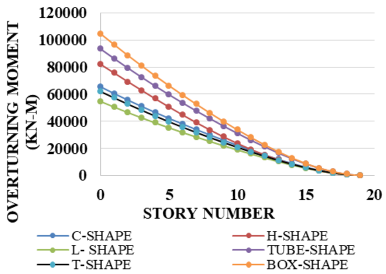

Fig.5: story overturning moment in x-direction by Response spectrum method

It has been found that overturning moment varies oppositely with the height of the story. The maximum overturning moment occur in Box-shape building comparing to other shape of the building. As the height increases the overturning moment also decreases in all the cases in Y-direction as shown in the fig.6

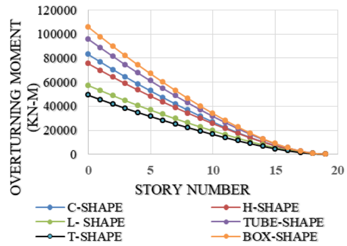

Fig.6: story overturning moment in Y-direction by Response spectrum method

The below figure shows the story drift for the 1st, 5th, 10th, 15th and 19th story of the building in X-direction. It shows that for the 1st floor story drift is maximum for Box shape building and as the story number increases story drift is minimum for Box-shape building for all the cases. The maximum permissible limit for story drift ratio is 0.004. The maximum story drift ratio among all the cases is 0.000946 <0.004, hence all the building is safe in term of story drift as shown in the Fig.7

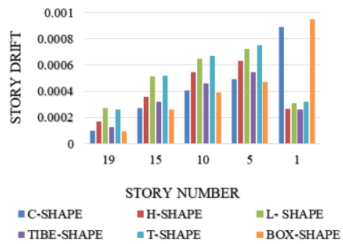

Fig.7: story drift in x-direction by Response spectrum method

The below figure shows the story drift for the 1st,5th,10th, 15th and 19th story of the building in Y-direction. It shows that for the 1st floor story drift is maximum for C-shape building and as the story number increases story drift is minimum for Box-shape building for all the cases. The maximum permissible limit for story drift ratio is 0.004. The maximum story drift ratio among all the cases is 0.001122 <0.004, hence all the building is safe in term of story drift. For the stable structure story drift should be low as shown in the Fig.8

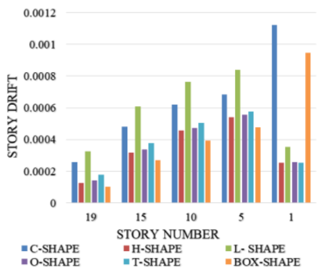

Fig.8: story drift in Y-direction by Response spectrum method

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Fig.9 shows the comparison between static and dynamic method in term of displacement in X-direction. It shows that maximum displacement is produced by static method and minimum displacement is produced by Time history method.

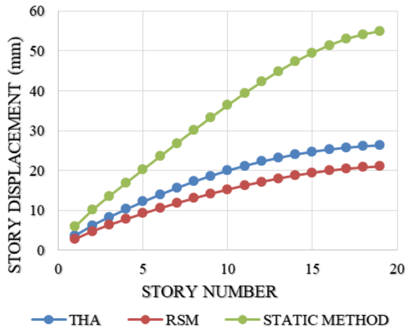

Fig. 9: comparison of story displacement of box shape in x-direction by static and dynamic method

Fig.10 shows the comparison between static and dynamic method in term of displacement in Y-direction. It shows that maximum displacement is produced by static method and minimum displacement is produced by Time history Analysis method.

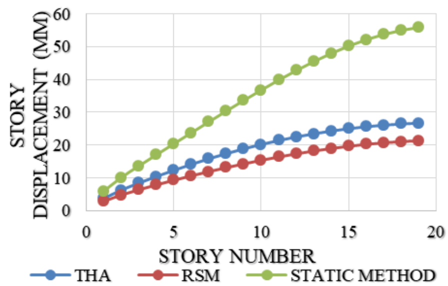

Fig.10: comparison of story displacement of box shape in y-direction by static and dynamic method

VI. CONCLUSION

Following are the conclusion made from the above graph

1) Static method gives more displacement than dynamic analysis. Hence static method is uneconomical.
2) Displacement for static method for lower stories is insignificant but for higher stories it is significant hence dynamic analysis should be performed.
3) Above figure shows that irregular shape building produces more deformation therefore regular shape building should be preferred.
4) From the above figure it has been concluded that Box-shape building perform well while compared to all other mentioned case.
5) From the overall comparison it has been found that C-shape building is more vulnerable than other case.
6) All the above-mentioned shape of the building is safe in displacement, story drift, as the calculated value is less then permissible value.

VII. ACKNOWLEDGMENT

The authors wish to gratefully acknowledge the support of Head of the Department and Structural Engineering Research Group members of Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur, A.P., India, is gratefully acknowledged.

REFERENCES

1. Moehle, J. P. (1984). Seismic response of vertically irregular structures. *Journal of Structural Engineering*, *110*(9), 2002-2014.
2. Sultan, M. R., &Peera, D. G. (2014). Dynamic Analysis Of Multi-story building for different shapes. *International Journal of Innovative Research in Advanced Engineering (IJIRAE)*, *2*.
3. Reddy, K. U., &Arunakanthi, E. DYNAMIC ANALYSIS OF MULTI STORY STRUCTURE FOR DIFFERENT SHAPES.
4. Rajesh, B., Khan, M. S. A., Kandan, M. M., &Babu, D. S. S. (2015). Comparision of both linear static and dynamic analysis of multistoryed buildings with plan irregularities. *International Journal of Scientific Engineering and Applied Science (IJSEAS)*, *1*.
5. Yousuf, M., &Shimpale, P. M. (2013). Dynamic analysis of reinforced concrete building with plan irregularities.
6. Tejaswini, M. L., & Naik, S. (2018). COMPARATIVE STUDY OF ZONE 2 AND ZONE 3 FOR EQUIVALENT STATIC METHOD, RESPONSE SPECTRUM METHOD AND TIME HISTORY METHOD OF ANALYSIS FOR SINGLE MULTI-STORY BUILDING.
7. Monish, S., & Karuna, S. (2015). A study on seismic performance of high rise irregular RC framed buildings. *International Journal of Research in Engineering and Technology (IJRET)*, *4*(5), 340-346.
8. WIN, N., & KYAM, L. H. (2014). Comparative study of static and dynamic analysis of irregular reinforced concrete building due to earthquake. *International journal of scientific engineering and technology. research, Volume3, Issue7*.
9. Banginwar, R. S., Vyawahare, M. R., & Modani, P. O. (2012). Effect of plans configurations on the seismic behaviour of the structure by response spectrum method. *International Journal of Engineering Research and Applications (IJERA)*, *2*(3), 1439-1443.
10. Gottala, A., &shaikYajdhani, D. (2015). Comparative Study of Static and Dynamic seismic Analysis of Multistoried Building. *IJSTE-International Journal of Science Technology & Engineering*, *2*(01July2015).
11. Standard, I. (1893). Criteria for earthquake resistant design of structures. *Bureau of Indian Standards, Part*, *1*.
12. IS-875-1987. "Indian Standard code of practise for structural safety loadings standards part-1,2 " Bureau of Indian Standards , New -Delhi
13. IS-456-1978 and IS-456-2000."Indian Standard of code and practise for plain and Reinforced concrete "Bureau of Indian Standards ,New Delhi-2002

AUTHORS PROFILE

Om prakash mahato Received the B.Tech Degree in Civil Engineering from Sri Krishna Institute of Technology, VTU, banglore, India in 2016. He is Pursuing M.Tech degree in Structural Engineering from K L Deemed to be University, Guntur, AndhraPradesh, India. He actively participating in workshops and Seminars in and around the University.

M. Anil Kumar is an Assistant professor in the Department of Civil Engineering at KL Deemed to be University, Guntur, A.P, India. He has obtained his Post graduation degree inStructural Engineeringdiscipline from J. N. T.U Kakinada, E.G District, A.P, India. His area of Interest in research is “Concrete Technology”.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication