International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Earthquake Analysis of G+10 Building using Response Spectrum Method and Time History Method - A Comparison

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Abstract: ***Earthquake occurred in recent past have indicated that if structure are not properly designed and constructed may causes great damage to the structures. Hence we will have to confirm safety against the dynamic force like earthquake force that are affecting the structures, and determine seismic responses of such building. Time history analysis is significant technique for structural seismic analysis particularly when evaluated structural response is nonlinear. In present work an attempt has been made to study the dynamic behavior of G+10 multistoried building frame for two distinct plan geometries one bisymmetric regular rectangular frame and another frame with T shaped plan using IS1893-2002 recommended response spectrum method and time history analysis. In time history analysis, two earthquake data from previous earthquakes corresponding to (Nepal 2015) and (EL Centro 1940) is taken. Study focuses to evaluate two important parameters which are (a) Base shear and (b) maximum deflection. Analysis has been carried out using ETABS software. Based on result it is found that the base shear obtain from RSM is slightly higher compared to THM, and also storey deflection is more in response spectrum method than time history method.***

Keywords: Response spectrum method, Time history method, Dynamic analysis

1. Introduction

In the recent past the impact of urbanization is very common. Today's generation the building and development of sky scrapers is much needed, but when earthquake occurs those structure can be damaged to very large extent. Therefore such structures need to be analyzed and designed properly before constructing. Every year earthquake of approximate magnitude more than 3 strike and result thousands of person killed or injured, thousand are homeless and reinforced concrete building also get damaged to very large extent because of irregularity in mass and plan of the building and contradictory seismic response.

Different earthquake have different intensities, different magnitude at different place and in these place the destruction causes are also different. Therefore it is very important to study the seismic behavior of RC structure for different function in terms of responses such as Base shear, storey displacement etc. Seismic analysis is needed to calculate the seismic response of the building, seismic analysis it is part of the process of structural design where earthquake are prevalent.

2. Types of Seismic Analysis

Code based procedure for seismic analysis (IS1893-2002)

2.1 Equivalent static analysis (seismic coefficient method)

All design against seismic loads must consider the dynamic nature of the load. However analysis simple regular structures by equivalent linear static method is often sufficient this is permitted in most codes of practice for regular, low-to medium-rise buildings. It begins with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code. Equivalent static analysis can therefore work well for low to medium rise building without significant coupled lateral torsional modes, in which only the first mode in each direction is considered. Tall building (over, say 75m), where 2nd and higher modes can be important, or buildings with torsional effects, are much less suitable for the method, and require more complex method to be used in these circumstances.

2.2 Response spectrum method

This method is derived from time history analysis. A designer is not often bothered about the structure's response at every instance of time, maximum response is enough information to design adequately strong structure. In this method graph between maximum spectral acceleration and various time period of structure is prepared for some ground acceleration and structures response at every instance of time is not calculated. Response spectrum method, it is the linear dynamic analysis method6. This method involves the calculation of only the maximum values of displacements and member forces in each mode of vibration. This method uses smooth design spectra that are the average of several earthquake motions. Different earthquake will have different response spectra but for ease of structural engineer IS 1893:2002 has given a general purpose response spectra which is derived by considering few big earthquake from past.

2.3 Time history method

This method calculates response of structure subjected to earthquake excitation at every instant of time (hence the name Time History). Various seismic data are necessary to carry out the seismic analysis i.e. acceleration, velocity,

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displacement data etc., which can be easily procured from seismograph data's analysis for any particular earthquake. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear.

3. Analysis

Model

The present study on earthquake analysis is to compare the two popular method of dynamic analysis i.e. Time History Method and Response Spectrum Method. The comparative study has been carried out by considering two frames first a symmetric rectangular frame and another a T-shaped frame of 10 storey high RCC building. The mass of each floor of the two model are kept intentionally equal for a more even comparison.

Parameters considered for earthquake forces-

Seismic zone factor- .36 Site type- II

Importance factor- 1 Response reduction factor- 5

Proportion of load considered for calculation of story mass-

Rectangular frame

Mass= 100% of Dead load + 25% of live load

T shaped frame

Mass= 200% of Dead load + 25% of live load

Ground acceleration data is used in analysis are El Centro Earthquake 1940- (Imperial Valley Earthquake) and Gorkha earthquake, Nepal 2015

4. Results

The results of analysis are plotted below

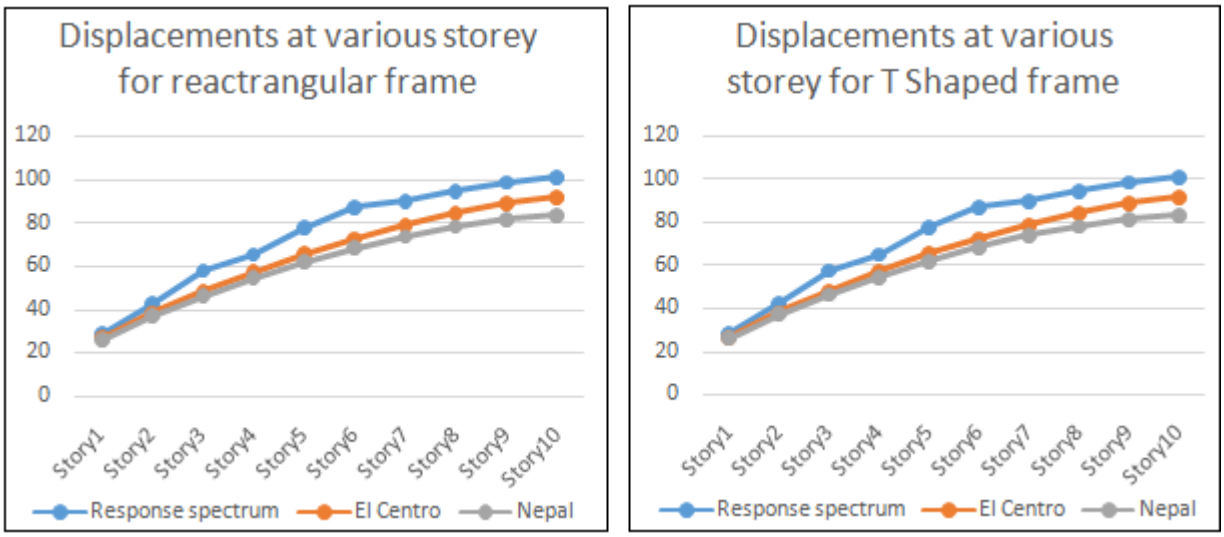


Figure 1: Plot of displacement of various storey

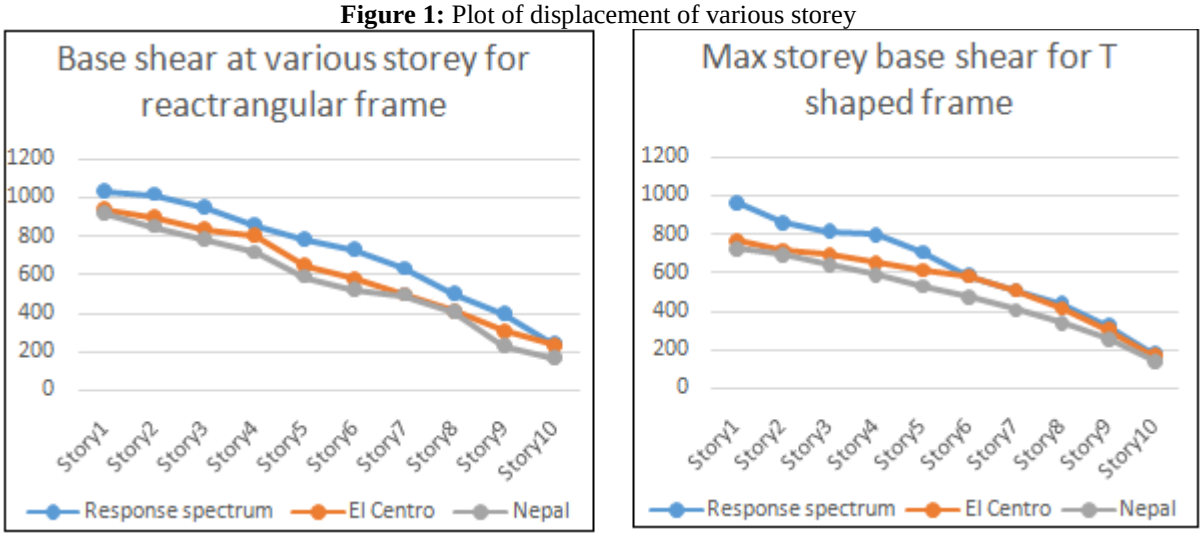


Figure 2: Plot of base shear of various storey

The obtained has following highlights-

Rectangular geometry frame

1) Storey deflection is more in response spectrum method than in any of the earthquack exicitation with time history analysis.
2) The diffrence in deflection becomes more in higher storey.
3) Near ground floor both method result aproximatly identical displacement.
4) Response spectrum give more base shear than time history method for any one of the earthquack exicitation.
5) Nepal's and El Centro's exicitation gives aproximatly same result but el centroe's base shear is on slightly higher side.

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T Shaped geometry frame

1) T shaped plan has more storey deflection than reactrangulare planin all the methods which is because of higher stifness of reactrangular frame and symetry in geometry.
2) Simmilar trend in three method is obserbed as for symetrical structure as following -
   a) Storey deflection is more in response spectrum method than in any of the earthquack exicitation with time history analysis.
   b) The diffrence in deflection becomes more in higher storey.
   c) Near ground floor both method result aproximatly identical displacement.
3) The magnitude of varition between time history and response spectrum is larger for unsymetrical building.

5. Conclusion

It evident from above table that Top displacement given by time history analysis is on average 10% to 15% smaller than the displacement from response spectrum analysis. Variation in displacement in uni-symmetric T shaped plane is of higher magnitude upto 25 %.

A similar pattern arises in base shear, Response spectrum gives on average about 15% to 20% higher base shear value as compared to time history. This over estimation of base shear in response spectrum will lead to higher stresses in structural component and Design based on such analysis are uneconomical as large dimension members are required to resist large displacement and stresses.

From the analysis it can be seen that the difference in the results of response spectrum method is significant in higher storey (above 5th floor), so for high rise structure time history method should be preferred and for smaller building as response spectrum and time history gives almost identical result so response spectrum method should be preferred because time history method is very time consuming because of the input it requires (earthquake excitation) and the interpretation of results is not straight forward.
Time history method gives better and close to correct visualization of structures behavior during earthquake, so for sensitive structure like long bridges, nuclear power plant or any hazardous industrial building should be designed based on time history method by taking number of past historically devastating earthquake data.

The main finding of this work can be summarized in following points-

1) Response spectrum approach overestimates base shear by 15% to 20%.
2) Response spectrum approach overestimates displacement by 10 to 15%
3) The over estimation of response spectrum is more for high rise.
4) Above mentioned trend is more pronounced in Unsymmetrical structure.
5) Time history methods results depends heavily on earthquake excitation so a number of various earthquake of varying intensities should be taken and maximum of these should be considered.
6) Time history gives the time distribution base shear and displacement which can be used to predict failure mode of structure and such results can be very useful in designing sensitive and important structure.
7) Time history method is quit time consuming and involves lot of calculation as compared to response spectrum but with specialized softwares like Etabs and others this is not a major issue.
8) Time history analysis is a more accurate description of the actual structures under dynamic load
9) As response spectrum method cannot give the time variation of base shear and deflection therefore with response spectrum it would be difficult to predict the location and mode of failure under dynamic load.

Based on this study it can be concluded that time history method is superior to the response spectrum method and it should be prefered whenever detailed analysis is required but response spectrum is not a bad aproximation it gives fairly accurate results and overestimates on saffer side for low rise building.

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