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Seismic Analysis of Vertical Irregular Building with Time History Analysis

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Abstract: *Seismic building analysis is one of the research interest now a days, it is because earthquake causes lots of damage and losses with respect to life, loss or damage of structures, loss of economy or finance. It is desired to study seismic response with real time history to prevent seismic effect by designing structure to withstand against earthquake. This paper analysed four different building models which are vertically irregular and each model is analysed for without mass irregularity, with mass irregularity increasing from bottom to top, and with mass irregularity decreasing bottom to top. Combinations of four models and three mass irregularities are then also analysed against four different time histories which are Chichi (1999), Petrolia (1992), Friuli (1976), Northridge (1994) and Sylmar respectively. All analysis are compared for outcomes such as story deflection, story drift, overturning moment and base reaction. Conclusion for each model and mass irregularity combination is presented in different time histories at the end of the paper.*
Keywords: *Time history analysis, mass irregularity, vertical irregularity, E-Tabs, drift, displacement, overturning moment, periods & frequencies, base shear.*

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I. Introduction

Researchers studied for earthquakes since long time and still they earthquakes are unpredicted. It is impossible to predict time and place of earthquake. To design and construct the structure which can withstand against earthquake is research interest since last many years, also researchers required to measure the frequency and intensity of earthquake for future structural design. Safety, strength and performance are the parameters which are to be considered while designing structure in seismic zones specially. However codes and guidelines are prepared by engineering societies in world which can be used to design buildings.

II. Literature Review

Poncet, L. And Tremblay (2004) proposed the impact and effect of mass irregularity considering case of an eight-storey concentrically braced steel frame structure with different setback configurations. Methods used in present paper are equivalent static load method and the response spectrum analysis method.

Devesh P. Soni (2006) considered several vertical irregular buildings for analysis. Various criteria's and codes have been discussed and reviewed in this paper. Vertical irregular structure performance and response is reviewed and presented. The studies suggested that for combined-stiffness-and-strength irregularity large seismic demands are found.

Patil and Kumbhar (2013) considered ten story building and tested against nonlinear dynamic response under seismic effect. SAP 2000 is used as a software application tool in this paper. Five number of seismic time histories are used to compare results of considered cases.

Aijaj and Rahman (2013) tried to analyse the proportional distribution of lateral forces involved in earthquake for individual storey due to changes in stiffness of vertically irregular structure.

S.Varadharajan et al. (2013) reviewed existing works regarding plan irregularities and justified the preference of multistory building models over single storey building models.

Himanshu BansaL (2014) analysed vertical irregular building with Response spectrum analysis and Time history Analysis. Irregularities considered are mass irregularity, stiffness irregularity and vertical geometry irregularity. The storey shear force was found maximum for the first storey and it decreases to minimum in the top storey in all cases.

Harshitha. R (2014) studied dynamic behavior of high-rise building using IS1893-2002 code recommended response spectrum method and time history method STAAD Pro software is used to analyze the building models and it is found that the base shear obtained from Time history analysis is higher than Response Spectrum analysis. This is because of variation in amplitude and frequency content of the ground motions.

Bansal, and Gagandeep (2014) studied ductility based design is carried considering vertical irregular building and methods used are RSA and THA. Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered.
Ramesh Konakalla (2014) analysed four different 20 story building for effect of vertical irregularity under Dynamic Loads Using Linear Static Analysis. Response of all cases is compared and concluded that in regular structure there is no torsional effect in the frame because of symmetry. The response for vertically irregular buildings is different for the columns which are located in the plane perpendicular to the action of force. This is due to the torsional rotation in the structure.
Reddy and Fernandes (2015) conducted analytical study for regular and irregular buildings to analyze response of buildings in seismic zone V.15 storey building is considered and ETABS software is used to model and simulate building response. Analysis is performed for static and dynamic methods of analysis. Paper concluded behavior of irregular structures as compared to regular structure.
Hema Mukundan (2015) found shear wall provision in building has been effective and economical. A 10 storey building in Zone IV is tested to reduce the effect of earthquake using reinforced concrete shear walls in the building. The results are presented after analyzing model using ETABS software and RSA method is used. Researchers also studied results varying thickness of shear walls. It is concluded that shear walls are more resistant to lateral loads in regular/Irregular structure and for safer design, the thickness of the shear wall should range between 150mm to 400mm.
Sagar et al. (2015) analysed the performance on various type of irregularity Considered i.e. (a) Horizontal Irregularity-plan irregularity (b) Vertical Irregularity -Mass Irregularity. To achieve objective of the project Time history Analysis & Response spectrum analysis method were carried out.
Khan & Dhamge (2016) highlighted the effect of mass irregularity on different floor in RCC buildings with as Response Spectrum analysis using STAAD-Pro V8i software. In the project work seismic analysis of RCC buildings with mass irregularity at different floor level were carried out. Models are compared with each other for response in terms of drift and deflection.
Salunkhe and Kanase (2017) investigated that response of mass irregular structure need to be studied for the earthquake scenario. In this paper researcher deal with RCC framed structure in both regular and mass irregular manner with different analysis methods.
Oman Sayyed (2017) focused his study on the effect of infill and mass irregularity on different floor in RC buildings. The results were concluded that the brick infill enhances the seismic performance of the RC buildings and poor seismic responses were shown by the mass irregular building, therefore it should be avoided in the seismic vulnerable regions.

PROBLEM FORMULATION

Various time histories are considered as a real time seismic data to perform ETABS analysis. The time histories are: Chichi, Petrolia, Friuli and Northridge. Several data's are to be decided to use as an input parameters for software analysis. The parameters are tabulated in tabular format.

Table: Input Parameters Used

Specification	Details
Type of structure	Multi-storey rigid jointed plane frame(Special RC moment resisting frame)
Seismic zone	V
Zone Factor	0.36
Importance factor	1
Time History Analysis data	Chichi, Petrolia, Friuli, Northridge, Sylmar
Type of soil	Medium soil
Number of storey	G+20
Dimension of building	30 m x 30 m
Floor Height (Typical)	4m
Base floor height	5m
Materials	Concrete (M30) and Reinforcement Fe415
Size of Column	Story 1-7 = 650x650mm, Story 8-14 = 500x500mm Story 15-20 = 400mmx400
Size of Beam	300x450 mm
Model (A)	6x6 bay up to top floor
Model (B)	6x6 bay up to 10 floor- 2x2 bay up to top floor (corner position)
Model (C)	6x6 bay up to 10 floor- 2x2 bay up to top floor (center position)
Model (C)	6x6 bay up to 10 floor- 2x2 bay up to top floor (edge position)
Model (A,B,C,D)	i. Without Mass irregularities ii. With Mass irregularity increasing towards top iii. With Mass irregularity decreasing towards top

Various Models Considered as Cases to be considered are:

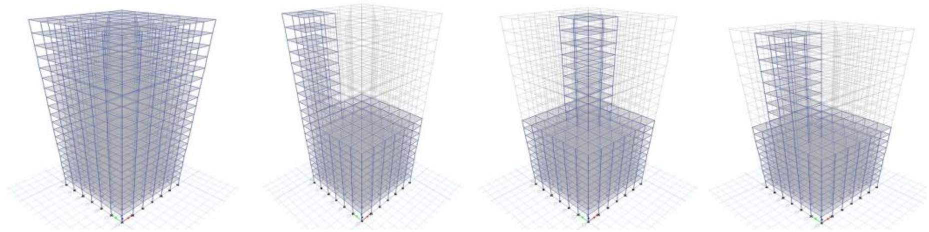
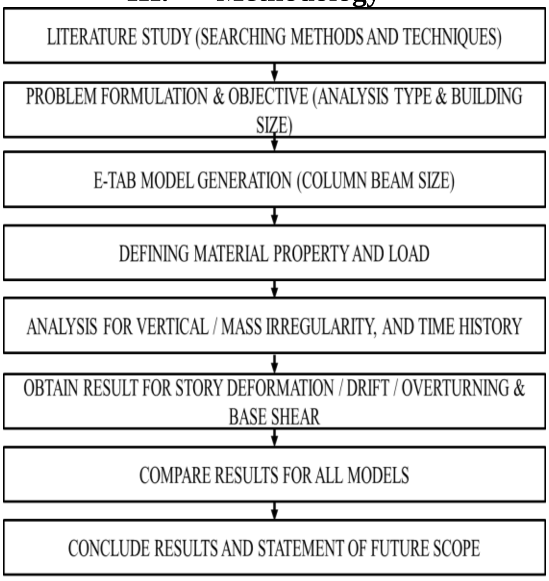


Figure 1: Model A, B, C and D

III. Methodology



IV. Time History Analysis Data

Time history analysis is performed for all five models (Chichi (1999), Petrolia (1992), Friuli (1976), and Northridge (1994), Sylmar respectively) and each model is analysed without mass irregularity, with mass irregularity increasing from bottom to top, and with mass irregularity decreasing from bottom to top. All combinations of cases are also analysed for considered time history data available. Data is collected for maximum deflection, maximum story drift, overturning moment and base reaction.

ANALYSIS AND RESULTS

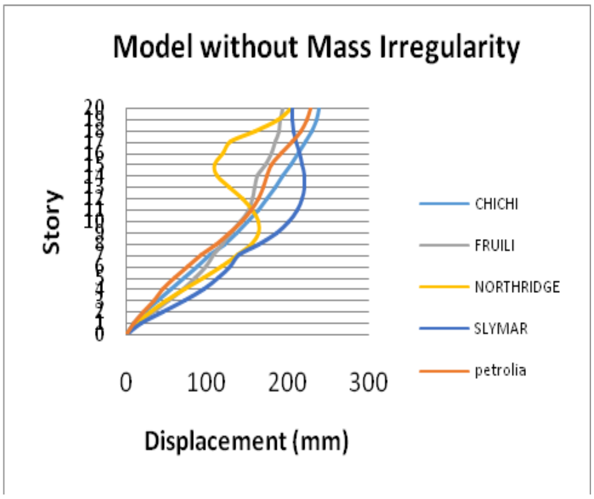


Figure 1 Story VS Displacement for different Time History Data

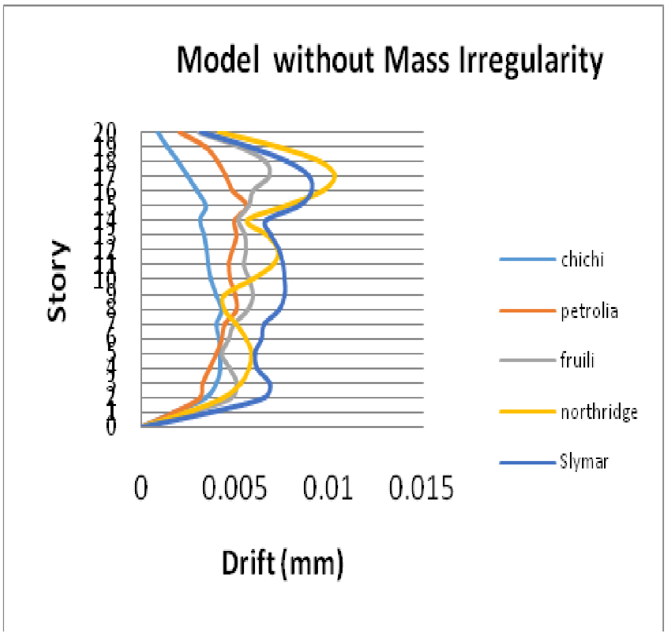


Figure 2 Story VS Drift for different Time History Data

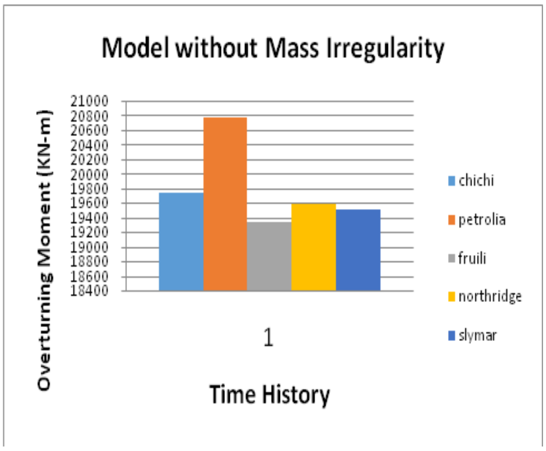


Figure 3 Overturning Moment VS Different Time History Data

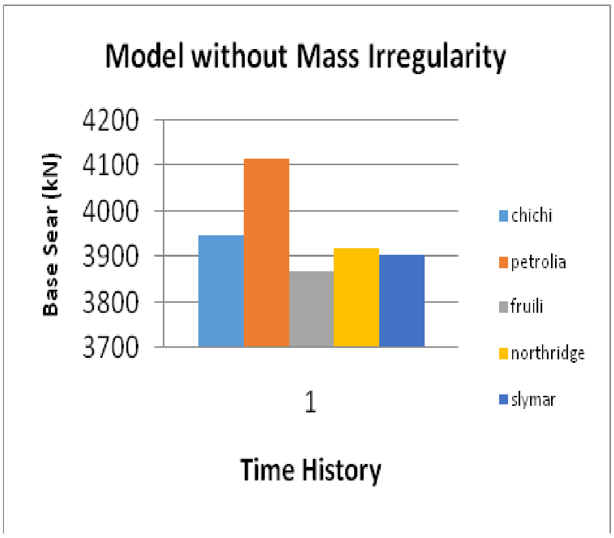


Figure 4 Base Shear VS Different Time History Data

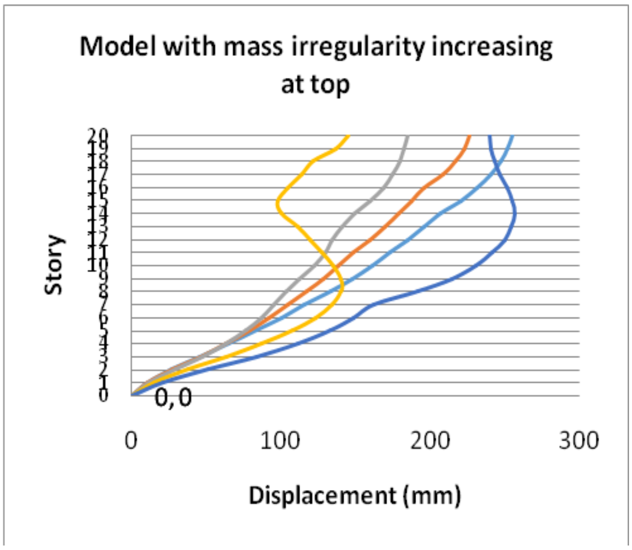


Figure 5 Story VS Displacement for different Time History Data

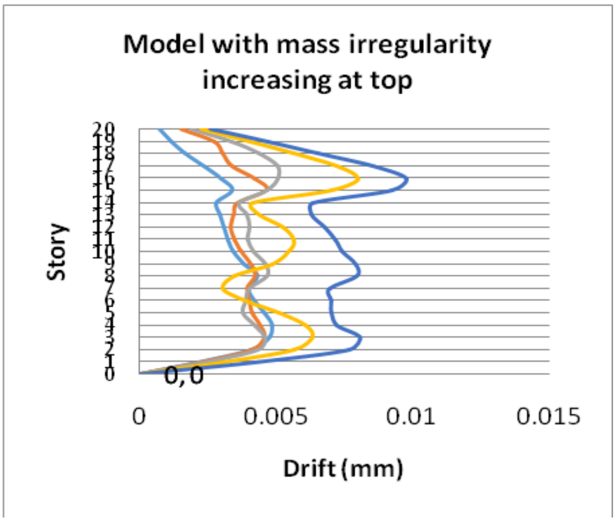


Figure 6 Story VS Drift for different Time History Data

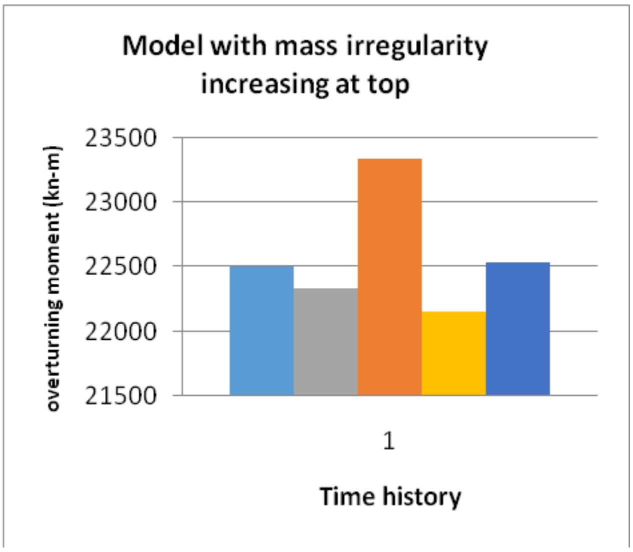


Figure 7 Overturning moment VS Different Time History Data

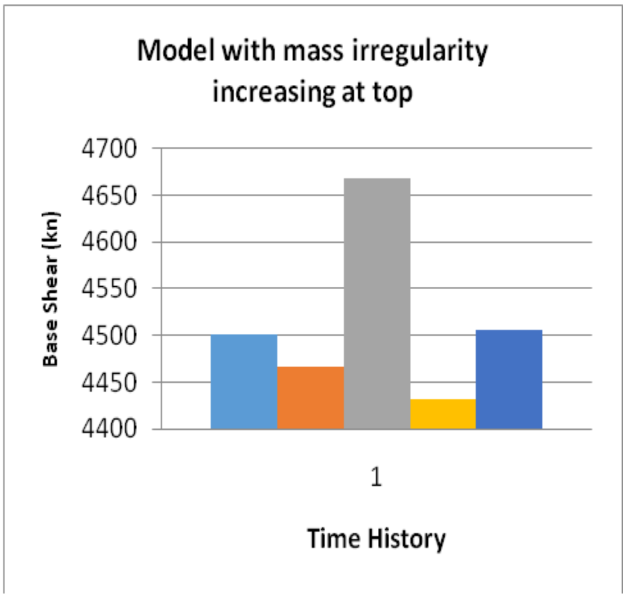


Figure 7 Base Shear VS Different Time History Data

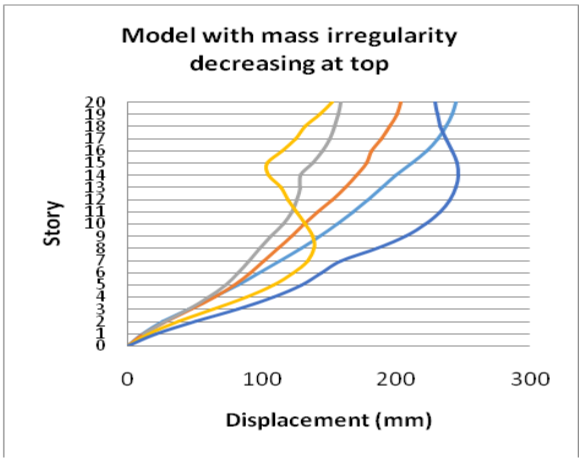


Figure 8 Story VS Displacement for different Time History Data

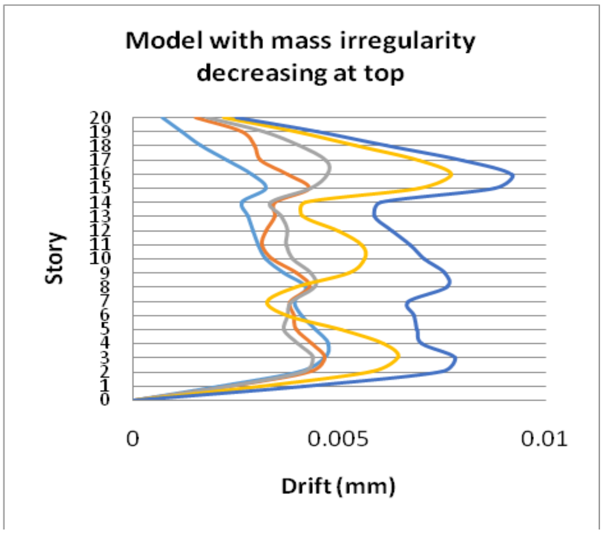


Figure 9 Story VS Drift for different Time History Data

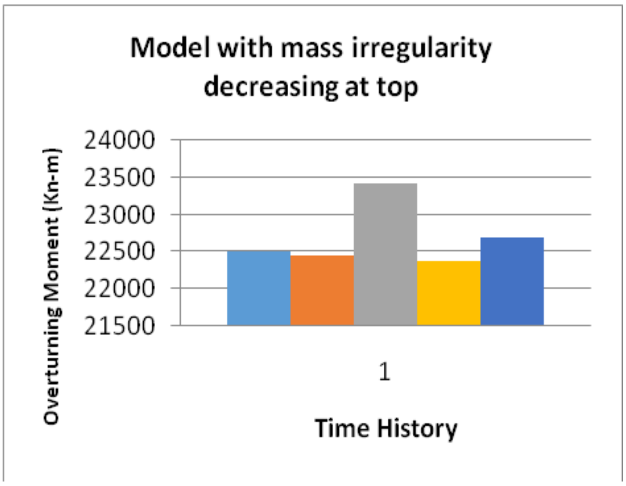


Figure 10 Overturning Moment VS Different Time History Data

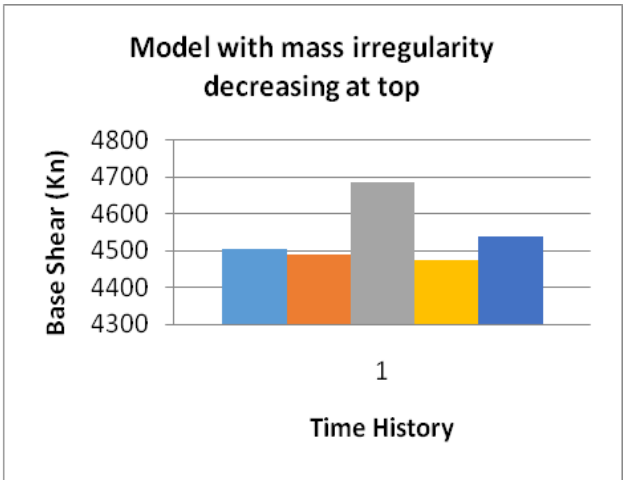


Figure 11 Base Shear VS Different Time History Data

V. Results Discussion and Conclusion

Results of time history analysis for different model like A, B, C and D (for Chichi, Petrolia, Friuli, Northridge, Sylmar) are indicated below:

- In Model A, displacement decreases after 8th story in chichi time history whereas in Sylmar time history, after 9th story displacement is suddenly increases and after 15th story it decreases. It is common for all cases of model A i.e. without mass irregularity, with mass irregularity increasing bottom to top, and with mass irregularity decreasing bottom to top.
- In Model B, from story 6th to 10th a sudden increase in displacement is seen in Northridge and similar for model with mass irregularity increasing bottom to top and also in decreasing bottom to top.
- In Model C displacement is decreasing from floor 10th to 15th and then increases in Northridge time history. It is common for with mass irregularity, increasing bottom to top and decreasing bottom to top.
- In Model D displacement is decreasing from floor 10th to 15th and then increases in Northridge time history. It is common for with mass irregularity, increasing bottom to top and decreasing bottom to top.
- In Model A overturning moment and base shear is maximum in Petrolia time history and minimum in Friuli time history for both cases which are without mass irregularity and increasing mass irregularity bottom to top. While in case of decreasing mass irregularity bottom to top Friuli time history has maximum value and in Northridge time history has minimum value.
- In Model B overturning moment and base shear is maximum in Northridge time history and minimum in Petrolia time history for both cases which are without mass irregularity and increasing mass irregularity bottom to top. While in case of decreasing mass irregularity bottom to top Northridge time history has maximum value and in Friuli time history has minimum value.
- In Model C Northridge time history has maximum Overturning Moment and Base Shear for without mass irregularity and with mass irregularity in increasing and decreasing irregularities bottom to top. In Friuli

time history overturning moment and base shear is minimum for without irregularity. In Petrolia time history Overturning Moment and Base Shear are minimum for with mass irregularity increasing bottom to top. In Chichi time history Overturning Moment and Base Shear are minimum for with mass irregularity decreasing bottom to top.

- In Model D Northridge time history has maximum Overturning Moment and Base Shear for without mass irregularity, with mass irregularity increasing and decreasing from bottom to top.
- Friuli time history has minimum overturning moment and base shear for without mass irregularity and mass irregularity in increasing mass irregularity from bottom to top. In chichi time history it is minimum for decreasing irregularity from bottom to top.

Conclusion

- It is concluded from results and discussion that the outcomes varies from time history to time history. The designers worked for seismic zones must consider time history data while designing vertical and mass irregular buildings. Building with irregularities may be designed with software applications effectively. It saves time and cost for designer.
- Results from various time histories can be efficiently presented and utilized for future building design problems. Standards can be establish for same.
- The buildings can be compared for their mass irregularities using software application to decide whether to construct particular design in required time history or not.

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