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Time History Comparison of Building Structure Using Etabs

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***Abstract**:*

Seismic building analysis is critical to test and perform, as extreme damage and structural losses noticed due to earthquake in past. It is important and desired to analyse building structure response for possible losses. Seismic response for real time seismic history is required to test and to design building with seismic consideration. The research includes analysis of two different building models which are vertically irregular. The method selected is vertical irregular problem analysis with respect to time history analysis. Two building models are considered with time history reference data to perform and conduct research work. Software used to perform analysis is ETABS. All analysis are compared for outcomes such as deflection, base reaction and stress.
The data collection is then arranged mainly in the tabular format for deflection, base shear and stress. Time history based analysis is tested for vertical irregular buildings and cases. Result and discussion is described with the help of graphs to conclude the outcome and summary of analysis from each graph.
Keywords: Multistory Buildings, Vertical Irregularity, Seismic Analysis, Time History Analysis, Displacement, Base Shear, Stress.

1. Introduction

Several studies have been conducted in the past explaining the behavior of irregular structures. However, such studies have not been conducted particularly to quantify the variation in response associated with various time history (Holliste, Yermo, Chi Chi, Petrolia, Friuli, Northridge, Sylmar).There is therefore a need to address the above issue. This thesis seeks to time history analysis for various vertical irregularities.
Following are the objectives.

1. To perform time history analysis on all model prepared in ETABS software,
2. To obtain and compare results based on parameters i.e. displacement, base shear and stress with different time history.

There are two major methods of seismic analysis which are:

1. **Response Spectrum Analysis:** This is based on ideal predefined data which are not real time data's collected from real earthquake in the area.
2. **Time History Analysis:** This is based on actual real time data collected under real earthquake. Building response and behavior is collected in real time and can be used to design future buildings under seismic loading.

ETABS full **form** is extended three-Dimensional analysis of building system. it's a kind of **software** generally used for structural analysis of building or any structure ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems.

2. Literature Review

Poncet and Tremblay (2004)[11] analysed the response with mass irregularity considering G+8 storey case which is concentrically braced steel frame structure with different configurations. Mass irregularity is considered at number of locations with different seismic weight ratios. **Soni (2006)[16]** 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. **Patil and Kumbhar (2013)[9]** Research is performed with ten story building the building is analyzed under seismic effect considering nonlinear dynamic response. Sofware used to perform analysis is SAP 2000. **Aijaj and Rahman (2013)[1]** Author analyses vertical irregular structure for the proportional distribution of lateral forces due to earthquake for individual storey due to changes in stiffness. A ground plus ten vertical irregular storey building structure is modelled to analyse stiffness irregularity at floors. Analysis is performed to obtain and compare Drift, deflection and shear under seismic force performing linear static & dynamic analysis.
Varadharajan et al. (2013)[18] reviewed literatures available in the field of plan irregularities to investigate the decision to decide preference of multistory building models against single storey building models. It was concluded that dynamic analysis is more accurate than pushover analysis for seismic cases. **Ramesh Konakalla et al. (2014)[5]** studied topic "Linear Behavior of the Buildings with Plan Irregularities under Earthquake and Wind Loads". Method

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adopted was Linear Static Analysis and analysis for four different frames are analyzed. **Bansal (2014)**[2] Selected Response spectrum analysis and time history analysis to analyse Vertical irregular building. Mass irregularity, stiffness irregularity and vertical geometry irregularity are considered in problem. The storey shear force was found maximum for the first storey and it decreases to minimum in the top storey in all cases.

Harshitha (2014)[17] investigated dynamic behavior of high rise building using IS1893.2002 code. Response spectrum method and time history method are recommended to perform. **Bansal and Gagandeep (2014)**[3] Author considered ductility based design to be performed with vertical irregular building. Methods applied to perform analysis are RSA and THA. Mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. **Konakalla (2014)**[6] analysed 20 story buildings with different cases ti investigate effect of vertical irregularity under Dynamic Loads Using Linear Static Analysis. Results obtained for all cases are compared and concluded that in regular structure there is no torsional effect in the frame because of symmetry.

Reddy and Fernandes (2015)[12] performed analytical study for regular and irregular buildings in zone V to analyze seismic response of buildings. ETABS software is used to model and simulate building response. Static and dynamic methods are used to analyze models. Paper concluded behavior of irregular structures as compared to regular structure. **Mukundan (2015)**[8] Highlights that it is suitable and economical to use shear wall in building. A ten storey building in Zone IV is tested to reduce the effect of earthquake using reinforced concrete shear walls in the building. ETABS software is used to perform analysis with RSA method. **Sagar et al. (2015)**[13] analysed the buildings with different irregularities. Horizontal Irregularity, plan irregularity, vertical Irregularity and mass Irregularity were used. To achieve objective of the project Time history Analysis & Response spectrum analysis were performed.

Khan &Damage (2016)[17] highlighted the effect of mass irregularity on different floor in RCC buildings with as Response Spectrum analysis using STAAD.Pro V8i software. **Salunkhe and Kanase (2017)**[14] analyses response of mass irregular structure considering seismic actions. RCC framed structure in both regular and mass irregular manner with different analysis methods is analysed in this research. **Sayyed (2017)**[15] Effect of infill and mass irregularity on different floor in RC buildings are considered to investigate in this paper. The results were concluded that the brick infill improves the seismic performance of the RC buildings and poor seismic responses are obtained with mass irregular building, therefore it should be avoided in the seismic regions.

3. Problem Formulation

Structure is first selected as Multi storey rigid jointed plane frame with Seismic zone V. Time history analysis data is considered from two different places. Building plan is selected as 30m x 25m with G+19 stories.

In this research G+19 multi-storey building of plan dimensions 30m x 25m, beam size 325x425 mm, column sizesfor Story 1-7 =625mmx625mm, Story 8-14 = 525mmx525mm, Story 15-19 = 425mmx425mm is modelled with different vertical irregularities i.e. Setback and mass irregularity and analyzed with various time history data (Fruili and Petrolia).

The setback irregularities considered in the modeling are as follows:

- Model 1 consist of 6x5 bay up to 10 floor. 2x2 bay up to top floor (edge position).
- Model 2 consist of 6x5 bay up to 10 floor. 2x2 bay up to top floor (center position).

The material properties used in the Critical data considered during whole problem analysis are given in table.

Table 1: Input parameters to be used for Analysis

Parameters	Description
Type of structure	Multistorey rigid jointed plane frame(Special RC moment resisting frame)
Seismic zone	V
Zone Factor, Importance Factor	0.36, 1
Time History Analysis data	Fruili and Petrolia
Type of soil	Medium soil
Number of storey	G+19
Dimension of building	30 m x 25 m
Floor Height (Typical)	3m
Base floor height	3.5m

Materials	Concrete (M30) and Reinforcement Fe415
Size of Column	Story 1-7 = 625mmx625mm, Story 8-14 = 525mmx525mm Story 15-19 = 425mmx425mm
Size of Beam	325x425 mm
Model (1)	6x5 bay up to 10 floor. 2x2 bay up to top floor (edge position)
Model (2)	6x5 bay up to 10 floor. 2x2 bay up to top floor (center position)

Various time histories

The following figure obtained from earthquakes in time zones, the same is considered for all cases and references to test building considered in problem statement with seismic loading in different time zones.

Fruili Earthquake and Petrolia Earthquake

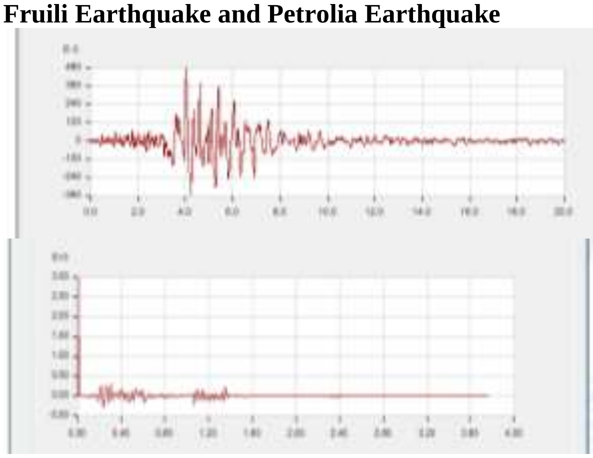

Figure 2: Time History Graph Fruili and Petrolia Earthquake

Various Models Considered

Following are the two models considered, modelled and analysed with seismic loading under different time zones. The models are considered with variation and difference in term of vertical irregularity.

Models

Model 1 consist 6x5 bay up to 10 floor. 2x2 bay up to top floor (edge position) and V

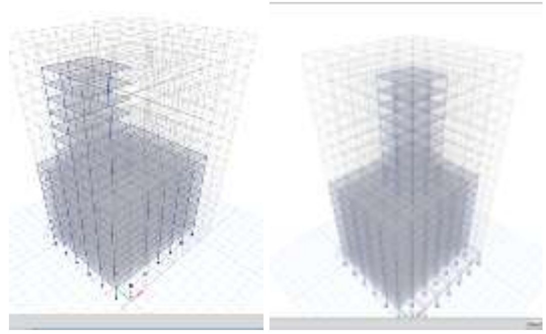

Figure 1: Model 1 and Model 2, Vertical Irregularity Case

4. Methodology

Building response is planned to test with ETABS software defining all dimensional parameters and material properties. Analysis is to be performed for vertical irregularities in different time history.

In short description:

- Initially taking a model of plan dimension30mX25m G+19 storey building with all the data listed in the Table in ETABS
- Modelling of model is done with different types of vertical irregularities.
- The model is considered to be taken in zone V.
- Time History Analysis is done on the models in ETABS.
- Results are tabulated and then compared with time history and vertical irregularities.
- After comparing results it is concluded.

5. Results and Discussion

Comparison of Models for Fruili Time History Data

Table 2: Displacement Comparison

Sr. No.	Model Name	Maximum Displacement (mm)
1	Fruili 1	302
2	Fruili 2	292.8

Table 3: Base Reaction Comparison

Sr. No.	Model Name	Base Reaction (KN)
1	Fruili 1	2513.2089
2	Fruili 2	2535.837

Table 4: Stress Comparison

Sr. No.	Model Name	Stress (E^{-3}) KN/mm^2

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1	Fruili 1	216
2	Fruili 2	252

Comparison of Models for Petrolia Time History Data

Table 5: Displacement Comparison

Sr. No.	Model Name	Maximum Displacement (mm)
1	Petrolia 1	302
2	Petrolia 2	292.8

Displacement is compared under various load combinations for both Models subjected to Petrolia time history. It is seen that Displacement is greater for model1.

Table 6: Base Reaction Comparison

Sr. No.	Model Name	Base Reaction (KN)
1	Petrolia 1	2335.54
2	Petrolia 2	2535.84

Table 7: Stress Comparison

Sr. No.	Model Name	Stress (E^{-3}) KN/mm^2
1	Petrolia 1	13
2	Petrolia 2	60

Graphical Comparison (Fruili Time History)

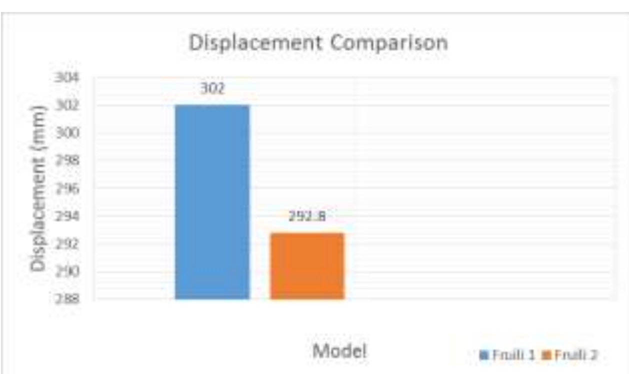

Figure 3: Model Displacement Comparison

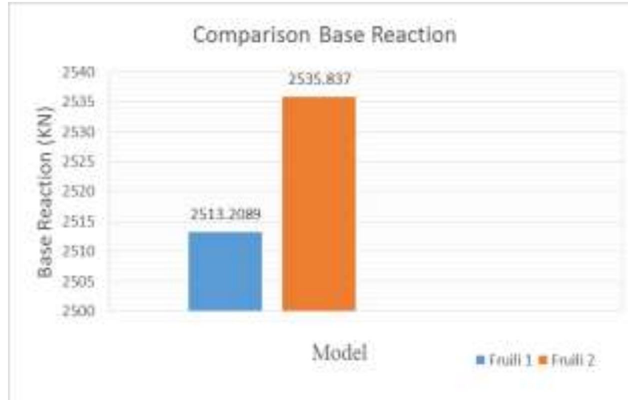

Figure 4: Base Reaction Comparison

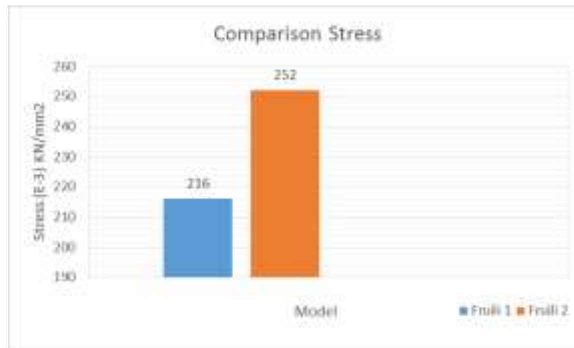

Figure 5: Stress Comparison

Graphical Comparison (Petrolia Time History)

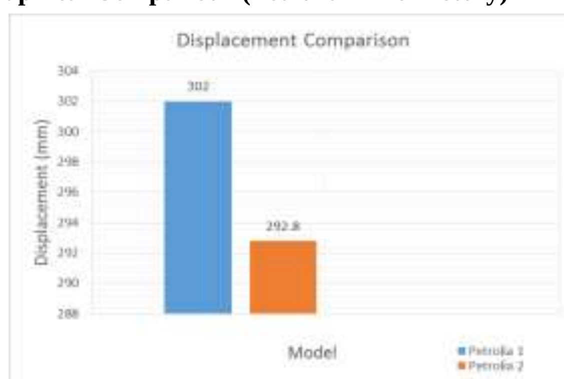

Figure 6: Model Displacement Comparison

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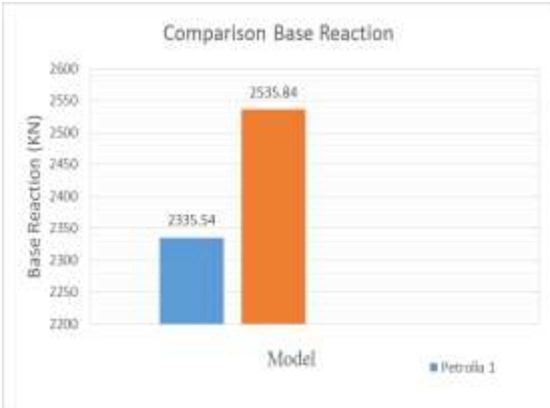

Figure 7: Base Reaction Comparison

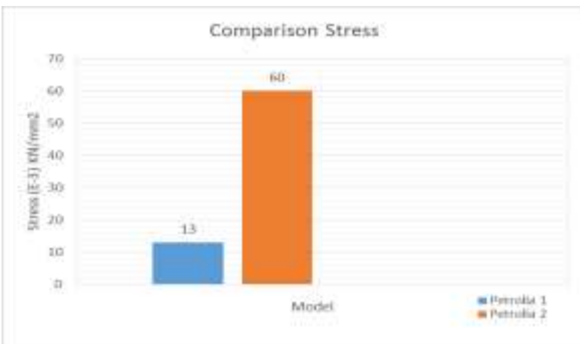

Figure 8: Stress Comparison

Time History Results Comparison

Table 8: Result Comparison (Time History Results)

	Fruili		
Model	Base Reaction (KN)	Displacement (mm)	Stress (KN/mm^2)
1	2513.2089	302	216
2	2535.837	292.8	252

Petrolia		
Base Reaction (KN)	Displacement (mm)	Stress (KN/mm^2)
2335.54	302	13
2535.84	292.8	60

All the results for base reaction, displacement and Stresses are tabulated under one table. The table is designed categorizing all results under both Fruili and Petrolia time history.

Time History Graphical Comparison

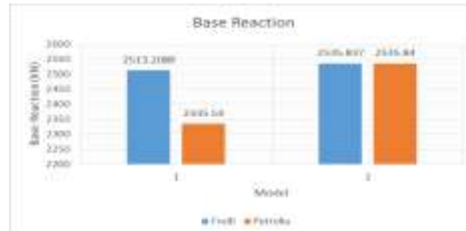

Figure 9: Base Reaction Comparison (Model Wise)

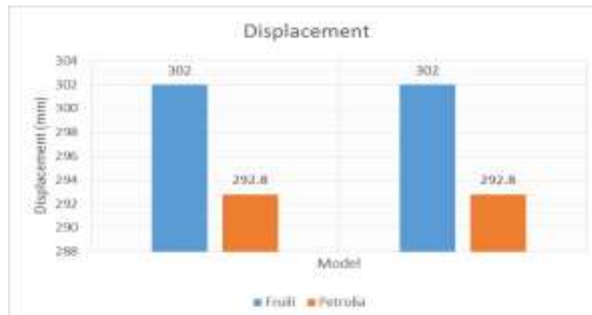

Figure 10: Displacement Comparison (Model Wise)

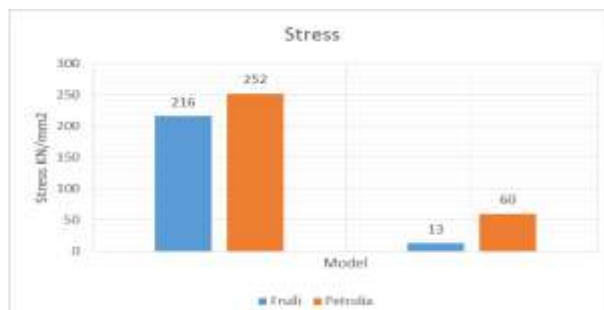

Figure 11: Stress Comparison (Model Wise)

6. Conclusion

It is concluded that two models are considered and modelled in ETABS and two time histories are considered to analyse the models. It is recommended that ETABS can be successfully considered and employed to analyse such cases and buildings considering various time histories. Present research considered fruili time history and Petrolia history one by one for both building cases considered.

1. It is found that results obtained from Fruili time history are higher than Petrolia time history for all values of displacement and base reaction. Only Stresses are lower for both models in case of fruili time history.

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2. It is recommended as conclusion that irregular buildings are safer than regular building under seismic conditions and should be preferred over regular buildings.
3. The column size is designed lighter with the height of building therefore it is concluded that designing lighter column saves cost of building and helps to achieve optimized design of building.

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