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VERTICAL IRREGULARITY AND ITS IMPACT OVER STRUCTURES IN EARTHQUAKE PRONE ZONES

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ABSTRACT

This paper is worried with the impacts of different vertical anomalies on the seismic response of a structure. The goal of the venture is to do Response spectrum analysis (RSA) and Time history Analysis (THA) of vertically sporadic RC building outlines and to complete the flexibility based plan utilizing IS 13920 comparing to Equivalent static analysis and Time history analysis. Examination of the aftereffects of analysis and outline of sporadic structures with general structure was finished. The extent of the venture additionally incorporates the assessment of response of structures subjected to high, low and middle of the road recurrence content seismic tremors utilizing Time history analysis. Three sorts of abnormalities in particular mass irregularity, stiffness irregularity and vertical geometry irregularity were considered. As indicated by our perception, the story shear drive was observed to be most extreme for the principal story and it abatements to least in the top story in all cases. The mass unpredictable structures were seen to encounter bigger base shear than comparative customary structures. The stiffness sporadic structure experienced lesser base shear and has bigger between story floats. The outright relocations gotten from time history analysis of geometry sporadic structure at individual hubs were observed to be more noteworthy than that in the event of normal structure for upper stories however step by step as we moved to lower stories removals in both structures had a tendency to focalize. Bring down stiffness brings about higher relocations of upper stories. In the event of a mass sporadic structure, time history analysis gives marginally higher removal for upper stories than that in customary structures while as we move down lower stories demonstrate higher relocations when contrasted with that in general structures. At the point when time history analysis was accomplished for consistent and also stiffness unpredictable structure, it was found that removals of upper stories did not shift much from each other but rather as we moved down to lower stories the outright uprooting in the event of delicate story were higher contrasted with individual stories in standard structure. Tall structures were found to have low common recurrence subsequently their response was observed to be most extreme in a low recurrence seismic tremor. It is on account of low common recurrence of tall

structures subjected to low recurrence seismic tremor prompts reverberation bringing about bigger relocations.

Key Words: **seismic response, Response spectrum analysis (RSA), Time history Analysis (THA).**

1. INTRODUCTION

Amid a seismic tremor, disappointment of structure begins at purposes of shortcoming. This shortcoming emerges because of irregularity in mass, stiffness and geometry of structure. The structures having this intermittence are named as Irregular structures. Sporadic structures contribute a huge segment of urban foundation. Vertical inconsistencies are one of the real reasons of disappointments of structures amid tremors. For instance, structures with delicate story were the most remarkable structures which caved in. Along these lines, the impact of vertically anomalies in the seismic execution of structures turns out to be truly vital. Stature insightful changes in stiffness and mass render the dynamic qualities of these structures not quite the same as the customary building. IS 1893 definition of Vertically Irregular structures: The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated. There are two types of irregularities-

1. Plan Irregularities.
2. Vertical Irregularities.

Seismic analysis is a subset of structural analysis and is the calculation of the response of the building structure to earthquake and is a relevant part of structural design where earthquakes are prevalent. The seismic analysis of a structure involves evaluation of the earthquake forces acting at various level of the structure during an earthquake and the effect of such forces on the behaviour of the overall structure. The analysis may be static or dynamic in approach as per the code provisions. Thus broadly we can say that linear analysis of structures to compute the earthquake forces is commonly based on one of the following three approaches Basically two methods of analysis are available to predict the seismic performance of structures. Each method has its own advantages and limitations.

2 LITURATURE REVIEW

Rajeeva and Tesfamariam (2012) Fragility based seismic vulnerability of structures with consideration of soft -storey (SS) and quality of construction (CQ) was demonstrated on three, five, and nine storey RC building frames designed prior to 1970s. Probabilistic seismic demand model (PSDM) for those gravity load designed structures was developed, using non-linear finite element analysis, considering the interactions between SS and CQ. The response surface method is used to develop a predictive equation for PSDM parameters as a function of SS and CQ. Result of the analysis shows the sensitivity of the model parameter to the interaction of SS and CQ.

Sarkar et al. (2010) proposed a new method of quantifying irregularity in vertically irregular building frames, accounting for dynamic characteristics (mass and stiffness).

Karavasilis et al. (2008)studied the inelastic seismic response of plane steel moment-resisting frames with vertical mass irregularity. The analysis of the created response databank showed that the number of storeys, ratio of strength of beam and column and the location of the heavier mass influence the height-wise distribution and amplitude of inelastic deformation demands, while the response does not seem to be affected by the mass ratio. Athanassiadou (2008) concluded that the effect of the ductility class on the cost of buildings is negligible, while performance of all irregular frames subjected to earthquake appears to be equally satisfactory, not inferior to that of the regular ones, even for twice the design earthquake forces. DCM frames were found to be stronger and less ductile than the corresponding DCH ones. The over strength of the irregular frames was found to be similar to that of the regular ones, while DCH frames were found to dispose higher over strength than DCM ones. Pushover analysis seemed to underestimate the response quantities in the upper floors of the irregular frames.

3. METHODOLOGY

3.1 Response Spectrum Analysis

Response Structure analysis was performed on regular and various irregular buildings using Staad-Pro. The storey shear forces were calculated for each floor and graph was plotted for each structure.

Table 3.1: Structural modelling specifications

Live Load	4kN/m2
Density of RCC considered:	25kN/m3
Thickness of slab	150mm
Depth of beam	450mm
Width of beam	300mm

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Dimension of column	450x450mm
Density of infill	20kN/m3
Thickness of outside wall	230mm
Thickness of inner partition wall	120mm
Height of each floor	3.0m
Earthquake Zone	II
Damping Ratio	5% (0.05)
Importance factor	1
Type of Soil	Medium soil
Type of structure	Special Moment Resisting Frame
Response reduction Factor	5

Four types of buildings were considered, Regular structure, Mass irregular structure, structure with ground storey as the soft storey and vertically geometric irregular building. The first three structures were 16 storeyed. The structure is modelled as same as that of regular structure except the loading due to swimming pool is provide in the fourth and eighth floor. Loading due to swimming pool - 20kN/m2.

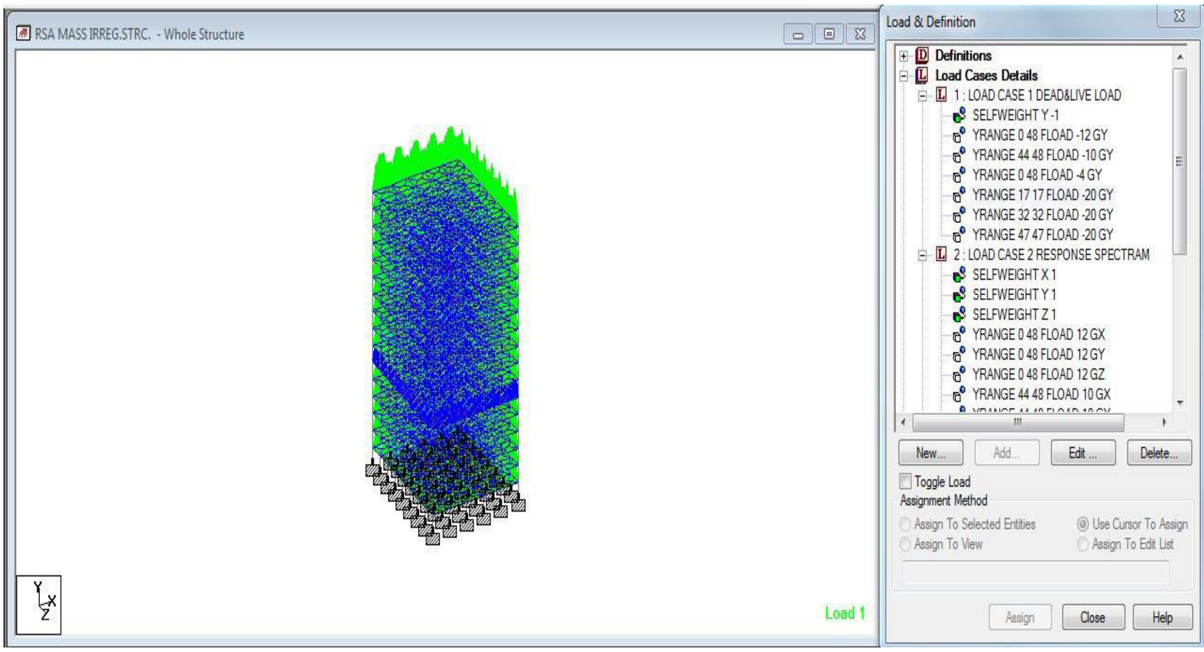

Fig 3.1 3D view of mass regular structure (16 storeys) with swimming pools on 5th, 10th and 16th storeys

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3.1 Time History Analysis

Regular and various types of irregular buildings were analyzed using THA and the response of each irregular structure was compared with that of regular structure for IS code Ground motion. The IS code ground motion used for the analysis had PGA of 0.2g and duration of 10 seconds.

Table 3.2 structural models and their top floor time history displacement specifications

Live Load	4kN/m2
Density of RCC considered:	25kN/m3
Thickness of slab	150mm
Depth of beam	450mm
Width of beam	300mm
Dimension of column	450x450mm
Density of infill	20kN/m3
Thickness of outside wall	230mm
Thickness of inner partition wall	120mm
Height of each floor	3.0m
Force Amplitude factor	9.81

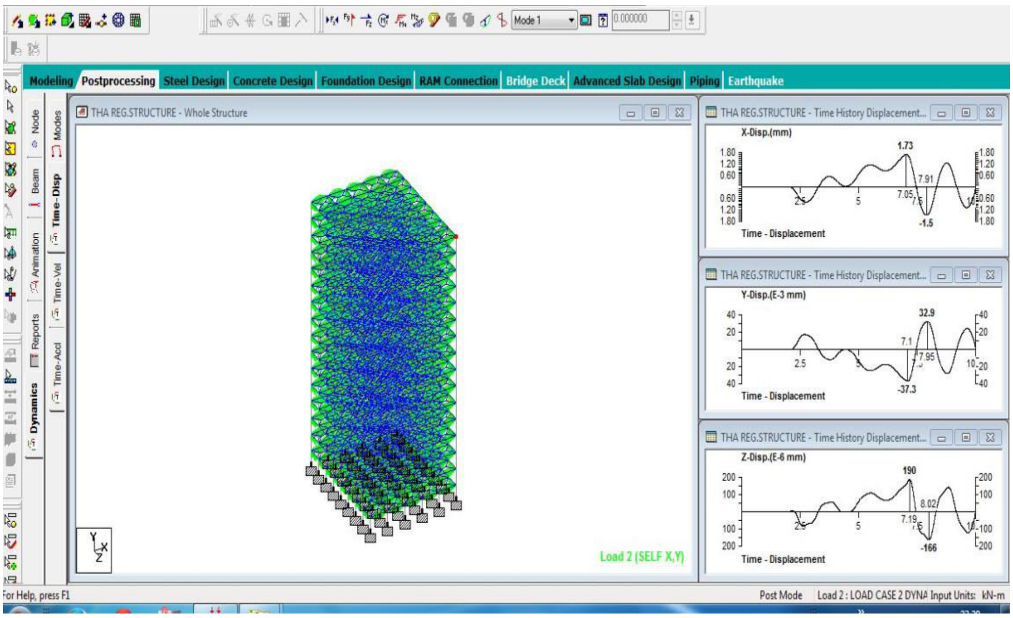

Fig 3.2 Time history displacement of the highlighted node of regular structure

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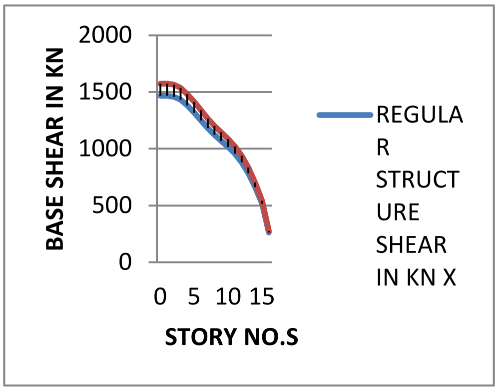
4. RESULT:

In this chapter the results and observations of the tests conducted are presented, analyzed and discussed. The storey shear force is maximum in ground storey and it decreases as we move up in the structure. Mass irregular storey shear force is more in lower storeys as compared to regular structure. The graph closes in as we move up the structure and the mass irregular storey shear force becomes less than that in regular structure above 15th storey. The comparison graphs are shown below.



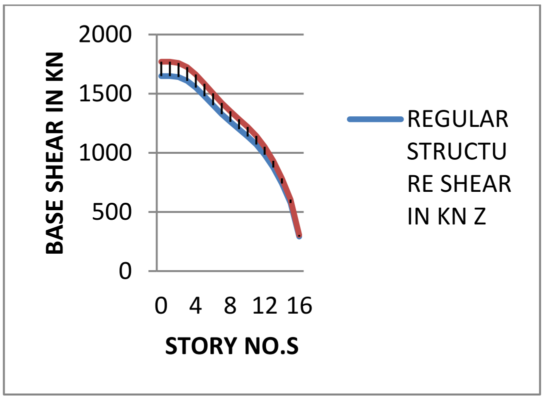


Fig 4.1: Comparison of Peak storey shear forces of regular and mass irregular structure.

Regular and various types of irregular buildings were analyzed using THA and the response of each irregular structure was compared with that of regular structure for IS code Ground motion.

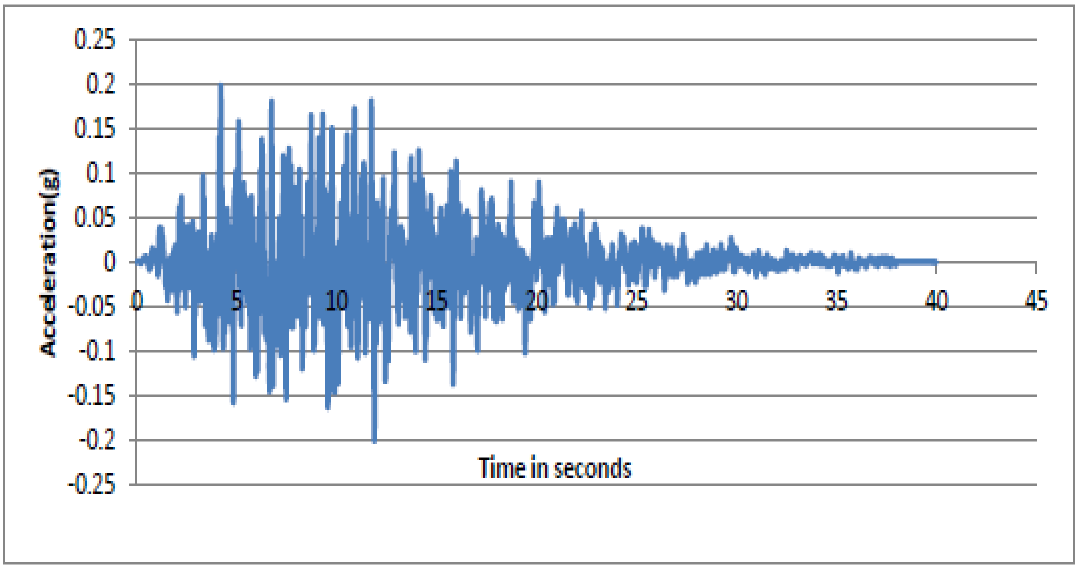


Fig 4.2: IS code ground motion with PGA scaled to 0.2g and duration equal to 40 seconds

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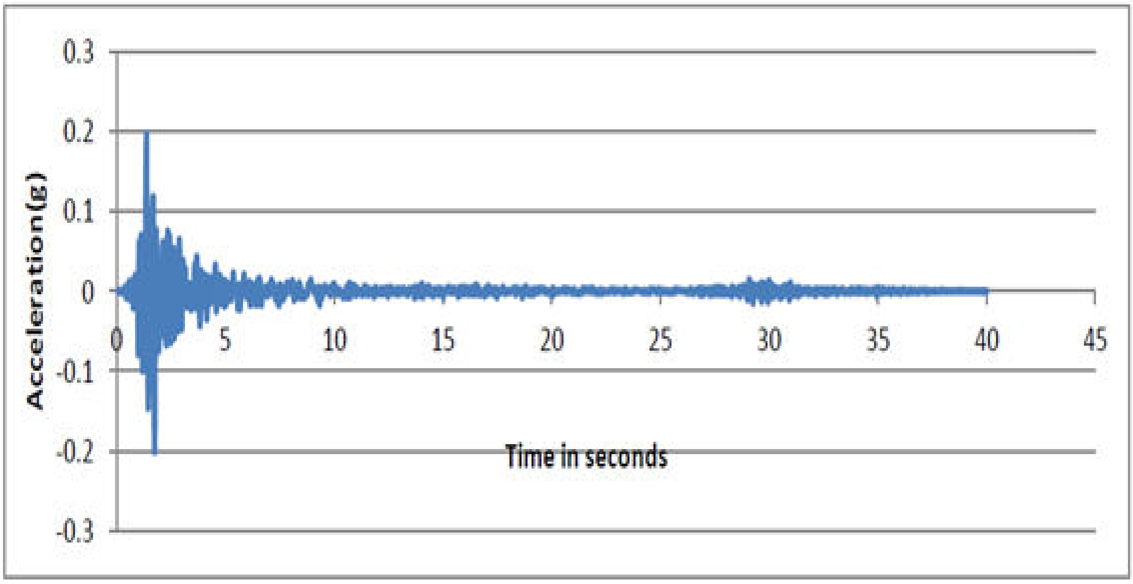

Fig 4.2: San Francisco ground motion

5. CONCLUSION

Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered .all three kinds of irregular RC building frames had plan symmetry. Response spectrum analysis (RSA) was conducted for each type of irregularity and the storey shear forces obtained were compared with that of a regular structure. Time history analysis (THA) was conducted for each type of irregularity corresponding to the above mentioned ground motions and and nodal displacements were compared. Our results can be summarized as follows-

 According to results of RSA, the storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.

 According to results of RSA, it was found that mass irregular building frames experience larger base shear than similar regular building frames.

 According to results of RSM, the stiffness irregular building experienced lesser base shear and has larger inter storey drifts.

 The absolute displacements obtained from time history analysis of geometry irregular building at respectivenodes were found to be greater than that in case of regular building for upper stories but gradually as we move to lower stories displacements in both structures tended to converge. This is because in a geometry irregular structure upper stories have lower stiffness (due to L-shape) than the lower stories. Lower stiffness results in higher displacements of upper stories.

 In case of a mass irregular structure, Time history analysis yielded slightly higher displacement for upper stories than that in regular building, whereas as we move down, lower stories showed higher displacements as compared to that in regular structures.

 When time history analysis was done for regular as well as stiffness irregular building (soft storey),it was found that displacements of upper stories did not vary much from each other but as we moved down to lower stories the absolute displacement in case of soft storey were higher compared to respective stories in regular building.

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