A Review of Comparative Study of Seismic Analysis of RC Building in Vertical Mass Irregularities

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Abstract - *In this review paper, we study some research papers related to the seismic analysis of the RC building vertical irregularities and we gave some conclusion after reading this research paper. Earthquake is a phenomenon in which a large amount of elastic energy released within fraction due to sudden transition motion in the ground and this energy travels in the form of unstable waves called seismic waves. Mass irregularity in the structures is due to uneven distribution of mass, strength or stiffness or due to their structural form. The percentage difference is small of changes in mass in comparison to the total mass of the building; the effect of mass irregularity is small on the mode shapes in regular buildings. According to the Indian Standard Code 1893 part-1:2016, from clause number 7.1, the mass irregularities should be considered when the seismic weight of the floor is greater than 150 % concerning the upper or lower floor.*

Key Words: *Vertical Irregularities, Mass Irregularities, RC Structure, Etabs, Seismic Analysis*

1. INTRODUCTION

Mass irregularities are defined based on the seismic weight of the floor if the seismic weight of the floor is 150% greater than the other floor which may be above or below the floor concerning that floor where the seismic weight is greater than 150%. According to the Indian Standard Code, if we construct an RC building in the seismic zone 3rd, 4th, and 5th, then we should analyze that model with help of the dynamic analysis which may be time history analysis and Response Spectrum analysis. The construction of the mass irregularities building increasing day by day because mostly hotel type structure is under it, where the load is not constant at each floor. The figure of the mass irregularities is given below:

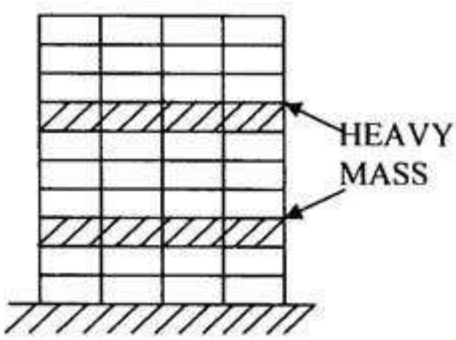

Fig -1: Mass Irregularities Building

2. LITERATURE REVIEW

In the literature review, we studied some research paper which was related to mass irregularities in the building and their conclusions are given below:

[1]Poncet, L 2004 "INFLUENCE OF MASS IRREGULARITY ON THE SEISMIC DESIGN AND PERFORMANCE OF MULTI-STOREY BRACED STEEL FRAMES" According to IBC 2003, the structures with setbacks would not be considered as having a mass irregularity because the computed storey drifts did not increase by more than 130% between one storey and the storey below. The results of the analyses can be summarized as follows:

1. All structures were found to be adequate for immediate occupancy after frequent but low amplitude earthquakes, but the irregular structures designed with static analysis generally experienced the storey drift limit at lower ground motion amplitudes than the reference regular structure. The use of dynamic analysis in design improved the response of all irregular structures. Except for buildings with a mass discontinuity at mid-height, irregular structures designed with the dynamic method behaved similarly to or better than the regular structure.
2. When subjected to ground motions scaled to the design hazard level, mass irregularity, and analysis method did not seem to have any significant effect on the building response and all structures exhibited a stable inelastic response with maximum peak storey drifts below the code limit.

3. When designed according to the equivalent static force procedure, the regular building and all irregular structures except the building with 300% mass discontinuity at mid-height were found to have similar and acceptable confidence level against collapse. The use of dynamic analysis had a positive impact on the response of 4 of the 6 irregular buildings but this impact was limited.

[2]Devesh P. Soni 2006 "QUALITATIVE REVIEW OF SEISMIC RESPONSE OF VERTICALLY IRREGULAR BUILDING FRAMES" From the above discussion, it can be concluded that a large number of research studies and building codes have addressed the issue of effects of vertical irregularities. Building codes provide criteria to classify the vertically irregular structures and suggest elastic time history analysis or elastic response spectrum analysis to obtain the design lateral force distribution. A majority of studies have evaluated the elastic response only. Most of the studies have focused on investigating two types of irregularities:

1. For the soft and weak first story structures, increase in seismic demand has been observed as compared to the regular structures. For buildings with discontinuous distributions in mass, stiffness, and strength (independently or in combination), the effect of strength irregularity is larger than the effect of stiffness irregularity, and the effect of combined-stiffness-and strength irregularity is the largest. It has been found that the seismic behaviour is influenced by the type of model (i.e., beam hinge model or column hinge model) used in the study.
2. Finally, buildings with a wide range of vertical irregularities that were designed specifically for code-based limits on drift, strength and ductility, have exhibited reasonable performances, even though the design forces were obtained from the ELF (seismic coefficient) procedures.

[3]Vinod K. Sadashiva 2009 "DETERMINATION OF STRUCTURAL IRREGULARITY LIMITS – MASS IRREGULARITY EXAMPLE" This study on structural irregularity effects can be summarized as below:

1. Current regularity provisions in NZS 1170.5 are based on overseas irregularity recommendations. They are based on engineering judgement and lack rational justification.
2. Past research on vertical irregularities effects does not justify the appropriateness of regularity limits slated in NZS 1170.5. A better and more meaningful comparison is obtained if structures designed to a target drift are compared with the actual drift demand rather than tuning the structures to have the same period. Also, earlier works may not be appropriate for structures designed for New Zealand;
3. A method to quantify vertical irregularity effects was proposed for all irregularity types. This method was applied to evaluate the effects of mass irregularity on simple shear-type structures with 3, 5, 9 and 15 storey heights.

[4]N.Anvesh 2015 "Effect of Mass Irregularity on Reinforced Concrete Structure Using Etabs"

1. From the results, it was observed that Beams in the refuse area are expected to have more shear force and bending moment.
2. From the results, it was observed that Deflection is more in case of refuse area beams of mass irregular building when compared to building without mass irregularity.
3. From the results, it was observed that there is an increase of 67% in the moments of mass irregular buildings than buildings without mass irregularity.
4. Size of the structural members also increases for buildings with mass irregularity.
5. Since the load acting in the mass irregular building is more the displacements in buildings with mass irregularity are less than buildings without mass irregularity.
6. From the results, it was observed that Drifts in building without mass irregularity are more than buildings with mass irregularity.
7. From the results, it was observed that there is an increase in steel for the building with mass irregularity.

[5]Shaikh Abdul Aijaj Abdul Rahman 2016 "Seismic analysis of vertically irregular buildings"

1. When there is a sudden change in mass between two storeys (mass irregularity) of a building, there will be a sudden change in storey displacement or storey drift at that level and if masses are heavy then drift ratio will go beyond the permissible limit.
2. For a building with heavy mass at some storey, storey shear will be high compared to the same building having normal mass distribution.
3. Vertical stiffness irregularity at a storey in a building causes an increase in storey drift beyond specified limits at that storey, while buildings without stiffness irregularity perform well for lateral loads.
4. Buildings having mass and stiffness irregularity should be analysed and designed properly. Special detailing and designing methodology should be utilized to keep the displacement and stresses within the permissible limit.

[6]More Amol R 2017 "Study of seismic responses of multi-storied RCC building with mass irregularity & column stiffness variation" based on the present study done & literature studied, and discussions, the following conclusions can be made,

1. The irregular structure shows critical responses as compared to the regular structure.
2. Frames having irregular floors at a larger height from the ground are critical. Hence as far as possible, irregularity should be introduced on the floor close to the ground.
3. Most economical combination of irregular structure can be worked out using the present study.
4. Displacements drift and periods can be reduced by adopting columns with higher stiffness.
5. As we increase the column stiffness, axial forces in columns and base shear increases.

[7]Mr. Umesh Salunkhe 2017 "Seismic Demand of Framed Structure with Mass Irregularity"

1. As the RSA method is more accurate than the ESA, however, it gives lesser values for storey drift. Hence it is recommended to use ESA for calculation of story drift.
2. For high storey buildings, the storey shear obtained by NLTA is greater than the storey shear by ESA for top storeys only irrespective of location and intensities of mass irregularity.
3. Location of heavier floors does not affect the storey shear considerably.
4. A 10-storey building drifts by NLTA are less than ESA except when a mass irregularity is on middle floors where the drift is 2.02 times that of the regular building.
5. The amount of irregularity has not shown a considerable effect on the storey shear.

[8]Vahid Mohsenian 2019 "A study on the effects of vertical mass irregularity on seismic performance of tunnel-form structural system" The results obtained herein, indicate the desirable seismic performance of tunnel-form buildings with irregular distribution of mass in building's height. Accordingly, the most notable conclusions are as follows:

1. It was found that the order of vibration modes is not affected by the building's height and patterns of mass distribution in elevation.
2. Irregular distribution of mass in height increases the fundamental period as well as coefficient of the mass contribution of the vibration modes.
3. Vertical mass irregularity amplifies the displacement responses of buildings and subsequently, deformation responses of the elements. Accordingly, the taller building was found to be more susceptible to this issue.
4. The results indicate that until the middle of the building's height is not reached, an increase in several stories possessing extra weight leads to amplification in structural responses and reduces the building's capacity. However, exceeding this limit (half of the building's height) is accompanied by a decreasing trend in the responses approaching the basic state.

3. CONCLUSIONS

After reading the above research paper related to the mass irregularities in the RC building, we analyzed some conclusions which come-out, this conclusion is given below:

1. The numerical value of the storey stiffness at that floor where seismic weight is 150 % greater than below or above the floor will be an increase because the numerical value of the storey stiffness is directly proportional to the base shear or lateral force and base shear is depend upon the seismic weight of the floor or building.
2. The value of the natural period is suddenly changed at the floor where heavy mass is placed, to reduce the value of the natural period; we should increase the stiffness of the column.
3. Vertical mass irregularities increase the value of the storey drift that that particular floor where the mass irregularities will be considered.
4. The twisting moment depends upon the distribution of the mass on the floor of the building or structure.

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