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Seismic Response of a Irregular Building : A Review

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Abstracts

This paper is the brief account of the research conducted in the recent past related to the different structural irregularities. The plan related and vertical irregularities have been covered. The norms described by the numerous structural codes viz. IS18932 have been highlighted in short. It has been seen that the code identifies the almost same limits for the Plan and vertical irregularities. The variety of structural modelling has been described briefly. On the basis of the review of the work related to plan irregularities it can be stated that multi-storeyed buildings are more safe as compared with single storeyed structures. The idea of balanced Centre strength (CV) and Centre Rigidity(CR) location can very well improve the seismic response of the structure. It is also seen that strength Vertical Irregularity has the utmost effect on the seismic behaviour and minimum effect due to mass irregularity. Dynamic Analysis is more effective accurate in studying the seismic behaviour due to different irregularities.

Keywords: Centre of strength, centre of rigidity Vertical Irregularity, Mass Irregularity, Modal Pushover analysis

I. INTRODUCTION

The structure fails at the geometrical feeble points. The lack of strength in the structure is due to distorted geometry and irregularity in mass, shape and rigidity. The structure with such shortcomings are called as irregular structure. The buildings collapse during horizontal movements in case vertical irregularities. The structures having less rigid bottom storeys show larger damages. It is worthwhile to consider the vertical irregularities when designing the high rise structures. The non–uniformity in the vertical direction leads to dynamic behaviour under seismic forces. Regular buildings are safer. The irregularity can contributed by mass non-uniformity , discontinuity in solidity and strength. It is tedious and complex to design such structure in earthquake prone areas.

There are two category of anomalies in building structure-

1. **Plan Abnormalities** 2. **Vertical Abnormalities**.

The Vertical Abnormalities are: **Stiffness Anomalies**- The fragile level which has stiffness below 70% just one level up and less than 80% of the strength in horizontal direction is considered as Stiffness Abnormality.

2. **Strength Abnormality**- Very Weak Level- The level of the building with lateral strength below 60% of the level just above and below 70% of mean strength of three level above this.

Mass Abnormality- Weight or mass abnormality of the structure arises when level of the structure more than double of the seismic weight of close by level. The abnormality of the roof is ignored.

Vertical Geometric Abnormality- A building with horizontal measurement one and half time that of the adjacent storey.

In-Plane Non- regularity Vertical components Resisting Lateral Force- An in-plane offset of the sideways force resisting elements greater than the length of those elements.

Disjointedness in Capability — I, Delicate Storey-A feeble storey is one in which the storey lateral strength is less than 80% of that in the storey above.

Indian Code 1893 –I has put forth the Linear Static Analysis (LDA) can be applied on low rise building structures. The forces are computed keeping fundamental time in mind. LDA has been modified for the betterment over Linear Static Analysis (LSA). The higher modes are considered which gives more accurate picture of forces within the elastic range.

The structural designs can be improved by considering actual forces on the structure. It is a customary to consider ductile structure in the high-risk zones. The chief target is to provide the sufficient steel to face the earthquake safely.

II. LITERATURE REVIEW

Jui-Liang Lin, et al.(2020)[1]. In this work Numerical modelling is used to estimate the seismic behaviour of the building and test is also conduct to validate the mathematical model. Incremental DA(dynamic Analysis) is also performed I near and the far field to estimate the damages.

Reza Ramezani Azghandi et al. (2019)[2]This work is based on structure is simulated to understand the seismic behaviour. The structure model uses the FEM (Finite Element Method) and forces are applied in predefined pattern till the structure collapses. The mass stiffness and vertical non-geometric are also analysed. FEM seems to be a reliable method. Timoshenko beam element is used.

B. L. Chandrahas, P. P Raju, et. al (2019)[3]. The work describes the need of parking space at ground floor has forced designers to have open story. There is a need of open space at different heights. This makes the structure seismic prone and more responsible for the structure failures. The conventional methods are not able to account for the feeble storey. The authors have used POA to estimate the seismic demands of the building.

Trishna Choudhury et al. (2018)[4]. In this paper the vertical irregularity has been discussed in RC frames where the ground storey is open and therefore, weak. Nonlinear dynamic analysis(NLDA) is performed to find the global drift ductility demand also known as Engineering Demand Parameters (EDPs) are evaluated to predict the damages under the state of collapse.

Pushpendra Singh kushwah et al(2018)[5]of soft storey were higher **The authors have investigated** the storey cut force is supreme for the first storey and it decreases to least in the top storey. The simulation results show more base shear in case of irregular structure but regular structure experience lesser shear forces. The structure with the vertical irregularity is easy to design. The RSA results show decreasing shear forces from lower to upper storeys. There is trade-off between stiffness and storey drift. TH (Time History) Analysis results in horizontal displacement for upper levels of the structure for irregular structures. The lower level structure have more displacement than regular shaped structures. In soft storey that is strength wise irregular structures, the observation (displacement) is not significant for upper levels.

Shridhar Chandrakant et al. (2018) [6] The authors after analysing by conventional static method varying geometric shapes for non-uniform structures the results are summarised as under: The building shows the improvement in the ductility by providing infill walls in irregular structure in different arrangement. This arrangement reduces the forces and the displacement of the members. It is recorded as the result of the simulation that risk of the structure increases with the irregularity.

Shaikh Abdul Aijaj Abdul Rahman et al(2018) [7]The seismic response of eleven storeyed building with strength no-uniformity has been examined in this work.The experiment considers a bas model which has irregularities. The other models are created by incrementing the height of the fourth level and column height of the first level is also increased. The abrupt change in the mass at different level increases the storey drift**. The mass distribution equally results in stable building**. The structure with strength and weight non-uniformity must be designed with care so that the building doses not collapse under the horizontal shaking by earthquakes.

Xiaoge Renet al.(2018)[8]The research evaluates the irregular hybrid RC structure.The numerical model constructed considering six variants retrofitted with different strength. The Non-Linear FEM(Finite Element Method) is used. It is seen that the shear walls are found be most effective.

Shaikh Abdul Aijaj Abdul Rahman et al. (2017)[9]. This paper is based on the simulation of different frames with heavy masses at different levels of the structure. Frame 1 considered to be stronger than Frame 2 and due to this it has maximum displacement. The Frame-1 having mass irregularity is most vulnerable under the interaction of the seismic forces.The vertical irregularity appears to most risky that is why complex structures must be avoided.

Piyush Mandloi et al (2017)[10]. It is concluded from results and simulation that results vary. 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 established 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.

Gita Devi et al(2017) [11]Following important observations are made with the study of irregular buildings. Irregularity affects the dynamic characteristics of the structure i.e. time period and mode shapesSeismic coefficient method may not be accurate for earthquake force calculations. Proper calculation of regularity index is necessary for assessment of irregularity buildings.There is a loss of strength, stiffness and ductility of the irregular buildings subjected to base excitation.

Piyush Mandloi et al (2016)[12]. It is concluded from the simulation that the results varies from time history to time history. The researchers 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.

III. CONCLUSION

The aim of this research is to perform response spectrum analysis and to compare the design horizontal forces on regular and irregular buildings. The second objective is to study the effect of the irregularities on the structure. The study emphasis to identify the most vulnerable building among the selected buildings for seismic Zone IV.

RC Frame structure is considered for the analysis. Floor height of 3.0m is considered for all the models. The model of the RC Frame structure is developed in SAP2000. The model is first analysed as a regular frame structure. Then mass irregularity is introduced by providing a pool at 4th and 9th floors. The stiffness irregularity is provided by increasing the ground floor columns by 1.0m and, vertical irregularity by providing steps at 4th and 8th floors. Seismic zone IV and Soil Type II (medium soil) is considered for the analysis. The RC Frame structure is provided with applied loads which include live load, earthquake load and dead load confirming to to IS 875 part I, part II and IS1893-2016 respectively.In the present study, effect of irregularities on multi-story RC frame structure under seismic load is investigated. RC frame structure with Stiffness Irregularity, Mass Irregularity, Vertical Irregularities are analysed and a comparison is made with regular building. Response spectrum analysis of the RC frame structure has been done by subjecting the whole system to earthquake ground motion of El Centro earthquake using SAP 2000software.

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