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Seismic Analysis of Symmetric and Unsymmetric Buildings in Plan

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A B S T R A C T

Structural analysis is mainly used for finding out the behaviour of a structure when subjected to some action. Structural design of buildings for seismic loads is very important for structural safety during major ground motions. Buildings with symmetric and unsymmetrical buildings in plan also have different geometry, strength, stiffness. Buildings with a symmetric distribution of stiffness and strength in plan undergo coupled lateral and torsional motions during earthquakes stiffness. The recent earthquakes, in which many reinforced concrete structures have been severely damaged or collapsed, indicated the need for evaluating the Seismic performance buildings. Earthquakes have shown that the irregular distribution of mass, stiffness and strengths i.e. unsymmetrical buildings may cause serious damage in structural systems. From this project it is concluded that symmetric buildings perform better than un-symmetric buildings when subjected to earthquake forces.

Keywords:Symmetrical building, Asymmetrical building, Earthquake Analysis, Static and Dynamic Loads.

1. Introduction

For the design of structures qualitative seismic design provisions and structural engineers require to perform both static and dynamic analysis. Both seismologists and earthquake engineers use the seismological data for the understanding of an earthquake and its effects, but their aims are different. It is very important to modify the prediction of the seismic behaviour of existing structures. This is the reason why studies of Seismic vulnerability of Buildings have been developed to evaluate the expected damage in the different types of buildings. The earthquake resistance structures are designed based on the some factors. The factors are natural frequency of the structure, damping factor, type of foundation, importance of the building and ductility of the structure. For high performance, the building is designed as an SMRF. It needs to be designed only for lesser forces than it is designed as an OMRF. Asymmetry can be reason for a buildings poor performance under sever seismic loading. The building with vertical setbacks and L, H, U or T shaped in plans are more affected during seismic event. Structural asymmetry can be a major reason for buildings poor performance under severe seismic loading. Earthquake is a sudden and transient motion of the earth’s surface. Seismological data from many earthquakes were collected and analysed to map and understand the phenomena of earthquakes. Seismologists focus their attention on the global issues of earthquakes and are more concerned with the geological aspects, including the prediction of earthquakes. Loading on buildings can vary from normal commercial loads to heavy loads for special buildings used for specific purpose, such as Data centre buildings. Plan layout of all analytical models are kept same for symmetrical buildings on plain grounds and asymmetrical buildings on sloping grounds. To study the seismic effects of infill on symmetrical and asymmetrical models, seismic analysis is performed using linear dynamic (Response spectrum method) and nonlinear static methods (Pushover analysis) equivalent static analysis and Nonlinear dynamic analysis.

1.1. LITERATURE REVIEW

- Seismic analysis of structure (T. k. Datta) (2010): The author studied of collected seismological data and it has helped in the rational design of structures to withstand earthquakes, it has also revealed the uncertain nature off earthquakes for which such structures are to be designed. Therefore, probabilistic concepts in dealing with earthquakes and earthquake resistant designs have also emerged. The author has used Modal Analysis Using the Substructure Technique to analyse the seismic forces on frame of building. He has taken two circular footings of radius 1 m below the two columns to analyse its behaviour
- DesaleSachin L3, JondhaleRohini B4, SabaleGanesh(2011): Structural analysis is mainly used for finding out the behaviour of a structure when subjected to some action. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc.
- Dr. S. D. Bhole, Sabahat J. Ansari (2015): In present scenario, most of the buildings are often constructed with irregularities such as soft storey, torsional irregularity, unsymmetrical layout of in-fill walls, vertical and plan irregularity, etc. Past earthquake studies shows that the most of the RC buildings having such irregularities were severely damaged under the seismic ground motion.
- SayantikaSaha(2015): The author says at present scenario many buildings are symmetric in plan or in elevation based on the distribution of mass and stiffness along each storey throughout the height of the building. She has taken a G+9 building with symmetrical distribution and unsymmetrical distribution by plan. Then she simulates building in a software and compares both buildings. Buildings with a symmetric distribution of stiffness and strength in plan undergo coupled lateral and torsional motions during earthquakes. Most recent earthquakes have shown that the irregular distribution of mass, stiffness. In conclusion she says In case of unsymmetric buildings the centre of stiffness and the centre of mass does not coincide with each other. Therefore torsional moments arise when the structure is subjected to dynamic earthquake loads.
- B K Raghuprasad, Vinay S, Amarnath. (2016): In this paper author says structural asymmetry can be a major reason for the poor performance of buildings under severe seismic loading, Asymmetry contributes significantly for translational-torsional coupling in the seismic response which can lead to increased lateral deflections, increased member forces and ultimately collapse. In this paper the inelastic seismic behaviour of symmetric and asymmetric single. Then he defines a problem for research. A single storey frame with 150mm thickness of slab resting on four numbers of beams 300 x 300mm cross section of span 4m and 300 x 300mm four numbers of columns is considered for the analysis. In conclusion the author says natural frequencies of an asymmetric spring model are greater than those of symmetric spring model while the rotations about the vertical axisthrough the mass centre of an asymmetric model are lesser than those of symmetric model displacement of asymmetric column model due to an earthquake ground motion is greater than that of symmetric column model.
- Md. JaweedJilani Khan, SeshadriSekhar and BellamSivarama Krishna Prasad (2017): In this study the focus is the seismic design of buildings with heavy loadings such as Data centre Buildings which are compared with the normal buildings with normal loads. Buildings may be symmetric or asymmetric in plan or elevation which depends on the stiffness and mass distribution in each storey. Hilly regions of India fall under the high seismic zones.

2. PROPOSED METHOLOGY

The calculation of the response of a building structure to earthquakes is part of the process of structural design. Structural analysis methods can be divided into the following five categories.

2.1. Equivalent static analysis

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting.

2.2. Response spectrum analysis

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions.

2.3. Nonlinear static analysis

In general, linear procedures are applicable when the structure is expected to remain nearly elastic for the level of ground motion or when the design results in nearly uniform distribution of nonlinear response throughout the structure. As the performance objective of the structure implies greater inelastic demands, the uncertainty with linear procedures increases to a point that requires a high level of conservatism in demand assumptions and acceptability criteria to avoid unintended performance. Therefore, procedures incorporating inelastic analysis can reduce the uncertainty and conservatism. This approach is also known as "pushover" analysis. A pattern of forces is applied to a structural model that includes non-linear properties (such as steel yield), and the total force is plotted against a reference displacement to define a capacity curve. Nonlinear static procedures use equivalent SDOF structural models and represent seismic ground motion with response spectra. Story drifts and component actions are related subsequently to the global demand parameter by the pushover or capacity curves that are the basis of the non-linear static procedures.

2.4. Nonlinear dynamic analysis

Nonlinear dynamic analysis utilizes the combination of ground motion records with a detailed structural model, therefore is capable of producing results with relatively low uncertainty. In nonlinear dynamic analyses, the detailed structural model subjected to a ground-motion record produces estimates of component deformations for each degree of freedom in the model and the modal responses are combined using schemes such as the square-root-sum-of-squares. In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous, and is required by some building codes for buildings of unusual configuration or of special importance. a comprehensive assessment calls for numerous nonlinear dynamic analyses at various levels of intensity to represent different possible earthquake scenarios. This has led to the emergence of methods like the incremental dynamic analysis.

3. Objective

- To study the seismic parameters of building structure.
- Defining a problem statement for symmetric buildings.
- Creating a model of symmetric building on software and analysis of symmetric building subjected to seismic forces.
- Defining a problem statement for unsymmetrical building.
- Creating a model of unsymmetrical building on software and analysis of unsymmetrical building subjected to seismic forces.
- Comparison between symmetrical and unsymmetrical building subjected to earthquake.

4. Result

Response Structure analysis was performed on regular and various irregular buildings using Etabs. The storey shear forces, storey drift, displacement and base shear were calculated for each floor and graph was plotted for each structure.

4.1. Comparison of Regular and Plan Irregular structure:

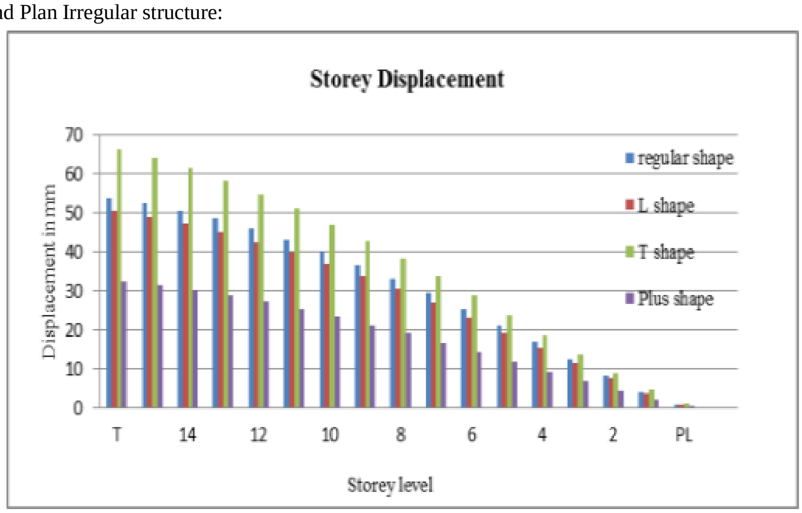

Fig. 1 - Storey displacement in X direction

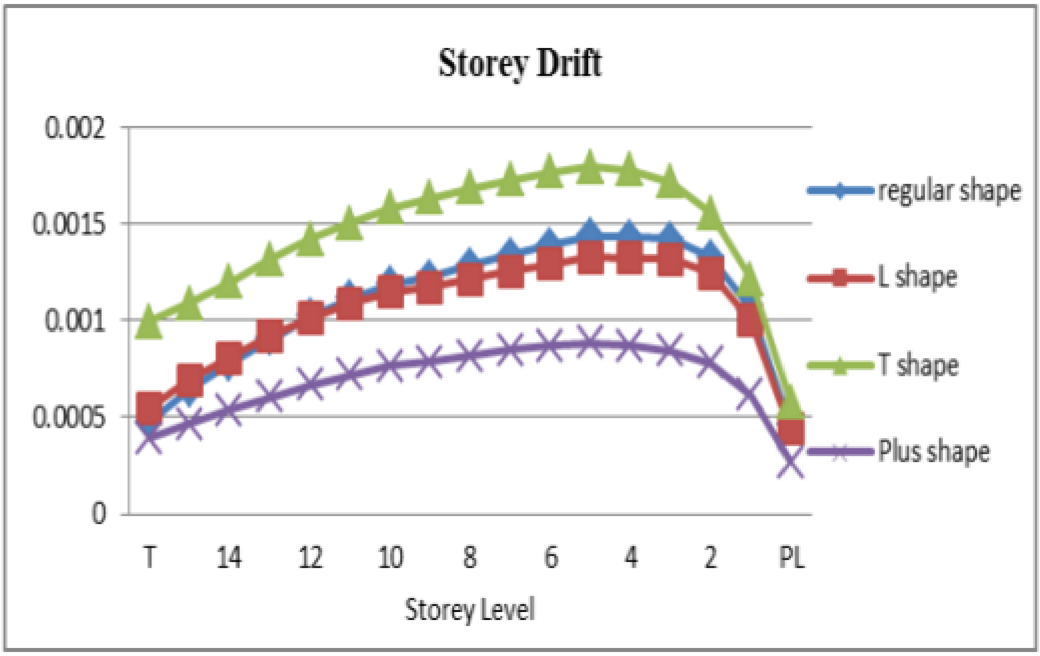

Fig. 2 - Storey drift in X direction

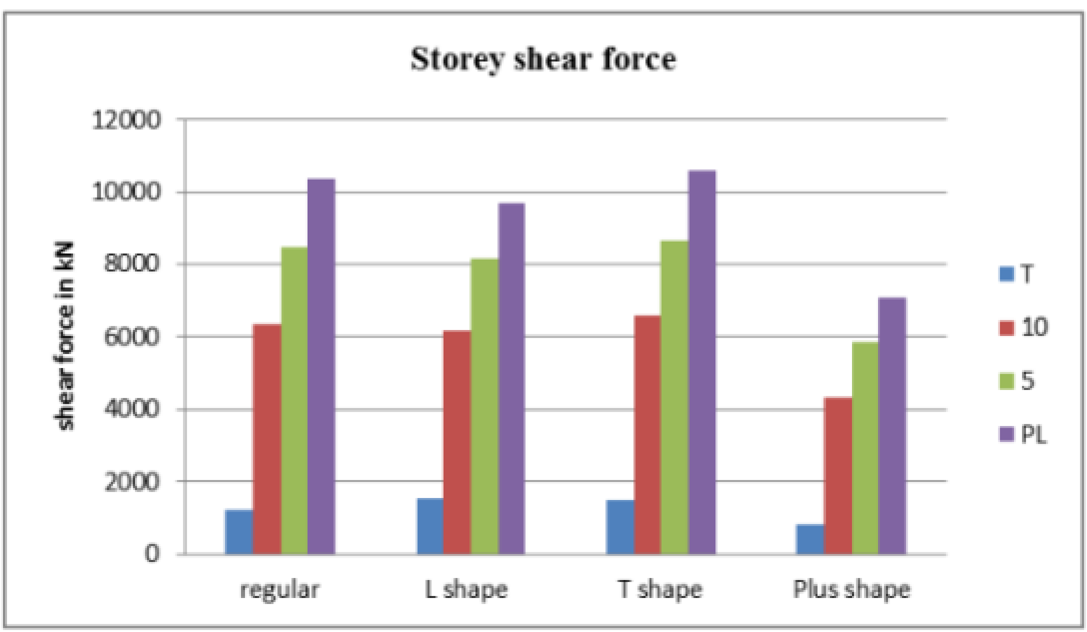

Fig. 3 - Storey shear force in X direction

5. CONCLUSION

- Buildings constructed on hilly sloping terrain are very irregular in configuration and behaves differently than those built on plains.
- Presence of infills have overall effect on the behavior of buildings when subjected to the seismic forces. Displacements are considerably reduced in Model-3 because the effect of infill walls is considered.
- 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.
- Large displacement was observed in the T shape building. It indicates that building with severe irregularity shows maximum displacement and storey drift.
- According to results of RSA, the stiffness irregular building experienced lesser base shear and has larger inter storey drifts.

- As a result of comparison between time history method and response spectrum method it has been observed that the values obtained by response spectrum analysis of base shear and top storey displacement are higher than time history analysis
- From the results it is recommended that time history analysis should be performed as it predicts the structural response more accurately than the response spectrum analysis
- Displacements in buildings with heavy loading of data centre are higher compare to the buildings with normal loading for response spectrum method.

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