Assessment of the Codal Provisions for Asymmetric Buildings

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Abstract - *The exploration on asymmetrical structures has been broad essentially concentrating on the soundness of a structure when subjected to tremor (earthquake).I have in this thesis endeavored to assess the viability of the rules gave in the IS: 1893 (2000). Asymmetrical structures are more typical now than they have ever been and their prevalence has been becoming basically because of the usefulness they give. Because of the regular quakes that India endures being at the intersection of two structural plates it has turned out to be progressively vital to consider Indian structures for seismic security*

For a working to be symmetric it must have, at each floor level, correspondent focuses of mass and firmness that lie on regular vertical pivot. By and by, this condition is once in a while experienced and most structures are asymmetrical to shifting degrees, because of asymmetry in plan, rise, and circulation of vertical individuals or mass conveyance on the floors. Various events of destroying tremors in India obviously require the need of assessment of Indian structures for seismic security. The structures are examined in view of the impact of torsion which is the primary driver of harm for Asymmetric Buildings. In this study Pushover analysis is used to analyse asymmetrical structure. Attempt has been made to improve torsional stability of the structure using SAP 2000 software.

Key Words: **Asymmetric Building, Mass Eccentricity, Dynamic Analysis, Pushover analysis, Torsional Rigidity**

1. INTRODUCTION

Structural asymmetry can be a major reason for the poor performance of buildings under severe seismic loading, Asymmetric design results significantly for translational-torsional coupling in the seismic response which can lead to more lateral deflections, force in members and ultimately results into collapse. The limitation of space in urban cities has caused many new changes in the symmetry of structure. The apartment complexes used to be a collection of apartments form the ground where the limitation of parking spaces has led to the modification of the lower floors into parking spaces for the residents. The design though provides utility but also makes the building asymmetric. Seismic damage surveys and analyses conducted after the earthquakes have shown that the modes of failure of the structures. It is apparent that the most vulnerable structures are those, which are asymmetric in nature. Hence the seismic behavior of an asymmetric structure has become important. Vertical irregularities in buildings are very common feature in urban area. In most of situations, buildings become vertically irregular at the planning stage itself due to some architectural and functional reasons. This type of buildings demonstrated more vulnerability in the past earthquakes. The topics related to of vertical irregularities have been in focus of research for a long time. Many studies have been conducted in this area in deterministic domain. Hence the focus of present study is to assess the relative performances of typical vertically irregular buildings in a Probabilistic domain. Seismic analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design.

1.1 ANALYSIS METHODS ARE:

1. Equivalent static analysis
2. Response spectrum analysis
3. Linear dynamic analysis
4. Nonlinear static analysis
5. Nonlinear dynamic analysis

2. EXISTING RESEARCH WORK

Rahila Thaskeen et al. (2016) In this paper both symmetric and asymmetric structures with plan irregularity are compared. Symmetric structures have centre of mass coinciding with the centre of rigidity and the torsion effect in such structures occurs out of accidental eccentricity whereas in asymmetric structures have irregular distribution of mass and stiffness and its centre of mass and centre of rigidity do not coincide and hence causes the torsional effect on the structures which is one of the most important factor influencing the seismic damage of the structure.

Mahure .S.H et al (2016) The torsion, Base shear, maximum displacement, and maximum drift are studied. Relative torsional values of structure having above conditions are compared with a structure without shear wall. Proving shear wall at eccentric position can increase force and torsion on structure. That can lead to uneconomical structure. Four different cases of shear wall position for a 11-storey building have been analyzed as a space frame system using a ETABS.

Ahmed Abrar et al.(2017) A set of ten different models are taken into account out of which the first model is with the regular structure, second-fifth with horizontal irregularities and the remaining sixth-tenth with both horizontal and vertical irregularities. He got the fundamental natural time period is observed to be the less for the model which is symmetry in shape as compared to asymmetry in shape, base shear yields low value in Response spectrum analysis when compared with the Equivalent static analysis.

Saha (2016) In case of asymmetric buildings the center of stiffness and the center of mass does not coincide with each other. Therefore torsional moments arise when the structure is subjected to dynamic earthquake loads. Therefore it is not safe for buildings to be asymmetric in nature. The moments and all other forces are much higher in asymmetric buildings, as a result the design dimensions of the members are higher in case of asymmetric buildings

Haselton et al. (2012) This paper provides guidance to design professionals on selection and scaling of ground motions for the purpose of nonlinear response-history analysis. Specific recommendations for ASCE/SEI 7 (ASCE/SEI 2010) are also provided, along with a summary of future research needs. This effort was completed by the Applied Technology Council (ATC-82) and funded by the National Institute of Standards and Technology (NIST); this paper is based on the NIST GCR 11-917-15 report "Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analyses" (NIST, 2011a).

Fahzan et al. (2012) Seismic design is traditionally performed for most common structures by the means of equivalent lateral static loading or modal spectrum analyses. Nevertheless, in some cases such as, irregular, highly ductile, critical or higher modes induced structures, conventional response spectral analyses are not capable of estimating maximum responses of linear systems, for which a time-integration scheme is deemed more appropriate (Preumont, 1984). Seismic design codes generally define ground shaking in the form of a response spectrum of acceleration and permit to use spectrally matched natural accelerograms recorded during earthquakes, spectrum compatible artificially generated and synthetic ground motions for the linear or nonlinear analysis of structures in linear and nonlinear time domain analyses.

Peethambaram et al. (2008) Natural hazard like earthquake affects the stability of such structures which are restricted to expand vertically not horizontally. Performance of structures in different areas of Northern part of India, during the earthquakes, is reviewed. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry. Nonlinear pushover analysis has been used to evaluate the seismic performance of three buildings with four different plans having same area and height. The results of effects of plan aspect ratio on seismic response of buildings have been presented in terms of displacement, base shear. Behaviour parameters of the analyzed moment resisting frames also calculated.

Basu et al. (2004) a rigid floor diaphragm is a good assumption for seismic analysis of most buildings, several building configurations may exhibit significant flexibility in floor diaphragm. However, the issue of static seismic analysis of such buildings for torsional provisions of codes has not been addressed in the context. Apart from, the concept of center of rigidity needs to be formulated for buildings with flexible floor diaphragms. In this paper, the definition of center of rigidity for rigid floor diaphragm buildings has been extended to asymmetrical buildings with flexible floors. A superposition-based analysis procedure is proposed to implement code-specified torsional provisions for buildings with flexible floor diaphragms. The procedure recommend considering amplification of static and accidental eccentricity both. The approach is applicable to orthogonal as well as non-orthogonal asymmetrical buildings and account for all possible definitions of center of rigidity.

3. ANALYSIS

The modeling for structure was done using SAP 2000 and the analysis is being conducted in ETABS building design and other analysis were also conducted with ETABS.There are two structures (models) which is taken one is of 5 storey with height 15.5m with 4 bays in the X direction of spans lengths of 5m at the 2 spans at the periphery and the central span is about 4m in length. The structure has 3 spans in the Y direction with the 2 spans at the periphery being 5m each and the central span is about 4m in length. The assumed materials are Concrete of grade M30 and the Steel is Fe 415. The Beams are considered to have a cross-section size of about 350x600m and the columns are made of the same cross section sizes with the longer side along the longer span. The Structure is loaded with a live load of about 3KN/m^2 as per the live load requirements for a residential building as per IS 845 Part II. The load was applied to the center of mass at the first try for symmetric building. The center of mass (CM) was then applied at a point 1.9m away from the centroid of the structure. The design of the structure was designed in ETABS as per IS: 456. The designed reinforcements were then taken imported into the SAP 2000 software and Pushover analysis was conducted on the structure. The Hinge used in the model was based on FEMA 356 for the respective columns and beams. The Degrees of Freedom for the Beams was M3 and for the Columns was P-M2-M3. The Pushover analysis is then conducted and the occurrence of hinges is observed. Two Load Cases were constructed to conduct the analysis in both directions the force is applied as acceleration.

3.1 SUMMARY

Indian Standard 1893: 2002, International Building Code IBC 2003, Canadian code NBCC 1995 are examined to use the concept of minimum eccentricity to be assumed during design calculation for safety. The value of the dynamic eccentricity is also generally calculated based on the same formula involving the static eccentricity the width of the structure based on the direction of the eccentricity in question. The basis of difference among the codes is primarily on the values of the coefficients used in the formula while some codes prescribe a direct formula for calculation others codes prescribe a particular constant value. Most design eccentricities are based on the formula.

$$e_{di} = \alpha e + \beta b$$

$$e_{si} = \gamma e - \beta b$$

Table: Values in different codes

IS 456	IBC 2003	NZ4203:1992	NBCC 1995
1.5	1	1	1.5
0.05	$0.05A_x$	0.1	$.01A_x$
1	1	1	0.05

4. CONCLUSIONS

It can be concluded that though the impact of the earthquake force is great on the 15.5 m model the resultant effect of the eccentricity is small for the 15.5 story model while the 30.5m model experiences a more significant change when the mass eccentricity is applied. Hence the useful for tall structures like the 30.5m model but not so effective for the smaller 15.5m model. The change in the inner section of the building is small for the 15.5 and the 30.5 model, while the difference increases as we approach the periphery hence it is proposed that to save time the inner most columns can be designed for the column to the periphery and the design can be applied to all the innermost columns as the variation is very small while the outer columns at the buildings periphery need to be designed separately.

The rise in the reinforcement required with the height of the building makes it possible for a simpler formula for calculation of the reinforcements of the structure thought the exact formulation of the formula will require study of more models and further study.

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