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RESEARCH ARTICLE OPEN ACCESS

Behavior of Symmetric and Asymmetric Structure in High Seismic Zone

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Abstract:

In the present report, at present scenario many buildings are asymmetric in elevation based on the distribution of mass and stiffness along each storey throughout the height of the building. Most recent earthquakes have shown that the irregular distribution of mass, stiffness and strengths may cause serious damage in structural systems. This project performance of the torsionally balanced and torsionally unbalanced buildings also called as symmetric and asymmetric buildings by subjecting to response-spectrum analysis. The buildings have un-symmetrical distribution of vertical irregularinstorey's. In this project the effort is made to study the effect of eccentricity between centre of mass (CM) and centre of stiffness (CR) on the performance of the buildings. Three buildings (G+3), (G+6) & (G+9) models are considered for study, which are constructed on medium soil in seismic zone II of India (as per IS:1893-2002), one symmetric and asymmetric in vertical irregular distribution. The performance of a multi-storey framed building during sturdy earthquake motions depends on the distribution of mass, stiffness, and strength in both the horizontal and vertical planes of the building. In some cases, these weaknesses may be produced by discontinuities in stiffness, strength or mass between adjoining storeys. Such discontinuities between storeys are often allied with sudden variations in the frame geometry along the height.

Keywords — **Symmetric Structure, Asymmetric Structure, response-spectrum Analysis, SAP 2000, vertical geometric irregular**

I. INTRODUCTION:

Torsion has been the cause of major damage to buildings subjected to strong earthquakes, ranging from visible distortion of the structure to structural collapse. Torsion occurs under the action of earthquake forces when the centre of mass of a building does not coincide with its centre of rigidity. Some of the situations that can give rise to this situation in the building plan are positioning the stiff elements asymmetrically with respect to the centre of gravity of the story; The placement of large masses asymmetrically with respect to stiffness.

Irregular buildings constitute a large portion of the modern urban infrastructure. The group of people involved in constructing the building facilities, including owner, architect, structural engineer, contractor and local authorities, contribute to the overall planning, selection of structural system, and to its configuration. This may lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineer's role becomes more challenging. Therefore, the structural engineer needs to have a thorough understanding of the seismic response of irregular structures. In recent past, several studies have been carried out to evaluate the response of irregular buildings. In this project presents the details of the non-linear dynamic analysis performed on mass and stiffness irregular buildings. It is established that irregular buildings are subjected to large displacements compared to regular buildings and localized damages near the regions of irregularity

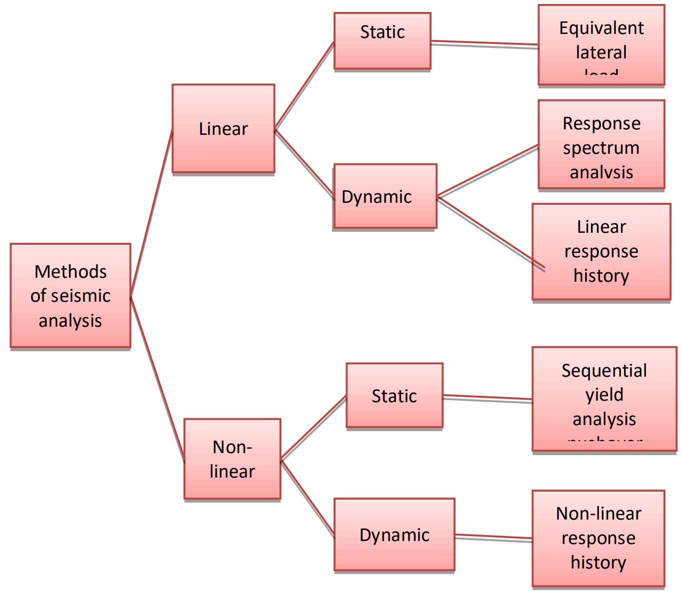
There are many earth quake resistant factors which can be considered while designing a structure. Some of the factors are Strong column, weak beam, Shear wall, Base isolation. The behaviors of each of these factors are unique. The performance of a structure for these factors can be studied analytically and experimentally. Behavior of a simple structure for these factors will give a good vision about the importance of these factors. In this project will give a brief idea about Strong column, Shear wall and Brick infill placed in a simple structure

Most buildings have some degree of irregularity in the geometric configuration or the distribution of mass, stiffness, and/or strength. Due to one or more of these asymmetries, the structure's lateral resistance to the ground motion is usually torsionally unbalanced creating large displacement amplifications and high force concentrations within the resisting elements which can cause severe damages and at times collapse of the structure. Eccentric arrangement of non-structural components, asymmetric yielding, presence of rotational component in ground motions and the variations in the input energy imparted by the ground motions also contribute significantly to the torsional response of buildings. In India, failure of two most famous apartments during the 2001 Bhuj earthquake was reported due to torsional response. The study of dynamic torsional effects in buildings, particularly in multi-storey structures where this effect is more pronounced has been possible only with the recent development of programmed for the dynamic analysis of three dimensional frame structures. Torsion occurs when the centre of mass does not coincide with the centre of rigidity in a story level. This can be a result of a lack of symmetry in the building plan or random disposition of live loads in an otherwise symmetrical structure. Torsion can also be included in symmetrical structures by the rotational components of ground motions. Structural symmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to the potential for translational-torsional coupling in the structures dynamic behavior which can lead to increased lateral deflections, increased member forces and ultimately the buildings collapse. The buildings with L, Y, U, H, or T shaped plans which built integrally as units; large forces may develop at the junction of the arms as a result of vibration components directed normal to the axes of the arms. In addition, there is horizontal torsional effect on each arm arising from the differential lateral displacements of the two ends of each arm.

II. OBJECTIVE OF STUDY:

1. To study the effect of torsion for symmetric and asymmetric multi-storiedR.C.building in high seismic zone.
2. To study the response spectrum methods for analysis of symmetric and asymmetricbuilding structures.
3. To compare the response parameters such as story drift, base shear, joint displacement, torsional moment of Symmetrical and conventional building.

III. METHOD OF ANALYSIS:



Response Spectrum method, being time consuming and tedious process, most of time, it resort to computer applications. Now while, modeling the structure, in most of available software's, usually, we model the space frame, neglecting the in-fill wall stiffness. These results in flexible frames, and due to which, in most of Cases, the program gives a higher Time Period and results into lower base shear. Today with the availability of Powerful Computers and Software, the seismic coefficient method should not be applied to anything other than mass concrete!! In such a case a reduction coefficient would not be applicable. The infill walls and slabs should be modeled. If software has plate modeling capability, these can be modeled as plates. Otherwise an "equivalent" pair of diagonal members connecting the four corners of the slab or wall (in each bay) would simulate the shear behavior The diagonal members shall be 'truss' members - i.e. capable of only carrying axial load. The elastic properties can be derived from first principle, by matching forces and deformations in a plate and the equivalent diagonals.

IV. LITERATURE REVIEW :

Dr. S. N. Tande[1] **S. J. Patil**[2] Presented "Seismic Response of Asymmetric Buildings" In this paper Structural asymmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to the potential for translational-torsional coupling in the structures dynamic behavior which can lead to increased lateral deflections, increased member forces and ultimately the buildings collapse. In this paper the inelastic seismic behavior and design of asymmetric multistoried buildings are studied. The effects of torsion on buildings are investigated. The buildings with setbacks are analyzed for torsion. Study also shows that there is increase in shear, in columns and the columns at outer frame need some special attention.

Undareson A[1], Ganesh Baravkar[2], Vijaya Sarathy R[3] Presented "Parametric study of response of an asymmetric building for various earthquake resistance factors" In this paper Earthquake is a major concern in high seismic prone areas. The structure which lies in seismic zones are to be specially designed. The goal of earthquake-resistant design is to construct structures that fare better during seismic activity than their conventional counterparts. In this paper a study is conducted on the performance of a asymmetric structure, with plan irregularity, strength and stiffness irregularities.. A time history analysis is performed using Relevant software, a comparative discussion is made on the response of structure between normal building and building which is designed for earthquake resistant. The results showed that it was important to select a suitable parameter, for the type of resistance that the building must offer. This parametric study clears the importance of each earthquake resistance factors.

Khante.S.N[1], Lavkesh R.Wankhade[2] Presented "Study of seismic response of symmetric and asymmetric base isolated building with mass asymmetry in plan" In this paper, the effect of mass asymmetry in symmetric and asymmetric building is studied. To study the effect of torsion in seismic behavior of base isolated structures, a symmetric and asymmetric multi story concrete building is chosen as reference model. These models with mass eccentricity of 5%, 10%, 15% and 20% of greatest dimension of building in indirection and bidirectional are considered. The response spectrum and non linear time history analysis of this eccentric model of fixed base and base isolated building using SAP2000 software is done.

Sachin G. Maske[1] , Dr. P. S. Pajgade[2] presented-"Torsional behavior of asymmetrical buildings" in this paper ,Torsionalbehavior of asymmetric building is one of the most frequent source of structural damage and failure during strong ground motions. In this work a study on the influence of the torsion effects on the behavior of structure is done. In building two cases are considered, case one is without considering torsion and case two is considering torsion. The Indian standard code of practice IS-1893 (Part I: 2002) guidelines and methodology are used to analyzed and designed building. Results are compared in terms of % Ast in columns.

Dr. B. G. Naresh Kumar[1], Avinash Gornale[2] and Abdullah Mubashir[3] Presented "Seismic Performance Evaluation of R c-Framed Buildings - An Approach to Torsionally Asymmetric Buildings". In in this paper the effort is made to study the effect of eccentricity between centre of mass (CM) and centre of stiffness (CR) and the effect of stiffness of infill walls on the performance of the buildings. The performance of the buildings is assessed as per the procedure prescribed in ATC-40 and FEMA-356. Four building models are considered for study, which are constructed on hard soil in seismic zone III of India (as per IS: 1893-2002[9]), one symmetric and 3 asymmetric in stiffness distribution. Infill's were modeled using equivalent strut approach. Static analysis (for gravity and lateral loads) and non-linear pushover analysis (assigning the hinge properties to beams and column sections) were performed. It is concluded that the performance of the models in which the stiffness of walls considered is found better when compared with the models in which the stiffness of walls ignored. And with increase in eccentricity, the performance point of the structure will be more but due to increase in stiffness, structure may fail in brittleness

V. STRUCTURAL MODELLING :

The method used in this study is *Seismic Coefficient Method* which is an equivalent static analysis considering a design seismic coefficient. In equivalent lateral procedure dynamic effects are approximated by horizontal static forces applied to the structure. This work is based on three dimensional reinforced concrete building with varying heights and widths. Various building geometries are taken for the study. These building configurations represent different degree of vertical irregularity or amount of setback. The same bay width of 3m is taken in both the horizontal direction .Two cases are considered for the bays. In first case, the numbers of bays are four and in second case, these are eight. The uniform storey height of 3.5m is considered in all the cases.

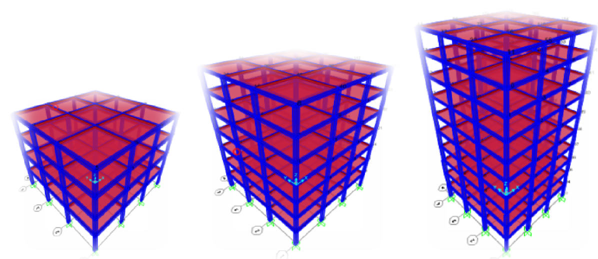


Fig.1 Different Models Considered

Number of Stories = G +03, G+06,G+09
Storey Height = 3 meters
Number of Bays along X-direction = 3
Number of bays along Y-direction = 3
Bay Width along X-direction = 5 meters
Bay Width along Y-direction = 5 meters
Size of 'Column' –500X250 mm
Size of 'Column0'– 450X250 mm
Size of 'Column1' – 600X300 mm
Size of Beam – 300X250mm
Depth of Slab – 150 mm

VI. RESULTS AND DISCUSSIONS:

The structure analyzed is a high rise , mid rise, low rise buildings reinforced concrete framed structure and high rise , mid rise, low rise buildings Symmetrical structure etc. Response spectrum method of analysis is used to study the behavior of structure. Various parameters such as Time Period, Lateral Displacement, Story Drift, and Base Shear are compared and conclusions are formulated for the same. The software used for the modeling and analysis is SAP2000.

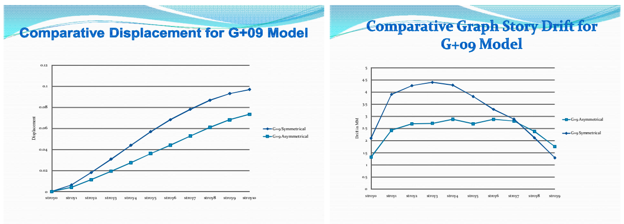


Fig.2 Comparative Graph Displacement & Story Drift for G+09 Model

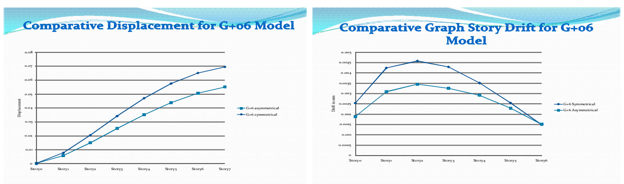


Fig.3 Comparative Graph Displacements & Story Drift for G+06 Model

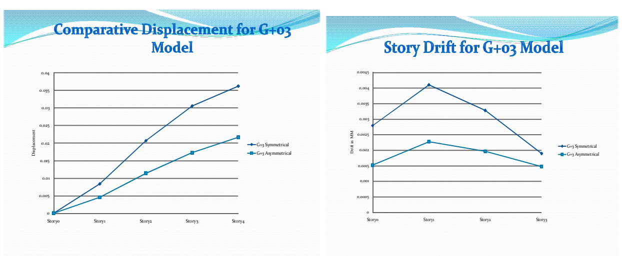
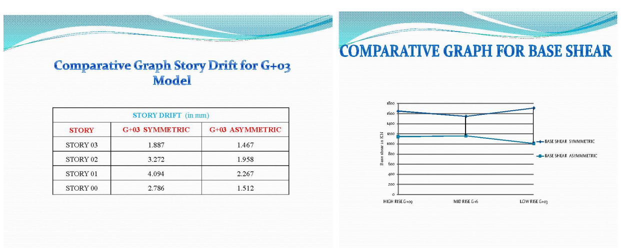


Fig.4 Comparative Graph Displacements & Story Drift for G+03 Model



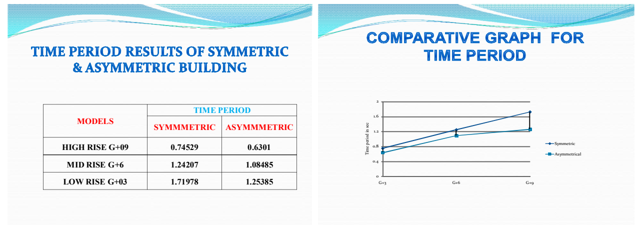
STORY	STORY DRIFT (in mm) G+03 SYMMETRIC	G+03 ASYMMETRIC
STORY 03	1.887	1.467
STORY 02	3.272	1.958
STORY 01	4.094	2.267
STORY 00	2.786	1.512

Fig.5 Base shear

OBSERVATIONS OF RESULT FOR BASE SHEAR

The result have been represented

1. From Graph it can be seen that, the Base shear of model G+09 is more as compared to other models. This Base shear goes on decreasing when No. of storey decreases.
2. From Graph can be seen that, the Base shear of Symmetrical building is more as compare to Asymmetrical building.



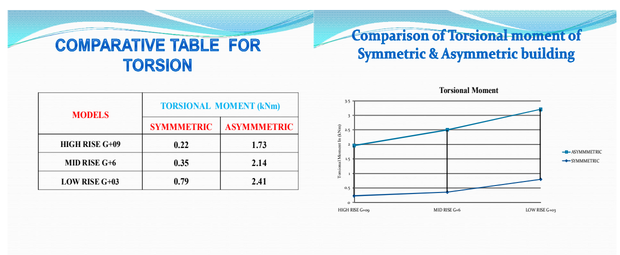
MODELS	TIME PERIOD SYMMETRIC	ASYMMETRIC
HIGH RISE G+09	0.74529	0.6301
MID RISE G+6	1.24207	1.08485
LOW RISE G+03	1.71978	1.25385

Fig.6 Time period

OBSERVATIONS OF RESULT FOR TIME PERIOD

The result have been represented

1. In comparison of Symmetric building and Asymmetrical building the time period is more for Symmetrical building than Asymmetrical building.
2. Natural time period increases as the height increases (no. of storey).
3. The time period of high rise building is more than mid and low rise building.
4. The time period decreases as the No. of storey decreases.
5. In Symmetrical building time period increases as the No. of storey increases.



MODELS	TORSIONAL MOMENT (kNm) SYMMETRIC	ASYMMETRIC
HIGH RISE G+09	0.22	1.73
MID RISE G+6	0.35	2.14
LOW RISE G+03	0.79	2.41

Fig.8 Torsional moment

OBSERVATIONS OF RESULT FOR TORSIONAL MOMENT

The result have been represented

1. In comparison of Symmetric building and Asymmetrical building the Torsional moment is more for Asymmetrical building than Symmetrical building.
2. Torsional moment decreases as the height increases (no. of storey).
3. The torsional moment of low rise building is more than mid and high rise building.

VII. CONCLUSIONS

The following conclusions are made from the current study

- Performance of Asymmetrical building is better than Symmetrical building for given loading and soil condition.
- The column sizes behavior changes differently for Asymmetrical and Symmetrical structure, as height of building increases.
- Structural parameters such as storey drift, lateral displacement, time period is higher into Asymmetrical structure.
- Base shear of Symmetrical structure is more as compare to Asymmetrical structure.
- Torsional moment in asymmetrical structure is more than symmetrical structure.

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