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# Comparison of Displacement for Regular and Irregular Building Due To Seismic Forces

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***Abstract***: *With the immense loss of life and property witnessed in the last couple of decades alone in India, due to failure of structures caused by earthquakes, attention is now being given to the evaluation of the adequacy of strength in framed RC structures to resist strong ground motions. In this study symmetrical (G+10) and irregular (G+13) reinforced concrete structure has been considered, which lies in Zone II, according to IS 1893:2000 classification of seismic zones in India. Masonry in-fills have been considered as non-structural members during this entire study. Conventional analyses of the buildings is done by taking the base of the structure to be fixed but in the real life the scenario will be different as compared to a fixed end condition because the soil beneath the foundation will vary the earthquake forces and thus varying the lateral forces acting on the structure. The analysis of structural members is done using STADD PRO. The results of the analysis obtained, necessitated a trial step requiring the variation in its dimension due to its plan irregularity. Further the comparison in the drift in X-direction and Z-direction were obtained.*

***Keywords***: *Symmetrical, unsymmetrical, displacement, drift*

## 1. Introduction

Earthquake has a high potential to cause a wide-spread damages in densely populated areas which causes heavy loss of human life and high economic losses. This cause of damage is due to lack of knowledge of the engineers and hence resulting in improper design of structures. The structural engineer who designs earthquake-resistant structures needs to know as to how exactly the soils respond during an earthquake, not only is this important for the foundation design itself, but the nature of soil overlaying bedrock may have a crucial modifying influence on the overall seismic response of the site.

### 1.1 Earthquake

Earthquake is defined as shaking of the ground produced by forces called seismic forces. This vibration causes the shaking of buildings causing mild to severe damages to buildings leading to loss of human life. Recently severe earthquakes have devastated many places and heavy loss of life. This has led to a detailed study of structures.

## 2. Literature Review

*Siamak Sattar and Abbie B. Liel*[1] analyze the seismic performance of masonry-infilled RC frames, including a set of 4 and 8-story buildings with different infill configurations. Seismic performance assessments indicate that, of the configurations considered (bare, partially-infilled and fully-infilled frames), the fully-infilled frame has the lowest collapse risk and the bare frame is found to be the most vulnerable to earthquake-induced collapse. Results of pushover analysis show an increase in initial stiffness, strength, and energy dissipation of the infilled frame, compared to the bare frame, despite the wall's brittle failure modes. *Putul Haldar and Yogendra Singh (2009)*[2] studied the adequacy importance of various code provisions are examined by estimating the expected performance of a set of code-designed buildings. The FEMA-440 and HAZUS methodologies are used for estimating the seismic performance and vulnerability. It is shown that the Special Moment-Resisting Frame design under the current design provisions of Indian standards has a higher probability of damage, as compared with the Ordinary Moment-Resisting Frame design, because of the higher allowable ultimate drift limit. It is also shown that the deterministic framework of performance-based seismic design does not provide complete insight into the expected performance and associated risks of the designed buildings.

*Abdur Rahman, et al (2012)* [3] analyze the drift for lateral loads and comparison on drift for earthquake and wind loads on tall structures. To analyze the drift, we used programming with C (version C++ 4.5). Mainly we analyzed three types of high rise structures such as rigid frame , couple shear wall and wall frame structures. Strength, serviceability and stability in tall structures have to include in design criteria. Strength is satisfied by limit stresses, while serviceability is satisfied by drift limits in the range of H/500 to H/1000.On the other hand stability is satisfied by sufficient factor of safety against buckling and P-Delta effects.

*Dr. Raghvendra, el al (2014)* [4]the present work is to compare the seismic behavior of regular multi-storey building frame with vertically irregular building frame at different positions. To study the behavior the response parameters selected are lateral displacement and storey drift. All the frames are assumed to be located in zone II, zone III, zone IV and zone V. For analysis STAAD Pro software is used. Present work provides a good source of information on the parameters lateral displacement and storey drift.

S Monish and S Karuna (2015)[5] studied the effect of seismic performance of the buildings with vertical irregularity namely vertical geometric irregularity and stiffness irregularity with sloping ground. The methods of analysis considered are static and dynamic method, with parameters like displacement, base shear and fundamental natural period. The modelling and analysis is carried out using ETABS software. Resultant, models resting on sloping ground are found to be the most vulnerable among all the models due to the shortening of the column length which results in reduction of stiffness and dynamic method of analysis is more accurate than static method hence the results obtained using response spectrum gives more realistic values.

**3. Structural Details**

**3.1 Isometric View of Buildings**

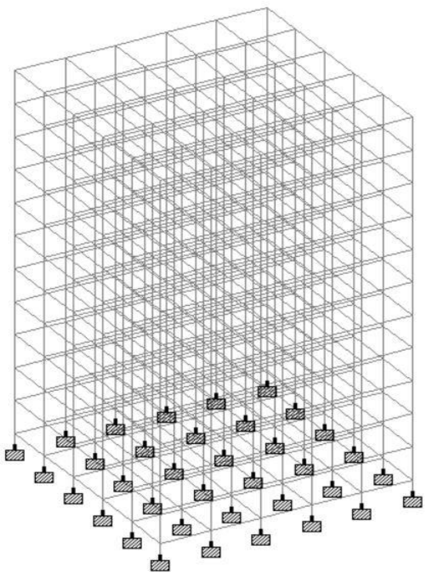

**Fig. 3.1 Symmetrical Building (G+10)**

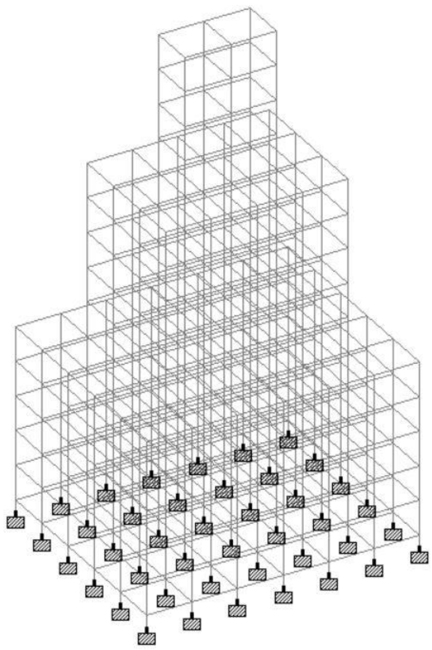

**Fig. 3.2 Irregular Building (G+13)**

**3.2 Geometric Parameters**

**Table 3.1 Geometric Parameters of Space Frame**

| Sl. No. | Parameters | Symmetrical Building | Irregular building |
|---|---|---|---|
| 1 | Type of Structure | Symmetrical building | Irregular building |
| 2 | Number of storeys | 11 | 14 |
| 3 | Number of bays in X-direction | 5 | 6 |
| 4 | Number of bays in Z-direction | 5 | 5 |
| 5 | Bay width in X-direction | 4 m | 4 m |

| | | | | | |
|---|---|---|---|---|---|
| 6 | Bay width in Z-direction | 4 m | | 4 m | |
| 7 | Storey height | 3 m | | 3 m | |
| 8 | Slab thickness | 125 mm | | 125 mm | |
| 9 | Beam size | 0.3 × 0.3 m | | 0.45 × 0.23 m | |
| 10 | Column sizes | i.1st four floors<br>ii.5th to 8th floor<br>iii. Last 3 floors | 0.52×0.52 m<br>0.45×0.45 m<br>0.38×0.38 m | i. 10th floor and 4 corner of boundary of the structure.<br>ii. 10th floor except 4 corner of boundary and core of structure.<br>iii. core of structure upto 10th floor. | 0.3×0.45 m<br>0.45×0.45 m<br>0.6×0.6 m |

### 3.3 Dead Load and Live Load on Structure

**Table 3.2 Dead Load and Live Load on Structure**

| Sl. No. | Description | Symmetrical Building | Irregular Building |
|---|---|---|---|
| 1 | Dead load of floor finish | 1 KN/$m^2$ | 1 KN/$m^2$ |
| 2 | Live load on floors | 3 KN/$m^2$ | 3 KN/$m^2$ |
| 3 | Brick walls | 17.25 KN/m | 13.8 KN/m |
| 4 | Parapet wall on roof periphery | 5.75 KN/m | 4.6 KN/m |
| 5 | Floor load | 7.125 KN/$m^2$ | 7.125 KN/$m^2$ |

### 3.4 Material Properties

**Table 3.3 Material Properties of Concrete and Steel**

| Sl. No. | Property | Value |
|---|---|---|
| 1 | Grade of concrete for all structural elements | M20 |
| 2 | Modulus of elasticity of concrete (N/mm2) | Ec = 5000√fck |
| 3 | Poisson's ratio of concrete | 0.17 |
| 4 | Density of concrete | 25000 N/$m^3$ |
| 5 | Grade of Steel for all structural elements | 415 N/$mm^2$ |

## 4. Analysis of Structure

STAAD contains a broad set of facilities for designing structural members as individual components of an analyzed structure.

The operations to perform a design are:

- Specify the members and the load cases to be considered in the design.
- Specify whether to perform code checking or member selection.
- Specify design parameter values, if different from the default values.
- Specify whether to perform member selection by optimization.

Earthquake motion often induces force large enough to cause inelastic deformations in the structure. If the structure is brittle, sudden failure could occur. Therefore ductility is also required as an essential element for safety from sudden collapse during severe shocks. STAAD has the capabilities of performing concrete design as per IS 13920. While designing it satisfies all provisions of IS 456 – 2000 ,IS 1893-2002 and IS 13920 for beams and columns.

## 5. Result And Validation

The building model (G+10) & (G+13) has been analyzed using STAAD pro. The model validation is done to check the safety of members in the structure, lateral displacements and also to find the storey drift of the structure.

**5.1 Symmetrical Building**

**Table 5.1 Lateral displacements along X and Z directions**

| Floors | Maximum displacement in X direction (mm) | Maximum displacement in Z direction (mm) | Storey Drift both X and Z direction (mm) |
|---|---|---|---|
| 0 | 1.16 | 1.16 | 0 |
| 1 | 14.528 | 14.528 | 13.368 |
| 2 | 35.383 | 35.385 | 20.857 |
| 3 | 59.177 | 59.18 | 23.795 |
| 4 | 83.81 | 83.813 | 24.633 |
| 5 | 109.362 | 109.367 | 25.554 |
| 6 | 133.519 | 133.526 | 24.159 |
| 7 | 155.471 | 155.479 | 21.953 |
| 8 | 174.671 | 174.68 | 19.201 |
| 9 | 191.585 | 191.596 | 16.916 |
| 10 | 202.8 | 202.811 | 11.215 |
| 11 | 208.6 | 208.6 | 5.789 |

**5.2 Irregular Building**

**Table 5.2 Lateral displacements along X and Z directions**

| Floors | Maximum displacement in X direction (mm) | Storey Drift in X direction (mm) | Maximum displacement in Z direction (mm) | Storey Drift in Z direction (mm) |
|---|---|---|---|---|
| 0 | 0.344 | 0 | 0.326 | 0 |
| 1 | 3.992 | 3.648 | 3.764 | 3.438 |
| 2 | 9.043 | 5.051 | 8.497 | 4.733 |
| 3 | 14.48 | 5.437 | 13.558 | 5.061 |
| 4 | 20.082 | 5.602 | 18.728 | 5.17 |
| 5 | 25.723 | 5.641 | 23.882 | 5.154 |
| 6 | 32.226 | 6.503 | 30.045 | 6.163 |
| 7 | 39.047 | 6.821 | 36.638 | 6.593 |
| 8 | 45.453 | 6.406 | 42.866 | 6.228 |
| 9 | 51.18 | 5.727 | 48.441 | 5.575 |
| 10 | 56.222 | 5.042 | 53.303 | 4.862 |
| 11 | 67.495 | 11.273 | 61.281 | 7.978 |
| 12 | 77.727 | 10.232 | 69.502 | 8.221 |
| 13 | 84.658 | 6.931 | 75.644 | 6.142 |
| 14 | 87.979 | 3.321 | 79.247 | 3.603 |

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**5.3 Lateral Displacements Graph**
**Symmetrical building**

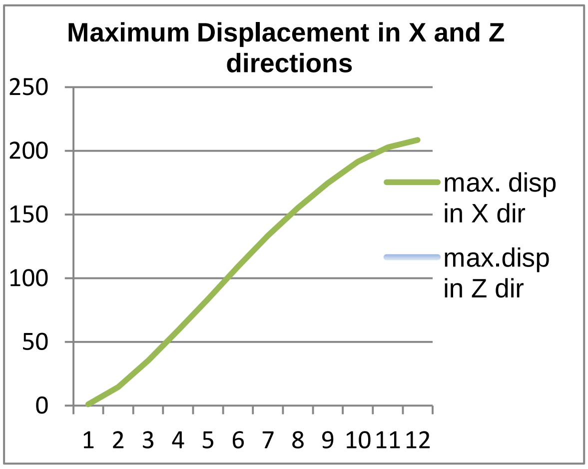


**Fig. 5.1 Displacement graph along X and Z directions**

**Irregular building**

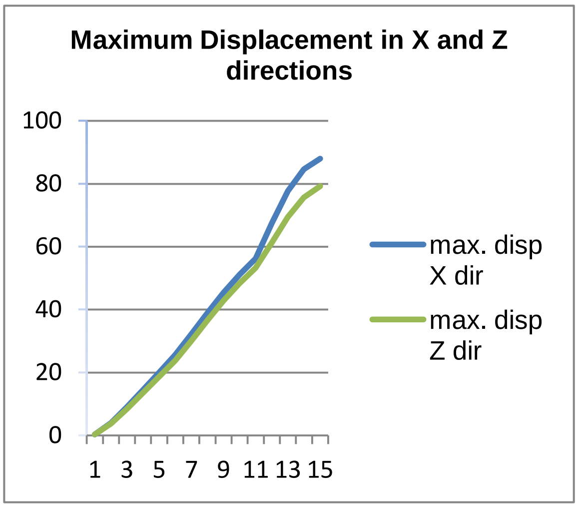


**Fig. 5.2 Displacement graph along X and Z directions**

**5.4 Storey Drifts Graph**

**Symmetrical building**

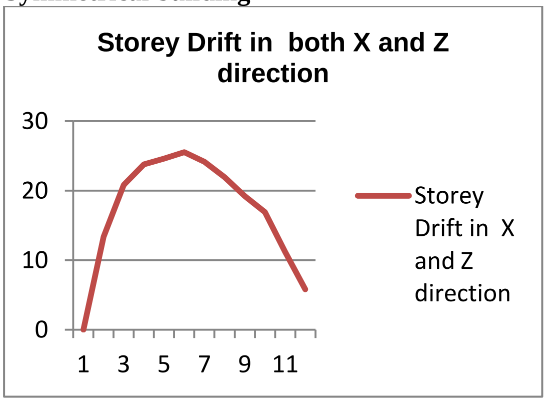


**Fig. 5.3 Storey Drift along both X and Z directions**

**Irregular building**

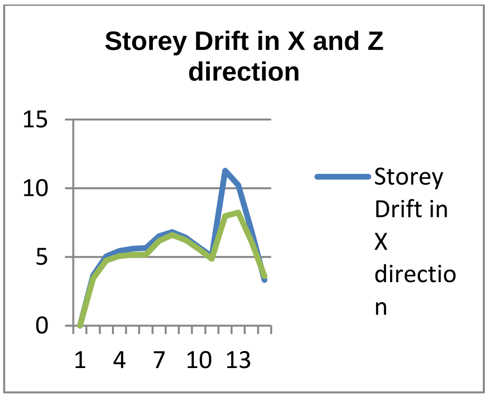


**Fig. 5.4 Storey Drift along X and Z directions**

**6. Conclusion**

Structure failure during earthquakes in the past demonstrated effects and its consideration to avoid failure and ensure safety. In this, the building was modelled and analysed in STADD Pro, the maximum displacement and storey in X and Z directions was taken.

- In Symmetrical building the maximum displacement is 208.6 mm in X and Z directions.
- In Irregularity structure the maximum displacement in X direction was 87.9mm and Z direction was 79.2mm.
- This shows that the displacement had direct correlation with plan dimension. As the plan dimension was higher in X direction (24m) than the Z direction (20m) the values of displacement is also higher correspondingly in irregular building.
- The storey drift in irregular building is less than that of regular building, as the mass is reduced in irregular building though the number of storeys is more.

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