Effect of Geometric Irregularity on Steel Building Subjected To Seismic Load

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Abstract-*In this study, an attempt is made to study the behaviour of steel building having geometric irregularity when subjected to seismic load. For the study purpose, 9 models are selected each possessing varying percentage of Re-entrant corner (Plan) irregularity. The comparison is then to be carried out for all those buildings on the basis of parameters such as – base shear, lateral displacement and fundamental time period. Analysis done is Equivalent Static analysis and Response spectrum Analysis. Staad-Pro software is used for the study purpose.*

Keywords- Re-entrant Corner irregularity, Response spectrum analysis, Steel building, Staad-Pro.

I. INTRODUCTION

Over the past century, steel frame buildings have become a frontrunner in the construction industry. In recent years, the construction of irregular buildings have increased and especially in urban areas. One of the reason is the client wants to have a unique architectural elevation instead of sound structural system. Therefore, a need has developed to check whether this irregularly planned building can withstand the lateral loads acting on the building and the effect these irregularities produce in the building.

An attempt is thus made to research the effect of geometric irregularities on a steel building when a seismic load acts on it. For the study purpose, a regular building without any irregularity is analyzed by Equivalent static analysis and then with response spectrum analysis. 8 models of bay frame 6x6 with bay width of 5 meter each having re-entrant corner irregularity in them in varying percentage is modeled in Staad-Pro.

Parameters considered for the comparison of regular building with the building having irregularity are – Base Shear, Lateral Displacement and fundamental time period.

II. LITERATURE REVIEW

Before commencing the study work, various research papers were studied to understand the topic in depth.

Pradip Sarkar, A. Meher Prased and Devdas Menon [1], proposed a new method of quantifying irregularity in building frames, accounting for dynamic characterisctics (mass and stiffness). The proposed ‘irregularity index’ provides a basis for assessing the degree of irregularities in a stepped building frame. The paper also proposed a modification of the code specified empirical formula for estimating fundamental period for regular frames and to estimate the fundamental time period of the stepped building frame. The proposed equation for fundamental time periods was expressed as a function of the regularity index.

Amin Alavi and P. Srinivasa Rao [2], tried to understand the behaviour of the structure in high seismic zone. For this purpose, a five storey-high building on eight different configurations having re-entrant corners, with a regular configuration which served as a comparison, were investigated.

Dr. S.K. Dubey and P.D. Sangamnerkar [3], tried to understand different irregularity and torsional response due to plan and vertical irregularity, and to analyze “T”-shaped building while earthquake forces acts and to calculate additional shear due to torsion in the columns.

III. ANALYTICAL WORK

Models are prepared in Staad-Pro software. A software validation was carried out to validate the accuracy of the software and the results were satisfying.

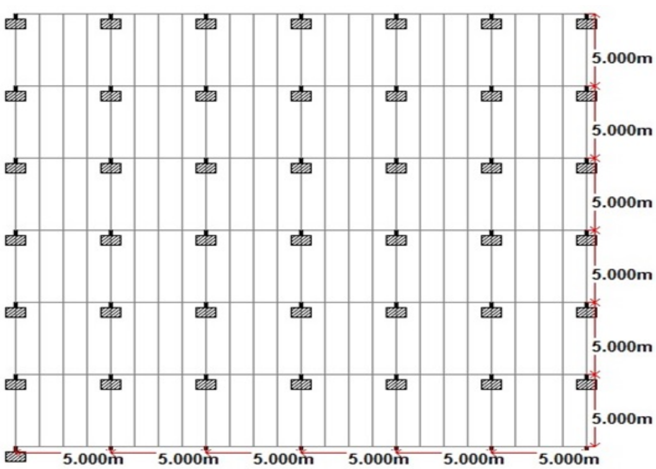
First a model of regular building without any irregularity is prepared. Model has 6x6 bays with bay width of 5 meter each. Building is G+10 building with storey height of typical floor as 3 meter and foundation depth as 2.5 meter. Seismic zone is Zone III of IS : 1893 – 2002.

Model Name	% of Irregularity
M1	-
M2	5.56
M3	11.12
M4	16.67
M5	22.23
M6	27.78
M7	33.34
M8	44.45
M9	55.56

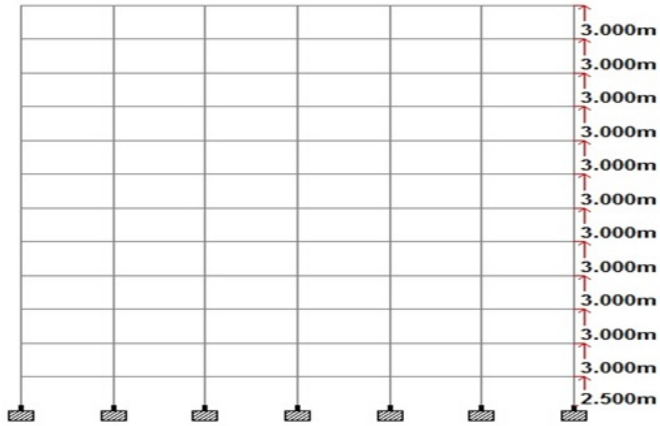
Irregularity % is calculated by, (Area of bay removed / Total bay area) x 100.

Loads applied are dead load, live load and seismic load. Dead load is of wall load on periphery considering the wall of 230 mm. Partition wall is applied alternatively of 115 mm thickness. Parapet wall load is applied on terrace of 115 mm thickness. Live load is of 4 kN in all floors except ground floor and roof terrace floor load is of 2 kN.

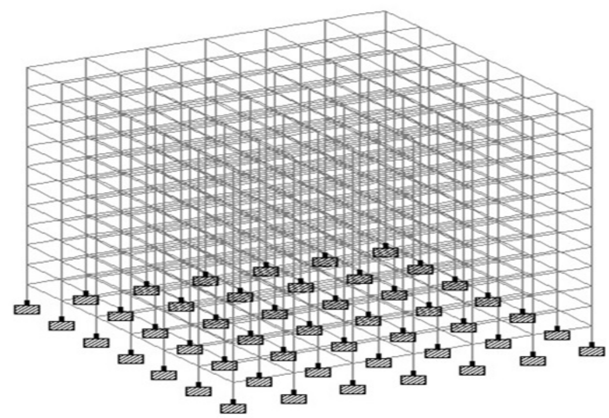
9 Models are first analyzed for equivalent static analysis. Reading and results are noted. Then those 9 models are then analyzed for response spectrum analysis. Again results are noted for further comparison.



Typical Floor Plan of M1 model



Elevation of model M1

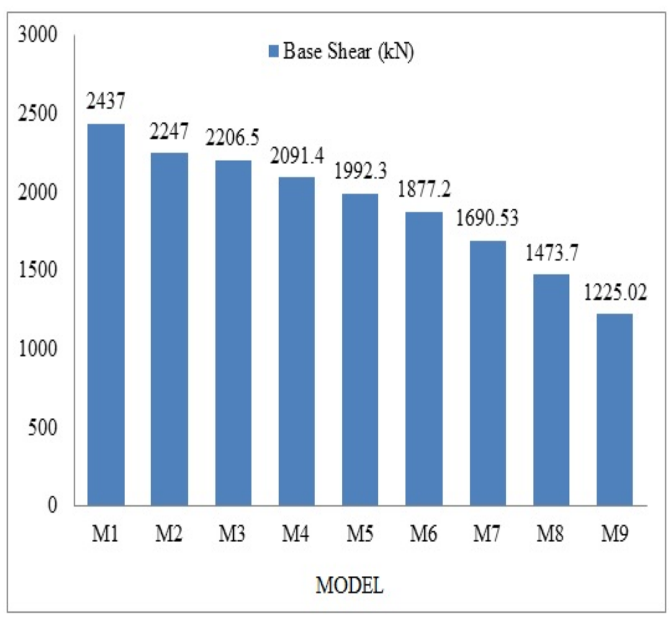


3D view of model M1

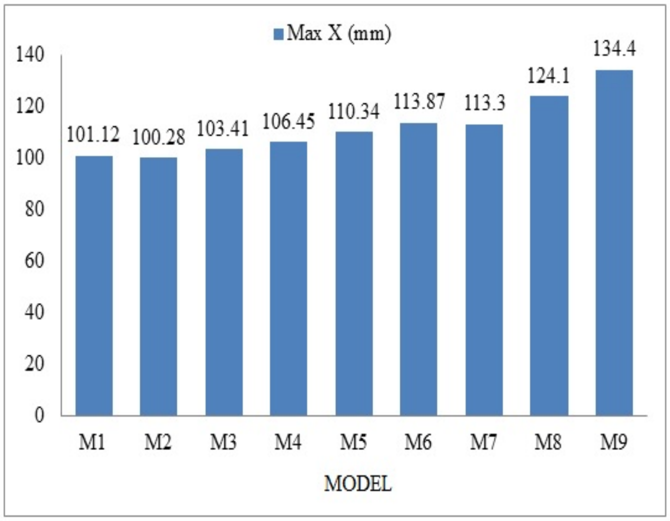
IV. RESULT

a) Equivalent Static Analysis :-

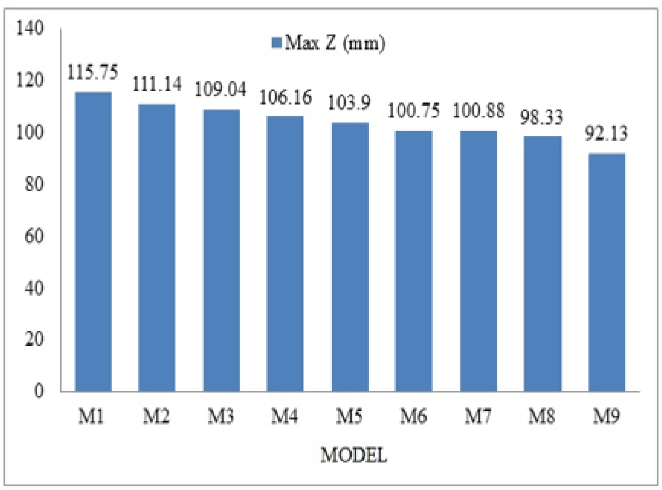
i. Base Shear –

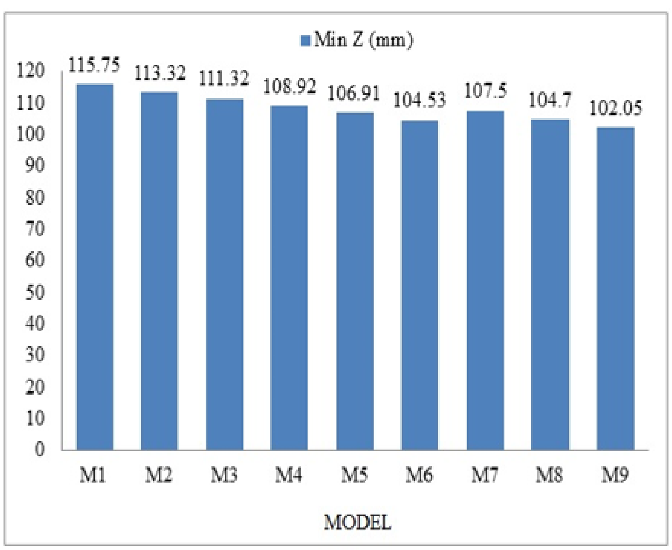


ii. Lateral Displacement –

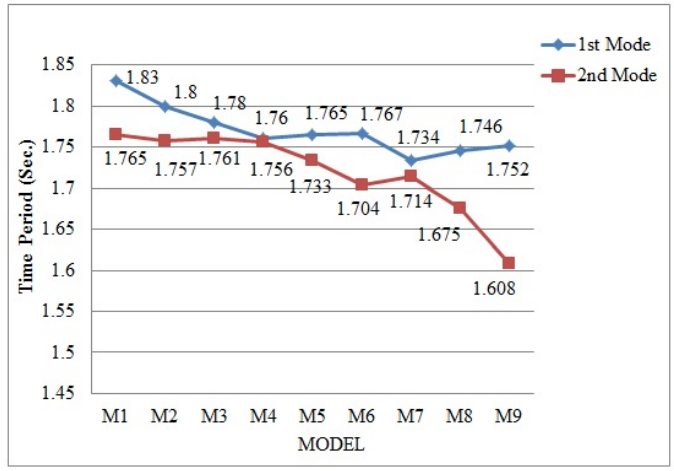


Max and Min X are having the same value, hence a single display of chart.

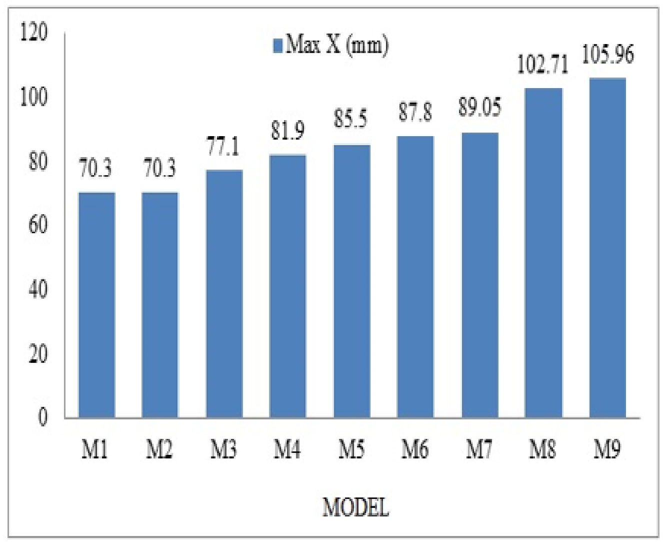


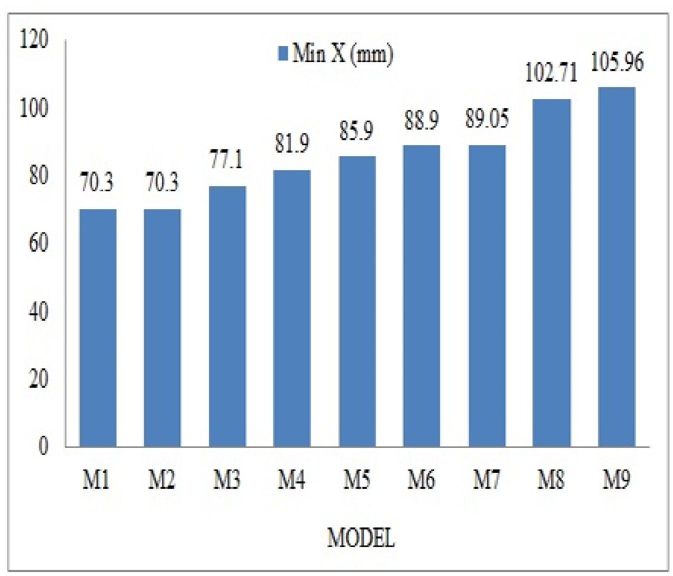


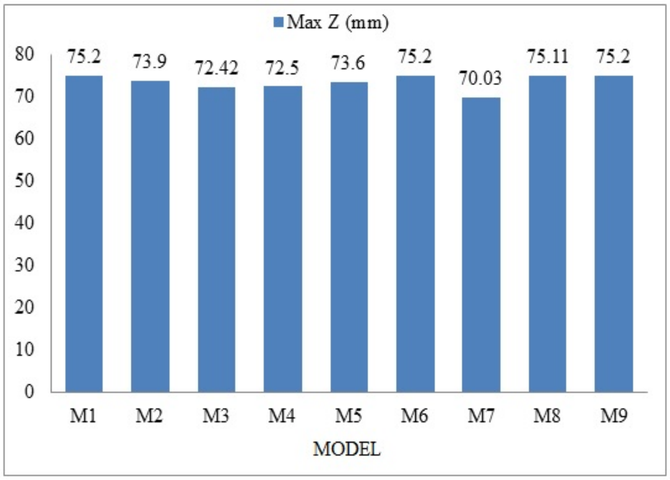
a) Response Spectrum Analysis :-

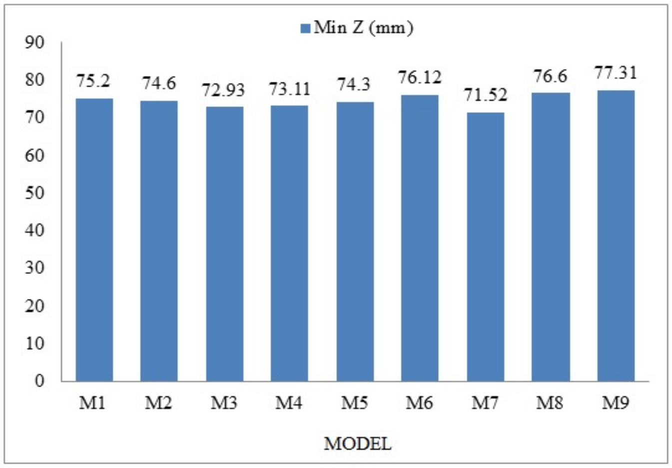


ii. Lateral Displacement -









V. CONCLUSION

After undertaking the equivalent static analysis and response spectrum analysis, the results obtained gave the following conclusion:-

- As understood, due to decrease in the mass of the building, the base shear is to be decreased and that can be clearly reflected from the result of base shear obtained by equivalent static analysis.
- Lateral displacement of the building in X direction increases as the irregularity increases in both the directions i.e. maximum X and Minimum X.
- Whereas for direction Z, the lateral displacement of the building decreases as the irregularity increases.
- One thing found from the lateral displacements is that the lateral displacement chances its pattern from model ‘M7’. If the displacement increases then at ‘M7’ it decreases for some value and then it increases drastically to the above mentioned pattern and vice versa. The reason can be stated that number of bay having irregularity in X and Z directions changes at model ‘M7’. Till ‘M6’ bays removed for irregularity in X directions were 2 whereas from ‘M7’ they are 4.
- From response spectrum analysis, time period of the buildings are found from the 1st mode and 2nd mode of the building. The comparison of first mode and second mode can be seen in the result.
- First mode time period decreases as irregularity increases till ‘M4’. It increases for ‘M5’ and ‘M6’ but decreases again for ‘M7’. “M8’ and ‘M9’ sees rise in the time period but it still remains lower than ‘M4’ and ‘M6’.
- Second mode sees the decrease in time period till ‘M6’. It increases for ‘M7’ but then sees drastic decrease for ‘M8’ and ‘M9’.
- Lateral displacement of the building in X direction increases with increase in irregularity for both maximum X and minimum X.
- For displacement of building in Z direction, the displacement decreases as irregularity increases till ‘M3’. It then increases up to ‘M6’. It decreases for ‘M7’ but again increases for ‘M8’ and ‘M9’.
- The same is the case for lateral displacement in minimum Z direction.

We can derive a conclusion from the above that irregularity does affect the building. Lateral displacement increases with increase in irregularity. Therefore, care should be taken as to provide proper measures to reduce the lateral drift if it exceeds the code provisions.

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