ANALYTICAL STUDY ON SEISMIC PERFORMANCE OF PLAN IRREGULAR STRUCTURES

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Abstract- The buildings constructed in irregular configuration due to economical feasibility, land availability and other factors. From the observations of past earthquakes, a structure with regular configuration structures stay safe in Earthquakes than an structure with irregularities. Structures experience lateral displacements under earthquake loads. This work focuses on studying the various sorts of building irregularities possible and their behaviour during earthquake forces. The various structural behaviour parameters such as displacement, base shear, storey drift, moment, end forces etc., are needed to be studied. The structures are designed and analysed by Time History Analysis using STAAD.PRO V8i software. From this analysis the results obtained shows that the base shear was higher in regular structure but the load transfer was uniform throughout its height. The L shaped structure showed a least performance during an earthquake.

Keywords: **Irregular structures, time history analysis, staad.pro, displacement, base shear.**

I. INTRODUCTION

An earthquake is the shaking of the surface of the earth resulting from a sudden release of energy in the Earth's lithosphere that creates seismic waves. Large strain energy released during an earthquake travels as seismic waves in all directions through the Earth's layers, reflecting and refracting at each interface. There are number of factors that affect the behavior of a building during an earthquake. Structural irregularities are more important factors which decrease the seismic behavior of the structures. There are two types of irregularities in structures, plan irregularity and vertical irregularity. The seismic behavior of a structure can be analyzed using Response spectrum analysis and Time history analysis. In this study Time history analysis method is adopted.

II. LITERATURE SURVEY

Chandler and Hutchinson (1986) concluded that torsional coupling induces a significant amplification of earthquake forces which should be accounted for in their design. **Abd-el-rahim and Farghaly (2010)**, found that the induced base shear perpendicular to the earthquake direction is sensitive to the torsional eccentricity and increases by about 80%, 65%, and 40% of the base shear in earthquake direction for T, L, and U shape respectively. **Gokdemir et al. (2013)**, Under excessive torsion, structural elements may reach to their torsional moment capacity or the whole structure may be forced to deflect beyond its lateral deflection limit. **Padol et al. (2015),** whenever structure has different irregularity the effect of earthquake on structure can be minimize by providing shear wall, base isolation etc. **Soni (2015)**, Buildings with soft storey and heavy mass at top storey suffered maximum displacement. Storey drift is maximum, which change abruptly when heavy loaded. **Sweetlin et al. (2016)**, says that displacement have direct co relation with mass of building so displacement in regular building is more than irregular building. **Kabir et al. (2015)**, concluded that C- shaped and L- shaped multi-storey buildings are more susceptible to static, dynamic seismic load and wind load compared to the rectangular and irregular shaped buildings. **Momen et al. (2016)**, observed that the response of L shaped building is higher than that of the regular frame due to torsion. **Reena Sahu et al. (2017)**, Provision of the diaphragm opening alters the seismic behaviour of the buildings. The increase in the opening percentage, increase the storey drift in all the models. **Ahirwal et al. (2019)**, Due to the reduction in floor area dead load of the regular structure is more than irregular structure which leads to increase in base shear of regular diaphragm building.

III. BUILDING DETAILS

Table-1: BUILDING DETAILS

Plan Dimension	16 x 16 m
Number of Storey	G+11
Storey Height	3 m per storey
Material used in the Building	Reinforced Cement Concrete
Beam Dimension	0.3 x 0.3
Column Dimension	0.4 x 0.4
Support	Fixed support (hard stratum)
Integration Time	0.001 Seconds
Force Amplitude	1

Damping Ratio	5%
Analysis Method	Time History Analysis

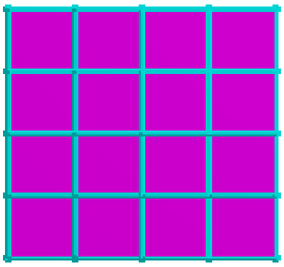

Fig-1

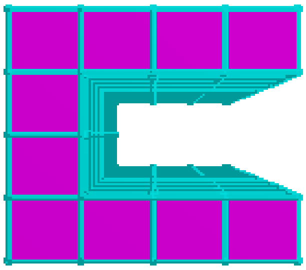

Fig-2

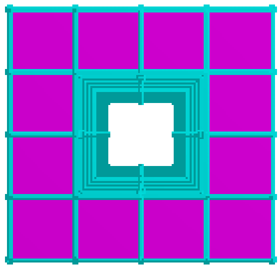

Fig-3

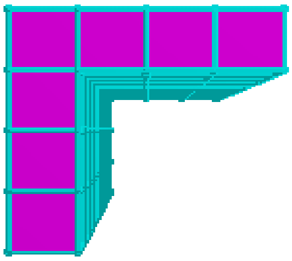

Fig-4

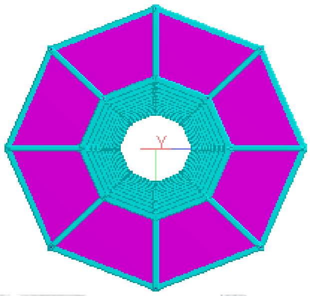

Fig-5

Plan View of Fig-1 Symmetric structure, Fig-2 C shaped structure, Fig-3 O shaped structure, Fig-4 L shaped structure, Fig-5 Octagonal structure

IV. RESULTS AND DISCUSSION

4.1 Comparison of Base Shear

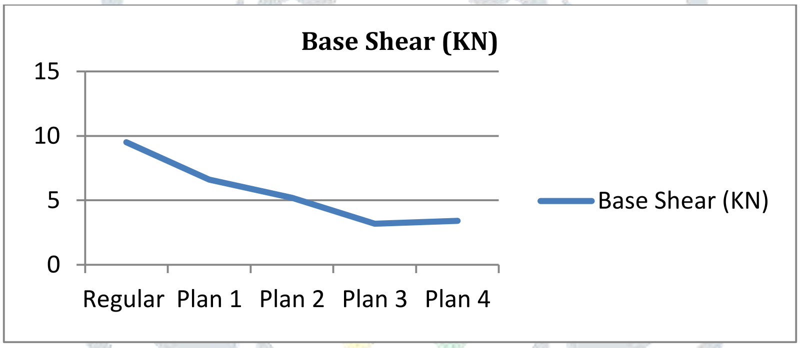

Fig-6: COMPARISION OF BASE SHEAR

The graph in Fig-6 clearly shows that the symmetric structure has highest base shear. The structure with L shaped plan has the lowest base shear

4.2 Comparison of Maximum Displacement

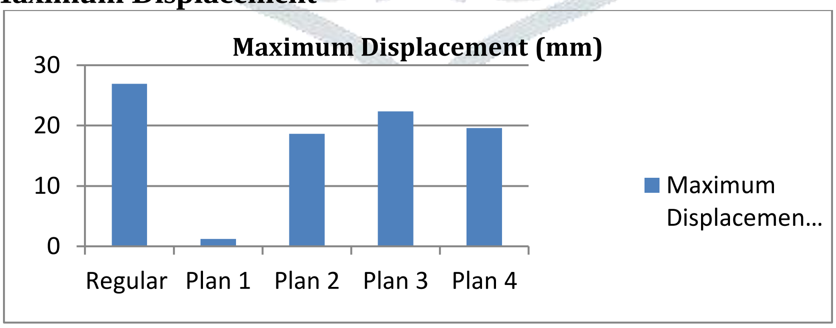

Fig-7: COMPARISION OF MAXIMUM DISPLACEMENT

The chart shown in Fig-7 compares the displacement of various structures along X- direction. From the chart it is evident that again the symmetric structure has the highest displacement. The "C" shaped structures have the least displacement value.

4.3 Comparison of Maximum Moment

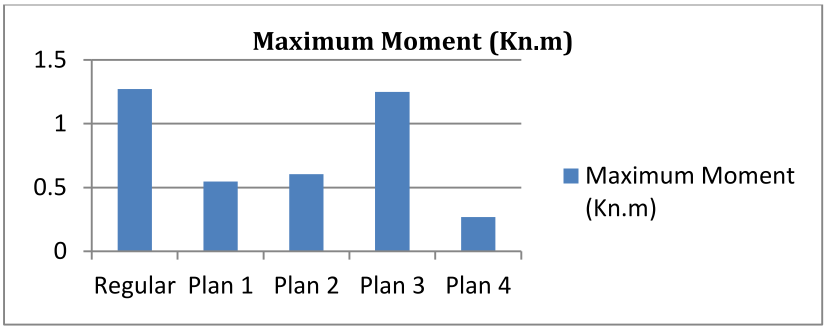

Fig-8: COMPARISION OF MAXIMUM MOMENT

In this chart in Fig-8 the maximum moment capacity between various structures have been compared. The maximum moment was carried by the symmetric structure. The octagonal structure suffered the least moment.

4.4 Comparison of Beam End Forces

The beam end forces of the structures are compared in this chart in Fig-9. As again the symmetric structure has to resist great level of beam end forces. The octagonal structure suffered a least value of beam end forces may be due to formation of reentrant corners.

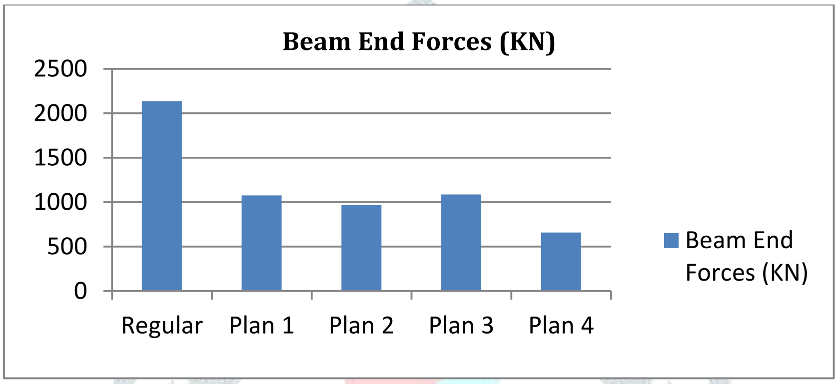

Fig-9: COMPARISION OF BEAM END FORCES

4.5 Storey Height Vs Displacement

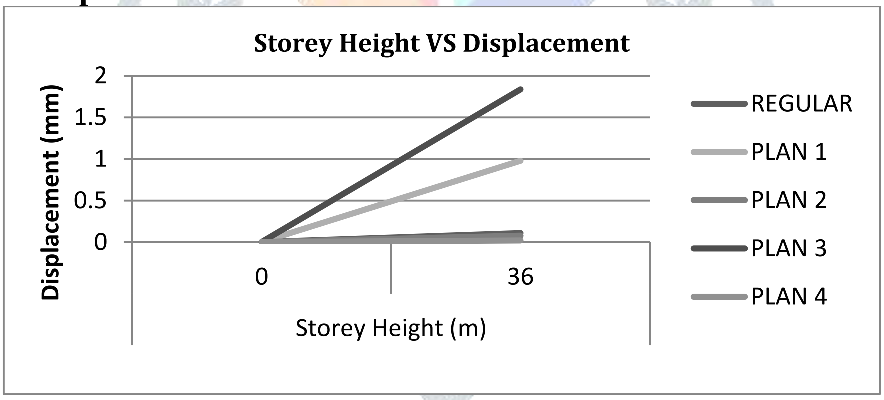

Fig-10: STOREY HEIGHT VS DISPLACEMENT

The graph in Fig-10 indicates the displacement variation along the height of the building with irregularities in plan. The displacement at the bottom of the building is zero at the structure was designed to have fixed support. The top floor of the structure suffers significant displacement. The "L" shaped structure showed highest displacement at top floors. The symmetric structure and the "O" shaped structure have least displacement at the top stories. The load transfer was even throughout the height in symmetric structure.

4.6 Storey Height Vs Beam End Forces

The beam end forces are concentrated at bottom floors of the structures. The graph in Fig-11 is plotted for the comparisons of beam end forces acting on the symmetric structure and the plan irregularity structures. The symmetric structure has the highest beam end forces value as the mass is concentrated at bottom and due to its heavier weight.

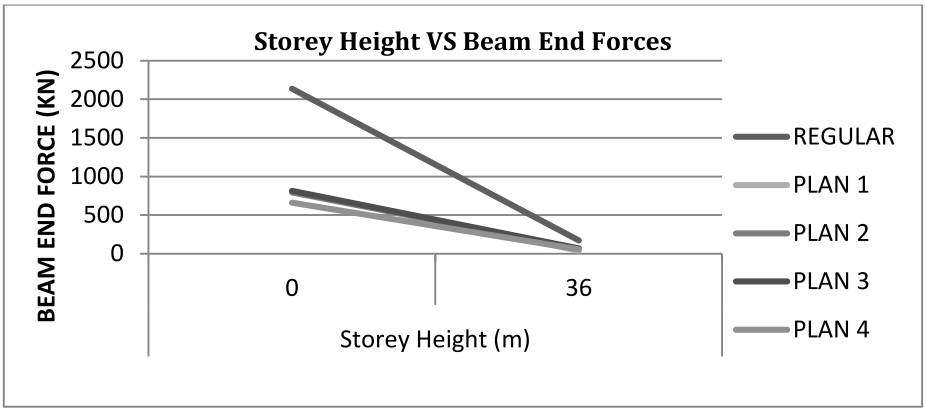

Fig-11: HEIGHT VS BEAM END FORCE

4.7 Storey Height Vs Moment

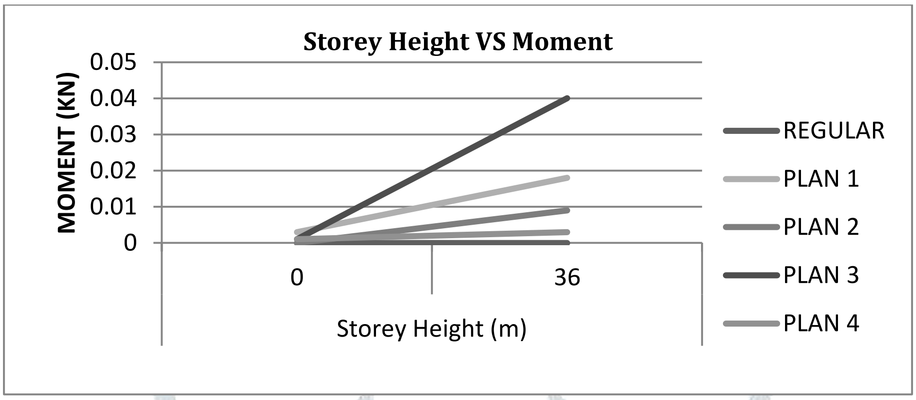

Fig-12: STOREY HEIGHT VS MOMENT

This graph in Fig-12 reveals the relationship between the height and the moment capacity of a symmetric structure and plan irregular structure. The moment was higher at top floor of 'L' shaped structure. The regular structure shows least moment generation at the top of the structure. The moment distribution was almost even and gradual throughout the symmetric structure.

V. CONCLUSION

The structures with plan irregularities are modeled and analysed using STAAD Pro V8i by Time history analysis method. The perfectly symmetric structure about X- direction and Z- direction has been chosen as standard reference structures. The output results are discussed as follows:

- The behaviour of building during the earthquake is depend upon many conditions like stiffness, strength, ductility and most probably on configuration of structure.
- Irregularities in buildings causes eccentricity between the building mass and stiffness centers, give rise to damaging effect on building. Structures with plan irregularities quite often suffer severe damage in earthquake events.
- Response spectrum analysis is the generally used method for analysis and design of earthquake resistance structures. But Time history analysis is more eminent and precise than Response spectrum analysis.
- Plan regular structure and 'O' shaped structure suffered maximum displacement compared to other irregularities.
- Though the regular structure showed more base shear and displacement value, the load transfer was even throughout the structure, which is an important while considering a structures safety during an earthquake.
- The formation of re-entrant corners greatly affects the load path.
- The L shaped structure showed the least performance during an earthquake.
- The moment of inertia has much importance in the stability of seismic resistant building which in turn clears the influence of mass of a structure.
- In high rise buildings the top stories are the one most affected if the structures are with irregularities.

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