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A Comparative Study on Seismic Analysis of Regular, Plan and Vertical Irregular G+12 RC Structure

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Abstract: Due to urbanization and less availability of construction land, the engineers are planning for multi-storied construction. In this study, a multi-storied (G+12) RC building is considered for earthquake analysis by using previous earthquake data i.e., the analytical method used for this work is response spectrum analysis. When the multistorey building constructions comes into the practice there are various possibility of failure of the structures, either it might be due to gravity loading or might be due to lateral pressures i.e., Earthquake or wind loads. If the structures are not analysed and designed for the above-mentioned loading conditions as per the IS codal specifications, a severe damage might be observed. So, in this study, the analysis is performed for gravity loadings and by using the previous earthquake analytical data, "Response Spectrum Analysis" method is used for the earthquake analysis. There is various finite element approach software are available in the market, for this study ETABS (version 21) is used for analysing the structure. In this study totally 5 models are used they are plan regular, regular and vertical irregular building are considered and the results for all of these are discussed in the coming chapters.

Keywords: Comparative Study on Regular building, Irregular building, Vertical irregular building, Seismic Zone, Response spectrum method.

I. INTRODUCTION

This study examines the impact of structural irregularities on the seismic performance of multi-story buildings. Irregular configurations whether in plan or elevation are frequently linked to structural failures during earthquakes due to stress concentrations and disrupted force flow. Misalignments between canters of mass and rigidity often cause torsional effects, increasing vulnerability. As architectural design decisions largely dictate structural layout, they play a critical role in seismic resilience and cost-effectiveness. Despite widespread use of irregular structures in urban environments for functional and aesthetic reasons, these irregularities especially in stiffness, mass distribution, and vertical geometry must be carefully evaluated. Among them, stiffness irregularity exerts the most significant influence on a building's dynamic response. Furthermore, the study underscores that analysing irregularities in isolation can yield misleading results, given that most buildings exhibit multiple forms. In regions where retrofitting existing structures is more urgent than new construction, risk-based strategies and seismic upgrades like the use of shear walls are essential. Shear walls enhance both strength and stiffness, reducing lateral displacement and improving overall performance under seismic loads. This research aims to support informed design of asymmetrical and irregular buildings without compromising structural integrity.

II. METHODOLOGY

The methodology adopted to achieve the above said objectives are as follows: To develop a suitable Analysis of Response Spectrum method for analysing story shear, storey drift, and story displacement in structures, a thorough assessment of the body of literature was carried out, in addition to pertinent regulations from the Indian Standard Codes. For our study we considered 12 stories tall building, with 5 bays and plan dimensions of (25 x 30) meters. The height of each floor is 3.1 meters and base 3 meter. A total of 40.2 meters is the elevation of the building from the first to the twelfth floor and base. The columns are 600 mm by 900 mm in size, the beams are 300 mm by 450 mm, and the slab thickness is 150 mm.

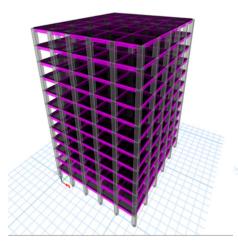
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Seismic loads are applied to the structure models in both X and Y directions, based on ground motions from earthquakes. In the present study, a 12-storey RC framed building is analysed using the response spectrum method. The parameters evaluated include base shear, storey shear, 13 storey displacement, and storey drift for plan-regular, plan-irregular, and vertically irregular buildings. For modelling purposes, the following considerations are adopted, the following considerations are made which are tabulated below:

Table 3.1: Basic Parameters for the development of the structural models

Sl. No	Parameter	Value
1.	Type of Structure	Commercial
2.	No. of Stories	12
3.	Total Height of Building	40.2 m
4.	Storey Height	3.1m
5.	Base height	3m
6.	Plan Size	25 m x 30m
7.	Column Size	600 mm x 900mm
8.	Beam Size	300 mm x 450 mm
9.	Grade of Concrete	M30
10.	Steel Grade	Fe550
11.	Slab Thickness	150 mm
12.	Bays Width in X-Direction	5 m
13.	Bays Width in Y-Direction	6m
14.	Concrete Density	25 kN/cum
15.	Brick Density	20 kN/cum
16.	Earthquake Load	As per IS 1893-2016
17.	Moment Resisting Frame	SMRF
18.	Types of Soil	П
19.	Zone Factor	0.16
20.	Importance Factor	1.2
21.	Response Reduction Factor	5
22.	Earth quick zone	3





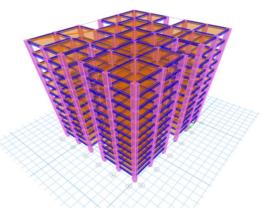


Fig b: Column 3D View of Irregular Model

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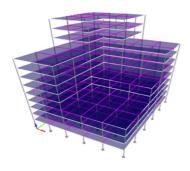


Fig c: Column 3D View of L-Shape (Vertical irregular) Model

III. RESULTS AND DISCUSSIONS

The response spectrum analysis is performed on all the model's comparative study on earthquake data used in response spectrum method analysis are as mentioned in clause 4.2. The behaviour of models is studied by extracting the results from the analysis in the form of Storey Drift, Storey Shear and Storey Displacement. The results are plotted in a graphical form as shown in following figure below.

1) Storey Drift: The comparison of regular, irregular and vertical irregular model of story drift in X-direction

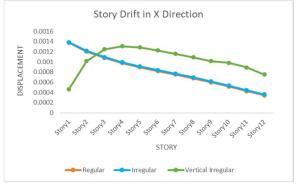
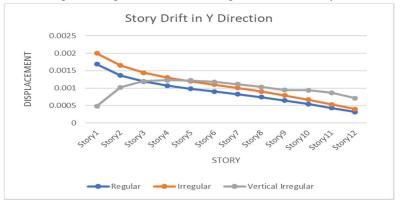


Fig 4.10: Storey Drift of structures in X direction

"From the graph, it is noticed that for a 12-storey structure with specific material and section properties, the maximum storey drift of the earthquake data in the X-direction is maximum for the irregular shape structure, around at the storey when it is compared with regular shape and irregular shape

2) Storey Drift: The comparative of regular, irregular and vertical irregular model of story drift in Y-direction



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"From the graph, it is observed that for a 12-storey structure with specific material and section properties, the maximum storey drift of the earthquake data in the Y- direction is maximum for the irregular -shape structure around maximum at the storey when it compared with Regular shape, irregular shape.

3) Storey Shear: The comparative of regular, irregular and vertical irregular model of story shear in X-direction

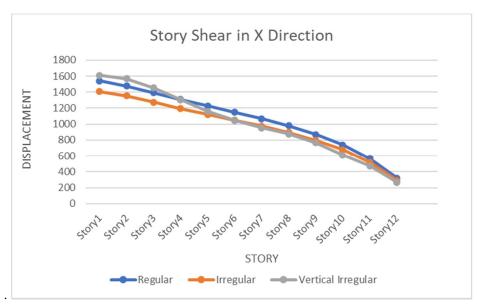


Fig 4.12: Storey Shear of structures in X direction

From the graph, it is observed that for a 12-storey structure with specific material and section properties, the maximum storey shear of the earthquake data in the X- direction for a regular shaped building, when compared with irregular shaped building, it is decreased to about 8.52%, whereas it got increased to about 4.3%.

4) Storey Shear: The comparative of regular, irregular and vertical irregular model of story shear in Y-direction

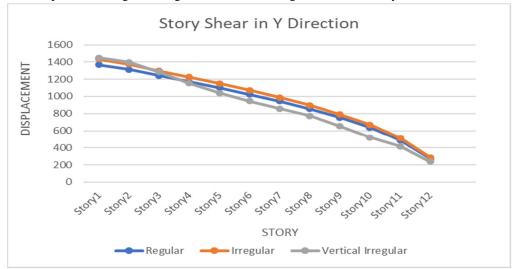


Fig 4.13: Storey Shear of structures in Y direction

"From the graph, it is observed that for a 12-storey structure with specific material and section properties, the maximum storey shear of the earthquake data in the Y-direction is a regular shaped building, when compared with irregular shaped building, it is increased to about 4.63%, whereas it got increased to about 5.81%.

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5) Storey Displacement: The comparative of regular, irregular and vertical irregular model of story displacement in X-direction

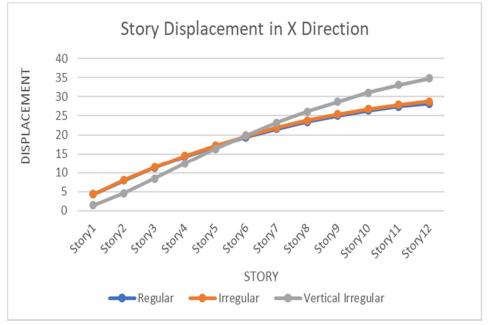


Fig 4.14: Storey Displacement of structures in X direction

"From the graph, it is observed that for a 12-storey structure with specific material and section properties, the maximum story displacement of the earthquake data in the X-direction is a regular shaped building, when compared with irregular shaped building, it is increased to about 1.76%, whereas it got increased to about 23.42 %

6) Storey Displacement: The comparative of regular, irregular and vertical irregular model of story displacement in Y-direction

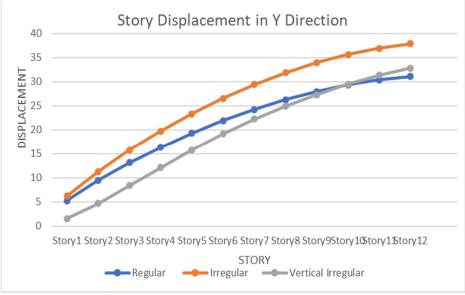


Fig 4.15: Storey Displacement of structures in Y direction

From the graph, it is observed that for a 12-storey structure with specific material and section properties, the largest storey displacement of the earthquake data in the Y-direction is a regular shaped building, when compared with irregulated building, it is increased to about 22.02%, whereas it got increased to about 5.62%.



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IV. CONCLUSION

The comparative analysis for plan regular, plan irregular and vertical irregular structures are made by channelized graphs and tabular columns and the discussion w.r.t results are discussed in the chapter 4 and the conclusions for those results and discussions are derived here:

- 1) Analysis of RSA method using ETABS has provided a comprehensive understanding of the building's response to particularly during seismic events.
- 2) As per the analytical results, the comparison between plan regular, plan irregular and vertical irregular buildings, the results of plan irregular showed 22.02% displacement w.r.t Y-direction is higher than plan regular building and w.r.t vertical irregular building, it showed 5.62%. Hence it can conclude that keeping the requirement of the architectural considerations, can be suggested to consider vertical irregular structure.
- 3) As per the analytical results, the comparison between plan regular, plan irregular and vertical irregular buildings, the results of plan irregular showed 1.76% displacement w.r.t X-direction is higher than plan regular building and w.r.t vertical irregular building, it showed 23.42%. Hence it can be concluded that is keeping the requirement of the architectural considerations, this can be suggested to consider vertical irregular structure.
- 4) As per the analytical results, the comparison between plan regular, plan irregular and vertical irregular buildings, the results of plan irregular showed 8.52% shear w.r.t X-direction is lesser than plan regular building and w.r.t vertical irregular building, it showed higher 4.3%. Hence it can be concluded that keeping the requirement of the architectural considerations, it can be suggested to consider vertical irregular structure.
- 5) As per the analytical results, the comparison between plan regular, plan irregular and vertical irregular buildings, the results of plan irregular showed 5.81% shear w.r.t Y-direction is higher than plan regular building and w.r.t vertical irregular building, it showed higher 4.63%. Hence it can be concluded that keeping the requirement of the architectural considerations, it can be suggested to consider irregular structure.
- 6) As per the analytical results, the comparison between plan regular, plan irregular and vertical irregular buildings, the results of plan irregular showed drift w.r.t X-direction is higher than plan regular building and w.r.t vertical irregular building, it showed lesser. Hence it can be concluded that keeping the requirement of the architectural considerations, it can be suggested to consider irregular structure.
- 7) As per the analytical results, the comparison between plan regular, plan irregular and vertical irregular buildings, the results of plan irregular showed drift w.r.t Y-direction is higher than plan regular building and w.r.t vertical irregular building, it showed lesser. Hence it can be concluded that keeping the requirement of the architectural considerations, can be suggested to consider irregular structure.

All the models were analysed in ETABS using the response spectrum method. In comparison with plan regular, plan irregular, and vertical irregular buildings, the plan regular building showed better performance than the other two types. However, considering architectural requirements, the plan irregular building proved to be safer with respect to storey shear, storey drift, and storey displacement. Therefore, it can be concluded that, taking into account economy, structural safety, stability, and overall requirements, the plan irregular building can be suggested as the final choice.

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