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Comparative Seismic Analysis of Vertically Geometric Irregular Multi- Storeyed Buildings

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ABSTRACT: Structures nowadays are advancing in terms of its planning and construction technologies due to the rise in demand of aesthetics and uniqueness in the ever-developing world. This development has also given rise to the planning of irregular buildings to achieve the desired aesthetics and functions in the structure. With such developments, these buildings due to their irregularities are becoming more prone to earthquakes and hence it has become essential to consider earthquake loads while designing these buildings. Therefore, in the course of this study, we shall be analysing the seismic response of such vertically irregular buildings using response spectrum analysis on Etabs software. The results obtained from different models with different forms of vertical irregularities will be compared on the basis of seismic parameters such as base shear, storey drift, displacement, etc. After obtaining the results, a comparison will be made to draw out a meaningful conclusion with respect to the effective height and use of vertically irregular buildings in various earthquake zones.

KEYWORDS: Irregular building, Seismic force, Response spectrum analysis, Base shear, Storey drift, Displacement, Earthquake zone.

I. INTRODUCTION

In today's times, most of the structures are delineated by irregularities in both plan and vertical configurations. Thus to analyse or design such irregular structures an extra level of attention and effort is required. The repercussions of failure in such buildings would be greater than those with regular ones. Hence, irregular structures require detailed structural analysis to succeed in an acceptable behaviour throughout a devastating earthquake. There might be cases where shape of the plot for the construction of a structure may not be a regular one, may also have topographical variations because of which the structure might be influenced due to the configuration of the plot. Hence, it will be interesting to study the stability of buildings with different geometry or shape and their behaviour against seismic and other forces. In present study we will analyse such vertically irregular regular plan buildings using response spectrum analysis on Etabs software.

II. LITERATURE REVIEW

The present work is aimed at comparative study on analysis of vertically irregular buildings. A literature review is carried out on various studies of such types of vertically irregular buildings. A review of the work is presented in the following paragraphs.

Girish Deshmukh & Shaikh Abdul Aijaj Abdul Rahman (2013) The seismic analysis performed on G+10 vertical irregular building of two frame with similar dimension but having the stiffness irregular in 2nd frame. The dynamic analysis is analysed by Etabs software as per IS: 18931-2002. The dynamic response result to compare the both frame. The frame-1 (vertically irregular) develops least storey drifts while the building with stiffness irregularity on vertically irregular building (frame-2) shows maximum storey drift on the respective storey levels. The building was modeled as a simplified lump mass model having stiffness irregularity at fourth floor. The response parameters like storey drift, storey deflection and storey shear of the building were evaluated. The results show that, stiffness irregularity causes instability in the building and attracts huge storey shear.



Bansal and Gagandeep (2014) carried out response spectrum analysis (RSA) and time history analysis (THA) of vertically irregular RC building frames. They considered mass, stiffness and vertical geometric irregularity. They found that mass irregular building experience larger base shear than similar regular building. The stiffness irregular building experienced lesser base shear and has larger inter storey drifts.

Mahesh and Rao (2014) studied the behavior of regular and irregular G+11 residential building under seismic motion. They considered different seismic zones and three different types of soils namely hard, medium and soft. The analysis was done by two softwares ETABS and STAAD PRO.

Rana and Raheem (2015) studied the performance of vertical geometric irregular RC frame structures under seismic motion. A comparative study between one regular frame & four irregular building frames were carried out. Various seismic responses like shear force, bending moment, storey drift, storey displacement etc. were obtained. It was concluded that regular building frames possess very low shear force compared to setback irregular frames.

Oman Sayyed, et.al. (2017) carried out the seismic performance & behaviour of 8 models of G+10 regular and vertical with soft irregular building is analysed by Response spectrum analysis method with the help of Etabs 2015 software. By the different seismic response to compare the regular and irregular building. The storey displacement and storey drift in case of stiffness irregular buildings is more than that of the regular building. The result remarks the conclusion that, a building structure with stiffness and setback irregularity provides instability during seismic loading. To control the instability, a proportionate amount of stiffness is beneficial in RC building.

Shaikh Abdul Aijaj Abdul Rahman & Ansari Ubaidurrahman Salik (2018) The seismic response of G+10 storey of two frames having the same dimension with mass and the vertical irregular building has been analyzed by linear static and dynamic method with the help of Etabs software as per IS:1893-2002. The dynamic response of the structure frame-1 (vertically irregular) develops least storey drifts while the building with mass irregularity on vertically irregular building (frame-2) shows maximum storey drifts on the respective storey levels. Hence, this is the most vulnerable to damages.

III. METHODOLOGY

The study to be conducted for this project will mostly be done using ETABS software. Modelling the building in the software and carrying out subsequent analysis for obtaining results will be done. A detailed step by step procedure of the methodology is as follows. 1. In present research we have used different models of vertically irregular multi-storied buildings. 2. Model the structures in ETABS. 3. Seismic analysis will be done as per IS 1893-2016. 4. Running the models in ETABS. 5. Obtaining seismic parameters like base shear, storey drift and displacement. 6. Comparing results of these parameters. 7. Conclusion

IV. STRUCTURAL MODELLING

In this study, structure will be modeled for the following cases

1. 40 storeyed building with geometric irregularity at 10th & 30th storey on different sides.
2. 40 storeyed building with geometric irregularity at 10th & 30th storey on same sides.
3. 40 storeyed building with geometric irregularity on ALL sides at 10th, 20th & 30th storey.
4. 30 storeyed building with geometric irregularity at 10th, 12th, 14th, 16th, 18th, 20th, 22nd, 24th & 26th storey on 3 sides.
5. 30 storeyed building with geometric irregularity at 10th storey.

All the above cases will also be modelled for seismic zone III, IV & V as specified in IS:1893 2016

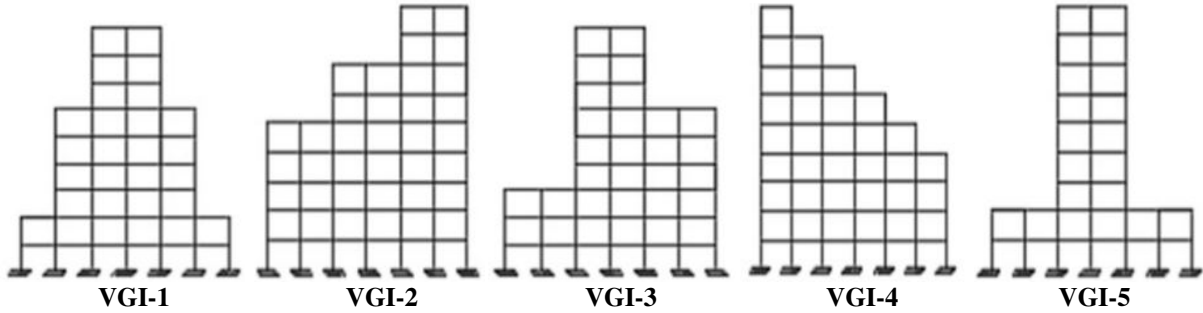
V. PRELIMINARY DATA

Following are the data assumed for carrying out this study. 1. Length in X direction = 40m. 2. Length in Y direction = 32m. 3. Typical storey height = 3m. 4. Ground storey height = 3.5m. 5. No of stories: 30 and 40. 6. Height of buildings = 90.5m & 120.5m. 7. Bay spacing in X direction = 4m. 8. Bay spacing in Y direction = 4m. 9. Plan Area = 1280 sq.m. 10. Size of beams = 300*450 mm. 11. Size of columns = 400*800 mm. 12. Grade of concrete = M40. 12. Grade of steel = Fe500 mm. 13. Type of support – fixed. Seismic Zone: I, II, III.

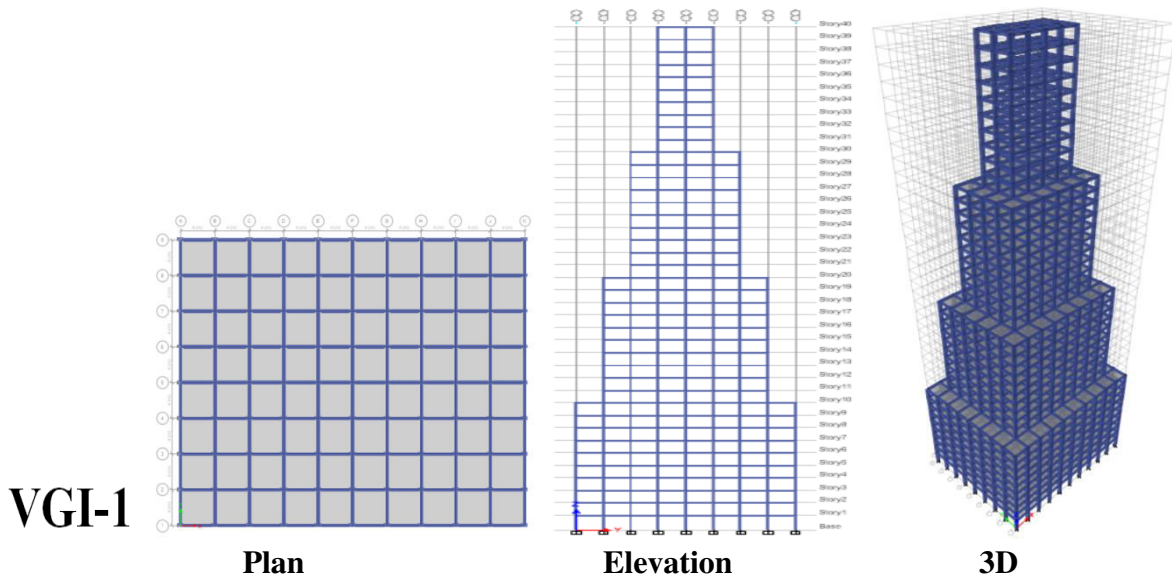


VI. MODELS

Models are considered for 30 and 40 storeys in seismic zones III, IV and V as per IS-1893 2016.



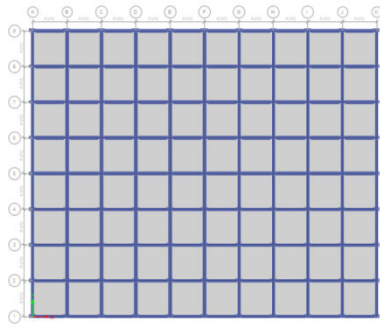
VII. DISCUSSION AND RESULTS



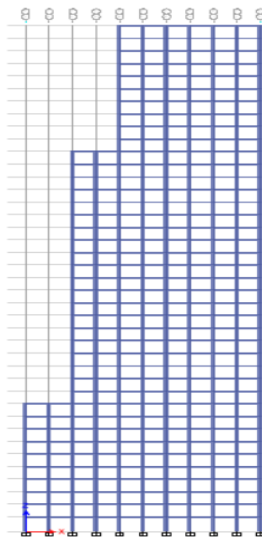
Zones	Seismic Parameters Load Cases	Base Shear (KN)	Displacement (mm)		Storey Drift (mm)	
			X direction	Y direction	X direction	Y direction
Zone III	RSX Max	3379.839	66.88	-	3.319	-
	RSY Max	2775.44	-	86.11	-	4.825
Zone IV	RSX Max	4663.52	100.32	-	4.979	-
	RSY Max	4163.17	-	129.166	-	7.238
Zone V	RSX Max	6995.289	150.48	-	7.468	-
	RSY Max	6244.751	-	193.749	-	10.856

Result

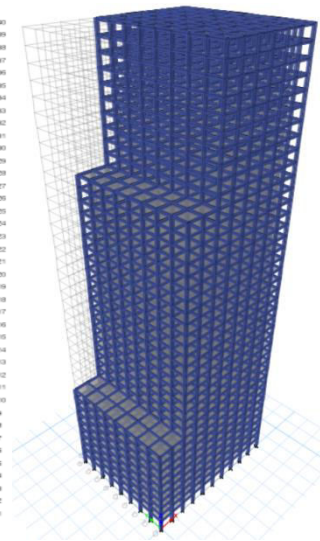
VGI-2



Plan

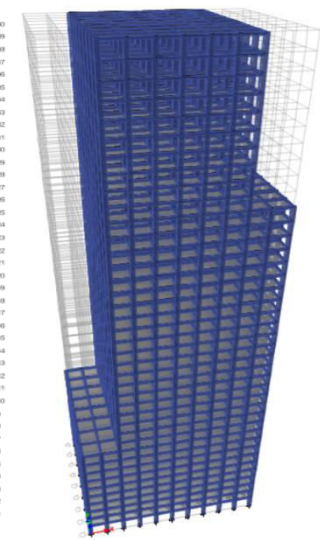
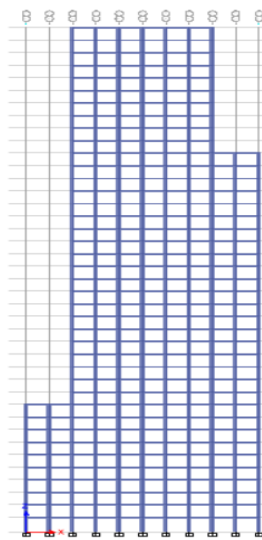
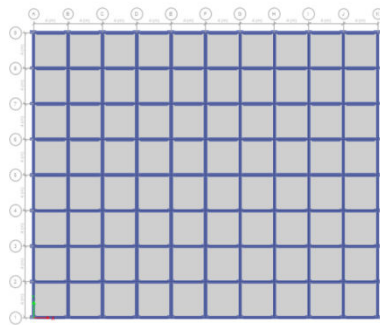


Elevation



3D

VGI-3



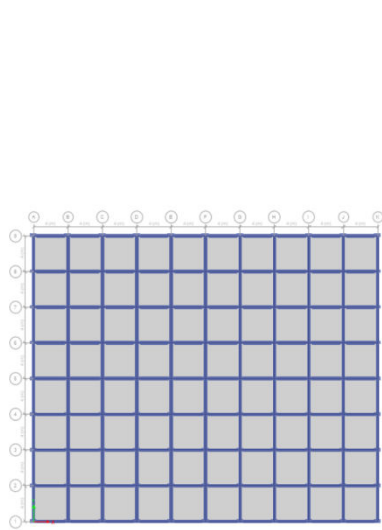
Zones	Seismic Parameters Load Cases	Base Shear (KN)	Displacement (mm)		Storey Drift (mm)	
			X direction	Y direction	X direction	Y direction
Zone III	RSX Max	4921.579	94.128	-	3.325	-
	RSY Max	4393.539	40.26	145.244	1.567	5.142
Zone IV	RSX Max	7382.39	141.192	-	4.987	-
	RSY Max	6590.321	60.39	217.867	2.35	7.713
Zone V	RSX Max	11073.6	211.789	-	7.481	-
	RSY Max	9885.482	90.585	326.8	3.525	11.57

Result VGI-2

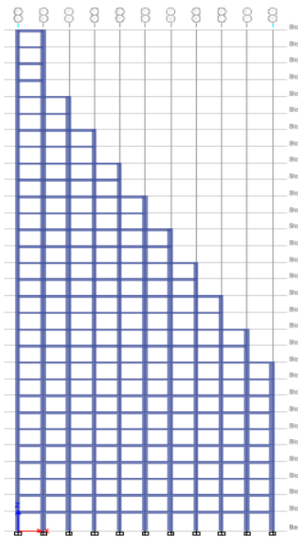
Zones	Seismic Parameters Load Cases	Base Shear (KN)	Displacement (mm)		Storey Drift (mm)	
			X direction	Y direction	X direction	Y direction
Zone III	RSX Max	4921.59	93.814	-	3.327	-
	RSY Max	4393.539	-	113.861	-	4.191
Zone IV	RSX Max	7382.39	140.722	-	4.99	-
	RSY Max	6590.321	-	170.792	-	6.286
Zone V	RSX Max	11073.6	211.083	-	7.485	-
	RSY Max	9885.48	-	256.188	-	9.429

Result VGI-3

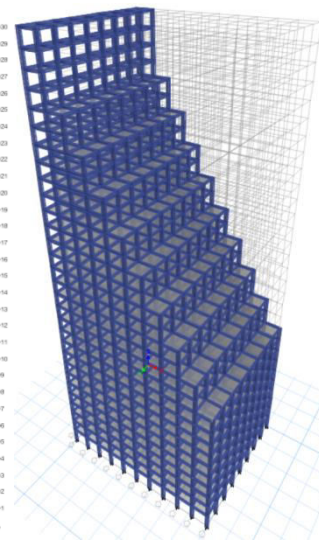
VGI-4



Plan

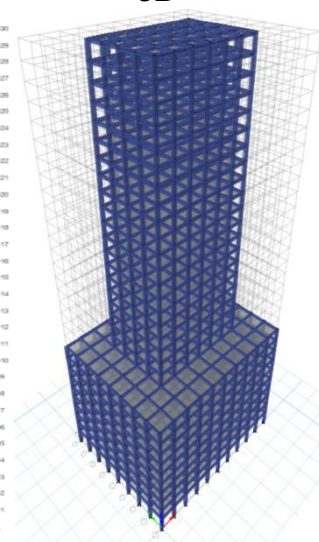
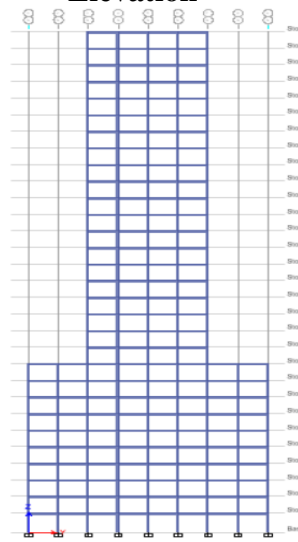
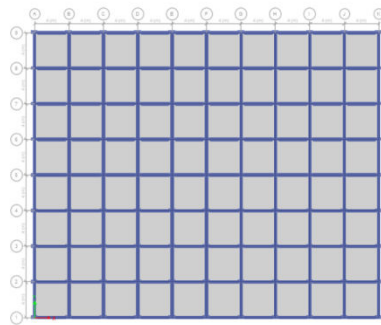


Elevation



3D

VGI-5



Zones	Seismic Parameters Load Cases	Base Shear (KN)	Displacement (mm)		Storey Drift (mm)	
			X direction	Y direction	X direction	Y direction
Zone III	RSX Max	3948.079	54.603	-	3.132	-
	RSY Max	3536.82	45.134	76.64	2.327	3.994
Zone IV	RSX Max	5922.121	81.904	-	4.699	-
	RSY Max	5305.241	67.7	114.96	3.49	5.992
Zone V	RSX Max	8883.189	122.856	-	7.048	-
	RSY Max	7907.469	100.908	171.348	5.202	8.93

Result VGI-4

Zones	Seismic Parameters Load Cases	Base Shear (KN)	Displacement (mm)		Storey Drift (mm)	
			X direction	Y direction	X direction	Y direction
Zone III	RSX Max	3296.89	48.775	-	2.822	-
	RSY Max	2953.461	-	57.314	-	3.308
Zone IV	RSX Max	4945.33	73.163	-	4.232	-
	RSY Max	4430.192	-	85.971	-	4.963
Zone V	RSX Max	7417.998	109.744	-	6.348	-
	RSY Max	6645.291	-	128.956	-	7.444

Result VGI-5



The structural behaviour of multi-storey frames with single and combinations of irregularities is studied. The results indicate that irregularity considerably affects the structural response. In all the cases analysed, change in response is observed for frames having single or multiple irregularities with respect to the regular configuration. The present study indicates that the presence of irregularities does not always amplify the response. Certain combinations of irregularities bring down the structural response. All the single irregularity cases analysed have shown an increase in response when compared to the regular configuration under seismic loads. Among these cases, the configurations with vertical geometric irregularity have given maximum response. The combination of stiffness and vertical geometric irregularities has shown maximum displacement response whereas the combination of re-entrant corner and vertical geometric irregularities has shown less displacement response. The Torsion and Base shear values of the building decreases with increase in height of the structure. Greater the height of the structure (building), higher will be the Storey Displacement. It has been concluded that the Storey Overturning moment decreases with increase in the storey height. The Drift values increases along with the storey height to some extent and then decreases.

In the modern world, where people are not ready to compromise with their needs, incorporation of combinations of irregularity in structures is inevitable. As the structural response depends on the type, location and degree of irregularity, these factors need to be taken care while designing any structure. This would help in incorporating irregularities in structures without compromising their performance.

VIII. CONCLUSION

1. The first four cases chosen for the study was modelled and consequently response spectrum analysis was performed using ETABS.
2. Results were obtained for all the cases for seismic zone III, IV and V as per IS 1893:2016.
3. The results obtained show increase in base shear value as height of building decreases, however base shear values decrease considerably from seismic zone V to III.
4. Displacement values increases with the increase in building height as well as variation in seismic zones.
5. Displacement values decrease considerably from seismic zone V to III.
6. Storey drift does not vary a lot with decrease in building height, but shows huge decrease with variation in seismic zones.
7. In case of stiffness irregular buildings, the overturning moment and storey shear force in case of irregular buildings are slightly greater than that in regular building. A moderate increase in the slope of the shear force curve has been observed at the irregular storeys.
8. In case of stiffness irregular buildings, a sudden decrease in stiffness of the building has been observed at the irregular storeys. The results of setback irregular buildings show that, as the amount of setback increases the stiffness of the building decreases.
9. The analysis shows that the vertical irregularities widely affect the performance of a RC building under seismic loading.
10. As far as possible these irregularities must be avoided, but if it has to be introduced they must be properly designed.

IX. FUTURE SCOPE

The topic chosen for research has many more fields to explore and can yield useful results. As we are well aware of the increasing population and due to urbanisation there is decrease in area of development land. This sometimes more often than not these days give little option but to plan an irregular plan building. Hence intensive research in this topic can be very helpful. Some avenues that can be considered for further research are listed below.

- Studies can be done for irregular plan with vertical irregularity as well.
- Design of actual buildings of such irregularity can yield meaningful results.
- Analysis can be carried out for such buildings with a lateral support system or combinations.
- Research can be carried out for construction of such buildings on sloping land in hilly terrains.
- Analysis can be done for buildings with other irregularities such as diaphragm discontinuity or combination of irregularities.

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