iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53943

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Effect of Variation in Shapes of High Rise Structures on Resistance against Seismic Loads

Mr. Vaibhav B. Dudhal[1], Mr. Shubham U. Khedkar[2], Ms. Nikita D. Kshirsagar[3], Ms. Ketaki A. Mallelwar[4], Prof. Sangeeta Mishra[5]
[1, 2, 3, 4]Student, B.E, Dept. of Civil Engineering, JSPM's Rajarshi Shahu College of Engineering, Tathavade
[5]Professor, Dept. of Civil Engineering, JSPM’s Rajarshi Shahu College of Engineering, Tathavade

Abstract: When a building is carried by Heavy Loads, which includes both Earthquakes and wind loads, a major building collapse occurs. Many modern buildings are involved in the value of buildings, and it is very difficult to plan with a standard design. This inconsistency is the cause of building collapse due to flexible loads. As a result, thorough research is needed to achieve high performance and even poor configuration. The impact of vertical alignment and bulk instability on multi-storey buildings under flexible loads is investigated in this work. Three RC building frames have been selected, and it is recommended that all framed and modified frames be analyzed. The ETABS analysis system is recommended to be analyzed by all parties to determine all migrations. The 3-D frames of the G + 20 floor with the same height arrangement across its entire length and the exact uneven configuration starting on the 9th floor are considered in this study. It is suggested that the responses of all previous frames are limited to all upload combinations. The reaction spectrum analysis method is proposed to detect lateral loads and floor checks of all three frames due to earthquake loads, and IS 1893 (Part 1): 2016 recommends dynamic analysis (direct dynamic analysis).
Keyword: RCC, Irregularity, ETABS, IS 1893, G+20 storied, Earthquake

I. INTRODUCTION

Structure failure begins in weak locations during an earthquake. The instability of the mass, stiffness, and geometry of the structure all contribute to this vulnerability. Unusual structures are buildings that have this suspension. Unusual structures have a significant impact on urban infrastructure. One of the leading reasons of structural failure during an earthquake is poor location. Soft flooring, for example, are the most significant of the collapses. As a result, the impact of direct negative consequences on seismic activity is becoming increasingly essential. Variations in height and size give variable elements for these structures that distinguish them from standard structures. (Thowdoju et al. 2016)

The problems of building materials could be attributed to their odd distribution of size, strength, and durability. Analysis and design are exceedingly difficult when such structures are built at high elevations. There are two kinds of flaws.

A building is considered to be regular when its configurations are nearly symmetrical along the axis, and it is said to be irregular when there is no symmetry and discontinuity in geometry, mass, or load resisting materials. Torsion forces are amplified in asymmetrical setups. IS 1893: 2016 (part 1) explains the building configuration concept for improved seismic performance of RC structures. In terms of the size and shape of the structure, the arrangement of structural parts, and mass, the building configuration has been defined as regular or irregular. Irregularities are classified into two categories. 1) Horizontal irregularities include asymmetrical plan forms (L, T, U, and F) or discontinuities in horizontal resisting elements such as re-entrant corners, wide apertures, cut outs, and other modifications such as torsion, deformations, and stress concentrations. 2) Vertical irregularities relate to abrupt changes in a structure's strength, stiffness, geometry, and mass in the vertical direction. The primary goal of this work is to investigate the reaction of irregular structures under dynamic loads. It is proposed in this study to take into account building frames with uneven elevations and examine the reaction and behaviour of the structures under earthquake and wind loads. Three RC building frames are chosen for this purpose, and it is recommended to assess all of the frames that are considered and modelled. The ETABS analysis programme is recommended for the study of all structures in order to get all displacements. G+20 Storied 3-D frames with symmetrical elevation arrangement throughout its height and unsymmetrical vertical configuration beginning on the 9th storey are investigated in this study. It is proposed that the responses of all of the preceding frames be calculated for all load combinations. The response spectrum analysis approach is proposed to estimate the lateral loads and storey shears of all three frames owing to seismic loads, and the IS 1893(Part 1): 2016 has approved dynamic analysis (linear dynamic analysis).

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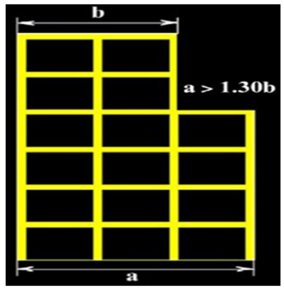


Fig 1 Vertical Geometric Irregularities in Building

A. Scope

Irregular structures constitute a large percentage of modern urban infrastructure. Because structures are never totally regular, designers must constantly assess the expected degree of irregularity and the effect of this irregularity on a structure during an earthquake. There is a need for research to develop an inexpensive and efficient lateral stiffness solution for high seismic prone locations. For the optimization and design of high-rise buildings with various structural and frame systems that are subjected to seismic loads. To get a better knowledge of the seismic behaviour of buildings with vertical imperfections.

II. PROBLEM STATEMENT

There were two stages to the project study. The primary data was acquired through a literature research, which included web searches and an examination of e books, manuals, codes, and journal papers. Following a review, the issue statement is developed, and three specimens are selected for detailed research and analysis. This project is carried out in accordance with the flow chart below: The flow chart below provides a high-level overview of the project's layout. In addition, models are examined for response spectrum analysis.

Table 1 Model Input Data

Number of Stories	G+20
Total Height Of building	61.9 m
Height of Stories	Base to Storey 1 – 1.5m Storey 2 to Storey 9 – 3.2m Storey 10 to Storey 15 -3 m Storey 15 to Storey 21 – 2.8 m
Dimension of building	55m X 55m
Size of Beam	300 x 550 mm
Slab Thickness	S150 mm
Location	Pune
Seismic Zone	Zone IV – 0.16
Response Reduction Factor	5.0
Importance Factor	1.2
Grade Of Concrete	M 30
Grade Of Reinforcing Steel	Fe500
Supports at base	Fixed
Diaphragm	Rigid
Load Description	DL-Dead Load LL-Live load – 3 KN SDL- Super Dead load - 1KN EQX- Earthquake in X direction EQXN- Earthquake in X Negative direction EQY- Earthquake in Y direction EQYN- Earthquake in Y Negative direction Response Spectrum
Load Combinations	1.2 (DL + LL + EQX)

III. MODELING

Table 2 Models Description

MODEL 1	Vertical Irregularity At One Side
MODEL 2	Vertical Irregularity At Center
MODEL 3	Vertical Irregularity At Corner

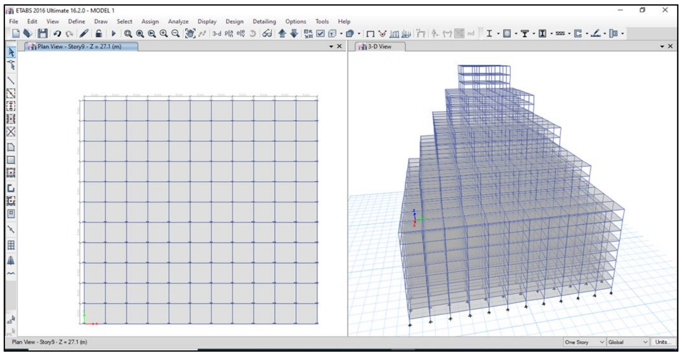


Fig 3 Model 1 Irregularity At One Side

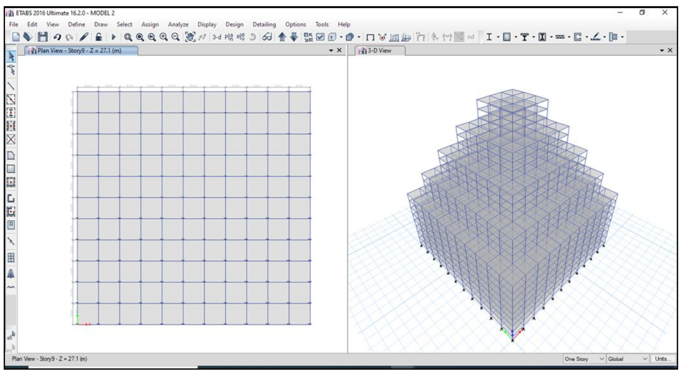


Fig 4 Model 2 Irregularity At Center

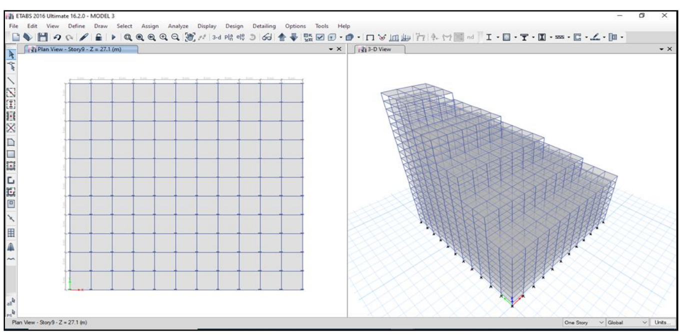


Fig 5 Model 3 Irregularity At Corner

IV. RESULTS AND DISCUSSION

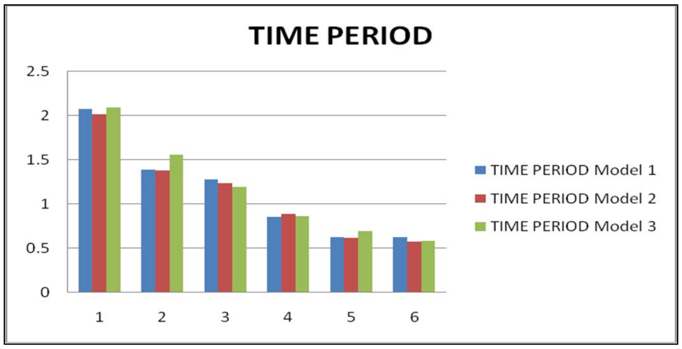
A. Results for Equivalent Static Analysis

1) Time Period (Sec)

Every structure has a set of natural frequencies at which it gives the least resistance to shaking caused by external factors (such as earthquakes and wind) and internal factors (like motors fixed on it). A Natural Mode of Oscillation is made up of each of these natural frequencies and the related deformation shape of a structure.

Table 3 Time Period (Sec)

Time Period			
MODE NO	Model 1	Model 2	Model 3
1	2.075	2.016	2.097
2	1.389	1.379	1.556
3	1.283	1.237	1.192
4	0.856	0.889	0.867
5	0.63	0.62	0.691
6	0.626	0.578	0.586



Graph 1 Time Period (Sec)

We can see from the following table and graph that the percentage variation for Time Period for Equivalent Static Analysis for model 2 is smaller than that of models 1 and 3. The variance is determined to be 10-15% smaller for the model with Vertical Irregularity at Center than for the other two models.

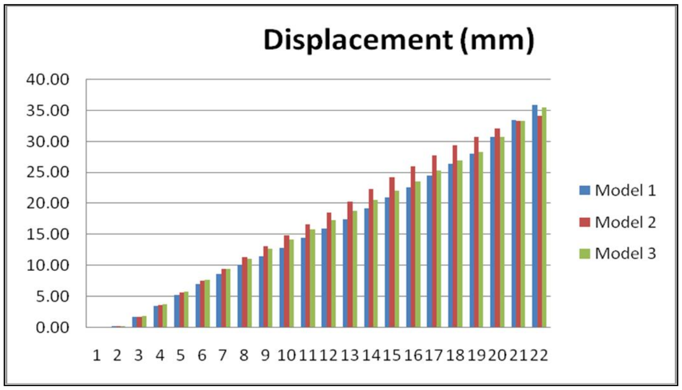
B. Results for Dynamic Analysis

1) Displacement (mm)

Displacement can be defined as "It is the displacement of a storey with respect to the base of a structure

Table 4 Displacement

Displacement (mm)			
Storey	Model 1	Model 2	Model 3
21	35.89	34.16	35.536
20	33.51	33.37	33.302
19	30.79	32.17	30.798
18	28.11	30.76	28.348
17	26.48	29.42	26.948
16	24.58	27.77	25.299
15	22.58	25.99	23.553
14	21.05	24.28	22.158
13	19.30	22.35	20.557
12	17.48	20.38	18.853
11	16.03	18.60	17.397
10	14.46	16.73	15.816
9	12.89	14.87	14.194
8	11.56	13.14	12.713
7	10.18	11.38	11.175
6	8.65	9.53	9.492
5	7.01	7.61	7.691
4	5.28	5.65	5.799
3	3.49	3.69	3.842
2	1.71	1.79	1.888
1	0.25	0.25	0.274
Base	0	0	0



Graph 2 Displacements (mm)

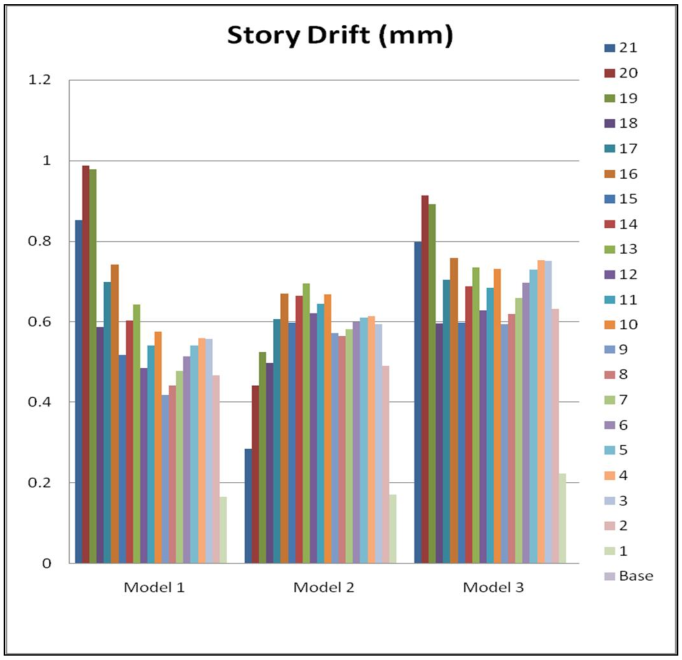
We can see from the following table and graph that the percentage variation of displacements for equivalent static analysis for model 2 is less than that of models 1&3. After the 9th storey, the variance is found to be 1-5 percent smaller for the model with Vertical Irregularity at Center than for the other two models.

2) Story Drift (mm)

Story drift is the difference of displacements between two consecutive stories divided by the height of that story.

Table 5 Story Drift (mm)

Story Drift (mm)			
Storey	Model 1	Model 2	Model 3
21	0.852	0.285	0.798
20	0.988	0.442	0.913
19	0.978	0.524	0.892
18	0.588	0.497	0.597
17	0.699	0.608	0.704
16	0.743	0.67	0.758
15	0.517	0.599	0.599
14	0.603	0.665	0.688
13	0.643	0.696	0.736
12	0.485	0.621	0.628
11	0.54	0.645	0.684
10	0.574	0.669	0.731
9	0.418	0.572	0.594
8	0.441	0.564	0.619
7	0.478	0.582	0.66
6	0.513	0.6	0.698
5	0.54	0.611	0.73
4	0.559	0.614	0.753
3	0.557	0.595	0.752
2	0.467	0.49	0.632
1	0.166	0.172	0.223
Base	0	0	0



Graph 3 Story Drift (mm)

From the above table & graph, we can observe that percentage variation of Story Drift for Equivalent Static Analysis for model 2 is less than model 1 &3. The variation is found to be 15-25% less for model having Vertical Irregularity at Center than other 2 models after 9th floor.

V. CONCLUSION

The primary goal of this study is to analyse Vertical irregular high rise building using ETABS Dynamic analysis to determine time period, storey drift, displacements, and floor responses by using Different Vertical irregularities models and keeping the same mass of the entire building and the stiffness irregularities of the floors for the analysis. The study includes the involvement of 90% of the building mass in each primary horizontal direction of response as defined by IS 1893(Part-I)-2016 by full Quadratic Combination (CQC). In the study, high performance concrete is employed, as well as modern structural framings such as moment resistant frames. The structure has been evaluated for Equivalent Static and response spectrum analysis. According to FEA findings, storey share was found to be highest in the first storey and dropped to minimum in the top storey in all cases, while storey drift/ displacements were found to be minimal in the first storey and increased to the top storey in all cases. According to the research, model 2 (with vertical irregularity in the centre) is the most cost-effective model, followed by model 1 (with vertical irregularity on one side) and model 3 (with vertical irregularity at the corner). The following debate has brought all of the outcomes to a close.

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