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Abstract: Irregularities in a structure are observed as the most important types of failures during seismic activities. A seismic activity causes utmost damage to a structure and the individuals residing in it depending on the Richter scale magnitude. It is necessary to analyse such structures before it hits the dangerous event. In this present study, a G+16 story RCC framed irregular building with torsional irregularity is analysed using ETABS software. Torsional irregularity, in this study is found by calculating the ratio of the maximum story drift to the average story drift which is obtained from the story response plots. This study has carried out the comparison between linear static analysis and response spectrum analysis on a G+16 story RC framed structure with irregularities in seismic zone III and seismic zone IV. The main objective of this study is to study the behaviour of the structure by determining different parameters such as storey response plots i.e., story displacements, story drifts, story shears etc. The analysis is carried out in JB Institute of Engineering and Technology on ETABS software at CAD laboratory, Moinabad, Hyderabad.

Keywords: Earthquakes; Response Spectrum Analysis; Linear Static Analysis; Torsional irregularity; Seismic Zone III and IV

1. Introduction

Earthquakes are caused by the movement of faults mostly in the peripheral regions of the plates. The impact of an earthquake can be unpredictable as the tectonic movements cannot be estimated using devices but can be measured using measuring devices like Richter scale. For an Indian tectonic plate, the seismologists concluded that there are four seismic zones across the country. They are seismic zone 2, 3, 4 and 5 based on the history of seismic events and the ground movements. Out of the four zones, seismic zone V is most vulnerable and highly prone to earthquakes frequently whereas seismic zone II is less vulnerable compared to all other zones. Therefore, during the construction practices in higher seismic zones, seismic analysis has to be performed without negligence. Here, in this study, an irregular building of G+16 is built in seismic zone III and seismic zone IV. These buildings are analysed using linear static method and response spectrum method and the results of both methods are analysed.

Regular structure: A regular structure is the one which have no significant discontinuity in the plan layout or the lateral force resisting system.

Irregular structure: An irregular structure will have considerable physical discontinuities in the configuration or in the lateral force resisting members. These are of different types, on a

broader classification, irregularities are of two categories. They are Plan irregularity and Vertical irregularity.

I. Plan irregularity^
   a. Torsion irregularity
   b. Re-entrant corners
   c. Diaphragm discontinuity
   d. Non-parallel systems
   e. Out of plane offsets

II. Vertical irregularity^
   a. Mass irregularity
   b. Stiffness irregularity
   c. Vertical geometric irregularity
   d. In-plane discontinuity in vertical lateral force resisting element
   e. Discontinuity in capacity(weak story)

Fatemeh Aliakbari, Sadegh Garivani and Ali Shahmari(2020), This study analysed the building structures with nine different plan layouts and designed three different methods for determining the ratio of maximum story drift to the average story drift. One of the methods is the conventional method of determining torsional irregularity of a regular plan and the other two are the experimental methods with plan irregularities. All the results of these methods are compared against the time history analysis results. Compared results are such that one of the methods underestimates the mentioned ratio in all the proposed layouts. However, the other two methods have shown similar results as the conventional one. This study concluded that plan layouts and irregularities can affect the estimation of ratios using different methods by comparing the results obtained through time history analysis results.

Shruthi Indaragi, M.B.Mogali(2019), This study analysed the behaviour of symmetric and asymmetric structures at different story levels and in two different zones using Response spectrum analysis on etabs and found the studied the storey response plot data.

S. R. Kangle, D. S. Yerudkar(2020), This study analysed a regular multi-storied building of height>40m using Response spectrum analysis in seismic zone III on STAAD pro and ETABS software. This study concluded that the multi-storied buildings are stiff for earthquake excitations because the modal participation factor is found to be greater than 75% and the base reactions have slight differences in both the software.

Dr. K. Chandrasekhar Reddy & G. Lalith Kumar (2019), This study analyses a high rise building of 30 floors(G+30) considering all four seismic zones. This study concludes that the lateral displacements and drifts are comparatively greater in zone 5 rather than zone 4,3 &2. It also suggests that better accuracy of the analysis can be obtained through ETABS software.

2. Methodology

In this present study, analysis of G+16 story RCC framed irregular building in seismic zones III and IV is carried out. A 3D rendered model is developed for G+16 story building using ETABS software. There are different types for the method of analysis.

- Linear Static Analysis Method
- Response Spectrum Analysis
- Time History Analysis
- Push over Analysis etc

^ data inscribed as per IS:1893-2016 code book

2.1 Modelling of structure

Irregular structure of G+16 in seismic zone III and IV are modelled for linear static method and response spectrum method using ETABS software.

Applied loads

1. Dead Load
2. Live Load
3. Seismic Loads as per IS 1893:2016 in X and Y direction without eccentricity

Building specification

PARAMETERS	VALUE
Type of Building	RC Residential Building
Number of Stories	G+16
Height	Ground: 3.5m
	Remaining: 3m
Grade of Concrete	M20
Rebar	HYSD415
Beam 1	200*150mm
Beam 2	250*300mm
Column 1	200*250mm
Column 2	200*300mm
Slab	120mm
Zone Factors	0.16 & 0.24
Importance factor I	1.2
Reduction factor R	5.0

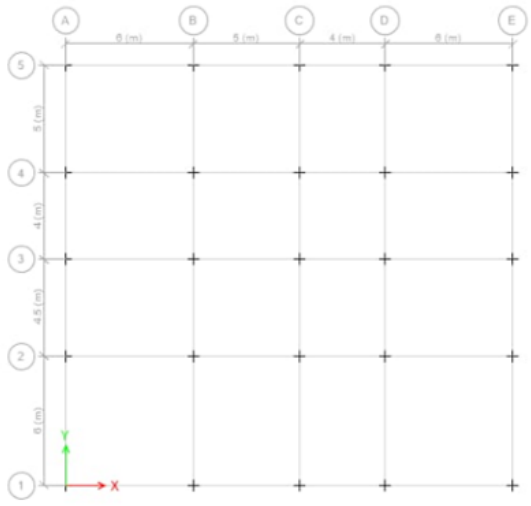

Figure 2.1: PLAN

Story	Elevation m
F16	51.5
F15	48.5
F14	45.5
F13	42.5
F12	39.5
F11	36.5
F10	33.5
F9	30.5
F8	27.5
F7	24.5
F6	21.5
F5	18.5
F4	15.5
F3	12.5
F2	9.5
F1	6.5
GF	3.5
Base	0

Figure 2.2: Elevation data

Figure 2.3: Grid data of the plan

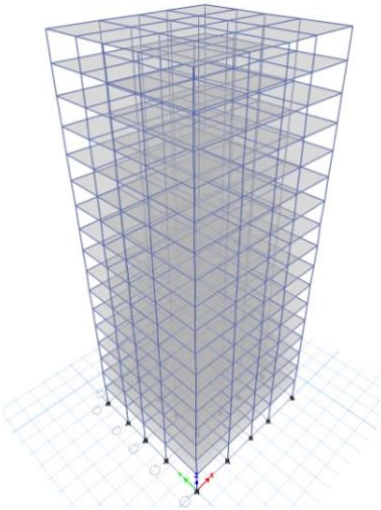

Figure 2.4: 3D ELEVATION

3. Results and discussion

3.1 STORY MAX/AVG DRIFTS

If the ratio of Max/Avg story drift is >=1.2, then the structure has torsional irregularity.

Storey	Max Drift(mm)	Avg Drift(mm)	Ratio
Storey 16	1.115	0.928	1.201
Storey 15	1.838	1.518	1.211
Storey 14	2.485	2.04	1.218
Storey 13	3.032	2.48	1.223
Storey 12	3.533	2.881	1.226
Storey 11	4.025	3.275	1.229
Storey 10	4.501	3.654	1.232
Storey 9	4.944	4.004	1.235
Storey 8	5.356	4.33	1.237
Storey 7	5.751	4.643	1.239
Storey 6	6.133	4.947	1.24
Storey 5	6.487	5.226	1.241
Storey 4	6.801	5.473	1.243
Storey 3	7.088	5.698	1.244
Storey 2	7.344	5.903	1.244
Storey 1	7.501	6.041	1.242
Ground	6.827	5.676	1.203

3.2 MODEL 1

For linear static analysis in zone III

Table 1: Story displacement

Storey	X direction	Y direction
Storey 16	0.001	0.027
Storey 15	0.001	0.027
Storey 14	0.001	0.026
Storey 13	0.001	0.026
Storey 12	0.001	0.025
Storey 11	0.001	0.024
Storey 10	0.001	0.023
Storey 9	0.001	0.021
Storey 8	0.001	0.02
Storey 7	0.001	0.018
Storey 6	0.001	0.016
Storey 5	0.001	0.014
Storey 4	0.027	0.012
Storey 3	0.0004067	0.01
Storey 2	0.0003072	0.008
Storey 1	0.0002042	0.005
Ground	0.00009949	0.003
Base	0	0

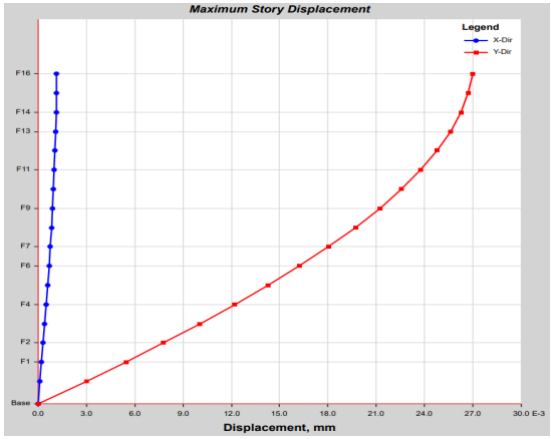

Figure 3.1: Story Displacement of modal

From Table 1, the Maximum and Minimum story displacement in X-direction are found as 0.001 and 0.00009949 at storey 16 and Ground stories. Maximum and Minimum displacements in Y-direction are found as 0.027 and 0.003 at storey 16 and Ground stories.

Table 2: Story drift

Storey	X direction	Y direction
Storey 16	0	0.00000009347
Storey 15	0.000000006185	0.0000001547
Storey 14	0.000000008952	0.0000002168
Storey 13	0.0000000117	0.000000278
Storey 12	0.00000001439	0.0000003379
Storey 11	0.00000001701	0.0000003961
Storey 10	0.00000001953	0.0000004521
Storey 9	0.00000002194	0.000001
Storey 8	0.00000002423	0.000001
Storey 7	0.00000002637	0.000001
Storey 6	0.00000002835	0.000001
Storey 5	0.00000003016	0.000001
Storey 4	0.00000003177	0.000001
Storey 3	0.00000003318	0.000001
Storey 2	0.00000003433	0.000001
Storey 1	0.00000003521	0.000001
Ground	0.00000002843	0.000001
Base	0	0

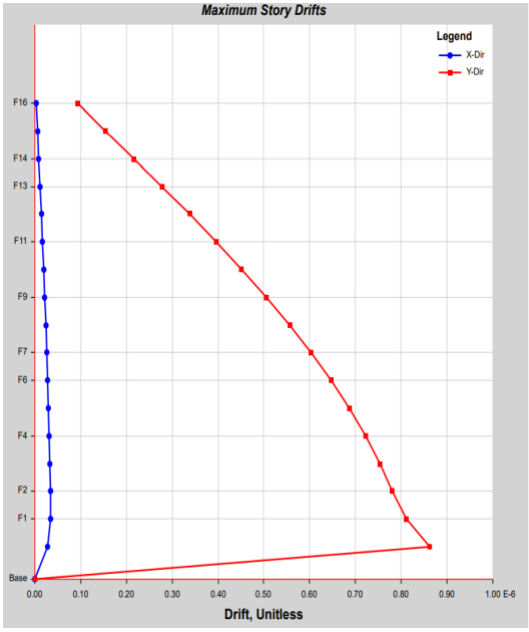

Figure 3.2: Story drift

From table 2, the Maximum and Minimum story drifts in X-direction are found as 0.00000003521 at storey 1 and 0 at storey 16. Maximum and Minimum story drifts in Y-direction are found as 0.000001 from Ground to storey 9 and 0.00000009347 at storey 16.

Table 3: Story shear

Storey	X direction	Y direction
Storey 16	-0.0001	-0.0053
Storey 15	-0.0001	-0.0107
Storey 14	-0.0003	-0.0161
Storey 13	-0.0004	-0.0214
Storey 12	-0.0005	-0.0266
Storey 11	-0.0006	-0.0317
Storey 10	-0.0007	-0.0366
Storey 9	-0.0008	-0.0413
Storey 8	-0.0008	-0.0457
Storey 7	-0.0009	-0.05
Storey 6	-0.001	-0.0539
Storey 5	-0.0011	-0.0576
Storey 4	-0.0011	-0.0609
Storey 3	-0.0012	-0.0639
Storey 2	-0.0012	-0.0665
Storey 1	-0.0012	-0.0687
Ground	-0.0013	-0.0706
Base	0	0

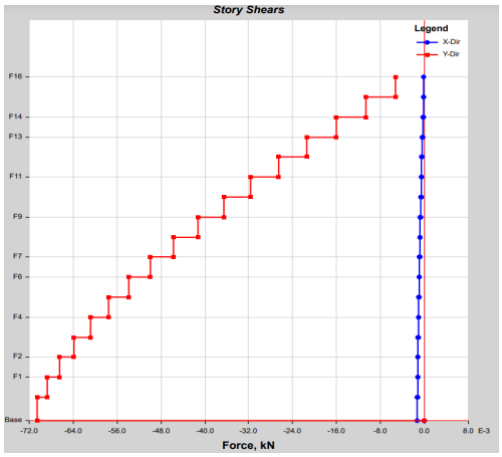

Figure 3.3: Story shear/ Base shear

From Table 3, the Maximum and Minimum values of story shears in X direction are found as -0.0001(0KN) at storey 16 and -0.0013(-1KN) at Ground. Maximum and Minimum story shears in Y direction are found as -0.0053(-5KN) at storey 16 and -0.0706(-70KN) at Ground. Base shear is maximum at base.

3.3 MODEL II

For Linear Static Analysis in Zone IV

Table 4: Story displacement

Storey	X direction	Y direction
Storey 16	0.001	0.027
Storey 15	0.001	0.027
Storey 14	0.001	0.026
Storey 13	0.001	0.026
Storey 12	0.001	0.025
Storey 11	0.001	0.024
Storey 10	0.001	0.023
Storey 9	0.001	0.021
Storey 8	0.001	0.02
Storey 7	0.001	0.018
Storey 6	0.001	0.016
Storey 5	0.001	0.014
Storey 4	0.001	0.012
Storey 3	4.067E-04	0.01
Storey 2	3.072E-04	0.008
Storey 1	2.042E-04	0.005
Ground	9.949E-05	0.003
Base	0	0

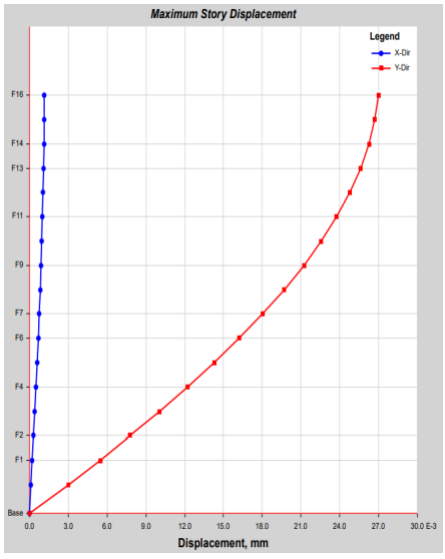

Figure 3.4: Storey displacement

From Table 4, the Maximum and Minimum values of Story displacement in X direction are found as 0.001 from storey 4 to storey 16 and 9.946E-05 at Ground. Maximum and Minimum values of Story displacement in Y direction are found as 0.027 at storey 15, 16 and 0.003 at Ground.

Table 5: Story drift

Storey	X direction	Y direction
Storey 16	0	9.347E-08
Storey 15	6.185E-09	1.547E-07
Storey 14	8.952E-09	2.168E-07
Storey 13	1.17E-08	2.78E-07
Storey 12	1.439E-08	3.379E-07
Storey 11	1.701E-07	3.961E-07
Storey 10	1.953E-08	4.521E-07
Storey 9	2.194E-08	0.000001
Storey 8	2.423E-08	0.000001
Storey 7	2.637E-08	0.000001
Storey 6	2.835E-08	0.000001
Storey 5	3.016E-08	0.000001
Storey 4	3.177E-08	0.000001
Storey 3	3.318E-08	0.000001
Storey 2	3.3433E-08	0.000001
Storey 1	3.521E-08	0.000001
Ground	2.843E-08	0.000001
Base	0	0

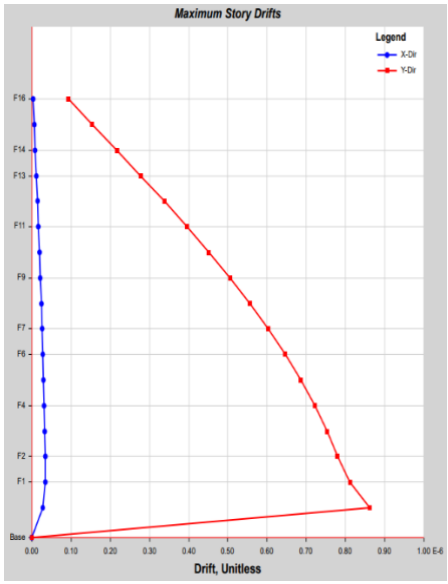

Figure 3.5: Story drift

From Table 5, the Maximum and Minimum values of Story drift in X direction are found as 0 at storey 16 and 1.17E-08 at storey 13. Maximum and Minimum values of Story displacement in Y direction are found as 0.000001 from Ground to storey 9 and 9.347E-08 at storey 16.

Table 6: Story shear/ Base shear

Storey	X direction	Y direction
Storey 16	-0.0001	-0.0053
Storey 15	-0.0002	-0.0107
Storey 14	-0.0003	-0.0161
Storey 13	-0.0004	-0.0214
Storey 12	-0.0005	-0.0266
Storey 11	-0.0006	-0.0317
Storey 10	-0.0007	-0.0366
Storey 9	-0.0008	-0.0413
Storey 8	-0.0008	-0.0457
Storey 7	-0.0009	-0.05
Storey 6	-0.001	-0.0539
Storey 5	-0.0011	-0.0576
Storey 4	-0.0011	-0.0609
Storey 3	-0.0012	-0.0639
Storey 2	-0.0012	-0.0665
Storey 1	-0.0012	-0.0687
Ground	-0.0013	-0.0706
Base	0	0

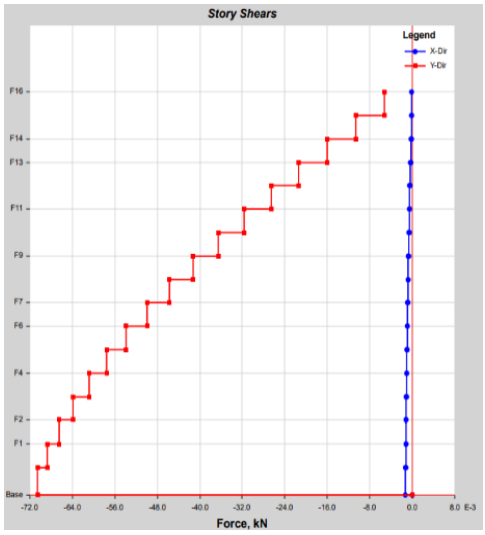

Figure 3.6: Story shear /Base shear

From Table 6, the Maximum and Minimum values of Story shear in X direction are found as -0.0001(0KN) at storey 16 and -0.0013(-1KN) at Ground. Maximum and Minimum values of Story shear in Y direction are found as -0.0053(-5KN) at storey 16 and -0.0706(-70KN) at Ground. Base shear is maximum at Ground.

3.4 MODEL III

For Response Spectrum Analysis in zone III

Table 7: Story displacement

Storey	X direction	Y direction
Storey 16	0.001	0.027
Storey 15	0.001	0.027
Storey 14	0.001	0.026
Storey 13	0.001	0.026
Storey 12	0.001	0.025
Storey 11	0.001	0.024
Storey 10	0.001	0.023
Storey 9	0.001	0.021
Storey 8	0.001	0.02
Storey 7	0.001	0.018
Storey 6	0.001	0.016
Storey 5	0.001	0.014
Storey 4	0.001	0.012
Storey 3	4.067E-04	0.01
Storey 2	3.072E-04	0.008
Storey 1	2.042E-04	0.005
Ground	9.949E-05	0.003
Base	0	0

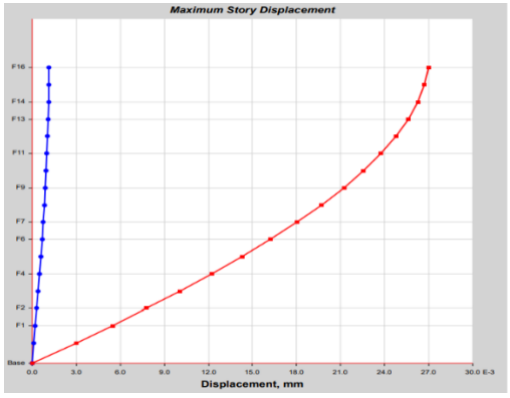

Figure 3.7: Story displacement

From Table 7, the Maximum and Minimum values of Story displacement in X direction are found as 0.001 from storey 4 to 16 and 9.949E-05 at Ground. Maximum and Minimum values of Story displacement in Y direction are found as 0.027 at storey 16 and 0.003 at Ground.

Table 8: Story drift

Storey	X direction	Y direction
Storey 16	0	9.347E-08
Storey 15	6.185E-09	1.547E-07
Storey 14	8.952E-09	2.168E-07
Storey 13	1.17E-08	2.78E-07
Storey 12	1.439E-08	3.379E-07
Storey 11	1.701E-08	3.961E-07
Storey 10	1.953E-08	4.521E-07
Storey 9	2.194E-08	0.000001
Storey 8	2.423E-08	0.000001
Storey 7	2.637E-08	0.000001
Storey 6	2.835E-08	0.000001
Storey 5	3.016E-08	0.000001
Storey 4	3.177E-08	0.000001
Storey 3	3.318E-08	0.000001
Storey 2	3.433E-08	0.000001
Storey 1	3.521E-08	0.000001
Ground	2.843E-08	0.000001
Base	0	0

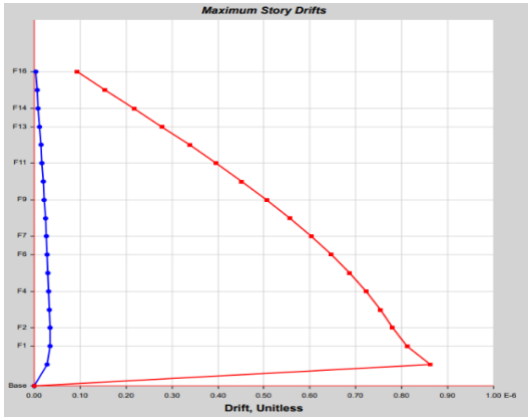

Figure 3.8: Story drift

From Table 8, the Maximum and Minimum values of Story drift in X direction are found as 0 at storey 16 and 6.185E-09 at storey 15. Maximum and Minimum values of Story drift in Y direction are found as 0.000001 from Ground to storey 9 and 9.347E-08 at storey 16.

Table 9: Story shear/ Base shear

Storey	X direction	Y direction
Storey 16	-0.0001	-0.0053
Storey 15	-0.0002	-0.0107
Storey 14	-0.0003	-0.0161

Storey 13	-0.0004	-0.0214
Storey 12	-0.0005	-0.0266
Storey 11	-0.0006	-0.0317
Storey 10	-0.0007	-0.0366
Storey 9	-0.0008	-0.0413
Storey 8	-0.0008	-0.0457
Storey 7	-0.0009	-0.05
Storey 6	-0.001	-0.0539
Storey 5	-0.0011	-0.0576
Storey 4	-0.0011	-0.0609
Storey 3	-0.0012	-0.0639
Storey 2	-0.0012	-0.0665
Storey 1	-0.0012	-0.0687
Ground	-0.0013	-0.0706
Base	0	0

Table 9 continued,

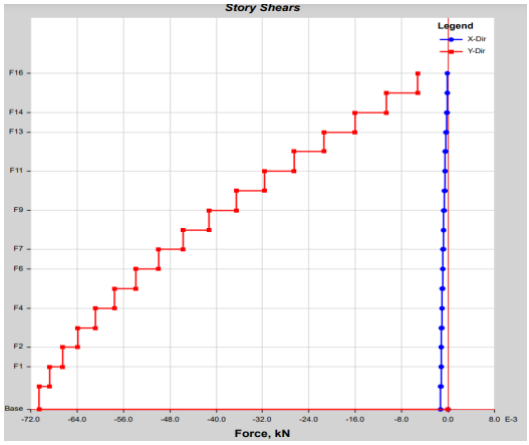

Figure 3.9: Story shear

From Table 9, the Maximum and Minimum values of Story shear in X direction are found as -0.0013(-1KN) at Ground and -0.0001(0KN) at storey 16. Maximum and Minimum values of Story shear in Y direction are found as -0.0053(-5KN) at storey 16 and -0.0706(-70KN) at Ground.

3.5 MODEL IV

For Response Spectrum Analysis in zone IV

Table 10: Story displacement

Storey	X direction	Y direction
Storey 16	0.001	0.027
Storey 15	0.001	0.027
Storey 14	0.001	0.026
Storey 13	0.001	0.026
Storey 12	0.001	0.025
Storey 11	0.001	0.024
Storey 10	0.001	0.023
Storey 9	0.001	0.021
Storey 8	0.001	0.02
Storey 7	0.001	0.018
Storey 6	0.001	0.016
Storey 5	0.001	0.014
Storey 4	0.001	0.012
Storey 3	4.067E-04	0.01
Storey 2	3.072E-04	0.008
Storey 1	2.042E-04	0.005
Ground	9.949E-05	0.003
Base	0	0

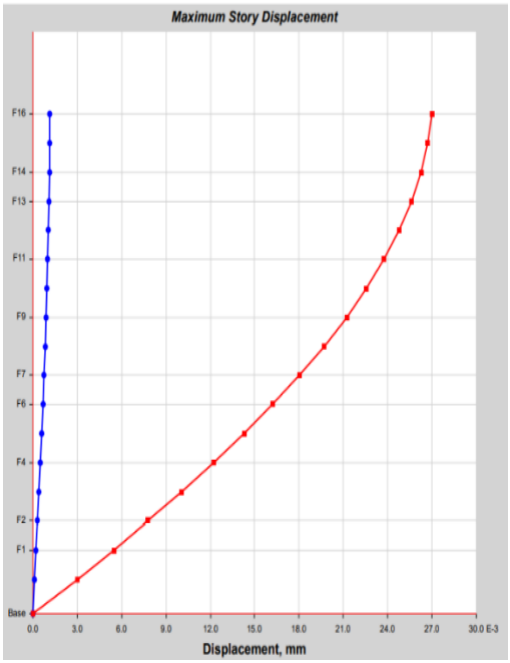

Figure 3.10: Story displacement

From Table 10, the Maximum and Minimum values of Story displacement in X direction are found as 0.001 from storey 4 to storey 16 and 9.949E-05 at Ground. Maximum and Minimum values of Story displacement in Y direction are found as 0.027 at storey 16 and 0.003 at Ground.

Table 11: Story drift

Storey	X direction	Y direction
Storey 16	0	9.347E-08
Storey 15	6.185E-09	1.547E-07
Storey 14	8.952E-09	2.168E-07
Storey 13	1.17E-08	2.78E-07
Storey 12	1.439E-08	3.379E-07
Storey 11	1.701E-08	3.961E-07
Storey 10	1.953E-08	4.521E-07
Storey 9	2.194E-08	0.000001
Storey 8	2.423E-08	0.000001
Storey 7	2.637E-08	0.000001
Storey 6	2.835E-08	0.000001
Storey 5	3.016E-08	0.000001
Storey 4	3.177E-08	0.000001
Storey 3	3.318E-08	0.000001
Storey 2	3.433E-08	0.000001
Storey 1	3.521E-08	0.000001
Ground	2.843E-08	0.000001
Base	0	0

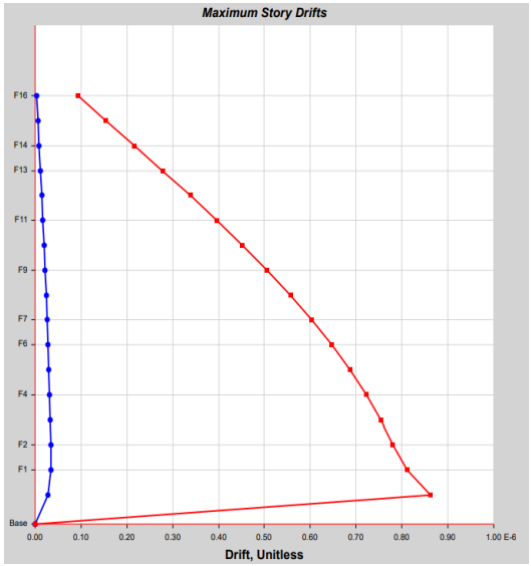

Figure 3.11: Story drift

From Table 11, the Maximum and Minimum values of Story drift in X direction are found as 0 at storey 16 and 6.185E-09 at storey 15. Maximum and Minimum values of Story drift in Y direction are found as 0.000001 from Ground to storey 9 and 9.347E-08 at storey 16.

Table 12: Story shear/ Base shear

Storey	X direction	Y direction
Storey 16	-0.0001	-0.0053
Storey 15	-0.0002	-0.0107
Storey 14	-0.0003	-0.0161
Storey 13	-0.0004	-0.0214
Storey 12	-0.0005	-0.0266
Storey 11	-0.0006	-0.0317
Storey 10	-0.0007	-0.0366
Storey 9	-0.0008	-0.0413
Storey 8	-0.0008	-0.0457
Storey 7	-0.0009	-0.05
Storey 6	-0.001	-0.0539
Storey 5	-0.0011	-0.0576
Storey 4	-0.0011	-0.0609
Storey 3	-0.0012	-0.0639
Storey 2	-0.0012	-0.0665
Storey 1	-0.0012	-0.0687
Ground	-0.0013	-0.0706
Base	0	0

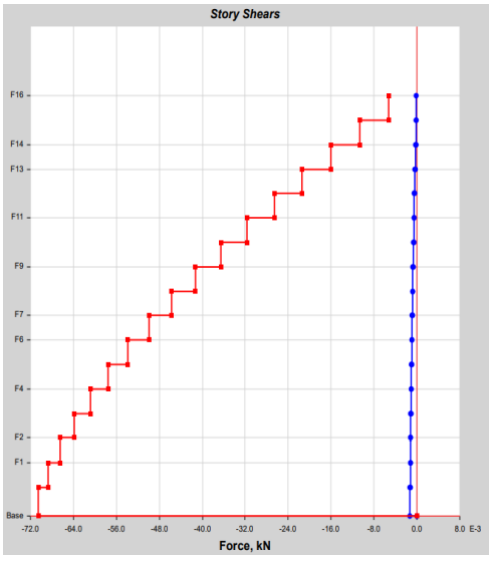

Figure 3.12: Story shear

From Table 12, the Maximum and Minimum values of Story shear in X direction are found as -0.0001(0KN) at storey 16 and -0.013(-1KN) at Ground. Maximum and Minimum values of Story shear in Y direction are found as -0.0053(-5KN) at storey 16 and -0.0706(70KN) at Ground.

4. Conclusions

An irregular building of torsional irregularity is considered for the analysis. The building assumed for analysis had plan asymmetry. For all the models, linear static analysis is carried out for Dead and Live loads and in case of MODEL III and MODEL IV response spectrum analysis is done for seismic load in x and y direction and the corresponding story response plots were compared.

Summary of the results:

i. The analysis is carried out considering all the loads on the building (100% of Dead,50% of Live and 0.25% of Seismic loads).
ii. The maximum earthquake load is found to be nearly 150KN in the lateral directions and a twisting moment of nearly 1720KN-m.
iii. The considered grade of concrete may not be sufficient for construction in higher zones. Therefore, the resulting values of base shear are observed to be negative indicating compression.
iv. Maximum displacements are found along the lateral direction in all the cases.
v. The base shear for dead load is positive and for seismic loads is negative. As concerned for the modal, it should be taken as the combination of all the loads and the base shear value becomes negative for the modal.
vi. It is observed that the tall buildings tend to respond majorly in displacements are greater along y direction.

From the above conclusions, it is suggested that the grade of concrete and the nominal dimensions of the structural members should be taken cared of and the lateral directions should be provided with a moment resisting systems.

5. References

1. IS 1893(Part 1)-2016: Indian Standard Criteria for Earthquake Resistant Design of Structures.
2. Dr. K. Chandrasekhar Reddy & G. Lalith Kumar, Seismic Analysis of High-Rise Buildings (G+30) by Using ETABS, IJTIMES, Volume 5, Issue 03, March-2019
3. S. R. Kangle, D. S. Yerudkar, Response Spectrum Analysis for Regular Multistory Structure in Seismic Zone III, IJERT, Vol. 9 Issue 09, September-2020
4. Shruthi Indaragi, M.B.Mogali, Response Spectrum Analysis of Symmetric and Asymmetric Structures in Seismic Zones, IRJET, Volume: 06 Issue: 07 | July 2019
5. Fatemeh Aliakbari, Sadegh Garivani and Ali Shahmari, Determination of torsional irregularity in response spectrum analysis of building structures, Structural Engineering and Mechanics, Vol. 74, No. 5 (2020) 699-709

6. Shaik Muneer Hussain, Dr. Sunil Kumar Tengli, Study on Torsional Effects of Irregular Buildings under Seismic Loads, IJAER, Volume 13, Number 7 (2018) pp. 55-60
7. M. Firoj and S. K. Singh, Response Spectrum Analysis for Irregular Multi-Storey Structure in Seismic Zone V, 16th Symposium on Earthquake Engineering December 20-22, 2018 IIT Roorkee, India, Paper No. 300
8. Sammelan Pokharel, S. Lakshmi Ganesh, G. Sabarish, Seismic Performance of Symmetric and Asymmetric Multi-Storeyed Buildings, IJRTE, Volume-8 Issue-1S3, June 2019
9. Pardeshi sameer, Prof. N. G. Gore, Study of seismic analysis and design of multi storey symmetrical and asymmetrical building, IRJET, Volume: 03 Issue: 01 | Jan-2016
10. Anirooth Velamuri, Y. Rajesh Kumar, Comparison of Response Spectrum, Time History and Matched Time History Method in Zone V and Zone IV Earthquake Zones of Multi Storied Building as per IS 1893-2016, IJRTE, Volume-7, Issue-6S5, April 2019
11. Abhishek Mishra, Mulayam Yadav, Kumar Vanshaj, Response Spectrum Analysis of a Multistorey Building in Seismic Zone– V, IRJMETS, Volume:04/Issue:03/March-2022