Journal of Engineering Sciences
Vol 13, Issue 06, June/2022
ISSN NO:0377-9254

DESIGN AND ANALYSI OF G+17 COMMERCIAL BUILDING USING E-TABS

B. Mahesh babu[1], M. Venkata Narasaiah[2]
[1]. Student, M. Tech, Chebrolu Engineering College, Chebrolu, Guntur (DT), A.P.
[2]Asst Professor. Chebrolu Engineering College, Chebrolu, Guntur (DT), A.P

Abstract

An earthquake occurs when substantial parts of the Earth's rocky outer layer suddenly break apart and move. One of the most destructive natural disasters on the planet, earthquakes can be deadly. In general, earthquakes do not cause death through direct impact. Instead, the collapse of buildings, bridges, and other infrastructure is responsible for a large number of fatalities and injury. We can't prevent natural disasters from happening, but we can make our buildings robust enough to withstand their destructive power. Using earthquake-resistant constructions can accomplish this. To minimize the damage caused by earthquakes, simple engineering and design principles can be applied at a low cost. This project explains the basics of engineering and design that must be taken into account while building earthquake-resistant structures. It is the goal of this research to determine the impact of earthquakes on a building and its ability to withstand these stresses. A building of height G+17 RCC structure is modeled with material properties M30 grade for concrete and Fe500 for reinforcing steel and structures dimensions of length 21m, width 17.5m and height of G+17 is 51.5m from the plinth level, the support conditions are chosen to be fixed base and foundation depth is considered as 1.5m below the ground level. Structures are modeled using ETABS in seismic zones III, IV, V as per IS 1893-2002 methods by using response spectrum method.

1.0 INTRODUCTION

The concept "structure" is used by civil engineers to designate any structure that includes a foundation, walls, columns, floors, roofs, doors, windows, ventilators, escalator lifts, and other types of surface treatments. In order to build a structure that can sustain all of the loads placed on it for the period of its intended lifespan without failing, structural analysis and design must be employed. An in-depth understanding of the supporting soil must be obtained through geotechnical investigation before designing any building. a geotechnical site investigation is the collection and evaluation of site information for the purpose of developing and building a construction foundation. In order to make sure that a building's final design and its intended function may be used for the intended purpose during construction, structural engineers have a challenge in finding the most cost-effective and efficient design. As the building's height increases, so does the structure's vulnerability to wind and seismic forces, which necessitates careful planning. Constructing a multi-story building requires the use of reinforced concrete the most. Due to its various advantages, it has become a key part of modern building practises. It has supplanted older materials including stone, lumber, and steel due to its shape-shifting ability and greater performance. This technology has helped engineers and architects to create magnificent structures. However, its value in several straight-line structural forms, such as multi-storey structures and bridges, is considerable. Unsymmetrical structures demand extra care in seismic analysis and design due to the influence of earthquake excitations.

Commercial building:

Structures used for commercial purposes are referred to as "business buildings." There are a variety of business buildings under the umbrella phrase "commercial building." In contrast to commercial property, which includes multi-family properties like apartment buildings, residential property is distinct. Why? Because businesses conduct their operations in commercial buildings, while commercial property generates profit for the owner while providing no requirement for the conduct of business to take place on site. In some cases, multi-use structures, such as shopping malls and residential apartments, may be referred to as commercial.

Important to understand commercial buildings

A fundamental understanding of business structures is helpful to a wide range of professionals. Knowing how local zoning restrictions may affect your company's ability to locate is essential before you begin the process of starting a business. The distinction between residential and commercial homes is important to know if you're in the real estate business and want to assist your clients effectively.

As a construction professional, you need to know what makes a commercial building commercial and what regulations and norms apply to different types of businesses to understand what makes a commercial building commercial. Industrial facilities have quite different needs when it comes to technology.

Seismic Zoning Map of India

In 1935, the Geological Survey of India (G. S. I.) produced the country's first seismic zoning map. This map was originally based on the amount of damage that earthquakes in various parts of India caused. It has since undergone multiple changes. This map depicts India's four unique seismic zones in a variety of red hues. The following is a list of the many seismic zones across the country, as depicted on the map:

- Zone - II: This is said to be the least active seismic zone.
- Zone - III: It is included in the moderate seismic zone.
- Zone - IV: This is considered to be the high seismic zone.
- Zone - V: It is the highest seismic zone.

Response Spectrum Analysis as per IS: 1893-2002

This strategy is also known as the modal method or the mode superposition method. the building's response is an amalgamation of numerous modes of vibration, each mode reacting with its own specific distortion, its own frequency, and its own modal dampening.

According to IS 1893(Part-l):2002, design spectra for high-rise and irregular structures must be assessed using a response spectrum technique. In each of the two orthogonal principle horizontal directions, at least 90% of the building's participating mass must be taken into account. However, the design base shear (VB) will be compared to a base shear (Vb) derived using a fundamental period (T). For smaller values of VB, all response quantities (such as member forces, displacements and storey forces and shears) must be multiplied by VB/Vb (and vice versa).

2.0 LITERATURE SURVEY

P. R. Patil, M. D. Pidurkar, R. H. Mohankar [1] investigated in various Analysis of portal frames necessitates a great deal of difficulty and time-consuming calculations when using conventional methods. An in-depth investigation like this takes a lot of time. Rotational contributions to portal frame analysis, such as Kani's Method and Moment Distribution Method, may be useful for approximation and rapid analysis so that detailed estimations can be obtained. [2] Balaji.U, Mr. Selvarasan M: ETABS was used to calculate the earthquake loads on a G+13 multi-story residential building that was proposed for this project. The material properties are considered to be linear static and dynamically analysed. When performing these non-linear studies, keep in mind the presence of high-magnitude earthquake zones and type II soil conditions. Responses to displacements, base shear, and other variables are plotted. Siva KiranKollimarla, Chadalawada Jagan Mohan [3] When it comes to seismic analysis and building design, there are numerous methods to choose from Standard codes can be used by engineers to examine a wide variety of projects. In order to highlight the utility of IS 1893:2002, Part-1's structural analysis provision, this study aims to present it. Varalakshmi V et.al [4] designed various components of a G+5-story residential structure, such as beam, column and foundation. HYSD bars (Fe 415) were used in accordance with IS 1986-85 in order to compute the dead and live loads. Reinforced concrete buildings' safety depends on their initial architectural and structural configuration, as well as their design and reinforcing detailing in order to ensure stability and ductility of the building's structural elements, according to the scientists. Chandrashekar et.al [5] ETABS programme was used to study and plan the multi-story skyscraper. A five-story G+5 structure that was subjected to wind and seismic lateral loading was examined using ETABS in this study. In addition to considering the risk of fire spread, it is essential to use fire-resistant materials that satisfy the highest levels of performance and dependability. Balaji. U and Selvarasan M.E [6] Static and dynamic loading conditions were analysed and designed with ETABS. ETABS was used to calculate the quake loads on a G+13-story residential building in this research. The linearity of material attributes was assumed for both static and dynamic evaluations. Non-linear analysis took into account seismically active areas and soils of class II. Maps of results like base shear and displacements were drawn to better understand their sources.

3.0 METHODOLOGY

In earthquake history, there has been a constant study of earthquakes and a detailed documentation of their occurrence and consequences on structures. Structural engineers have been working tirelessly since the 1970s to develop ways for developing earthquake-resistant structures that are basic and refined. Multiple updates to the criteria for "Earthquake Resistant Design of Structures" have been made to the Indian Standard 1893 by the Bureau of Indian Standards (BIS) New Delhi as a result of this continuing re-examination. By understanding the underlying design concepts for determining lateral forces, structural engineers can accurately comprehend code revisions. Linear elastic analysis and non-linear inelastic analysis can be used to calculate the lateral forces. In many countries, it is normal practise to incorporate some or all of the methods of analysis into the design process. Criteria for Earthquake Resistant Design of Structures, IS 1893 (Part I): 2002, limits the method of analysis described or utilised in this chapter to buildings alone, even if it can be used to other types of structures in some cases.

Methods of Seismic Analysis

When adopting the structural model, an analysis may be undertaken to identify the seismically induced forces in the structures. Analytical methods vary in their level of precision. Characterizing the process can be done by looking at the response of the structure or material, as well as what kind of structural model is being employed. Depending on the type of external action and structure behaviour being researched, the analysis can be classified as linear static, linear dynamic, non-linear static, or non-linear dynamic.

Journal of Engineering Sciences
Vol 13, Issue 06, June/2022
ISSN NO:0377-9254

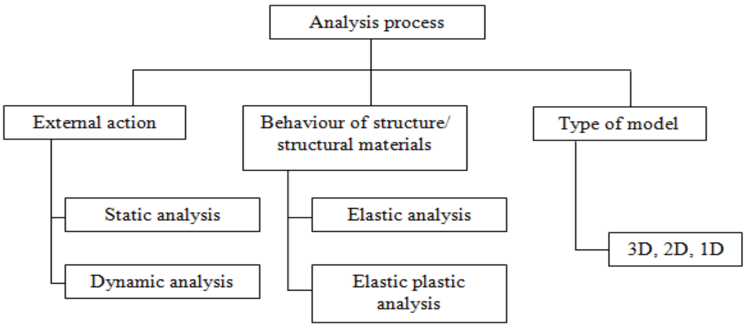


Fig 3.1 Method of Analysis Process

Linear static analysis or a similar static analysis can only be performed on regular structures with a limited height. Linear dynamic analysis can be done using the mode superposition method, the response spectrum method, or the elastic time history approach.

Response Spectrum Analysis

This method is also known as the modal method or the mode superposition method. Higher modes of vibration and the real distribution of forces in the elastic range can be better understood with this technique. This is the approach. Using the Reaction spectrum Analysis, the peak earthquake response of a structure can be determined immediately. This strategy takes into account a building's many responses to an earthquake. Each mode's response is derived from the design spectrum using the modal frequency and mass.

Modelling

ETABS is a user-friendly, all-in-one solution for structural design and analysis that handles all aspect of the process. ETABS is a good tool for multi-story building analysis. The entire input data can be generated graphically or by simply inputting simple commands. In a user-friendly environment, it has the most advanced algorithms and the most cutting-edge graphics.

- A building-type structure's distinctive properties are taken use of by the input, output and numerical solutions techniques of ETABS.
- In the age of nonlinear dynamic analysis and the additional computing power now available, structural engineers need a particular purpose programme more than ever before.
- ETABS has a long history of large-scale projects and has become the industry standard in that time. Static and dynamic analysis of multi-story frame and shear wall buildings can be performed using ETABS software.

Modeling of structures

In the present study, three G+17 structure models with 1.5m foundation depth and 3m and 3.5m bay widths in length and width directions, support conditions are considered to be maintained at the bottom or at the supports/footings. Total length is 21 m, width is 5 x 3.5 m, and height is 51.5 m for the structures in total. ETABS (structural analysis and design software) was used to simulate the structure, which was built with M30 concrete and Fe500 reinforcing steel bars for structural study and design. It has been suggested that a method called the response spectrum one be considered.

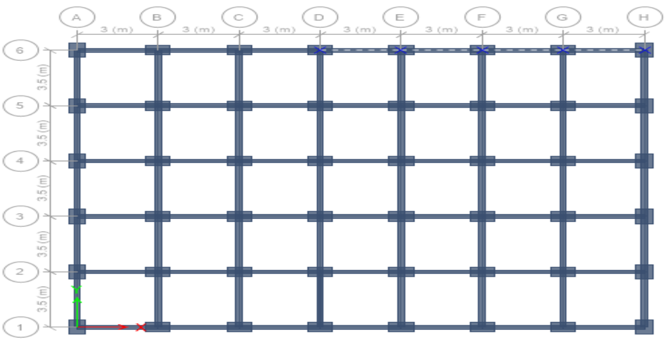


Figure 3.2 Floor plan of G+17 building

Vol 13, Issue 06, June/2022

ISSN NO:0377-9254

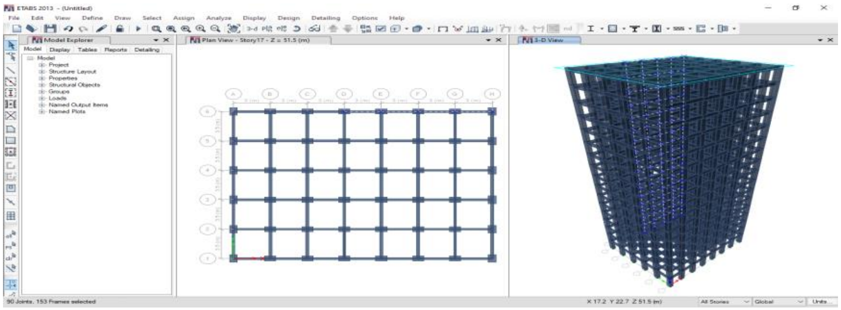


Fig 3.3: Three-dimensional view of G+ 17 structure

Table: Design data used in modeling and analysis of structure

Materials	M30, Fe500
Loadings	Dead, live, earthquake
Heights of building	G+17
Length	7x3 = 21m
Width	5x3.5 = 17.5m
Foundation depth	1.5m
Floor to floor height	3.0m
zones	III, IV, V
Software	ETABS
Size of column	900x600
Beam size	230x600
Soil type	II
Geometry of Building	Symmetric
Methods used in analysis	Response spectrum analysis

DESIGN OF BEAM:

Sectional area: 250mm x 750mm

Concrete grade: M30 Steel

used: Fe415

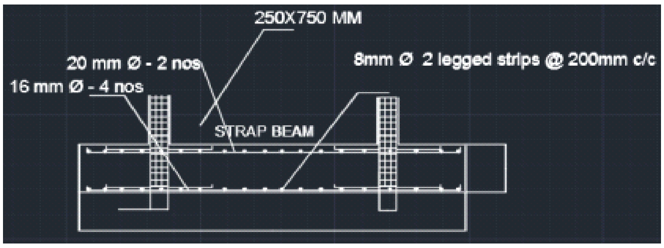


Figure 3.4: Reinforcement details of beam

DESIGN OF COLUMN

Dimension: 250mm x 750mm

Concrete grade: M30

Steel used: Fe415

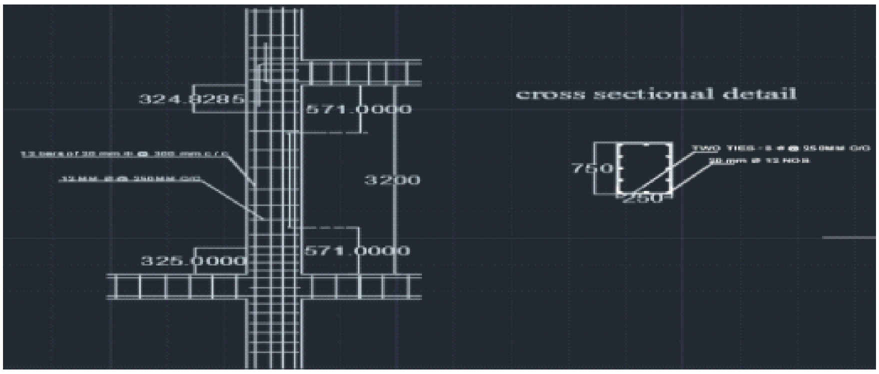


Figure 3.5: Reinforcement details of column

DESIGN OF FOOTING

Axial service load P = 1660 KN

Size of the column = 750 mm x 250 mm

Journal of Engineering Sciences
Vol 13, Issue 06, June/2022
ISSN NO:0377-9254

Safe bearing capacity of soil = 140 N/mm2
fck= 20 N/mm2 and fy = 415N/mm2

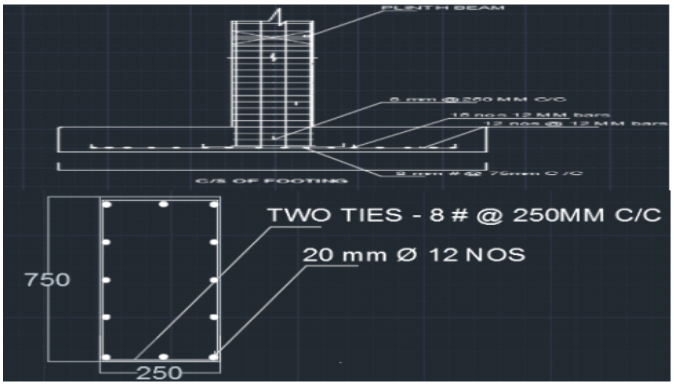


Figure 3.6: Reinforcement details of Footing

DESIGN OF STAIRCASE STAIR CASE TYPE=
DOG LEGGED Height of floor= 3.6m
Height of each flight= 1.8m Flight width=1.85m
Rise=150mm thread=300mm
No. of risers required=1.8/0.15=12 in each flight
No.of thread in each flight=12-1=11
Width of landing= 1.85m

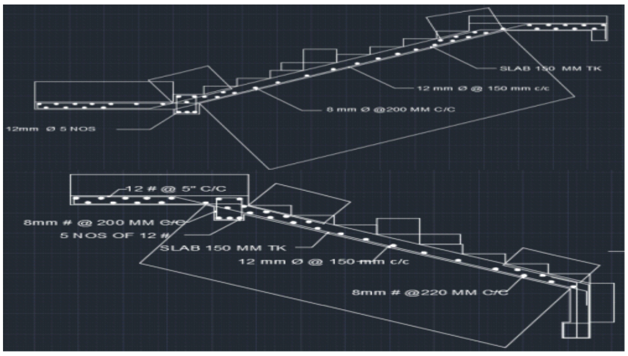


Figure 3.7: Reinforcement details of stair case

4.0 RESULTS AND DISCUSSION

There are tables and graphs detailing the results of G+17 building analysis in seismic zones III, IV, and V. Lateral loads, base reactions, bending moments, shear forces, and axial forces are among the parameters examined.

Results of G+17 building in zone III

Table: Storey displacements of G+17 in zone III

Story	Elevation m	Location	For EQ X		For EQ Y	
			X-Dir (mm)	Y-Dir (mm)	X-Dir (mm)	Y-Dir (mm)
Story17	51.5	Top	11.8	2.542E-02	1.369E-02	13.1
Story16	48.5	Top	11.6	2.548E-02	1.515E-02	12.8
Story15	45.5	Top	11.2	2.483E-02	1.492E-02	12.5
Story14	42.5	Top	10.8	2.398E-02	1.452E-02	12
Story13	39.5	Top	10.4	2.299E-02	1.421E-02	11.5
Story12	36.5	Top	9.8	2.184E-02	1.381E-02	10.9
Story11	33.5	Top	9.2	2.056E-02	1.329E-02	10.2
Story10	30.5	Top	8.6	1.916E-02	1.265E-02	9.5
Story9	27.5	Top	7.9	1.767E-02	1.191E-02	8.7
Story8	24.5	Top	7.1	1.61E-02	1.108E-02	7.9
Story7	21.5	Top	6.4	1.448E-02	1.016E-02	7.1
Story6	18.5	Top	5.6	1.281E-02	9.149E-03	6.3
Story5	15.5	Top	4.9	1.111E-02	8.062E-03	5.4

Story4	12.5	Top	4.1	9.374E-03	7.37E-03	4.6
Story3	9.5	Top	3.3	7.614E-03	7.471E-03	3.7
Story2	6.5	Top	2.5	5.76E-03	4.756E-03	2.8
Story1	3.5	Top	1.5	3.502E-03	1.342E-02	1.8
Base	0	Top	0	0	0	0

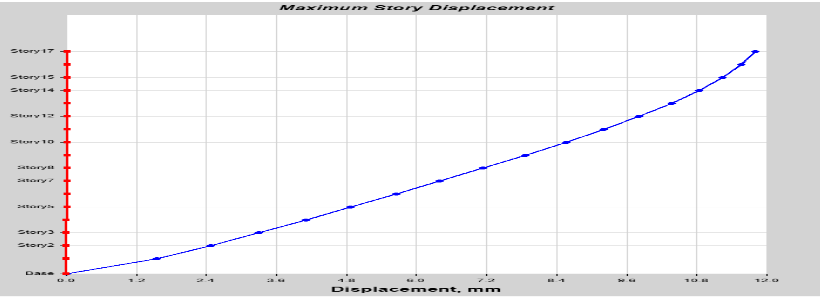


Fig: 5.1 Maximum storey displacements of structure for EQ X in zone III

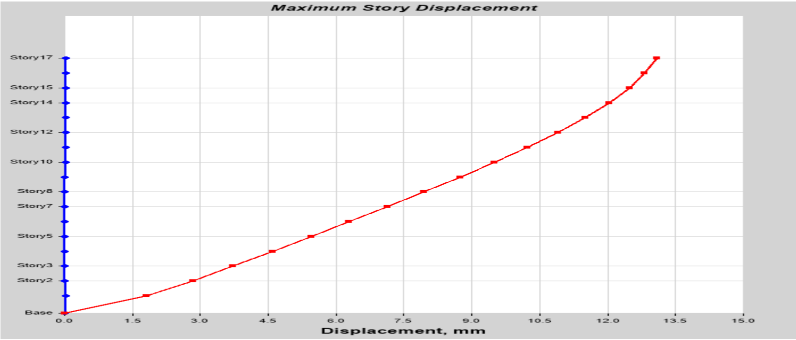


Fig: 5.2 Maximum storey displacements of structure for EQ Y in zone III

Table: Storey drifts of G+17 in zone III

Story	Elevation m	Location	For EQ X		For EQ Y	
			X-Dir	Y-Dir	X-Dir	Y-Dir
Story17	51.5	Top	0.00008	3.042E-07	0.000001	0.000089
Story16	48.5	Top	0.000105	2.159E-07	1.792E-07	0.000117
Story15	45.5	Top	0.000133	2.84E-07	1.349E-07	0.000148
Story14	42.5	Top	0.000159	3.298E-07	1.033E-07	0.000176
Story13	39.5	Top	0.000182	3.822E-07	1.33E-07	0.000202
Story12	36.5	Top	0.000202	4.278E-07	1.741E-07	0.000223
Story11	33.5	Top	0.000218	4.658E-07	2.12E-07	0.000241
Story10	30.5	Top	0.000231	4.97E-07	2.458E-07	0.000255
Story9	27.5	Top	0.000241	0.000001	2.769E-07	0.000266
Story8	24.5	Top	0.000248	0.000001	3.068E-07	0.000274
Story7	21.5	Top	0.000253	0.000001	3.373E-07	0.000279
Story6	18.5	Top	0.000257	0.000001	3.887E-07	0.000282
Story5	15.5	Top	0.000259	0.000001	0.000001	0.000284
Story4	12.5	Top	0.000263	0.000001	0.000001	0.000287
Story3	9.5	Top	0.000275	0.000001	0.000001	0.0003
Story2	6.5	Top	0.000313	0.000001	0.000005	0.000352
Story1	3.5	Top	0.00044	0.000001	0.000004	0.000515
Base	0	Top	0	0	0	0

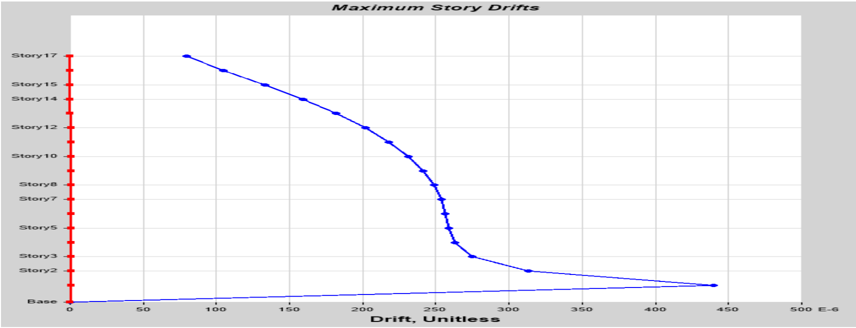


Fig: 5.3 Maximum storey drifts of structure for EQ X in zone III

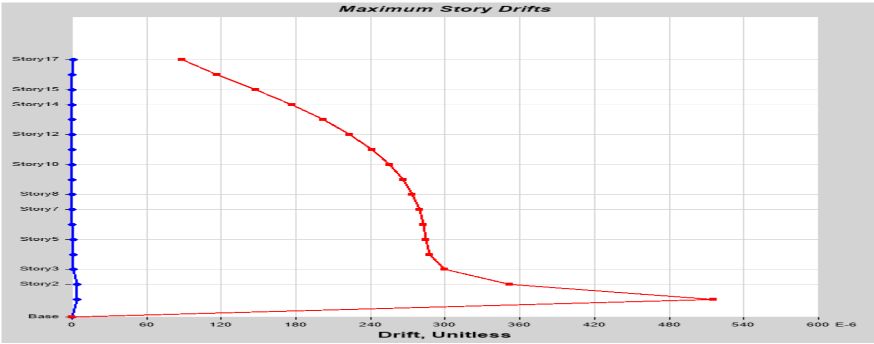
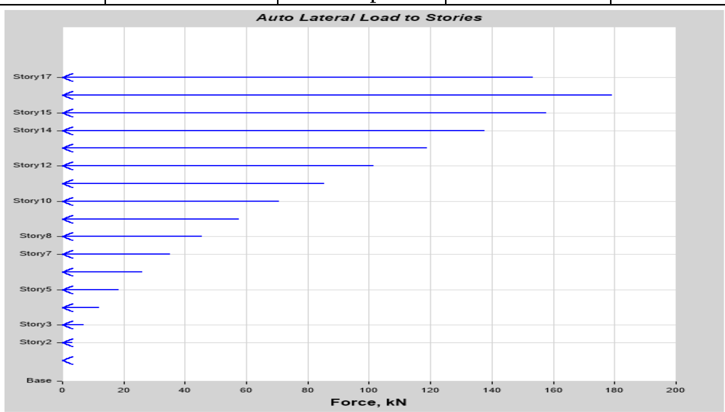


Fig: 5.4 Maximum storey drifts of structure for EQ Y in zone III

Table 5.3 Lateral loads on G+17 in zone III

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story17	51.5	Top	153.2853	137.7126
Story16	48.5	Top	179.1233	160.9256
Story15	45.5	Top	157.6491	141.633
Story14	42.5	Top	137.5455	123.5719
Story13	39.5	Top	118.8127	106.7422
Story12	36.5	Top	101.4505	91.1439
Story11	33.5	Top	85.4591	76.777
Story10	30.5	Top	70.8383	63.6417
Story9	27.5	Top	57.5883	51.7377
Story8	24.5	Top	45.7089	41.0652
Story7	21.5	Top	35.2002	31.6241
Story6	18.5	Top	26.0623	23.4145
Story5	15.5	Top	18.295	16.4363
Story4	12.5	Top	11.8984	10.6896
Story3	9.5	Top	6.8725	6.1743
Story2	6.5	Top	3.2173	2.8905
Story1	3.5	Top	0.9703	0.8717
Base	0	Top	0	0



Vol 13, Issue 06, June/2022

ISSN NO:0377-9254

Fig: 5.5Lateral seismic load distribution in X-direction on structure in zone III

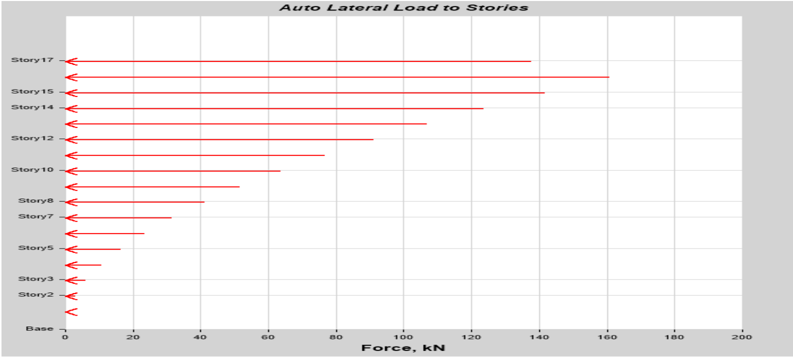


Fig: 5.6Lateral seismic load distribution in Y-direction on structure in zone III

Table 5.4 Storey shears of G+17 in zone III

Story	Elevation m	Location	For EQ X		For EQ Y	
			X-Dir (kN)	Y-Dir (kN)	X-Dir (kN)	Y-Dir (kN)
Story17	51.5	Top	-153.2853	0	0	-137.7126
		Bottom	-153.2853	0	0	-137.7126
Story16	48.5	Top	-332.4086	0	0	-298.6382
		Bottom	-332.4086	0	0	-298.6382
Story15	45.5	Top	-490.0577	0	0	-440.2712
		Bottom	-490.0577	0	0	-440.2712
Story14	42.5	Top	-627.6032	0	0	-563.8431
		Bottom	-627.6032	0	0	-563.8431
Story13	39.5	Top	-746.4159	0	0	-670.5852
		Bottom	-746.4159	0	0	-670.5852
Story12	36.5	Top	-847.8665	0	0	-761.7291
		Bottom	-847.8665	0	0	-761.7291
Story11	33.5	Top	-933.3256	0	0	-838.5062
		Bottom	-933.3256	0	0	-838.5062
Story10	30.5	Top	-1004.1639	0	0	-902.1478
		Bottom	-1004.1639	0	0	-902.1478
Story9	27.5	Top	-1061.7522	0	0	-953.8855
		Bottom	-1061.7522	0	0	-953.8855
Story8	24.5	Top	-1107.4611	0	0	-994.9507
		Bottom	-1107.4611	0	0	-994.9507
Story7	21.5	Top	-1142.6613	0	0	-1026.5749
		Bottom	-1142.6613	0	0	-1026.5749
Story6	18.5	Top	-1168.7236	0	0	-1049.9894
		Bottom	-1168.7236	0	0	-1049.9894
Story5	15.5	Top	-1187.0186	0	0	-1066.4257
		Bottom	-1187.0186	0	0	-1066.4257
Story4	12.5	Top	-1198.917	0	0	-1077.1153
		Bottom	-1198.917	0	0	-1077.1153
Story3	9.5	Top	-1205.7895	0	0	-1083.2896
		Bottom	-1205.7895	0	0	-1083.2896
Story2	6.5	Top	-1209.0068	0	0	-1086.1801
		Bottom	-1209.0068	0	0	-1086.1801
Story1	3.5	Top	-1209.9771	0	0	-1087.0518
		Bottom	-1209.9771	0	0	-1087.0518
Base	0	Top	0	0	0	0
		Bottom	0	0	0	0

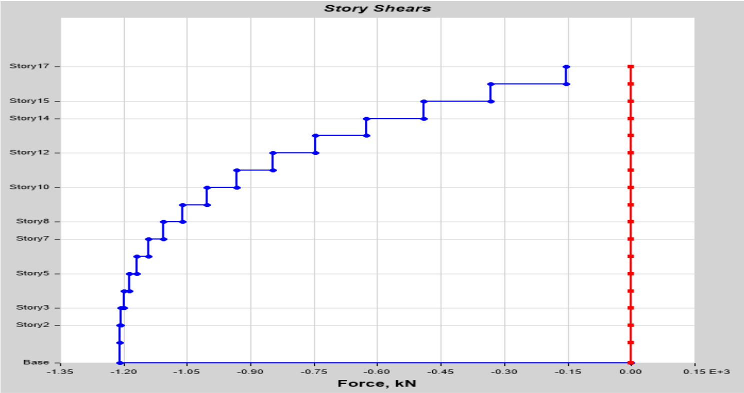


Fig: 5.7 Storey shears ofstructure for EQ X in zone III

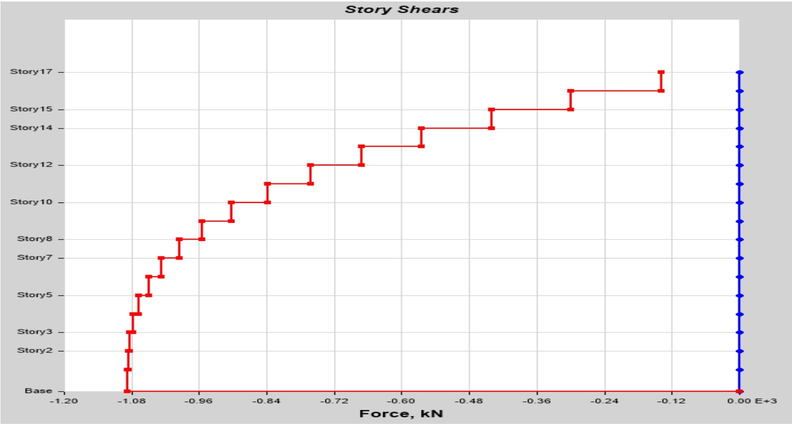


Fig: 5.8 Storey shears ofstructure for EQ Y in zone III

Table 5.5 Base reactions of G+17 in zone III

Load Case/ Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	0	0	125486.078	1096567	-1317296	0
Live	0	0	23152.5	202584.375	-243101	0
EQ X	-1209.977	0	0	0	-47484.29	10565.4405
EQ Y	0	-1087.052	0	42660.2156	0	-11409.836
Comb1	0	0	222957.867	1948727	-2340596	0
Comb2	-1451.973	0	178366.293	1558981	-1929458	12678.5286
Comb3	1451.9726	0	178366.293	1558981	-1815496	-12678.529
Comb4	0	-1304.462	178366.293	1610174	-1872477	-13691.803
Comb5	0	1304.4622	178366.293	1507789	-1872477	13691.8033
Comb6	0	0	222957.867	1948727	-2340596	0
Comb7	1814.9657	0	188229.117	1644850	-1904718	-15848.161
Comb8	0	-1630.578	188229.117	1708840	-1975944	-17114.754
Comb9	0	1630.5778	188229.117	1580860	-1975944	17114.7542
DCon1	0	0	188229.117	1644850	-1975944	0
DCon2	0	0	222957.867	1948727	-2340596	0
DCon3	-1451.973	0	178366.293	1558981	-1929458	12678.5286
DCon4	1451.9726	0	178366.293	1558981	-1815496	-12678.529
DCon5	0	-1304.462	178366.293	1610174	-1872477	-13691.803
DCon6	0	1304.4622	178366.293	1507789	-1872477	13691.8033
DCon7	-1814.966	0	188229.117	1644850	-2047170	15848.1607
DCon8	1814.9657	0	188229.117	1644850	-1904718	-15848.161
DCon9	0	-1630.578	188229.117	1708840	-1975944	-17114.754
DCon10	0	1630.5778	188229.117	1580860	-1975944	17114.7542
DCon11	-1814.966	0	112937.47	986910.013	-1256793	15848.1607
DCon12	1814.9657	0	112937.47	986910.013	-1114340	-15848.161

DCon13	0	-1630.578	112937.47	1050900	-1185566	-17114.754
DCon14	0	1630.5778	112937.47	922919.689	-1185566	17114.7542

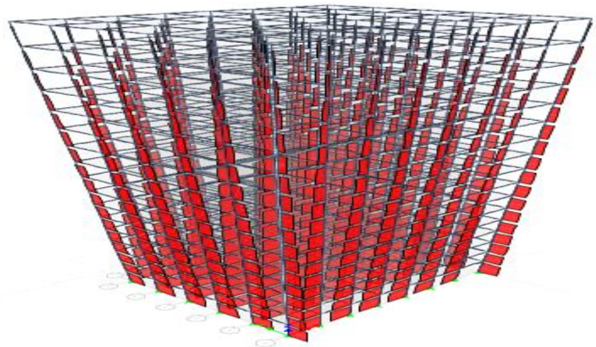


Fig5.9: Axial load variation in columns in zone III

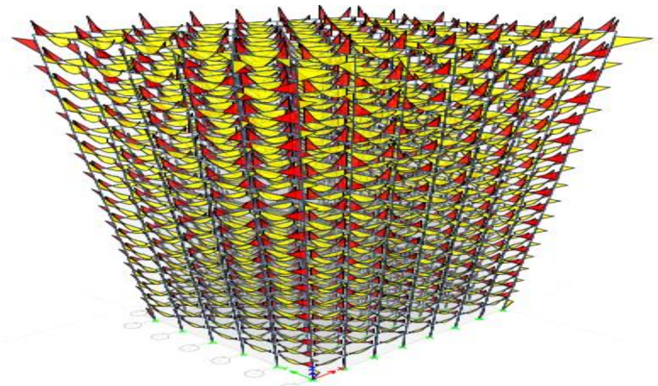


Fig5.10: Bending moment variation in beams in zone III

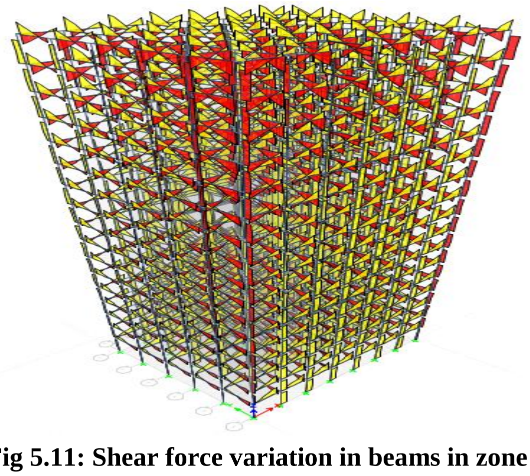


Fig 5.11: Shear force variation in beams in zone III

CONCLUSIONS

Based on a response spectrum analysis of G+17 building in zones III, IV, and V, the following are the results.

- As the level of the building rises, so do the displacement, drift, shear, and lateral loads.
- As the zone expands, storey displacement, storey drifts, lateral loads, and storey shears increase.
  - X-direction loads are bigger than those in Y-direction for every zone. When you get to storey 16, the lateral load maximums for each zone are as follows.
  - In zone III lateral load is 179.1233 KN
  - In zone IV lateral load is 268.685 KN
  - In zone V lateral load is 403.0275 KN
- The storey displacements, storey drifts and storey shears in X-direction increase with respect to Y-direction.

- The storey displacement is more in Y-direction at storey 17, storey drift is more in Y-direction at storey 1 and storey shear is more in X-direction at storey 1. Those values are as follows for different zones
  - In zone III displacement is 13.1 mm, drift is 0.000515 and shear is -1209.98 KN
  - In zone IV displacement is 19.6 mm, drift is 0.000773 and shear is -1814.97 KN
  - In zone V displacement is 29.5 mm, drift is 0.001159 and shear is -2722.45KN
- Maximum Support reactions at the base is 222957.867 KN
- Shorter columns are observed to be stiffer than longer columns and are subjected to higher storey forces.
- It is observed that with the increase in the seismic zones the parameters such as axial loads, bending moments, shear forces and deflections are increasing.

Further Scope of Study:

- Analysis and Design can be done for the same building by increasing the number of stories.
- The same building can further be modelled in Revit Architecture for Architectural and Aesthetic looks.

REFERNCES

1. Varalakshmi V,G shivakumar and R S Sarma (2014) "Designed and d G+5 residential building by ETABS", International Conference on Advance in Engineering and Technology.
2. Chandrashekarand and Rajashekar (2015), "Analysis and Design of Multi Storied Building by Using ETABS Software", International journals of scientific and research vol.4: issue.7: ISSN no. 2277-8179.
3. Balaji and Selvarasan (2016), "Design and Analysis of multi-storeyed building under static and dynamic loading conditions using ETABS", International Journal of Technical Research and Applications e-ISSN: 2320-8163, www.ijtra.com Volume 4, Issue 4, PP. 1-5
4. Geethu S N, Depthi M, Abdul Nasir N A and Izzudeen K M (2016)"Comparative study on design and analysis of multi storied building by STAAD. Pro and ETABS softwares".
5. Bahadur Shah Zafar Marg, New Delhi 110002. • IS: 875 (Part 2) – 1987 for Imposed Loads, Indian Standard Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan,