Vol 13, Issue 04, APRIL / 2022
ISSN NO:0377-9254

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

P. HYNDHAVA VATHSAL, G . SREEKANTH
M.Tech Student, Assistant Professor
Dept of Civil Engineering
Geethanjali College of Engineering & Technology, Kurnool

ABSTRACT

Earthquake is the shaking of the ground caused by the sudden breaking and shifting of large sections of earth's rocky outer shell. Earthquakes are among the most powerful events on earth, and their results can be terrifying. Earthquake is general does not kill people directly. Instead, many deaths and injuries result from the collapse of buildings, bridges and other structures. We cannot prevent natural disasters from striking, but we can prevent or limit their impact by making buildings strong enough to resist their destructive forces. This can be achieved by earthquake resistant structures. In the case of earthquakes, it is possible to neutralize their harm by applying basic engineering and planning principles that are in expensive. This project deals with the explanation of basic engineering and planning to be taken into account during the construction of earthquake resistant structures. The present study is to find the seismic effect on building and its performance under earthquake loads. 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. The results are shown in terms of graphs and tables.

I. INTRODUCTION

The world's urban population is growing at very faster rate. Currently, about half of the world's population is living in urban areas. In the coming decades, urban dwellers will make up roughly 60 to 70 percent of the world's population. Though the urban population is growing at an alarming rate, the land available for construction is limited. Increasing population coupled with urbanization has made the construction of multi-storey buildings a necessity to house the millions. Housing the millions is possible only by constructing multi-storey buildings. As The height of building increases, the behavior of the structure becomes more complex, these are more sensitive to wind and earthquake loads and hence, we need to be very careful to design them. Reinforced concrete is the best suited for multi-storey buildings. It has occupied a special place in the modern construction due to its several advantages. Owing to its flexibility in form and superiority in performance, it has replaced the earlier materials like stone, timber and steel. It has helped the engineers and architects to build pleasing structures. However, its role in several straight line structural forms like, multi-storey building and bridges etc. is enormous. The unsymmetrical buildings require great attention in the analysis and design under the action of seismic excitation.

1.1 origin of earthquake:

Sudden movement on faults is responsible for earthquakes. An earthquake is simply the vibrations caused by the blocks of rock on either side of a fault rubbing against each other as they move in opposite directions. Bigger the movement of faults bigger the earthquake.

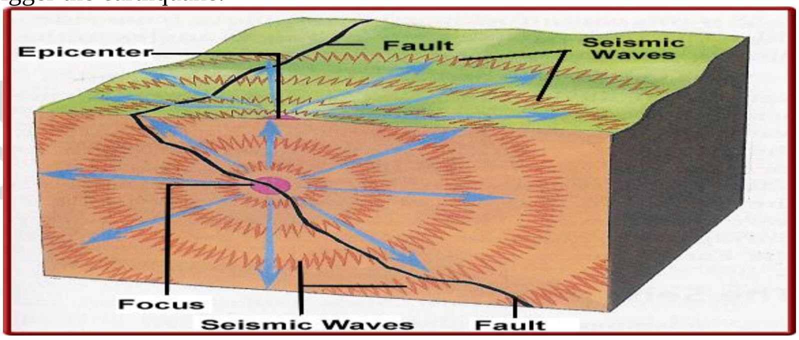


Fig 1.1: origin of earthquake from earth

1.2 Seismic zones India:

Based on magnitude of the earthquake India is classified into four zones (II, III, IV, and V) where zone V is high severity zone

Vol 13, Issue 04, APRIL / 2022
ISSN NO:0377-9254

Table 2 Zone Factor, *Z*
(*Clause* 6.4.2)

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

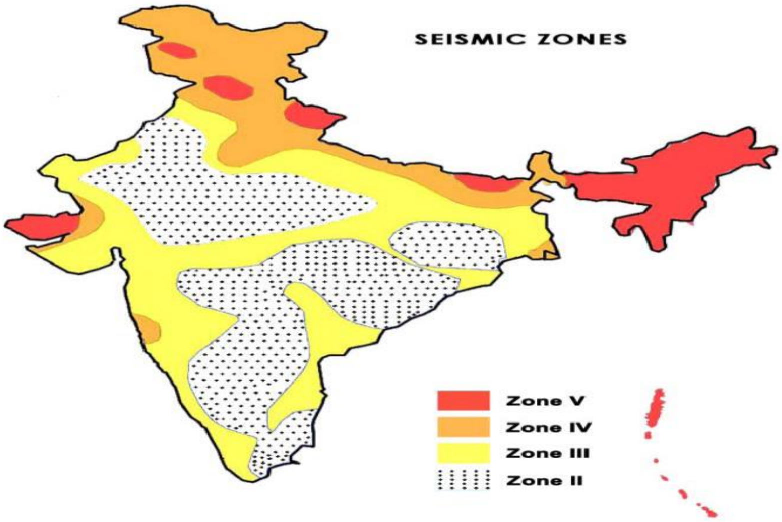
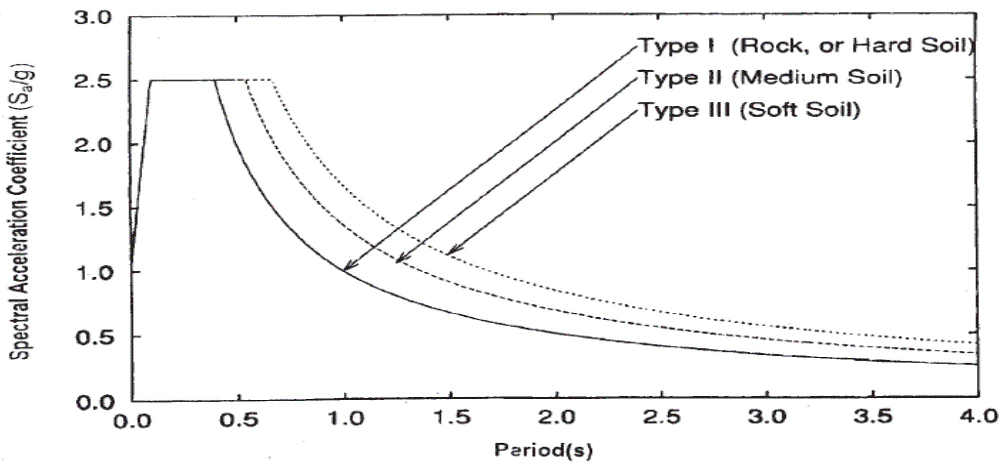


Fig 1.2: seismic map of India



1.4 Linear static analysis

Displacements, strains, stresses, and reaction forces under the effect of applied loads are calculated..A series of **assumptions** are made with respect to a linear static analysis:

Small Deflections Determine whether the deflections obtained or predicted are small relative to the size of the structure.

Small Rotations In linear codes all rotations are assumed to be small. Any angle measured in radians should be small enough that the tangent is approximately equal to the angle.

Material Properties Linear solvers assume that all material behaves in a linear elastic manner. Some materials have a non-linear elastic behavior, and although they do not necessarily yield.

1.5 Time history method:

The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure.

1.6 Response spectrum method:

The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic analysis of steel and reinforce concrete buildings, respectively

Vol 13, Issue 04, APRIL / 2022
ISSN NO:0377-9254

1.7 Response Spectrum Analysis as per IS: 1893-2002

This method is also known as modal method or mode superposition method. It is based on the idea that the response of a building is the superposition of the responses of individual modes of vibration, each mode responding with its own particular deformed shape, its own frequency, and with its own modal damping.

According to IS 1893(Part-l):2002, high rise and irregular buildings must be analysed by response spectrum method using design spectra Sufficient modes to capture such that at least 90% of the participating mass of the building (in each of two orthogonal principle horizontal directions) have to be considered for the analysis. However, in this method, the design base shear (V_B) shall be compared with a base shear (V_b) calculated using a fundamental period T. If V_B is less than V_b, all response quantities are (for example member forces, displacements, storey forces, storey shears and base reactions) multiplied by V_B/ V_b.

1.8 Modal combination as per IS: 1893-2002

Modal Response quantities for each mode of response may be combined by the complete quadratic combination (CQC) technique or by taking the square root of the sum of the squares (SRSS) of each mode of the modal values or absolute sum (ABS) method.

(i) CQC method: The peak response quantities shall be combined as per the complete quadratic combination (CQC) method.

$$\lambda = \sqrt{\sum_{i=1}^{r} \sum_{j=1}^{r} \lambda_i \rho_{ij} \lambda_j}$$

where

r = Number of modes being considered,

ρ_{ij} = Cross-modal coefficient,

λ_i = Response quantity in mode i (including sign),

λ_j = Response quantity in mode j (including sign),

(ii)SRSS method: If the building does not have closely spaced modes, then the peak response quantity due to all modes considered shall be obtained as

$$\lambda = \sqrt{\sum_{k=1}^{r} (\lambda_k)^2}$$

where

λ_k = Absolute value of quantity in mode k, and

r = Number of modes being considered.

(iii) ABS method: If the building has a few closely spaced modes, then the peak response quantity due to all modes considered shall be obtained as

$$\lambda^* = \sum_{c}^{r} \lambda_c,$$

Where, the summation is for the closely-spaced modes only. This peak response quantity due to the closely spaced modes (λ^*) is then combined with those of the remaining well-separated modes by the method described above.

1.9 El Centro earthquake for time history analysis

The 1940 El Centro earthquake occurred at 21:35 Pacific Standard Time on May 18 (05:35 UTC on May 19) in the Imperial Valley in southeastern Southern California near the international border of the United States and Mexico. It had a moment magnitude of 6.9 and a maximum perceived intensity of X (*Extreme*) on the Mercalli intensity scale. The earthquake was the result of a rupture along the Imperial Fault, with its epicenter 5 miles (8.0 km) north of Calexico, California, The event caused significant damage in the towns of Brawley, Imperial, El Centro, Calexico and Mexicali and was responsible for the deaths of nine people

1.10 Mass source for the calculation of seismic weights:

1. 100% of Dead loads from structural members and brick work are considered
2. 50% of live loads/imposed loads are considered

II. LITERATURE SURVEY

P. R. Patil, M. D. Pidurkar, R. H. Mohankarstudiedin generalAnalysis of portal frames involves lot of complications and tedious calculations by conventional methods. To carry out such analysis is a time consuming task. The rotation contribution method i.e. Kani's Method & Moment Distribution Method for analysis of portal frames can be handy in approximate and quick analysis so as to get the detailed estimates ready. In this work, these two methods have been applied only for vertical loading conditions. This paper presents the analysis of portal frame, considering mainly the case of single bay portal frame, which is the most common in practice. The Kani's method is self-correcting, that is, the error, if any, in a cycle is corrected automatically in the subsequent cycles. The checking is easier as only the last cycle is required to be checked. The convergence is generally fast. It leads to the solutions in just a few cycles of iterations.

Balaji.U, Mr. Selvarasan M, In this project they proposed a journal on a residential of G+13 multi-story building which is studied for earth quake loads using ETABS. .Assuming that material property is linear static and dynamic analysis is performed. These non-linear analyses are carried out by considering severe seismic zones and the behavior is assessed by taking types II soil condition. Different response like, displacements, base shear are plotted.

III.METHODOLOGY

3.1 Introduction

Earthquake and its occurrence and measurements, its vibration effect and structural response have been continuously studied for many years in earthquake history and thoroughly documented in literature. Since then the structural engineers have tried hard to examine the procedure, with an aim to counter the complex dynamic effect of seismically induced forces in structures, for designing of earthquake resistant structures in a refined and easy manner. This re-examination and continuous effort has resulted in several revisions of Indian Standard: 1893: (1962, 1966, 1970, 1975, 1984, and 2002) code of practice on the "Criteria for Earthquake Resistant Design of Structures" by the Bureau of Indian Standards (BIS), New Delhi. In order to properly interpret the codes and their revisions, it has become necessary; that the structural engineers must understand the basic design criteria and procedures for determining the lateral forces. Various approaches to seismic analysis have been developed to determine the lateral forces, ranging from purely linear elastic to non-linear inelastic analysis. Many of the analysis techniques are being used in design and incorporated in codes of practices of many countries. However, this chapter is restricted to the method of analysis described or employed in IS 1893 (Part I): 2002 of "Criteria for Earthquake Resistant Design of Structures" essentially to buildings although in some cases that may be applied to other types of structures as well.

3.2 General Terms

- Natural Period (T): Natural period of a structure is its time period of undamped free vibration.
- Fundamental Natural Period (T1): It is the first (longest) modal time period of vibration.
- Diaphragm:It is a horizontal or nearly horizontal system, which transmits lateral forces to the vertical resisting elements, for example, reinforced concrete floors and horizontal bracing systems.
- Seismic Mass: It is the seismic weight divided by acceleration due to gravity.
- Seismic Weight (W): It is the total dead load plus appropriate amounts of specified imposed load.
- Centre of Mass: The point through which the resultant of the masses of a system acts. This point corresponds to the centre of gravity of masses of system.
- Storey Shear: It is the sum of design lateral forces at all levels above the storey under consideration.
- Zone Factor (Z):It is a factor to obtain the design spectrum depending on the perceived maximum seismic risk characterized by Maximum Considered Earthquake (MCE) in the zone in which the structure is located. The basic zone factors included in this standard are reasonable estimate of effective peak ground acceleration.
- Response Spectrum Analysis: It is the representation of the maximum response of idealized single degree freedom system shaving certain period and damping, during earthquake ground motion. The maximum response is plotted against the undamped natural period and for various damping values, and can be expressed in terms of maximum absolute acceleration, maximum relative velocity, or maximum relative displacement.
- Time History Analysis: It is an analysis of the dynamic response of the structure at each increment of time, when its base is subjected to a specific ground motion time history.

3.3 Methods of Seismic Analysis

Once the structural model has been selected, it is possible to perform analysis to determine the seismically induced forces in the structures. There are different methods of analysis which provide different degrees of accuracy. The analysis process can be categorized on the basis of three factors: the type of the externally applied loads, the behavior of structure/or structural materials and the type of structural model selected. Based on the type of external action and behavior of structure, the analysis can be further classified as linear static analysis, linear dynamic analysis, non-linear static analysis, or non-linear dynamic analysis (Beskos and Anagnostoulos, 1997).

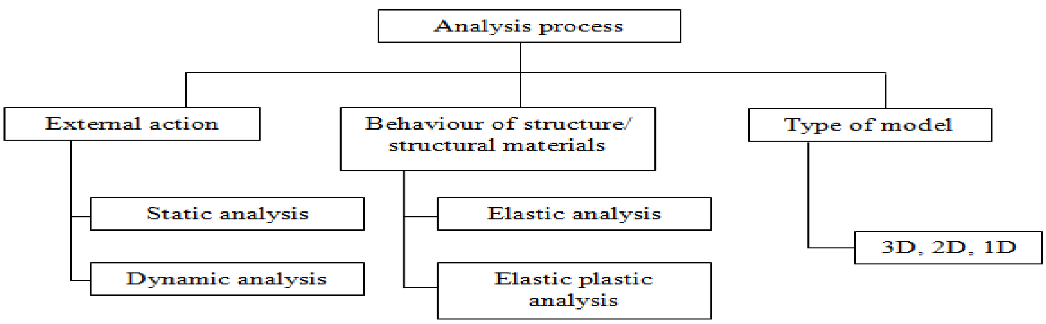


Fig 3.1 Method of Analysis Process (Syrmakezis, 1996)

Linear static analysis or equivalent static analysis can only be used for regular structures with limited height. Linear dynamic analysis can be performed in two ways either by mode superposition method or response spectrum method and elastic time history method. This analysis will produce the effect of the higher modes of vibration and the actual distribution of forces in the elastic range in a better way. They represent an improvement over linear static analysis. The significant difference between linear static and dynamic analysis is the level of force and their distribution along the height of the structure. Non – linear static analysis is an improvement over the linear static or dynamic analysis in the sense that it allows the inelastic behavior of the structure. The methods still assume a set of static incremental lateral load over the height of structure. The method is relatively simple to be implemented, and provides information on the strength, deformation and ductility of the structure and the distribution of demands. This permit to identify critical members likely to reach limit states during the earthquake, for which attention should be given during the design and detailing process. But this method contains many limited assumptions, which neglect the variation of loading pattern, the influence of higher modes, and the effect of resonance.

3.4 Response Spectrum Analysis

This method is also known as mode superposition method or modal method. In this method the analysis will produce the effect of higher modes of vibration and the actual distribution of forces in the elastic range in a better way. In the Response spectrum Analysis the peak response of the structure during an earthquake is obtained directly from the earthquake response (or design) spectrum. In this approach multiple modes of response of a building to an earthquake is taken into an account. For each mode a response is read from the design spectrum based on modal frequency and modal mass. The responses of the different modes are combined to provide an estimate of the total response of the structure using modal combination methods such as Complete Quadratic combinations (CQC), Square root of sum of squares (SRSS) and Absolute Method.

3.4.1 Determination of Eigen values and Eigen vectors, Clause 7.8.4.1:

Let the shear stiffness of the i^{th} storey is k_i and the mass is m_i subjected to an external dynamic force $f_i(t)$ and the corresponding displacement $x_i(t)$. Assuming damping in the system in small, so it may be ignored and the system is analyzed as undamped system. Using D'Alemberts's principle, the dynamic equilibrium equation of mass at each floor is,

$$m\ddot{x}_{n-1} + k_n(x_{n-1} - x_{n-2}) - k_n(x_n - x_{n-1}) = f_{n-1}(t)$$

IV.MODELLING

4.1: modeling of structures

In the present study three G+17 structure models with foundation depth of 1.5m and bay widths in length and width directions of 3m and 3.5m each respectively, support conditions are assumed to be fixed at the bottom or at the supports/footings. The structures having length = 7x3 = 21m, width = 5x3.5 = 17.5m and height = 51.5m. The structureis modeled in ETABS (structural analysis and design software) by considering various loads and load combinations by their relative occurrence are considered the material properties considered are M30 grade concrete and Fe500 reinforcing steel bars. Methods of analysis considered are response spectrum method.

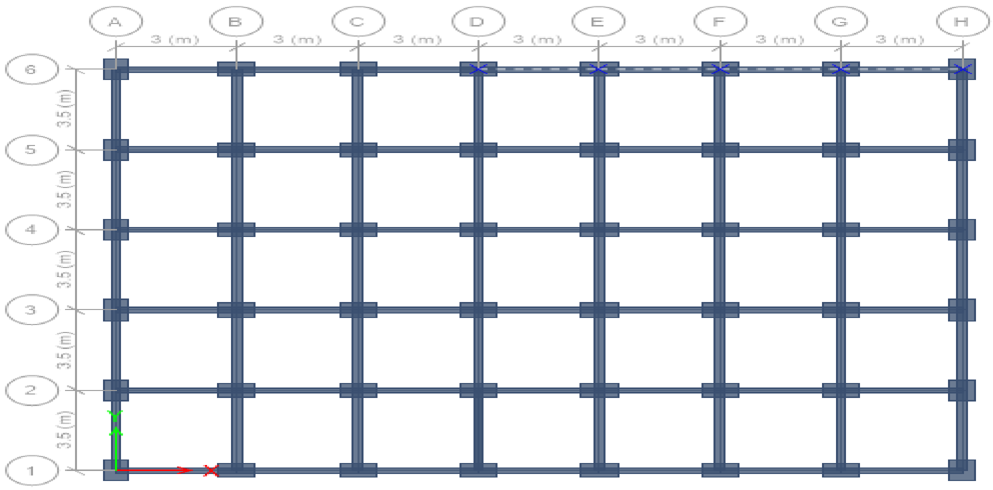


Fig 4.1: Floor plan of G+17 building

JES
Journal of Engineering Sciences
Vol 13, Issue 04, APRIL /2022
ISSN NO:0377-9254

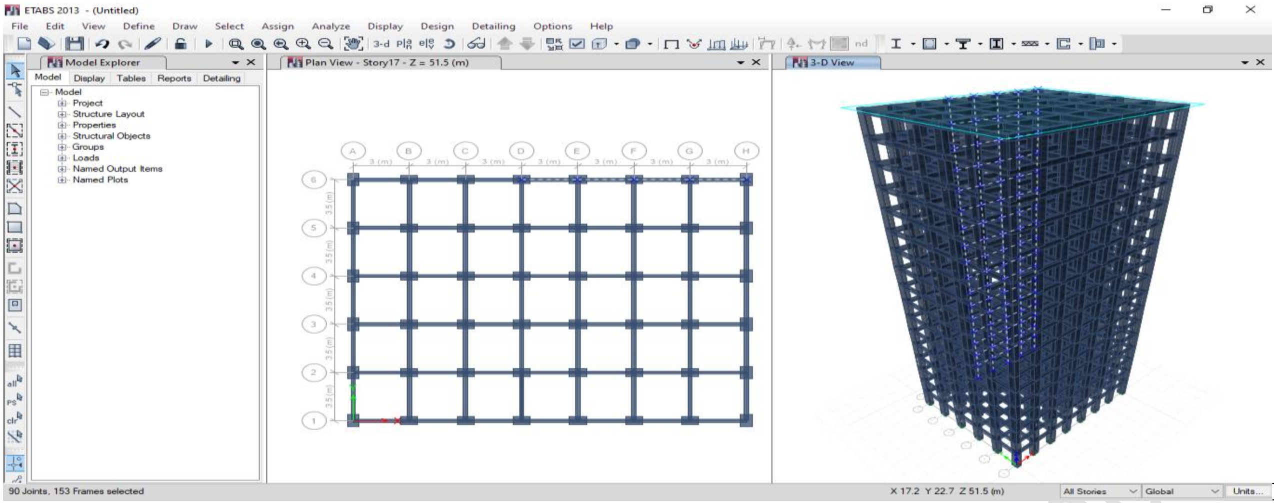


Fig 4.2: Three dimensional view of G+ 15 structure

Table 4.1: 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

4.2 Is codes used for analysis and design

[1] IS 1893:1984,"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi, India.
[2] IS 456: 2000,"Plain reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi, India.
[3] IS 875-3: 1987,"Code of practice for design wind loads(other than earthquake) for buildings and structures", Bureau of Indian Standards, New Delhi, India.

V. RESULTS AND DISCUSSION

In this chapter analysis results of G+17 building in seismic zones III, IV and V are listed in tables and graphs. The parameters studied are storey displacements, storey drifts, storey shears, lateral loads, base reactions, bending moments, shear forces and axial forces.

5.1 Results of G+17 building in zone III

Table 5.1 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

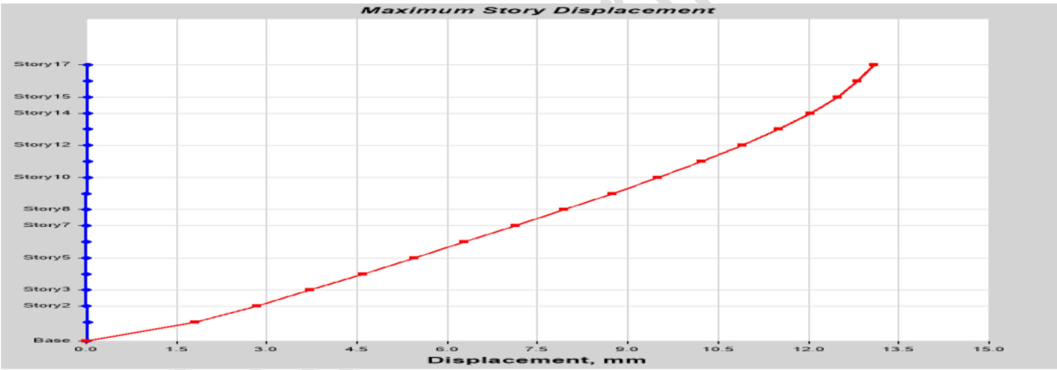


Fig: 5.2 Maximum storey displacements of structure for EQ Y in zone III

VI. CONCLUSIONS

The following are the results drawn from the analysis of G+17 buildingin zones III, IV and V by using response spectrum under seismic loads applied parallel to x and y directions.

1. As the storey increases displacement increases, drift decreases, storey shear increases and lateral loads increases.
2. As the zone increases the storey displacement, storey drifts, lateral loads and storey shears are increasing.
3. Lateral loads in X-direction are greater than Y-direction for every zone. The max lateral load in every zone is at storey 16 and those values 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
4. The storey displacements, storey drifts and storey shears in X-direction increase with respect to Y-direction.
5. 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
6. Maximum Support reactions at the base is 222957.867 KN
7. Shorter columns are observed to be stiffer than longer columns and are subjected to higher storey forces.
8. It is observed that with the increase in the seismic zonesthe parameters such as axial loads, bending moments, shear forces and deflections are increasing.

Vol 13, Issue 04, APRIL / 2022
ISSN NO:0377-9254

REFERNCES

1. IS 1893:1984,"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi, India.
2. IS 1893(Part1):2002,"Criteria for earthquake resistant design of structures -General provisions and buildings", Bureau of Indian Standards, New Delhi, India.
3. IS 456: 2000,"Plain reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi, India.
4. IS 13920: 1993,"Ductile detailing of reinforced concrete structures subjected to seismic forces-code of practice", Bureau of Indian Standards, New Delhi, India.
5. IS 875 Part I for Dead load calculations.
6. IS 875 Part II for live load calculations.
7. B.G. Birajdar1, S.S. Nalawade2" seismic analysis of buildings resting on sloping ground"
8. Likhitharadhya Y R1, Praveen J V2, Sanjith J3, Ranjith A4 "Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground"
9. Dr. R. B. Khadiranaikar1 and Arif Masali2 " Seismic performance of buildings resting on sloping ground a review"
10. Manjunath C S1, SidduKarthik C S2 "seismic performance of r c buildings on sloping grounds with different types of bracing systems"
11. P. R. Patil, M. D. Pidurkar, R. H. Mohankar studied(2013) on "Comparative Study of End Moments Regarding Application of Rotation Contribution Method (Kani's Method) & Moment Distribution Method for the Analysis of Portal Frame" (Volume 7, Issue 1)IOSR-JMCE
12. Balaji.U, Mr. Selvarasan M. studied (2016) "Design and analysis of multi storied building under static and dynamic loading conditions using ETABS" (Volume 4, Issue 4) International Journal of Technical Research and Applications e-ISSN: 2320-8163.
13. Siva KiranKollimarla, ChadalawadaJagan Mohan studied (2016)"Seismic Analysis of a Multi Storey Plane Frame using Static & Dynamic Methods Comparison of Equivalent Static Force & Response Spectrum on Frame with & without Infill's" (Vol. 5 Issue 04) (IJERT)
14. DeepmalaPandey (2016) on" Analysis& Design of G+5 Residential Building with Seismic Load Using STAAD .Pro "(Vol-2, Issue-8) (IJIR)
15. Aman, ManjunathNalwadgi , Vishal T, Gajendra studied (2016) " Analysis and design of multistorey building by using STAAD Pro"(Volume: 03 Issue: 06) (IRJET)