SEISMIC ANALYSIS OF G+10 BUILDING IN ZONE II USING ETABS SOFTWARE

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ABSTRACT

Because earthquakes are uncommon and may not occur during a building's lifetime, designing a structure with the intention of minimising damage during an earthquake renders the construction very uneconomical. The purpose of earthquake-resistant construction is to shield buildings from seismic activity. The aim of earthquake-resistant construction is to build buildings that fair better during seismic activity than their conventional equivalents, even though no structure can be completely immune to damage from earthquakes. Building rules state that buildings designed to withstand earthquakes are meant to be able to survive the greatest earthquake of a certain probability that is expected to occur at that site. This implies that in the case of a rare earthquake, life loss should be reduced by avoiding building collapse, and in the event of a more regular earthquake, functional loss should be restricted. ETABS software was used in this work to assess and design a G+10 RCC framed structure. In zone II seismic condition, the structure is examined for earthquake forces in accordance with IS 1893(Part 1):2002.

This study's primary goals are to examine the G+10 framed structure's variation storey drift, shear, bending, torsion, time period, and frequency values using response spectrum analysis.

KEYWORDS: Time period, ETABS, seismic activity, storey drift, shear, bending, and torsion values,

I. INTRODUCTION

1.1 General

At present people are facing problems of lad scarcity, cost of land. The population explosion and advent of industrial revolution led to the exodus of people from villages to urban areas i.e. construction of multi-storied buildings has become inevitable both for residential and as well as office purposes. The high raised structures are not properly designed for the resistance of lateral forces. It may cause to the complete failure of the structures. The earthquake resistance structures are designed based on the some factors. The factors are natural frequency of the structure, damping factor, type of foundation, importance of the building and ductility of the structure. The structures designed for ductility need to be designed for less lateral loads as it has better moment distribution qualities. This aspect is taken care of by response reduction factor R for different type of structure. For high performance, the building is designed as an SMRF. It needs to be designed only for lesser forces than it is designed as an OMRF.

In India most of the structures are low rise buildings. Now a days due to greater migration towards cities, results in increase in the population in most of the major cities. In order to fulfill the requirement of this increased population in limited land the height of building becomes medium to have high rise buildings. The improper design and construction of building may cause great destruction of structures all over the world. Hence we have to be concerned about the safety against the earthquake forces that are affecting the structures. The major factor is the asymmetry of the building the asymmetry contributes significantly for translational torsional coupling in the seismic responses which can lead to lateral deformation of the building. Buildings with asymmetric distribution of stiffness and strength in plan undergo coupled lateral and torsional motions during earthquake. In many of cases the centre of resistances dose not coincide with the centre of mass.

1.2 Earthquake

When two plates of the earth suddenly collide each other, there is sudden release of energy these energy is called as seismic waves that makes the ground shakes called earthquakes. Then the surface where the slip is called fault plane. The location below the earth surface where the earthquake starts is called hypocenter, and the location above the earth surface is called the epicenter. When the earth is disturbed by natural and artificial disturbances the vibrations are produced. These vibrations will transferred to all directions from the point of origin. The intensity of vibrations are high at the starting point then the vibrations will slowly decreases when going from the starting point. Seismographs is the instrument where the earthquakes are recorded and the recording is called seismogram when the earthquakes occurs the energy released is in the form of seismic waves. These seismic waves travel inside the earth and on the surface of the earth. The seismic waves are of two types body waves and surface waves. These body waves are again divided into two types primary Analysis of multistoried building in different seismic zones with different soil conditions 2 waves and secondary waves. P and S waves can cause higher damage to brick stone buildings especially the shorter ones. The surface wave can cause great damage to the tall buildings on soft soil conditions.

Earthquake analysis methods to incorporate the forces during event of an earthquake. Intensity of these forces depends on the magnitude of the earthquake.

1.2.1 Dynamic actions on buildings-wind and earthquake

Dynamic actions are caused on buildings by both wind and earthquake. But, design for wind forces and for earthquake effects are distinctly different. The initiative philosophy of structural design use force as the basis, which is consistent in wind design, wherein the building is subjected to a pressure on its exposed surface area; this is *force-type* loading. However, in earthquake design, the building is subjected to random motion of the ground at its base (Figure 1.1), which induces inertia forces in the building that in turn cause stresses; this is displacement-type loading. Another way of expressing this difference is through the load-deformation curve of the building – the demand on the building is force (i.e., vertical axis) in force-type loading imposed by wind pressure, and displacement (i.e., horizontal axis) in displacement-type loading imposed by earthquake shaking.

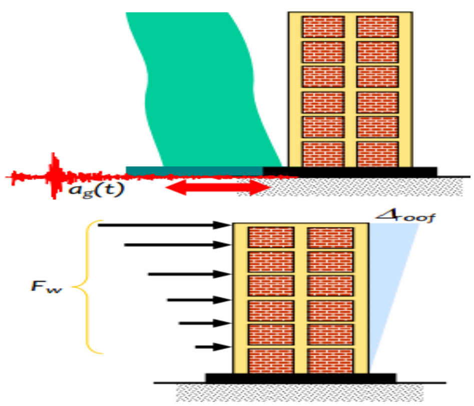


Figure 1.2: Difference in the design effect on a building during natural actions of earthquake ground movement at base and Wind pressure on exposed area

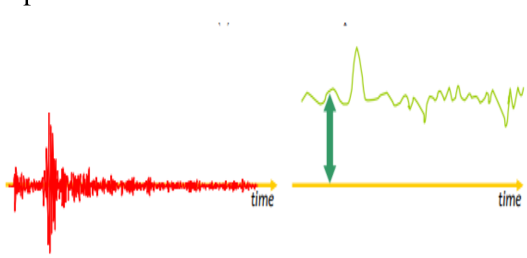


Figure 1.3: Nature of temporal variations of design actions: earthquake ground motion-zero mean, cytic and wind pressure-non zero mean, oscillatory

1.2.2 Basic aspects of seismic design

The mass of the building being designed controls seismic design in addition to the building

stiffness, because earthquake induces inertia forces that are proportional to the building mass. Designing buildings to behave elastically during earthquakes without damage may render the project economically unviable. As a consequence, it may be necessary for the structure to undergo damage and thereby dissipate the energy input to it during the earthquake.

Therefore, buildings are designed only for a fraction (~ 8 – 14%) of the force that they would experience, if they were designed to remain elastic during the expected strong ground shaking and thereby permitting damage. But, sufficient initial stiffness is required to be ensured to avoid structural damage under minor shaking. Thus, seismic design balances reduced cost and acceptable damage, to make the project viable. This careful balance is arrived based on extensive research and detailed post-earthquake damage assessment studies. A wealth of this information is translated into precise seismic design provisions. In contrast, structural damage is not acceptable under design wind forces. For this reason, design against earthquake effects is called as earthquake-resistant design and not earthquake-proof design.

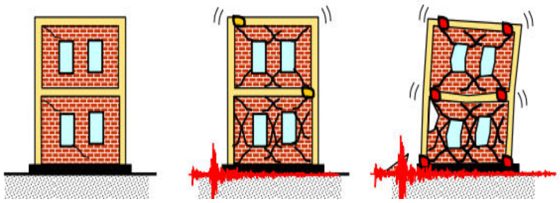


Figure 1.4: Earthquake-Resistant Design Philosophy for buildings: minor (frequent) shaking – No/Hardly any damage, Moderate Shaking - Minor structural damage, and some non-structural

damage and Severe (Infrequent) Shaking – Structural damage, but NO collapse

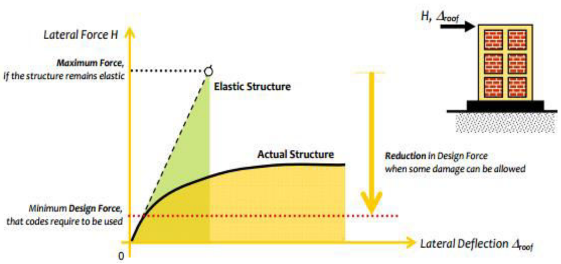


Figure 1.5: Basic strategy of earthquake design: Calculate maximum elastic forces and reduce by a factor to obtain design forces

1.3 OBJECTIVES OF THE STUDY

From this study the following objectives were made

1. How the seismic evaluation of a building should be carried out.
2. To study the behavior of a building under the action of seismic loads
3. Analysis and design of G+10 multi story building is done by using ETABS Software.
4. Comparison made between different floor of results in Zone II.
5. To study the displacement, shear force and bending moment of G+10 building was done.
6. To compare various analysis results of building under zone II.

1.4 Summary

Dynamic actions are caused on buildings by both wind and earthquakes. But, design for wind forces and for earthquake effects are distinctly different. The intuitive philosophy of structural design uses force as the basis, which is consistent in wind design, wherein the building is subjected to a pressure on its exposed surface area; this is force type loading. However, in earthquake design, the building is subjected to random motion of the ground at its base, which induces inertia forces in the building that in turn cause stresses; this is displacement-type loading. Another way of expressing this difference is through the load deformation curve of the building – the demand on the building is force(i.e., vertical axis) in force-type loading imposed by wind pressure, and displacement(i.e., horizontal axis) in displacement type loading imposed by earthquake shaking. Wind force on the building has a non-zero mean component superposed with a relatively small oscillating component.

II. LITERATURE REVIEW

A.Pavan Kumar Reddy, R.Master Praveen Kumar, et al[1] .,(2017)

From the ancient time we know earthquake is a disaster causing occasion. Up to date days constructions are fitting increasingly narrow and extra inclined to sway and consequently detrimental within the earthquake. Researchers and engineers have worked out within the past to make the constructions as earthquake resistant. After many functional reports it has proven that use of lateral load resisting methods in the constructing configuration has drastically increased the performance of the structure in earthquake by using ETABS 9.7.4, the work has been carried out for the distinctive instances utilizing shear wall and bracings for the exceptional heights, and maximum top regarded for the reward gain knowledge of is 93.5m. The modeling is completed to examine the outcome of special circumstances along with specific heights on seismic parameters like base shear, lateral displacements and lateral drifts. The gain knowledge of has been implemented for the Zone IV and Zone V in Soil Type II (medium soils) as targeted in IS 1893-2002.

Narla mohan, A.mounika vardhan, et al (2017)

When a structure is subjected to earthquake, it responds by vibrating. An earthquake force can be resolved into three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. It is very essential to consider the effects of lateral loads induced from wind and earthquakes in the analysis of reinforced concrete structures, especially for high-rise buildings. The basic intent of analysis for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage. It resists moderate earthquakes without structural damage but sometimes non-structural damage will resist major earthquakes without collapse the major structure. The present study is limited to reinforced concrete (RC) multi-storied commercial building with FOUR different zones II, III, IV & V .The analysis is Carried out the help of FEM software's ETabs. The building model in the study has twenty storey's with constant storey height of 3m. FOUR models are used to analyze with different bay lengths and the number of Bays and the bay-width along two horizontal directions are kept constant in each model for convenience. Different values of SEISMIC ZONE FACTOR are taken and their corresponding effects are interpreted in the results.

J.chiranjeevi yadav, I.Ramaprasad reddy, et al[3], (2017)

In the present scenario of construction industry, the buildings that are being constructed are gaining significance, in general, those with best possible outcomes with reference to optimal sizing and reinforcing of the structural elements, mainly beam and column members in multi-bay and multi–storey RC structures. Optimal sizing incorporates optimal stiffness co-relation among structural members and results in cost savings over the typical state-of-the practice design solutions. "Optimization" means making things the best. The race towards new heights and architecture has not been without challenges. When the building increases in height, the stiffness of the structure becomes more important. Tall structures have continued to climb higher and higher facing strange loading effects and very high loading values due to dominating lateral loads. The design criteria for tall buildings are strength, serviceability, stability and human comfort. Thus the effects of lateral loads like wind loads, earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. Effect of lateral load on moments, axial forces, shear force, base shear, maximum storey drift and tensile forces on structural system are studied and also comparing the results of zone 2 and zone 5.

III. EARTHQUAKE METHODOLOGY

3.1 Earthquake loading

Earthquake loading consists of the internal forces of the building mass that result from the shaking of its foundation by a seismic disturbance. Earthquake resistant design concentrates mainly on the translational inertial forces. These translational inertial pressures have a greater impact on a structure than vertical or rotational shaking components. Other strong earthquake forces exist, such as land slide, subsidence, and liquefaction of the local subgrade due to vibration, among others. The frequency of earthquakes is inversely proportional to their magnitude. Although a structure may be designed to withstand the most severe earthquake without substantial damage, the requirement for such strength throughout the project's lifetime would not justify the high additional expense.

Two main techniques are used to assess seismic loading. These methods take into account the structure's characteristics as well as the region's previous earthquake history. The comparable lateral force process is the first method. The maximum base shear is calculated using a basic calculation of the structure's fundamental period and the expected maximum ground acceleration, as well as other pertinent parameters.

The second technique is a modal analysis, which involves analysing the structure's modal frequencies and combining them with earthquake design spectra to determine the maximum modal response.

3.2 Importance of seismic design codes

A. Deformations and forces in buildings are caused by ground vibrations caused by seismic activity. As a result, buildings must be built to withstand these stresses and deformations. Seismic codes aid in improving the behaviour of structures so that they can survive the effects of earthquakes with minimal loss of life and property. Seismic code processes exist in every country to aid design engineers in the planning, designing, detailing, and construction of structures.

B. AN EARTHQUAKE RESISTANT STRUCTURE HAS FOUR VIRTUES IN IT, NAMELY

1) **Good Structural Configuration**: Its size, form, and load-bearing structural structure together allow a direct and seamless transfer of inertia forces to the ground.
2) **Lateral Strength** It can withstand a maximum lateral (horizontal) force without collapsing because to the damage it has sustained.
3) **Adequate Stiffness:** Its lateral load-resisting mechanism is designed in such a way that low-to-moderate shaking does not cause damage to its contents.
4) **Good Ductility:** Design and detailing methods increase its ability to withstand significant deformations even after yielding under strong earthquake shaking.

C. INDIAN SEISMIC CODES

Seismic codes are specific to a certain area or nation. They consider the local seismology, the recognised degree of seismic risk, building typologies, and construction materials and procedures. Seismic Codes issued by the Bureau of Indian Standards (BIS) are as follows:

a. IS 1893 (PART 1) 2002, Indian Standard Criteria for Earthquakes Resistant of Design Structures (5th revision).
b. IS 4326, 1993, Indian Standard Code of practice for Earthquake Resistant Design and Construction of Buildings. (2nd revision).
c. IS 13827, 1993, Indian Standard Guidelines for improving Earthquake Resistant of Earthen buildings.
d. IS 13828, 1993 Indian Standard Guidelines for improving Earthquake Resistant of Low Strength Masonry Buildings.
e. IS 13920, 1993, Indian Standard Code for practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

These guidelines do not guarantee that structures will be unaffected by earthquakes of all magnitudes. However, to the degree feasible, they ensure that structures can withstand moderate earthquake shaking without structural damage and strong earthquake shaking without catastrophic collapse.

3.3 Architectural features

Architects imagine beautiful and inventive buildings in order to produce an attractive and operationally effective structure. Sometimes the shape of the building draws the visitor's attention, and other times the structural system comes together to create a marvel. As a result, the forms and structures chosen have a considerable impact on the structure's performance. Previous earthquakes across the world have been highly instructive in identifying structural configurations that are desired and those that must be avoided.

3.4 Size of buildings

The horizontal displacement of the floors during ground shaking is considerable in high-rise buildings with a big height to base size ratio. The destructive effect of earthquake shaking is greater in short but extremely long buildings. Furthermore, in structures with vast plan areas, such as warehouses, the horizontal seismic loading might be too much for columns and walls to bear.

3.5 Vertical layout of buildings

Buildings with a few stores wider than the rest cause a sudden jump in earthquake forces at the level of discontinuity; any deviation or discontinuity in this load transfer path results in poor performance of the buildings with a few stores wider than the rest cause a sudden jump in earthquake forces at the level of discontinuity. Buildings with fewer columns or walls in a specific Storey, or Storeys that are exceptionally tall, are more prone to damage or collapse in that Storey. During the 2001 Bhuj earthquake in Gujarat, several buildings having a cellar or open ground Storey intended for parking fell or were badly damaged. Buildings built on sloppy terrain have different height columns down the slope, causing problems such as twisting and damage to shorter columns. There are discontinuities in the load transfer route in buildings with columns that sag or float on beams at an intermediate Storey and do not proceed all the way to the foundation. Some structures feature reinforced concrete walls to transmit earthquake loads to the foundation; however, if these walls do not extend all the way to the ground but end at a higher level, they are designed to be badly destroyed during earthquakes.

3.6 Adjacent buildings

When two structures are too near together, they may pound on one other during a severe earthquake. As building heights rise, this collision may become more of a concern. When the heights of the buildings do not match, the roof of the lower structure may pound at the midpoint of the taller one's column, which may be highly dangerous.

3.7 Design aspect

Earthquakes can happen on land or at sea, anywhere on the planet's surface where there is a significant fault. When an earthquake strikes on land, it damages the magnate structure near the epicentre, resulting in human casualties. When a strong earthquake happens beneath the ocean or sea, it not only impacts the structures nearby, but it also generates huge tidal waves known as tsunamis, which affect areas far distant from the source. To ensure that adequate vertical and lateral strength and stiffness are attained to fulfil the structural requirements and allowable deformation levels stipulated in the governing building code, all buildings are designed for the combined impacts of gravity and seismic loads. Most structures are effectively secured from vertical shaking due to the inherent factor of safety employed in the design standards. Vertical acceleration should be taken into account in constructions with wide spans, as well as in structural design and overall stability analysis.

3.8 Serviceability limit state

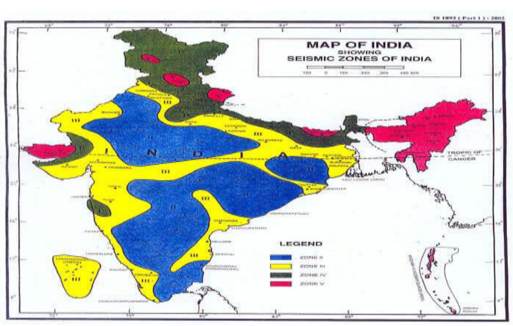
In this instance, the structure sustains little or no structural damage. Important structures that influence a society, such as hospitals, atomic power plants, places of assembly, and so on, should be built for elastic behaviour under predicted earthquake pressures. These buildings should be able to function even if there is an earthquake or a storm.

3.9 Damage controlled limit state

In this manner, if an earthquake or cyclone strikes, the structure may be damaged, but it may be restored even after the calamity has occurred. Because most permanent structures should fall into this category, the structure should only be built for limited ductility response.

IV. SEISMIC ZONES OF INDIA

Every nation carries out mapping of its territory based on all natural disasters like earthquake, cyclone, flood and volcano etc. This mapping is done on the basis of past history and factors responsible for such disaster of present in that area. This mapping helps people to design their home and other infrastructure so that they don't become the victim of such disaster and can withstand disasters with as minimum as possible loss of life and property. Code of practice of all nations for design of buildings and other structure recommended design guidelines based on such mapping or zoning.



Seismic zone map in India

Seismic zone have been categorized as follows:

1. ZONE V

The areas of this zone have the highest risk of effects by an earthquake. The earthquake intensity for this zone is MSK-IX or greater. The zone factor for this zone is 0.36, which is indicative of effective (zero period) level earthquake in this zone. This zone is called as Very High Damage Risk Zone. Some of the regions which fall under this zone are Rann of Kutch, Eastern regions etc.

Difference between Intensity & Magnitude of Earthquake

Intensity is number written in Roman numeral describing the severity of the earthquake in terms of its effect on earth surface, and on human and their structure. The higher the number, the higher the intensity of the effect/damage. While magnitude indicates amount of energy released at the source i.e. epic center. Intensity is measured as MMS (modified Meracallie Scale) while magnitude is measured on richter scale.

2. Zone VI:

The areas of this zone have the lesser risk to effects by an earthquake as compared to zone V. The earthquake intensity for this zone is between MSK VIII to MSK-IX. The zone factor for this zone is 0.24. This zone is called as High Damage Risk Zone. Some of the regions which fall under this zone are Northern regions, North Eastern regions, Delhi etc.

3. Zone III:

The areas of this zone have the lesser risk by an earthquake. The earthquake intensity for this zone is MSK VII. The zone factor for this zone is 0.16. This zone is called as Moderate Damage Risk Zone. Some of the regions which fall under this zone are some parts of Gujarat & Maharashtra, Andaman Nicobar Islands etc.

4. Zone II:

The areas of this zone have the least risk of an earthquake. The earthquake intensity for this zone is MSK VI. The zone factor for this zone is 0.10. This zone is called as Low Damage Risk Zone. Larger parts of India come under this zone.

One can see that in zone II, the intensity is VI on M scale while in zone V it is iX or greater, i.e. the damage and effect would be higher.

V. METHODOLOGY AND MODELLING OF BUILDING

5.1 Methodology (Response spectrum method)

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2016 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2016 (part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

This approach permits the multiple modes of response of a building to be taken in to account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonic" computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building.

5.2 Model in ETABS

A. General Building

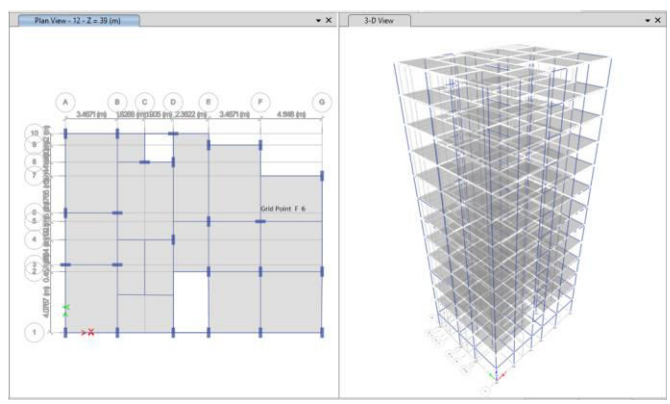


Figure 4. 24 Building In general condition

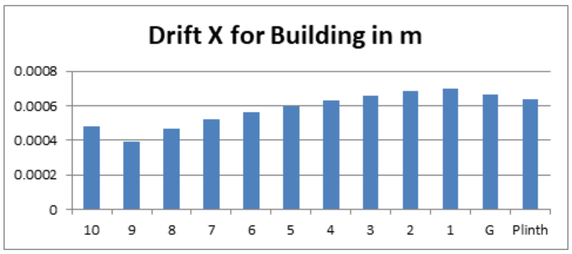
VI. RESULTS AND ANALYSIS

RSA X Results

Storey drift X Values

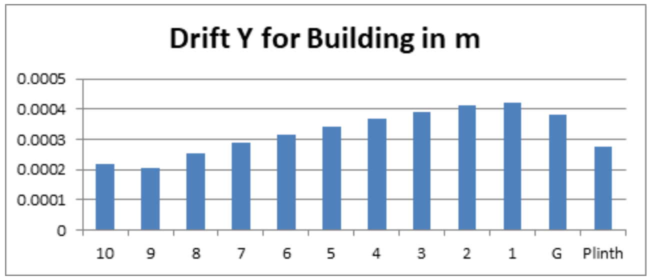
Story	Load Case	Drift X for Building in m
10	RS X	0.00048

9	RS X	0.0004
8	RS X	0.00047
7	RS X	0.00052
6	RS X	0.00056
5	RS X	0.0006
4	RS X	0.00063
3	RS X	0.00066
2	RS X	0.00068
1	RS X	0.0007
G	RS X	0.00066
Plinth	RS X	0.00064



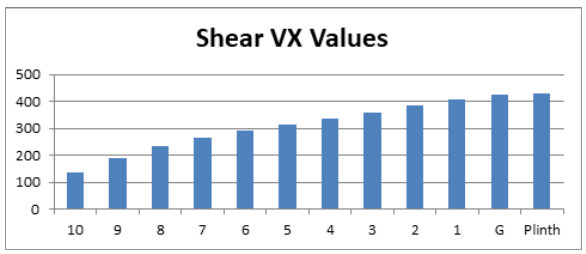
Storey drift Y Values

Story	Load Case	Drift Y for Building in m
10	RS X	0.00022
9	RS X	0.00021
8	RS X	0.00025
7	RS X	0.00029
6	RS X	0.00032
5	RS X	0.00034
4	RS X	0.00037
3	RS X	0.00039
2	RS X	0.00041
1	RS X	0.00042
G	RS X	0.00038
Plinth	RS X	0.00028



Shear Vx Values

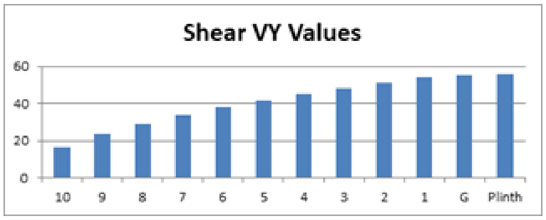
Story	Load Case	Shear VX Values
10	RS X	137.722
9	RS X	191.532
8	RS X	232.788
7	RS X	264.873
6	RS X	290.497
5	RS X	313.048
4	RS X	335.765
3	RS X	359.609
2	RS X	384.095
1	RS X	407.885
G	RS X	426.747
Plinth	RS X	430.518



Shear Vy Values

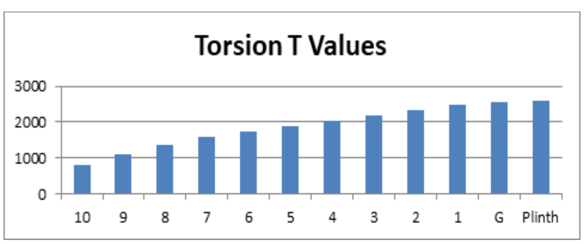
Story	Load Case	Shear VY Values
10	RS X	16.5272
9	RS X	23.5416
8	RS X	29.301
7	RS X	34.0189
6	RS X	37.9961
5	RS X	41.5599
4	RS X	44.9546

3	RS X	48.2467
2	RS X	51.3081
1	RS X	53.8407
G	RS X	55.4801
Plinth	RS X	55.7376



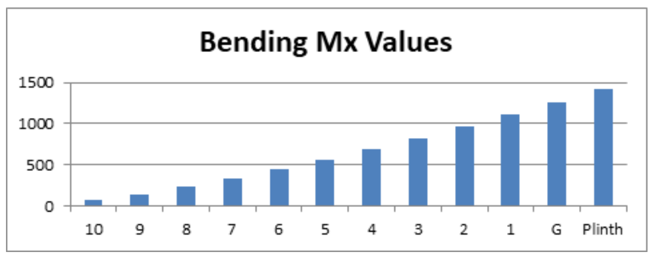
Torsion T Values

Story	Load Case	Torsion T Values
10	RS X	801.734
9	RS X	1122.28
8	RS X	1374.85
7	RS X	1577.35
6	RS X	1744.04
5	RS X	1892.43
4	RS X	2037.94
3	RS X	2184.1
2	RS X	2328.73
1	RS X	2466.17
G	RS X	2574.06
Plinth	RS X	2595.41



Bending Mx Values

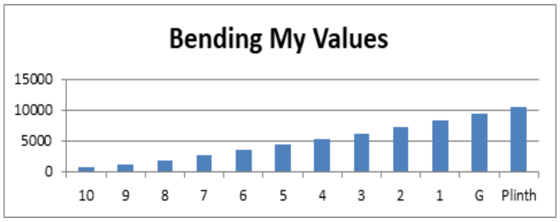
Story	Load Case	Bending Mx Values
10	RS X	74.7387
9	RS X	145.061
8	RS X	232.09
7	RS X	332.259
6	RS X	442.808
5	RS X	561.923
4	RS X	688.681
3	RS X	822.77
2	RS X	964.052
1	RS X	1112.07
G	RS X	1265.69
Plinth	RS X	1422.59



Bending My Values

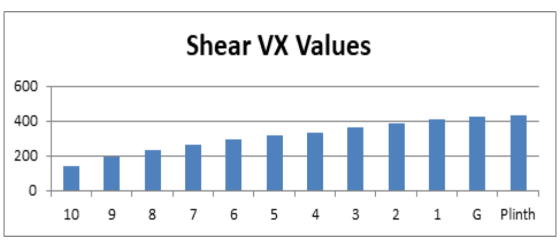
Story	Load Case	Bending My Values
10	RS X	625.227
9	RS X	1195.55
8	RS X	1880.81
7	RS X	2648.78
6	RS X	3476.41
5	RS X	4349.28
4	RS X	5262.49
3	RS X	6218.46
2	RS X	7222.91
1	RS X	8281.53
G	RS X	9395.46

Plinth	RS X	10551



Shear Vx Values

Story	Load Case	Shear VX Values
10	RS Y	137.722
9	RS Y	191.532
8	RS Y	232.788
7	RS Y	264.873
6	RS Y	290.497
5	RS Y	313.048
4	RS Y	335.765
3	RS Y	359.609
2	RS Y	384.095
1	RS Y	407.885
G	RS Y	426.747
Plinth	RS Y	430.518



VII.CONCLUSIONS

The following findings were drawn from this investigation:

1. Response spectrum analysis is used to analyse the G+10 story building model under Zone II seismic situation.
2. For both the RSX and RSY load cases, the larger value of story drift in the X direction was seen at the bottom storey level. Story drift in the X direction decreases from top story to bottom story.
3. For both the RSX and RSY load cases, the larger value of story drift in the Y direction was seen at the bottom storey level. Story drift in the Y direction decreases from the top story to the bottom story.
4. At plinth level, the maximum shear value was noted for the RSX and RSY load cases under Zone II conditions.
5. At plinth level, the maximum moment value was noted for the RSX and RSY load cases under Zone II conditions.
6. At plinth level, the greatest amount of torsion was noted for the RSX and RSY load cases under Zone II conditions.
7. In Zone II earthquake situation, the value of time period drops from mode 1 to mode 12.
8. In Zone II seismic situation, the frequency value rises from mode 1 to mode 12.

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