

INFLUENCE OF LATERAL LOADS ON TALL REINFORCED CONCRETE STRUCTURES

PROJECT REPORT

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of

Master of Technology

in

Structural Engineering & Construction Management



DEPARTMENT OF CIVIL ENGINEERING

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September 2022

DECLARATION

I undersigned hereby declare that the project report “Influence Of Lateral Loads On Tall Reinforced Concrete Structures”, submitted for partial fulfilment of the requirements for the award of the degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Prof. Shefeena N. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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CERTIFICATE

Certified that this report entitled **“INFLUENCE OF LATERAL LOADS ON TALL REINFORCED CONCRETE STRUCTURES”** is the report of project presented by **NASRIN ABU, Roll No: TKM19CESC11** during **2021-2022** in partial fulfilment of the requirements for the award of the Degree of Master of Technology in Structural Engineering and Construction Management of the A P J Abdul Kalam Technological University.

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ABSTRACT

The high-rise structure construction has become a feasible solution to the issues related with the urban society. 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. Effect of wind is predominant on tall structures depending on location of the structure, height of the structure and wind speed. Wind loads as specified in IS: 875 (Part 3)-2015 are considered in this analysis. In this project, multi-storey (G+19) structure with different shapes is modelled in the ETABS 2018 software. The severity of wind load on different structures in various wind zones and in different terrain category is studied. The effect of variation in terrain category is the major factor in this work because as the height increases the wind speed increases and thus the displacement increases but as the terrain category varies the obstruction for the wind flow increases so the effect of wind force decreases on the particular high rise structures, when the wind load is applied. Storey drift, storey displacement and base shear are analysed for various wind load cases and the main aim of this study is to obtain the best suitable structural shape for stability in wind prone area.

Keywords: *Wind loads, Zone Factor, Terrain Category Design Loads, High Rise Buildings, ETABS, IS: 875 (Part 3)-2015, Storey drift, Storey displacement , Base shear*

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Lateral loads are live loads that are applied parallel to the ground. They are horizontal forces acting on a structure and are different to gravity loads. Buildings are subjected to horizontal loads due to wind pressure acting on the buildings. Wind load is calculated as per IS 875 (Part 3)-2015. The horizontal wind pressures act on vertical external walls and exposed area of the buildings. Some of the pressure acting on exposed surfaces of structural walls and columns is directly resisted by bending of these members. The infill walls act as vertical plate supported at top and bottom by floor beams, thus transferring the loads at slab level. The parapet wall is at terrace transfers the wind loads to the surface slab by cantilever action. For simplicity, the wind loads acting on exposed surfaces of a given storey are idealized to be supported by upper and lower floors.

Movement of air with respect to the earth's surface is known as wind. Earth's rotation and terrestrial radiation differences are the major causes of wind. The effects of the radiation are mainly accountable for either upward or downward convection. Generally at high wind speeds, the wind blows to the ground horizontally. Vertical components of atmospheric motion are comparatively small. Thus the term wind almost exclusively means the horizontal wind. The capability of a structure to withstand enormous pressure of the wind depends on geography, nearness of other hindrances to the flow of air and also depends on the characteristics of the structure. The combined action of internal and external pressure acting on the structure as whole determines the effect of wind on it. The tall building can be described as a multistorey building generally provided with high speed elevators, constructed using a structural frame, and combining extraordinary height with ordinary room spaces such as could be found in low-buildings.

1.2 WIND LOADS

Wind is a term used to describe horizontal motion of air. Motion in a vertical direction is called a current. Winds are produced by differences in atmospheric pressure that are primarily attributable to differences in temperature. These differences are caused largely by unequal distribution of heat from the sun, and the difference in thermal properties of land and ocean

surfaces. When temperatures of adjacent regions become unequal, the warmer lighter air rises and flows over the colder heavier air.

Winds initiated in this way are modified by rotation of the earth. In describing global circulation of wind, modern meteorology relies on wind phrases used by yearly long-distance sailors. For example, terms like trade winds and westerlies were used by sailors who recognized the occurrence of steady winds blowing for long periods of time in the same direction. Near the equator, the lower atmosphere is warmed by the sun's heat. The warm air rises, depositing much precipitation and creating a uniform low-pressure area. Into this low-pressure area, air is drawn from the relatively cold high-pressure regions from northern and southern hemispheres, giving rise to trade winds between the latitudes of 30° from the equator. The air flows counter to the trade winds to descend into these latitudes, creating a region of high pressure. Flowing northward and southward from these latitudes in the northern and southern hemispheres, respectively, are the prevailing westerlies, which meet the cold dense air flowing away from the poles in a low-pressure region characterized by stormy variable winds. It is this interface between cold, dense air and warm, moist air which is of main interest to the television meteorologists of northern Europe and North America.

As the air above hot earth expands and rises, air from cooler areas such as the oceans floats in to take its place. The process produces two types of wind circulation:

1. General global circulation extending around the earth
2. Smaller secondary circulations producing local wind conditions

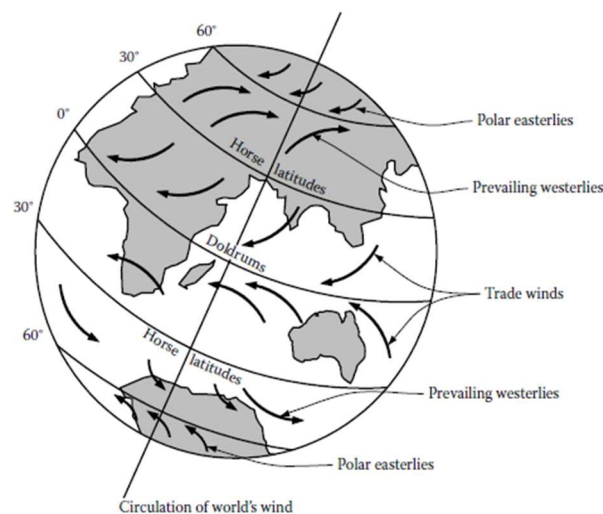


Figure 1.1 Circulation of world's winds (Bungale, 2016)

Figure 1.1 shows a model of circulation of prevailing winds that result from the general movement of air around the earth. Observe that there are no prevailing winds within the equatorial belt, which lies roughly between latitudes 10° S and 10° N. Therefore, near the equator and up to about 700 miles (1127 km) on either side of it, there exists a region of relative calm called the doldrums. In both hemispheres, some of the air that has risen at the equator returns to the earth's surface at about 30° latitude, producing little or no wind. These high-pressure areas are called horse latitudes, possibly because many horses died on the sailing ships that got stalled because of lack of wind. The winds that blow between the horse latitudes and the doldrums are called trade winds because sailors relied on them for sailing ships. The direction of trade winds is greatly modified by the rotation of the earth as they blow from east to west. Two other kinds of winds that result from the general circulation of the atmosphere are called the prevailing winds and the polar easterlies. The prevailing winds blow into the belts bounded by the horse latitudes and 60° north and south of the equator. Thus the moving surface air produces six belts of winds around the earth. Figure 1.2 shows positive pressure on windward wall, and negative pressure (suction) on leeward wall and roof. For a hermetically sealed building, internal pressures cancel out, hence no effect on overall building loads.

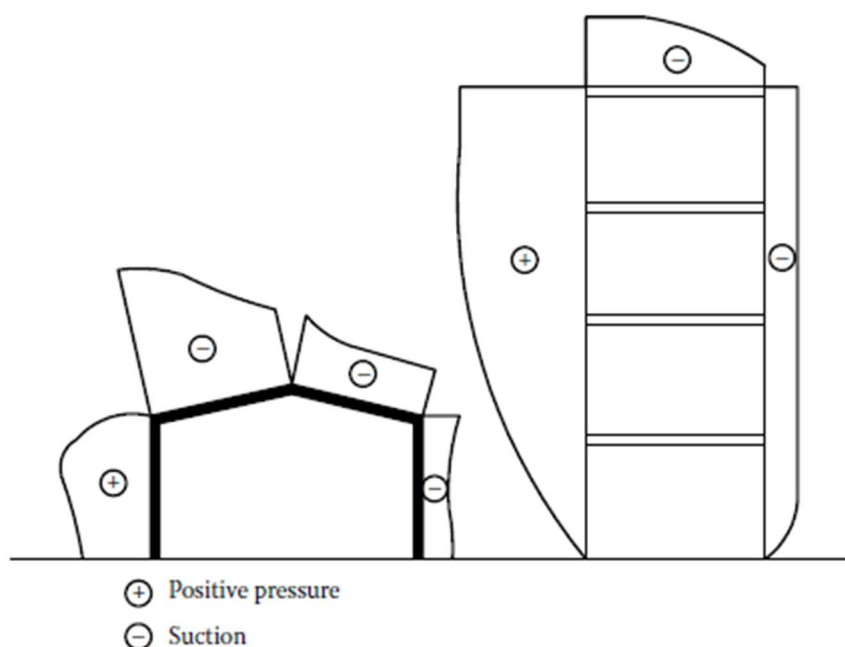


Figure 1.2 Wind load distribution (Sayed Rehan, 2014)

Forces due to wind are generated on the exterior of the building based on its height, local ground surface roughness (hills, trees, and other buildings) and the square of the wind velocity. The weight of the building, unlike in earthquake design, has little effect on wind forces, but is helpful in resisting uplift forces. Unless the structure has large openings, all the wind forces are applied to the exterior surfaces of the building. This is in contrast to earthquake forces where both exterior and interior walls are loaded proportionally to their weight. Wind pressures act inward on the windward side of a building and outward on most other sides and most roof surfaces. Special concentrations of outward force, due to aerodynamic lift, occur at building corners and roof edges, particularly so at overhangs. The overall structure is designed for the sum of all lateral and uplift pressures and the individual parts to resist the outward and inward pressure concentrations. They must be connected to supporting members to form a continuous load path. Forces are also generated on structures by airborne missiles such as those caused by dislodging of roofing gravel from neighbouring buildings.

1.3 DESIGN CONSIDERATIONS

In designing for wind, a building cannot be considered independent of its surroundings because configuration of nearby buildings and natural terrain has substantial influence on the design loads, and hence on the sway response of the building. Sway is defined as the horizontal displacement at the top of a building. The sway at the top of a tall building caused by wind may not be seen by a passerby, but may be of concern to those experiencing wind-motion problems at the top floors. There is scant evidence that winds, except those due to a tornado or hurricane, have caused major structural damage to buildings. Nevertheless, it is prudent to investigate wind-related behavior of modern skyscrapers, typically built using lightweight curtain walls, dry partitions, and high-strength materials, because they are more prone to wind-motion problems than the early skyscrapers, which had the weight advantage of heavy masonry partitions, stone facades, and massive structural members.

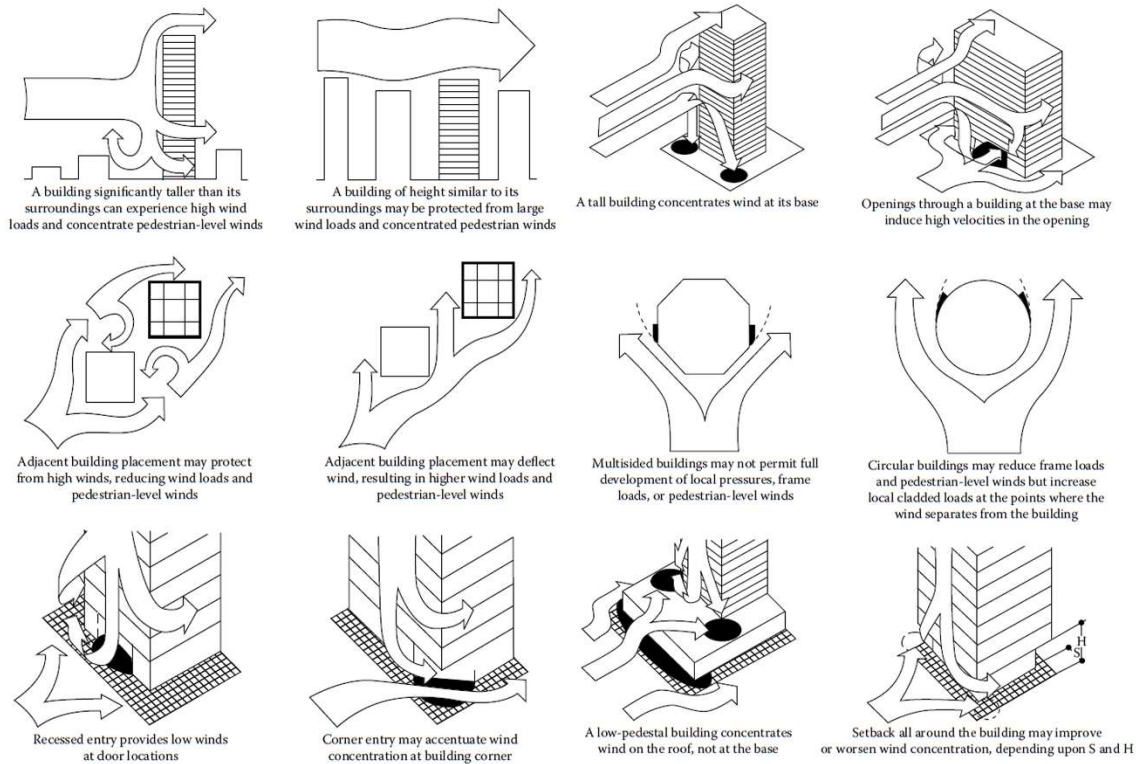


Figure 1.3 Wind flow around buildings (Stafford Smith, 1991)

As wind hits the structure and flows around it, several effects are possible as illustrated in Figure 1.3. Pressure on the windward face and suction on the leeward face creates drag forces. Analogous to flow around an airplane wing, unsymmetrical flow around the structure can create lift forces. Air turbulence around the leeward corners and edges can create vortices, which are high-velocity air currents that create circular updrafts and suction streams adjacent to the building. Periodic shedding of vortices causes the building to oscillate in a direction transverse to the direction of the wind and may result in unacceptable accelerations at the upper floors of tall buildings. The effects of downdrafts must also be considered: Downdrafts have been known to completely strip trees in plaza areas and to buffet pedestrians dangerously. Some tall buildings that extend into high wind velocity regions have been known to sway excessively in strong winds. High suction forces have blown off improperly anchored lightweight roofs.

To be sure, all buildings sway during windstorms, but the motion in old tall buildings with heavy full-height partitions has usually been imperceptible and, therefore, has not been a cause for concern. Structural innovations coupled with lightweight construction have reduced the stiffness, mass, and damping characteristics of modern buildings. In these buildings, objects

may vibrate, doors and chandeliers may swing, pictures may lean, and books may fall off shelves. Additionally if the building has a twisting action, its occupants may get an illusory sense that the world outside is moving, creating symptoms of vertigo and disorientation. In more violent storms, windows may break, creating safety problems for pedestrians below. Sometimes, strange and frightening noises may be heard by occupants as the wind shakes elevators, strains floors and walls, and whistles around the building sides.

1.4 WIND EFFECTS ON TALL BUILDINGS

The wind is the most powerful and unpredictable force affecting tall buildings. Tall building can be defined as a mast anchored in the ground, bending and swaying in the wind. This movement, known as wind drift, should be kept within acceptable limits. Moreover, for a well-designed tall building, the wind drift should not surpass the height of the building divided by 500. The effects of wind load on structures include deflection, moment, drift, shear, etc. as shown in figure. The wind load is the most important factor that determines the design of all buildings over 10 storeys. Buildings taller than 10 storeys would generally require additional steel for lateral system. An important problem associated with wind induced motion of buildings is concerned with human response to vibration and perception of motion.

The complexities of wind loading should be kept in mind when applying a design document. Because of the many uncertainties involved, the maximum wind loads experienced by a structure during its lifetime, may vary widely from those assumed in design. The structural forms used today have greater flexibility combined with less mass and damping than those used for traditional structures of the past. These factors have increased the importance of wind in design consideration. For estimations of the overall stability of a structure and of the local pressure distribution on the building, knowledge of the maximum steady or time averaged wind loads is usually sufficient. Figure 1.4 shows the effect of wind load on tall structures.

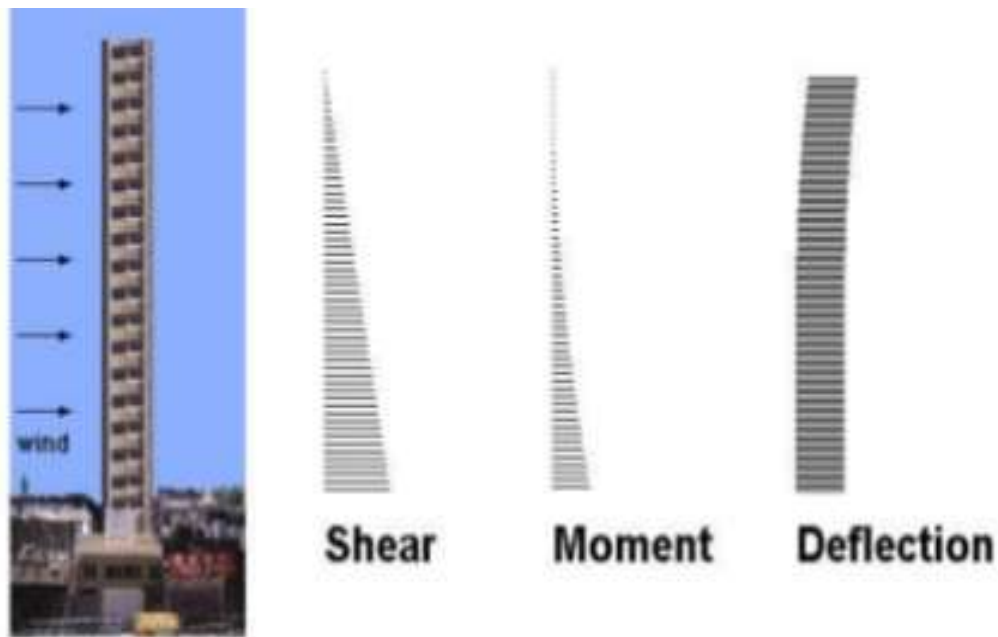


Figure 1.4 Effect of wind load on tall structures (Sukanta Adhikari, 2005)

Wind loads on buildings increase considerably with the increase in building heights. Furthermore, the speed of wind increases with height, and the wind pressures increase as the square of the wind speed. Thus, wind effects on a tall building are compounded as its height increases. Besides this, with innovations in architectural treatment, increase in the strengths of materials, and advances in methods of analysis, tall buildings have become more efficient and lighter, and so, more vulnerable to deflection, and even to swaying under wind loading. Unlike dead loads and live loads, wind loads change rapidly and even abruptly, creating effects much larger than when the same loads were applied gradually, and that they limit building accelerations below human perception. Thus an important characteristic of wind is the variation of its speed with height.

The wind speed increase follows a curved line varying from zero at the ground surface to a maximum at some distance above the ground. The height at which the speed stops to increase is called the gradient height, and the corresponding speed, the gradient wind speed. At heights of approximately 366m from the ground, surface friction has an almost negligible effect on the wind speed. The height through which the wind speed is affected by the topography is called atmospheric boundary layer. Figure 1.5 shows the variation of wind speed with height.

Wind flow is complex because numerous flow situations arise from the interaction of wind with structures. However, in wind engineering, simplifications are made to arrive at the design wind loads by distinguishing the following characteristics:

- Variation of wind velocity with height (velocity profile)
- Wind turbulence
- Statistical probability
- Vortex shedding
- Dynamic nature of wind–structure interaction

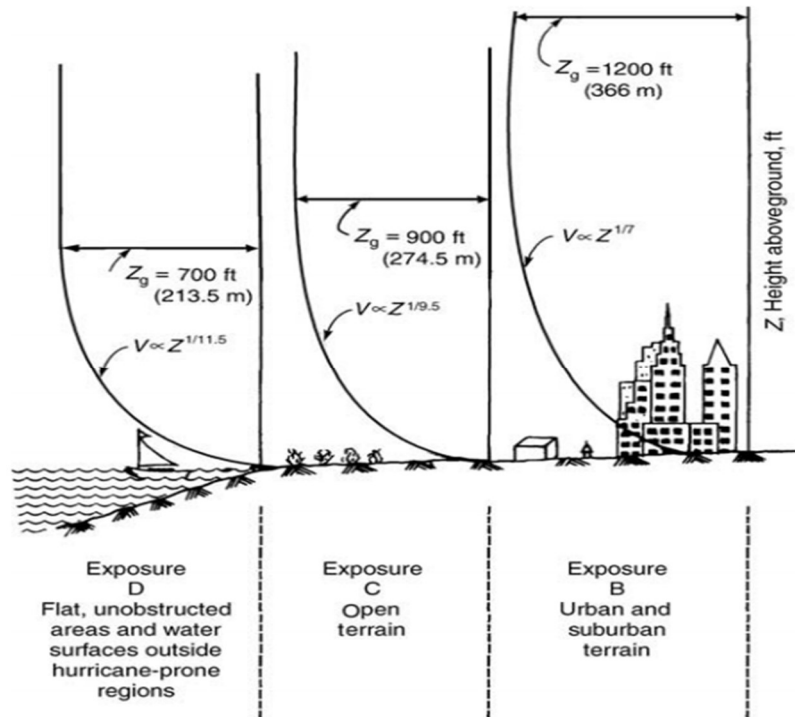


Figure 1.5 Influence of exposure terrain on variation of wind velocity with height

(Shraddha J. Patil, 2018)

1.5 WIND LOAD ANALYSIS AS PER IS 875 (PART 3)-1987

Wind forces acting on a given surface is equal to the wind pressures multiplied by the affected area. The design wind speed (V_Z in m/s) at any height z is given by the equation:

$$V_Z = V_b \times k_1 \times k_2 \times k_3 \times k_4 \quad , \quad \text{where}$$

V_b = Basic wind speed (m/s)

k_1 = probability factor (risk coefficient)

k_2 = terrain roughness and height factor

k_3 = topography factor

k_4 = importance factor for the cyclonic region

The wind speed may be taken as constant upto a height of 10 m. However, pressures for buildings less than 10m high may be reduced by 20% for stability and design of the framing.

Table 1.1 Wind Zones (IS 875 (PART 3):2015)

	Basic wind speed (m/s)
Zone I	33
Zone II	39
Zone III	44
Zone IV	47
Zone V	50
Zone VI	55

Basic wind speed V_b , depends on the location of the building. For this purpose, the country is divided into six zones with specified wind speeds ranging from 33m/s to 55 m/s. Basic wind speed is based on gust velocity averaged over a short time interval of 3 seconds at 10m height from mean ground level in an open terrain and for 50 years return period. The risk coefficient k_1 takes into account the degree of reliability required and the expected life of structure.

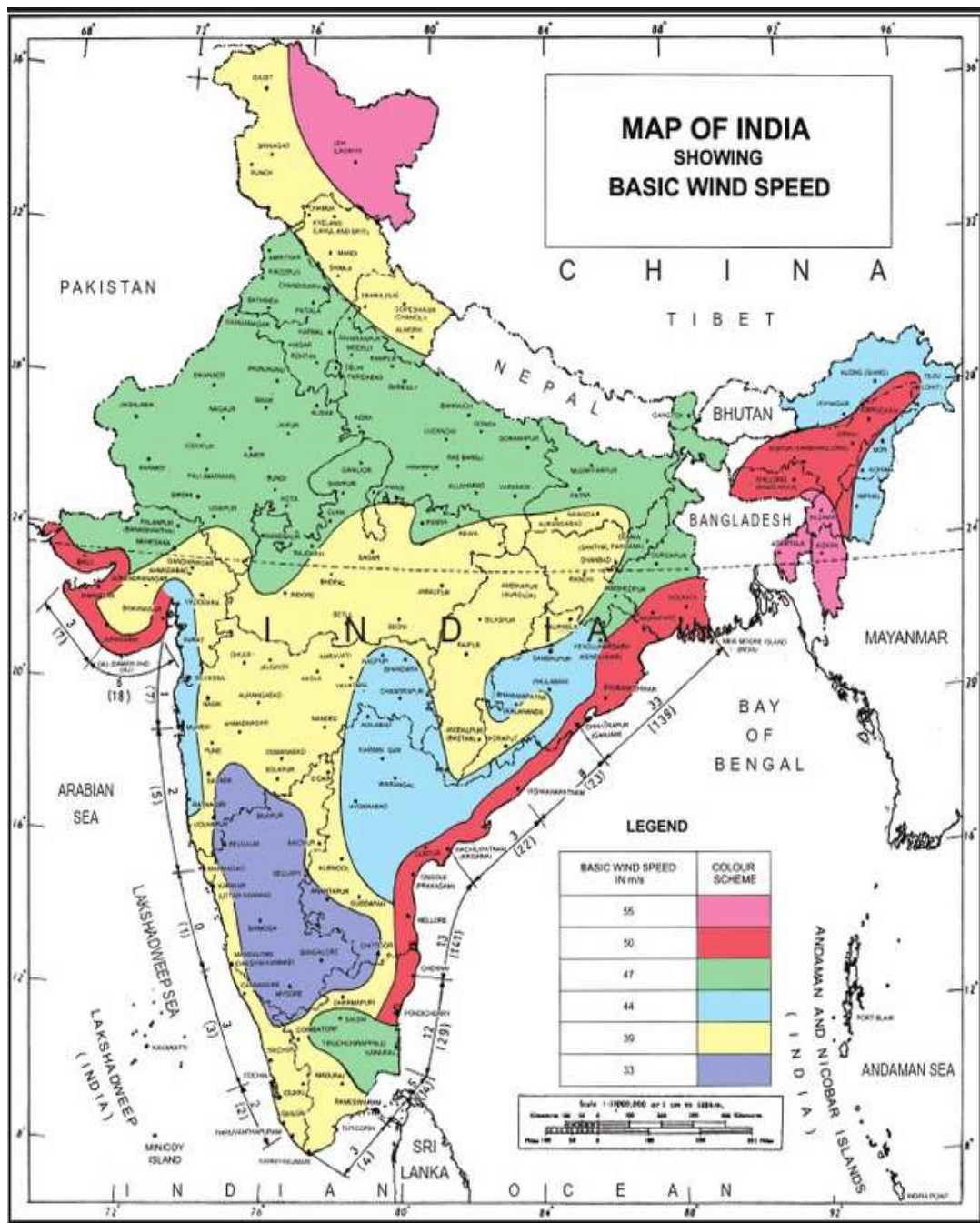


Figure 1.6 Wind Speed Map of India (IS 875 (Part 3):2015)

Table 1.2 Risk coefficients for different classes of structures in different wind speed zones
(Clause 6.3.1 IS 875 (PART 3):2015)

Class of Structure	Mean Probable design life of structure in years	k_1 factor for Basic Wind Speed (m/s) of					
		33	39	44	47	50	55
All general buildings and structures	50	1.0	1.0	1.0	1.0	1.0	1.0
Temporary sheds, structures such as those used during construction operations (for example, formwork and false work), structures during construction stages, and boundary walls	5	0.82	0.76	0.73	0.71	0.70	0.67
Buildings and structures presenting a low degree of hazard to life and property in the event of failure, such as isolated towers in wooded areas, farm buildings other than residential buildings, etc.	25	0.94	0.92	0.91	0.90	0.90	0.89
Important buildings and structures such as hospitals, communication buildings, towers and power plant structures	100	1.05	1.06	1.07	1.07	1.08	1.08

Table 1.3. Terrain roughness factor with variation in height for different terrains
(Clause 6.3.2.2 IS 875 (PART 3):2015)

Height (z) (m)	Terrain and height multiplier (k_2)			
	Terrain Category 1	Terrain Category 2	Terrain Category 3	Terrain Category 4
10	1.05	1.00	0.91	0.80
15	1.09	1.05	0.97	0.80
20	1.12	1.07	1.01	0.80
30	1.15	1.12	1.06	0.97
50	1.20	1.17	1.12	1.10
100	1.26	1.24	1.20	1.20
150	1.30	1.28	1.24	1.24
200	1.32	1.30	1.27	1.27
250	1.34	1.32	1.29	1.28
300	1.35	1.34	1.31	1.30
350	1.37	1.36	1.32	1.31
400	1.38	1.37	1.34	1.32
450	1.39	1.38	1.35	1.33
500	1.40	1.39	1.36	1.34

k_2 depends on terrain category and building class/size of structure. Four terrain categories are specified by the code depending on the availability of obstruction to the flow of wind.

Terrain Category I: Refers to no obstructions available to the building (e.g.) sea coasts and flat treeless plains where other structures if any have heights less than 1.5m.

Terrain Category II: Refers to open terrain with scattered obstructions of 1.5m to 10m height. (e.g.) industrial area.

Terrain Category III: Refers to areas of closed spaced buildings of height up to 10m (e.g.) buildings at outskirts of city

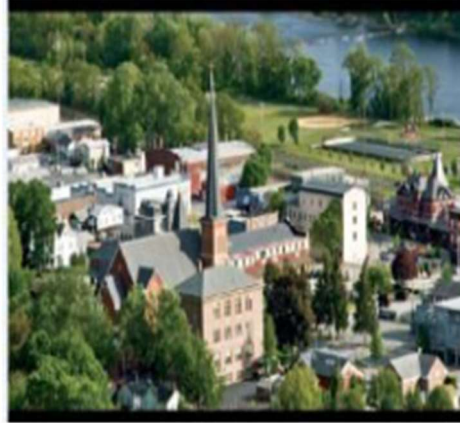
Terrain Category IV: Refers to area with highly closed buildings of large heights (e.g.) dense city area.



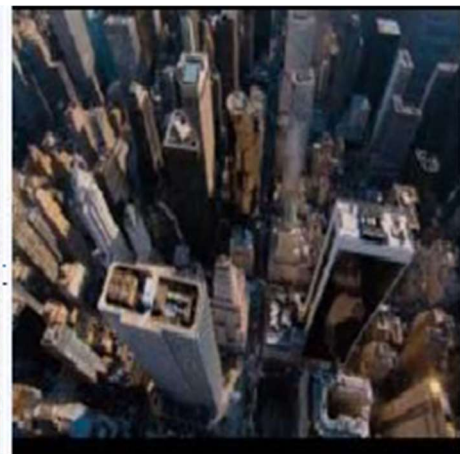
TERRAIN
CATEGORY I



TERRAIN
CATEGORY II



TERRAIN
CATEGORY
III



TERRAIN
CATEGORY
IV

Figure 1.7 Photographs indicative of different terrain categories (Vinayak M, 2016)

k_2 factor also depends on the dimensions of the building under considerations. Based on dimension of building, the structures are classified as Class A, Class B and Class C.

Class A: Maximum of l, b, h < 20m.

Class B: Maximum of l, b, h → 20m to 50m.

Class C: Maximum of l, b, h > 50m.

k_3 depends on the topography i.e. hill region, cliffs and ridges. If the upward ground slope $0 \leq 3^\circ$, value of k_3 shall be taken as 1.0. For $0 > 3^\circ$, the value of k_3 lies between 1.0 to 1.36.

Design Wind Pressure (P_z) = $0.6 V_z^2$, where P_z = Design Wind speed in N/m^2 at height z

V_z = Design wind speed in m/s.

Wind load on a building is calculated for the “Building as a whole”. Force coefficients are given for the building as a whole in the code for clad or unclad buildings.

The wind force acting normal to the building surface is given by:

$$F = C_f A_e P_d \text{ , where}$$

C_f = force coefficient

A_e = effective frontal area

P_d = design wind pressure

1.6 SIGNIFICANCE OF THE STUDY

Today, tall buildings are a worldwide architectural phenomenon. The behaviour of the structures under wind loads definitely has a major role, not only from structural engineering point of view, but also safety of humans living in the structure. It is a major challenge to study the impact and performance of tall structures under wind loading. The wind is the most powerful and unpredictable force affecting tall buildings. Tall building can be defined as a mast anchored in the ground, bending and swaying in the wind. Wind effect will cause and produce wind induce movement in the structure. As high rise buildings move onward the envelope to larger heights, the structural designers are not only faced with difficulty to choosing a structural elements to take the lateral load such as wind load and earthquake load but also insuring the design criteria that meets reliability and serviceability requirement under difficult wind environment. Wind load take action as lateral weight on buildings which is act as along and across wind. In IS Code 875 (Part 3):2015, the basic wind speed are specified in map and categorized by zones. The shape and size of building is very significant in wind analysis, because the wind pressure is mainly depends on the exposed area of building in opposition to wind speed.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

This chapter deals with a brief review of the past and recent study performed by researchers on wind load analysis in tall reinforced concrete structures.

2.2 REVIEW OF LITERATURE

P Krishnam Raju et al (2021) conducted a study to assess the influence of wind on a 17-storey multipurpose reinforced concrete tall building according to the revised wind code of IS 875 (Part 3): 2015 compared to its previous version i.e., IS 875 (Part 3): 1987. The study covers all basic wind speeds of 33, 39, 44, 47, 50 and 55m/s as specified in the Indian standards. Dynamic effects due to ‘along wind’ and ‘across wind’ are considered in the analysis using ETABS evaluation software. The Lateral load, Lateral sway and Longitudinal Rebar Percentage (LRP) are found to be increased as per the revised version. The LRP in the Middle, Edge and Corner columns are also reported. An increase of total Rebar quantity by about 3.7% (beams and columns) in the entire structure for a basic wind speed of 50m/s is observed.

Ahesan Hameed et al (2019) aimed to understand the provisions of international standards and compared them with Indian standard. The wind load effects on RC buildings was conducted utilizing major codes and standards: IS 875 (Part-3):1987, IS 875 (Part-3):2015, ASCE 7-05. He also focused on Indian code i.e. IS 875 (Part-3):2015 and pointed out the advantages over IS 875 (Part-3):1987, and also deals with the buildings of different shape such as regular plans and irregular plans. IS: 875 (Part-3):2015 is the standard code of practice for design load of buildings and structures which was used to calculate the along wind load effect i.e. gust factor. To determine along wind load effect on different shapes of building using Indian standard, spread sheets were prepared. Further, all these shapes were analysed using finite element software package ETAB-2016. Each building is a 20 storied building with story height as 4m summing upto a total height of 80m. For, the purpose of analysis the plan area of regular shape like Square, Rectangular, Elliptical, Circular and Rectangle with two semicircle shapes kept same as well as the frame properties also kept equal.

M Vinayak et.al (2016) discussed the method of calculation of wind responses of structures for various parameters by static and gust factor methods by considering the effect of change in

terrain category as described by the code (IS: 875(Part 3):1987). Tall buildings of height 91.5m have been analysed for 1 to 4 terrain categories as per the code IS 875 (Part 3):1987) manually and by a user ETABS program. Typical results of variation of Displacement, Story drift, Story Shear and Story moment have been included. The analysis of these building using present code indicates that for Terrain Category 1, 2, 3 and 4 by Static and Gust factor Method. Then various shapes of buildings are considered for this study in category-2 (I shape, C shape, L shape, and T shape), and responses of various shapes are compared with square shape. The results for Structural responses are seen that the Gust factor methods are considerably higher compared to static method.

Ranjitha K.P et al (2014) presented a framework for evaluating the equivalent static wind load and a new description of the loading based on the gust loading envelope/peak dynamic loading was presented. The gust response factors and the equivalent static wind loads for various along wind response components at different shapes of building are discussed. The analytical investigation of different shapes of building situated in wind zone I and zone IV of India, in accordance with IS 875(Part 3):1987, was taken as an example and the various analytical approaches (linear static and dynamic analysis) were performed on the building to identify the base shear, storey displacement, storey drift, overturning moment and storey shear. Also compared for different storey building models in both X and Y directions by using finite element software package ETAB.

K. Rama Raju et.al (2013) studied both seismic analysis with response spectrum method and wind load analysis with gust factor method are used for analysis of a 3B+G+40-storey RCC high rise building as per IS 1893(Part 1):2002 and IS 875(Part 3):1987codes respectively. The building is modelled as 3D space frame using STAAD.Pro software. Safety of the structure is checked against allowable limits prescribed for inter-storey drifts, base shear, accelerations and roof displacements in codes of practices and other literature for earthquake and wind.

Anupam Rajmani et al (2015) studied the performance of tall buildings against wind loads and earthquake loads and found an appropriate choice of building shape and architectural modifications that is extremely important and effective design approaches to reduce wind and earthquake induced motion by altering the flow pattern around the building. Four different shaped buildings were studied namely circular, rectangular, square and triangular. The results were interpreted for different shaped buildings and of different storey thereby concluding as to which shaped high rise building is most stable for different conditions. For analysis and

comparison purpose the base area of all the four shaped building under consideration was kept same, along with building parameters like properties of column and beam, the support condition, loading condition namely earthquake load, wind load, live and dead load and also the design parameters like grade of concrete and steel. For 15 storey building the most stable structure is circular shape and triangular shape for maximum earthquake and maximum wind load respectively, similarly for 30 storied building, rectangular shape is most stable for maximum earthquake and wind load and for 45 storied building circular shape & rectangular shape is most stable for maximum earthquake and wind load respectively.

Sandeep Tembhurkar et al (2014) presented a study on wind loads to decide the design critical parameter of a multistoried building and estimated the design loads estimate based on the basic wind speed and other factors of a structure. The critical analysis of a multistoried building frame was carried out for wind loads using IS 875 code. The wind loads were estimated for a twenty storied, twenty five storied and thirty storied RC framed structure, based on the design wind speed of that zone. The wind loads so obtained on the building had been compared for different building. It was found the wind loads are more critical in bending moment, shear force and displacement. The critical value of bending moment is obtained at 30 storeys. The wind loads increases with height of structure and are more critical for tall structures.

Chandradhara G. P et al (2015) studied the wind effects on buildings with different aspect ratio using ETABS. The models were categorized based on storey height and aspect ratio of the building. Frame models with increasing in the aspect ratio from 0.25 to 2 were considered and effect of wind load on gravity load was studied. Also the effect of wind load on height of building was studied by varying number of stories from 3 to 20 storeys. All the frame models were idealized as 3D models, and analyzed using the software ETABS. To study the behavior of frames variations of bending moment and axial force in columns are considered. It was concluded that wind effect reduces as aspect ratio of the building reduces. As the aspect ratio increases moments in the column decreases considerably for wind load cases, whereas the moments remain same for all aspect ratio for gravity loads. As the height of the building increases moments in the column increases for low rise building and remain constant for medium height buildings. Column moments are considered critical while designing for the tall buildings.

Vikram.M.B et al (2014) performed a study on the wind effects on buildings with different aspect ratio. The E-TABS software is used to develop 3D model and to carry out the analysis.

The lateral loads to be applied on the buildings are based on the Indian standard IS-875-Part 3: 1987 the building consists of reinforced concrete elements. 10, 15, 20, 25, and 30 storied building with different aspect ratios 0.25, 0.5, 1.0, 1.5 and 2.0 analyzed for bare frame models. Variations of bending moment and axial force in columns were considered to study the behavior of frames. The dynamic response factor increases with height. This is because of the increase in the slowly varying background component of the fluctuating response. From the study it was concluded that wind effects are significant compared to gravity effects, when the aspect ratio is less, however its effect reduces as aspect ratio increases. It was also observed that for symmetrical frames the dynamic effect is not significant compared to static effect. Bending moments due to gravity will remain same for gravity and wind cases in all aspect ratios.

Daryl W. Boggs et al (2000) have analyzed 28 storey building. They have applied the wind force at various rotation of building (25 to 360 degree rotation) for finding the torsional force in building and they have found maximum torque (Mz direction) at initial stage of application of load. Wind-tunnel tests on model buildings have revealed that torsional loads usually exist, and span a great range of significance. They identified some common sources of torsional loading in terms of building shape, interfering effects of nearby buildings, and dynamic characteristics of the structural frame. The normalized eccentricity gives a common and intuitive indication of the additive effect of torsion on the total building shear, at a given wind direction. The maximum eccentricity does not occur at the same wind direction as the maximum shear. If torsion is resisted by shear walls placed near the ends of the building then a given torque may increase the shear stresses only slightly, and the wind direction of maximum overall building shear may well represent the design case. If the shear walls are concentrated near the core then the same torque will produce a much greater shear stress, and the design condition is more likely to occur at the direction of maximum eccentricity. Wind tunnel studies have been the only way to identify torsion, but they also provide help in minimizing it or designing for it.

D. K. Mokashi et al (2017) studied the effect of aerodynamic characteristics on triangular shape of tall building model. They conducted pressure measurement studies on triangular shape building model with geometric scale 1:300 and of plan size 15cm x15cm and height 15 cm. The models are tested in an open circuit boundary layer wind tunnel. Pressure profile changes due to angle made in 0° , 60° and 90° and effect of distance between object building and interfering building on wind loads was studied. Maximum pressure acted when skew formation is along the direction of wind. In case of 60° angle maximum wind pressure is acted and which create

maximum twisting moment on the structure. Pressure distribution spread over large area in 0° as compare to 60° and 90° .

M. R. Wakchaure et al (2015) studied the effects of building shape on wind forces using gust factor approach. Different shapes of building of height 150 m having equal plan area, equal stiffness of column were considered for wind load analysis. Wind loads were determined based on gust effectiveness factor method. The critical gust loads for design were determined. The calculated wind loads were applied to the building models having different shapes such as square rectangular circular and elliptical, prepared. The building models were analysed in finite element software package ETABS and the results were compared in various aspects such as storey displacements, storey drifts, storey shear, axial forces in column etc. Based on the results, conclusions are drawn showing the effectiveness of different shapes of the structure under the effect of wind loads. Buildings having circular or elliptical plan have a smaller surface perpendicular to the wind direction, the wind pressure is less than in prismatic buildings. It was also concluded that with the change in shape of building from square to elliptical the wind intensity, storey drifts, the lateral displacements, storey shear of the building decreased. The wind load is reduced by maximum percentage with an elliptical plan.

Shaikh Muffassir et al (2016) performed a study of wind analysis of multi-story composite structure for plan irregularity. ETABS 2015 was used to analyse the multi story structure, for the system of forces, Earthquake analysis, Time history analysis, and Wind analysis. The effect of wind on multi story composite structure for plan irregularity is observed. The comparison of impact of wind for square, rectangular, U-shape, and H-shape building structure was conducted. The post analysis consist typical characteristic comparison related to storey displacement, storey drift, time period, base reaction, etc. The categorization of structure as Class-B, Class-C of wind code consideration for different height is used for modelling of structure. Modelling of as category-2 is taken constant to compare the result. The study concluded that rectangular structure for along wind or across wind direction is preferable due to large stiffness and less displacement against wind. Also the exposed area of building need to be altered or needs to deviate to some angle to reduce wind pressure.

Swati D.Ambadkar et al (2012) studied the behaviour of multistoried building under the effect of wind load. Wind loads as specified IS: 875 (Part 3) - 1987 were considered in the analysis. The analysis of G +11 building was carried out by using STAAD PRO. Analysis is done for various variations in terrain categories according to internal pressure coefficients (C_{pi}) provided

for that various variations. The analysis was done for wind speed 44 m/s, 47 m/s, 50 m/s. Results obtained from STAAD-PRO analysis were used for obtaining significant relations of moments, forces and displacement with wind speeds. Moments, forces and displacement obtained from all cases were compared with wind speeds, according to their percentage of opening provided for various variations. Displacement increases as the wind speed increases for various types of opening, category.

Suraj Sangtiani et al (2017) studied the performance of tall buildings under lateral loads using different types of structural systems. With the evolution of technology numerous structural systems came out such as Shear Wall System, Tube in Tube, Core Out-trigger System etc. They considered a G+53 storey building concrete structure which was analyzed in ETABS software package with different earthquake zones and using different structural systems such as conventional system, shear wall system, core out-trigger system. Wind forces exerted was calculated from IS-875-2015 (Gust Analysis). An attempt was made to compare the performance of the three structural systems in all four earthquake zones. Base shear, time period, top storey displacement, storey drift, seismic weight of structure were found and results are compared and Out-trigger system giving the tremendous performance with an adoption of huge engineering. As the height increases, lateral forces plays the dominating role, since till 300m, one can start the preliminary design by adopting any of structure system such as out-trigger, shear wall etc. Beyond this height one can also go with a combination of the various structural systems.

Alkesh Bhalerao et al (2016) conducted wind analysis of RCC structure. A multi-storey (G+25) structure with different shape was modeled in the ETABS 2015 software, to check its lateral load stability in concern with the wind load. Four models having different structural shapes rectangle, square, U-shape and bundled tube are analyzed for displacement and story drift and the effect of wind is analyzed for different structural shape. The wind prone zone area is considered and parameters regarding the case had selected to analyze the model. All considered structure was compiled using RCC frame design system. The study concluded that the effective shape for to resist wind lateral load is rectangular shape structure for G+25 consideration. U-shape structure is not preferred as it gives the maximum displacement and maximum drift due to its geometric shape most susceptible for wind load.

Ashwini S Gudur et al (2016) conducted dynamic wind analysis of tall building provided with steel bracing and with the effect of soft storey. RC framed buildings are generally designed

without considering the structural action of masonry infill walls present. These walls are widely used as partitions and considered as non-structure elements. But they affect both structural and non-structural performance of the RC buildings with lateral load. Infill model effectively braces the RC frame structure and increases the lateral resistance to wind loads. The effect of infill has to be taken in consideration during the design of structure. Wind forces remain constant up to 3 stories and increase linearly over the height of the building. The displacement limits are exceeding wind speed zones for bare framed model. Though practically such system does not exist it is very vulnerable.

K. Vishnu Haritha et al (2013) studied the effect of wind on tall building frames with the influence of different aspect ratio. Equivalent static method was used for analysis of wind loads on buildings of 10, 15 and 20 stories. The aspect ratio can be varied by changing number of bays. Aspect ratio 1, 2, 3 were considered for the study. The analysis was carried out using STAAD PRO. It was concluded that when wind load is applied along the length of the building frame displacement for 20 storied frames is very high when compared to 10 and 15 storied frames. When wind load is applied across the length of the building frame; as aspect ratio increases, displacement gradually decreases. This displacement reduction is high in case of 20 storied frame compared to 10 and 15 storied frames. The displacement decreases when wind load is applied across the building frame. As the stiffness of the member increases the displacement of the frame decreases.

B. Dean Kumar et al (2010) studied wind effects on tall building frames with influence of dynamic parameters. The gust effectiveness factor method is used, which is more realistic particularly for computing the wind loads on flexible tall slender structures and tall building towers. In the study frames of different heights are analyzed and studied. The gust pressures computed by gust effectiveness factor method increase with the height of the building and they are more critical than static pressures and also gust effectiveness factor method gives critical wind pressures to be considered in the design of tall multi-storey frames.

Mohammed Asim Ahmed (2015) studied the effect of wind load on tall buildings in different terrain category. Three models were analysed using ETABS 2015 package. The displacement occurs in different storey due to wind in different terrain category was found out and studied variation in deflection as height of model changes and percentage change in deflection of same model in different terrain category. The deflection on top storey increases as the height of the model increases.

CHAPTER 3

OBJECTIVES AND SCOPE

3.1 GAPS IDENTIFIED

On performing the extensive survey of the literature available on building structure it can be concluded that due to a wide variety of buildings, the in-depth understanding in the field of wind analysis and design of building structures is inadequate. The IS codes has provided certain guideline on the basis of which the building structures can be designed when subjected to wind loads. The literature survey in the performance and behavior of building structures when subjected to wind loads suggests that the requirement of establishing a methodology for studying the response of building structure to wind loads has become essential. Many researchers has performed work over various types of building and find out the important parameter which is useful for understanding the behavior of wind forces.

3.2 OBJECTIVES OF THE STUDY

- To study the behavior of tall RC structures when subjected to wind loads.
- To critically study the provisions of IS: 875 (Part 3):2015.
- To determine the effect of wind loads on various parameters like storey drift, storey displacements and base shear of different shaped buildings(square, rectangle and octahedral).
- To compare the analysis results under different terrain categories of wind loads.
- To perform the seismic analysis of different building models in seismic zone V
- Comparative study of the effects of wind and earthquake loads of a multi-storey building
- To define the most efficient geometry in high rise building by observing the comparative studies

3.3 SCOPE OF THE STUDY

The scope of the present work includes the study of wind loads on tall buildings for the structural design purpose using IS 875 (Part 3):2015. The performance was studied in terms of storey displacements, storey drifts, and base shear. The modelling, analysis, and design were carried out by using ETABS 2018 software.

3.4 ORGANIZATION OF THE THESIS

The study is described in ten chapters. The general information to the study including wind loads on tall buildings and wind analysis as per IS 875 (Part 3):2015 along with the significance of the study. Chapter 2 provides a brief review of the literature that were referred for the preparation of this work. Chapter 3 gives the research gaps identified, objectives and scope of the study. Chapter 4 explains the detailed methodology adopted in the study. It gives a clear idea about various stages of work. Chapter 5 deals with the details of validation of analysis procedure. Chapter 6 and 7 includes problem definition and loads on the building respectively. Chapter 8 is the details of seismic analysis of multi-storey G+19 building. Chapter 9 gives the results obtained in the study along with other observations arrived at the end of the study. Chapter 10 discusses the conclusion drawn from the work.

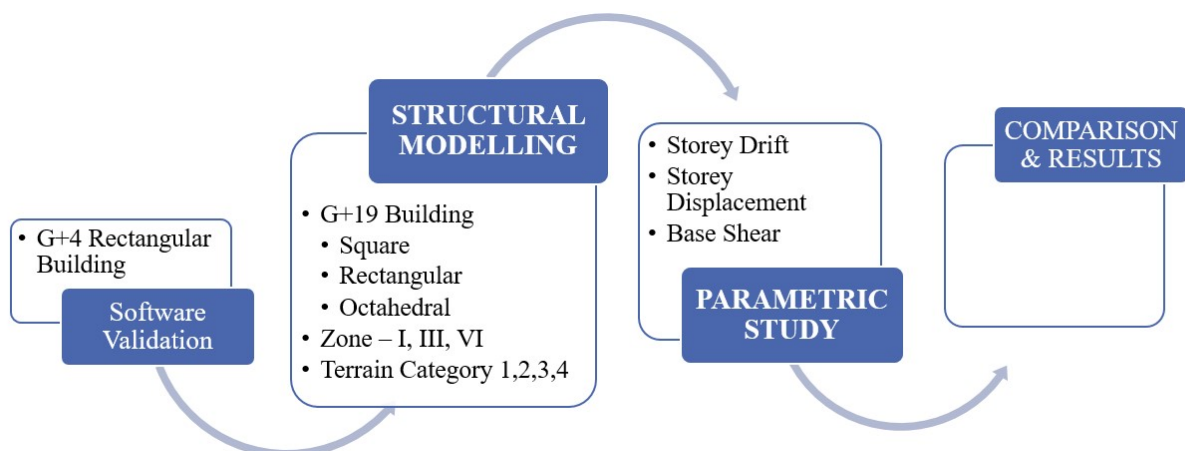
CHAPTER 4

METHODOLOGY

4.1 GENERAL

The methodologies adopted in this study are as follows:

- A thorough literature review to understand the nature and effects of wind loads on tall rc structures.
- Fixing the objectives of the thesis
- Software study-ETABS 2016 is used to develop 3D model and to carry out the analysis. The lateral loads to be applied on the buildings are based on the Indian standard IS 875 (Part 3): 2015.
- Modelling of building frames:
 - (i) Square
 - (ii) Rectangle
 - (iii) Octagonal
- Application of loads
- Analysis is carried out in all models with different zones and terrain categories.
- Determine the effect of wind loads on various parameters like storey drift, storey displacements and base shear of the building
- Comparative study on the result obtained from the above analysis with earthquake response spectrum.
- Conclusion



CHAPTER 5

VALIDATION OF SOFTWARE

5.1 GENERAL

The effect of wind load on tall structures cases are analyzed in this thesis using ETABS 2018 software. So to check the percentage of variation and accuracy of results, a similar problem is analyzed in ETAB 2018 software and the results are validated by manual calculations. The percentage differences in results were found out.

5.2 INTRODUCTION TO ETABS 2018

ETABS is the abbreviation of 'Extended 3D Analysis of building system'. It is recognized globally as the pioneering leader in structural engineering analysis and design software for structural and earthquake engineering. The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings.

ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

5.2.1 Problem Description

A RC building frame having G+4 stories with plan dimension 10m × 10m and floor height 3m is selected as a model for the study. Wind analysis of the model is carried out and the total wind load acting on surface is compared. The description of the building frame model selected for the validation is given in Table 5.1. Table 5.2 and table 5.3 shows the material properties and external loads applied and wind factors respectively. The plan and elevation of building model for validation is shown in Figure 5.1 and Figure 5.2 shows 3D view of building.

Table 5.1 Building Description (Narla Mohan, 2017)

Type of building	General Building (class A)
Bay width	5m
Storey height	3m
Beam size	0.3m×0.45m
Column size	0.45m×0.45m
Slab thickness	0.15m
Wall thickness	0.23m

Table 5.2 Material Properties (Narla Mohan, 2017)

Density of concrete	25kN/m ³
Density of brick	21kN/m ³
Grade of concrete	M30
Grade of steel	Fe 415

Table 5.3 Loads and Wind Factors (Narla Mohan, 2017)

Live load	4kN/m ²
Floor finish load	1.5kN/m ²
Basic wind speed (V_b)	39m/s
Terrain category	2
Risk coefficient (k_1)	1
Terrain and height factor (k_2)	1.05

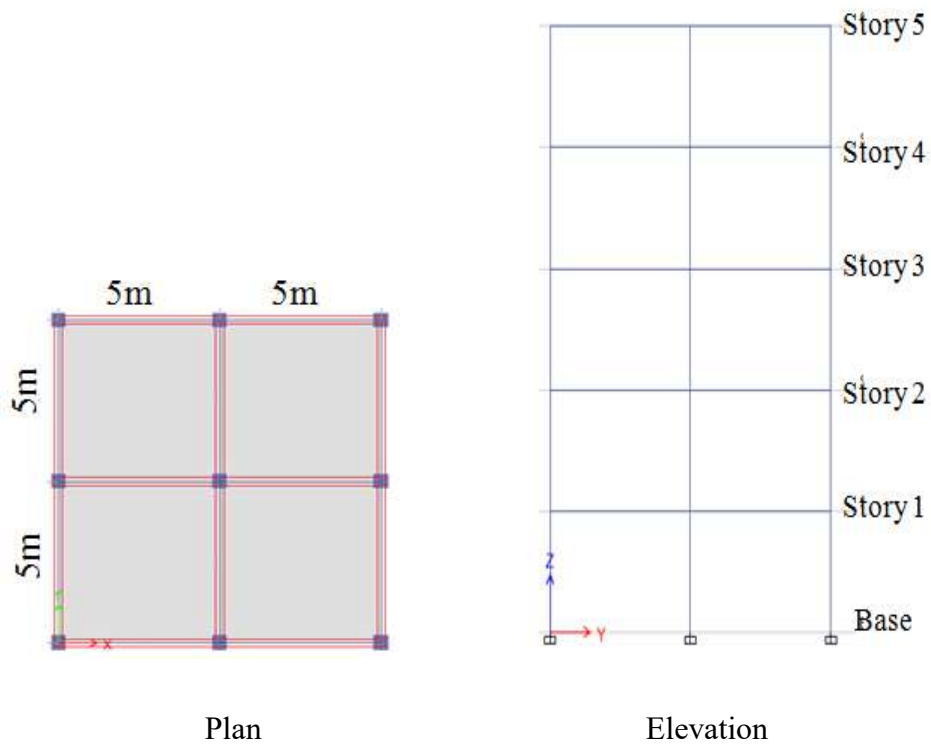


Figure 5.1 Plan And Elevation of Building Model

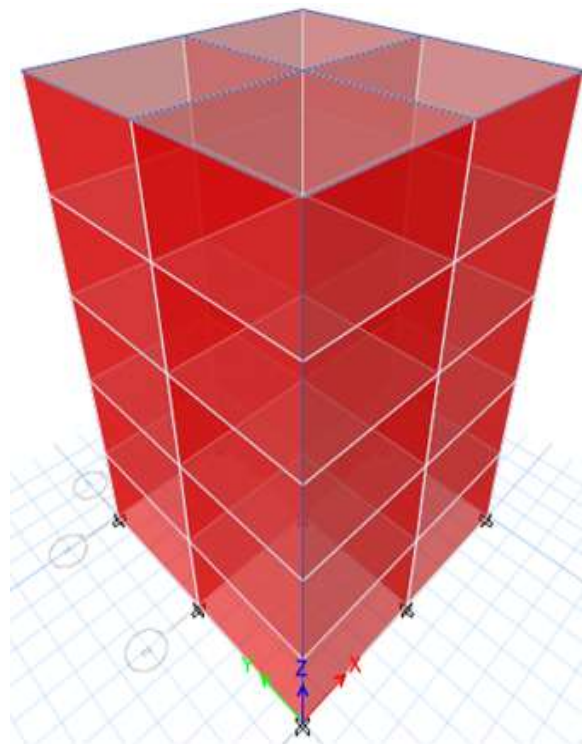


Figure 5.2 3D View of Building Model for Validation

The wind load acting on the surface perpendicular to wind direction is obtained by manual calculations using IS 875 (Part 3):2015.

Design wind speed: $V_z = V_b \times k_1 \times k_2 \times k_3 \times k_4$

V_z = design wind speed at any height z in m/s,

V_b = basic wind speed

k_1 = probability factor (risk coefficient)

k_2 = terrain roughness and height factor

k_3 = topography factor

k_4 = importance factor for the cyclonic region

$$V_z = 39 \times 1 \times 1.05 \times 1 \times 1 = 40.95 \text{ m/s}$$

Design wind pressure: $P_z = 0.6 V_z^2$

P_z = the design wind pressure in N/m^2 at height z

$$P_z = 0.6 \times 40.95^2 = 1006.1415 \text{ N/m}^2$$

Wind load perpendicular to surface $F = C_p A P_z$

F = wind load acting normal to surface in kN

C_p = pressure coefficient

$$C_p = 1.2$$

A = exposure area

$$A = 150 \text{ m}^2$$

Wind load acting on surface, $F = 181 \text{ kN}$

From numerical method using software ETABS,

The total wind load acting on the surface = 98.32 kN

The difference in base shear obtained = $75.643 - 73.4436 = 2.199$

Percentage difference = $2.199 \times 100 / 75.643 = 2.908\%$

CHAPTER 6

PROBLEM DEFINITION

6.1 GENERAL

A G+19 storey building with different shapes is modeled and analysis is carried out under different wind load conditions.

6.2 MODEL DESCRIPTION

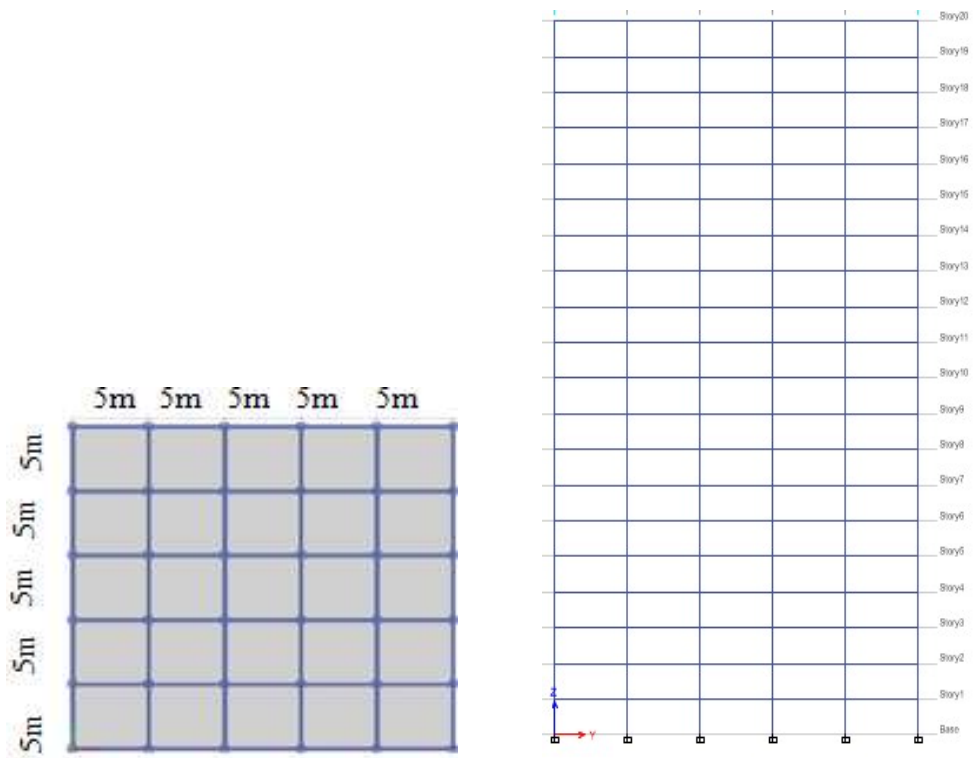
The ETABS software is used to develop 3D model and to carry out the analysis. The lateral loads to be applied on the buildings are based on IS 875 (Part 3): 2015. The building consists of reinforced concrete elements. Symmetrical general building, having floors of height 3m is selected as a model for the study. Three shaped buildings are modeled namely rectangular, square and octagonal. The width of all buildings in X direction is same.

The wind speed corresponding to wind zones I, III, VI is 33m/s, 44m/s and 55m/s respectively. The properties of the building selected for the study is given in table 6.1. The typical plan, elevation and 3D view of the models considered for the study i.e. square, rectangle and octagonal are shown in Figure 6.1, Figure 6.2 and Figure 6.3 respectively.

Table 6.1 General Specification of Building

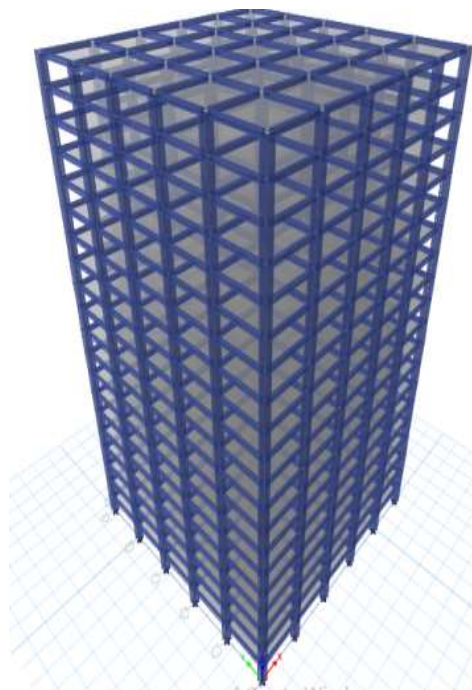
PARAMETERS	VALUES
Number of storeys	G+19 (Square, Rectangle , Octagonal)
Bottom storey height	3m
Storey height	3m
Structural class	B
Wind zone	I, III, VI
Terrain category	I,II,III,IV
Thickness of wall	0.23m

Beam size	0.3m × 0.5 m
Column size	0.85m × 0.85m
Thickness of slab	0.150m
Grade of concrete	M30
Young's modulus of concrete	$25 \times 10^6 \text{ kN/m}^2$
Grade of steel	Fe 415
Density of RC	25 kN/m^3
Density of brick	21 kN/m^3
Floor finish	1.5 kN/m^2
Live load	4 kN/m^2
Wall load	13.8 kN/m^2
Risk coefficient (k_1)	1
Topography factor (k_3)	1
Importance factor for the cyclonic region(k_4)	1



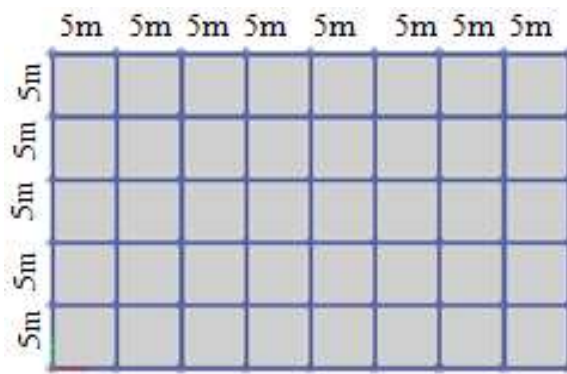
Plan

Elevation

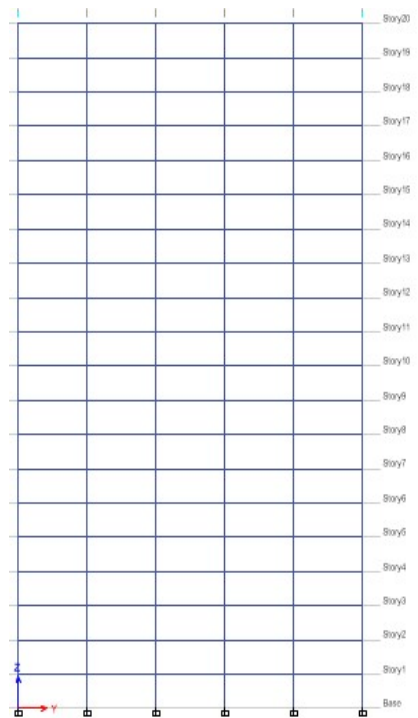


3D view

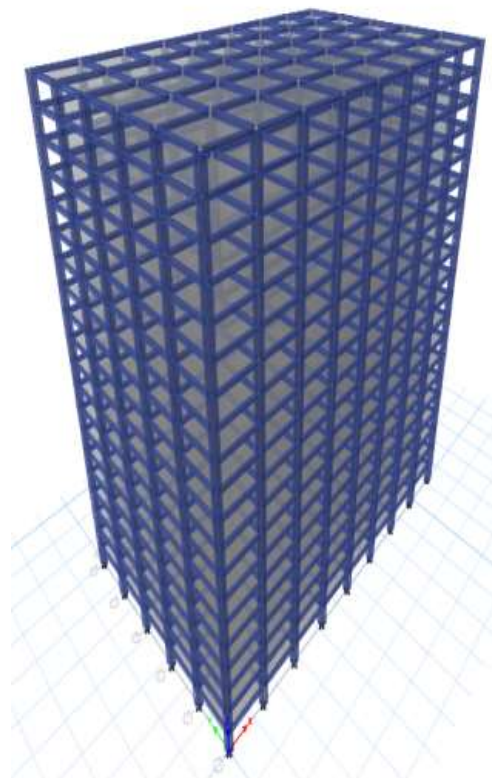
Figure 6.1 Plan, Elevation And 3D Model of Square Building



Plan

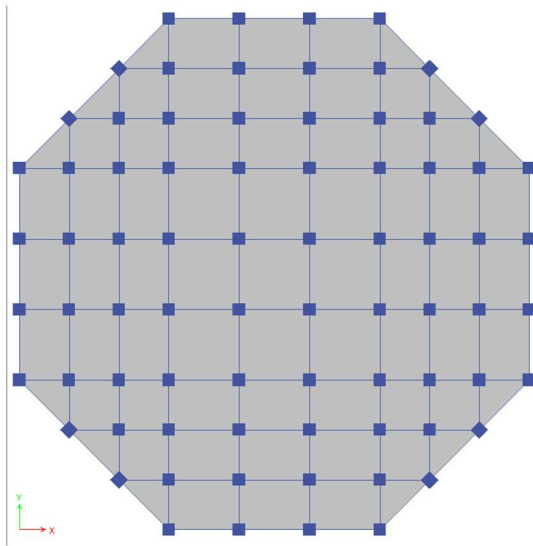


Elevation

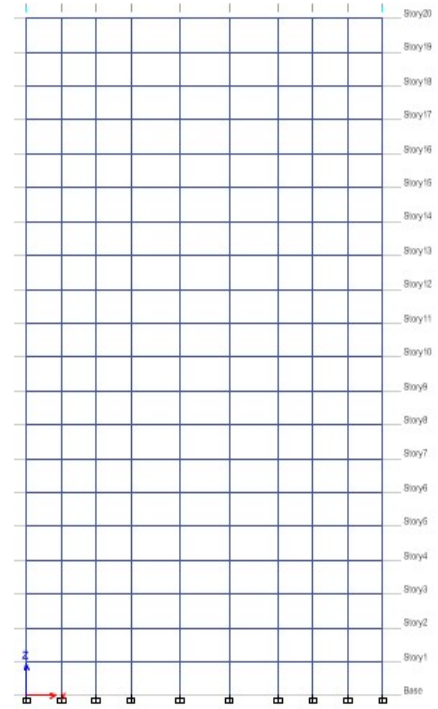


3D view

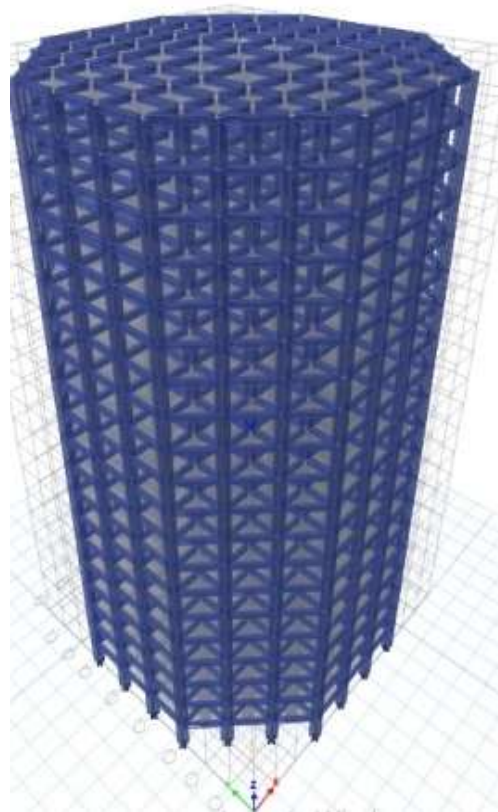
Figure 6.2 Plan, Elevation And 3D Model of Rectangular Building



Plan



Elevation



3D view

Figure 6.3 Plan, Elevation And 3D Model of Octagonal Building

CHAPTER 7

LOADS ON THE BUILDING

7.1 DEAD LOADS

Dead load is the self-weight of the reinforced concrete members and walls. It could be the weight of the materials or any other components in the structure that will remain permanent throughout the life of the structure. Dead loads vary from structure to structure. Every building is unique and has different considerations. Hence for a building, the dead load includes the weights of the columns, beams and girders, the floor slabs and walls. The dimensions of the cross sections are to be assumed initially which enable to estimate the dead load from the known unit weight of the structure. The values of the unit weight of the materials are specified in IS 875 (Part 3):2015. Self-weight of the structural members will be calculated by the software ETABS. Floor finish load of 1.5kN/m^2 is also applied to the structure.

7.2 LIVE LOADS

Live loads are imposed loads on a building by use and occupancy and are considered as movable or temporary which includes people, furniture and movable equipment. Live loads are established by code for different occupancies. The minimum live loads specified in codes are determined from studying the history of their effects on existing structures. Usually, these loads include additional protection against excessive deflection or sudden overload. The standard values are stipulated in IS 875(Part 3):2015. The live load applied for each floor except terrace is 4kN/m^2

7.3 BRICK LOAD

The masonry load act directly on the beam beneath the walls as a uniformly distributed load.

Wall thickness – 0.23m

Height of the wall – 3m

Total load – 13.8 kN/m

7.4 WIND LOADS

Wind loads depend on the velocity of the wind where the structure is located, the permeability of the structure, height of the structure etc. Depending on the angle of inclination of the roof for pitched roof structures they may be horizontal or inclined forces. Wind loads are specified in IS 875 (Part 3):2015. The buildings situated in different wind zones having different basic wind speeds are analyzed. The effect of wind load also depends on different terrain categories in which building is situated.

Table 7.1 Basic Wind Speed for Wind Zones (IS 875 (Part 3): 2015)

Wind Zones	Location	Basic Wind Speed(m/s)
I	Bengaluru	33
II	Kochi	39
III	Mumbai	44
IV	Delhi	47
V	Chennai	50
VI	Agartala	55

CHAPTER 8

SEISMIC ANALYSIS OF A MULTI-STOREY (G+19) BUILDING

8.1 GENERAL

As earthquakes can happen almost anywhere, some measure of earthquake resistance in the form of reserve ductility and redundancy should be built into the design of all structures to prevent catastrophic failures. Moreover, during the life of a building in a seismically active zone, it is usually expected that the building will be subjected to many small earthquakes, including some moderate ones, one or more large ones, and possibly a very severe one. Building massing, shape and proportion, ground acceleration, and the dynamic response of the structure, influences the magnitude and distribution of earthquake forces. On the other hand, if irregular forms are inevitable, special design considerations are necessary to account for load transfer at abrupt changes in structural resistance. Therefore, two general approaches are utilized to determine the seismic loading, which take into consideration the properties of the structure, and the past record of earthquakes in the region. When compared to the wind loads, earthquake loads have stronger intensity and shorter duration.

8.2 DESIGN CONSIDERATIONS

Moreover, despite the advancements in earthquake engineering during the last three decades, many uncertainties still exist. The plan layout of a building plays a vital role in its resistance to lateral forces and the distribution of earthquake forces. Experience has shown that the buildings with an unsymmetrical plan have a greater vulnerability to earthquake damage than the symmetrical ones. Therefore, symmetry in both axes, not only for the building itself but also for the arrangement of wall openings, columns, and shear walls is very important. For irregular featured buildings, such as asymmetry in plan or vertical discontinuity, assumptions different from the buildings with regular features should be used in developing seismic criteria.

8.3 TALL BUILDING BEHAVIOR DURING EARTHQUAKES

Seismic motion response of tall buildings is to some extent generally different than low-rise buildings. The magnitude of inertia forces generated by an earthquake depends on the building mass, ground acceleration, the nature of foundation, and the dynamic characteristics of the structure (Figure 8.1). Although tall buildings are more flexible than low-rise buildings, and usually experience accelerations much less than low-rise ones, a tall building subjected to

ground motions for a prolonged period may experience much larger forces if its natural period is near that of the ground waves.

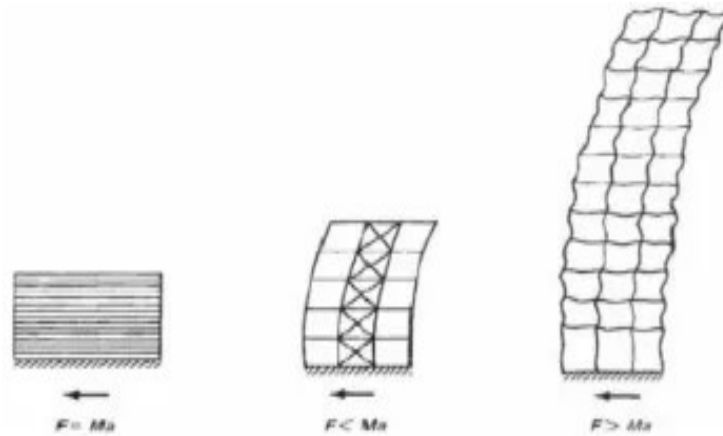


Figure 8.1 Schematic Representation of Seismic Force (Bhushan G, 2021)

8.4 SEISMIC ANALYSIS AS PER IS 1893 (PART 1):2016

Effects of design earthquake loads applied on structures can be considered in two ways namely:

Equivalent Static method and Dynamic Analysis method. In turn, dynamic analysis can be performed in three ways, namely: Response spectrum method, Modal time history method and Time history method. In this standard Equivalent Static method, Response spectrum method and Time history method are adopted.

8.4.1 Equivalent Static Force Analysis

The equivalent static force analysis for an earthquake is a unique idea that is applied to the construction of earthquake-resistant structures. This concept is useful because it changes a dynamic analysis into a partly static and dynamic analysis in order to determine the maximum displacements created in the structure as a result of ground motion caused by an earthquake. Only these maximal displacements, not the time history of stresses, are relevant for earthquake-resistant structural design.

For an earthquake, equivalent lateral force is defined as a collection of static lateral forces that induce identical peak reactions in the structure as those produced in the dynamic analysis of the building under similar ground motion. This concept has a disadvantage in that it only exploits one form of structure vibration. Equivalent Static method may be used for analysis of regular

structures with approximate natural period T_n less than 0.4 s. It shall be applicable for regular buildings with height less than 15m in seismic zone II.

8.4.2 Response Spectrum Method

Multiple modes of vibration of a structure can be utilized in this approach. Except for basic or complicated structures, this analysis can be employed in a variety of building regulations. A building's vibration is characterized as a collection of several special modes in a vibrating string that correspond to the harmonics. The structure's mode forms are determined using computer-aided structural analysis. For each mode shape, the responses of the design spectrum are investigated using metrics such as modal participation mass and modal frequency, and then they are combined to offer an assessment of the structure's total reactions.

8.4.3 Time History Analysis

If non-linear behaviour is not encountered, a linear time history analysis asphyxiates all of the drawbacks of modal response spectrum analysis. For calculating the reaction at discrete time intervals, this method necessitates more processing effort. One intriguing benefit of this method is that the relative signs of response quantities are preserved in response histories. When interaction effects between stress resultants are taken into account in design, this is crucial. While too simple to apply to an actual construction, the Heaviside Step Function is a good model for the display of many real loads, such as the addition of a chunk of furniture or the removal of a prop from a freshly cast concrete floor. In reality, loads are never imposed instantly; rather, they accumulate over time (this may be very short indeed). The rising time is the name given to this period. As the number of degrees of freedom of a structure grows, manually evaluating the time history becomes increasingly complex; genuine constructions are studied using non-linear finite element analysis software. The application of time-history analysis in the design of new structures and the evaluation of existing ones is becoming more common. Seismic action is described by a set of ground acceleration data in time-history analysis

8.4.4 Pushover Analysis

It has proven an ideal tool for seismic performance evaluation of structures by major rehabilitation standards and codes. It allows you to trace the sequence of yielding, failure at the member and structural levels, as well as the evolution of the structure's overall capacity curve. It gives statistics on a variety of response characteristics that an elastic static or elastic dynamic study cannot provide. Pushover analysis is a static nonlinear approach in which the magnitude

of structural loading is steadily raised along the lateral direction of the structure in accordance with a pre-defined pattern.

The behaviour of the structure is often considered to be monitored by its fundamental mode, and the preset pattern is described either in storey shear locations or in terms of fundamental mode form. The predetermined lateral load pattern is then applied and raised throughout the building height until some members yield. The structural model is changed to account for the reduced stiffness of yielding members, and the lateral forces are increased once more until more members yield. Weak links and failure modes of the structure are discovered as the amplitude of loading increases. The technique is repeated until a regulated displacement at the building's top achieves a certain amount of distortion or structure becomes unstable. The roof displacement is plotted with base shear to get the global capacity curve and it is shown in figure 8.2.

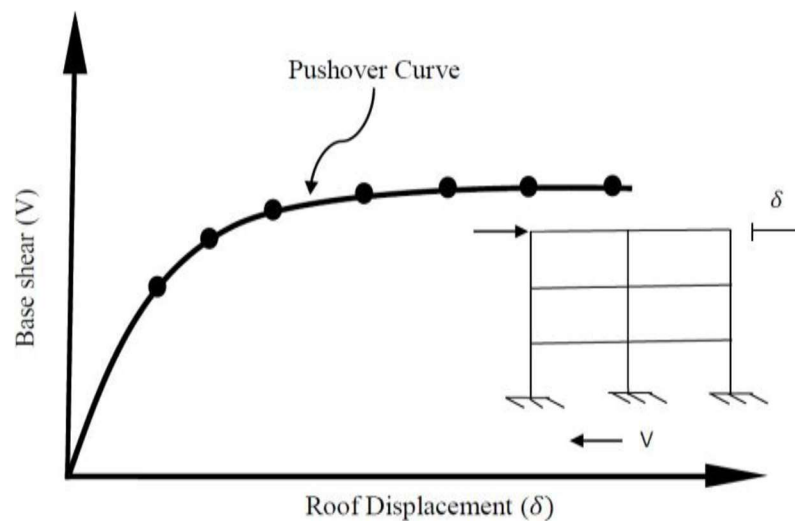


Figure 8.2 Pushover Curve (Sushant M, 2021)

Because of the computing time, a pushover analysis is more convenient than a full dynamic analysis. Pushover analysis produced results in a fraction of the time that dynamic analysis did. As a result, in a design office, pushover analysis is more practical. It offers supplementary information on the limit states, the plastic hinge sequence, and the force redistribution induced by a seismic event once the structure has been developed or retrofitted using suitable codes or design principles. The designer can alter the design configuration to get the required plastic hinge sequence when lateral loads are applied.

The pushover analysis also provides detailed member information, such as maximum inter-story drift needs and plastic hinge rotations, which helps to improve the design efficiency. The structure's performance was a phenomena, and the structure had to be able to withstand the

earthquake's demands. The circumstance in which the seismic demand exerted on the structure was equal to the seismic capacity is referred to as a performance point. Figure 8.3 shows a graphical representation of performance levels using a pushover curve.

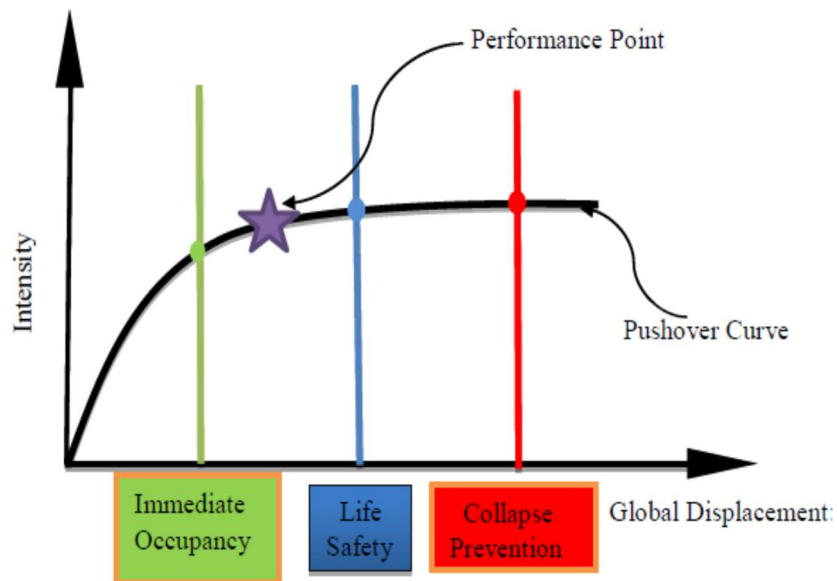


Figure 8.3 Performance Levels with Pushover Curve (Sushant M, 2021)

8.5 CONSIDERABLE PARAMETERS

Historically, seismic loads were treated as static accelerations that were affected by a variety of parameters such as the seismicity of the region, the soil qualities, the structure's normal frequency, and the structure's planned use. Over time, the approach was developed to allow for progressively adequate designs. The underlying design idea remained mostly unchanged, albeit significant earthquakes forced minor adjustments to the coefficients. Other changes were made to accommodate for new information by defining acceptable structural features for various construction materials.

a) Seismic zone factor, Z : For the extreme considered earthquake and service life of the structure in a zone, India has been split into four seismic zones according to IS 1893 (Part 1): 2016. The zone factor varies depending on the zone. There are four earthquake zones in India. IS 1893 (Part 1): 2016 distinguishes between three types of soil: soft, medium, and hard soil.

Table 8.1 Seismic Zone Factor (Clause 6.4.2) IS 1893 (Part 1): 2016

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

b) Seismic weight of the floors: The imposed load on the roof must not be considered when calculating the design seismic forces of a building. However, in this scenario, the weight of equipment and other permanently established services should be taken into account while reducing the imposed loads listed in table 8.1.

Table 8.2 Percentage of imposed loads to be considered seismic weight (IS 1893 (Part 1):2016)

Imposed uniformity distributed floor loads (kN/m ²)	% of imposed load
Up to and including 3.0	25
Above 3.0	50

c) Design Seismic Base Shear:-The total design lateral force or design seismic base shear (V_B) along any principal direction shall be determined by the following expression: $V_B = A_h W$,

A_h- Design horizontal acceleration seismic coefficient (Clause 6.4.2 of IS 1893 (Part 1):2016)

$$A_h = \frac{\frac{Z}{2} \times \frac{S_a}{g}}{R/I}$$

I- Importance Factor given in IS 1893 (Part 1 to 5) for the corresponding structures; when not specified, the minimum values of I shall be 1.5 for critical and lifeline structures, 1.2 for business continuity structures and 1.0 for the rest.

R- Response reduction factor given in IS 1893 (Parts 1 to 5) for the corresponding structures

(Table 9, clause 7.2.6 of IS 1893 (Part 1):2016)

$\frac{Sa}{g}$ - Design acceleration coefficient for different soil types, normalized with peak ground acceleration, corresponding to natural period T of structure (considering soil-structure interaction, if required). It shall be as given in Parts 1 to 5 of IS 1893 for the corresponding structures; when not specified, it shall be taken as that corresponding to 5 percent damping Fig.2(a) and Fig.2(b) of IS 1893 (Part 1):2016.

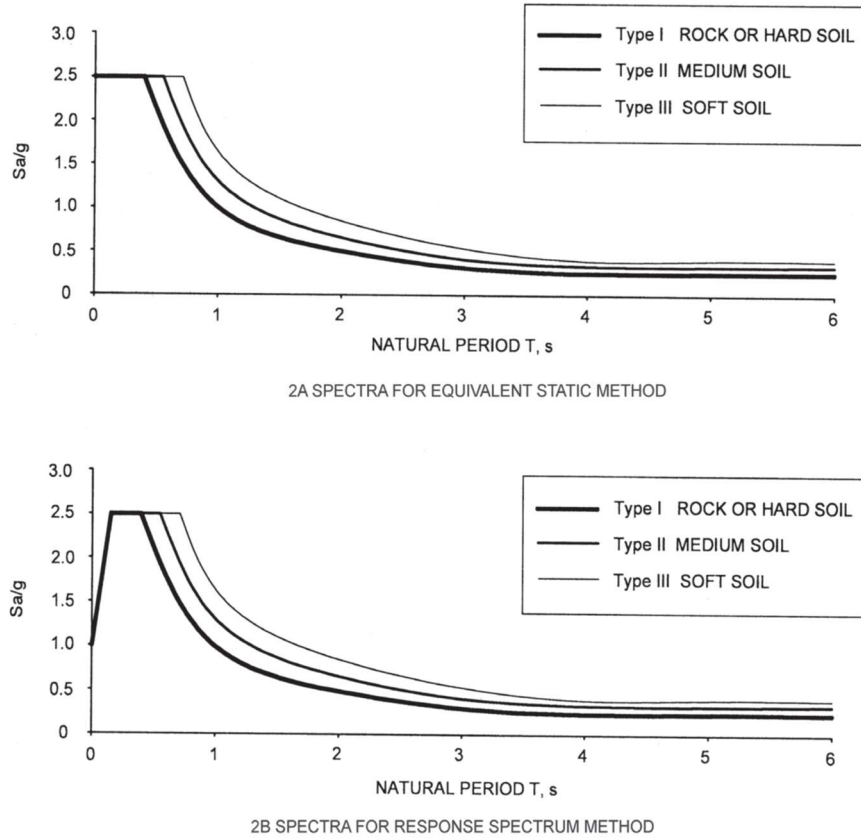


Figure 8.4 Design Acceleration Coefficient (Sa/g) Corresponding to 5% damping

(IS 1893 (Part 1):2016)

The approximate fundamental translational natural period T_a of oscillation, in second, as per clause 7.6.2 of IS 1893 (Part 1):2016, and W - Seismic weight of the building.

d) Vertical distribution of base shear to different floor levels is given by the following expression

$$Q_i = \left(\frac{W_i h_i^2}{\sum_{j=1}^n W_j h_j^2} \right) V_B$$

Q_i - design lateral force at floor i , W_i - seismic weight of floor i , h_i -height of floor i measured from base and n - number of storeys in building, that is, number of levels at which masses are located.

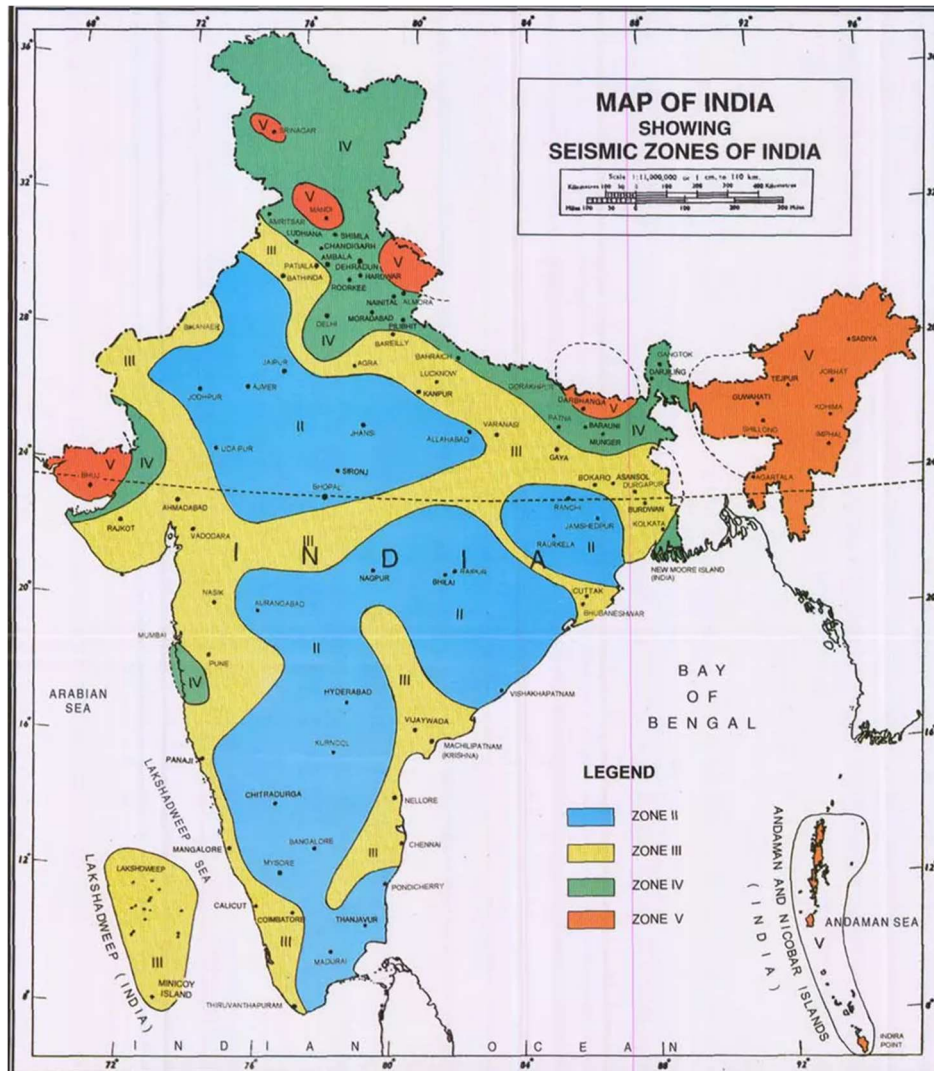
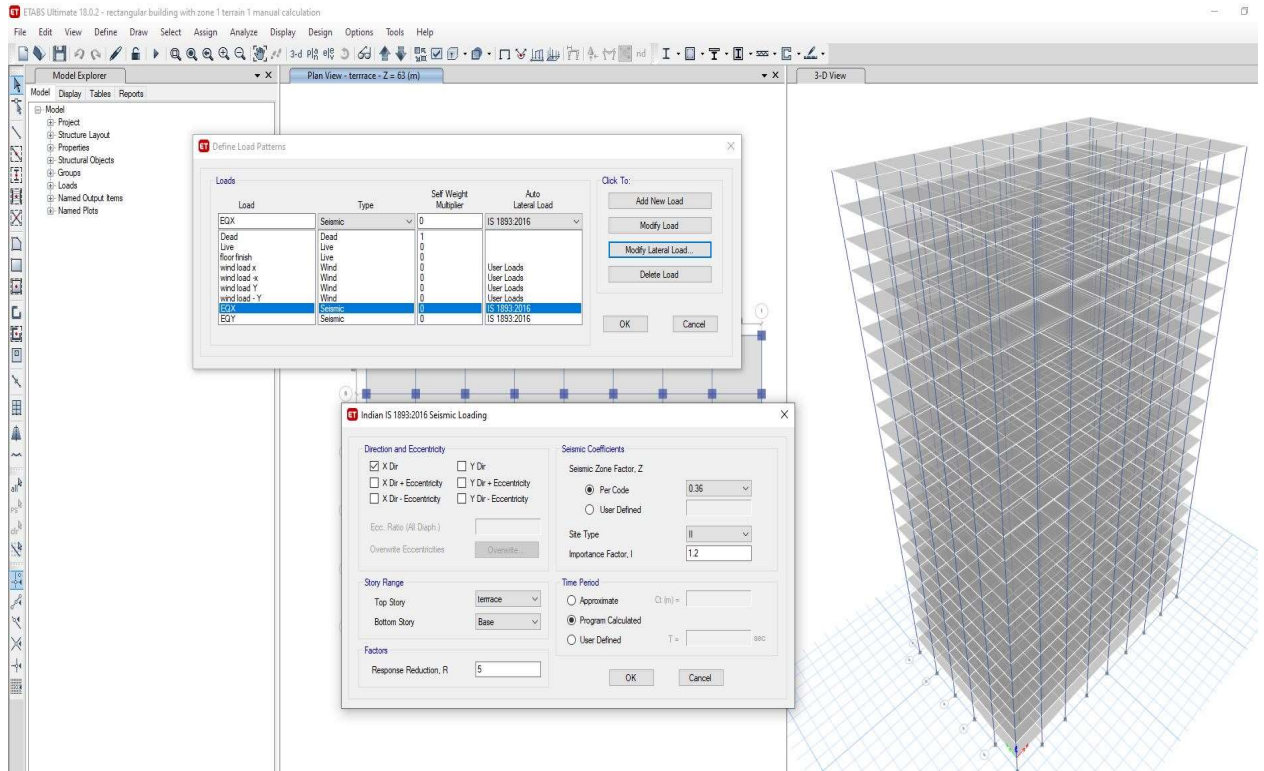


Figure 8.5 Seismic Zones of India (IS 1893 (Part 1):2016)

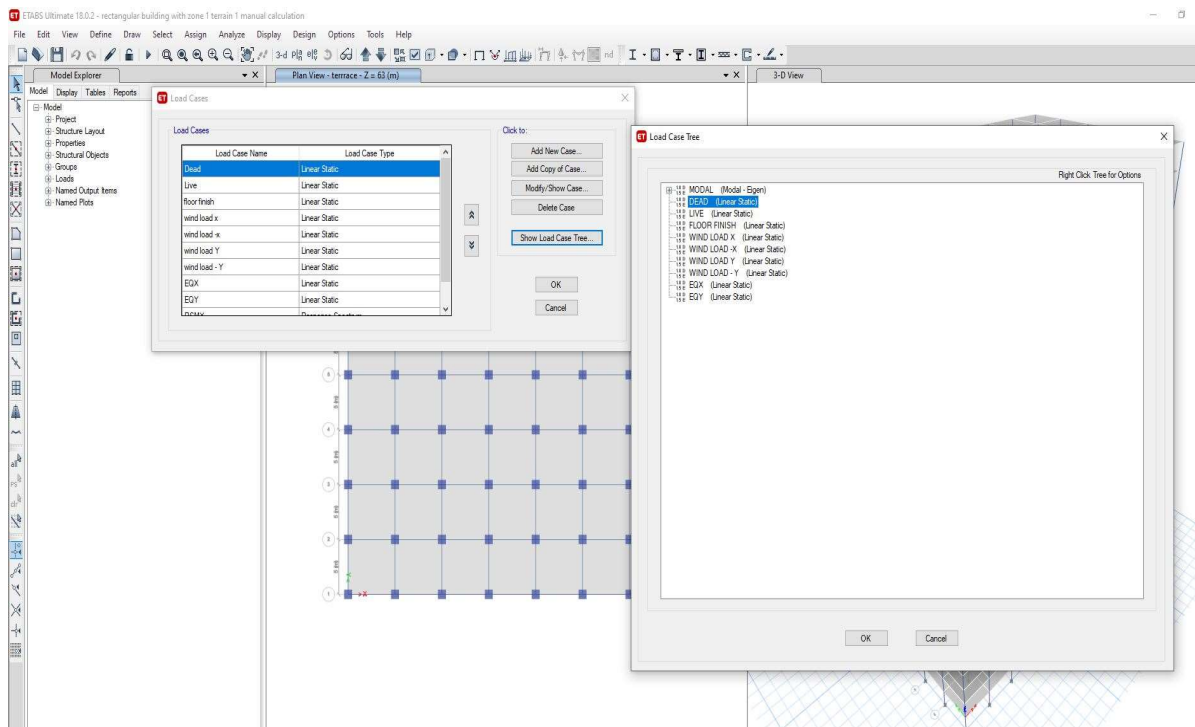
Table 8.3 Building Specifications

PARAMETERS	VALUES
Number of storeys	G+19 (Square, Rectangle , Octagonal)
Bottom storey height	3m
Storey height	3m

Structural class	B
Seismic zone	V
Thickness of wall	0.23m
Beam size	0.3m × 0.5 m
Column size	0.85m × 0.85m
Thickness of slab	0.150m
Grade of concrete	M30
Young's modulus of concrete	$25 \times 10^6 \text{ kN/m}^2$
Grade of steel	Fe 415
Density of RC	25 kN/m^3
Density of brick	21 kN/m^3
Floor finish	1.5 kN/m^2
Live load	4 kN/m^2
Wall load	13.8 kN/m^2
Earthquake load	As per IS 1893 (Part 1):2016
Importance factor	1.2 (business continuity structures)
Seismic zone factor	0.36
Response reduction factor	5 (RC building with special moment resisting frame -SMRF)
Soil type	II, Medium or stiff soil



(a)



(b)

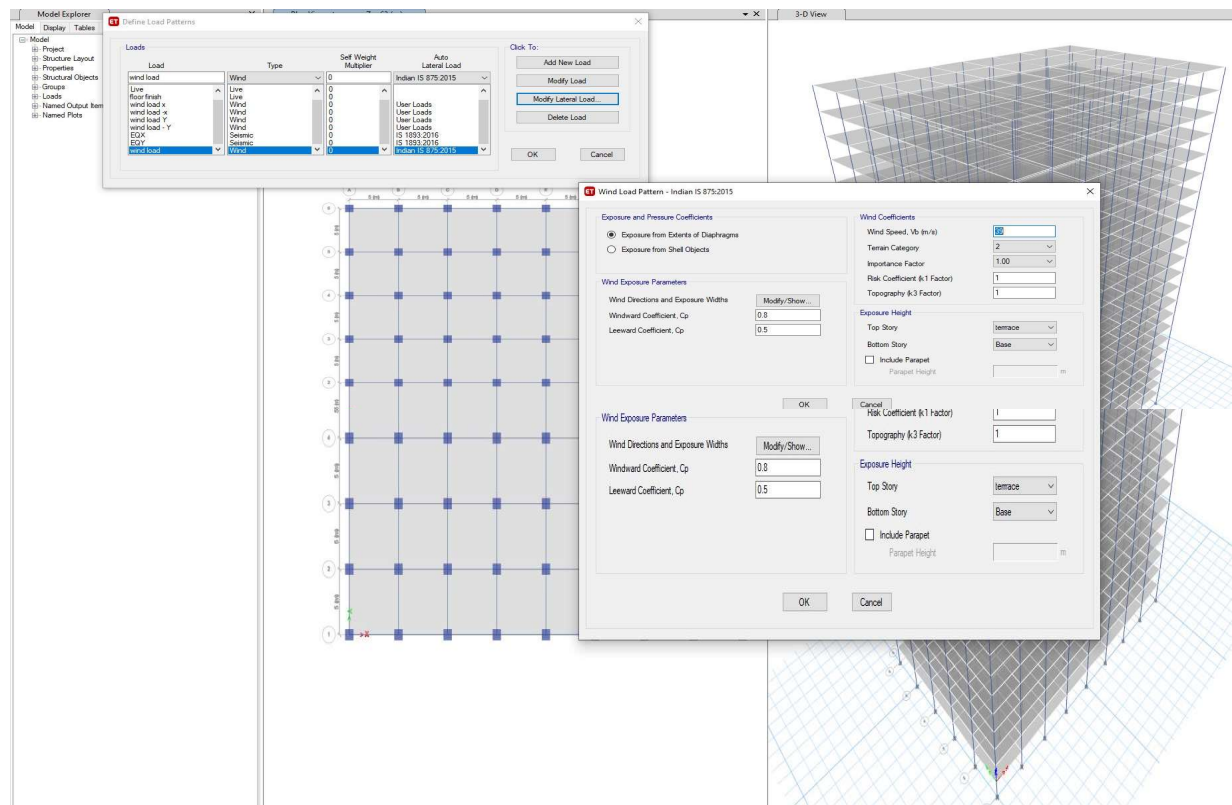
Figure 8.6 (a) and (b) ETABS –Load Cases and Load Patterns

CHAPTER 9

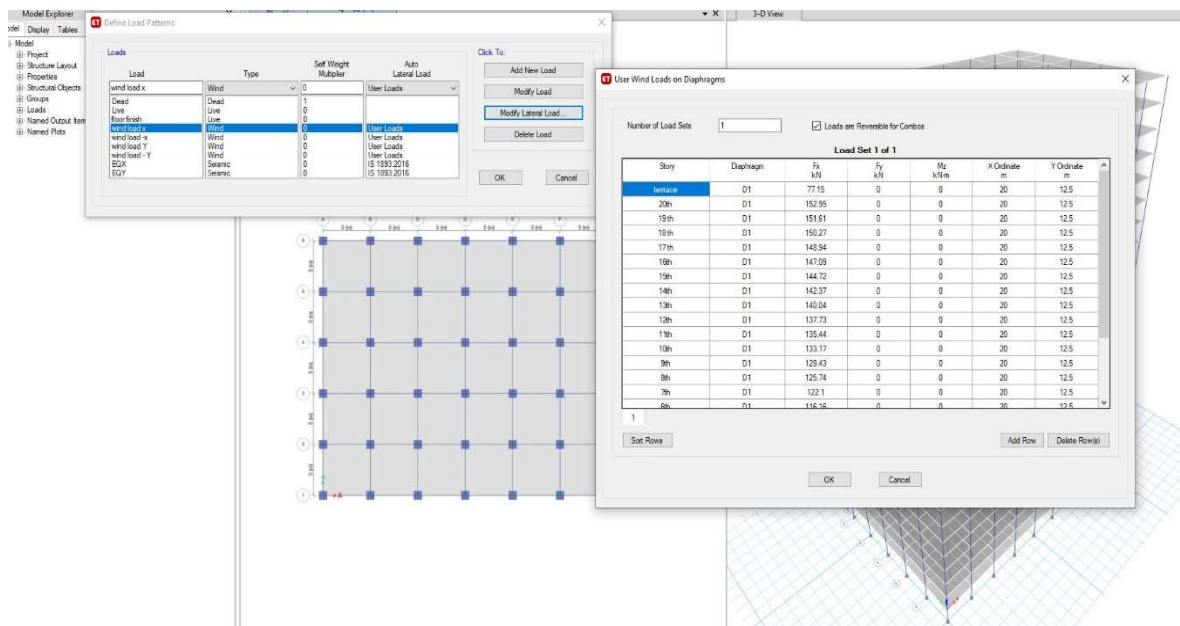
RESULTS AND DISCUSSIONS

9.1 GENERAL-WIND ANALYSIS

In structures of ordinary height, dead and live loads are predominant. The wind loading effects are covered by the increase of permissible stresses as recommended by the IS 875 (Part 3): 2015. Hence, for the design of buildings of low to medium height the wind effects are usually ignored. As the height of the building increases, the wind effects become gradually considerable. In the case of very tall slender frames they even become predominant compared to dead and live load effects. Very tall slender building frames are flexible in nature and as a result they interact with the wind dynamically and the safety and the stability of structure may become critical. Hence, for design of very tall frames, a thorough study of wind effects and investigation of criticality are very much necessary. This is particularly considered in regions where wind is more critical than earthquakes. In order to understand the effect of wind load on the tall building for wind loads at bottom storey column for different aspect ratio and different storey height.



(a)



(b)

Figure 9.1 (a) and (b) ETABS –Define Load Patterns and Load Combinations

Results are required to obtain from analysis of building models in different zones and terrains and compare in the form of various parameters. The analysis which is to be carried out for G+19 storey buildings (square, rectangular and octagonal shape) shows variation in results includes storey displacement, storey drift, shear at base, overturning moments etc. for different terrain categories and wind zone values.

Following are the various results obtained by analyzing different models.

9.2 STOREY DISPLACEMENT

Displacement is an important criterion to describe the dynamic behavior of building. Storey displacement is the movement of each floor due to lateral forces of wind in either X or Y direction. The analysis results have been tabulated and represented in chart. From the tabulated values it can be observed that the lateral displacement is more at terrace level for buildings situated in different zones and terrains. The lateral displacement is minimum at base level thus as the storey level increases lateral displacement also increases.

9.2.1 Square Building

Table 9.1, table 9.2 and table 9.3 shows storey displacements of square shaped G+19 RC building situated in different terrain categories I, II, III and IV in zone I, zone III and zone VI respectively.

Table 9.1 Storey Displacements for Zone I

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	15.123	14.348	13.075	11.671
18	14.673	13.916	12.671	11.295
16	13.973	13.246	12.048	10.709
14	13.005	12.322	11.193	9.905
12	11.772	11.145	10.11	8.892
10	10.282	9.725	8.806	7.688
8	8.545	8.073	7.296	6.316
6	6.581	6.209	5.598	4.809
4	4.429	4.174	3.753	3.206
2	2.212	2.082	1.868	1.59

Table 9.2 Storey Displacements for Zone III

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	26.885	25.448	23.052	20.748
18	26.085	24.686	22.353	20.08
16	24.84	23.501	21.266	19.039
14	23.12	21.864	19.767	17.608
12	20.928	19.779	17.86	15.807
10	18.278	17.26	15.563	13.667
8	15.191	14.329	12.897	11.229
6	11.699	11.022	9.898	8.55
4	7.874	7.41	6.637	5.7
2	3.932	3.697	3.304	2.826

Table 9.3 Storey Displacements for Zone VI

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	42.009	39.762	36.019	32.419
18	40.758	38.572	34.926	31.374
16	38.813	36.721	33.229	29.748
14	36.125	34.163	30.885	27.512
12	32.7	30.905	27.907	24.699
10	28.559	26.969	24.317	21.355
8	23.736	22.389	20.152	17.545
6	18.279	17.222	15.466	13.359
4	12.302	11.578	10.371	8.905
2	6.144	5.776	5.163	4.416

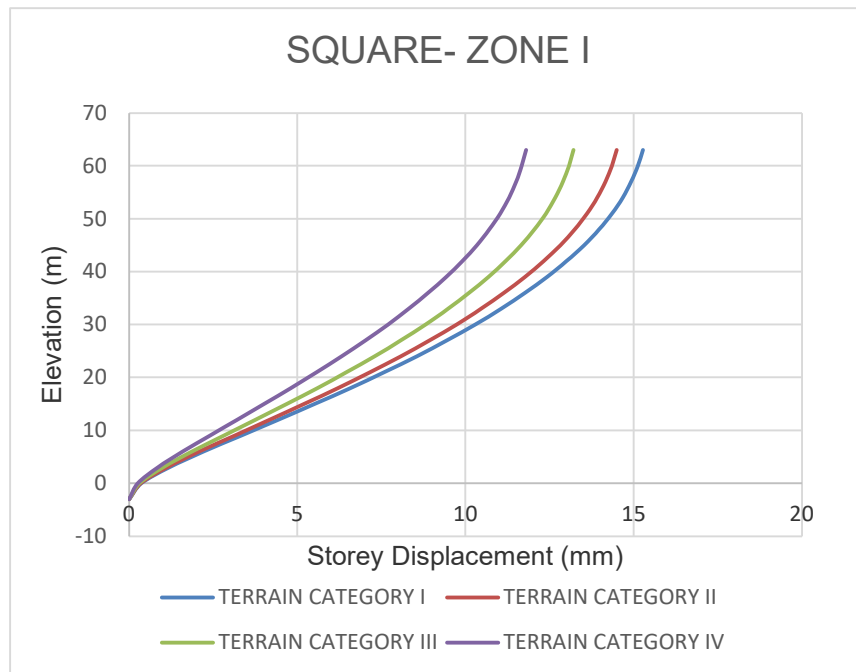


Figure 9.2 Storey Displacements for Zone I

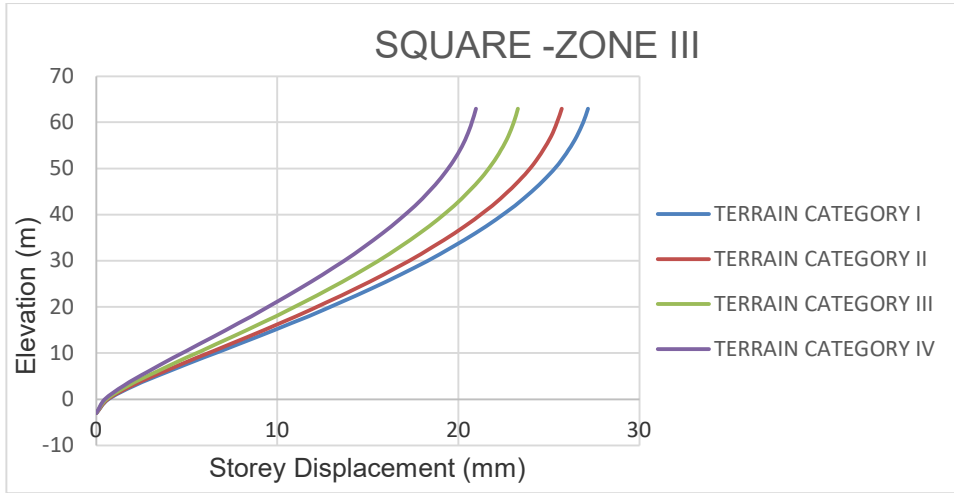


Figure 9.3 Storey Displacements for Zone III

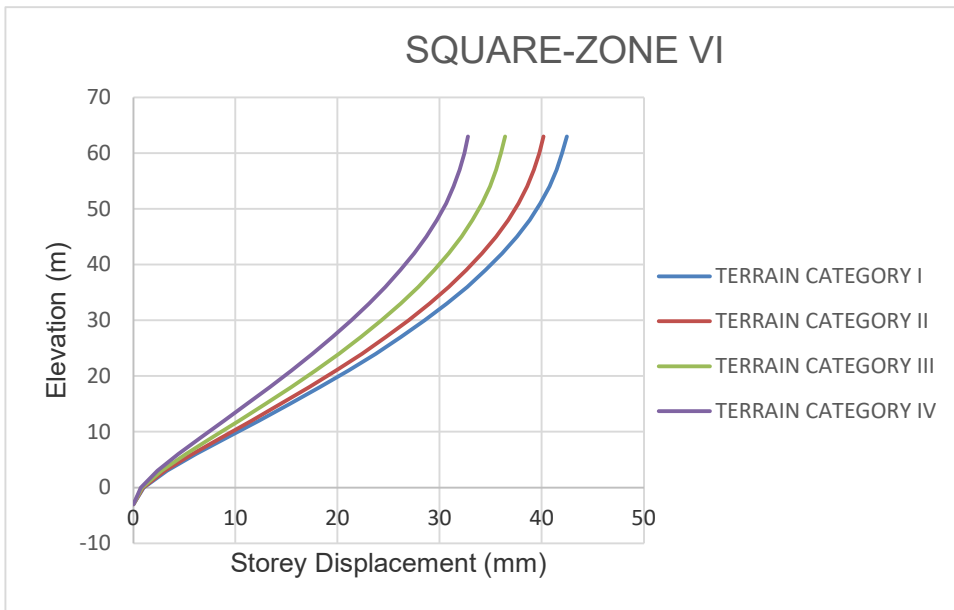


Figure 9.4 Storey Displacements for Zone VI

9.2.2 Rectangle Building

Table 9.4, table 9.5 and table 9.6 shows storey displacements of rectangular shaped G+19 RC building situated in different terrain categories I, II, III and IV in zone I, zone III and zone VI respectively.

Table 9.4 Storey Displacements for Zone I

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	14.255	13.492	12.22	10.992
18	13.872	13.127	11.885	10.67
16	13.246	12.531	11.338	10.144
14	12.361	11.688	10.566	9.406
12	11.218	10.601	9.572	8.466
10	9.825	9.277	8.364	7.34
8	8.191	7.726	6.952	6.049
6	6.332	5.965	5.356	4.623
4	4.282	4.03	3.609	3.097
2	2.154	2.025	1.809	1.547

Table 9.5 Storey Displacements for Zone III

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	25.342	23.985	21.724	19.541
18	24.661	23.336	21.128	18.969
16	23.549	22.277	20.156	18.034
14	21.975	20.779	18.783	16.722
12	19.943	18.847	17.016	15.051
10	17.466	16.492	14.868	13.048
8	14.561	13.734	12.36	10.753
6	11.256	10.604	9.521	8.218
4	7.613	7.164	6.416	5.506
2	3.829	3.599	3.216	2.75

Table 9.6 Storey Displacements for Zone VI

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	39.598	37.477	33.944	30.533
18	38.533	36.463	33.013	29.638
16	36.795	34.808	31.494	28.178
14	34.335	32.467	29.349	26.128
12	31.161	29.448	26.588	23.516
10	27.29	25.769	23.232	20.388
8	22.751	21.46	19.312	16.802
6	17.588	16.569	14.877	12.841
4	11.895	11.194	10.025	8.603
2	5.982	5.624	5.025	4.296

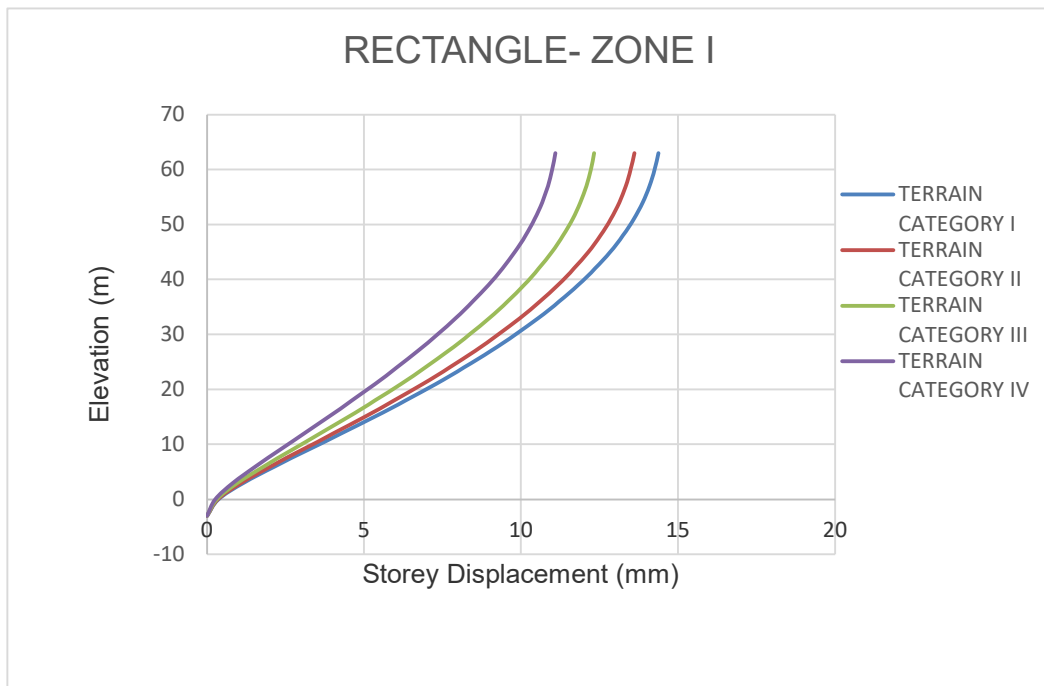


Figure 9.5 Storey Displacements for Zone I

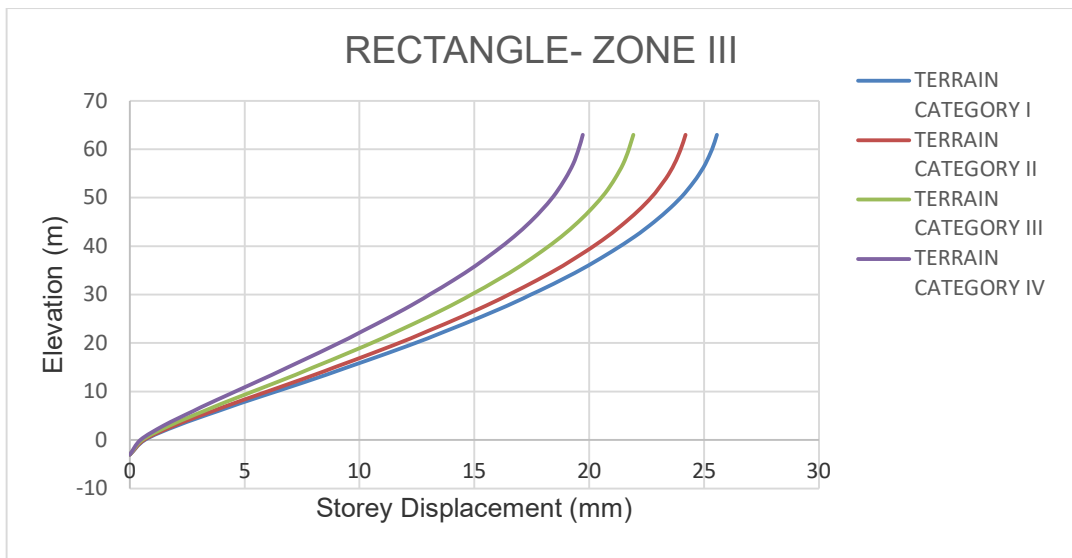


Figure 9.6 Storey Displacements for Zone III

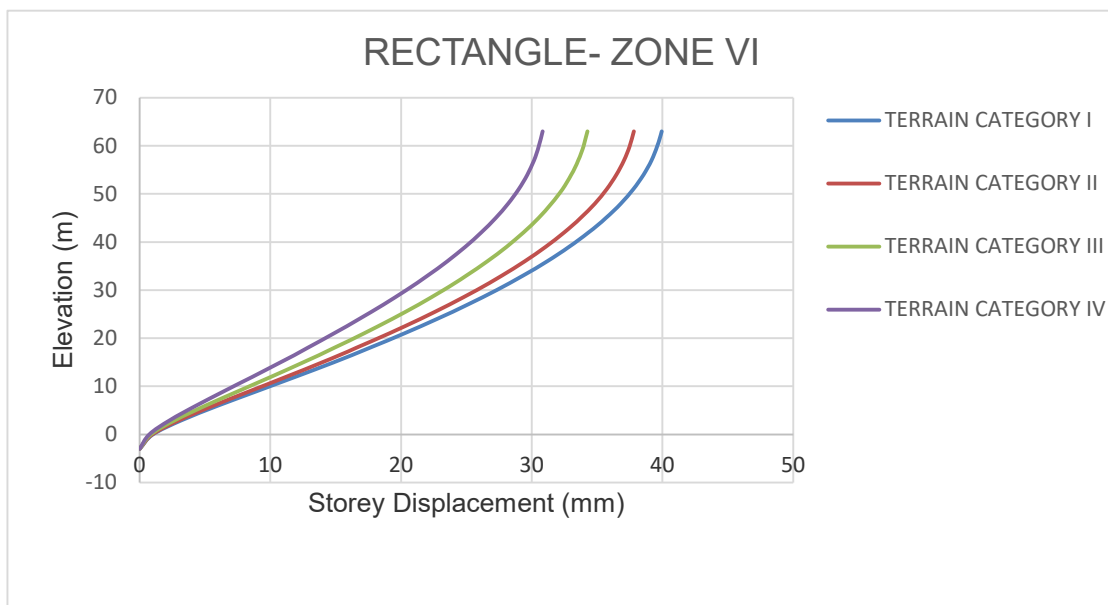


Figure 9.7 Storey Displacements for Zone VI

9.2.3 Octagonal Building

Table 9.7, table 9.8 and table 9.9 shows storey displacements of octagonal shaped G+19 RC building situated in different terrain categories I, II, III and IV in zone I, zone III and zone VI respectively.

Table 9.7 Storey Displacements for Zone I

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	9.278	8.779	7.936	7.094

18	9.011	8.525	7.704	6.873
16	8.616	8.149	7.359	6.544
14	8.086	7.645	6.897	6.105
12	7.424	7.015	6.322	5.562
10	6.635	6.265	5.638	4.925
8	5.725	5.402	4.852	4.206
6	4.702	4.433	3.974	3.421
4	3.573	3.366	3.011	2.579
2	2.333	2.197	1.962	1.675

Table 9.8 Storey Displacements for Zone III

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	16.506	15.607	14.109	12.612
18	16.031	15.156	13.695	12.219
16	15.329	14.487	13.082	11.634
14	14.386	13.591	12.262	10.853
12	13.21	12.472	11.239	9.888
10	11.807	11.139	10.023	8.756
8	10.19	9.603	8.626	7.478
6	8.371	7.881	7.064	6.081
4	6.363	5.985	5.352	4.585
2	4.156	3.906	3.487	2.978

Table 9.9 Storey Displacements for Zone VI

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	25.79	24.387	22.045	19.705
18	25.049	23.681	21.398	19.091
16	23.951	22.636	20.441	18.178

14	22.479	21.236	19.159	16.958
12	20.64	19.487	17.56	15.45
10	18.449	17.404	15.661	13.681
8	15.922	15.005	13.479	11.684
6	13.08	12.314	11.038	9.502
4	9.942	9.351	8.363	7.164
2	6.494	6.103	5.449	4.654

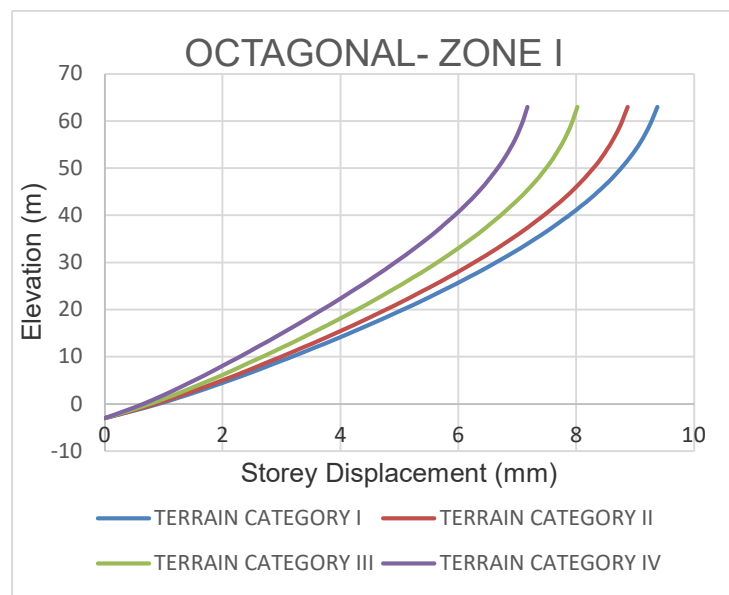


Figure 9.8 Storey Displacements for Zone I

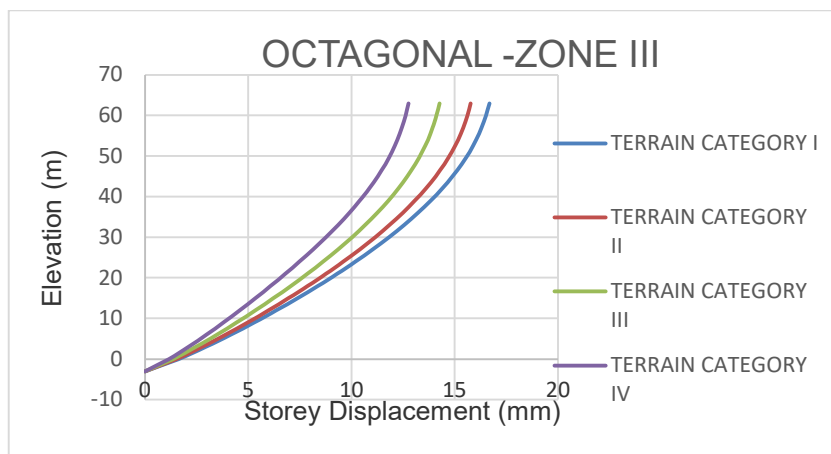


Figure 9.9 Storey Displacements for Zone III

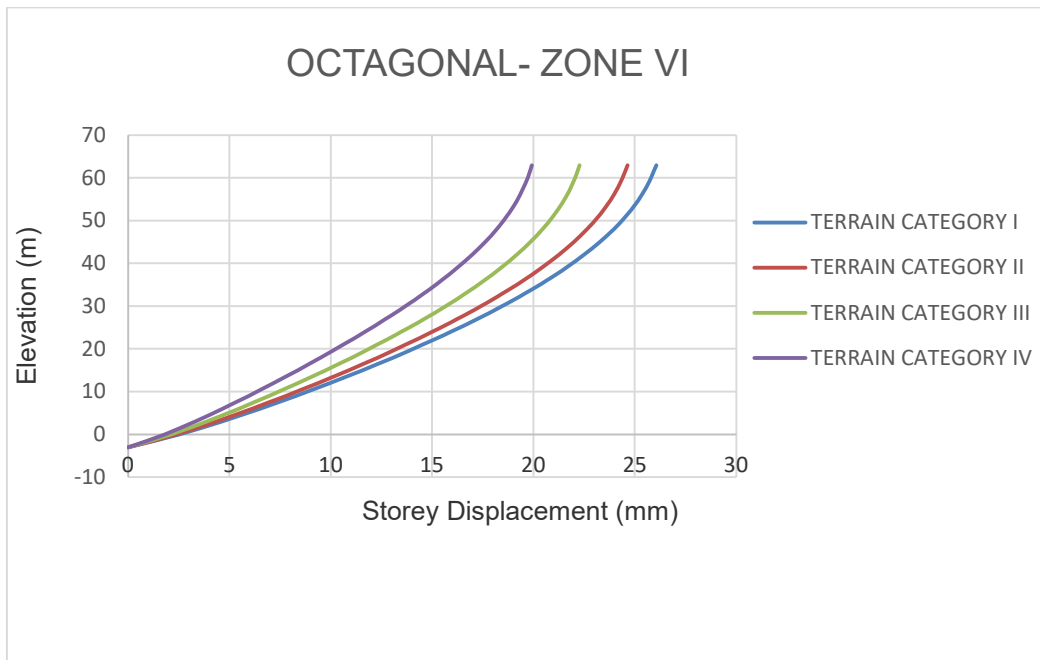


Figure 9.10 Storey Displacements for Zone VI

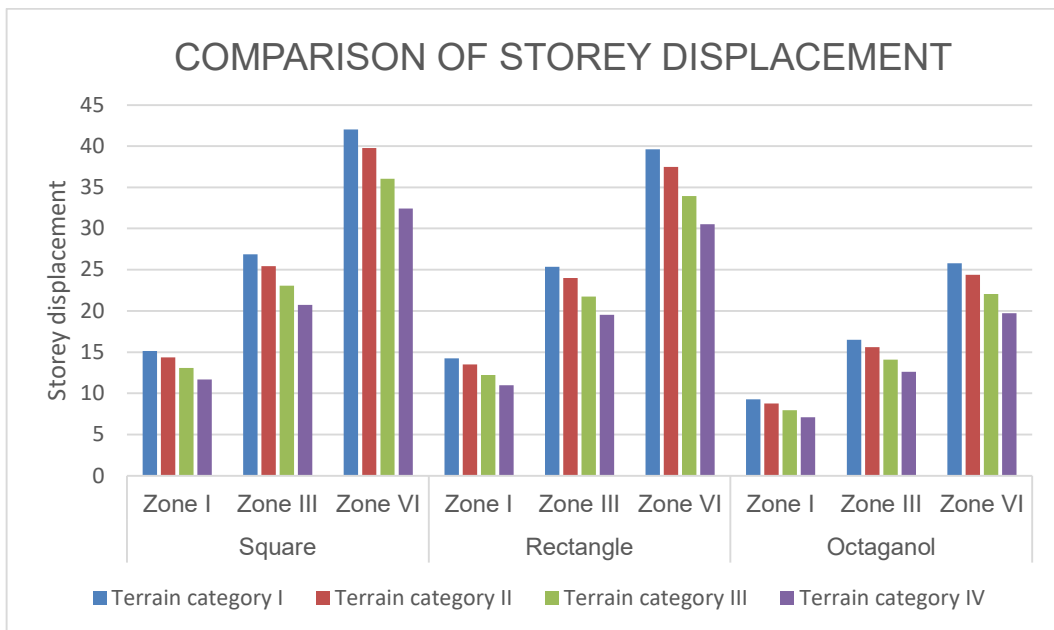


Figure.9.11 Storey Displacements of Different Building Models

The top storey displacements of square, rectangular and octagonal shaped building in different zones and terrains are compared and corresponding graph is shown in figure 9.11. Zone VI and terrain category I is more critical since it has maximum displacement in all the three cases. The

square shaped building have maximum storey displacement in zone VI and terrain I. On comparing all the three models octagonal shaped building has less storey displacement.

9.3 STOREY DRIFT

Storey drift is the drift of one level of multistory building relative to the level below. It is defined as ratio of displacement of two consecutive floors to height of that floor. Storey drift is minimum at base level.

9.3.1 Square Building

Table 9.10, table 9.11 and table 9.12 shows storey drifts of square shaped G+19 RC building situated in different terrain categories I, II, III and IV in zone I, zone III and zone VI respectively.

Table 9.10 Storey Drift for Zone I

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.000066	0.000063	0.000059	0.000055
18	0.000106	0.000101	0.000094	0.000088
16	0.00015	0.000143	0.000133	0.000125
14	0.000195	0.000186	0.000171	0.00016
12	0.000238	0.000227	0.000208	0.000193
10	0.000279	0.000266	0.000243	0.000222
8	0.000318	0.000302	0.000276	0.000246
6	0.000352	0.000333	0.000303	0.000264
4	0.000372	0.000351	0.000317	0.000272
2	0.000341	0.000322	0.000289	0.000246

Table 9.11 Storey Drift for Zone III

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.000117	0.000111	0.000102	0.000097
18	0.000188	0.000179	0.000164	0.000157
16	0.000267	0.000254	0.000233	0.000222
14	0.000346	0.000329	0.000301	0.000285
12	0.000423	0.000402	0.000367	0.000343
10	0.000497	0.000472	0.00043	0.000395
8	0.000566	0.000537	0.000487	0.000438
6	0.000626	0.000592	0.000535	0.00047
4	0.000661	0.000623	0.00056	0.000484
2	0.000607	0.000571	0.000511	0.000437

Table 9.12 Storey Drift for zone VI

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.000182	0.000173	0.000159	0.000152
18	0.000293	0.000279	0.000256	0.000246
16	0.000417	0.000397	0.000364	0.000348
14	0.000541	0.000514	0.00047	0.000446
12	0.000611	0.000628	0.000573	0.000536
10	0.000776	0.000737	0.000671	0.000617
8	0.000885	0.000838	0.000761	0.000684
6	0.000979	0.000925	0.000836	0.000734
4	0.001032	0.000973	0.000875	0.000756
2	0.000948	0.000892	0.000798	0.000683

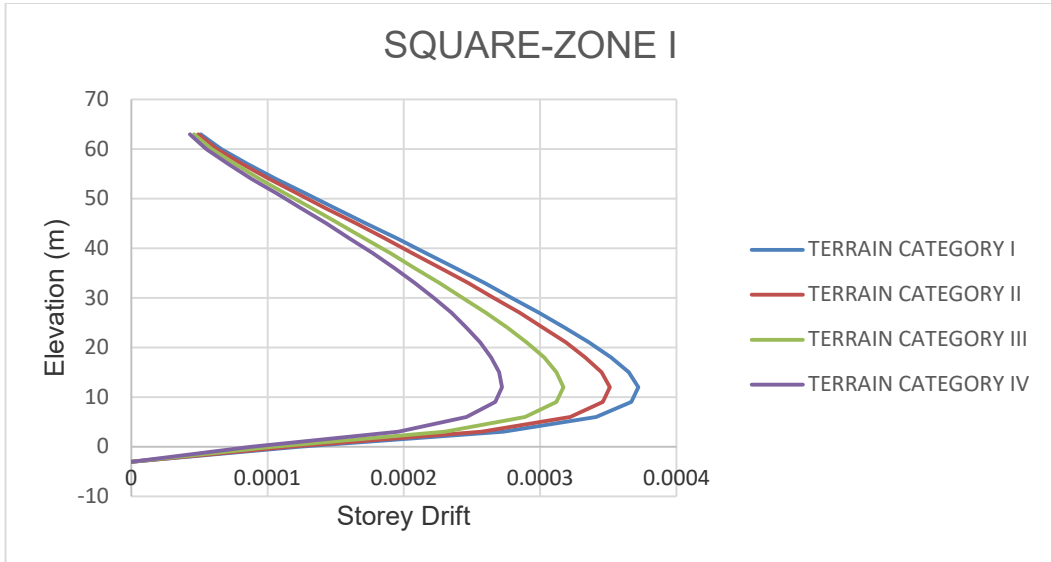


Figure.9.12 Storey Drift for Zone I

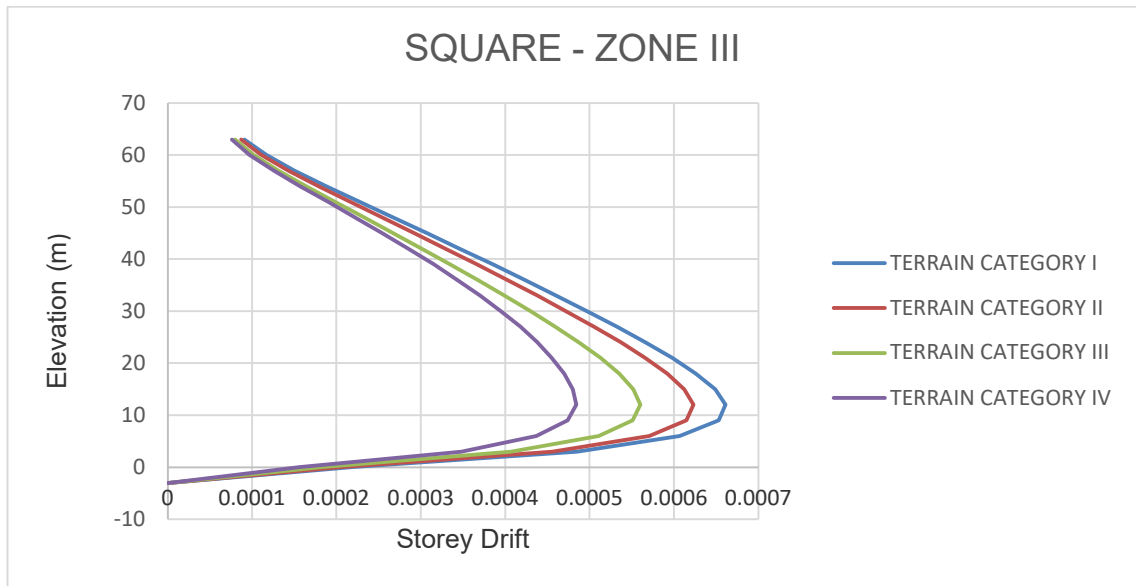


Figure.9.13 Storey Drift for Zone III

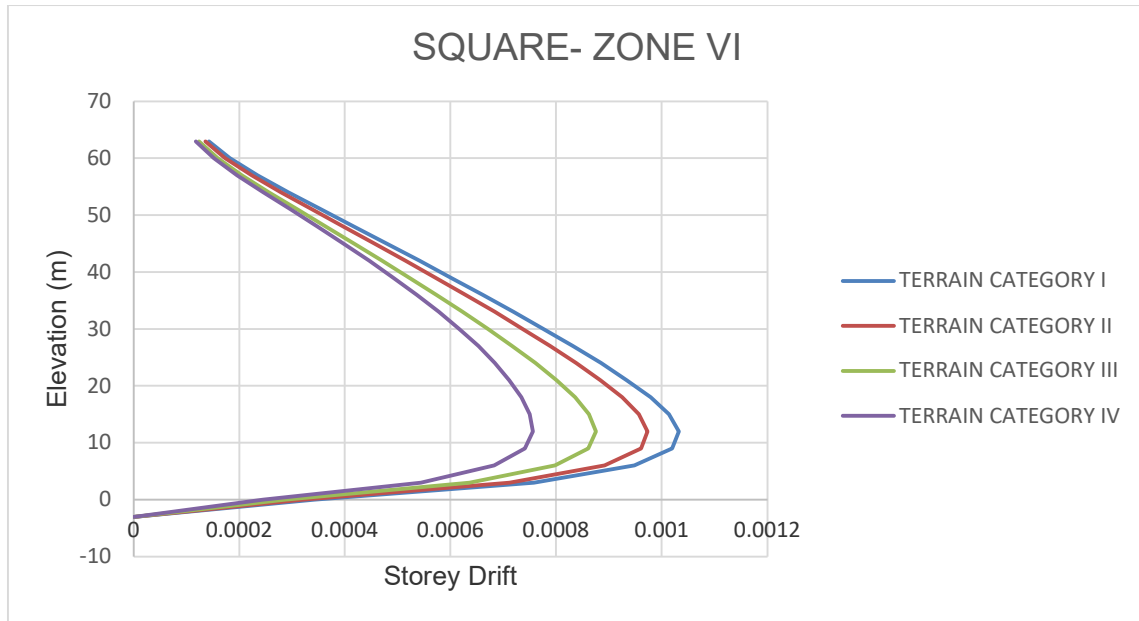


Figure.9.14 Storey Drift for Zone VI

9.3.2 Rectangle Building

Table 9.13, table 9.14 and table 9.15 shows storey drifts of rectangular shaped G+19 RC building situated in different terrain categories I, II, III and IV in zone I, zone III and zone VI respectively.

Table 9.13 Storey Drift for Zone I

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.000055	0.000052	0.000048	0.000046
18	0.000094	0.000089	0.000082	0.000079
16	0.000137	0.00013	0.000119	0.000114
14	0.00018	0.000171	0.000157	0.000149
12	0.000222	0.000211	0.000193	0.00018
10	0.000263	0.000249	0.000227	0.000209
8	0.000301	0.000285	0.000259	0.000233
6	0.000335	0.000316	0.000286	0.000251
4	0.000356	0.000336	0.000302	0.00026
2	0.000331	0.000311	0.000278	0.000238

Table 9.14 Storey Drift for Zone III

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.000097	0.000093	0.000085	0.000082
18	0.000166	0.000158	0.000145	0.00014
16	0.000243	0.000231	0.000212	0.000203
14	0.00032	0.000304	0.000278	0.000264
12	0.000395	0.000375	0.000342	0.000321
10	0.000467	0.000443	0.000404	0.000371
8	0.000535	0.000507	0.00046	0.000414
6	0.000595	0.000563	0.000509	0.000446
4	0.000633	0.000597	0.000536	0.000463
2	0.000588	0.000553	0.000494	0.000423

Table 9.15 Storey Drift for Zone VI

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.000152	0.000145	0.000133	0.000127
18	0.00026	0.000248	0.000277	0.000219
16	0.00038	0.000361	0.000331	0.000317
14	0.0005	0.000475	0.000435	0.000413
12	0.000616	0.000586	0.00535	0.000501
10	0.000729	0.000693	0.000631	0.00058
8	0.000836	0.000792	0.000719	0.000646
6	0.00093	0.000879	0.000795	0.000697
4	0.000989	0.000932	0.000838	0.000723
2	0.000918	0.000863	0.000772	0.000661

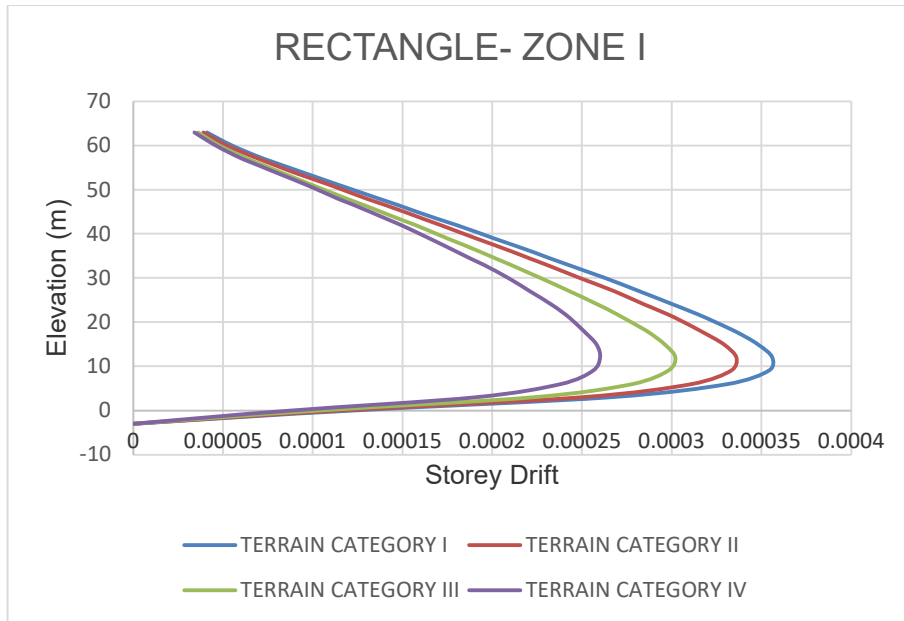


Figure.9.15 Storey Drift for Zone I

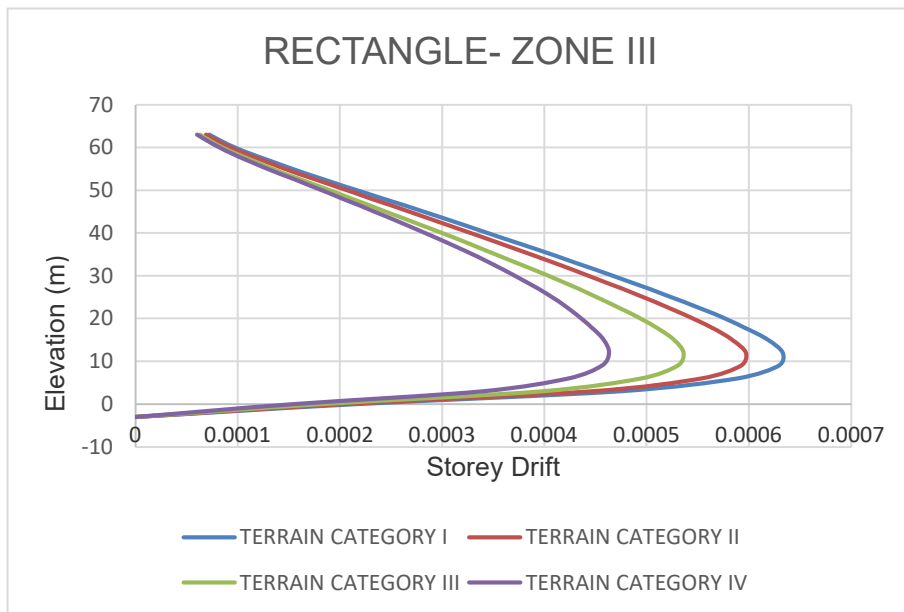


Figure.9.16 Storey Drift for Zone III

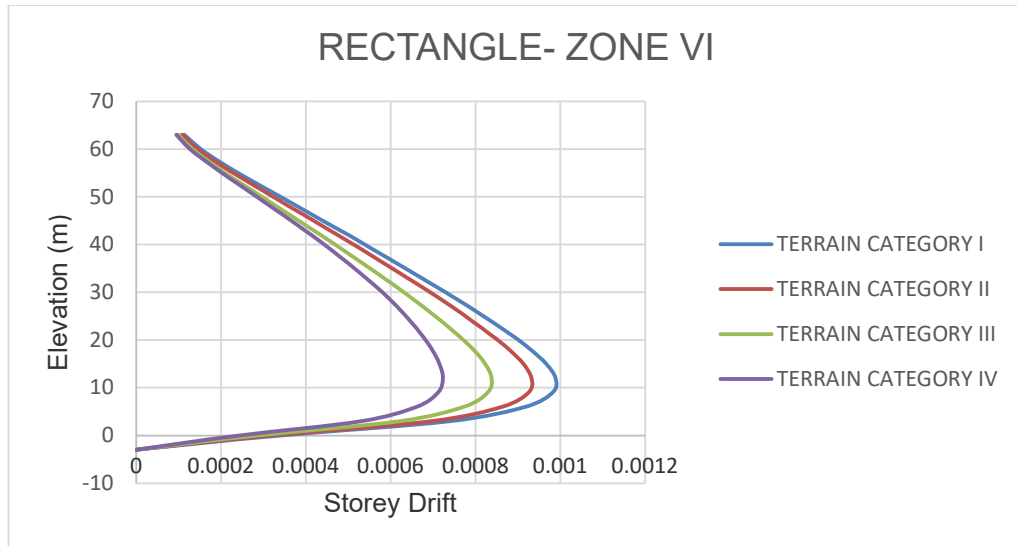


Figure.9.17 Storey Drift for Zone VI

9.3.3 Octagonal Building

Table 9.16, table 9.17 and table 9.18 shows storey drifts of octagonal shaped G+19 RC building situated in different terrain categories I, II, III and IV in zone I, zone III and zone VI respectively.

Table 9.16 Storey Drift for Zone I

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.00004	0.000038	0.000034	0.000033
18	0.00006	0.000057	0.000053	0.00005
16	0.000083	0.000079	0.000072	0.000069
14	0.000105	0.0001	0.000091	0.000086
12	0.000126	0.00012	0.00011	0.000102
10	0.000147	0.000139	0.000127	0.000117
8	0.000166	0.000157	0.000143	0.000128
6	0.000184	0.000174	0.000157	0.000138
4	0.000202	0.00019	0.000171	0.000148
2	0.000226	0.000213	0.00019	0.000163

Table 9.17 Storey Drift for Zone III

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.00007	0.000067	0.000061	0.000058

18	0.000107	0.000102	0.000093	0.000089
16	0.000147	0.00014	0.000128	0.000122
14	0.000187	0.000177	0.000162	0.000153
12	0.000225	0.000213	0.000195	0.000182
10	0.000261	0.000248	0.000226	0.000208
8	0.000295	0.00028	0.000254	0.000228
6	0.000327	0.000309	0.000279	0.000245
4	0.000358	0.000338	0.000304	0.000262
2	0.000403	0.000379	0.000338	0.00029

Table 9.18 Storey Drift for Zone VI

Storey	Terrain category I	Terrain category II	Terrain category III	Terrain category IV
20	0.00011	0.000105	0.000096	0.000091
18	0.000167	0.000159	0.000146	0.000139
16	0.00023	0.000219	0.0002	0.000191
14	0.000291	0.000277	0.000253	0.00024
12	0.000351	0.000334	0.000304	0.000285
10	0.000408	0.000387	0.000352	0.000324
8	0.000461	0.000437	0.000397	0.000357
6	0.000511	0.000483	0.000436	0.000383
4	0.00056	0.000528	0.000474	0.00041
2	0.000629	0.000592	0.000529	0.000453

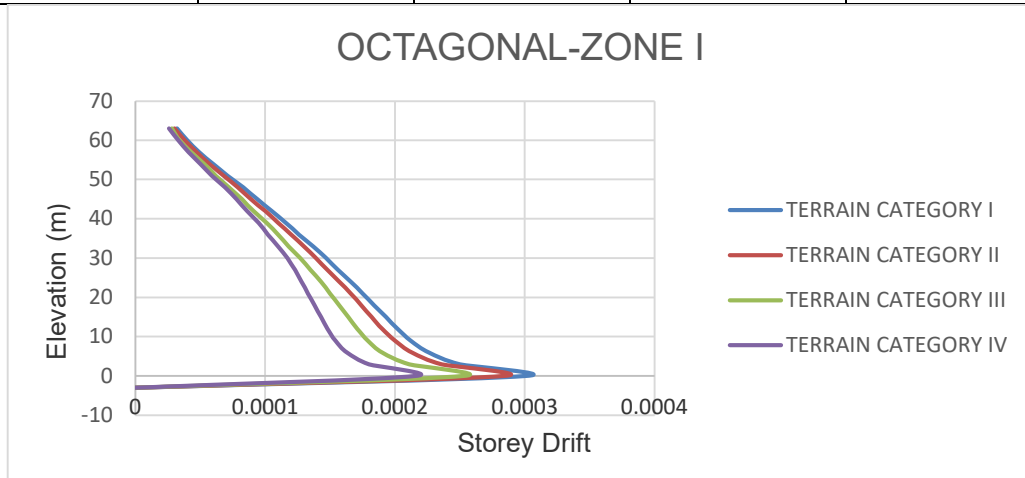


Figure.9.18 Storey Drift for Zone I

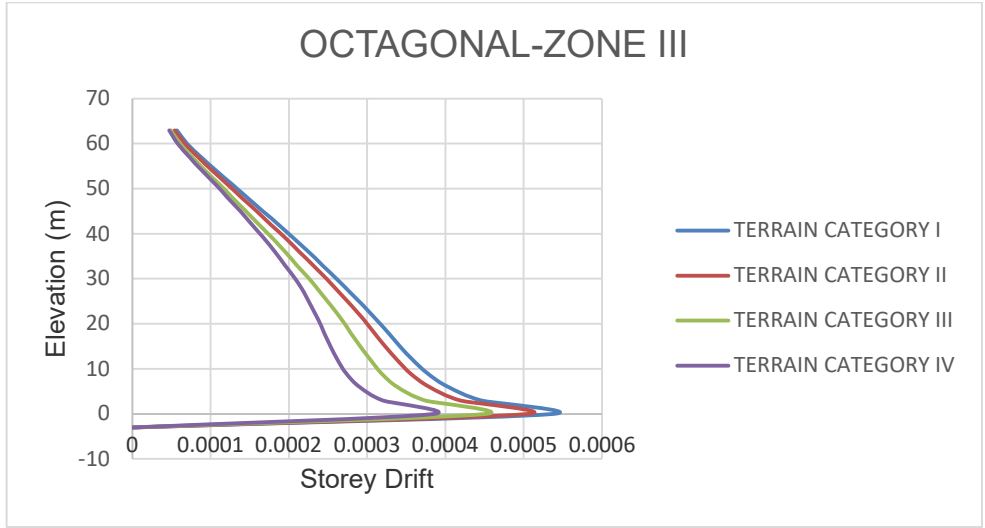


Figure.9.19 Storey Drift for Zone III

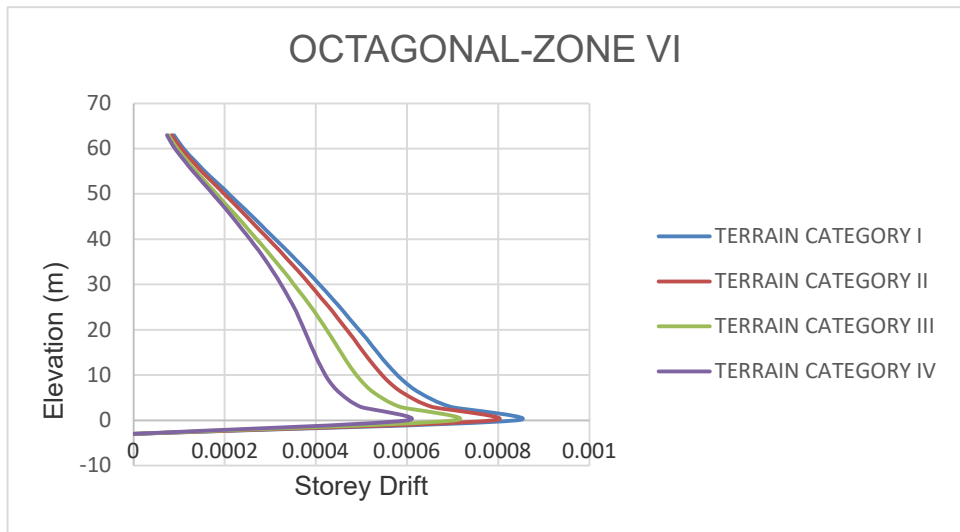


Figure.9.20 Storey Drift for Zone VI

The maximum storey drift of different shaped buildings in different zones and terrains are compared and shown in figure 9.21.

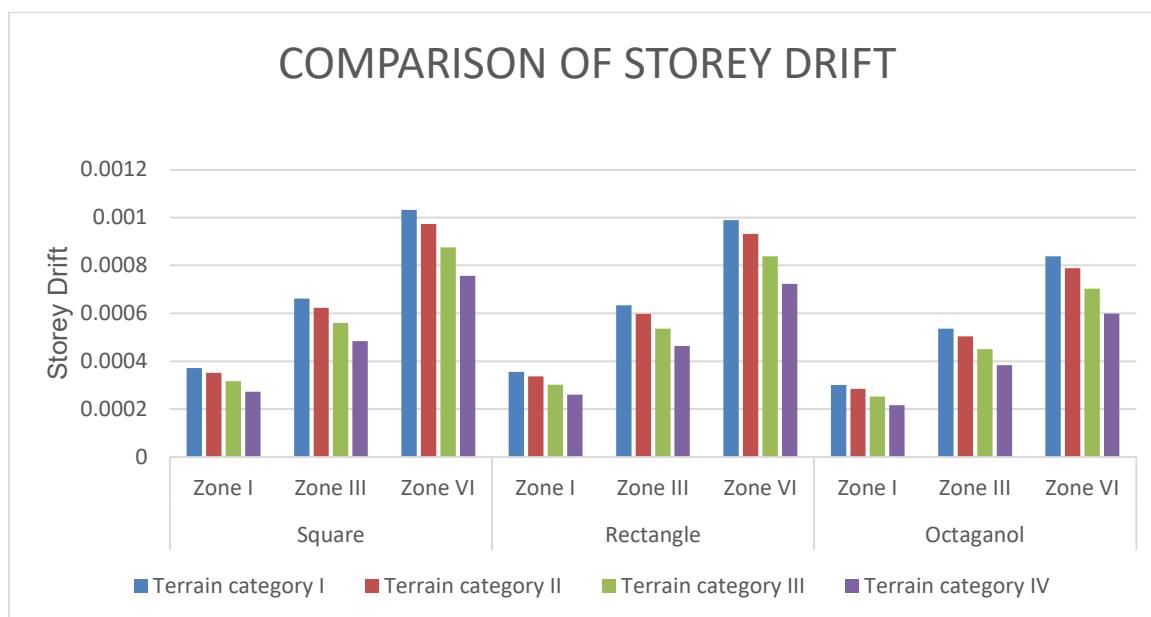


Figure.9.21 Storey Drift for Different Building Models

The maximum impact of the drift for square building is found when it is situated in terrain category I and zone VI. Storey drift for square and rectangular building model is almost same. The octagonal shaped building have less storey drift compared to other shapes and have maximum storey drift in zone VI and terrain I.

9.4 BASE SHEAR

Base shear is the total design lateral force expected at the base of the structure. Storey shear is the total design lateral force expected at each floor levels of the structure. The storey shear value of all type buildings is more at the base level. The base shear acting at floors of square, rectangle and octagonal shaped G+19 RC building situated in different terrains categories I, II, III and IV in zone I, III and VI are shown below in figure 9.22 and table 9.19 to 9.21.

Table 9.19 Base Shear for Square (G+19) Building Model

TERRAIN CATEGORY	SQUARE		
	ZONE I	ZONE III	ZONE VI
I	1002.12	1781.53	2783.65
II	942.37	1673.11	2614.22
III	842.75	1491.08	2329.81
IV	714.02	1269.37	1983.35

Table 9.20 Base Shear for Rectangle (G+19) Building Model

TERRAIN CATEGORY	RECTANGLE		
	ZONE I	ZONE III	ZONE VI
I	1536.57	2731.68	4268.27
II	1443.03	2565.39	4008.43
III	1286.07	2286.31	3572.37
IV	1094.8	1946.36	3041.13

Table 9.21 Base Shear for Octagonal (G+19) Building Model

TERRAIN CATEGORY	OCTAGONAL		
	ZONE I	ZONE III	ZONE VI
I	1395.59	2494.13	3897.12
II	1317.57	2342.33	3659.91
III	1174.24	2087.5	3261.73
IV	999.61	1777.12	2776.71

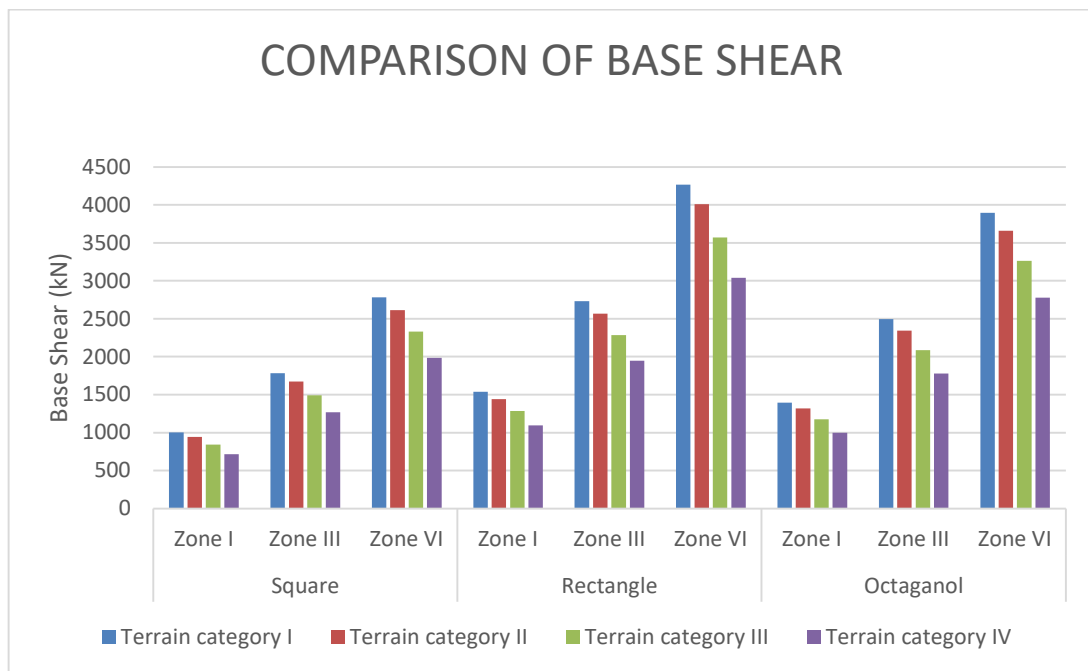


Figure.9.22 Base Shear for Different Building Models

Rectangular building shows maximum base shear in terrain category I and zone VI.

9.5 SEISMIC ANALYSIS OF A MULTI-STOREY (G+19) BUILDING

Response spectrum analysis (RSA) is linear dynamic analysis method. Response spectra curves are those plotted for maximum response of single degree of freedom system (SDOF) subjected to specified earthquake ground motion and its time period (or frequency). Plot with system time period on x-axis and response quantity on y-axis is the response spectra pertaining to specified damping ratio and input ground motion. A design response spectrum available for different zones and different soil conditions in IS 1893:2016 (Part 1). Unlike Equivalent static analysis, response spectra method can be applied to high rise buildings. The procedure of RSA using ETABS doesn't require as many manual calculations as of equivalent static analysis for calculation of lateral load. A multi-storey G+19 building of three different shapes was modelled and analysis under seismic zone V to obtain the parameters such as storey displacements, storey drifts and storey shear.

Table 9.22 Storey Displacements for (G+19) Building in Seismic Zone V

Storey	Elevation (m)	SQUARE	RECTANGLE	OCTAGONAL
Terrace	63	72.685	71.083	42.974
20 th	60	71.654	70.199	42.414
19 th	57	70.374	69.061	41.724
18 th	54	68.793	67.617	40.876
17 th	51	66.905	65.861	39.866
16 th	48	64.716	63.8	38.701
15 th	45	62.238	61.445	37.39
14 th	42	59.483	58.807	35.944
13 th	39	56.464	55.898	34.371
12 th	36	53.193	52.731	32.68
11 th	33	49.683	49.319	30.878
10 th	30	45.947	45.672	28.97
9 th	27	41.996	41.804	26.96
8 th	24	37.843	37.726	24.85
7 th	21	33.501	33.45	22.643
6 th	18	28.98	28.986	20.338

5 th	15	24.294	24.348	17.937
4 th	12	19.47	19.559	15.436
3 rd	9	14.569	14.677	12.829
2 nd	6	9.728	9.835	10.092
1 st	3	5.23	5.311	7.171
g.f	0	1.629	1.664	3.922
base	-3	0	0	0



Figure.9.23 Storey Displacement for Zone V

Table 9.23 Storey Drifts for (G+19) Building in Seismic Zone V

Storey	Elevation (m)	SQUARE	RECTANGLE	OCTAGONAL
Terrace	63	0.000466	0.000419	0.000221
20 th	60	0.000591	0.000546	0.00028
19 th	57	0.000725	0.000681	0.00035
18 th	54	0.000844	0.000801	0.000418
17 th	51	0.000945	0.000902	0.000479
16 th	48	0.001031	0.000989	0.000533
15 th	45	0.00111	0.001069	0.00058
14 th	42	0.001184	0.001144	0.00062

13 th	39	0.001253	0.001216	0.000655
12 th	36	0.001318	0.001283	0.000685
11 th	33	0.001379	0.001346	0.000711
10 th	30	0.001436	0.001406	0.000735
9 th	27	0.001489	0.001462	0.000758
8 th	24	0.001536	0.001512	0.00078
7 th	21	0.001577	0.001557	0.000802
6 th	18	0.001611	0.001595	0.000824
5 th	15	0.001638	0.001626	0.000849
4 th	12	0.001648	0.001642	0.000878
3 rd	9	0.001619	0.001619	0.000916
2 nd	6	0.001501	0.001509	0.000975
1 st	3	0.001201	0.001216	0.001083
g.f	0	0.000543	0.000555	0.001307
base	-3	0	0	0

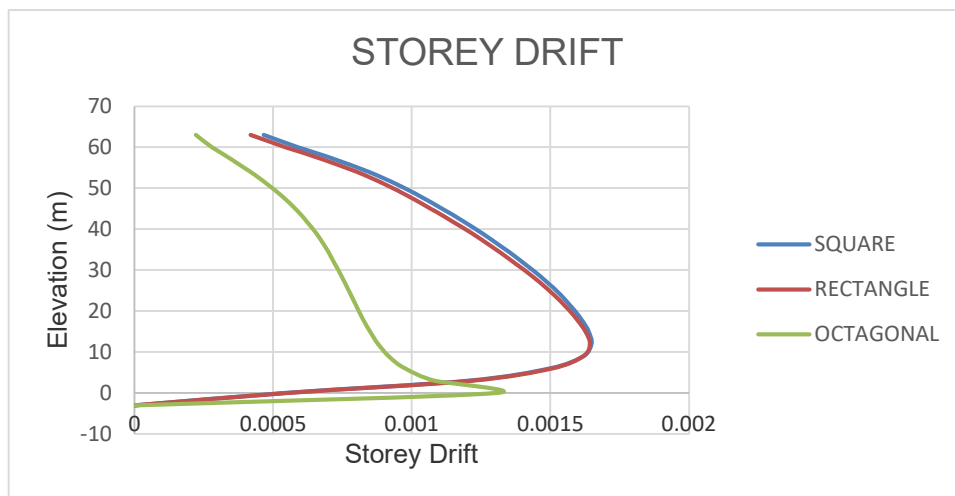


Figure.9.24 Storey Drift for Zone V

Table 9.24 Storey Shear for (G+19) Building in Seismic Zone V

Storey	Elevation (m)	SQUARE	RECTANGLE	OCTAGONAL
Terrace	63	526.2923	839.308	633.4817
20 th	60	1050.0341	1671.5428	1366.3554

19 th	57	1525.0834	2426.4043	2031.0935
18 th	54	1953.8154	3107.6668	2631.0196
17 th	51	2338.6054	3719.1046	3169.4574
16 th	48	2681.8285	4264.492	3649.7307
15 th	45	2985.8601	4747.6034	4075.1631
14 th	42	3253.0753	5172.213	4449.0782
13 th	39	3485.8495	5542.0951	4774.7999
12 th	36	3686.5578	5861.0241	5055.6517
11 th	33	3857.5756	6132.7742	5294.9574
10 th	30	4001.278	6361.1198	5496.0407
9 th	27	4120.0403	6549.8352	5662.2252
8 th	24	4216.2378	6702.6947	5796.8347
7 th	21	4292.2457	6823.4725	5903.1928
6 th	18	4350.4392	6915.9431	5984.6232
5 th	15	4393.1937	6983.8806	6044.4496
4 th	12	4422.8842	7031.0594	6085.9957
3 rd	9	4441.8862	7061.2539	6112.5853
2 nd	6	4452.5748	7078.2383	6127.5419
1 st	3	4457.3253	7085.7869	6134.1892
g.f	0	4458.5129	7087.674	6135.8511
base	-3	0	0	0

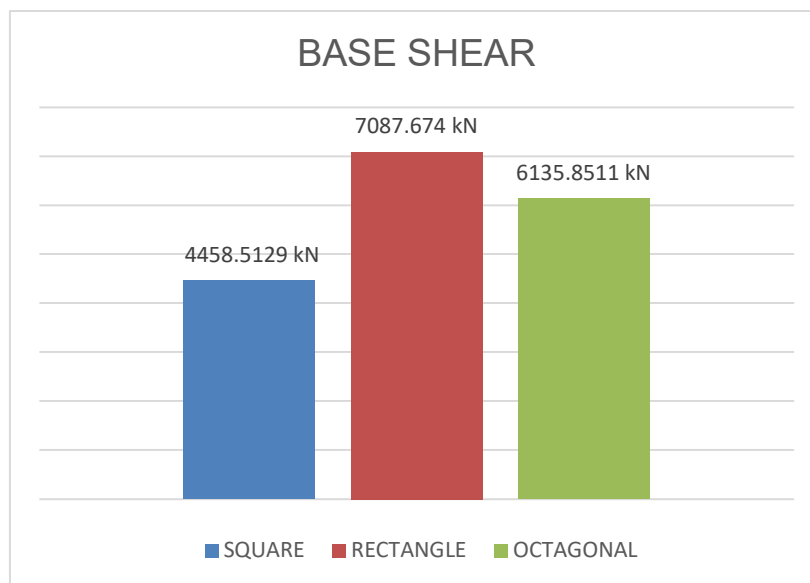


Figure.9.25 Base Shear for Zone V

9.6 COMPARITIVE STUDY OF THE EFFECTS OF WIND AND EARTHQUAKE LOADS OF A MULTI-STOREY (G+19) BUILDING IN AGARTALA

Agartala is the capital city of the Indian state of Tripura, and is one of the largest cities in northeast India. It is located on the banks of the Haora River, near the Bangladesh border, about 90 kilometres east of Bangladesh's capital Dhaka and about 2,499 km from the national capital New Delhi. Agartala is being developed under the Smart Cities Mission, a flagship scheme of the Government of India. Agartala is India's third international internet gateway after the ones in Mumbai and Chennai. The state lies in seismic zone V, as per seismic zoning map of India, which is considered as the most vulnerable zone for high intensity earthquakes. The capital Agartala is located on a plain to the west with a height of 15m above mean sea level. The state observes moderately warm temperatures during summer and moderately cold temperatures during winter. Due to the presence of Bay of Bengal to its south, the humidity in the state is fairly high during summer. It lies in the zone VI, as per wind zone map of India.

Table 9.25, table 9.26 and table 9.27 shows storey displacements, storey drifts and storey shears values for seismic zone V and for the analysis of wind loads in terrain category I and wind zone VI of a G+19 storey building of three different models in Agartala.

Table 9.25 Storey Displacements

		SQUARE		RECTANGLE		OCTAGONAL	
Storey	Elevation (m)	Earthquake	Wind	Earthquake	Wind	Earthquake	Wind
Terrace	63	72.685	42.436	71.083	39.937	42.974	26.056
20 th	60	71.654	42.009	70.199	39.598	42.414	25.79
19 th	57	70.374	41.462	69.061	39.142	41.724	25.461
18 th	54	68.793	40.758	67.617	38.533	40.876	25.049
17 th	51	66.905	39.878	65.861	37.753	39.866	24.547
16 th	48	64.716	38.813	63.8	36.795	38.701	23.951
15 th	45	62.238	37.563	61.445	35.655	37.39	23.261
14 th	42	59.483	36.125	58.807	34.335	35.944	22.479
13 th	39	56.464	34.504	55.898	32.837	34.371	21.605
12 th	36	53.193	32.7	52.731	31.161	32.68	20.64
11 th	33	49.683	30.717	49.319	29.312	30.878	19.587

10 th	30	45.947	28.559	45.672	27.291	28.97	18.449
9 th	27	41.996	26.23	41.804	25.103	26.96	17.226
8 th	24	37.843	23.736	37.726	22.752	24.85	15.922
7 th	21	33.501	21.082	33.45	20.244	22.643	14.539
6 th	18	28.98	18.279	28.986	17.588	20.338	13.08
5 th	15	24.294	15.344	24.348	14.797	17.937	11.547
4 th	12	19.47	12.302	19.559	11.895	15.436	9.942
3 rd	9	14.569	9.205	14.677	8.929	12.829	8.262
2 nd	6	9.728	6.144	9.835	5.982	10.092	6.494
1 st	3	5.23	3.299	5.311	3.228	7.171	4.607
g.f	0	1.629	1.026	1.664	1.01	3.922	2.515
base	-3	0	0	0	0	0	0



Figure.9.26 Storey Displacement for Square

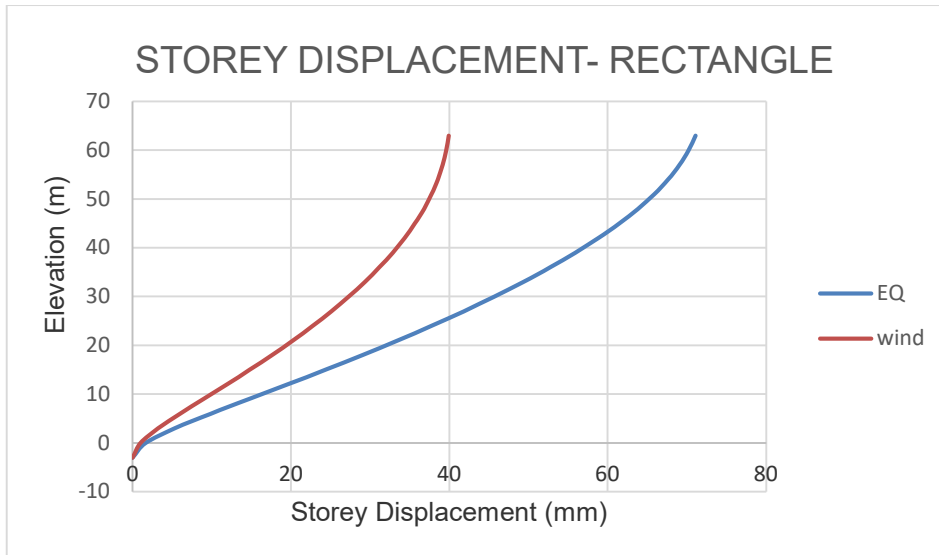


Figure.9.27 Storey Displacement for Rectangle

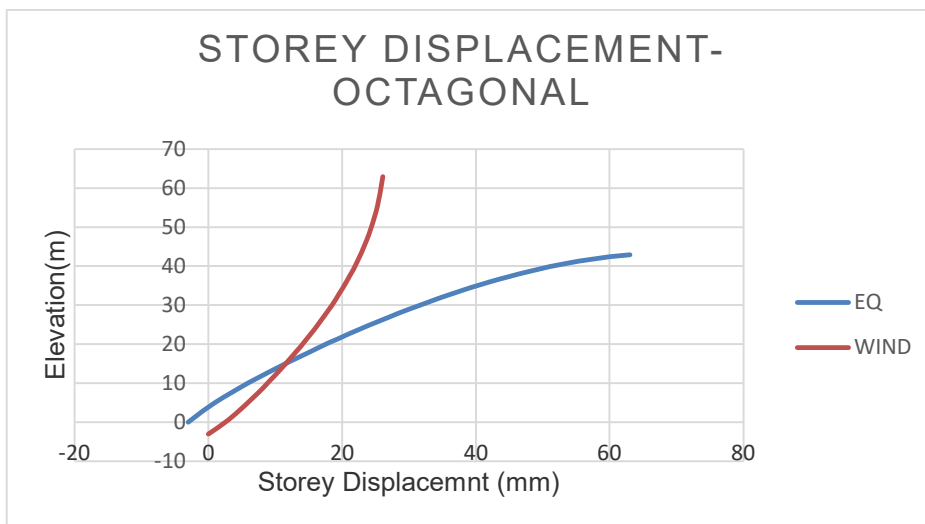


Figure.9.28 Storey Displacement for Octagonal

Table 9.26 Storey Drifts

		SQUARE		RECTANGLE		OCTAGONAL	
Storey	Elevation (m)	Earthquake	Wind	Earthquake	Wind	Earthquake	Wind
Terrace	63	0.000466	0.000143	0.000419	0.000113	0.000221	0.000089
20 th	60	0.000591	0.000182	0.000546	0.000152	0.00028	0.00011
19 th	57	0.000725	0.000235	0.000681	0.000203	0.00035	0.000137
18 th	54	0.000844	0.000293	0.000801	0.00026	0.000418	0.000167

17 th	51	0.000945	0.000355	0.000902	0.00032	0.000479	0.000199
16 th	48	0.001031	0.000417	0.000989	0.00038	0.000533	0.00023
15 th	45	0.00111	0.000479	0.001069	0.00044	0.00058	0.000261
14 th	42	0.001184	0.000541	0.001144	0.0005	0.00062	0.000291
13 th	39	0.001253	0.000601	0.001216	0.000558	0.000655	0.000321
12 th	36	0.001318	0.000661	0.001283	0.000616	0.000685	0.000351
11 th	33	0.001379	0.000719	0.001346	0.000673	0.000711	0.00038
10 th	30	0.001436	0.000776	0.001406	0.000729	0.000735	0.000408
9 th	27	0.001489	0.000832	0.001462	0.000784	0.000758	0.000435
8 th	24	0.001536	0.000885	0.001512	0.000836	0.00078	0.000461
7 th	21	0.001577	0.000934	0.001557	0.000886	0.000802	0.000486
6 th	18	0.001611	0.000979	0.001595	0.00093	0.000824	0.000511
5 th	15	0.001638	0.001014	0.001626	0.000967	0.000849	0.000535
4 th	12	0.001648	0.001032	0.001642	0.000989	0.000878	0.00056
3 rd	9	0.001619	0.00102	0.001619	0.000982	0.000916	0.000589
2 nd	6	0.001501	0.000948	0.001509	0.000918	0.000975	0.000629
1 st	3	0.001201	0.000758	0.001216	0.000739	0.001083	0.000697
g.f	0	0.000543	0.000342	0.000555	0.000337	0.001307	0.000838
base	-3	0	0	0	0	0	0

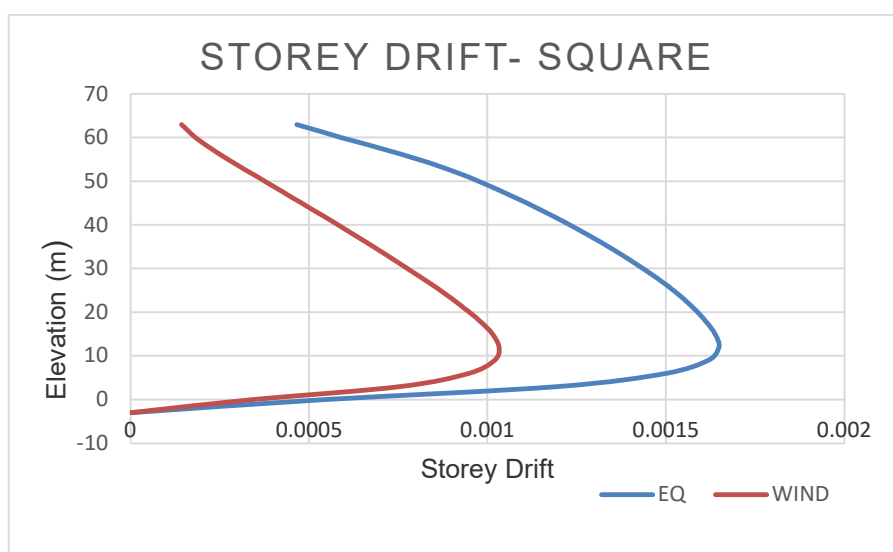


Figure.9.29 Storey Drift for Square

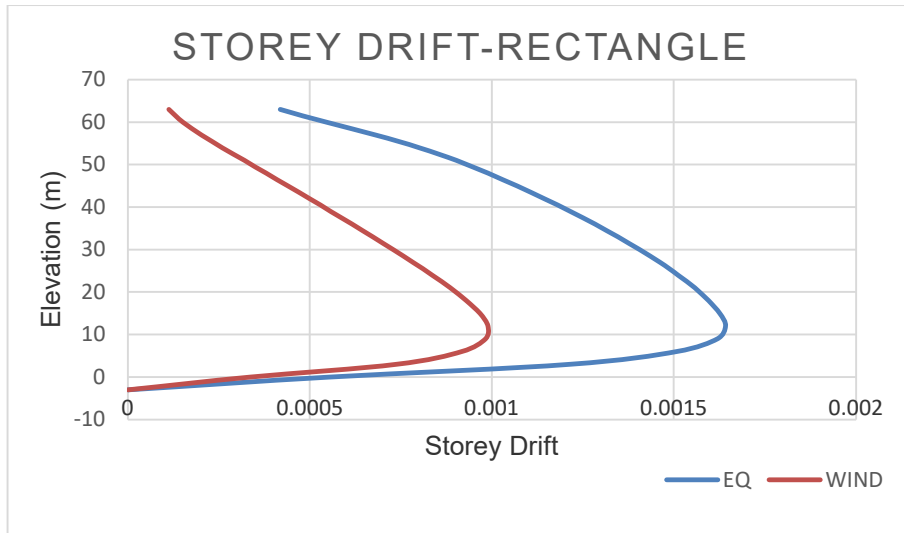


Figure.9.30 Storey Drift for Rectangle

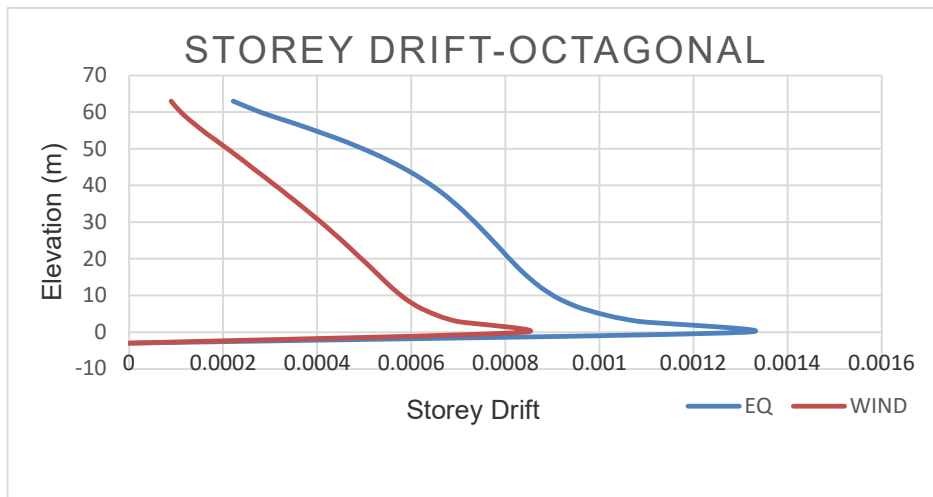


Figure.9.31 Storey Drift for Octagonal

Table 9.27 Storey Shear

		SQUARE		RECTANGLE		OCTAGONAL	
Storey	Elevation (m)	Earthquake	Wind	Earthquake	Wind	Earthquake	Wind
Terrace	63	526.2923	78.13	839.308	119.8	633.4817	109.38
20 th	60	1050.0341	233.62	1671.5428	358.22	1366.3554	327.06
19 th	57	1525.0834	388.08	2426.4043	595.07	2031.0935	543.31
18 th	54	1953.8154	541.78	3107.6668	830.74	2631.0196	758.49
17 th	51	2338.6054	694.46	3719.1046	1064.85	3169.4574	972.24

16 th	48	2681.8285	845.62	4264.492	1296.62	3649.7307	1183.86
15 th	45	2985.8601	995.01	4747.6034	1525.69	4075.1631	1393.01
14 th	42	3253.0753	1142.4	5172.213	1751.68	4449.0782	1599.35
13 th	39	3485.8495	1287.79	5542.0951	1974.62	4774.7999	1802.9
12 th	36	3686.5578	1431.45	5861.0241	2194.9	5055.6517	2004.03
11 th	33	3857.5756	1573.39	6132.7742	2412.54	5294.9574	2202.75
10 th	30	4001.278	1713.38	6361.1198	2627.19	5496.0407	2398.73
9 th	27	4120.0403	1851.19	6549.8352	2838.49	5662.2252	2591.66
8 th	24	4216.2378	1986.83	6702.6947	3046.47	5796.8347	2781.56
7 th	21	4292.2457	2120.32	6823.4725	3251.16	5903.1928	2968.45
6 th	18	4350.4392	2250.27	6915.9431	3450.42	5984.6232	3150.38
5 th	15	4393.1937	2376.03	6983.8806	3643.25	6044.4496	3326.45
4 th	12	4422.8842	2496.31	7031.0594	3827.69	6085.9957	3494.85
3 rd	9	4441.8862	2613.01	7061.2539	4006.63	6112.5853	3658.23
2 nd	6	4452.5748	2727.5	7078.2383	4182.18	6127.5419	3818.51
1 st	3	4457.3253	2783.65	7085.7869	4268.27	6134.1892	3897.12
g.f	0	4458.5129	2783.65	7087.674	4268.27	6135.8511	3897.12
base	-3	0	0	0	0	0	0

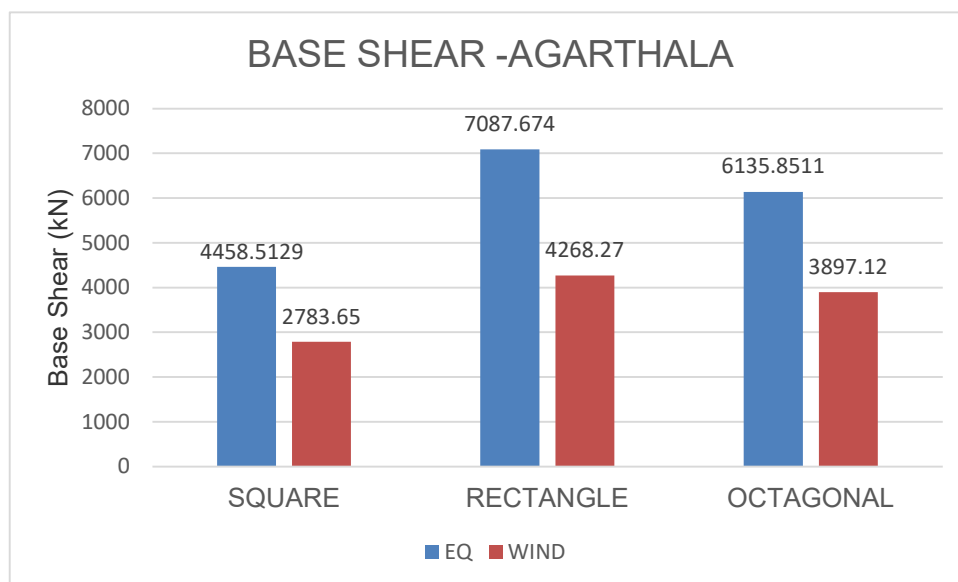


Figure.9.32 Base Shear

CHAPTER 10

CONCLUSION

10.1 GENERAL

The lateral loading due to wind is the major factor that causes the design of high-rise buildings to differ from those of low-to medium rise buildings. For buildings of up to about 10 stories and of typical proportions, the design is rarely affected by wind loads. Above this height, however, the increase in size of the structural members, and the possible rearrangement of the structure to account for wind loading, incurs a cost premium that increases progressively with height.

With innovations in architectural treatment, increases in the strengths of materials, and advances in method of analysis, tall building structures have become more efficient and lighter, consequently more prone to deflect and even to sway under wind loading. Several wind engineering techniques were employed into the design of high rise buildings to control the dynamic response under wind loading by disorganizing the vortex shedding formation (frequency and direction) along the building height and tuning the dynamic characteristics of the building to improve its dynamic behavior and to prevent lock-in vibration.

Wind load analysis is critical to ensure that the following criteria are honored:

- Serviceability of the building, despite expected wind deflections.
- Stability to counter toppling, uplift or sliding of the building.
- Strong structural components to withstand excess loads during the buildings life cycle.

10.2 MAJOR FINDINGS

There is not a definite description for “tall buildings”, “high-rise buildings” and “skyscraper” in terms of height or number of stories. Although the terms all mean the same type of building which is built extremely high, there is an implicit difference among them. Many factors such as aesthetics, functionality and the requirements of city planning authorities dictate the shape of the building. Because of the enormous variety of the possible shapes in building design and their different interactions with the surrounding structures, it is difficult to develop simple general rules for the preference of shapes as a tool for reducing wind related problems. In this respect,

the wind tunnel testing is usually the best way for determining project specific wind loads and building motions.

G+19 storey building with square, rectangular and octagonal plan without shear under wind load analysis have been done using ETABS. The buildings are studied for different parameters such as storey displacement, storey drift and base shear.

Wind analysis of square, rectangular and octagonal plan buildings at Zone I to Zone VI with terrain categories I, II, III and IV were analysed. From this it is understood that the zone, terrain category, shape, height and slenderness ratio have great influence on the strength and stability of a building.

The following conclusions are deduced from this study:

1. While comparing all the three building models in wind analysis, it is understood that the buildings at Zone I have less displacement. Terrain category IV is best suited for the building. Maximum storey displacement value is 42.009 mm for the building with square plan at Zone VI and terrain category I. Minimum storey displacement value is 7.094 mm for the building with octagonal plan at Zone I and terrain category IV. Since zone VI and terrain category I is more critical, storey displacement for rectangular shaped building is reduced by 5.74% and octagonal model by 38.608%.
2. In wind analysis, square model has maximum storey drift (0.001032) in zone VI and terrain category I. Storey drift for rectangular building model is almost same as that of square. Octagonal building model have less storey drift. Rectangular shaped building shows maximum base shear (4268.27kN) in zone VI and terrain category I. Base shear is reduced by 34.78% for square and 8.7% for octagonal.
3. The effective shape to resist wind lateral load is octagonal shape structure for G+19 consideration. The storey displacement increases with increase in height and is maximum at top storey and zero at the base. Both the storey displacement and story drift increases from Zone I to Zone VI as the wind force increases for all the shapes and more for terrain category I. The storey drift decreases from terrain category I to IV for all the wind zones and for all the shapes. Zone I and terrain category IV is more suitable.
4. Generally symmetrical structure is preferred for high rise structure but in this case square shape found to be less stiff compare to rectangular structure in wind load consideration. Slenderness ratio is the ratio of height to width of building and have great effect in the strength and stability of the building. Octagonal building have less slenderness ratio and hence stable. It is more for square plan building.

5. In the seismic analysis of all the three building models in seismic zone V, storey drift and storey displacement is almost same for rectangular and square shaped G+19 building. Octagonal plan have minimum values. The maximum base shear value (7087.674 kN) is obtained for rectangular building. Terrain category has no impact in seismic analysis. Base shear for square is reduced by 39.77% and octagonal by 13.42%.
6. From the comparative study of both the lateral loads in Agarthala, it can be concluded that the earthquake forces have shown more severity with wind forces on a high rise building. The level of design wind load can alter the seismic performance of high rise buildings. Therefore even for the cases where the wind demands control the design of lateral load resisting system, the detailed performance based seismic evaluation should be carried out to ensure the overall structural stability and integrity.

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LIST OF PUBLICATIONS

- 1) Nasrin Abu, Prof. Shefeena N (2022), “Influence of Wind Loads on Tall Reinforced Concrete Structures in Different Terrains and Zones”, *International Journal Of Research In Engineering And Science (IJRES)*, Volume 10, Issue 7, pp:450-461
- 2) Paper will present on the topic “Dynamic Performance and Stability Analysis of Arch Supported Shell Structures ”, at International Conference on Construction Materials And Structures (ICCMS 2022) in NIT Calicut

APPENDIX A

A. WIND ANALYSIS

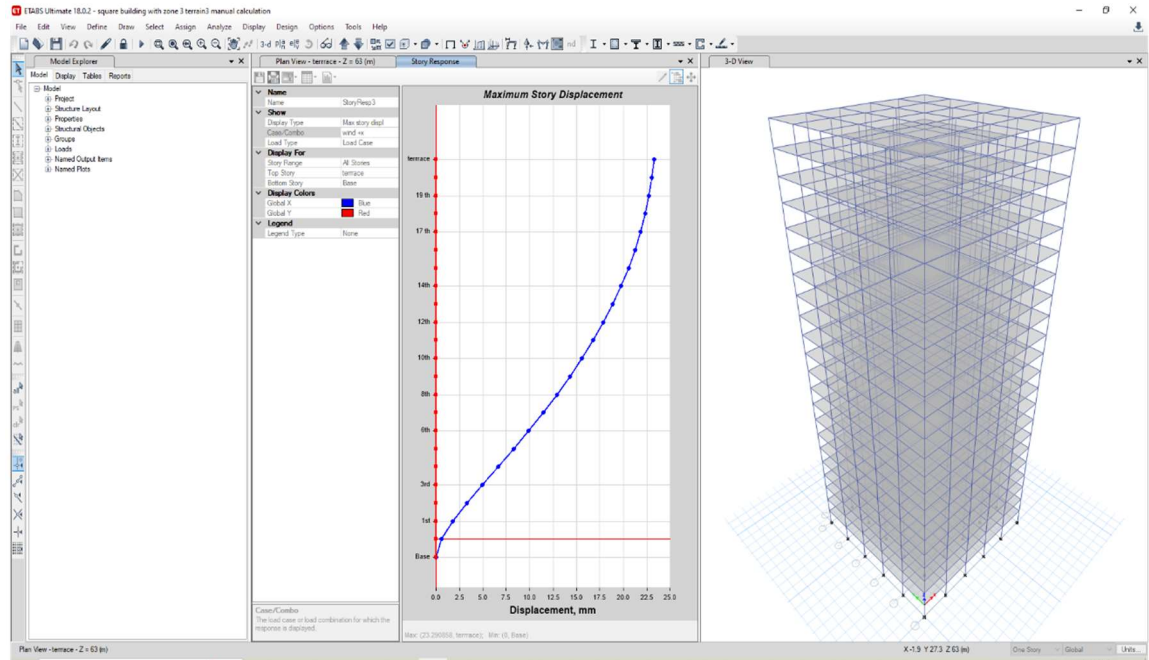


Figure A.1 Storey Displacement of a Building Model from ETABS

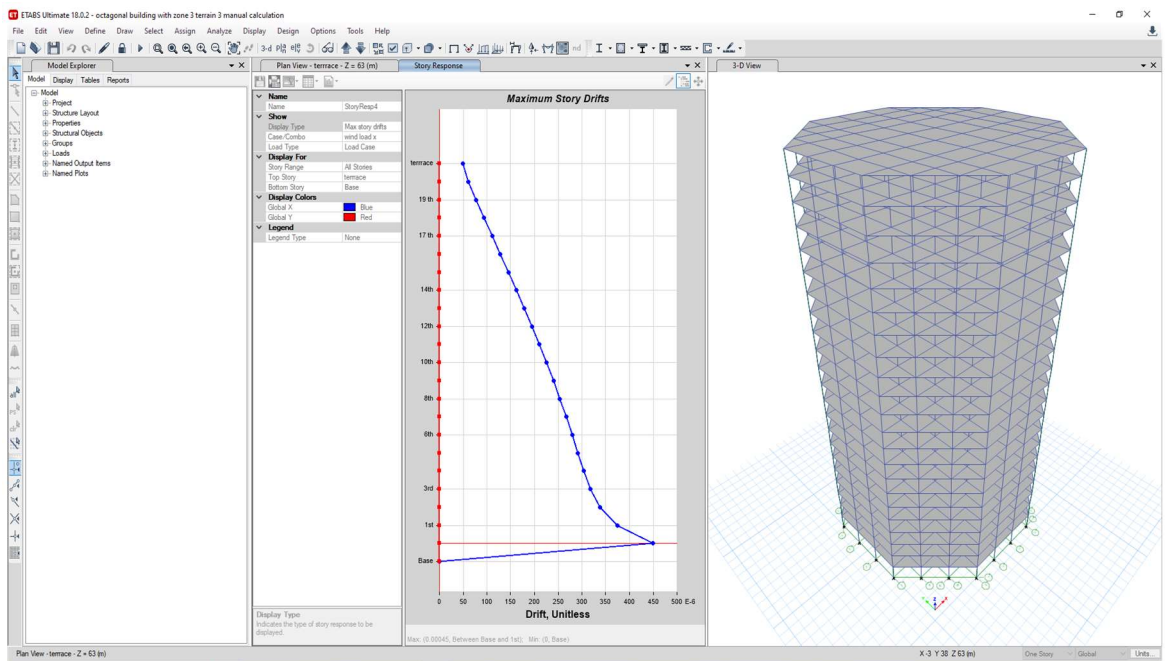


Figure A.2 Storey Drift of a Building Model from ETABS

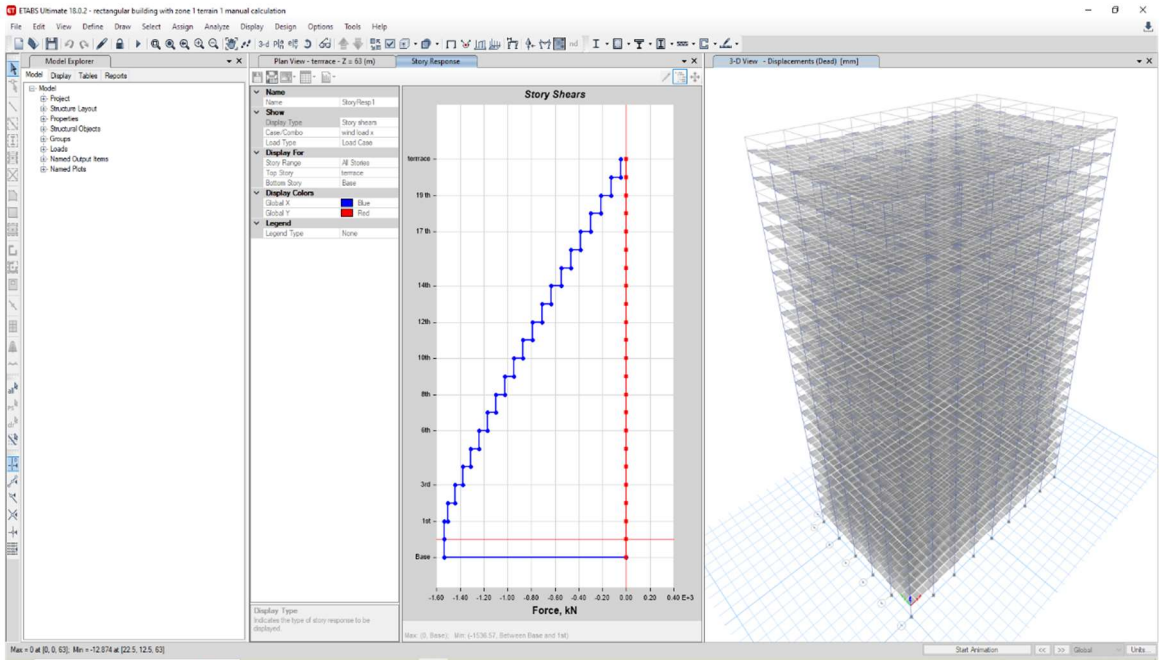


Figure A.3 Storey Shear of a Building Model from ETABS

B. SEISMIC ANALYSIS

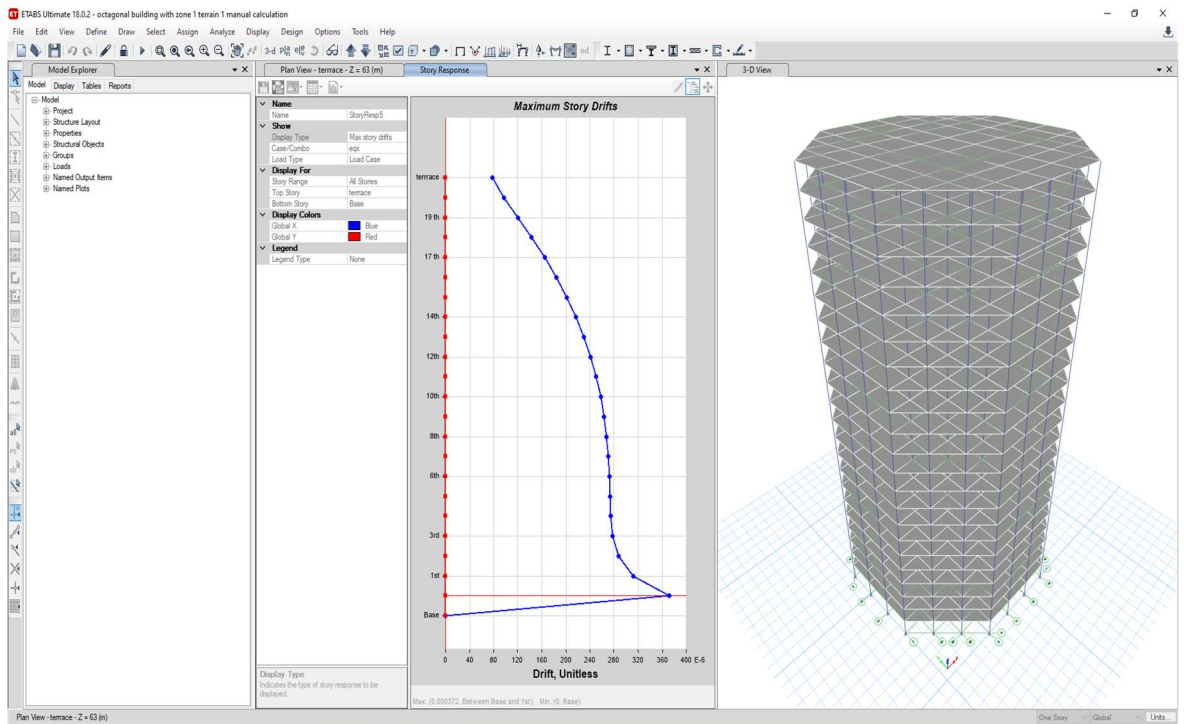


Figure B.1 Storey Drift of a Building Model from ETABS

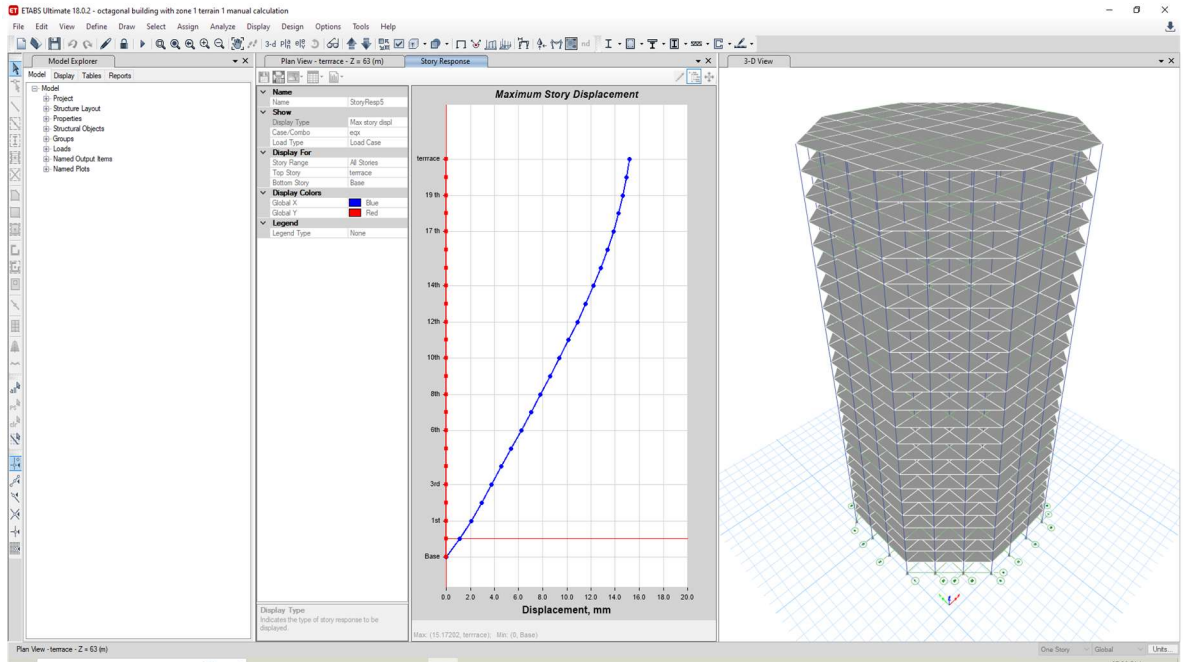


Figure B.2 Storey Displacement of a Building Model from ETABS

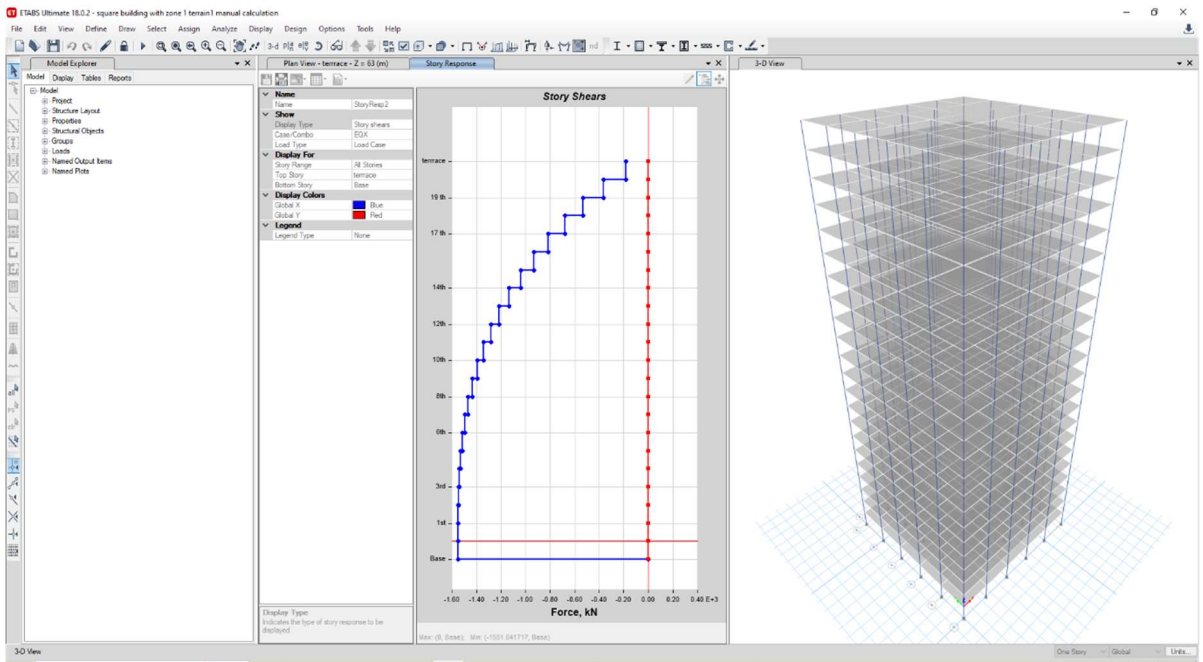


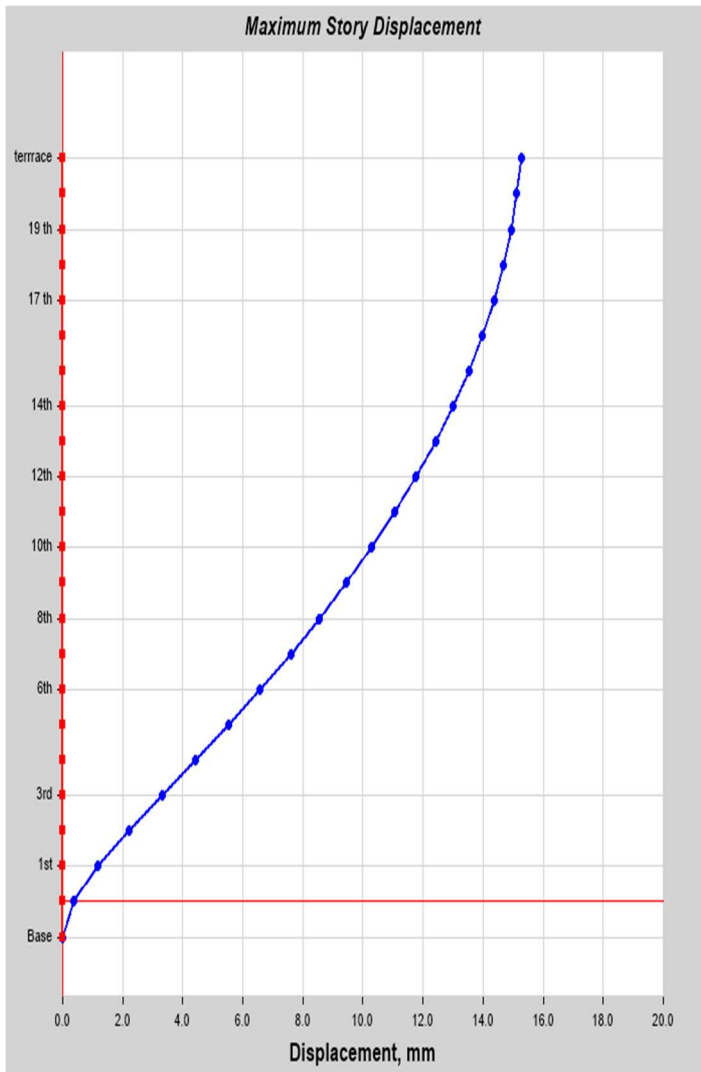
Figure B.3 Storey Shear of a Building Model from ETABS

APPENDIX B

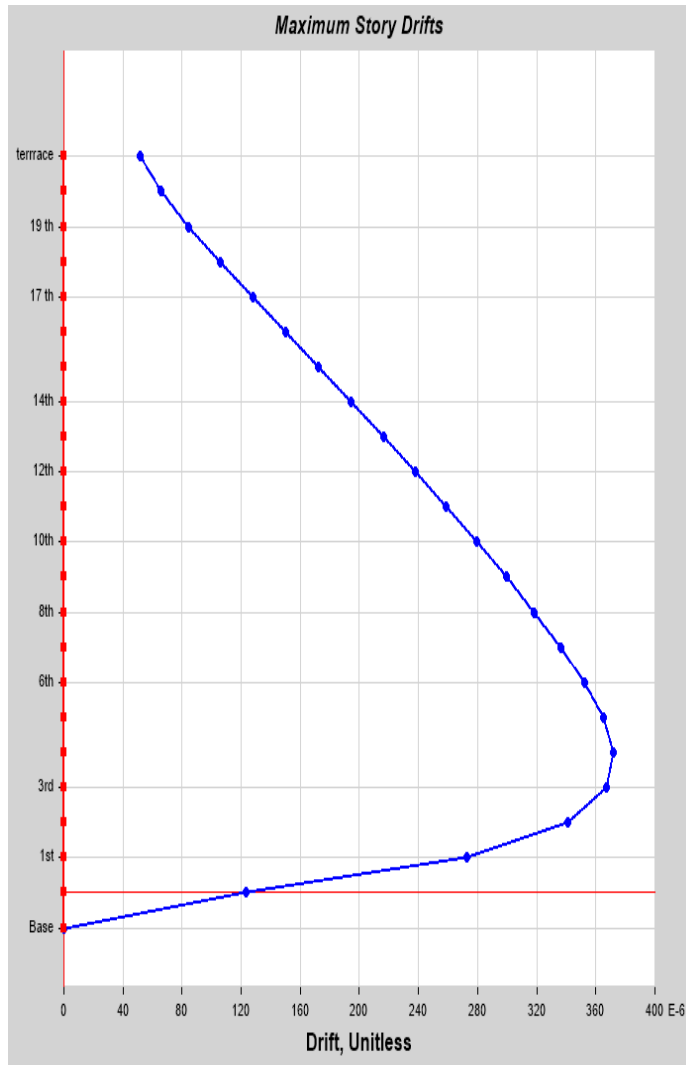
Following are the results obtained for the influence of lateral loads on G+19 building for three different shapes namely square, rectangle and octagonal.

WIND ANALYSIS SQUARE

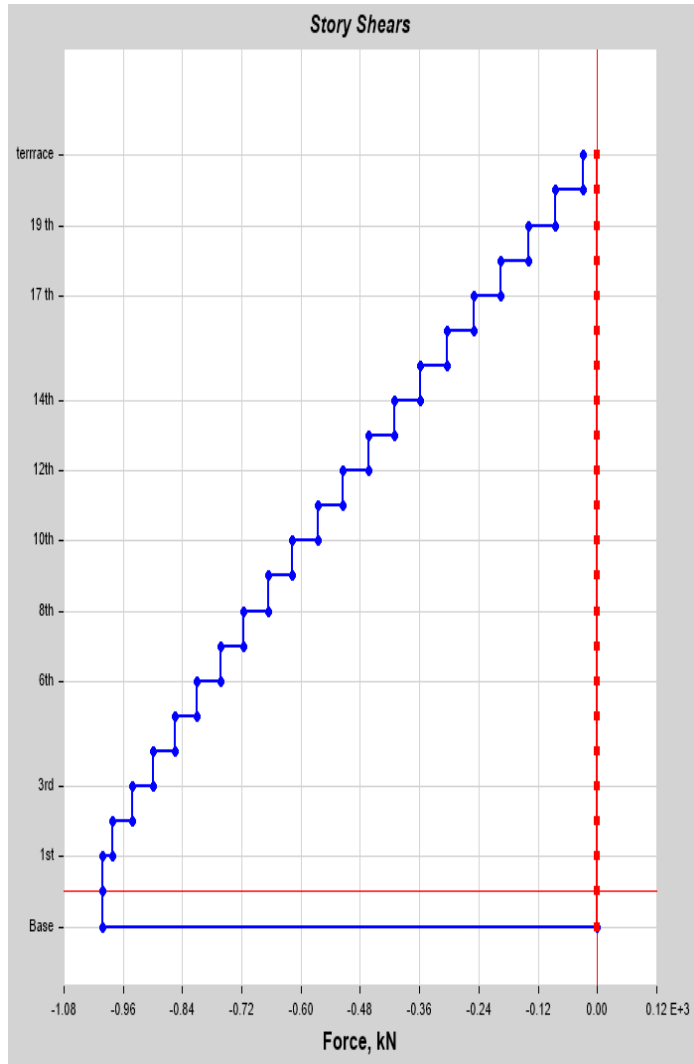
ZONE I – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	15.277
20th	60	15.123
19th	57	14.927
18th	54	14.673
17th	51	14.356
16th	48	13.973
15th	45	13.523
14th	42	13.005
13th	39	12.421
12th	36	11.772
11th	33	11.058
10th	30	10.282
9th	27	9.443
8th	24	8.545
7th	21	7.59
6th	18	6.581
5th	15	5.524
4th	12	4.429
3rd	9	3.314
2nd	6	2.212
1st	3	1.188
g.f	0	0.369
Base	-3	0

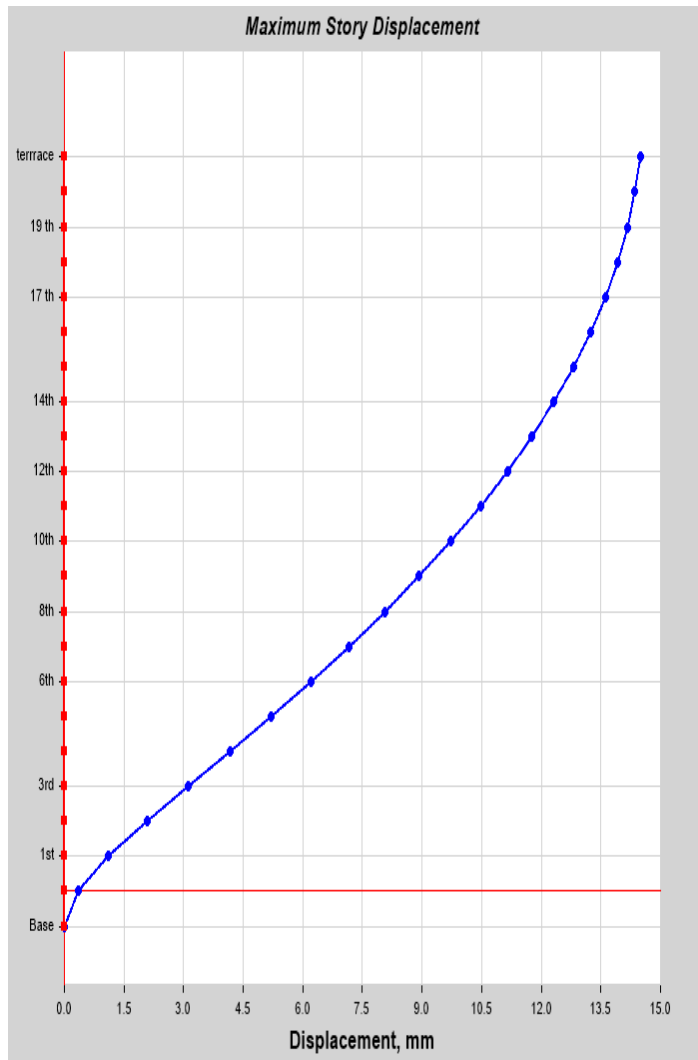


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000051
20th	60	0.000066
19th	57	0.000085
18th	54	0.000106
17th	51	0.000128
16th	48	0.00015
15th	45	0.000172
14th	42	0.000195
13th	39	0.000216
12th	36	0.000238
11th	33	0.000259
10th	30	0.000279
9th	27	0.000299
8th	24	0.000318
7th	21	0.000336
6th	18	0.000352
5th	15	0.000365
4th	12	0.000372
3rd	9	0.000367
2nd	6	0.000341
1st	3	0.000273
g.f	0	0.000123
Base	-3	0

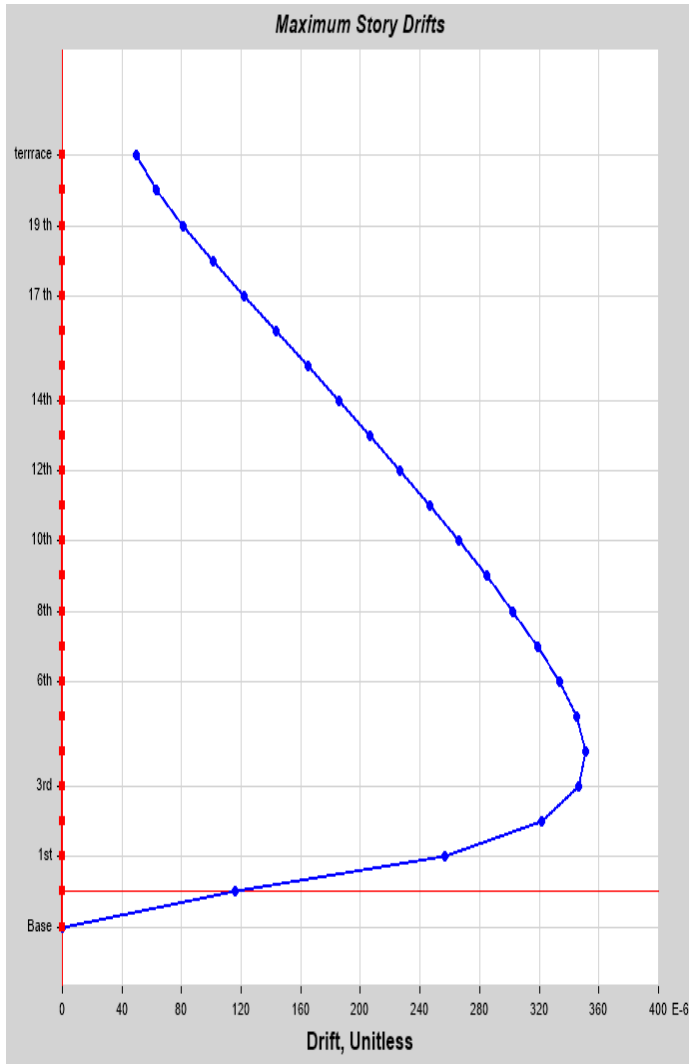


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	28.13
20th	60	84.11
19th	57	139.72
18th	54	195.05
17th	51	250.01
16th	48	304.43
15th	45	358.21
14th	42	411.27
13th	39	463.61
12th	36	515.33
11th	33	566.43
10th	30	616.83
9th	27	666.44
8th	24	715.27
7th	21	763.33
6th	18	810.11
5th	15	855.38
4th	12	898.68
3rd	9	940.69
2nd	6	981.91
1st	3	1002.12
g.f	0	1002.12
Base	-3	0

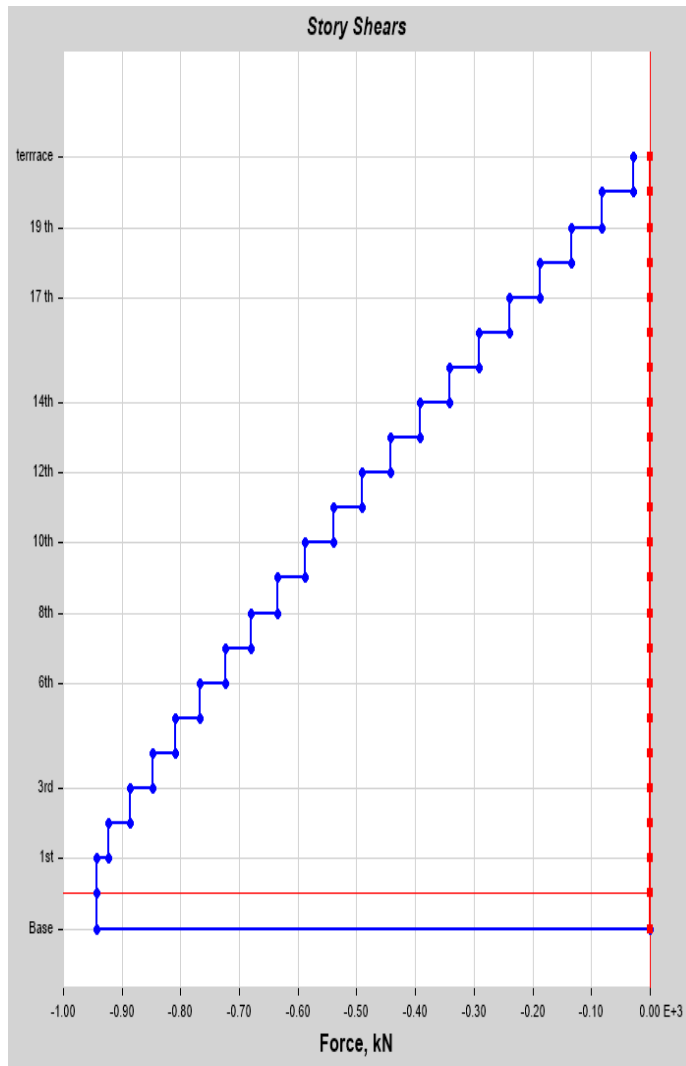
ZONE I – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	14.496
20th	60	14.348
19th	57	14.159
18th	54	13.916
17th	51	13.612
16th	48	13.246
15th	45	12.816
14th	42	12.322
13th	39	11.765
12th	36	11.145
11th	33	10.465
10th	30	9.725
9th	27	8.927
8th	24	8.073
7th	21	7.166
6th	18	6.209
5th	15	5.209
4th	12	4.174
3rd	9	3.121
2nd	6	2.082
1st	3	1.118
g.f	0	0.347
Base	-3	0

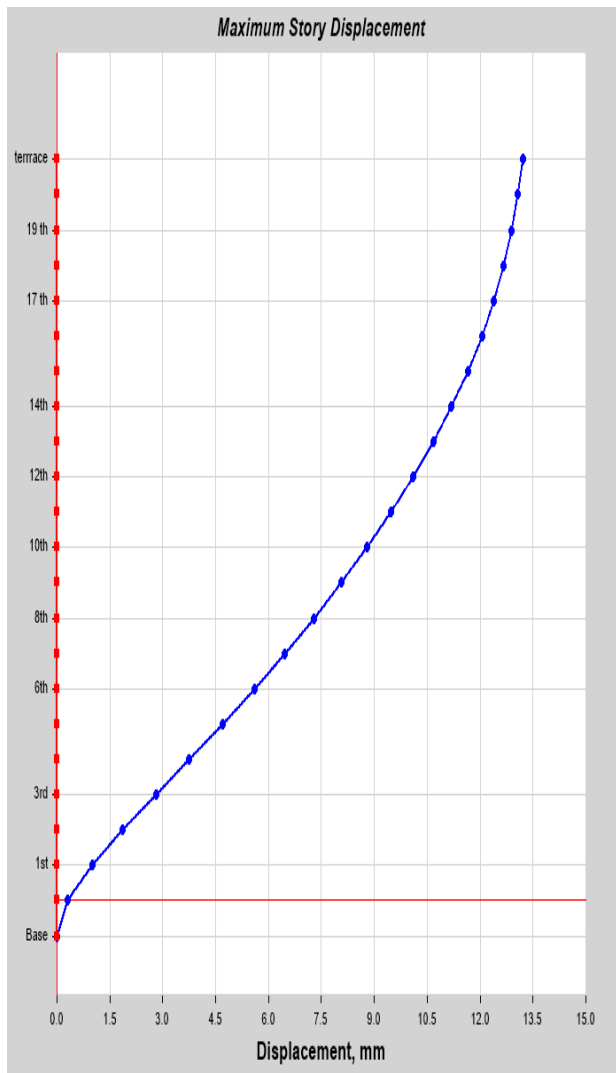


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000049
20th	60	0.000063
19th	57	0.000081
18th	54	0.000101
17th	51	0.000122
16th	48	0.000143
15th	45	0.000165
14th	42	0.000186
13th	39	0.000206
12th	36	0.000227
11th	33	0.000247
10th	30	0.000266
9th	27	0.000285
8th	24	0.000302
7th	21	0.000319
6th	18	0.000333
5th	15	0.000345
4th	12	0.000351
3rd	9	0.000346
2nd	6	0.000322
1st	3	0.000257
g.f	0	0.000116
Base	-3	0

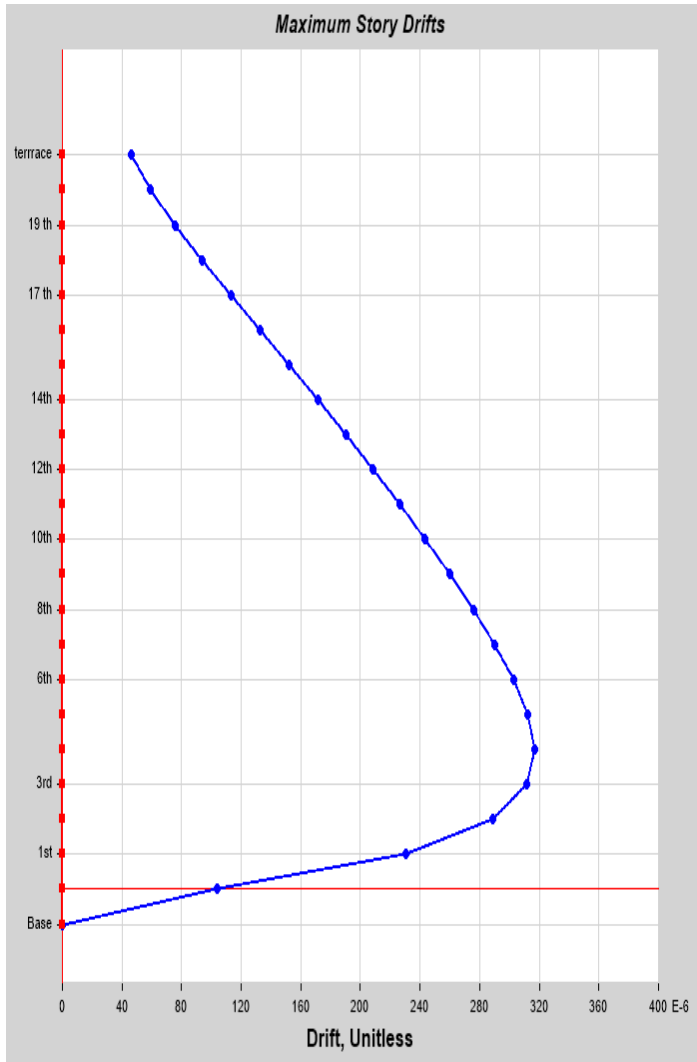


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	28.13
20th	60	81.55
19th	57	134.52
18th	54	187.13
17th	51	239.38
16th	48	291.1
15th	45	342.2
14th	42	392.6
13th	39	442.38
12th	36	491.47
11th	33	539.96
10th	30	587.76
9th	27	634.29
8th	24	679.56
7th	21	723.6
6th	18	766.58
5th	15	808.59
4th	12	848.24
3rd	9	886.35
2nd	6	923.7
1st	3	942.37
g.f	0	942.37
Base	-3	0

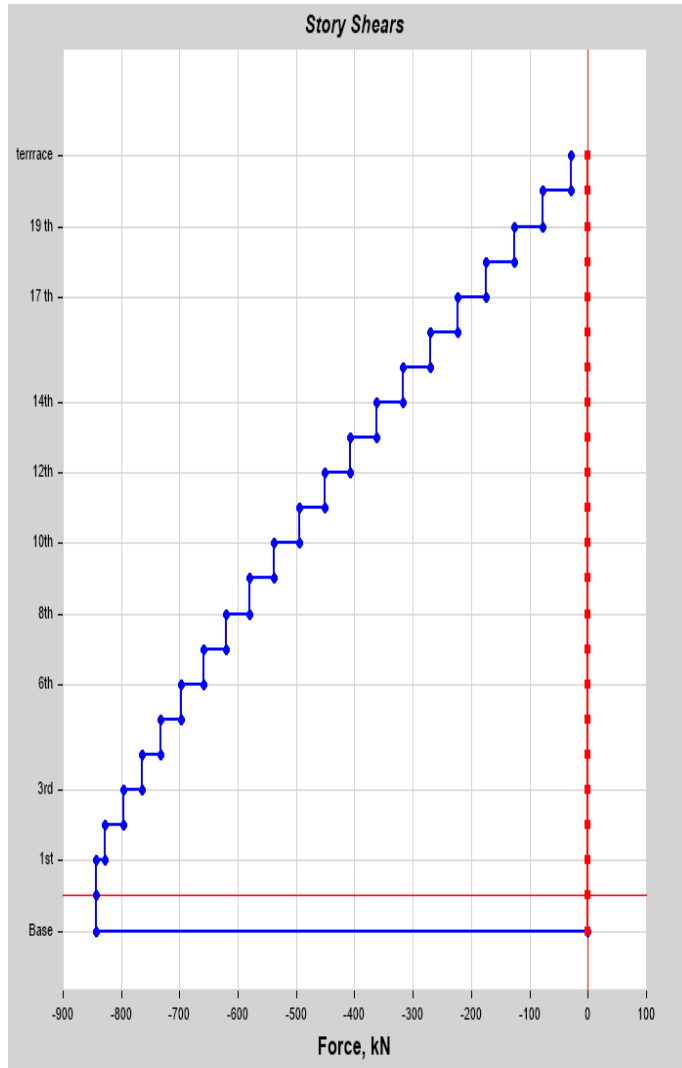
ZONE I – TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	13.214
20th	60	13.075
19th	57	12.898
18th	54	12.671
17th	51	12.388
16th	48	12.048
15th	45	11.65
14th	42	11.193
13th	39	10.68
12th	36	10.11
11th	33	9.485
10th	30	8.806
9th	27	8.076
8th	24	7.296
7th	21	6.468
6th	18	5.598
5th	15	4.69
4th	12	3.753
3rd	9	2.803
2nd	6	1.868
1st	3	1.002
g.f	0	0.311
Base	-3	0

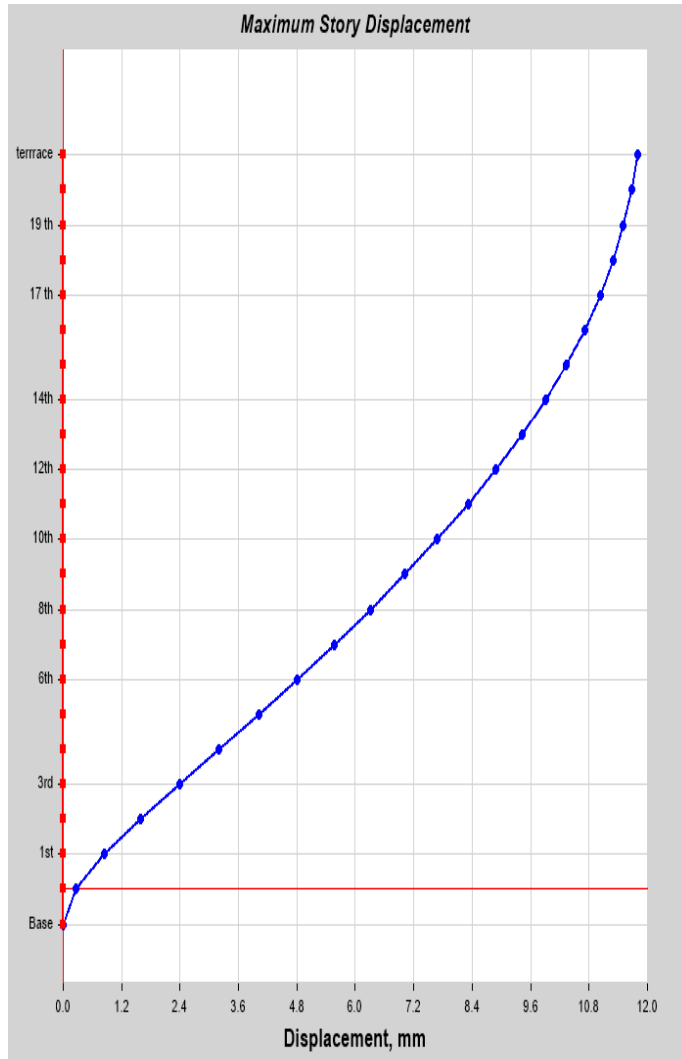


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000046
20th	60	0.000059
19th	57	0.000076
18th	54	0.000094
17th	51	0.000113
16th	48	0.000133
15th	45	0.000152
14th	42	0.000171
13th	39	0.00019
12th	36	0.000208
11th	33	0.000226
10th	30	0.000243
9th	27	0.00026
8th	24	0.000276
7th	21	0.00029
6th	18	0.000303
5th	15	0.000312
4th	12	0.000317
3rd	9	0.000312
2nd	6	0.000289
1st	3	0.00023
g.f	0	0.000104
Base	-3	0

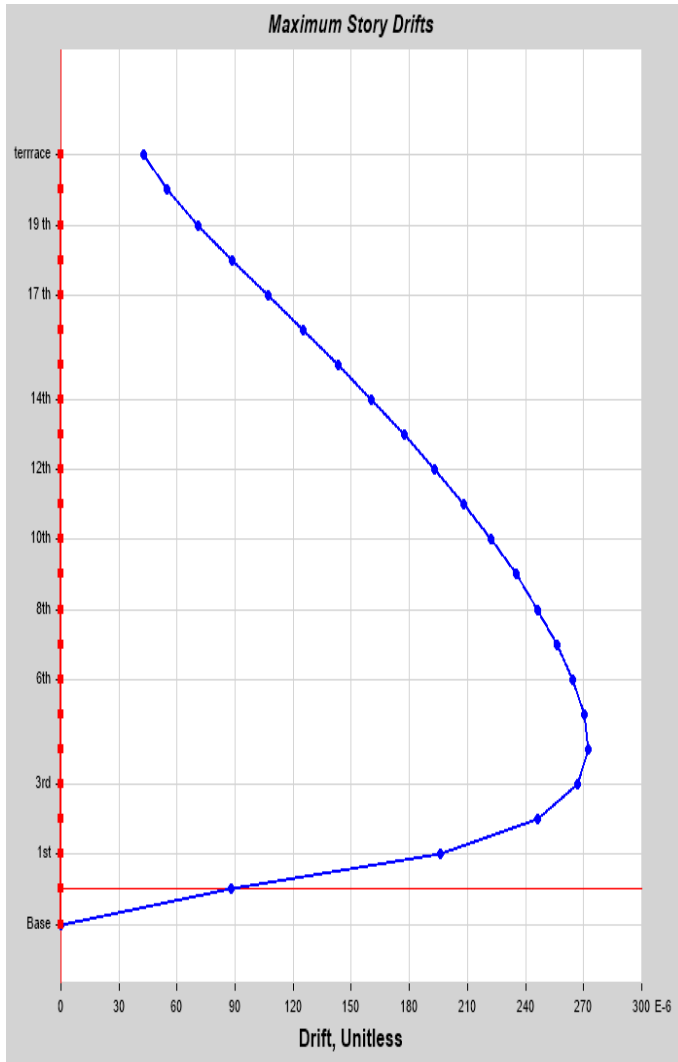


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	28.8
20th	60	77.98
19th	57	126.72
18th	54	175.03
17th	51	222.92
16th	48	270.21
15th	45	316.75
14th	42	362.51
13th	39	407.54
12th	36	451.82
11th	33	495.37
10th	30	538.19
9th	27	579.8
8th	24	620.23
7th	21	659.49
6th	18	696.84
5th	15	731.96
4th	12	764.92
3rd	9	796.48
2nd	6	827.35
1st	3	842.75
g.f	0	842.75
Base	-3	0

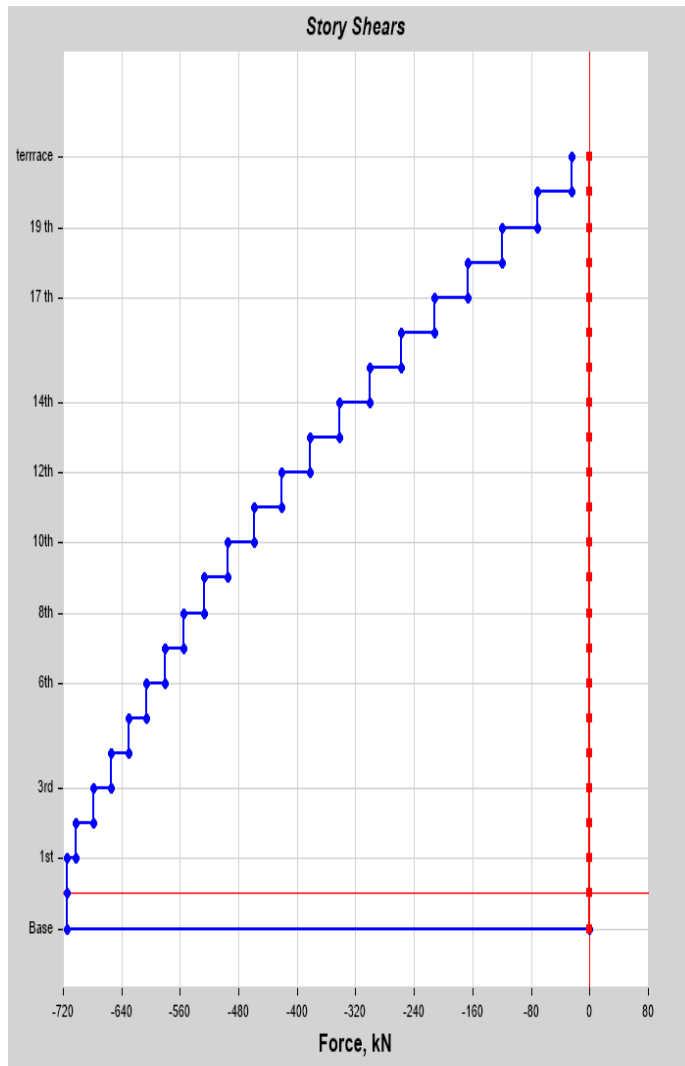
ZONE I – TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	11.799
20th	60	11.671
19th	57	11.507
18th	54	11.295
17th	51	11.03
16th	48	10.709
15th	45	10.334
14th	42	9.905
13th	39	9.423
12th	36	8.892
11th	33	8.312
10th	30	7.688
9th	27	7.021
8th	24	6.316
7th	21	5.577
6th	18	4.809
5th	15	4.016
4th	12	3.206
3rd	9	2.39
2nd	6	1.59
1st	3	0.852
g.f	0	0.264
Base	-3	0

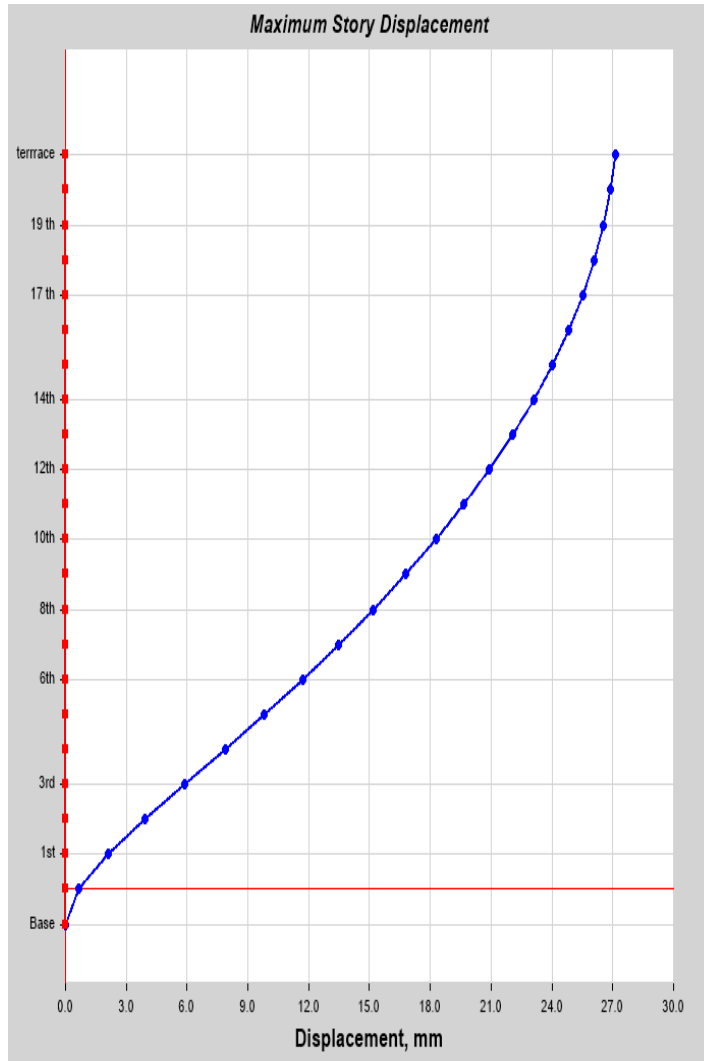


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000043
20th	60	0.000055
19th	57	0.000071
18th	54	0.000088
17th	51	0.000107
16th	48	0.000125
15th	45	0.000143
14th	42	0.00016
13th	39	0.000177
12th	36	0.000193
11th	33	0.000208
10th	30	0.000222
9th	27	0.000235
8th	24	0.000246
7th	21	0.000256
6th	18	0.000264
5th	15	0.00027
4th	12	0.000272
3rd	9	0.000267
2nd	6	0.000246
1st	3	0.000196
g.f	0	0.000088
Base	-3	0

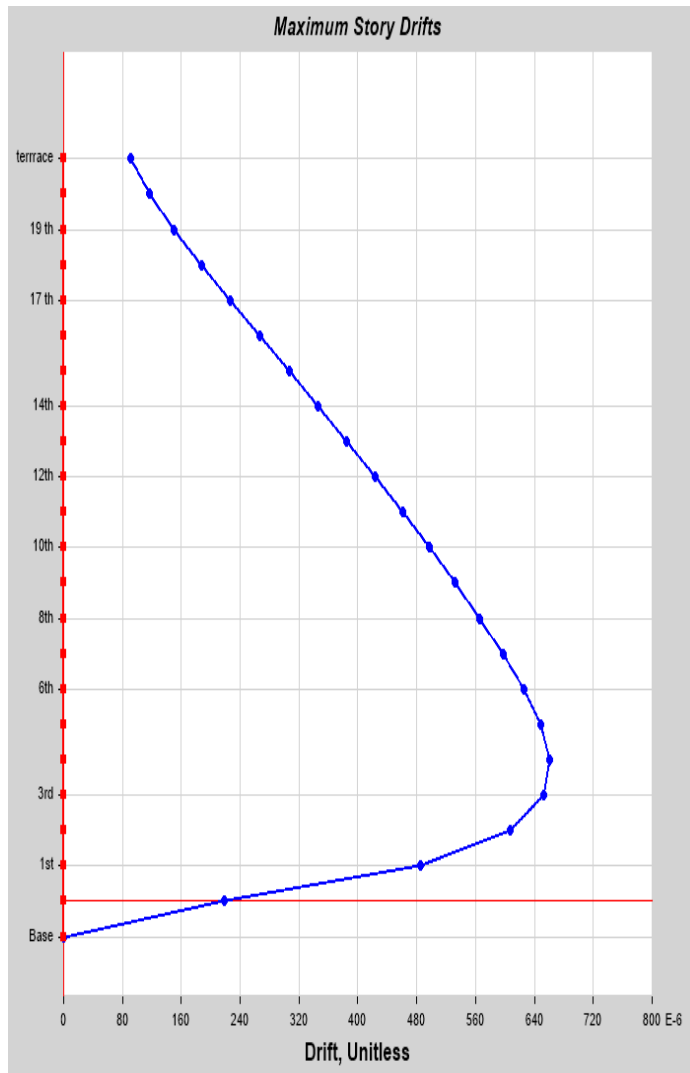


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	24.16
20th	60	71.96
19th	57	119.25
18th	54	166.03
17th	51	212.31
16th	48	257.34
15th	45	300.72
14th	42	342.57
13th	39	382.84
12th	36	421.64
11th	33	458.91
10th	30	494.76
9th	27	526.94
8th	24	555.65
7th	21	581.09
6th	18	605.48
5th	15	629.87
4th	12	654.26
3rd	9	678.65
2nd	6	702.43
1st	3	714.02
g.f	0	714.02
Base	-3	0

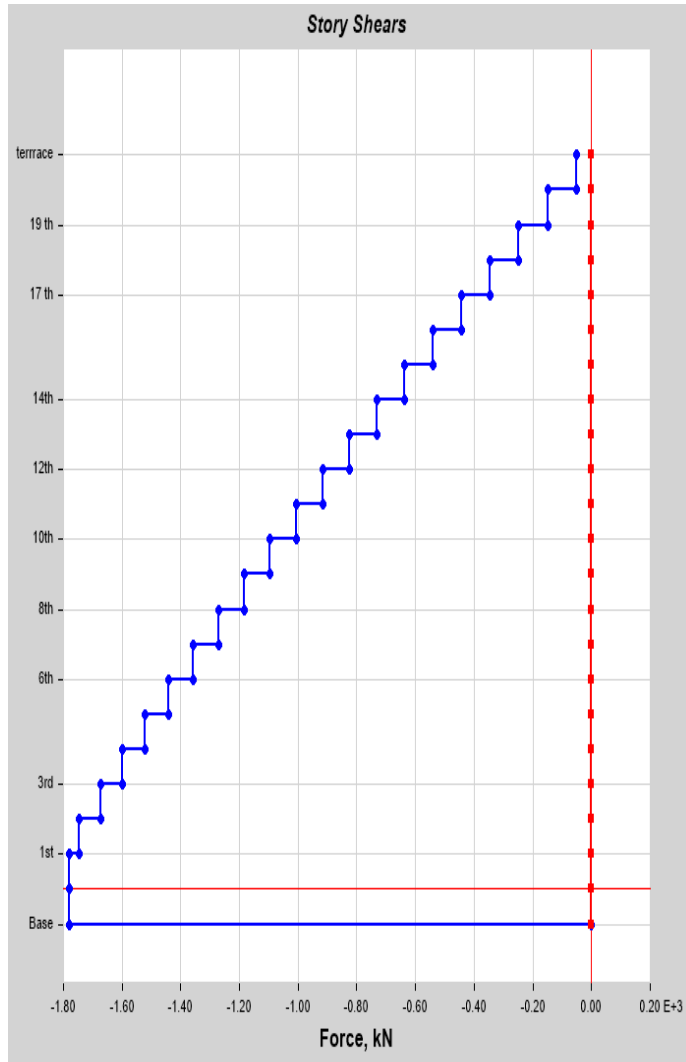
ZONE III – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	27.159
20th	60	26.885
19th	57	26.536
18th	54	26.085
17th	51	25.522
16th	48	24.84
15th	45	24.04
14th	42	23.12
13th	39	22.082
12th	36	20.928
11th	33	19.659
10th	30	18.278
9th	27	16.787
8th	24	15.191
7th	21	13.492
6th	18	11.699
5th	15	9.82
4th	12	7.874
3rd	9	5.891
2nd	6	3.932
1st	3	2.112
g.f	0	0.656
Base	-3	0

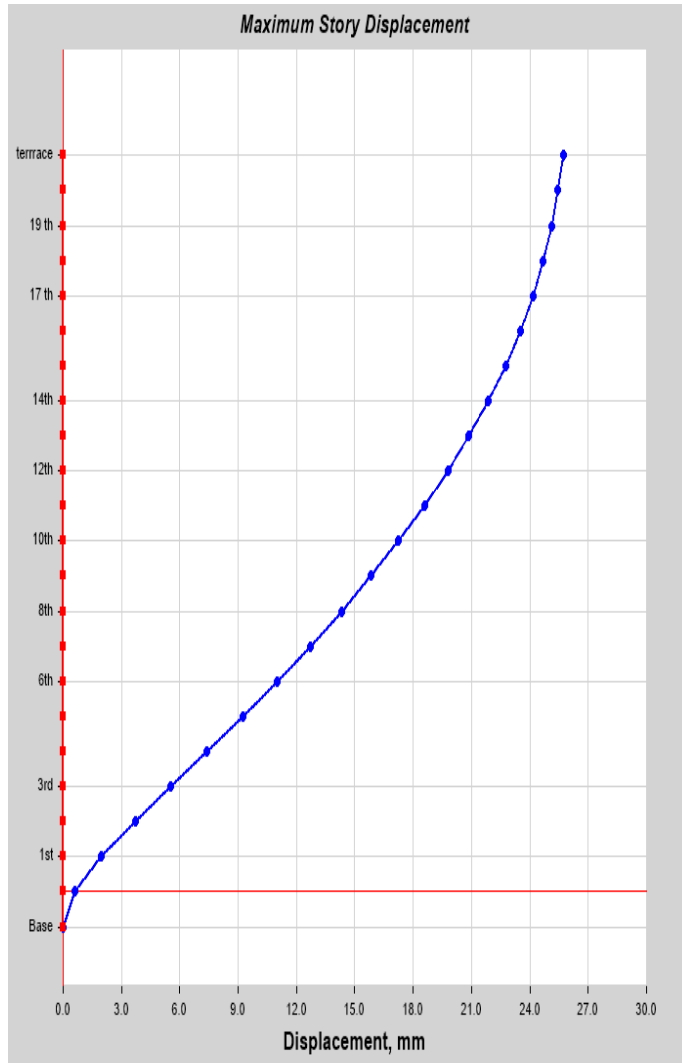


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000091
20th	60	0.000117
19th	57	0.00015
18th	54	0.000188
17th	51	0.000227
16th	48	0.000267
15th	45	0.000307
14th	42	0.000346
13th	39	0.000385
12th	36	0.000423
11th	33	0.00046
10th	30	0.000497
9th	27	0.000532
8th	24	0.000566
7th	21	0.000598
6th	18	0.000626
5th	15	0.000649
4th	12	0.000661
3rd	9	0.000653
2nd	6	0.000607
1st	3	0.000485
g.f	0	0.000219
Base	-3	0

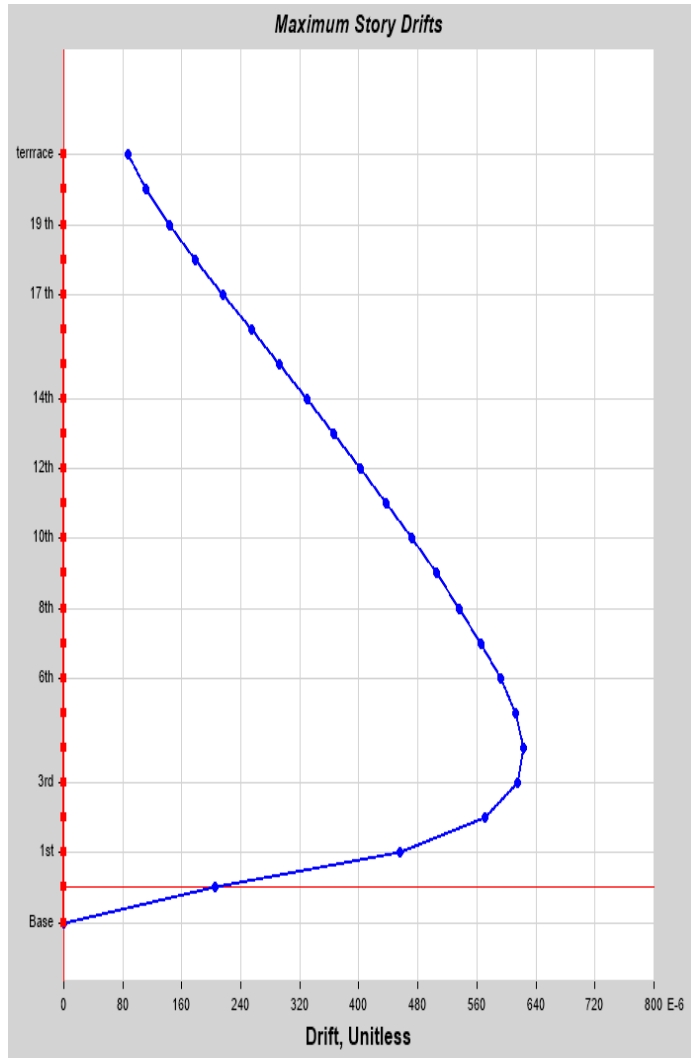


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	50
20th	60	149.51
19th	57	248.37
18th	54	346.74
17th	51	444.45
16th	48	541.19
15th	45	636.8
14th	42	731.13
13th	39	824.18
12th	36	916.12
11th	33	10006.96
10th	30	1096.55
9th	27	1184.75
8th	24	1271.56
7th	21	1356.99
6th	18	1440.16
5th	15	1520.65
4th	12	1597.63
3rd	9	1672.32
2nd	6	1745.59
1st	3	1781.53
g.f	0	1781.53
Base	-3	0

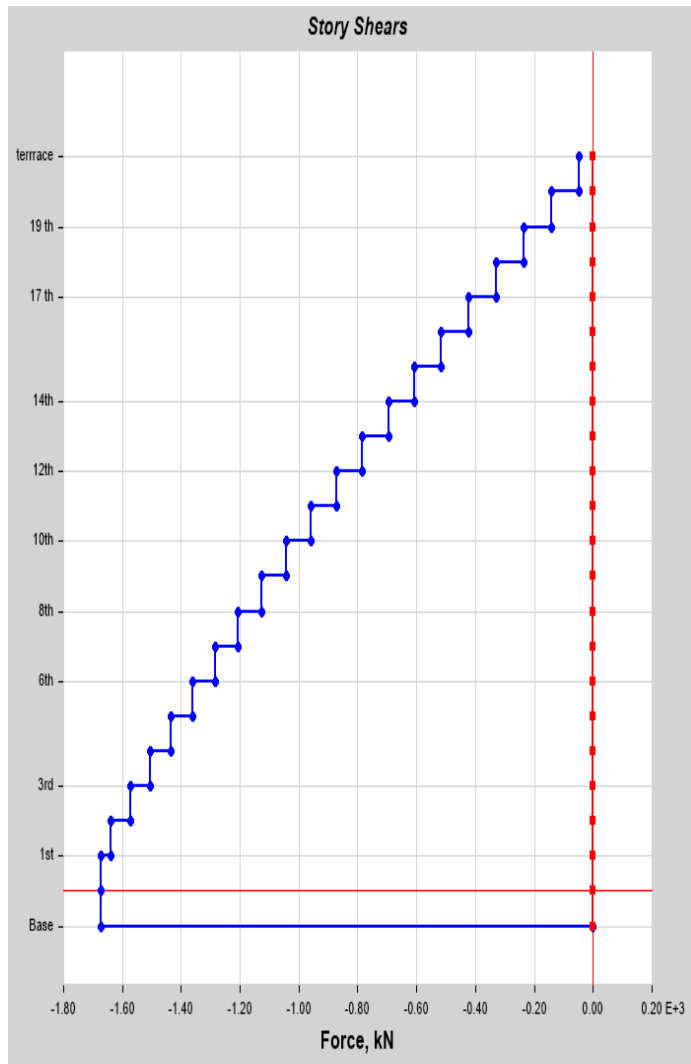
ZONE III – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	25.709
20th	60	25.448
19th	57	25.115
18th	54	24.686
17th	51	24.149
16th	48	23.501
15th	45	22.739
14th	42	21.864
13th	39	20.877
12th	36	19.779
11th	33	18.573
10th	30	17.26
9th	27	15.844
8th	24	14.329
7th	21	12.72
6th	18	11.022
5th	15	9.247
4th	12	7.41
3rd	9	5.541
2nd	6	3.697
1st	3	1.985
g.f	0	0.617
Base	-3	0

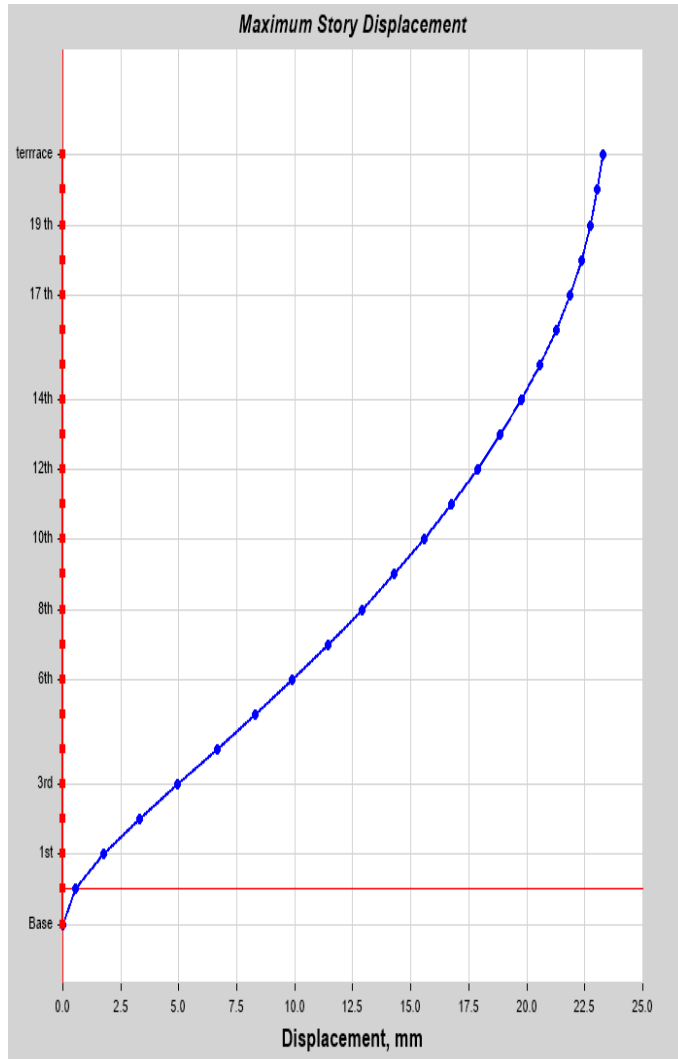


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000087
20th	60	0.000111
19th	57	0.000143
18th	54	0.000179
17th	51	0.000216
16th	48	0.000254
15th	45	0.000292
14th	42	0.000329
13th	39	0.000366
12th	36	0.000402
11th	33	0.000438
10th	30	0.000472
9th	27	0.000505
8th	24	0.000537
7th	21	0.000566
6th	18	0.000592
5th	15	0.000612
4th	12	0.000623
3rd	9	0.000615
2nd	6	0.000571
1st	3	0.000456
g.f	0	0.000206
Base	-3	0

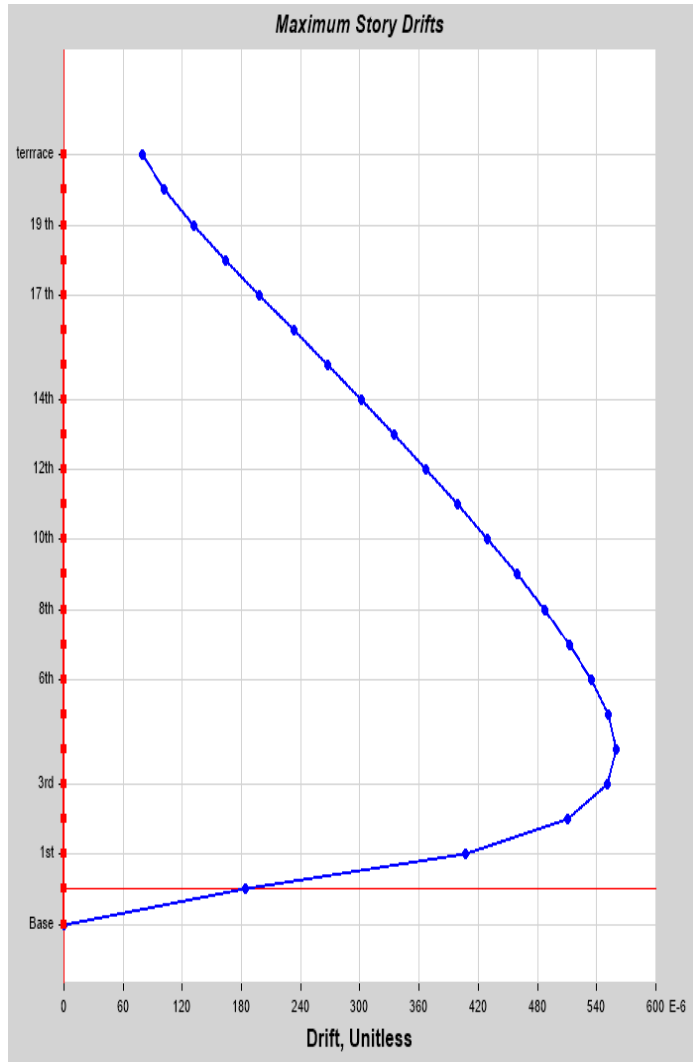


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	47.8
20th	60	142.78
19th	57	236.95
18th	54	330.48
17th	51	423.37
16th	48	515.31
15th	45	606.15
14th	42	695.74
13th	39	784.24
12th	36	871.51
11th	33	957.71
10th	30	1042.69
9th	27	1125.41
8th	24	1205.9
7th	21	1284.19
6th	18	1360.6
5th	15	1435.29
4th	12	1505.77
3rd	9	1573.51
2nd	6	1639.91
1st	3	1673.11
g.f	0	1673.11
Base	-3	0

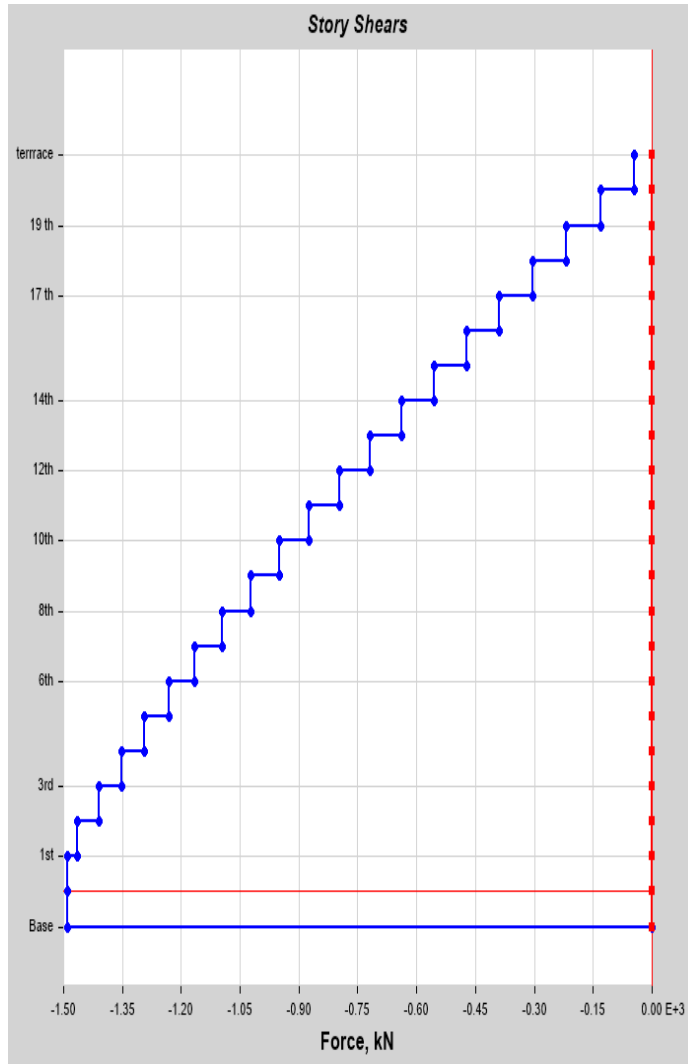
ZONE III – TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	23.291
20th	60	23.052
19th	57	22.747
18th	54	22.353
17th	51	21.861
16th	48	21.266
15th	45	20.568
14th	42	19.767
13th	39	18.863
12th	36	17.86
11th	33	16.759
10th	30	15.563
9th	27	14.274
8th	24	12.897
7th	21	11.436
6th	18	9.898
5th	15	8.293
4th	12	6.637
3rd	9	4.958
2nd	6	3.304
1st	3	1.772
g.f	0	0.55
Base	-3	0

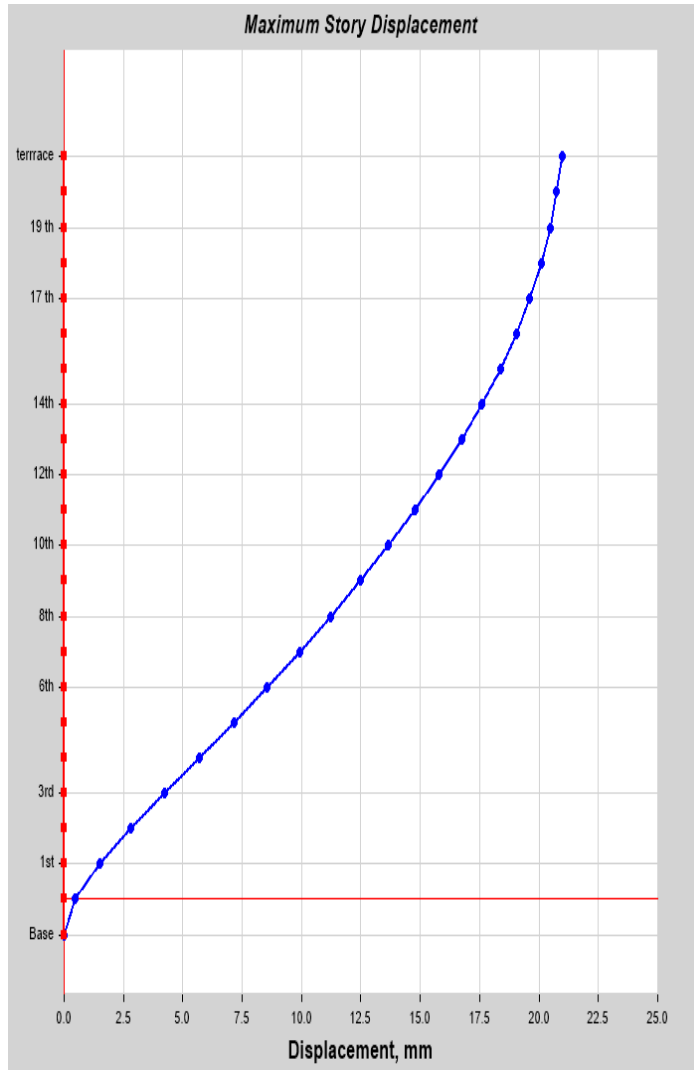


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.00008
20th	60	0.000102
19th	57	0.000131
18th	54	0.000164
17th	51	0.000198
16th	48	0.000233
15th	45	0.000267
14th	42	0.000301
13th	39	0.000334
12th	36	0.000367
11th	33	0.000399
10th	30	0.00043
9th	27	0.000459
8th	24	0.000487
7th	21	0.000513
6th	18	0.000535
5th	15	0.000552
4th	12	0.00056
3rd	9	0.000551
2nd	6	0.000511
1st	3	0.000407
g.f	0	0.000183
Base	-3	0

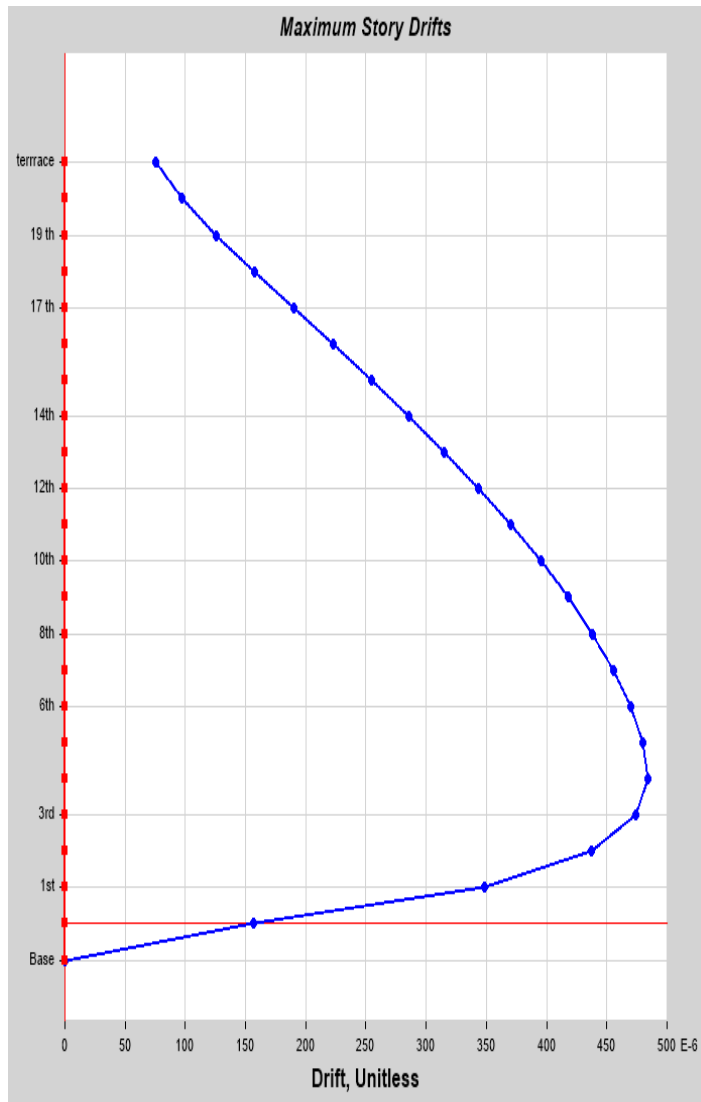


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	44.1
20th	60	131.52
19th	57	218.18
18th	54	304.07
17th	51	389.2
16th	48	473.27
15th	45	555.99
14th	42	637.37
13th	39	717.41
12th	36	796.13
11th	33	873.55
10th	30	949.67
9th	27	1023.65
8th	24	1095.52
7th	21	1165.31
6th	18	1231.71
5th	15	1294.14
4th	12	1352.73
3rd	9	1408.83
2nd	6	1463.7
1st	3	1491.08
g.f	0	1491.08
Base	-3	0

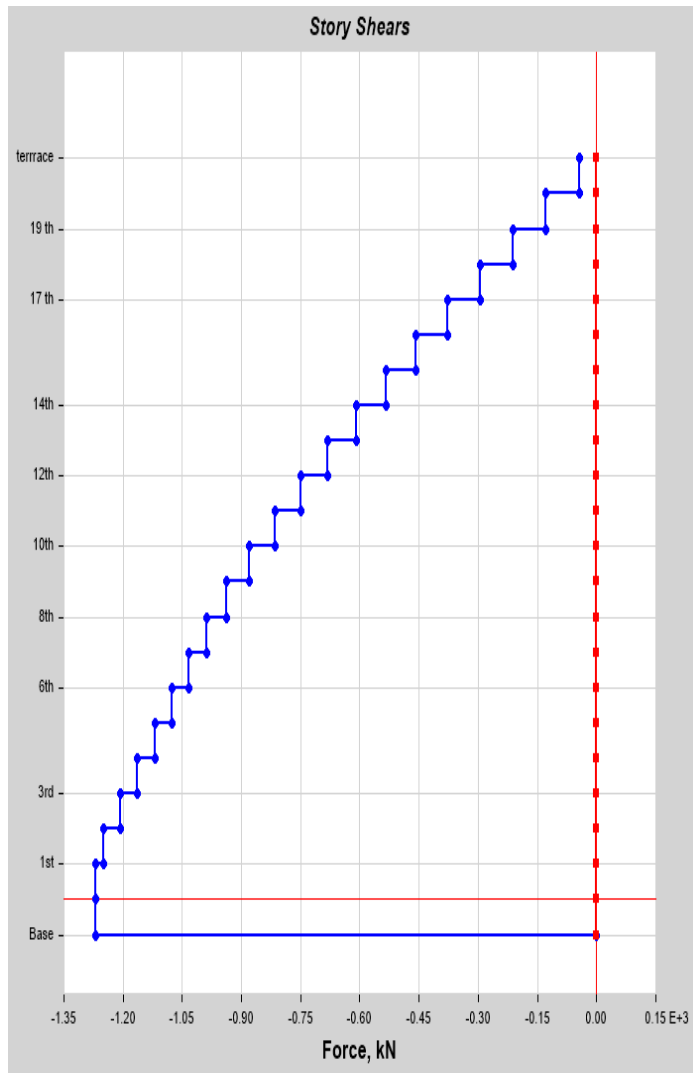
ZONE III – TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	20.976
20th	60	20.748
19th	57	20.457
18th	54	20.08
17th	51	19.608
16th	48	19.039
15th	45	18.371
14th	42	17.608
13th	39	16.752
12th	36	15.807
11th	33	14.777
10th	30	13.667
9th	27	12.482
8th	24	11.229
7th	21	9.915
6th	18	8.55
5th	15	7.14
4th	12	5.7
3rd	9	4.248
2nd	6	2.826
1st	3	1.514
g.f	0	0.47
Base	-3	0

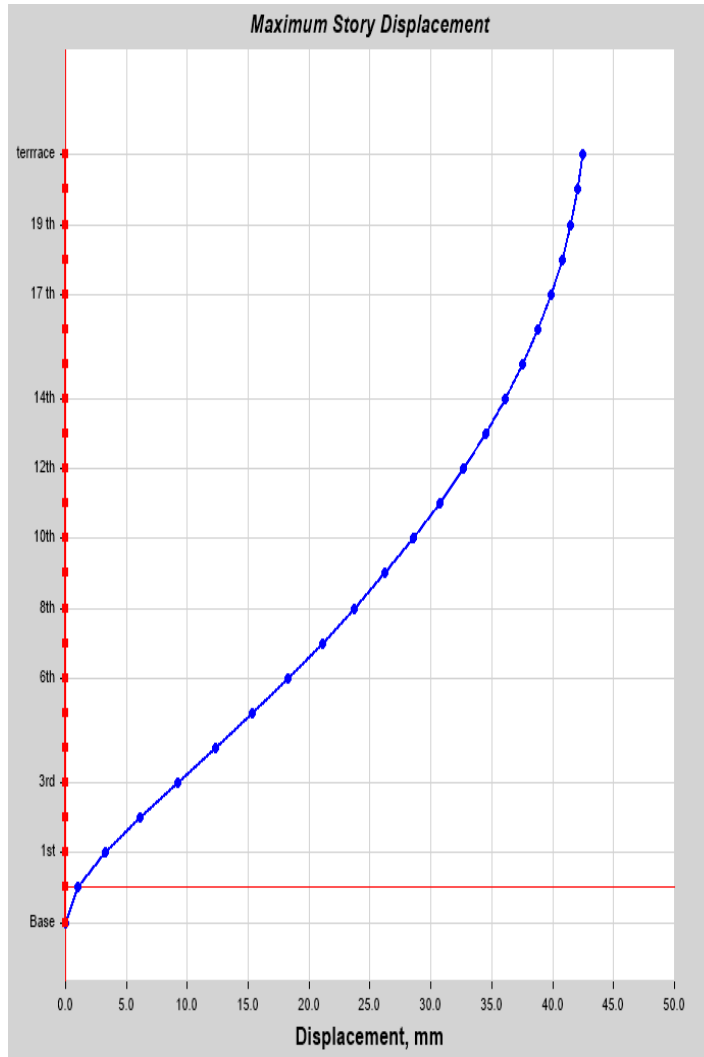


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000076
20th	60	0.000097
19th	57	0.000126
18th	54	0.000157
17th	51	0.00019
16th	48	0.000222
15th	45	0.000254
14th	42	0.000285
13th	39	0.000315
12th	36	0.000343
11th	33	0.00037
10th	30	0.000395
9th	27	0.000418
8th	24	0.000438
7th	21	0.000455
6th	18	0.00047
5th	15	0.00048
4th	12	0.000484
3rd	9	0.000474
2nd	6	0.000437
1st	3	0.000348
g.f	0	0.000157
Base	-3	0

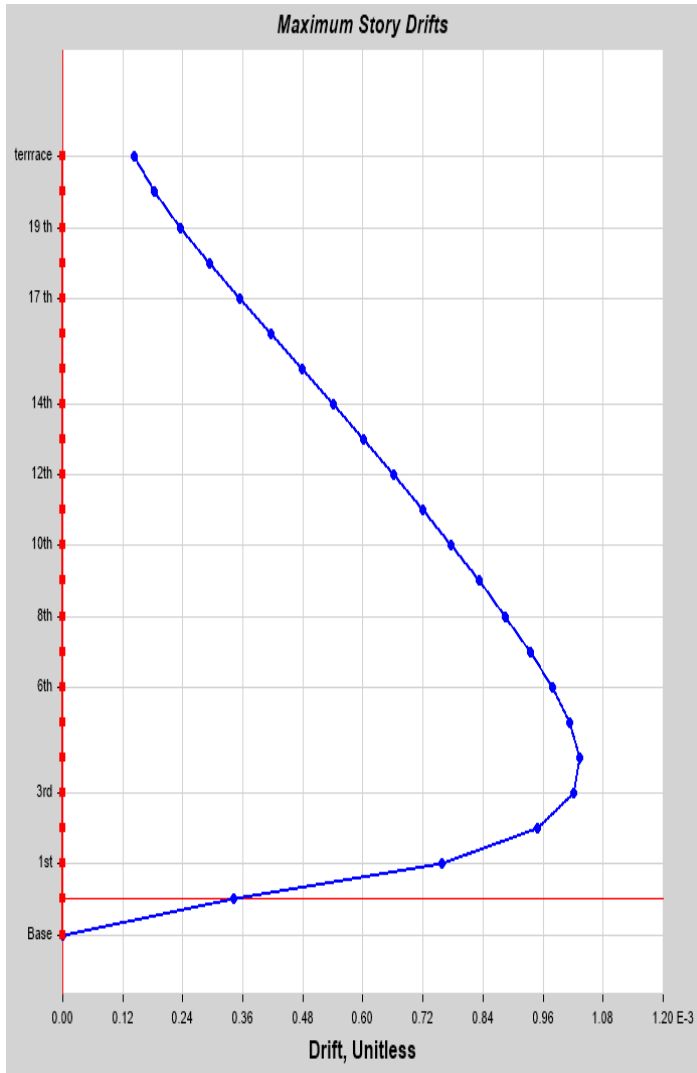


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	42.95
20th	60	127.93
19th	57	212
18th	54	295.17
17th	51	377.44
16th	48	457.48
15th	45	534.61
14th	42	609.01
13th	39	680.6
12th	36	749.57
11th	33	815.83
10th	30	879.57
9th	27	936.78
8th	24	987.82
7th	21	1033.04
6th	18	1076.4
5th	15	1119.76
4th	12	1163.12
3rd	9	1206.48
2nd	6	1248.76
1st	3	1269.37
g.f	0	1269.37
Base	-3	0

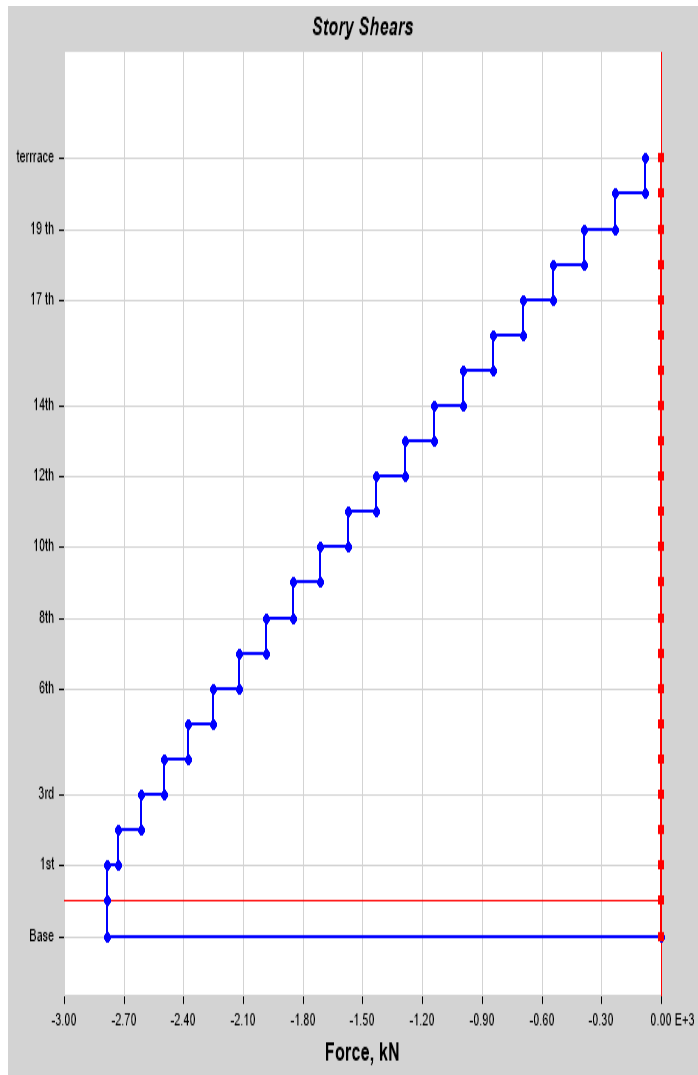
ZONE VI – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	42.436
20th	60	42.009
19th	57	41.462
18th	54	40.758
17th	51	39.878
16th	48	38.813
15th	45	37.563
14th	42	36.125
13th	39	34.504
12th	36	32.7
11th	33	30.717
10th	30	28.559
9th	27	26.23
8th	24	23.736
7th	21	21.082
6th	18	18.279
5th	15	15.344
4th	12	12.302
3rd	9	9.205
2nd	6	6.144
1st	3	3.299
g.f	0	1.026
Base	-3	0

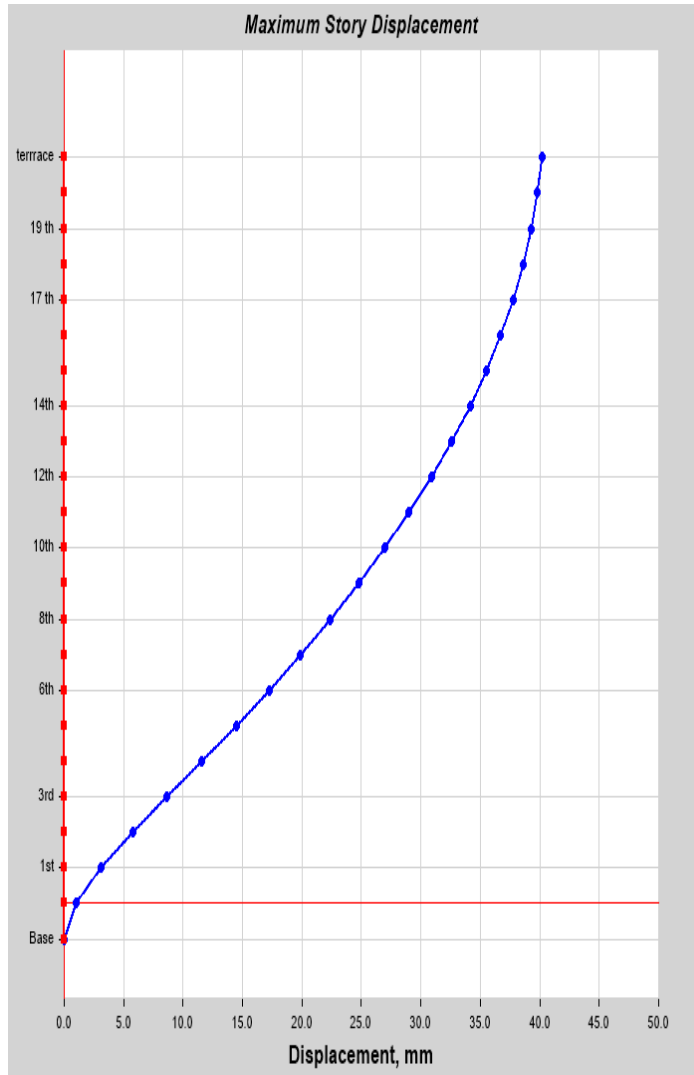


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000143
20th	60	0.000182
19th	57	0.000235
18th	54	0.000293
17th	51	0.000355
16th	48	0.000417
15th	45	0.000479
14th	42	0.000541
13th	39	0.000601
12th	36	0.000661
11th	33	0.000719
10th	30	0.000776
9th	27	0.000832
8th	24	0.000885
7th	21	0.000934
6th	18	0.000979
5th	15	0.001014
4th	12	0.001032
3rd	9	0.00102
2nd	6	0.000948
1st	3	0.000758
g.f	0	0.000342
Base	-3	0

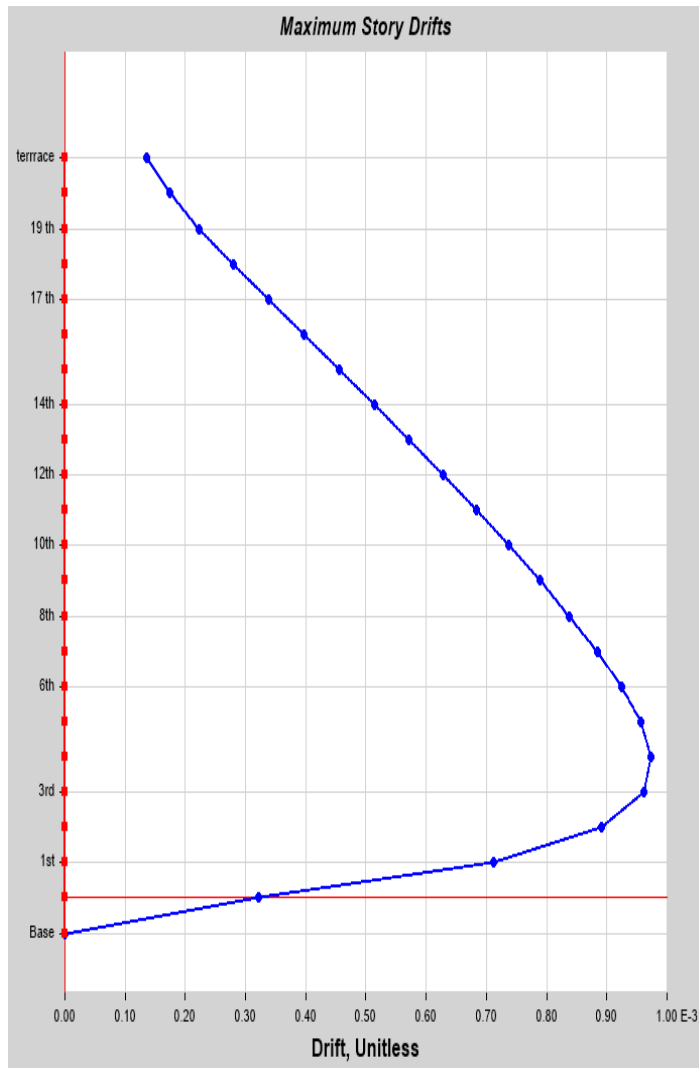


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	78.13
20th	60	233.62
19th	57	388.08
18th	54	541.78
17th	51	694.46
16th	48	845.62
15th	45	995.01
14th	42	1142.4
13th	39	1287.79
12th	36	1431.45
11th	33	1573.39
10th	30	1713.38
9th	27	1851.19
8th	24	1986.83
7th	21	2120.32
6th	18	2250.27
5th	15	2376.03
4th	12	2496.31
3rd	9	2613.01
2nd	6	2727.5
1st	3	2783.65
g.f	0	2783.65
Base	-3	0

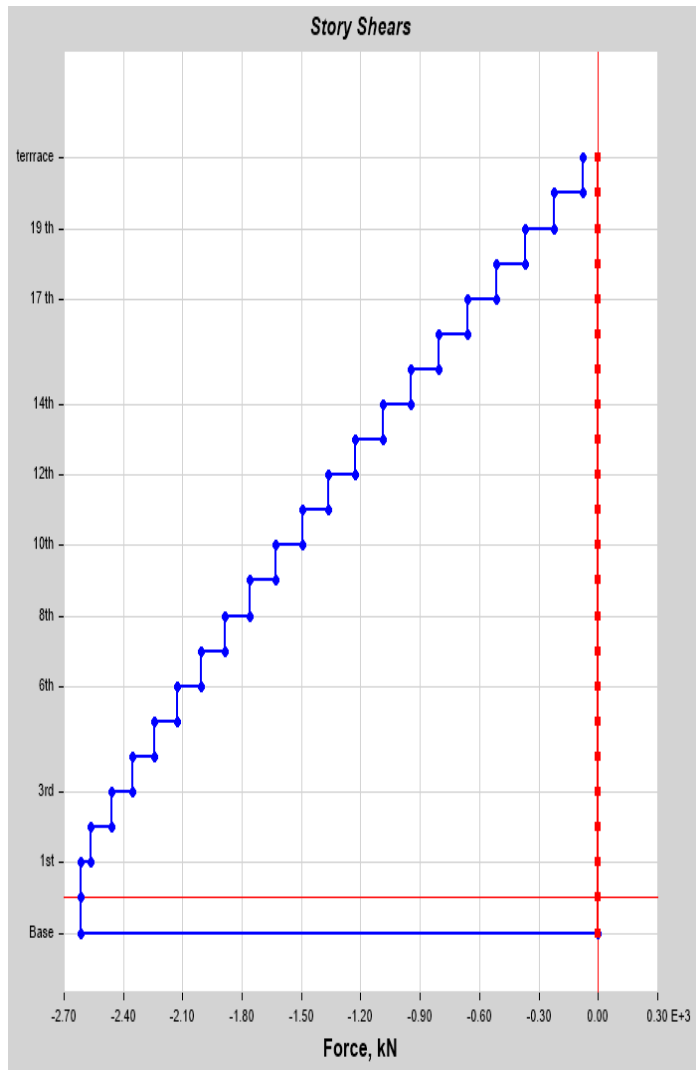
ZONE VI – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	40.17
20th	60	39.762
19th	57	39.242
18th	54	38.572
17th	51	37.734
16th	48	36.721
15th	45	35.53
14th	42	34.163
13th	39	32.62
12th	36	30.905
11th	33	29.02
10th	30	26.969
9th	27	24.757
8th	24	22.389
7th	21	19.875
6th	18	17.222
5th	15	14.448
4th	12	11.578
3rd	9	8.659
2nd	6	5.776
1st	3	3.101
g.f	0	0.964
Base	-3	0

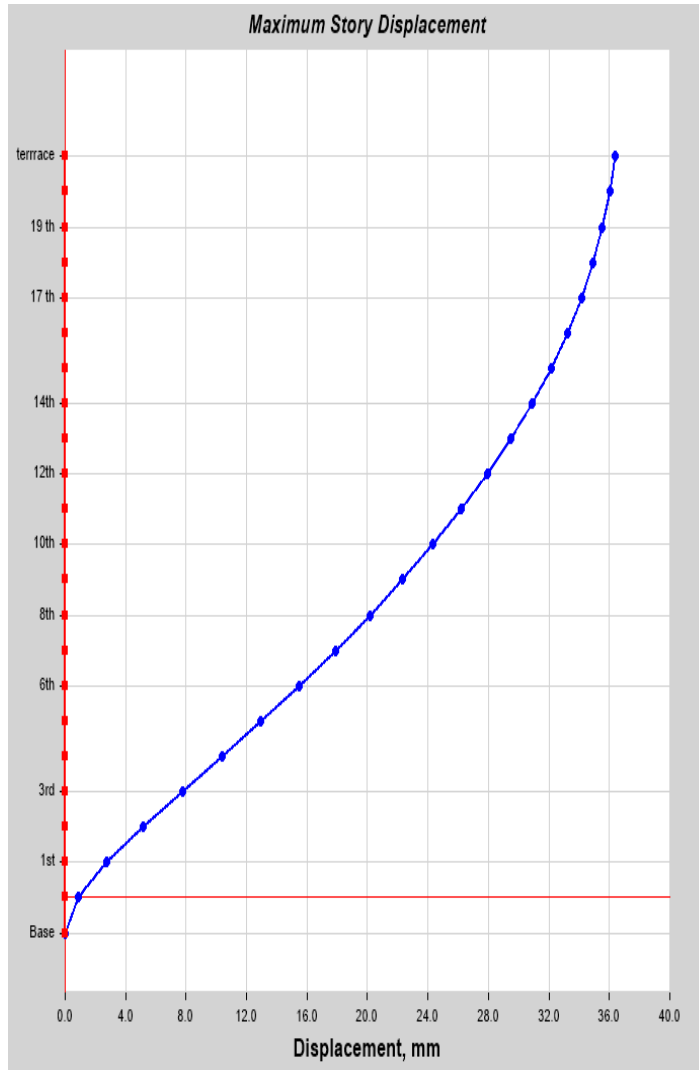


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000136
20th	60	0.000173
19th	57	0.000224
18th	54	0.000279
17th	51	0.000338
16th	48	0.000397
15th	45	0.000456
14th	42	0.000514
13th	39	0.000572
12th	36	0.000628
11th	33	0.000684
10th	30	0.000737
9th	27	0.000789
8th	24	0.000838
7th	21	0.000884
6th	18	0.000925
5th	15	0.000957
4th	12	0.000973
3rd	9	0.000961
2nd	6	0.000892
1st	3	0.000712
g.f	0	0.000321
Base	-3	0

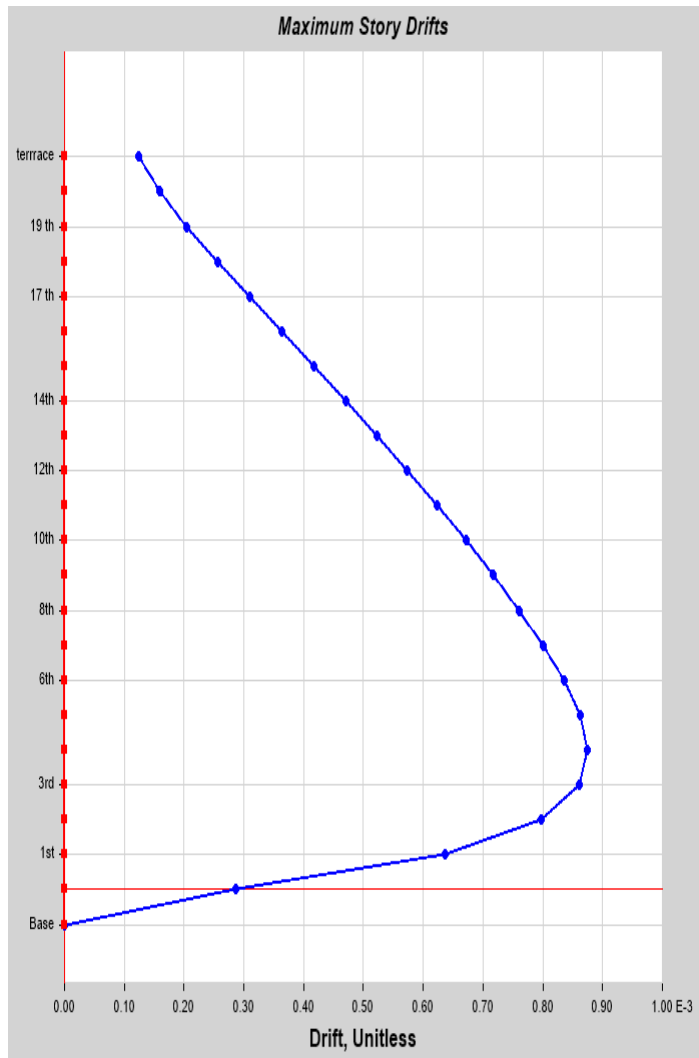


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	74.7
20th	60	223.09
19th	57	370.23
18th	54	516.37
17th	51	661.52
16th	48	805.18
15th	45	947.12
14th	42	1087.11
13th	39	1225.4
12th	36	1361.76
11th	33	1496.44
10th	30	1629.22
9th	27	1758.47
8th	24	1884.23
7th	21	2006.55
6th	18	2125.93
5th	15	2242.63
4th	12	2352.76
3rd	9	2458.61
2nd	6	2562.35
1st	3	2614.22
g.f	0	2614.22
Base	-3	0

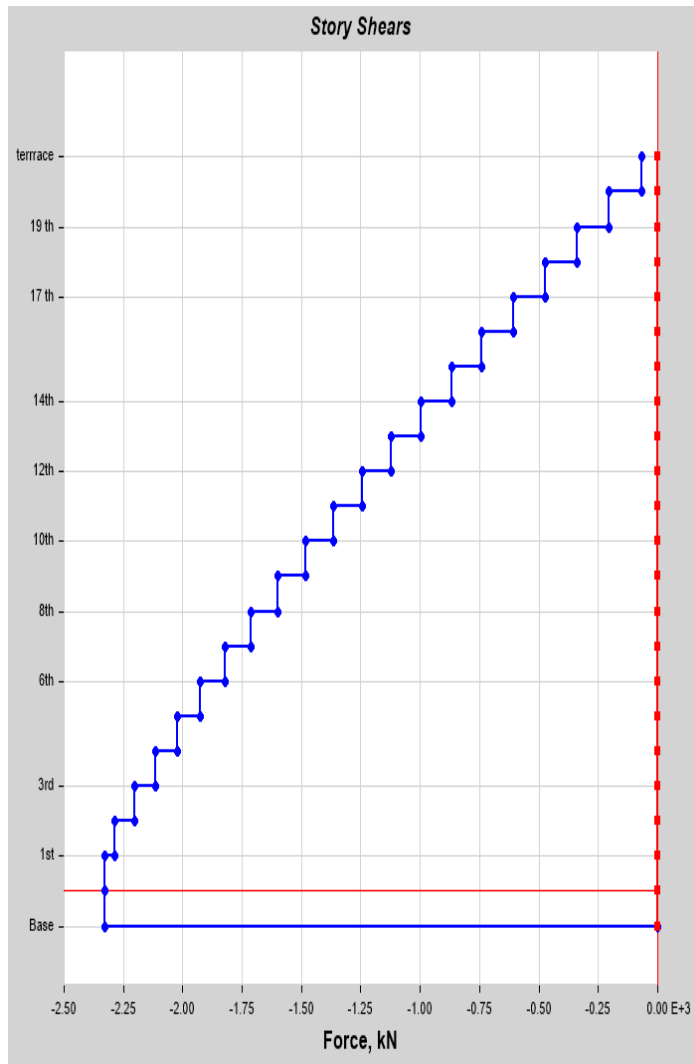
ZONE VI – TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	36.392
20th	60	36.019
19th	57	35.542
18th	54	34.926
17th	51	34.158
16th	48	33.229
15th	45	32.138
14th	42	30.885
13th	39	29.474
12th	36	27.907
11th	33	26.186
10th	30	24.317
9th	27	22.304
8th	24	20.152
7th	21	17.869
6th	18	15.466
5th	15	12.958
4th	12	10.371
3rd	9	7.746
2nd	6	5.163
1st	3	2.769
g.f	0	0.86
Base	-3	0

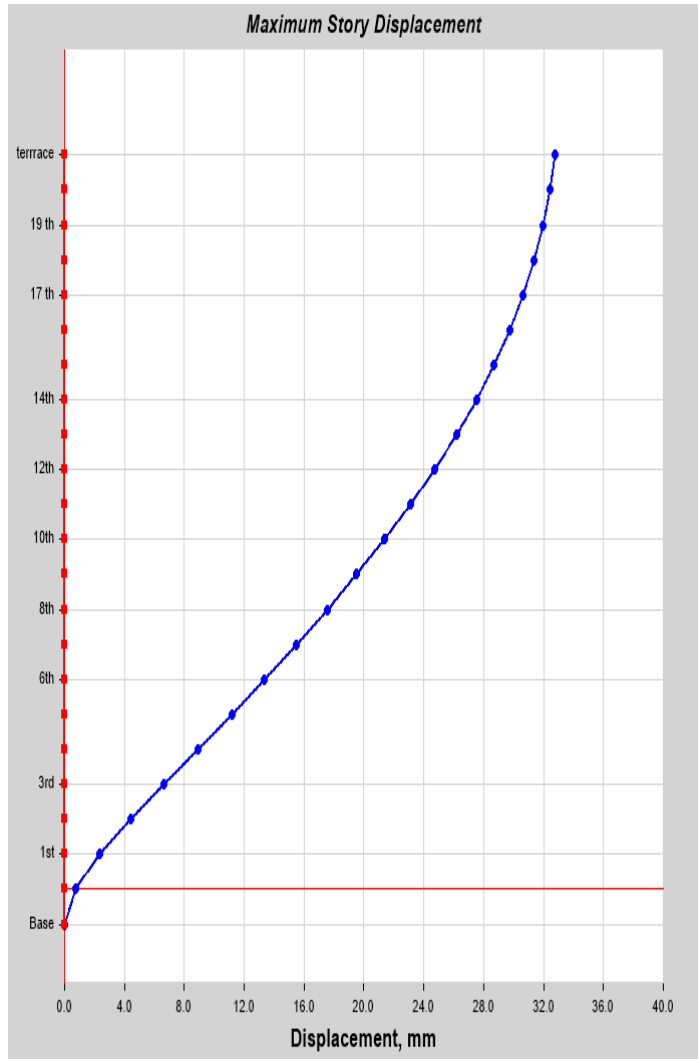


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000124
20th	60	0.000159
19th	57	0.000205
18th	54	0.000256
17th	51	0.00031
16th	48	0.000364
15th	45	0.000417
14th	42	0.00047
13th	39	0.000522
12th	36	0.000573
11th	33	0.000623
10th	30	0.000671
9th	27	0.000717
8th	24	0.000761
7th	21	0.000801
6th	18	0.000836
5th	15	0.000862
4th	12	0.000875
3rd	9	0.000861
2nd	6	0.000798
1st	3	0.000636
g.f	0	0.000287
Base	-3	0

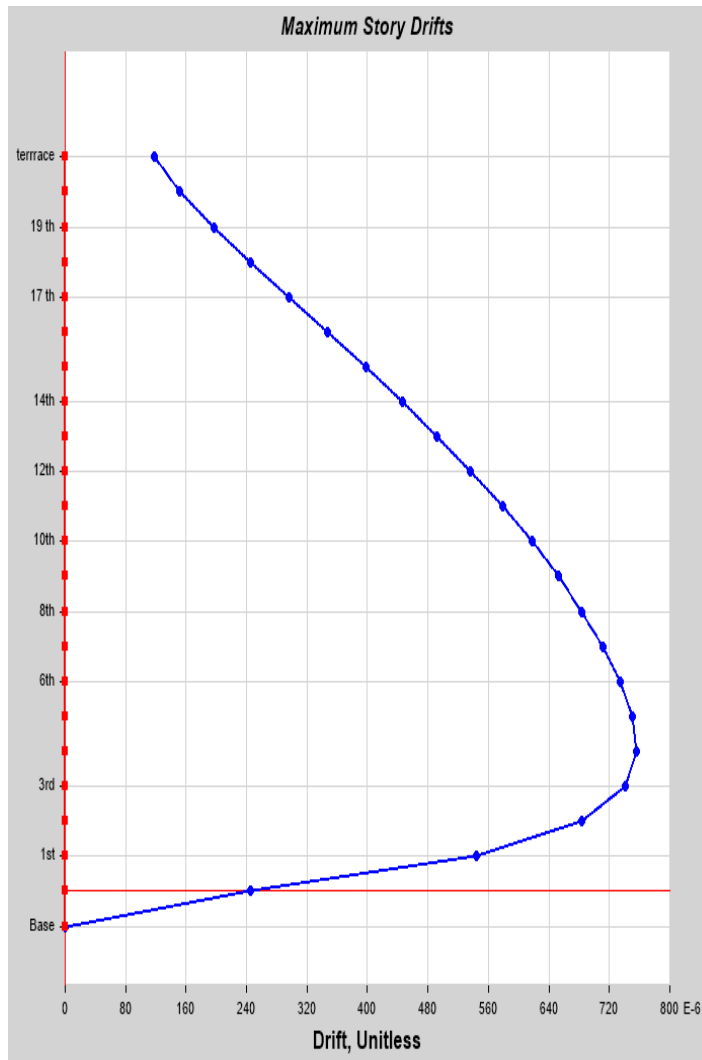


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	68.9
20th	60	205.5
19th	57	340.9
18th	54	475.11
17th	51	608.13
16th	48	739.49
15th	45	868.74
14th	42	995.89
13th	39	1120.96
12th	36	1243.97
11th	33	1364.93
10th	30	1483.86
9th	27	1599.45
8th	24	1711.75
7th	21	1820.8
6th	18	1924.54
5th	15	2022.09
4th	12	2113.64
3rd	9	2201.3
2nd	6	2287.04
1st	3	2329.81
g.f	0	2329.81
Base	-3	0

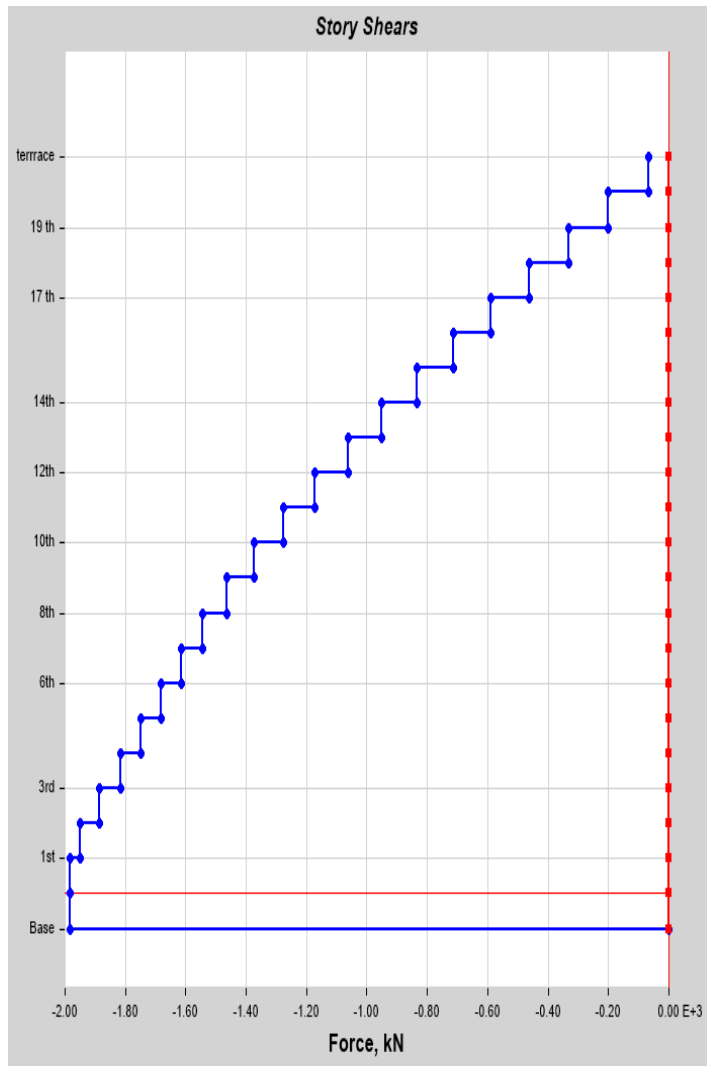
ZONE VI – TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	32.774
20th	60	32.419
19th	57	31.963
18th	54	31.374
17th	51	30.637
16th	48	29.748
15th	45	28.705
14th	42	27.512
13th	39	26.175
12th	36	24.699
11th	33	23.089
10th	30	21.355
9th	27	19.503
8th	24	17.545
7th	21	15.492
6th	18	13.359
5th	15	11.157
4th	12	8.905
3rd	9	6.638
2nd	6	4.416
1st	3	2.365
g.f	0	0.734
Base	-3	0



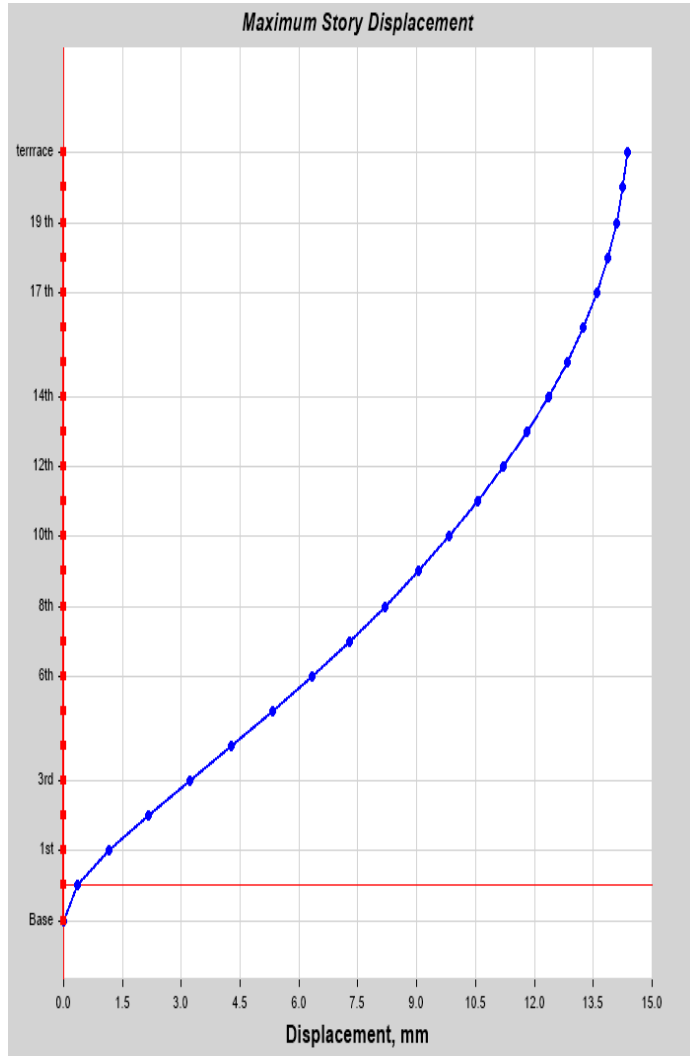
Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000118
20th	60	0.000152
19th	57	0.000196
18th	54	0.000246
17th	51	0.000297
16th	48	0.000348
15th	45	0.000397
14th	42	0.000446
13th	39	0.000492
12th	36	0.000536
11th	33	0.000578
10th	30	0.000617
9th	27	0.000653
8th	24	0.000684
7th	21	0.000711
6th	18	0.000734
5th	15	0.00075
4th	12	0.000756
3rd	9	0.000741
2nd	6	0.000683
1st	3	0.000544
g.f	0	0.000245
Base	-3	0



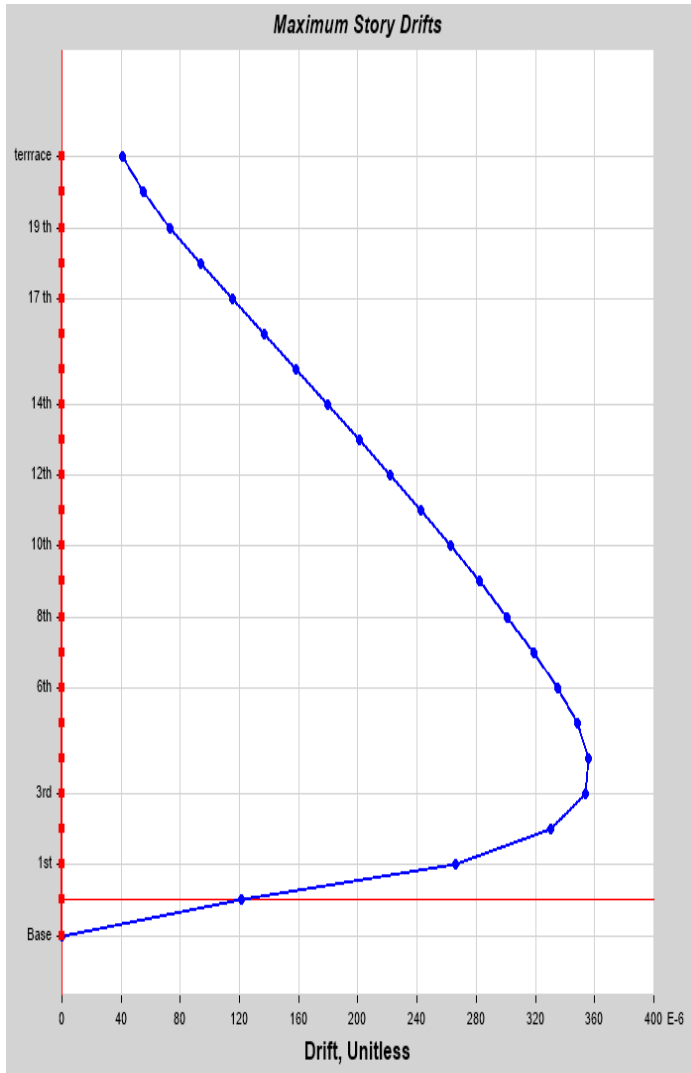
Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	67.1
20th	60	199.88
19th	57	331.24
18th	54	461.19
17th	51	589.74
16th	48	714.81
15th	45	835.32
14th	42	951.58
13th	39	1063.44
12th	36	1171.2
11th	33	1274.73
10th	30	1374.33
9th	27	1463.73
8th	24	1543.48
7th	21	1614.13
6th	18	1681.87
5th	15	1749.61
4th	12	1817.35
3rd	9	1885.09
2nd	6	1951.15
1st	3	1983.35
g.f	0	1983.35
Base	-3	0

RECTANGLE

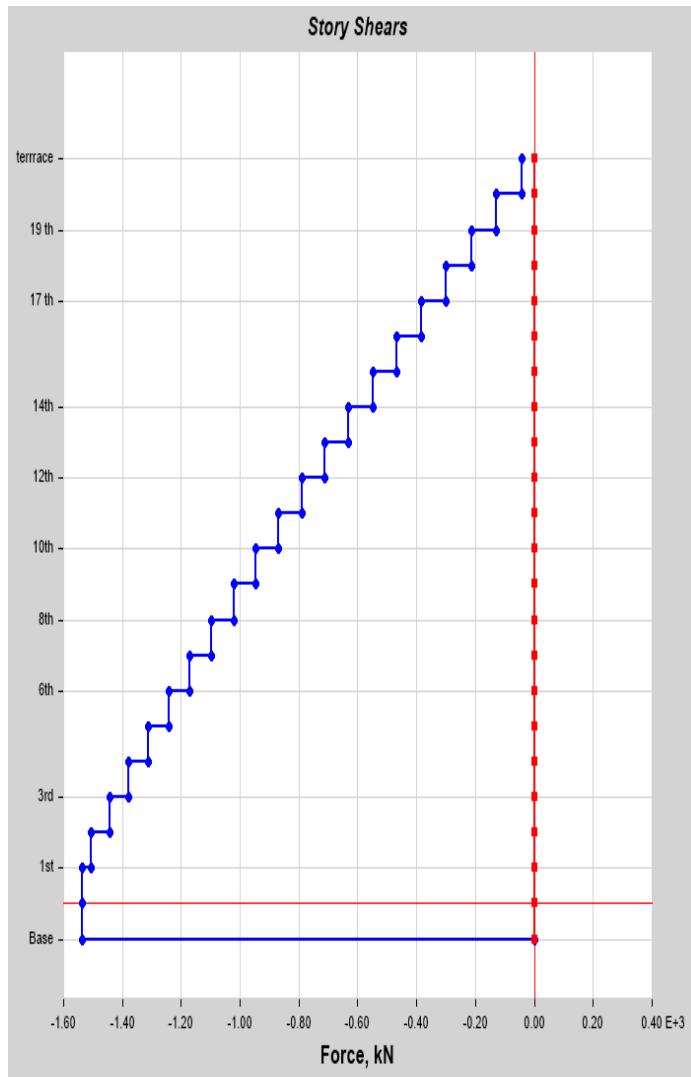
ZONE I – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	14.377
20th	60	14.255
19th	57	14.091
18th	54	13.872
17th	51	13.591
16th	48	13.246
15th	45	12.836
14th	42	12.361
13th	39	11.821
12th	36	11.218
11th	33	10.552
10th	30	9.825
9th	27	9.037
8th	24	8.191
7th	21	7.288
6th	18	6.332
5th	15	5.327
4th	12	4.282
3rd	9	3.214
2nd	6	2.154
1st	3	1.162
g.f	0	0.363
Base	-3	0

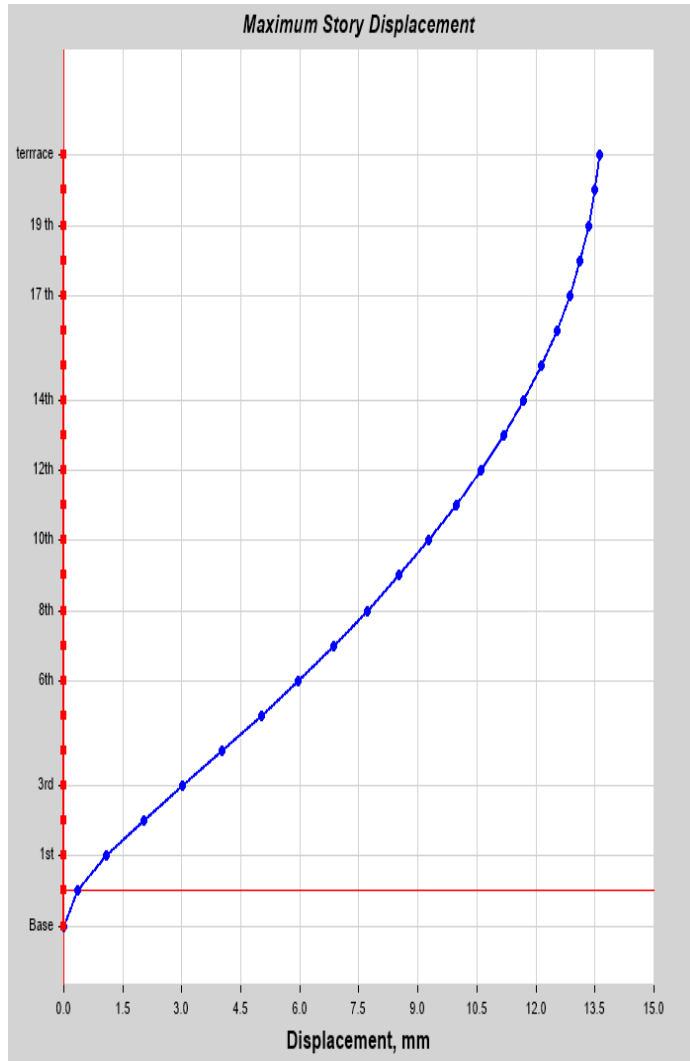


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000041
20th	60	0.000055
19th	57	0.000073
18th	54	0.000094
17th	51	0.000115
16th	48	0.000137
15th	45	0.000158
14th	42	0.00018
13th	39	0.000201
12th	36	0.000222
11th	33	0.000242
10th	30	0.000263
9th	27	0.000282
8th	24	0.000301
7th	21	0.000319
6th	18	0.000335
5th	15	0.000348
4th	12	0.000356
3rd	9	0.000354
2nd	6	0.000331
1st	3	0.000266
g.f	0	0.000121
Base	-3	0

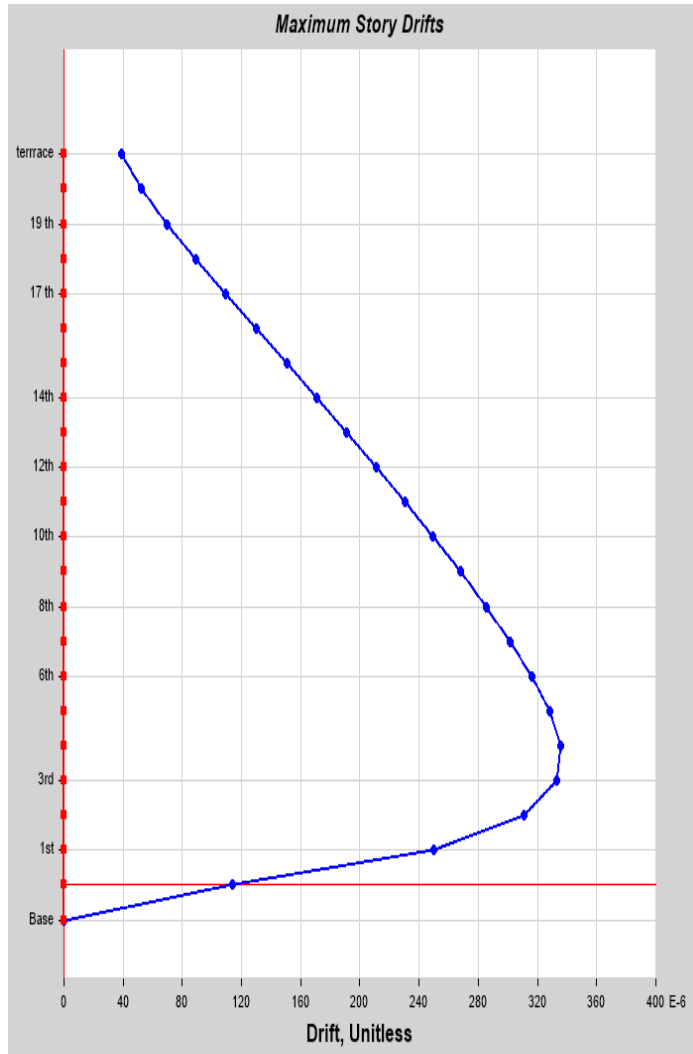


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	43.13
20th	60	128.96
19th	57	214.22
18th	54	299.06
17th	51	383.34
16th	48	466.78
15th	45	549.24
14th	42	630.6
13th	39	710.86
12th	36	790.16
11th	33	868.51
10th	30	945.78
9th	27	1021.85
8th	24	1096.72
7th	21	1170.41
6th	18	1242.14
5th	15	1311.56
4th	12	1377.96
3rd	9	1442.38
2nd	6	1505.58
1st	3	1536.57
g.f	0	1536.57
Base	-3	0

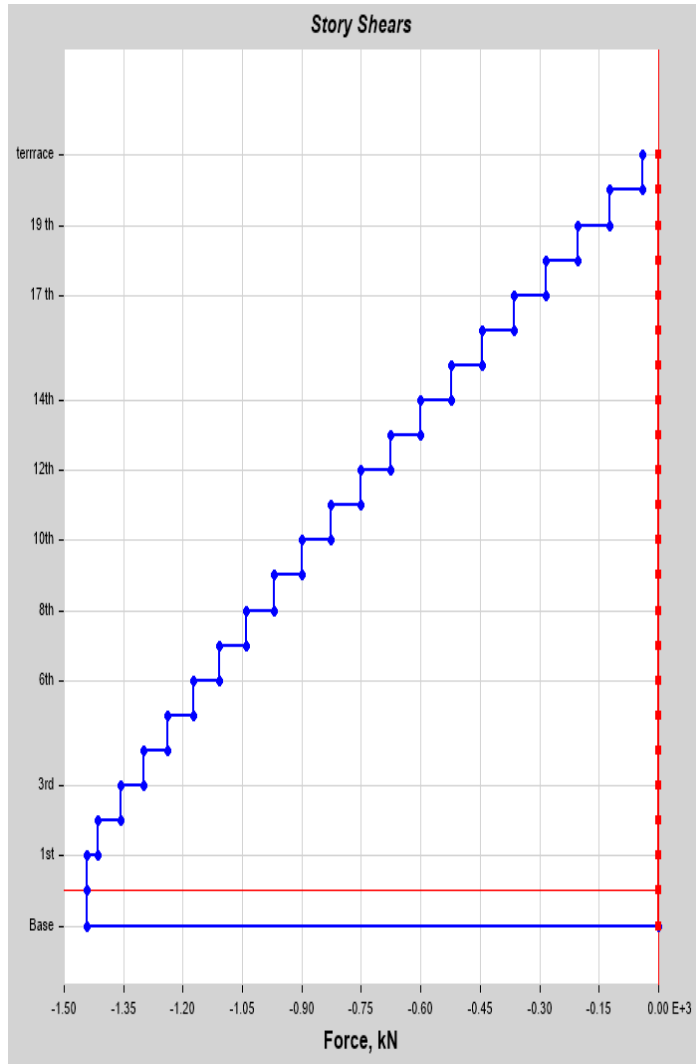
ZONE I – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	13.608
20th	60	13.492
19th	57	13.336
18th	54	13.127
17th	51	12.859
16th	48	12.531
15th	45	12.14
14th	42	11.688
13th	39	11.175
12th	36	10.601
11th	33	9.968
10th	30	9.277
9th	27	8.529
8th	24	7.726
7th	21	6.87
6th	18	5.965
5th	15	5.015
4th	12	4.03
3rd	9	3.023
2nd	6	2.025
1st	3	1.092
g.f	0	0.342
Base	-3	0

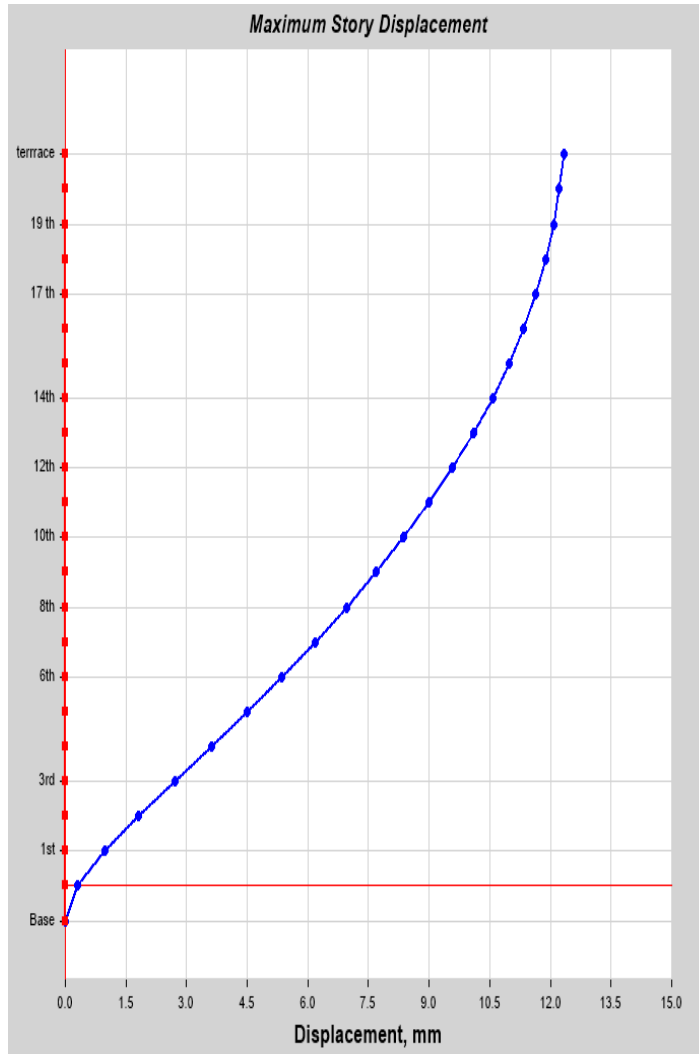


Storey	Elevation (m)	X-Dir
terrace	63	0.000039
20th	60	0.000052
19th	57	0.00007
18th	54	0.000089
17th	51	0.00011
16th	48	0.00013
15th	45	0.000151
14th	42	0.000171
13th	39	0.000191
12th	36	0.000211
11th	33	0.00023
10th	30	0.000249
9th	27	0.000268
8th	24	0.000285
7th	21	0.000302
6th	18	0.000316
5th	15	0.000329
4th	12	0.000336
3rd	9	0.000333
2nd	6	0.000311
1st	3	0.00025
g.f	0	0.000114
Base	-3	0

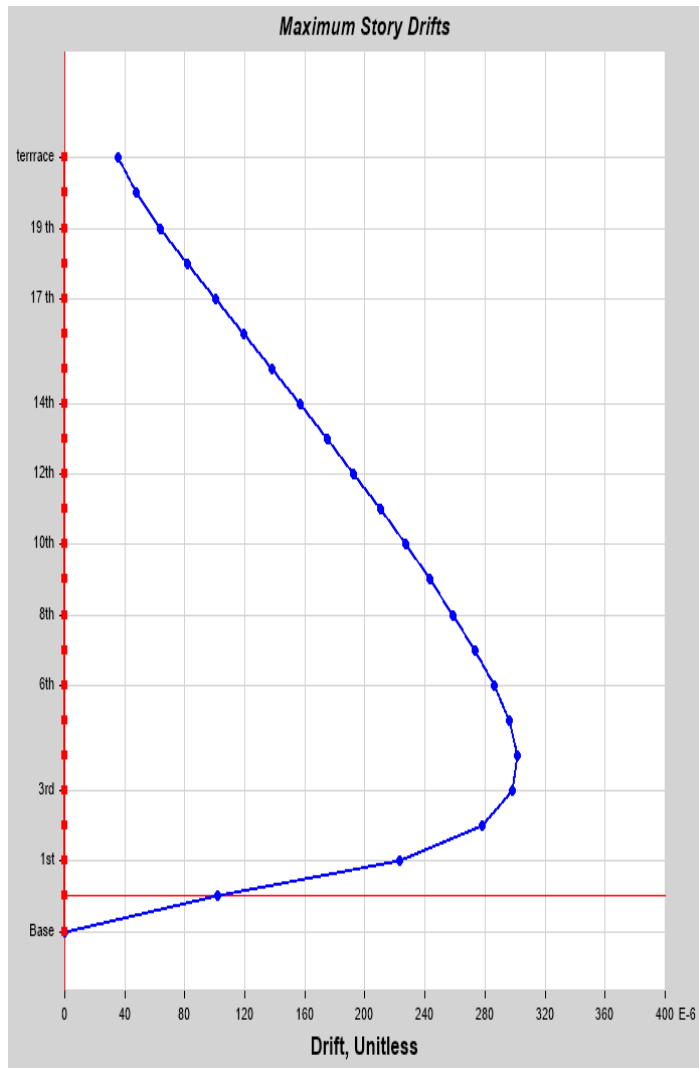


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	41.23
20th	60	123.14
19th	57	204.36
18th	54	285.03
17th	51	365.15
16th	48	444.45
15th	45	522.8
14th	42	600.07
13th	39	676.02
12th	36	751.68
11th	33	826.02
10th	30	899.31
9th	27	970.65
8th	24	1040.07
7th	21	1107.59
6th	18	1173.49
5th	15	1237.91
4th	12	1298.7
3rd	9	1357.13
2nd	6	1414.4
1st	3	1443.03
g.f	0	1443.03
Base	-3	0

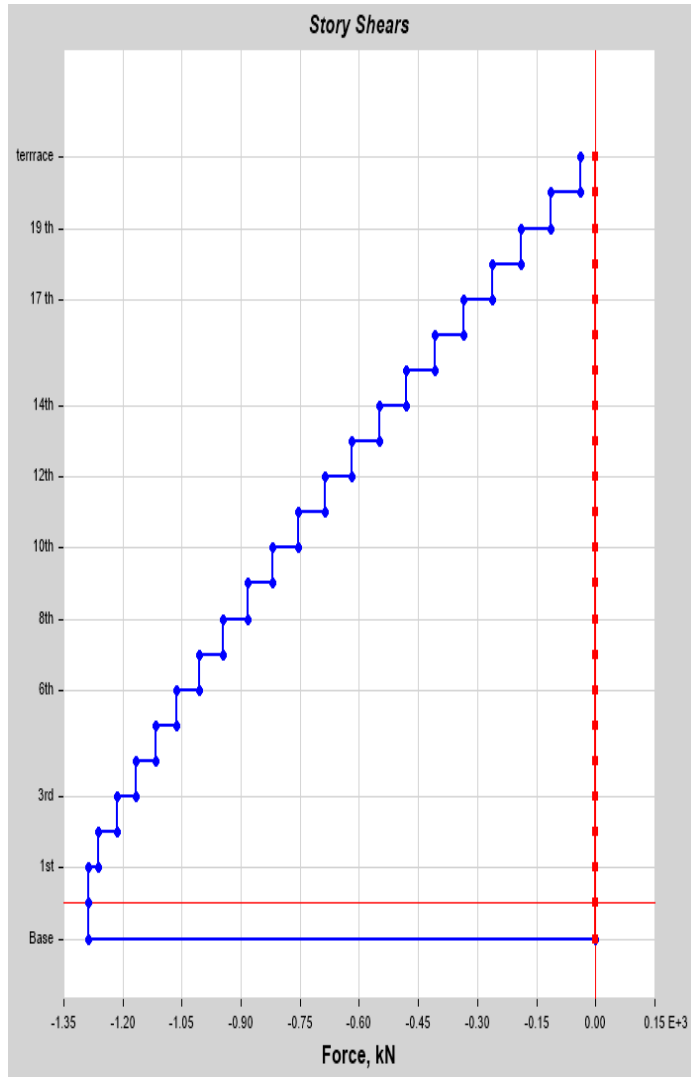
ZONE I – TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	12.326
20th	60	12.22
19th	57	12.076
18th	54	11.885
17th	51	11.639
16th	48	11.338
15th	45	10.98
14th	42	10.566
13th	39	10.096
12th	36	9.572
11th	33	8.994
10th	30	8.364
9th	27	7.683
8th	24	6.952
7th	21	6.176
6th	18	5.356
5th	15	4.498
4th	12	3.609
3rd	9	2.704
2nd	6	1.809
1st	3	0.975
g.f	0	0.305
Base	-3	0

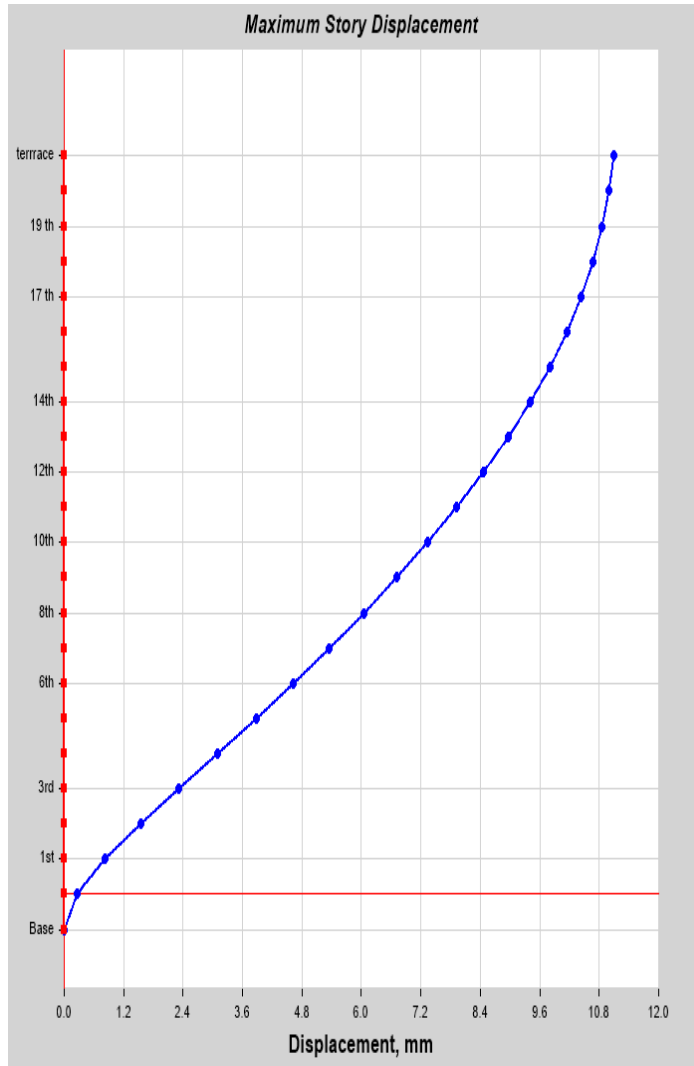


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000036
20th	60	0.000048
19th	57	0.000064
18th	54	0.000082
17th	51	0.0001
16th	48	0.000119
15th	45	0.000138
14th	42	0.000157
13th	39	0.000175
12th	36	0.000193
11th	33	0.00021
10th	30	0.000227
9th	27	0.000243
8th	24	0.000259
7th	21	0.000273
6th	18	0.000286
5th	15	0.000296
4th	12	0.000302
3rd	9	0.000298
2nd	6	0.000278
1st	3	0.000223
g.f	0	0.000102
Base	-3	0

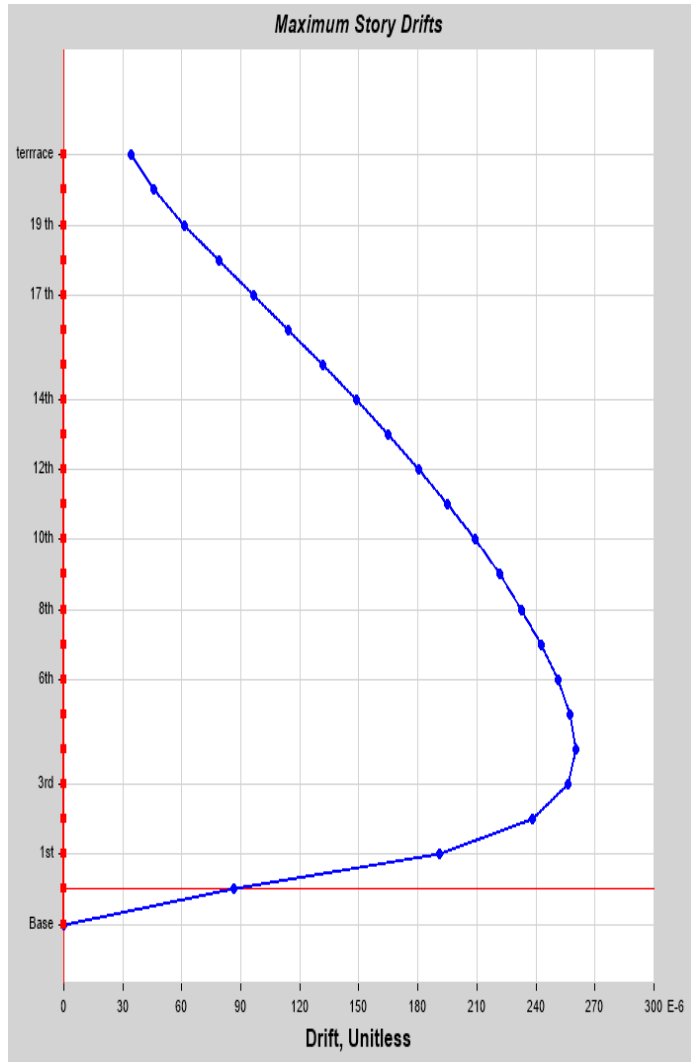


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	38.03
20th	60	113.43
19th	57	188.17
18th	54	262.25
17th	51	335.68
16th	48	408.19
15th	45	479.53
14th	42	549.72
13th	39	618.76
12th	36	686.66
11th	33	753.43
10th	30	819.08
9th	27	882.89
8th	24	944.88
7th	21	1005.08
6th	18	1062.35
5th	15	1116.2
4th	12	1166.74
3rd	9	1215.13
2nd	6	1262.46
1st	3	1286.07
g.f	0	1286.07
Base	-3	

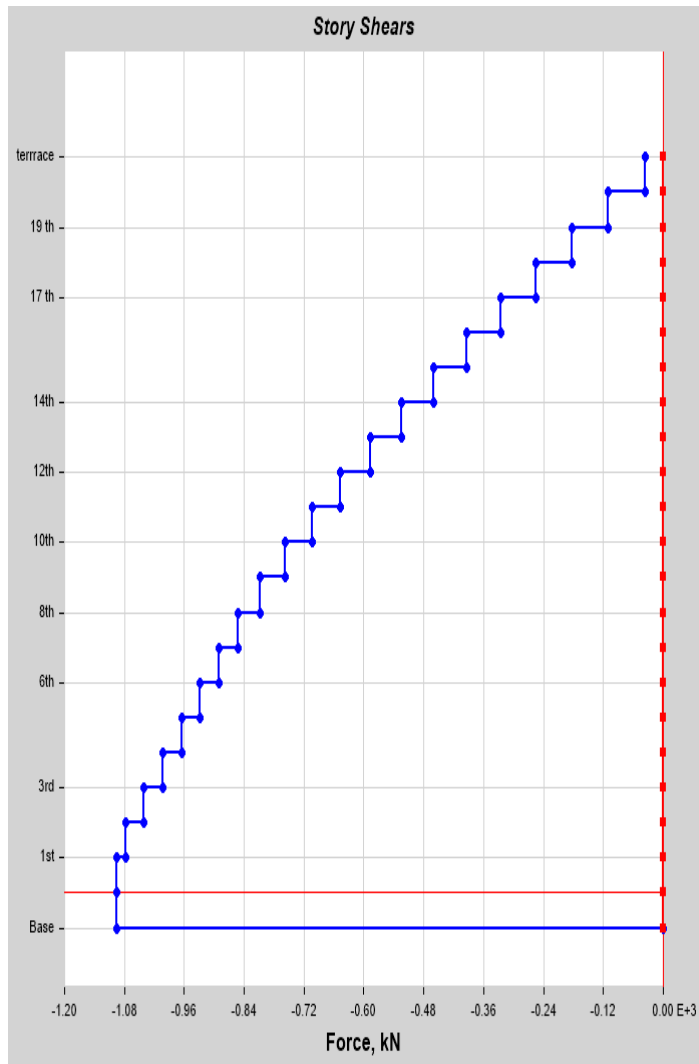
ZONE I – TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	11.094
20th	60	10.992
19th	57	10.854
18th	54	10.67
17th	51	10.434
16th	48	10.144
15th	45	9.801
14th	42	9.406
13th	39	8.96
12th	36	8.466
11th	33	7.925
10th	30	7.34
9th	27	6.713
8th	24	6.049
7th	21	5.35
6th	18	4.623
5th	15	3.87
4th	12	3.097
3rd	9	2.316
2nd	6	1.547
1st	3	0.833
g.f	0	0.26
Base	-3	0

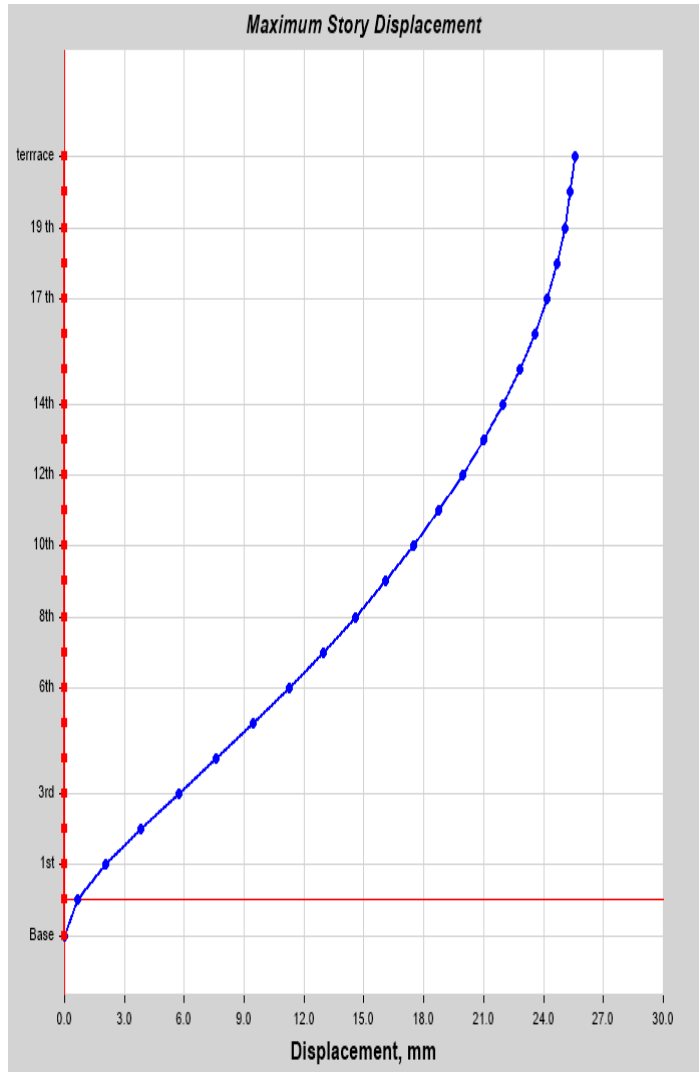


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000034
20th	60	0.000046
19th	57	0.000061
18th	54	0.000079
17th	51	0.000097
16th	48	0.000114
15th	45	0.000132
14th	42	0.000149
13th	39	0.000165
12th	36	0.00018
11th	33	0.000195
10th	30	0.000209
9th	27	0.000221
8th	24	0.000233
7th	21	0.000243
6th	18	0.000251
5th	15	0.000258
4th	12	0.00026
3rd	9	0.000256
2nd	6	0.000238
1st	3	0.000191
g.f	0	0.000087
Base	-3	0

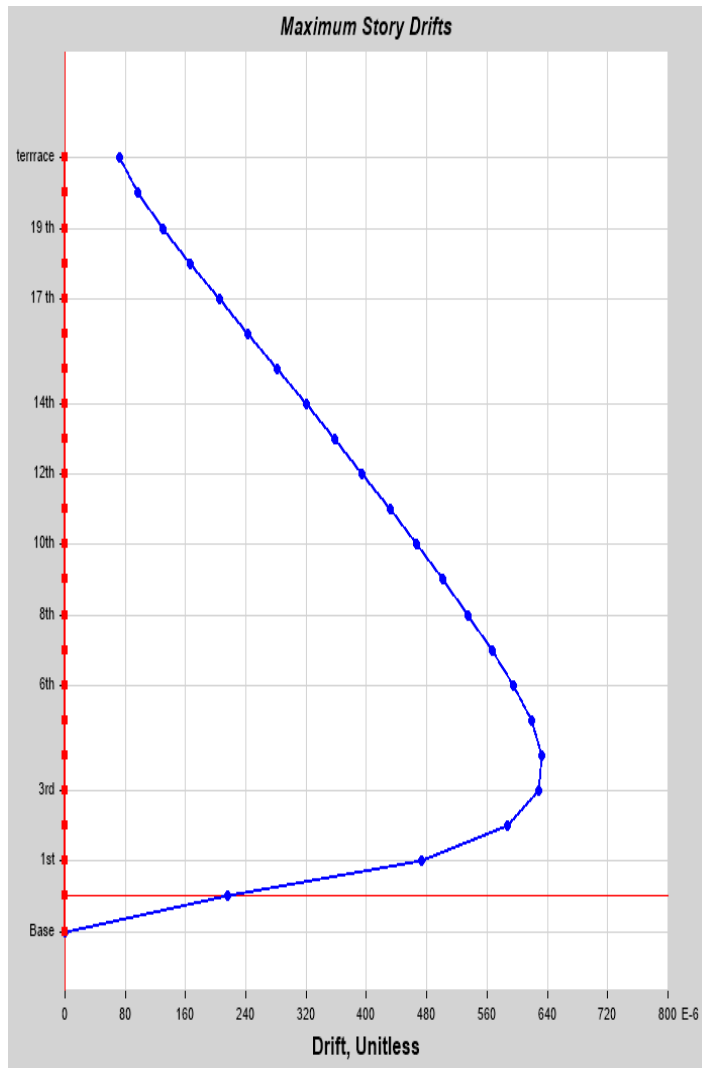


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	37.04
20th	60	110.33
19th	57	182.84
18th	54	254.57
17th	51	325.53
16th	48	394.57
15th	45	461.09
14th	42	525.26
13th	39	587.01
12th	36	646.5
11th	33	703.65
10th	30	758.63
9th	27	807.98
8th	24	852
7th	21	891
6th	18	928.39
5th	15	965.78
4th	12	1003.17
3rd	9	1040.56
2nd	6	1077.03
1st	3	1094.8
g.f	0	1094.8
Base	-3	0

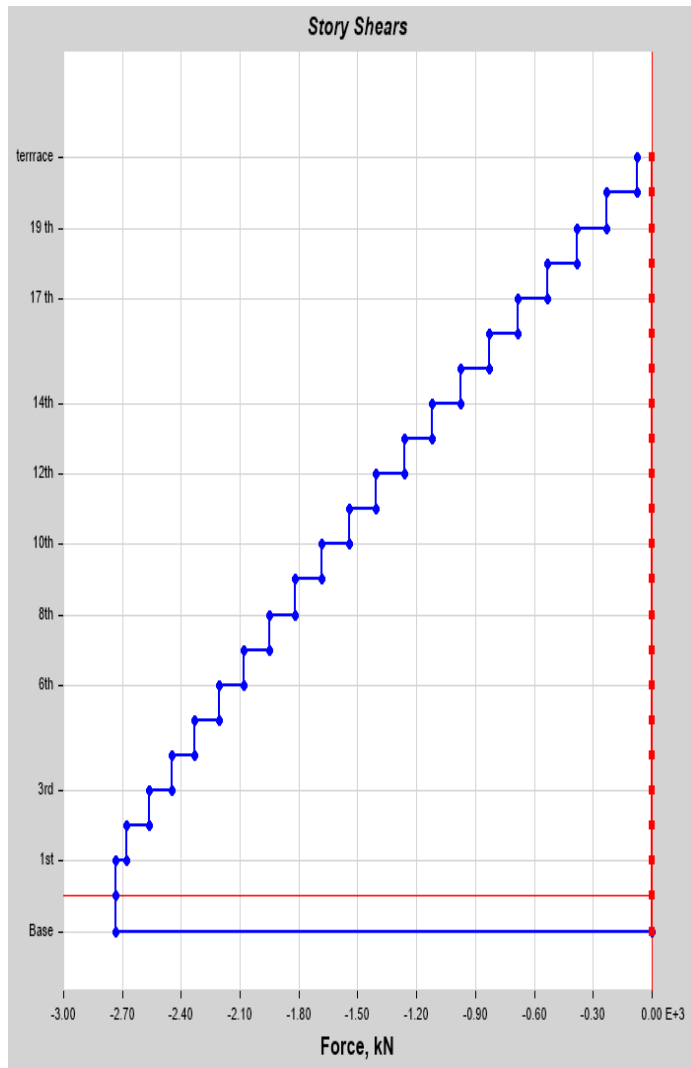
ZONE III – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	25.559
20th	60	25.342
19th	57	25.051
18th	54	24.661
17th	51	24.162
16th	48	23.549
15th	45	22.819
14th	42	21.975
13th	39	21.015
12th	36	19.943
11th	33	18.759
10th	30	17.466
9th	27	16.066
8th	24	14.561
7th	21	12.956
6th	18	11.256
5th	15	9.47
4th	12	7.613
3rd	9	5.714
2nd	6	3.829
1st	3	2.066
g.f	0	0.646
Base	-3	0

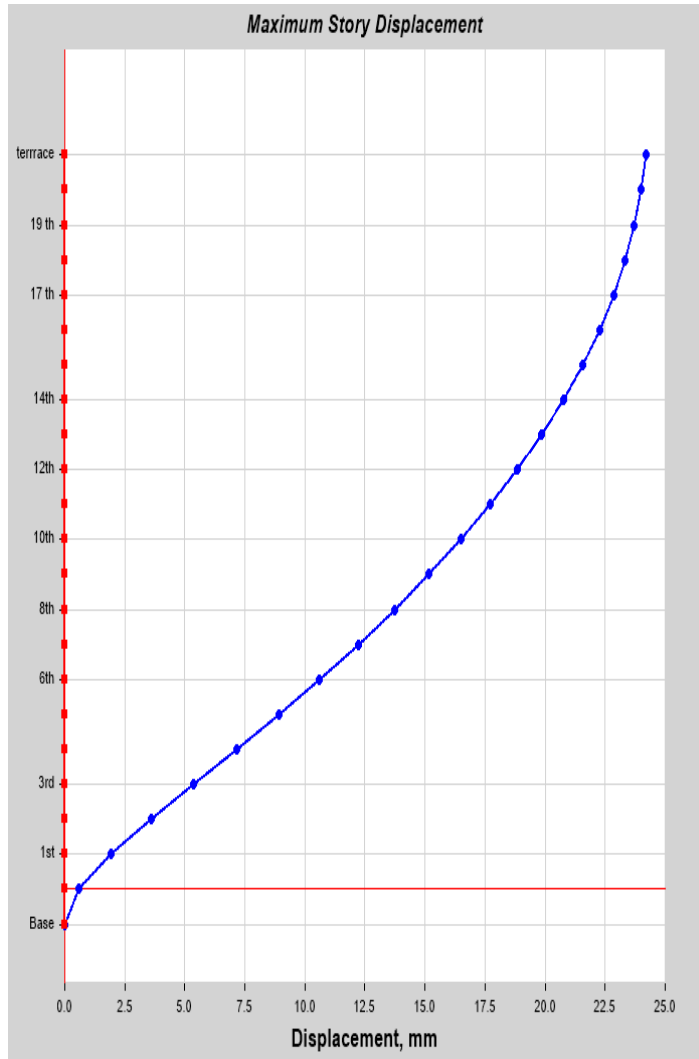


Storey	Elevation (m)	X-Dir
terrace	63	0.000072
20th	60	0.000097
19th	57	0.00013
18th	54	0.000166
17th	51	0.000204
16th	48	0.000243
15th	45	0.000282
14th	42	0.00032
13th	39	0.000357
12th	36	0.000395
11th	33	0.000431
10th	30	0.000467
9th	27	0.000502
8th	24	0.000535
7th	21	0.000567
6th	18	0.000595
5th	15	0.000619
4th	12	0.000633
3rd	9	0.000629
2nd	6	0.000588
1st	3	0.000473
g.f	0	0.000215
Base	-3	0

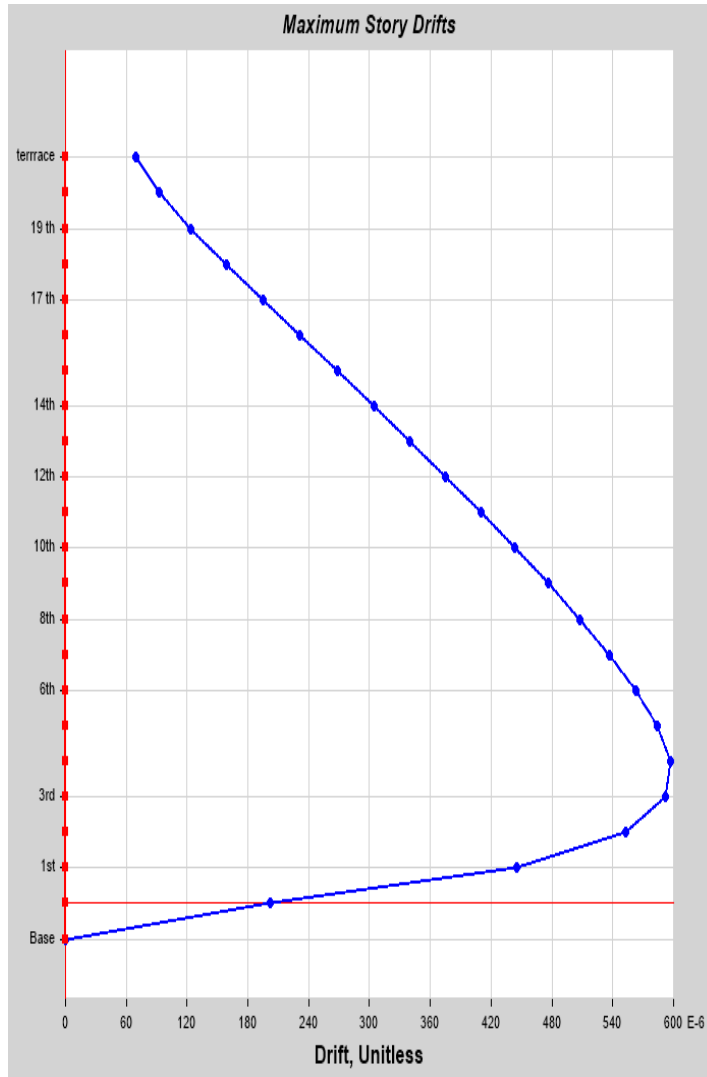


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	76.67
20th	60	229.26
19th	57	380.84
18th	54	531.67
17th	51	681.5
16th	48	829.84
15th	45	976.44
14th	42	1121.08
13th	39	1263.76
12th	36	1404.74
11th	33	1544.03
10th	30	1681.4
9th	27	1816.63
8th	24	1949.74
7th	21	2080.74
6th	18	2208.26
5th	15	2331.67
4th	12	2449.71
3rd	9	2564.23
2nd	6	2676.58
1st	3	2731.68
g.f	0	2731.68
Base	-3	0

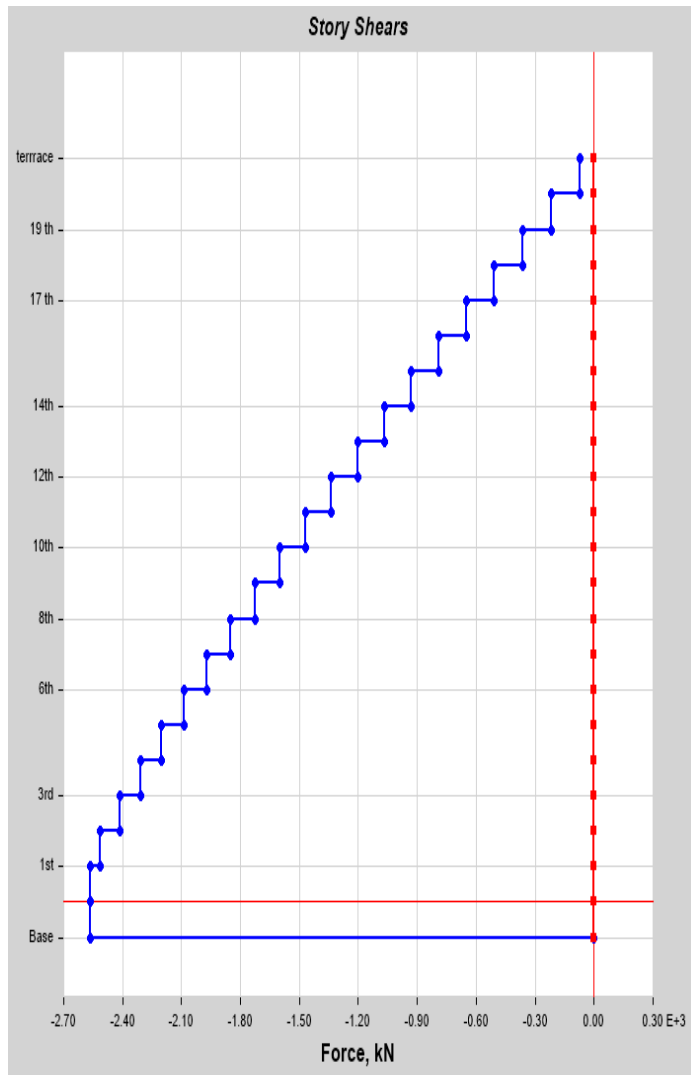
ZONE III – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	24.192
20th	60	23.985
19th	57	23.708
18th	54	23.336
17th	51	22.861
16th	48	22.277
15th	45	21.583
14th	42	20.779
13th	39	19.866
12th	36	18.847
11th	33	17.721
10th	30	16.492
9th	27	15.162
8th	24	13.734
7th	21	12.213
6th	18	10.604
5th	15	8.916
4th	12	7.164
3rd	9	5.374
2nd	6	3.599
1st	3	1.941
g.f	0	0.607
Base	-3	0

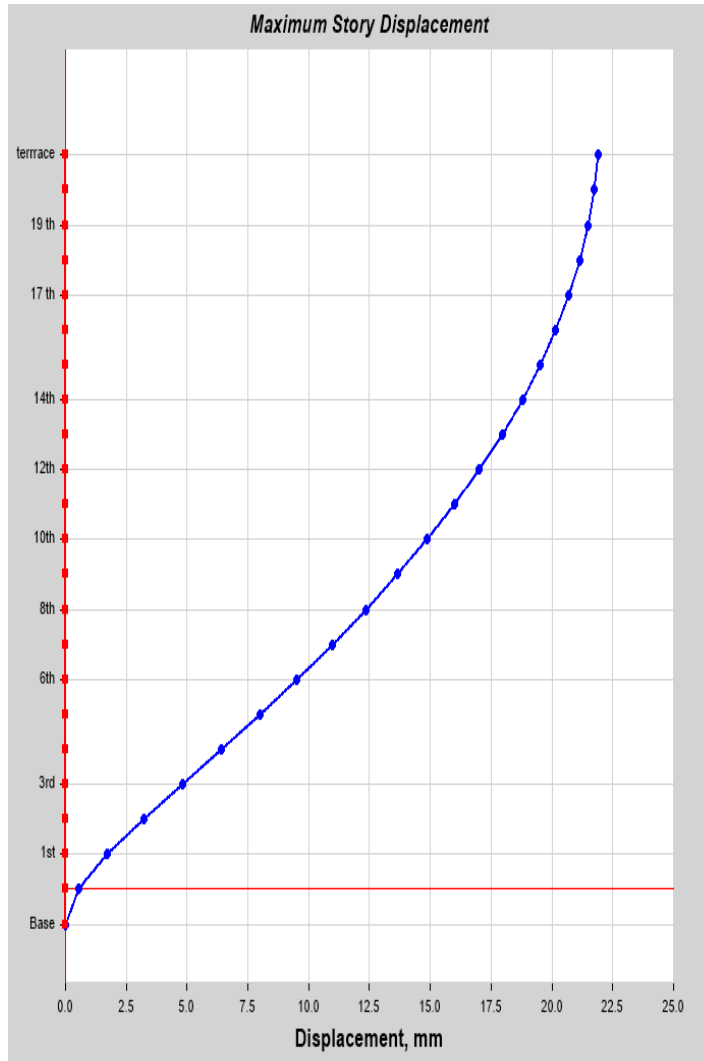


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000069
20th	60	0.000093
19th	57	0.000124
18th	54	0.000158
17th	51	0.000195
16th	48	0.000231
15th	45	0.000268
14th	42	0.000304
13th	39	0.00034
12th	36	0.000375
11th	33	0.00041
10th	30	0.000443
9th	27	0.000476
8th	24	0.000507
7th	21	0.000536
6th	18	0.000563
5th	15	0.000584
4th	12	0.000597
3rd	9	0.000592
2nd	6	0.000553
1st	3	0.000445
g.f	0	0.000202
Base	-3	0

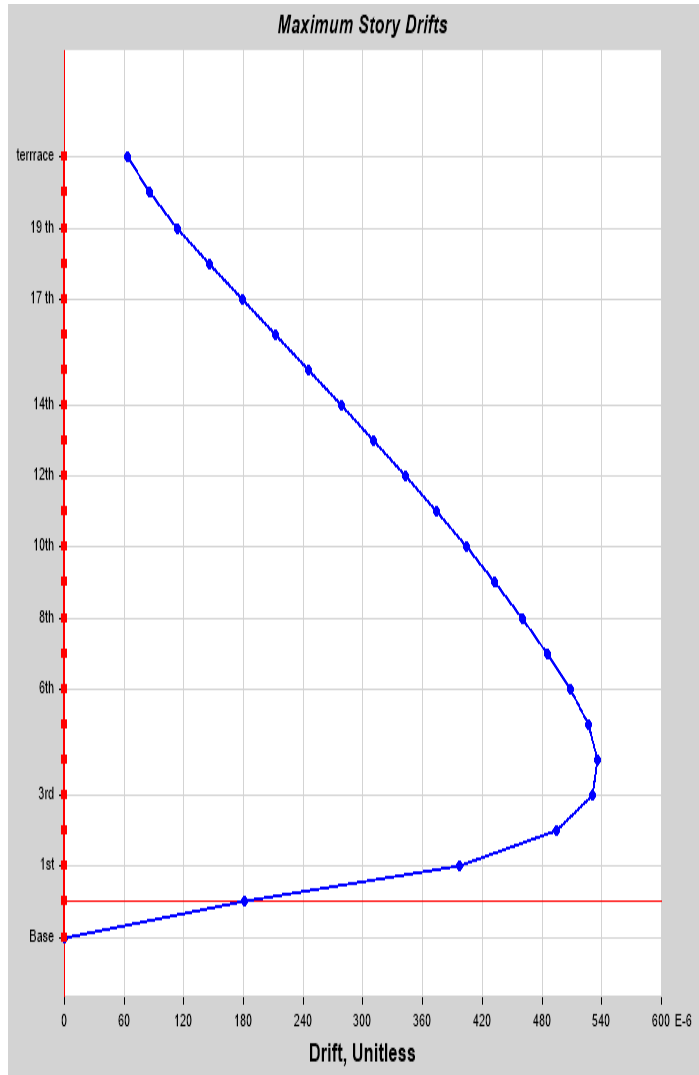


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	73.3
20th	60	218.92
19th	57	363.31
18th	54	506.72
17th	51	649.16
16th	48	790.14
15th	45	929.43
14th	42	1066.8
13th	39	1202.51
12th	36	1336.32
11th	33	1468.49
10th	30	1598.79
9th	27	1725.62
8th	24	1849.03
7th	21	1969.07
6th	18	2086.22
5th	15	2200.74
4th	12	2308.81
3rd	9	2412.68
2nd	6	2514.49
1st	3	2565.39
g.f	0	2565.39
Base	-3	0

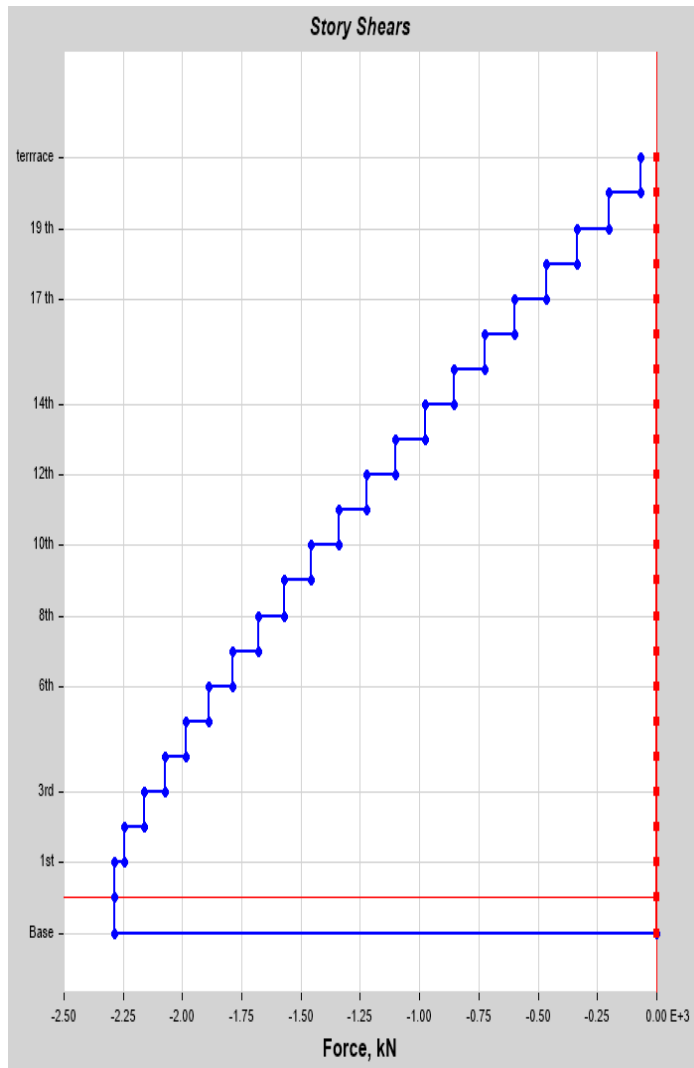
ZONE III – TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	21.914
20th	60	21.724
19th	57	21.469
18th	54	21.128
17th	51	20.692
16th	48	20.156
15th	45	19.519
14th	42	18.783
13th	39	17.948
12th	36	17.016
11th	33	15.989
10th	30	14.868
9th	27	13.658
8th	24	12.36
7th	21	10.979
6th	18	9.521
5th	15	7.996
4th	12	6.416
3rd	9	4.807
2nd	6	3.216
1st	3	1.733
g.f	0	0.542
Base	-3	0

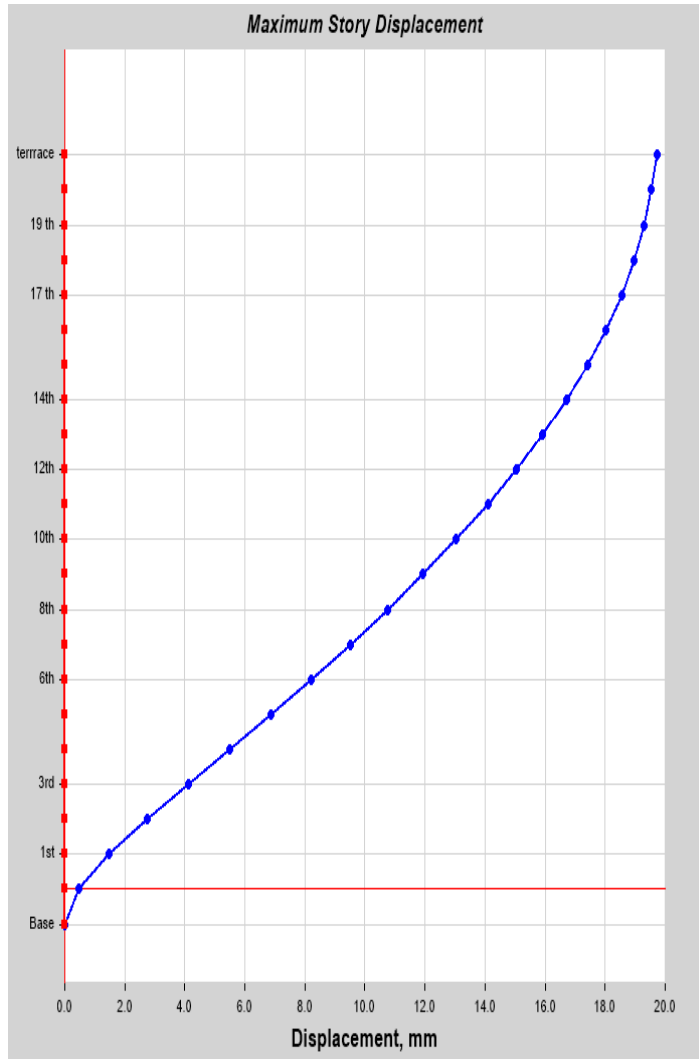


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000063
20th	60	0.000085
19th	57	0.000114
18th	54	0.000145
17th	51	0.000179
16th	48	0.000212
15th	45	0.000245
14th	42	0.000278
13th	39	0.000311
12th	36	0.000342
11th	33	0.000373
10th	30	0.000404
9th	27	0.000433
8th	24	0.00046
7th	21	0.000486
6th	18	0.000509
5th	15	0.000527
4th	12	0.000536
3rd	9	0.00053
2nd	6	0.000494
1st	3	0.000397
g.f	0	0.000181
Base	-3	0

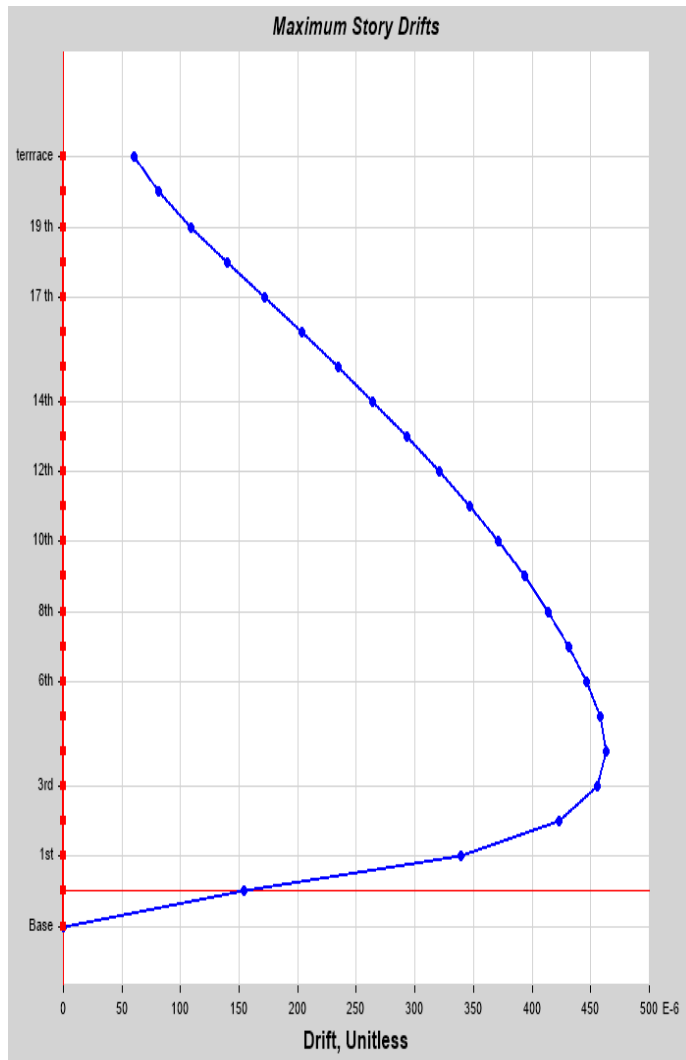


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	67.62
20th	60	201.67
19th	57	334.54
18th	54	466.24
17th	51	596.77
16th	48	725.68
15th	45	852.51
14th	42	977.29
13th	39	1100.03
12th	36	1220.74
11th	33	1339.44
10th	30	1456.15
9th	27	1569.58
8th	24	1679.78
7th	21	1786.79
6th	18	1888.6
5th	15	1984.33
4th	12	2074.17
3rd	9	2160.19
2nd	6	2244.33
1st	3	2286.31
g.f	0	2286.31
Base	-3	0

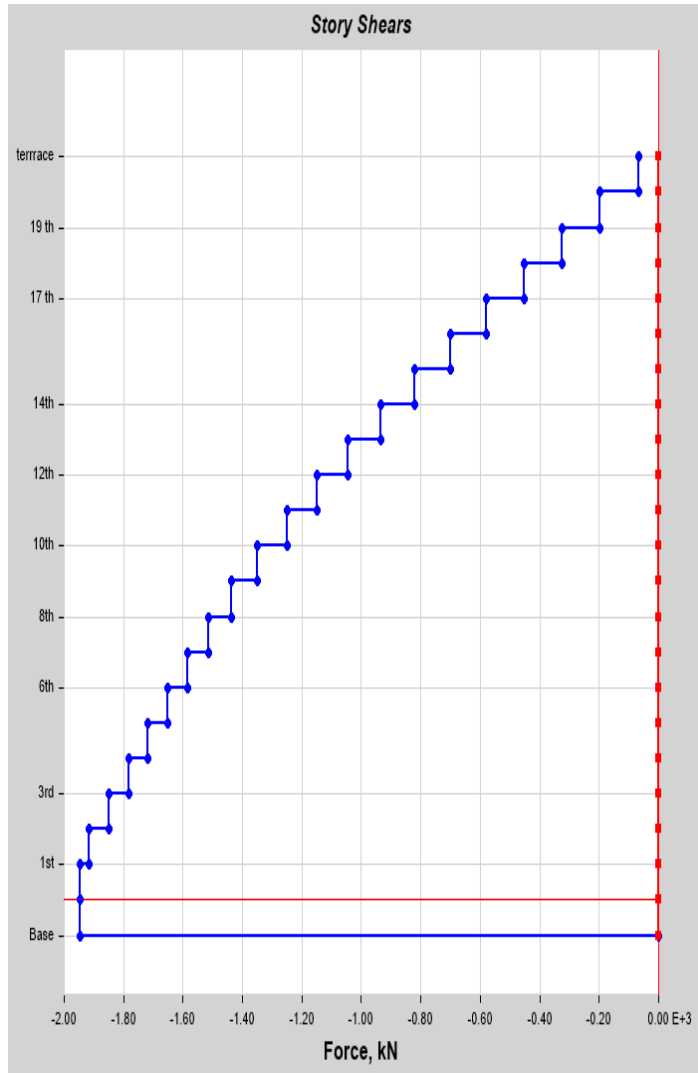
ZONE III – TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	19.722
20th	60	19.541
19th	57	19.296
18th	54	18.969
17th	51	18.549
16th	48	18.034
15th	45	17.425
14th	42	16.722
13th	39	15.93
12th	36	15.051
11th	33	14.089
10th	30	13.048
9th	27	11.934
8th	24	10.753
7th	21	9.512
6th	18	8.218
5th	15	6.879
4th	12	5.506
3rd	9	4.117
2nd	6	2.75
1st	3	1.48
g.f	0	0.462
Base	-3	0

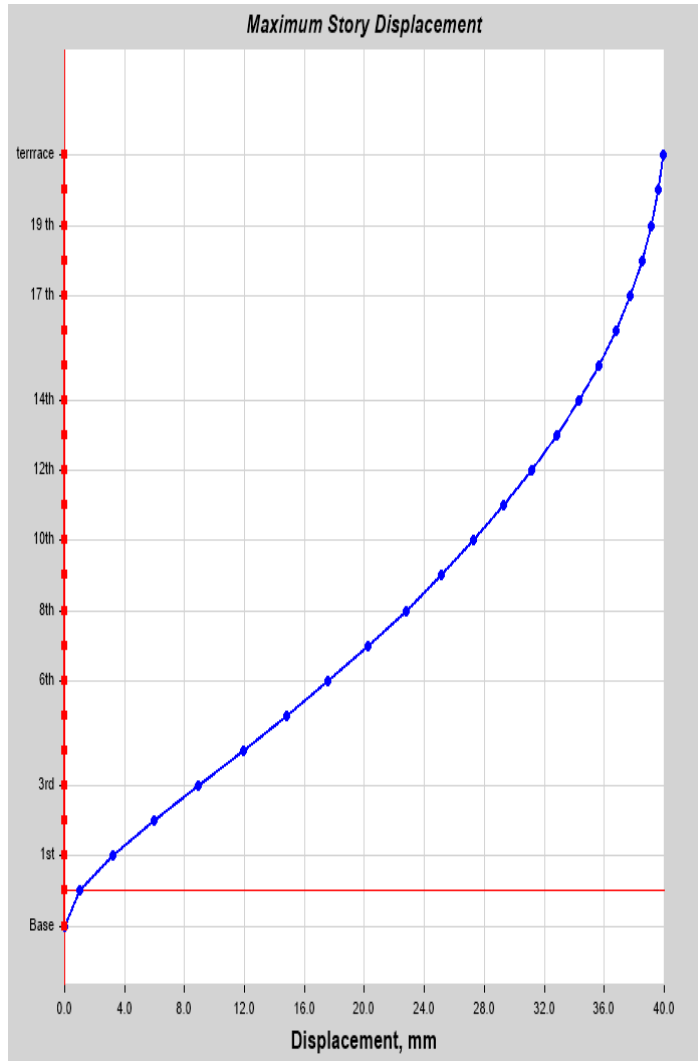


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.00006
20th	60	0.000082
19th	57	0.000109
18th	54	0.00014
17th	51	0.000172
16th	48	0.000203
15th	45	0.000234
14th	42	0.000264
13th	39	0.000293
12th	36	0.000321
11th	33	0.000347
10th	30	0.000371
9th	27	0.000394
8th	24	0.000414
7th	21	0.000431
6th	18	0.000446
5th	15	0.000458
4th	12	0.000463
3rd	9	0.000456
2nd	6	0.000423
1st	3	0.000339
g.f	0	0.000154
Base	-3	0

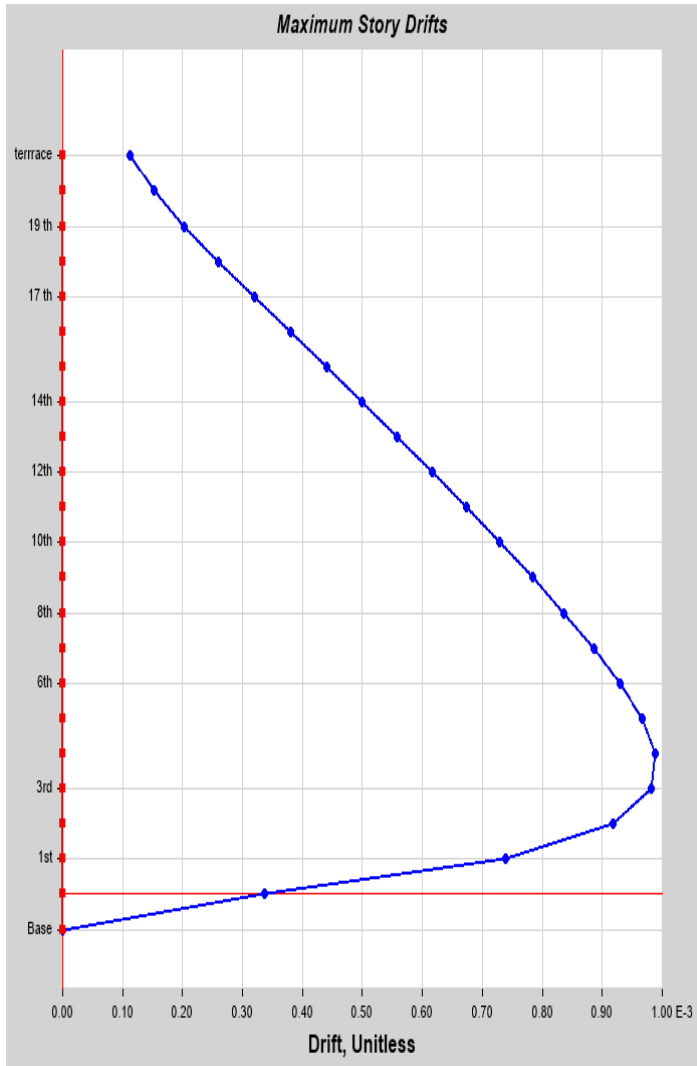


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	65.85
20th	60	196.15
19th	57	325.06
18th	54	452.58
17th	51	578.73
16th	48	701.47
15th	45	819.73
14th	42	933.82
13th	39	1043.59
12th	36	1149.34
11th	33	1250.94
10th	30	1348.68
9th	27	1436.41
8th	24	1514.67
7th	21	1584.01
6th	18	1650.49
5th	15	1716.97
4th	12	1783.45
3rd	9	1849.93
2nd	6	1914.76
1st	3	1946.36
g.f	0	1946.36
Base	-3	0

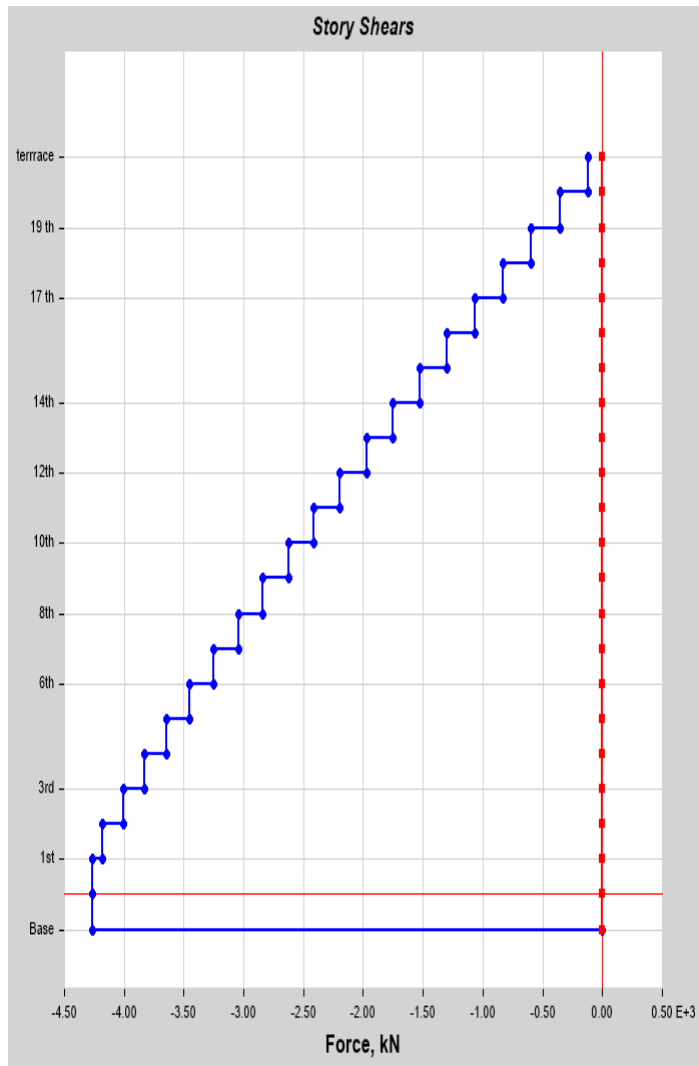
ZONE VI – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	39.937
20th	60	39.598
19th	57	39.142
18th	54	38.533
17th	51	37.753
16th	48	36.795
15th	45	35.655
14th	42	34.335
13th	39	32.837
12th	36	31.161
11th	33	29.312
10th	30	27.291
9th	27	25.103
8th	24	22.752
7th	21	20.244
6th	18	17.588
5th	15	14.797
4th	12	11.895
3rd	9	8.929
2nd	6	5.982
1st	3	3.228
g.f	0	1.01
Base	-3	0

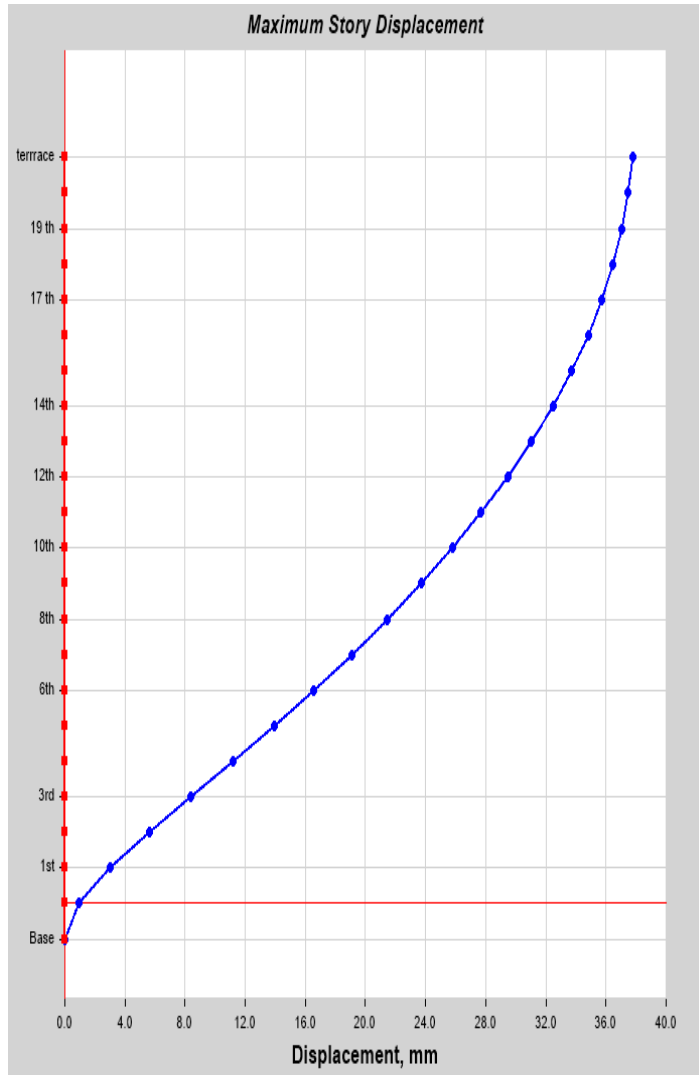


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000113
20th	60	0.000152
19th	57	0.000203
18th	54	0.00026
17th	51	0.00032
16th	48	0.00038
15th	45	0.00044
14th	42	0.0005
13th	39	0.000558
12th	36	0.000616
11th	33	0.000673
10th	30	0.000729
9th	27	0.000784
8th	24	0.000836
7th	21	0.000886
6th	18	0.00093
5th	15	0.000967
4th	12	0.000989
3rd	9	0.000982
2nd	6	0.000918
1st	3	0.000739
g.f	0	0.000337
Base	-3	0

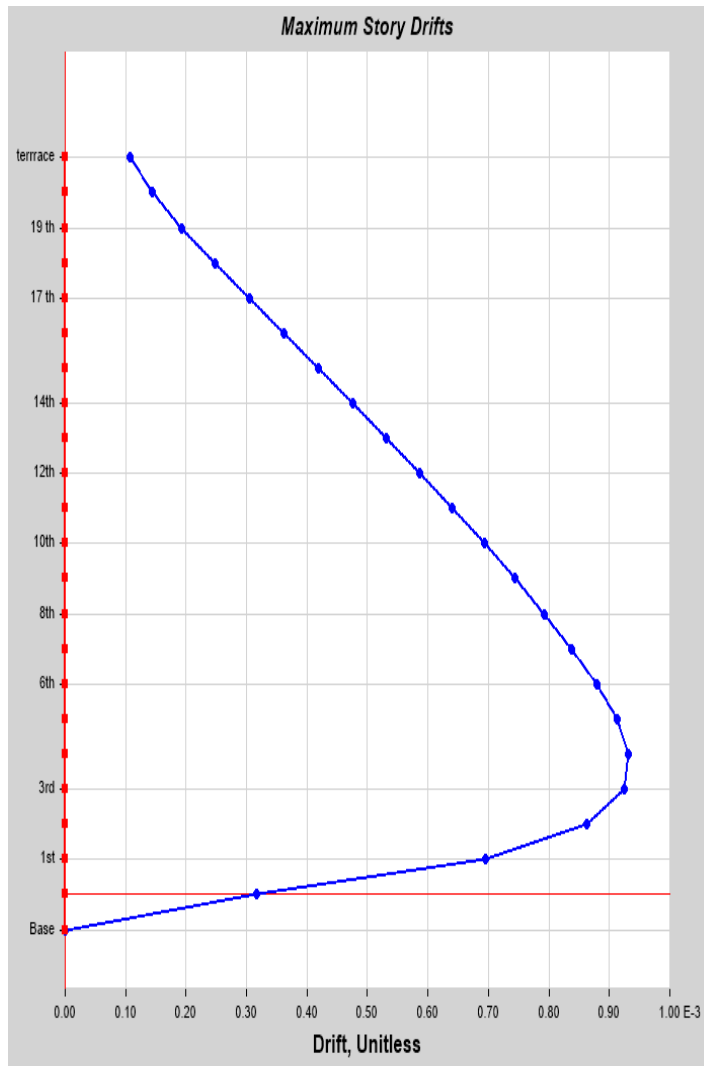


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	119.8
20th	60	358.22
19th	57	595.07
18th	54	830.74
17th	51	1064.85
16th	48	1296.62
15th	45	1525.69
14th	42	1751.68
13th	39	1974.62
12th	36	2194.9
11th	33	2412.54
10th	30	2627.19
9th	27	2838.49
8th	24	3046.47
7th	21	3251.16
6th	18	3450.42
5th	15	3643.25
4th	12	3827.69
3rd	9	4006.63
2nd	6	4182.18
1st	3	4268.27
g.f	0	4268.27
Base	-3	0

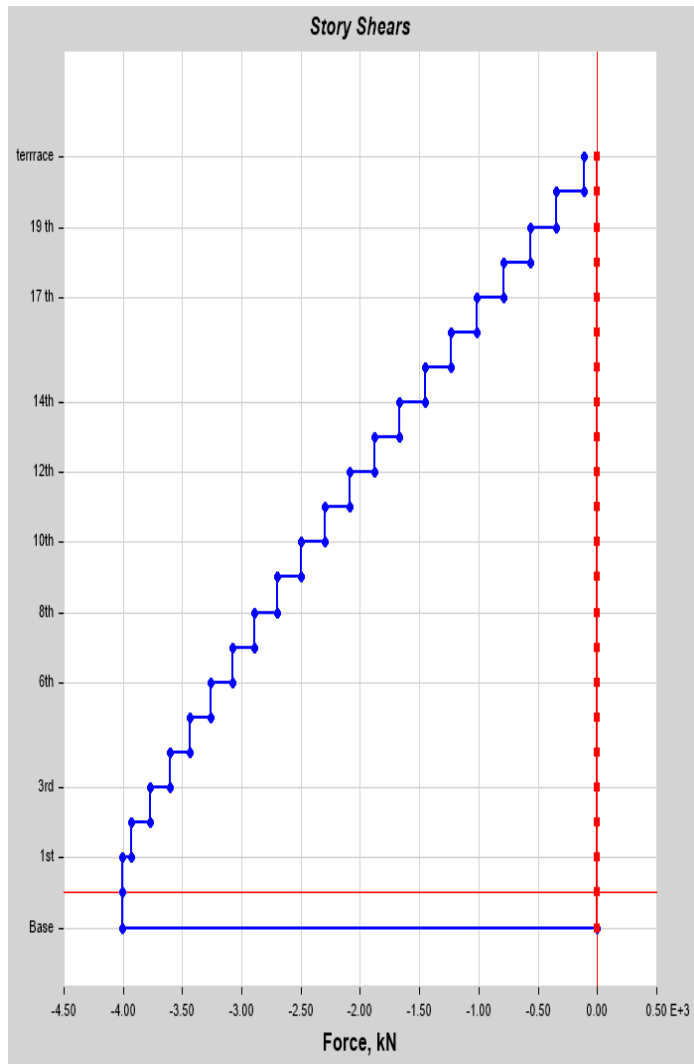
ZONE VI – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	37.8
20th	60	37.477
19th	57	37.043
18th	54	36.463
17th	51	35.72
16th	48	34.808
15th	45	33.723
14th	42	32.467
13th	39	31.041
12th	36	29.448
11th	33	27.689
10th	30	25.769
9th	27	23.691
8th	24	21.46
7th	21	19.083
6th	18	16.569
5th	15	13.932
4th	12	11.194
3rd	9	8.398
2nd	6	5.624
1st	3	3.034
g.f	0	0.949
Base	-3	0

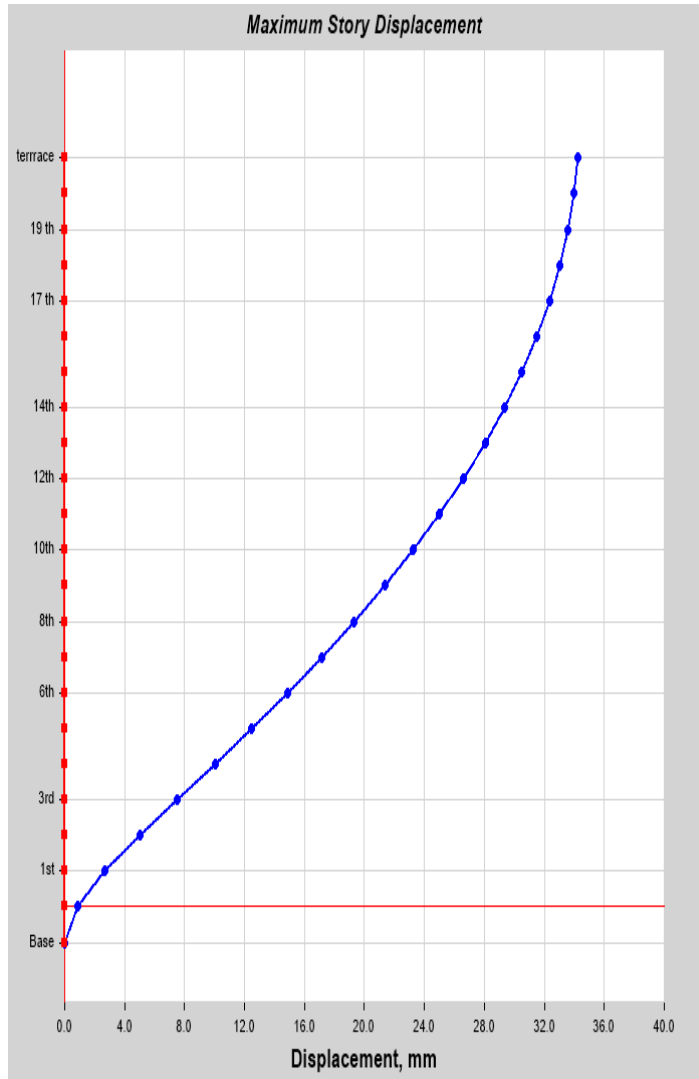


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000108
20th	60	0.000145
19th	57	0.000193
18th	54	0.000248
17th	51	0.000304
16th	48	0.000361
15th	45	0.000419
14th	42	0.000475
13th	39	0.000531
12th	36	0.000586
11th	33	0.00064
10th	30	0.000693
9th	27	0.000744
8th	24	0.000792
7th	21	0.000838
6th	18	0.000879
5th	15	0.000913
4th	12	0.000932
3rd	9	0.000925
2nd	6	0.000863
1st	3	0.000695
g.f	0	0.000316
Base	-3	0

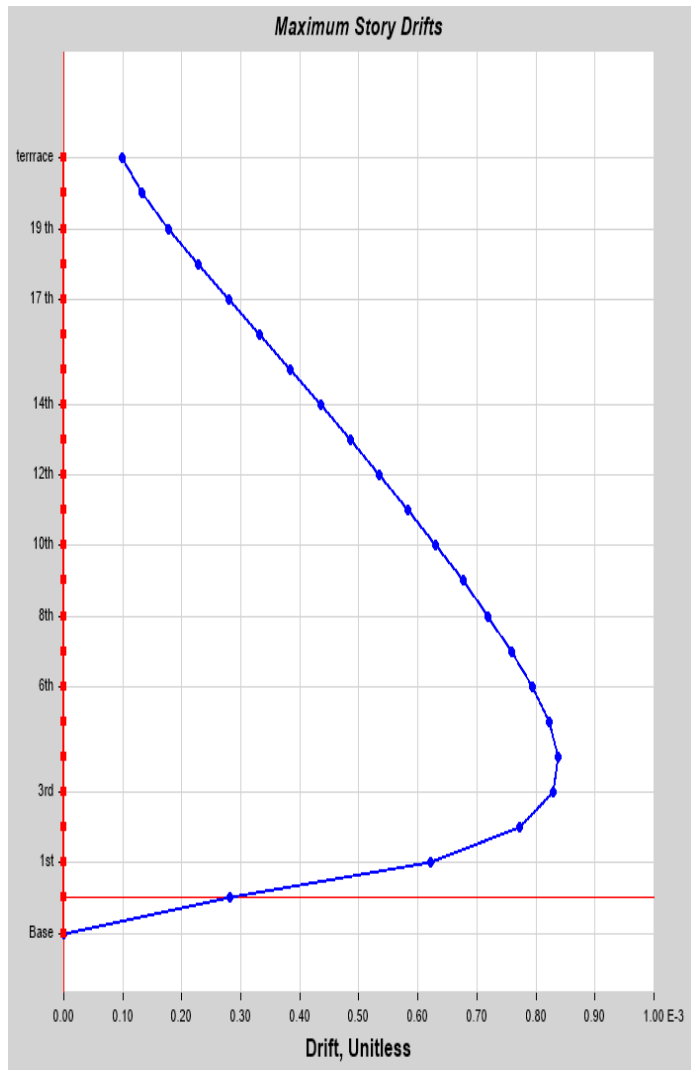


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	114.53
20th	60	342.06
19th	57	567.67
18th	54	791.75
17th	51	1014.31
16th	48	1234.59
15th	45	1452.23
14th	42	1666.88
13th	39	1878.92
12th	36	2088
11th	33	2294.51
10th	30	2498.1
9th	27	2696.28
8th	24	2889.11
7th	21	3076.67
6th	18	3259.72
5th	15	3438.66
4th	12	3607.52
3rd	9	3769.82
2nd	6	3928.89
1st	3	4008.43
g.f	0	4008.43
Base	-3	0

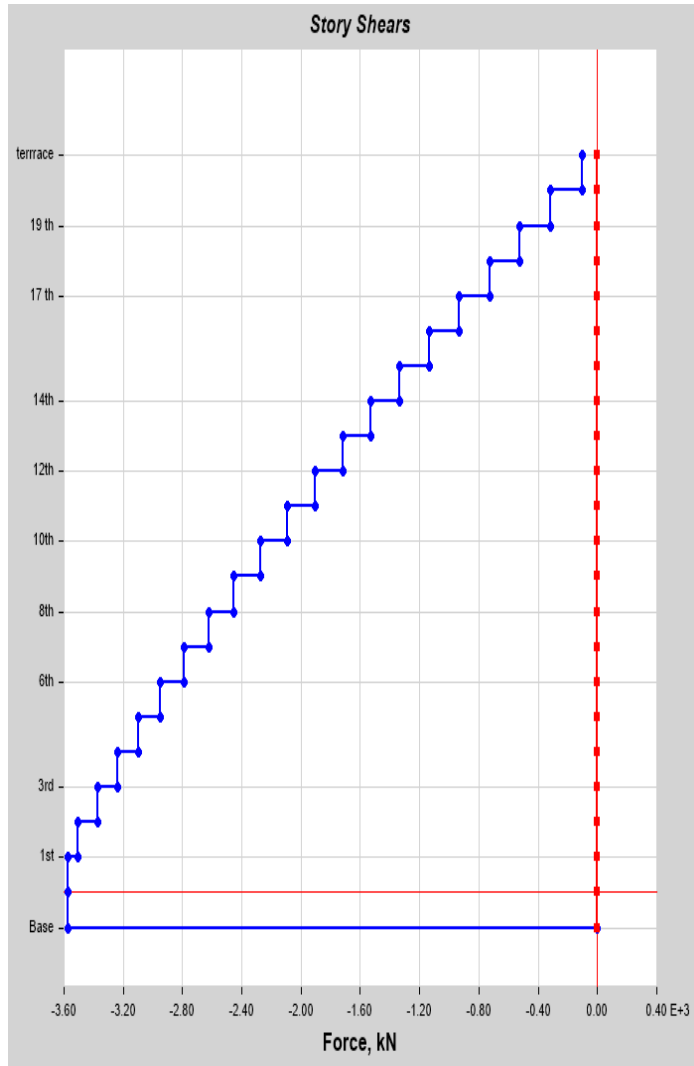
ZONE VI – TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	34.24
20th	60	33.944
19th	57	33.546
18th	54	33.013
17th	51	32.331
16th	48	31.494
15th	45	30.499
14th	42	29.349
13th	39	28.044
12th	36	26.588
11th	33	24.982
10th	30	23.232
9th	27	21.34
8th	24	19.312
7th	21	17.155
6th	18	14.877
5th	15	12.493
4th	12	10.025
3rd	9	7.512
2nd	6	5.025
1st	3	2.709
g.f	0	0.847
Base	-3	0

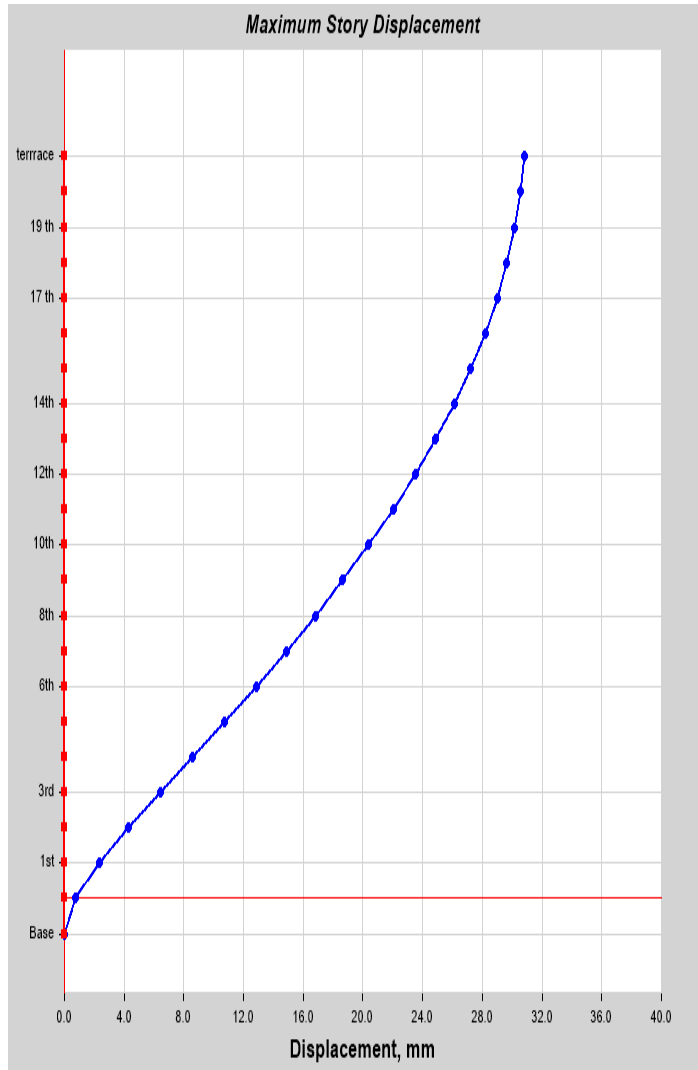


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000099
20th	60	0.000133
19th	57	0.000178
18th	54	0.000227
17th	51	0.000279
16th	48	0.000331
15th	45	0.000383
14th	42	0.000435
13th	39	0.000485
12th	36	0.000535
11th	33	0.000584
10th	30	0.000631
9th	27	0.000676
8th	24	0.000719
7th	21	0.000759
6th	18	0.000795
5th	15	0.000823
4th	12	0.000838
3rd	9	0.000829
2nd	6	0.000772
1st	3	0.000621
g.f	0	0.000282
Base	-3	0

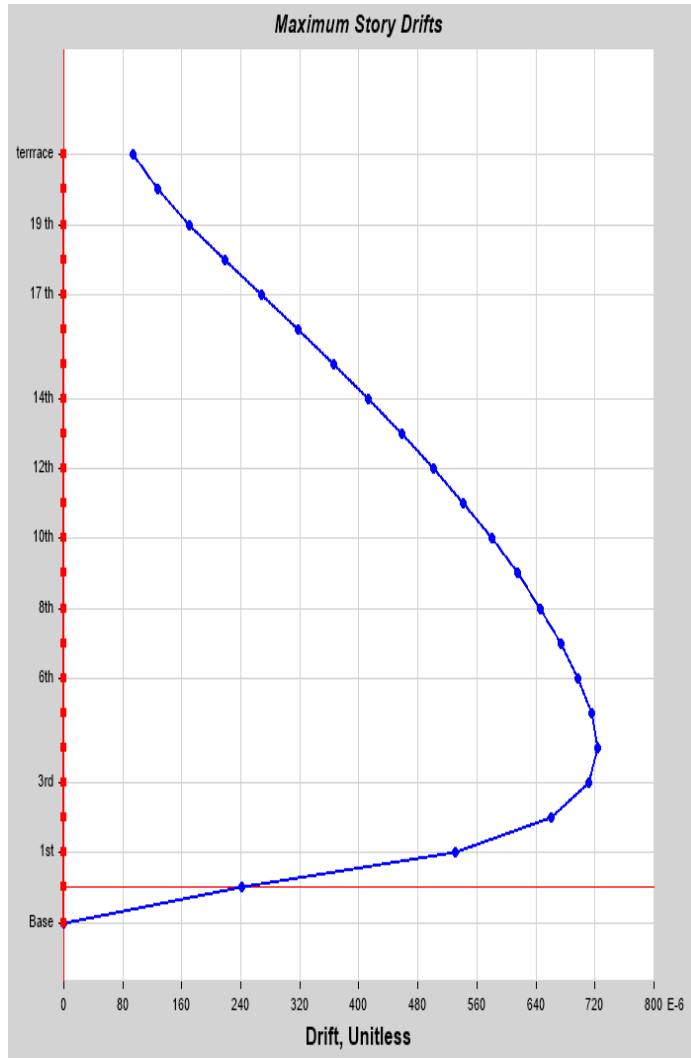


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	105.65
20th	60	315.1
19th	57	522.71
18th	54	728.49
17th	51	932.45
16th	48	1133.87
15th	45	1332.05
14th	42	1527.01
13th	39	1718.78
12th	36	1907.39
11th	33	2092.87
10th	30	2275.24
9th	27	2452.48
8th	24	2624.67
7th	21	2791.88
6th	18	2950.95
5th	15	3100.53
4th	12	3240.91
3rd	9	3375.31
2nd	6	3506.78
1st	3	3572.37
g.f	0	3572.37
Base	-3	0

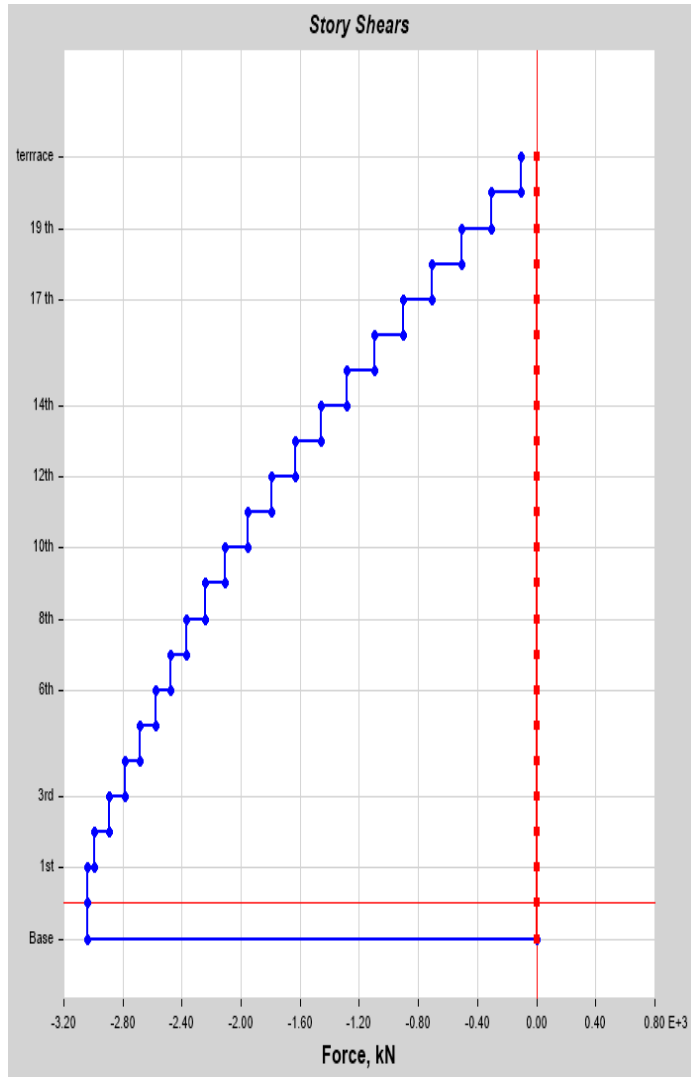
ZONE VI – TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	30.816
20th	60	30.533
19th	57	30.15
18th	54	29.638
17th	51	28.982
16th	48	28.178
15th	45	27.225
14th	42	26.128
13th	39	24.89
12th	36	23.516
11th	33	22.013
10th	30	20.388
9th	27	18.647
8th	24	16.802
7th	21	14.863
6th	18	12.841
5th	15	10.749
4th	12	8.603
3rd	9	6.433
2nd	6	4.296
1st	3	2.313
g.f	0	0.722
Base	-3	0



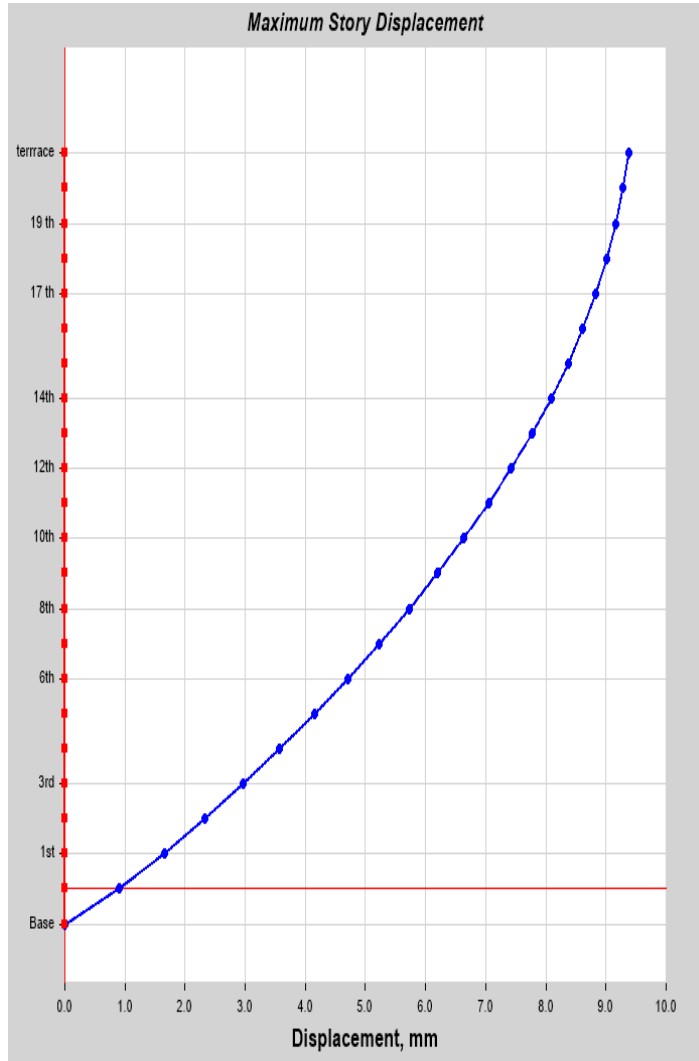
Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000094
20th	60	0.000127
19th	57	0.000171
18th	54	0.000219
17th	51	0.000268
16th	48	0.000317
15th	45	0.000366
14th	42	0.000413
13th	39	0.000458
12th	36	0.000501
11th	33	0.000542
10th	30	0.00058
9th	27	0.000615
8th	24	0.000646
7th	21	0.000674
6th	18	0.000697
5th	15	0.000715
4th	12	0.000723
3rd	9	0.000712
2nd	6	0.000661
1st	3	0.00053
g.f	0	0.000241
Base	-3	0



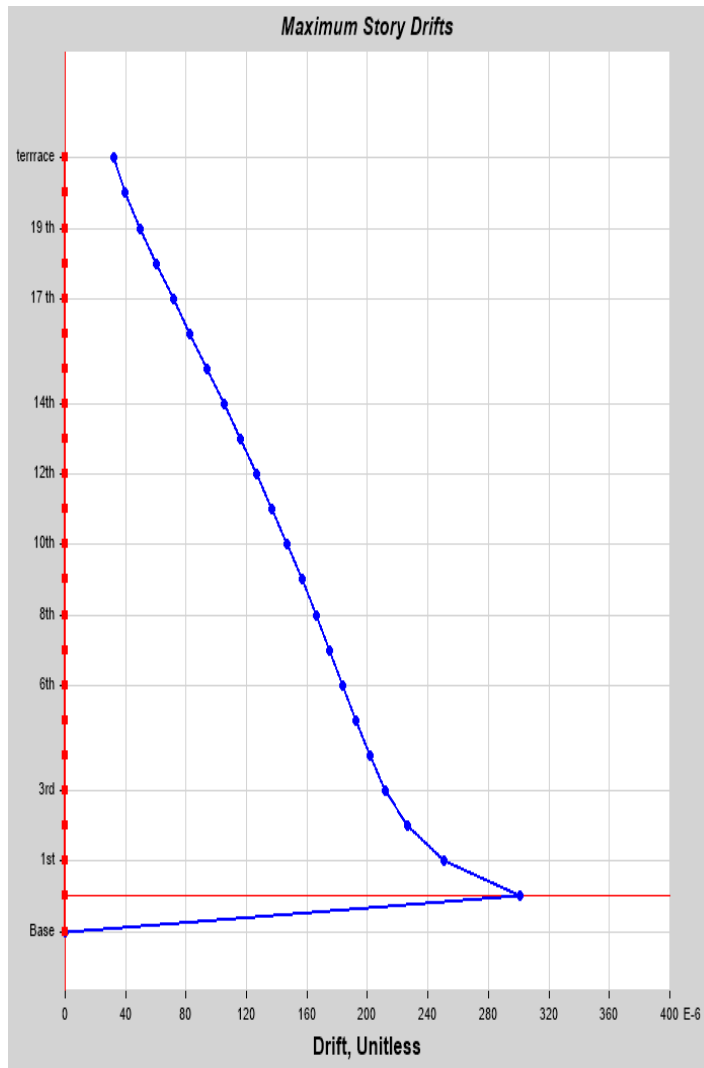
Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	102.89
20th	60	306.48
19th	57	507.9
18th	54	707.16
17th	51	904.26
16th	48	1096.03
15th	45	1280.81
14th	42	1459.07
13th	39	1630.59
12th	36	1795.83
11th	33	1954.58
10th	30	2107.29
9th	27	2244.37
8th	24	2366.65
7th	21	2474.99
6th	18	2578.86
5th	15	2682.73
4th	12	2786.6
3rd	9	2890.47
2nd	6	2991.76
1st	3	3041.13
g.f	0	3041.13
Base	-3	0

OCTAGONAL

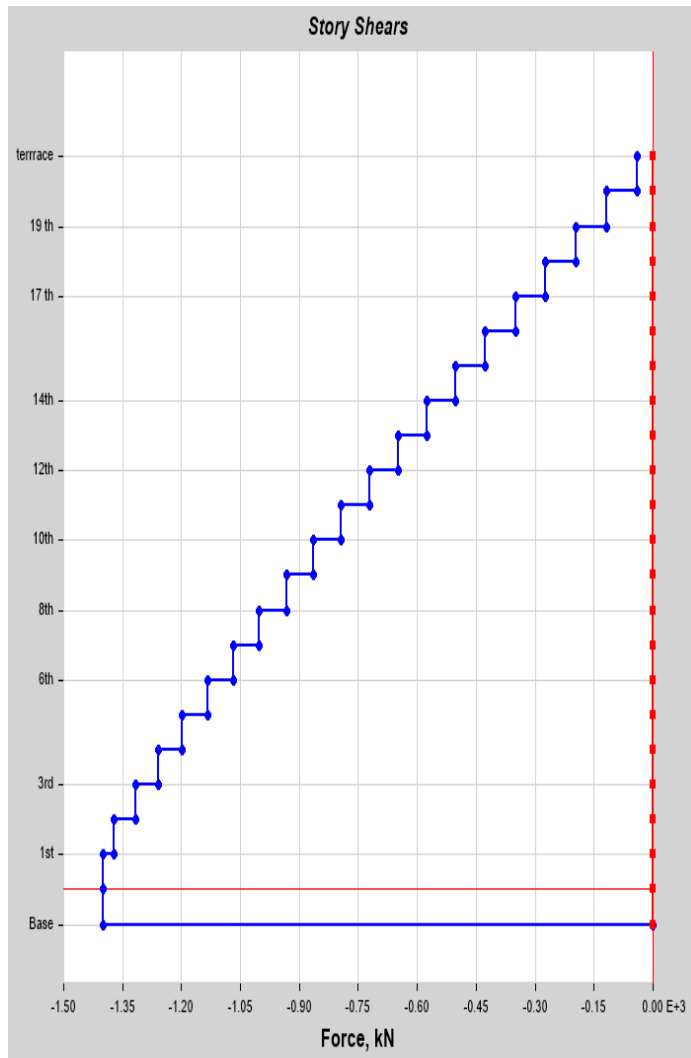
ZONE I – TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	9.374
20th	60	9.278
19th	57	9.159
18th	54	9.011
17th	51	8.83
16th	48	8.616
15th	45	8.368
14th	42	8.086
13th	39	7.771
12th	36	7.424
11th	33	7.045
10th	30	6.635
9th	27	6.195
8th	24	5.725
7th	21	5.228
6th	18	4.702
5th	15	4.151
4th	12	3.573
3rd	9	2.968
2nd	6	2.333
1st	3	1.654
g.f	0	0.903
Base	-3	0

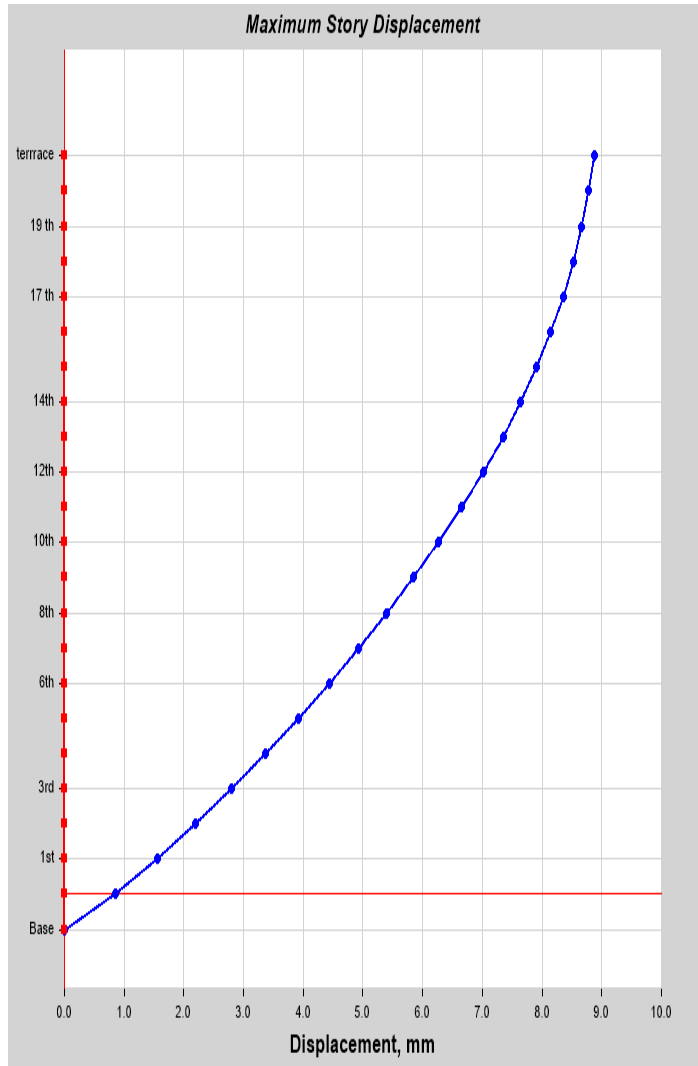


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000032
20th	60	0.00004
19th	57	0.000049
18th	54	0.00006
17th	51	0.000071
16th	48	0.000083
15th	45	0.000094
14th	42	0.000105
13th	39	0.000116
12th	36	0.000126
11th	33	0.000137
10th	30	0.000147
9th	27	0.000156
8th	24	0.000166
7th	21	0.000175
6th	18	0.000184
5th	15	0.000193
4th	12	0.000202
3rd	9	0.000212
2nd	6	0.000226
1st	3	0.00025
g.f	0	0.000301
Base	-3	0

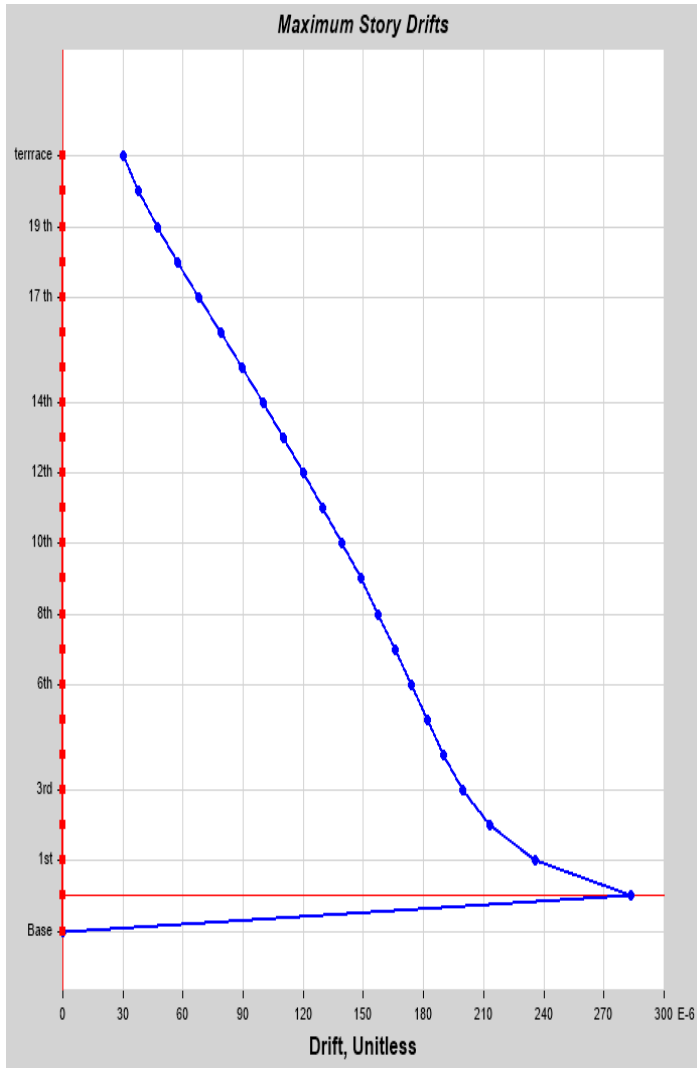


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	39.38
20th	60	117.75
19th	57	195.6
18th	54	273.06
17th	51	350.01
16th	48	426.19
15th	45	501.48
14th	42	575.76
13th	39	649.04
12th	36	721.45
11th	33	792.99
10th	30	863.54
9th	27	932.99
8th	24	1001.35
7th	21	1068.63
6th	18	1134.12
5th	15	1197.5
4th	12	1258.12
3rd	9	1316.94
2nd	6	1372.23
1st	3	1398.59
g.f	0	1395.59
Base	-3	0

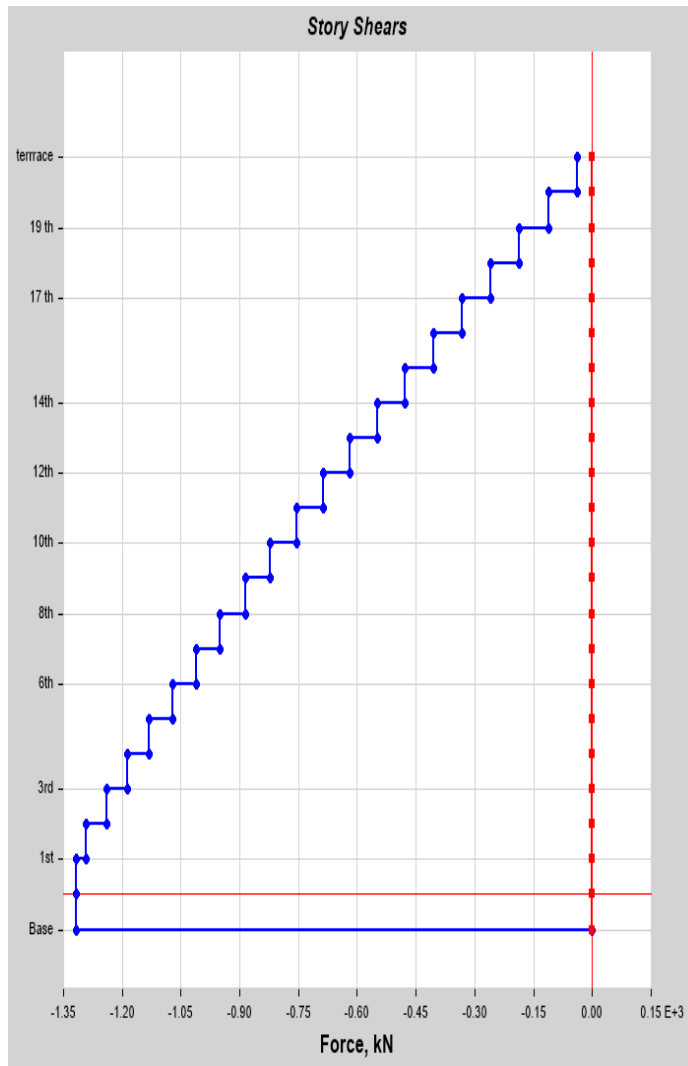
ZONE I – TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	8.87
20th	60	8.779
19th	57	8.666
18th	54	8.525
17th	51	8.353
16th	48	8.149
15th	45	7.913
14th	42	7.645
13th	39	7.346
12th	36	7.015
11th	33	6.655
10th	30	6.265
9th	27	5.847
8th	24	5.402
7th	21	4.93
6th	18	4.433
5th	15	3.912
4th	12	3.366
3rd	9	2.796
2nd	6	2.197
1st	3	1.558
g.f	0	0.851
Base	-3	0

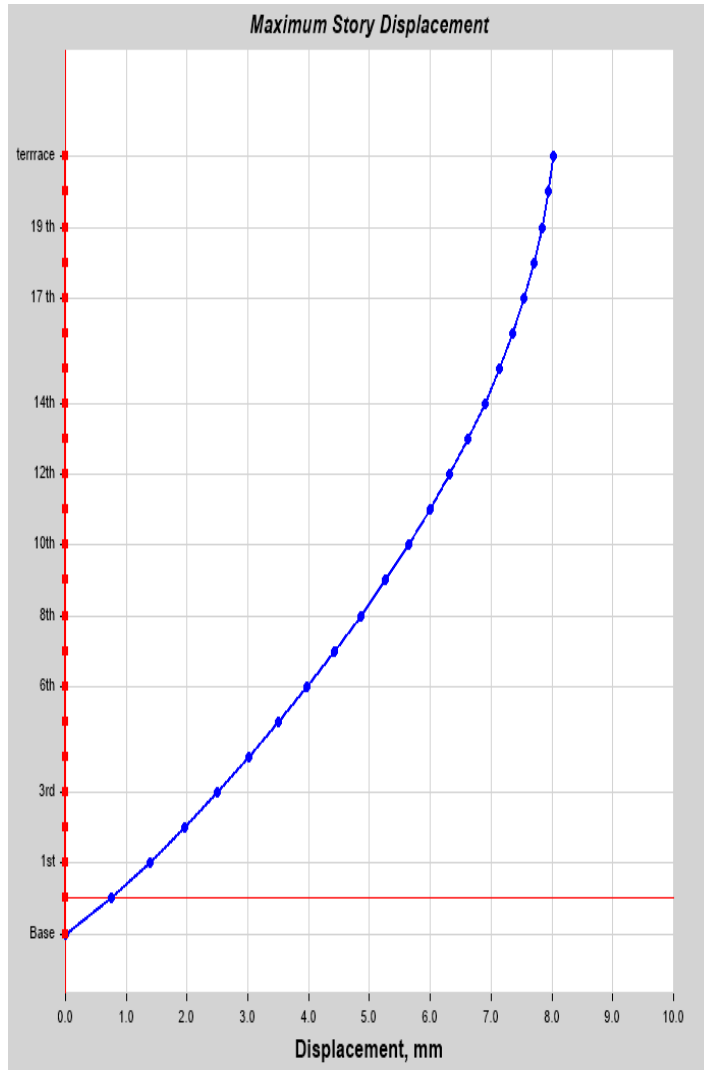


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.00003
20th	60	0.000038
19th	57	0.000047
18th	54	0.000057
17th	51	0.000068
16th	48	0.000079
15th	45	0.000089
14th	42	0.0001
13th	39	0.00011
12th	36	0.00012
11th	33	0.00013
10th	30	0.000139
9th	27	0.000148
8th	24	0.000157
7th	21	0.000166
6th	18	0.000174
5th	15	0.000182
4th	12	0.00019
3rd	9	0.0002
2nd	6	0.000213
1st	3	0.000236
g.f	0	0.000284
Base	-3	0

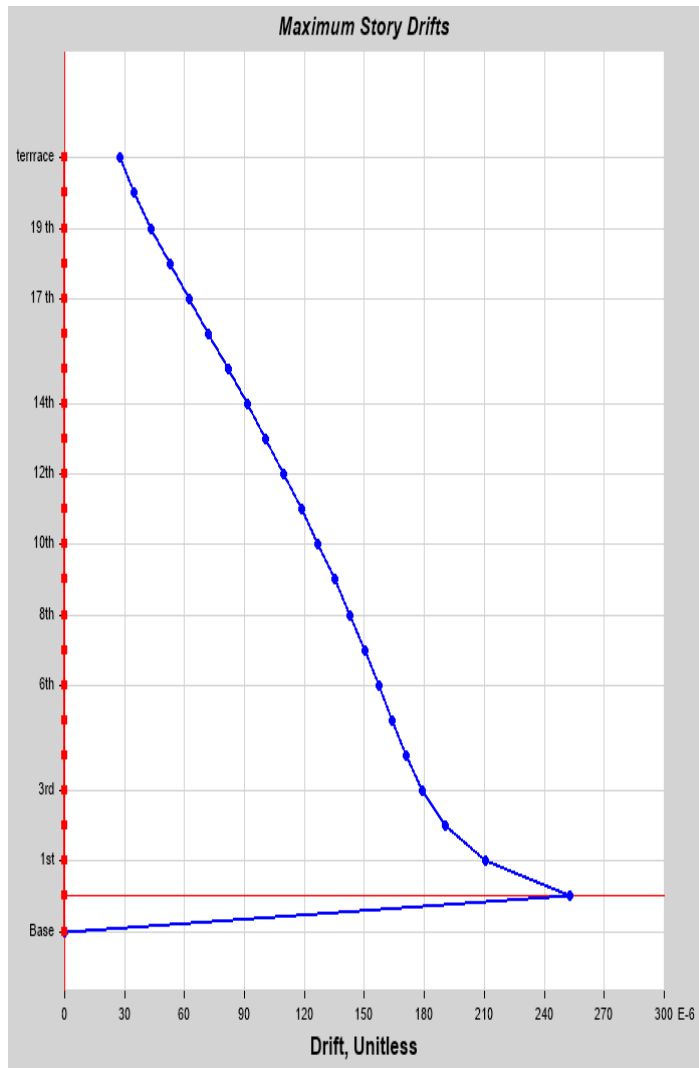


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	37.65
20th	60	112.44
19th	57	186.6
18th	54	260.25
17th	51	333.4
16th	48	405.81
15th	45	477.35
14th	42	547.9
13th	39	617.6
12th	36	686.33
11th	33	754.21
10th	30	821.13
9th	27	886.27
8th	24	949.65
7th	21	1011.3
6th	18	1071.47
5th	15	1130.29
4th	12	1185.79
3rd	9	1239.14
2nd	6	1291.43
1st	3	1317.57
g.f	0	1317.57
Base	-3	0

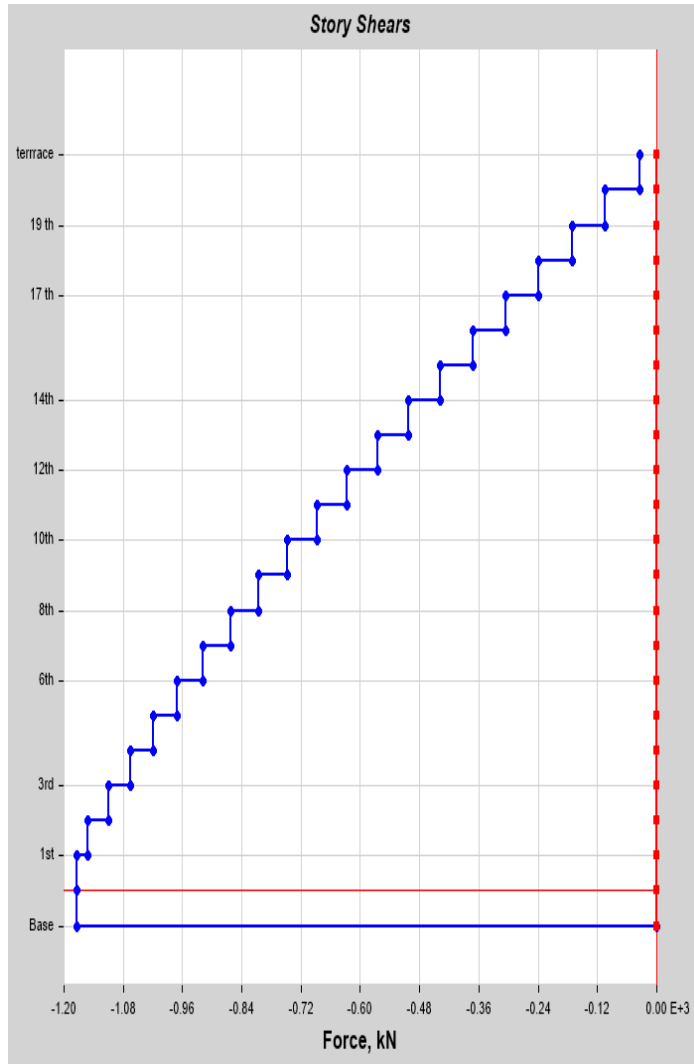
ZONE I –TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	8.019
20th	60	7.936
19th	57	7.833
18th	54	7.704
17th	51	7.546
16th	48	7.359
15th	45	7.143
14th	42	6.897
13th	39	6.623
12th	36	6.322
11th	33	5.993
10th	30	5.638
9th	27	5.257
8th	24	4.852
7th	21	4.424
6th	18	3.974
5th	15	3.502
4th	12	3.011
3rd	9	2.498
2nd	6	1.962
1st	3	1.39
g.f	0	0.759
Base	-3	0

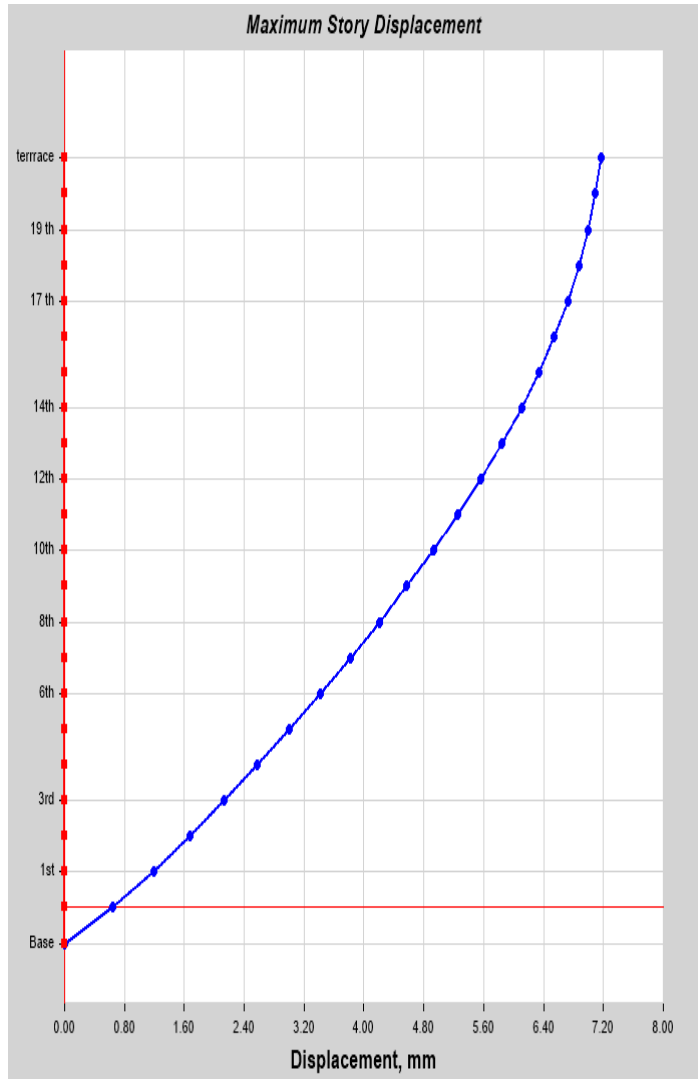


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000028
20th	60	0.000034
19th	57	0.000043
18th	54	0.000053
17th	51	0.000062
16th	48	0.000072
15th	45	0.000082
14th	42	0.000091
13th	39	0.000101
12th	36	0.00011
11th	33	0.000118
10th	30	0.000127
9th	27	0.000135
8th	24	0.000143
7th	21	0.00015
6th	18	0.000157
5th	15	0.000164
4th	12	0.000171
3rd	9	0.000179
2nd	6	0.00019
1st	3	0.000211
g.f	0	0.000253
Base	-3	0

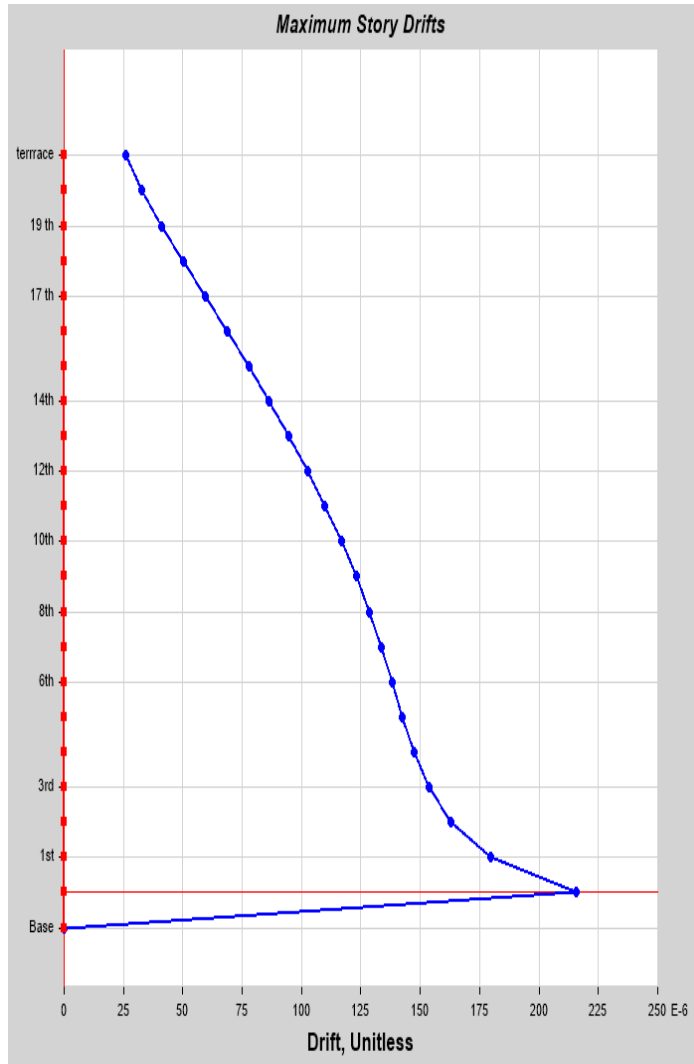


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	34.73
20th	60	103.58
19th	57	171.82
18th	54	239.46
17th	51	306.5
16th	48	372.71
15th	45	437.85
14th	42	501.93
13th	39	564.97
12th	36	626.97
11th	33	687.93
10th	30	747.87
9th	27	806.13
8th	24	862.73
7th	21	917.69
6th	18	969.98
5th	15	1019.15
4th	12	1065.29
3rd	9	1109.47
2nd	6	1152.68
1st	3	1174.24
g.f	0	1174.24
Base	-3	0

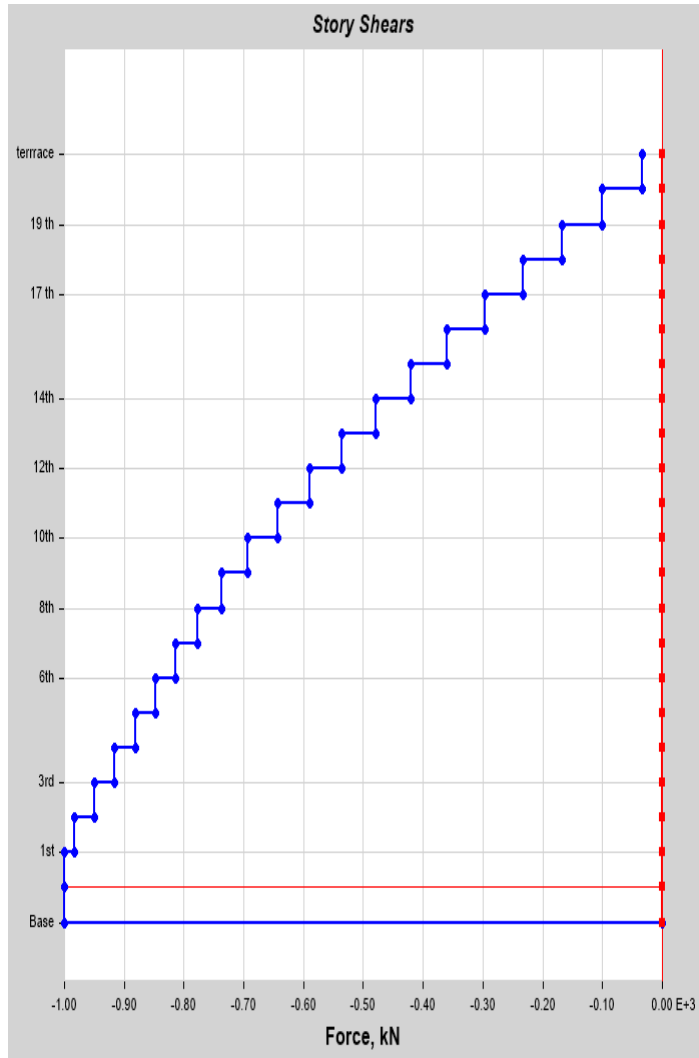
ZONE I –TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	7.172
20th	60	7.094
19th	57	6.996
18th	54	6.873
17th	51	6.722
16th	48	6.544
15th	45	6.338
14th	42	6.105
13th	39	5.846
12th	36	5.562
11th	33	5.255
10th	30	4.925
9th	27	4.575
8th	24	4.206
7th	21	3.821
6th	18	3.421
5th	15	3.007
4th	12	2.579
3rd	9	2.136
2nd	6	1.675
1st	3	1.186
g.f	0	0.647
Base	-3	0

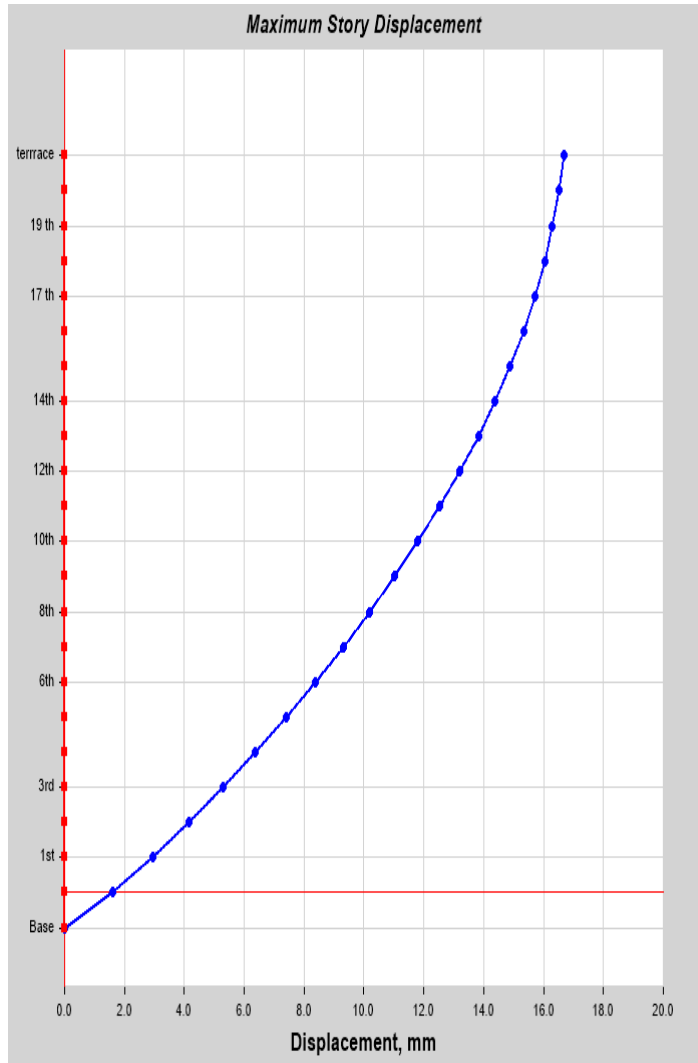


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000026
20th	60	0.000033
19th	57	0.000041
18th	54	0.00005
17th	51	0.000059
16th	48	0.000069
15th	45	0.000078
14th	42	0.000086
13th	39	0.000095
12th	36	0.000102
11th	33	0.00011
10th	30	0.000117
9th	27	0.000123
8th	24	0.000128
7th	21	0.000133
6th	18	0.000138
5th	15	0.000143
4th	12	0.000148
3rd	9	0.000154
2nd	6	0.000163
1st	3	0.00018
g.f	0	0.000216
Base	-3	0

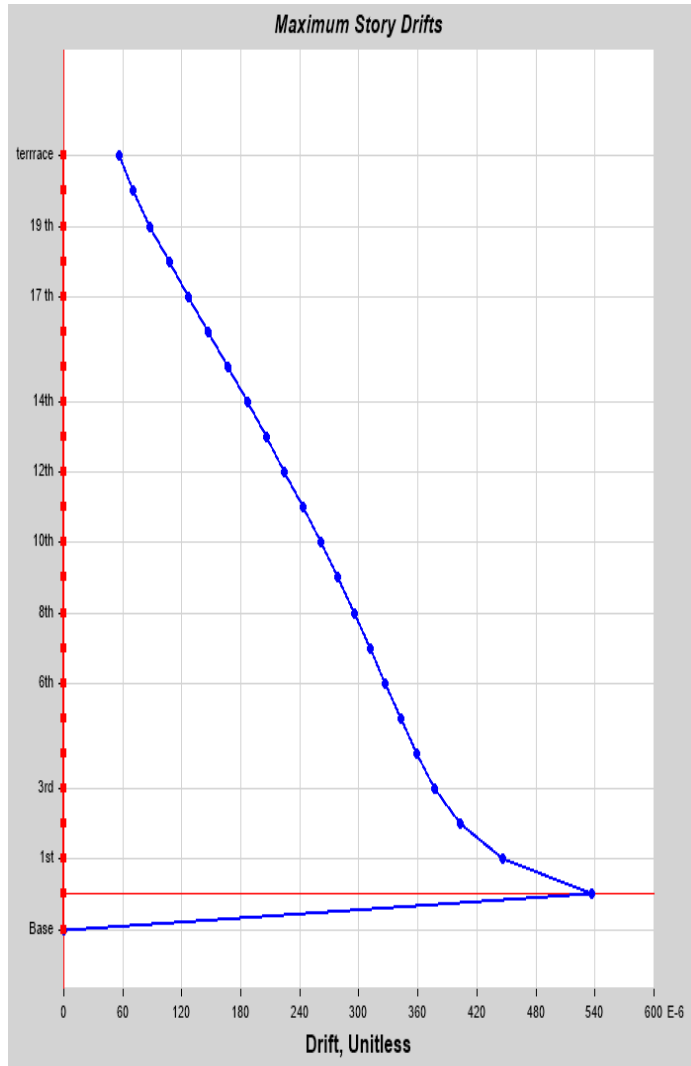


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	33.82
20th	60	100.74
19th	57	166.95
18th	54	232.44
17th	51	297.23
16th	48	360.27
15th	45	421.01
14th	42	479.6
13th	39	535.98
12th	36	590.29
11th	33	642.47
10th	30	692.67
9th	27	737.73
8th	24	777.92
7th	21	813.53
6th	18	847.67
5th	15	881.81
4th	12	915.95
3rd	9	950.09
2nd	6	983.38
1st	3	999.61
g.f	0	999.61
Base	-3	0

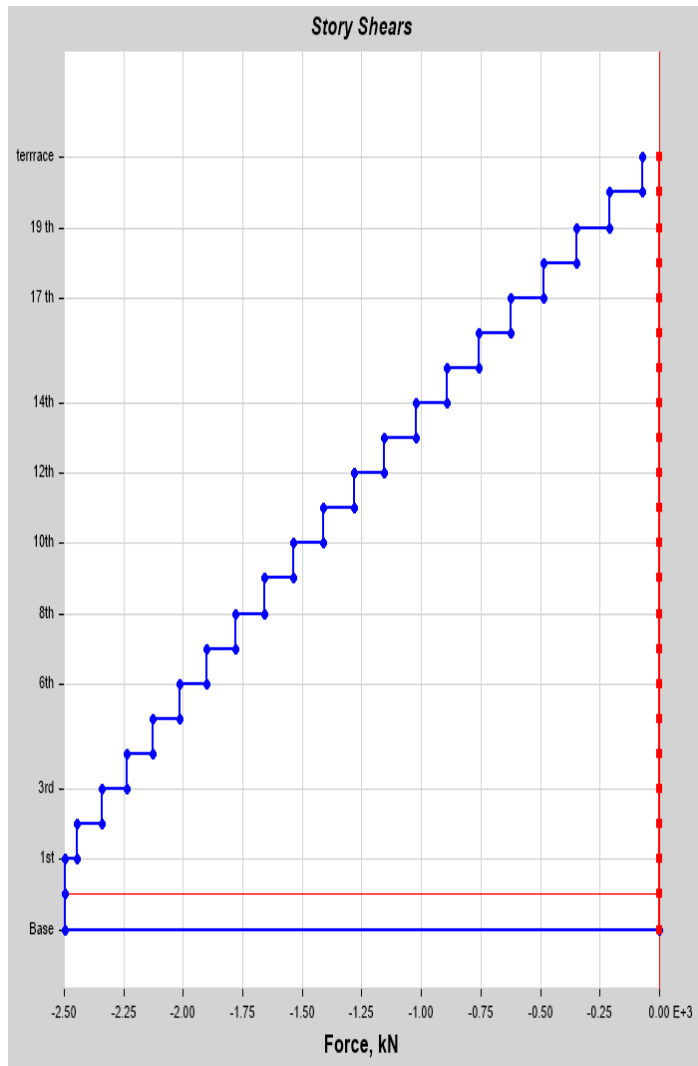
ZONE III –TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	16.676
20th	60	16.506
19th	57	16.295
18th	54	16.031
17th	51	15.71
16th	48	15.329
15th	45	14.887
14th	42	14.386
13th	39	13.827
12th	36	13.21
11th	33	12.536
10th	30	11.807
9th	27	11.024
8th	24	10.19
7th	21	9.305
6th	18	8.371
5th	15	7.39
4th	12	6.363
3rd	9	5.288
2nd	6	4.156
1st	3	2.948
g.f	0	1.609
Base	-3	0

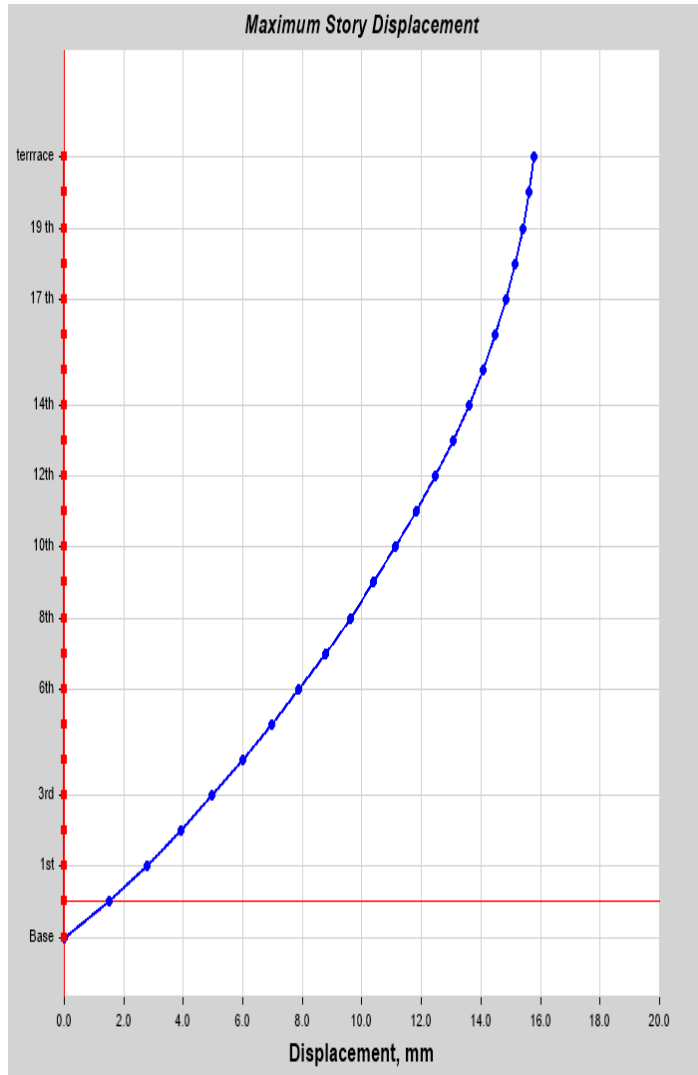


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000057
20th	60	0.00007
19th	57	0.000088
18th	54	0.000107
17th	51	0.000127
16th	48	0.000147
15th	45	0.000167
14th	42	0.000187
13th	39	0.000206
12th	36	0.000225
11th	33	0.000243
10th	30	0.000261
9th	27	0.000278
8th	24	0.000295
7th	21	0.000311
6th	18	0.000327
5th	15	0.000342
4th	12	0.000358
3rd	9	0.000377
2nd	6	0.000403
1st	3	0.000446
g.f	0	0.000536
Base	-3	0

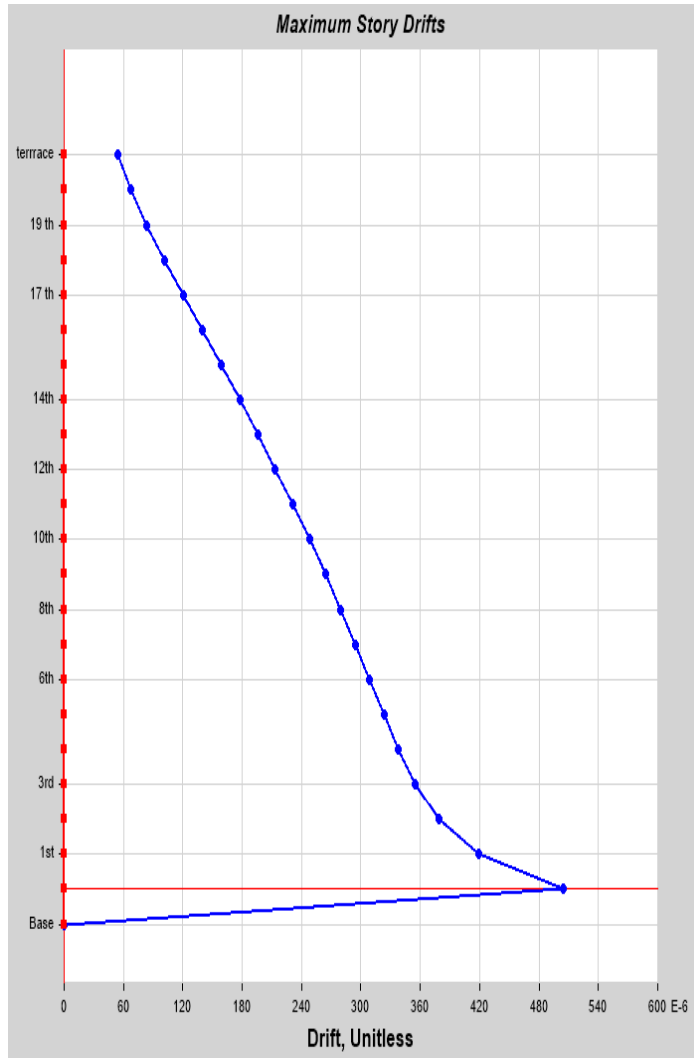


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	70
20th	60	209.32
19th	57	347.72
18th	54	485.43
17th	51	622.23
16th	48	757.67
15th	45	891.53
14th	42	1023.59
13th	39	1153.86
12th	36	1282.58
11th	33	1409.76
10th	30	1535.19
9th	27	1658.66
8th	24	1780.19
7th	21	1899.8
6th	18	2016.23
5th	15	2128.91
4th	12	2236.68
3rd	9	2341.24
2nd	6	2443.82
1st	3	2494.13
g.f	0	2494.13
Base	-3	0

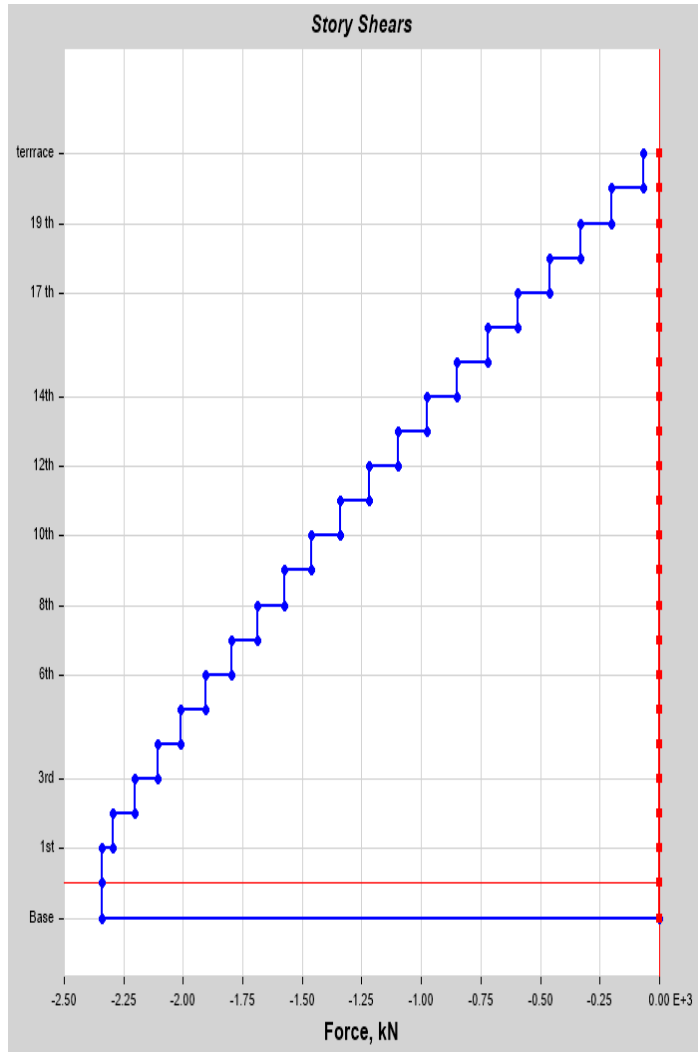
ZONE III –TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	15.769
20th	60	15.607
19th	57	15.407
18th	54	15.156
17th	51	14.85
16th	48	14.487
15th	45	14.067
14th	42	13.591
13th	39	13.059
12th	36	12.472
11th	33	11.831
10th	30	11.139
9th	27	10.395
8th	24	9.603
7th	21	8.765
6th	18	7.881
5th	15	6.954
4th	12	5.985
3rd	9	4.971
2nd	6	3.906
1st	3	2.77
g.f	0	1.512
Base	-3	0

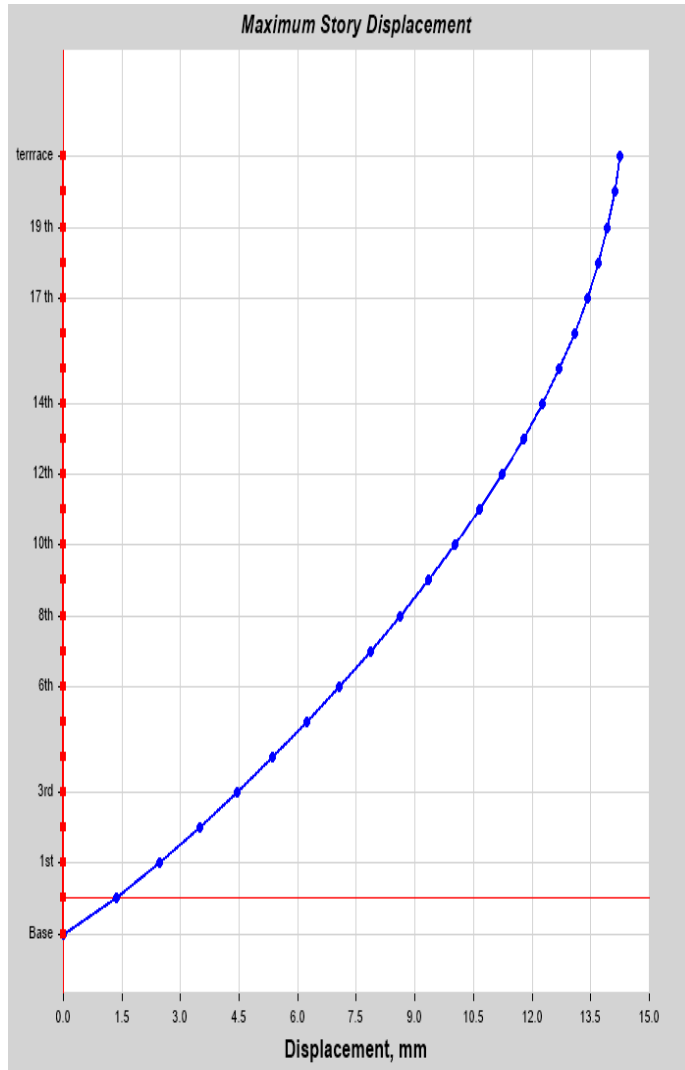


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000054
20th	60	0.000067
19th	57	0.000084
18th	54	0.000102
17th	51	0.000121
16th	48	0.00014
15th	45	0.000159
14th	42	0.000177
13th	39	0.000196
12th	36	0.000213
11th	33	0.000231
10th	30	0.000248
9th	27	0.000264
8th	24	0.00028
7th	21	0.000295
6th	18	0.000309
5th	15	0.000323
4th	12	0.000338
3rd	9	0.000355
2nd	6	0.000379
1st	3	0.000419
g.f	0	0.000504
Base	-3	0

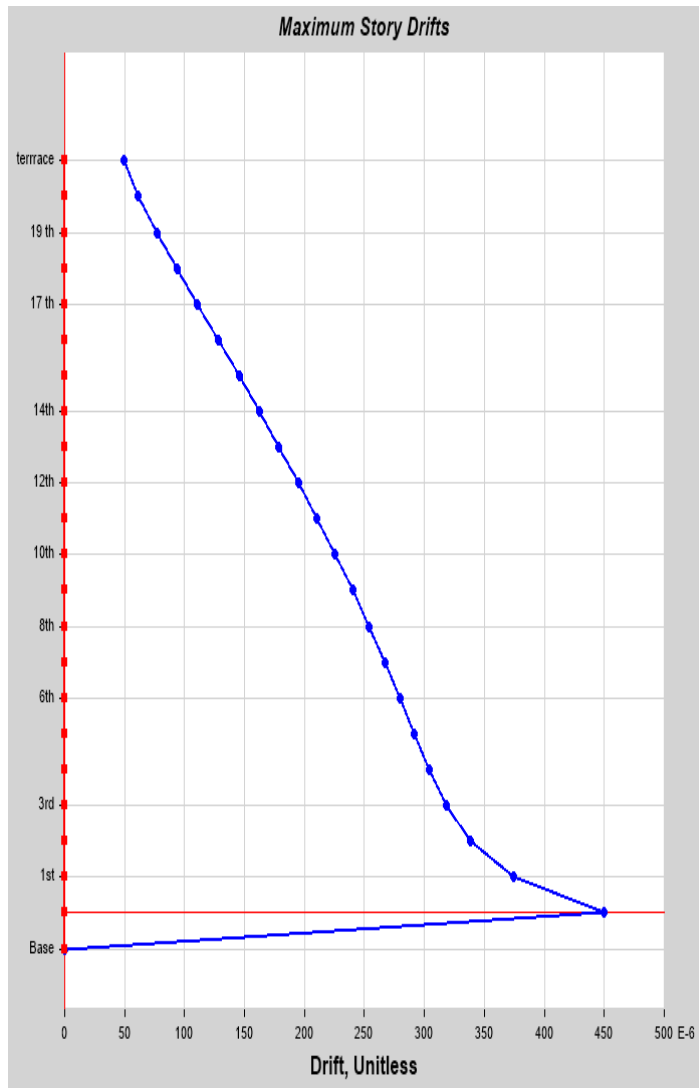


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	66.93
20th	60	199.89
19th	57	331.72
18th	54	462.66
17th	51	592.71
16th	48	721.43
15th	45	848.61
14th	42	974.04
13th	39	1097.95
12th	36	1220.13
11th	33	1340.81
10th	30	1459.78
9th	27	1575.58
8th	24	1688.26
7th	21	1797.86
6th	18	1904.83
5th	15	2009.39
4th	12	2108.06
3rd	9	2202.9
2nd	6	2295.85
1st	3	2342.33
g.f	0	2342.33
Base	-3	0

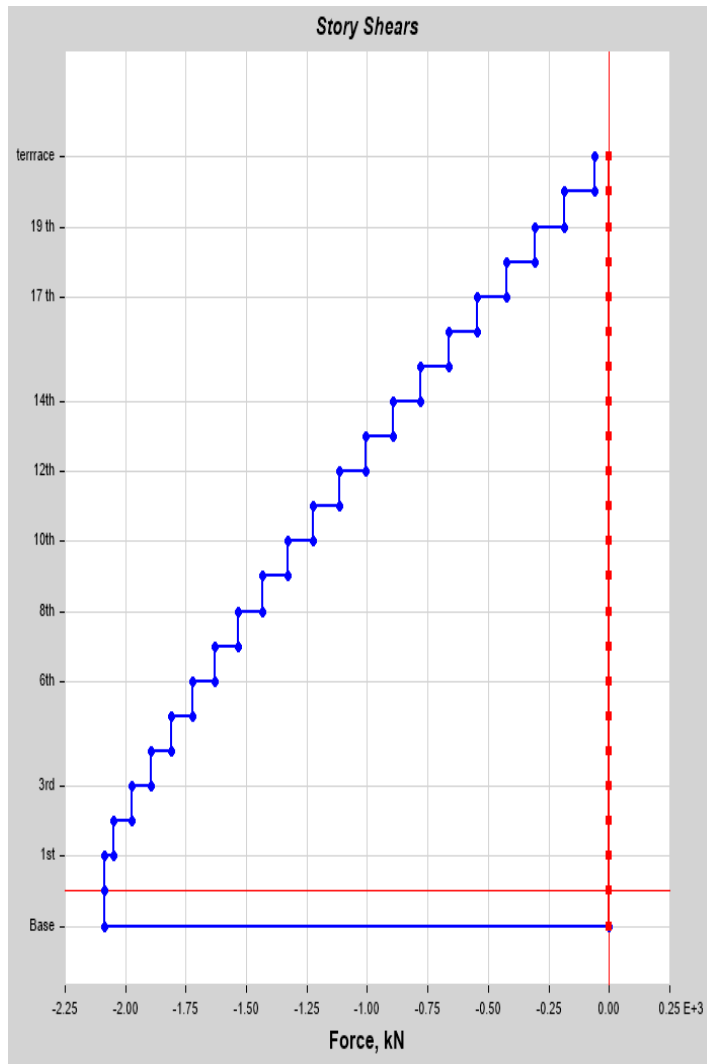
ZONE III –TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	14.257
20th	60	14.109
19th	57	13.925
18th	54	13.695
17th	51	13.414
16th	48	13.082
15th	45	12.698
14th	42	12.262
13th	39	11.775
12th	36	11.239
11th	33	10.654
10th	30	10.023
9th	27	9.346
8th	24	8.626
7th	21	7.865
6th	18	7.064
5th	15	6.226
4th	12	5.352
3rd	9	4.441
2nd	6	3.487
1st	3	2.472
g.f	0	1.349
Base	-3	0

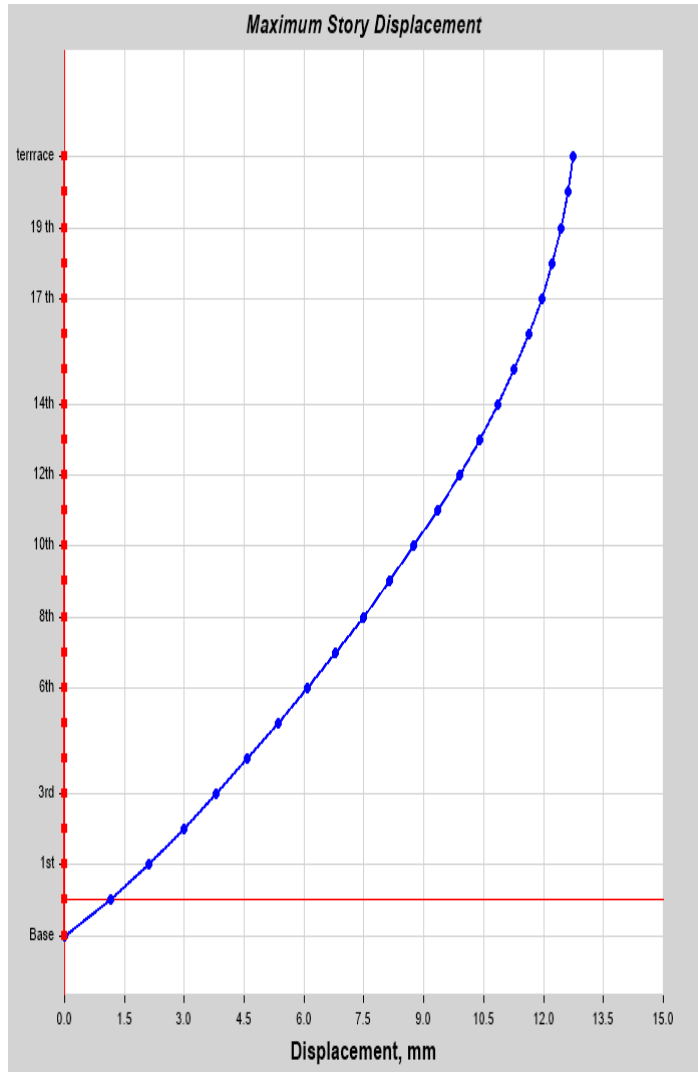


Storey	Elevation (m)	X-Dir
terrace	63	0.000049
20th	60	0.000061
19th	57	0.000077
18th	54	0.000093
17th	51	0.000111
16th	48	0.000128
15th	45	0.000145
14th	42	0.000162
13th	39	0.000179
12th	36	0.000195
11th	33	0.00021
10th	30	0.000226
9th	27	0.00024
8th	24	0.000254
7th	21	0.000267
6th	18	0.000279
5th	15	0.000291
4th	12	0.000304
3rd	9	0.000318
2nd	6	0.000338
1st	3	0.000374
g.f	0	0.00045
Base	-3	0

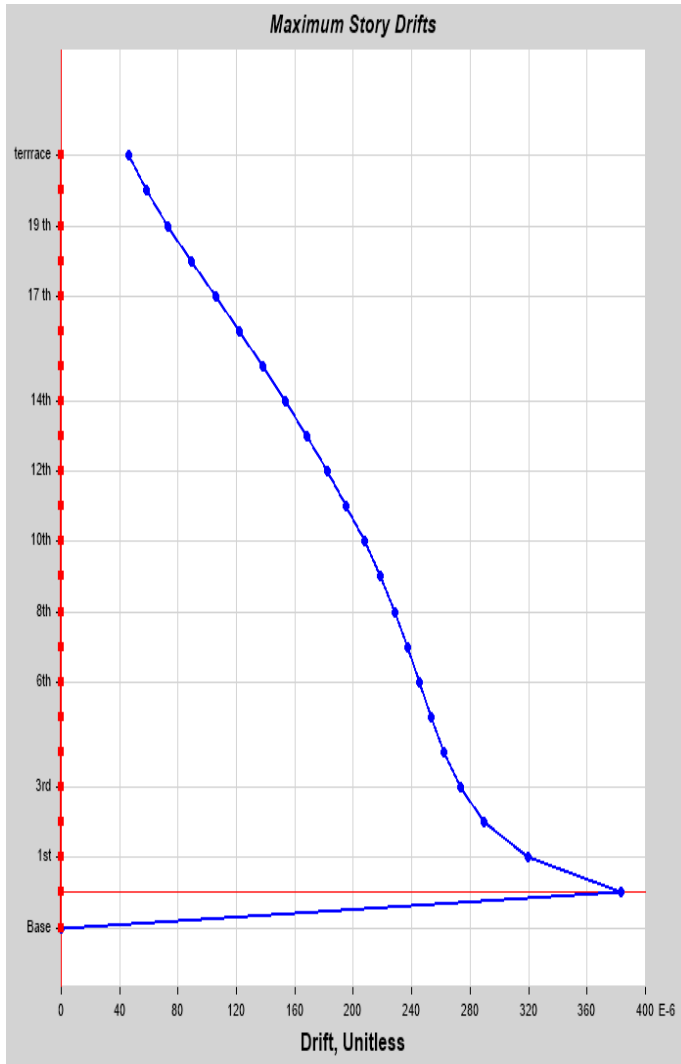


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	61.74
20th	60	184.13
19th	57	305.45
18th	54	425.7
17th	51	544.88
16th	48	662.58
15th	45	778.38
14th	42	892.31
13th	39	1004.37
12th	36	1114.58
11th	33	1222.96
10th	30	1329.52
9th	27	1433.09
8th	24	1533.71
7th	21	1631.42
6th	18	1724.37
5th	15	1811.78
4th	12	1893.81
3rd	9	1972.35
2nd	6	2049.17
1st	3	2087.5
g.f	0	2087.5
Base	-3	0

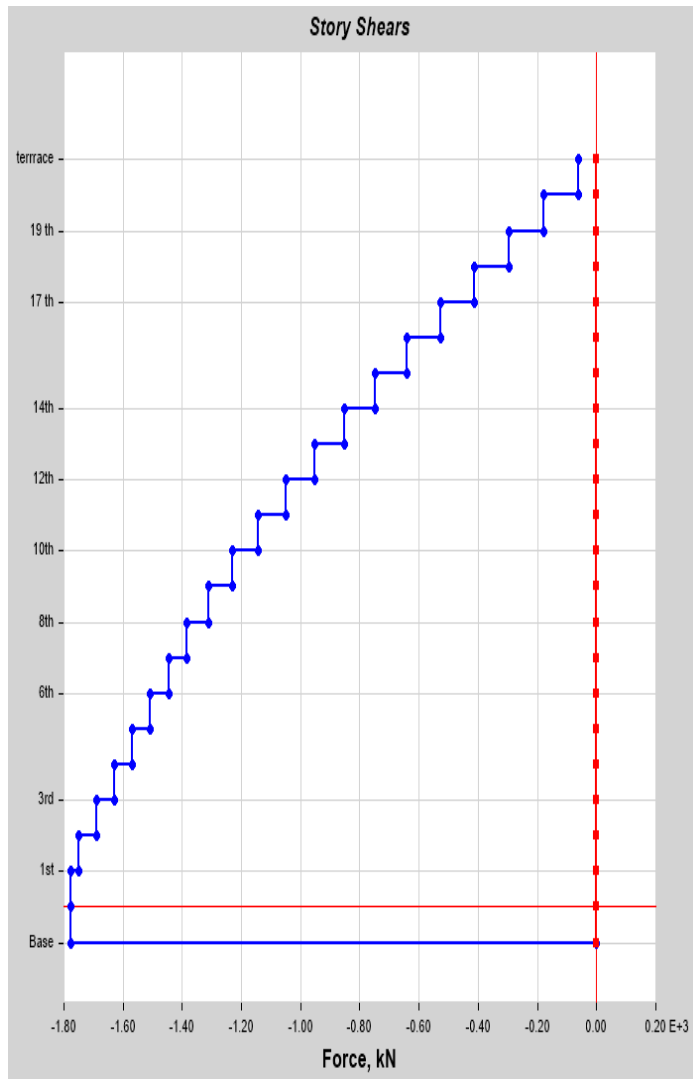
ZONE III –TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	12.751
20th	60	12.612
19th	57	12.437
18th	54	12.219
17th	51	11.951
16th	48	11.634
15th	45	11.267
14th	42	10.853
13th	39	10.393
12th	36	9.888
11th	33	9.342
10th	30	8.756
9th	27	8.133
8th	24	7.478
7th	21	6.793
6th	18	6.081
5th	15	5.345
4th	12	4.585
3rd	9	3.798
2nd	6	2.978
1st	3	2.109
g.f	0	1.151
Base	-3	0

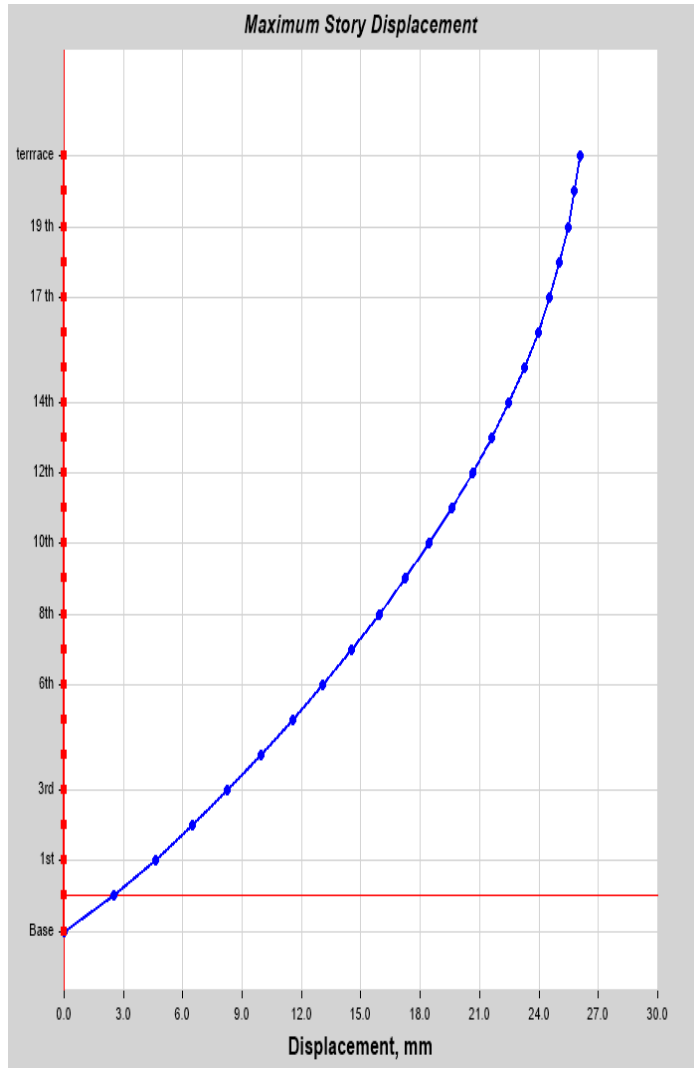


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000047
20th	60	0.000058
19th	57	0.000073
18th	54	0.000089
17th	51	0.000106
16th	48	0.000122
15th	45	0.000138
14th	42	0.000153
13th	39	0.000168
12th	36	0.000182
11th	33	0.000195
10th	30	0.000208
9th	27	0.000219
8th	24	0.000228
7th	21	0.000237
6th	18	0.000245
5th	15	0.000253
4th	12	0.000262
3rd	9	0.000273
2nd	6	0.00029
1st	3	0.00032
g.f	0	0.000384
Base	-3	0

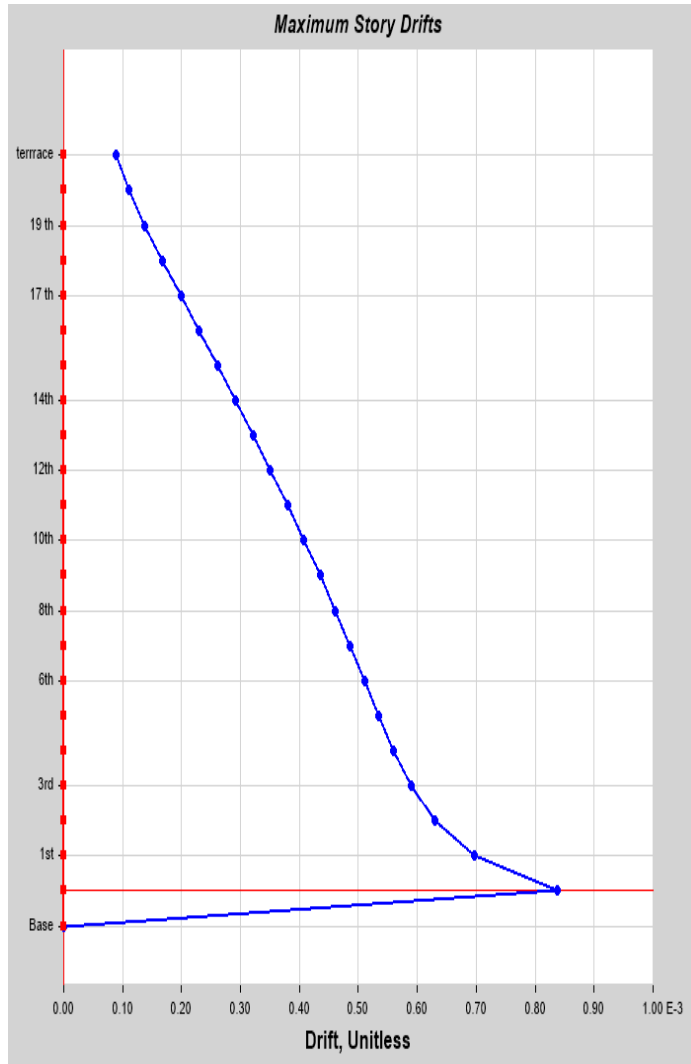


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	60.12
20th	60	179.09
19th	57	296.79
18th	54	413.22
17th	51	528.4
16th	48	640.46
15th	45	748.44
14th	42	852.61
13th	39	952.84
12th	36	1049.4
11th	33	1142.17
10th	30	1231.41
9th	27	1311.51
8th	24	1382.97
7th	21	1446.28
6th	18	1506.98
5th	15	1567.68
4th	12	1628.38
3rd	9	1689.08
2nd	6	1748.27
1st	3	1777.12
g.f	0	1777.12
Base	-3	0

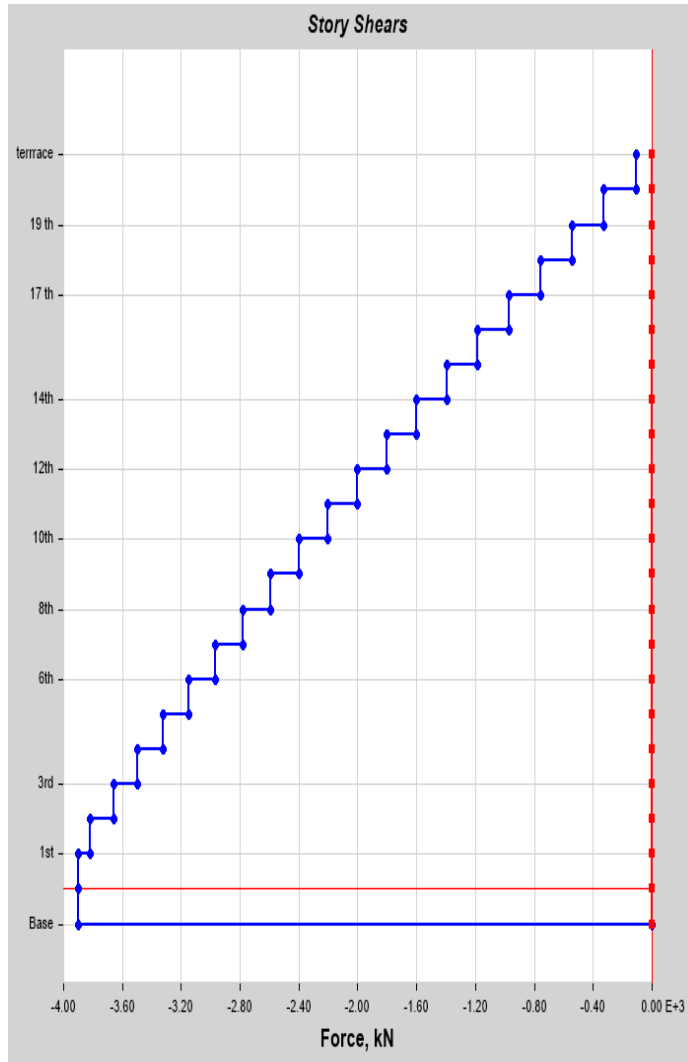
ZONE VI –TERRAIN CATEGORY I



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	26.056
20th	60	25.79
19th	57	25.461
18th	54	25.049
17th	51	24.547
16th	48	23.951
15th	45	23.261
14th	42	22.479
13th	39	21.605
12th	36	20.64
11th	33	19.587
10th	30	18.449
9th	27	17.226
8th	24	15.922
7th	21	14.539
6th	18	13.08
5th	15	11.547
4th	12	9.942
3rd	9	8.262
2nd	6	6.494
1st	3	4.607
g.f	0	2.515
Base	-3	0

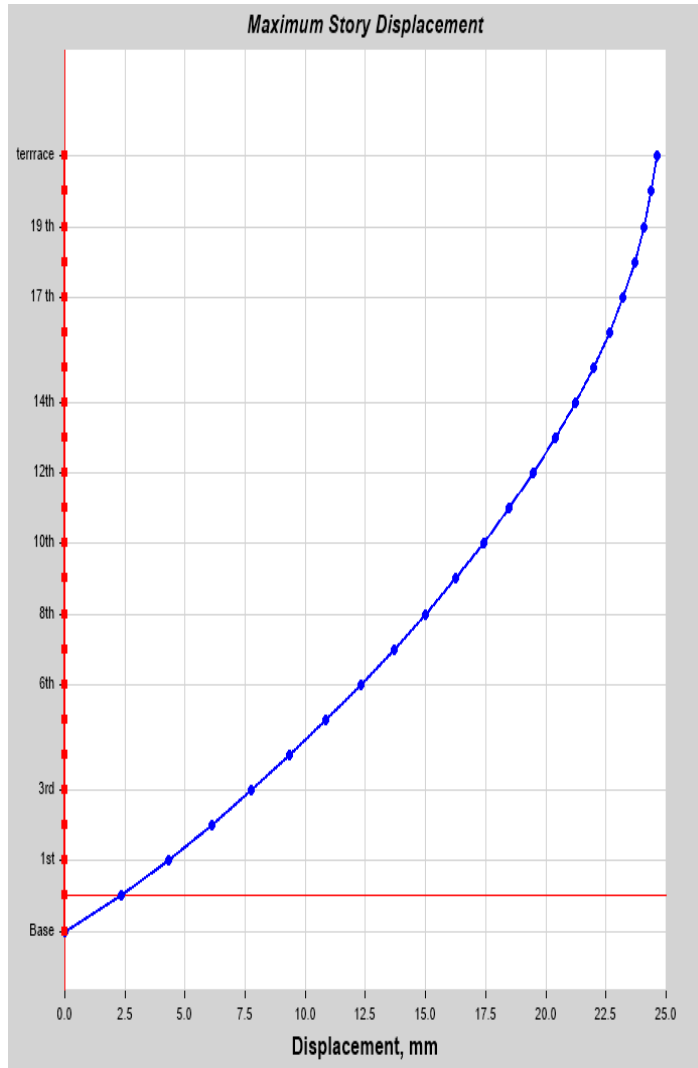


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000089
20th	60	0.00011
19th	57	0.000137
18th	54	0.000167
17th	51	0.000199
16th	48	0.00023
15th	45	0.000261
14th	42	0.000291
13th	39	0.000321
12th	36	0.000351
11th	33	0.00038
10th	30	0.000408
9th	27	0.000435
8th	24	0.000461
7th	21	0.000486
6th	18	0.000511
5th	15	0.000535
4th	12	0.00056
3rd	9	0.000589
2nd	6	0.000629
1st	3	0.000697
g.f	0	0.000838
Base	-3	0

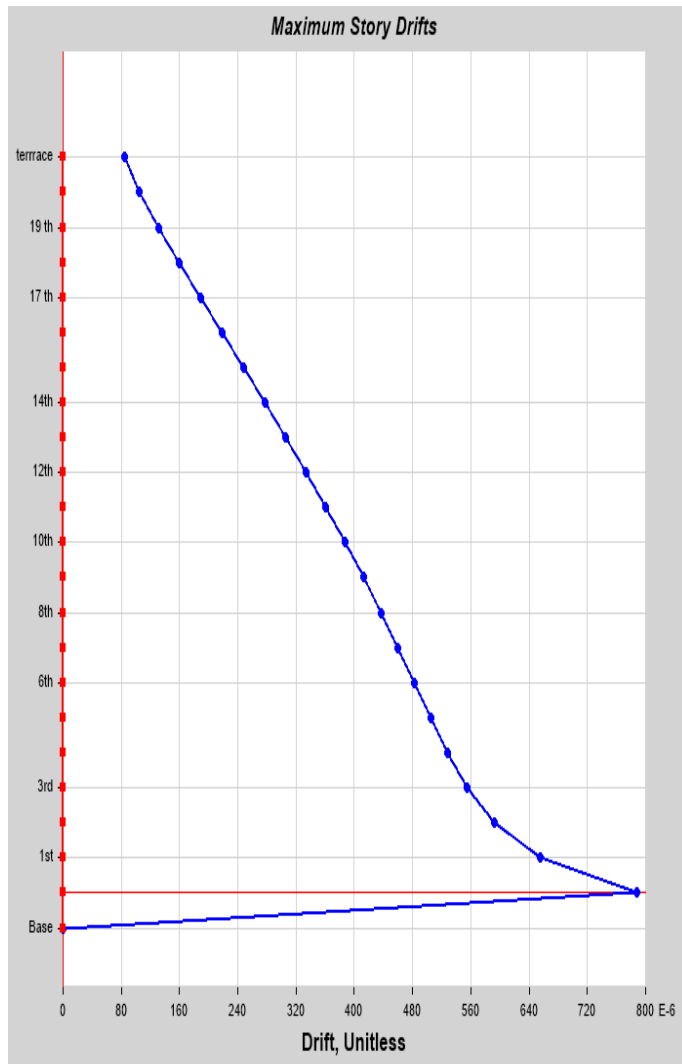


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	109.38
20th	60	327.06
19th	57	543.31
18th	54	758.49
17th	51	972.24
16th	48	1183.86
15th	45	1393.01
14th	42	1599.35
13th	39	1802.9
12th	36	2004.03
11th	33	2202.75
10th	30	2398.73
9th	27	2591.66
8th	24	2781.56
7th	21	2968.45
6th	18	3150.38
5th	15	3326.45
4th	12	3494.85
3rd	9	3658.23
2nd	6	3818.51
1st	3	3897.12
g.f	0	3897.12
Base	-3	0

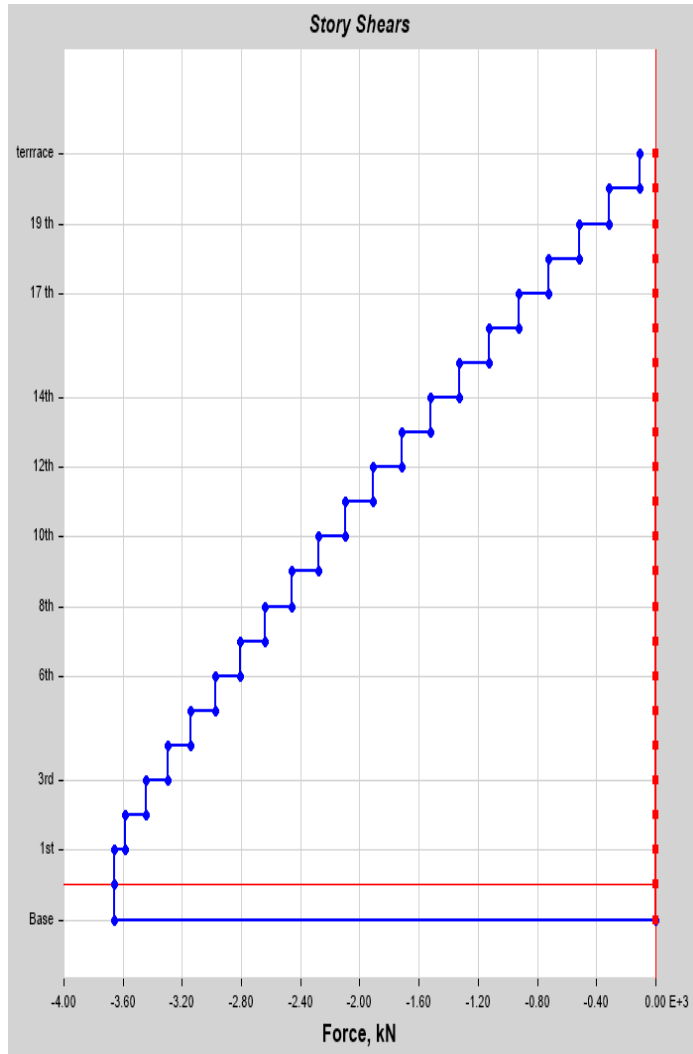
ZONE VI –TERRAIN CATEGORY II



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	24.639
20th	60	24.387
19th	57	24.073
18th	54	23.681
17th	51	23.203
16th	48	22.636
15th	45	21.98
14th	42	21.236
13th	39	20.404
12th	36	19.487
11th	33	18.486
10th	30	17.404
9th	27	16.243
8th	24	15.005
7th	21	13.695
6th	18	12.314
5th	15	10.866
4th	12	9.351
3rd	9	7.767
2nd	6	6.103
1st	3	4.328
g.f	0	2.363
Base	-3	0

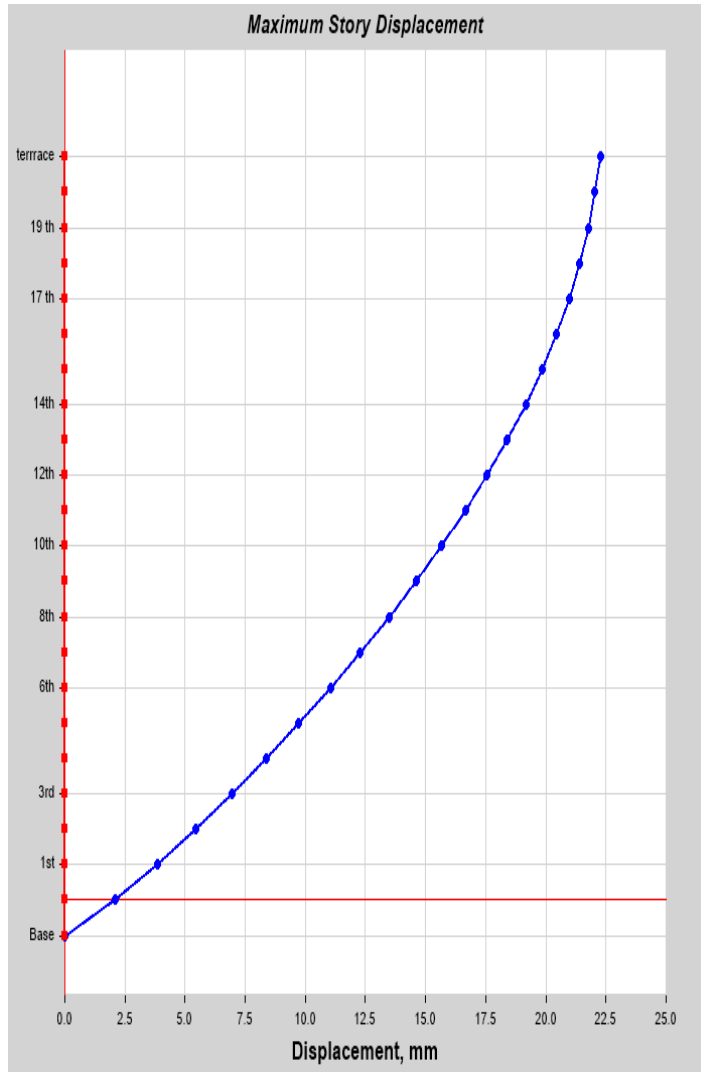


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000084
20th	60	0.000105
19th	57	0.000131
18th	54	0.000159
17th	51	0.000189
16th	48	0.000219
15th	45	0.000248
14th	42	0.000277
13th	39	0.000306
12th	36	0.000334
11th	33	0.000361
10th	30	0.000387
9th	27	0.000412
8th	24	0.000437
7th	21	0.00046
6th	18	0.000483
5th	15	0.000505
4th	12	0.000528
3rd	9	0.000555
2nd	6	0.000592
1st	3	0.000655
g.f	0	0.000788
Base	-3	0

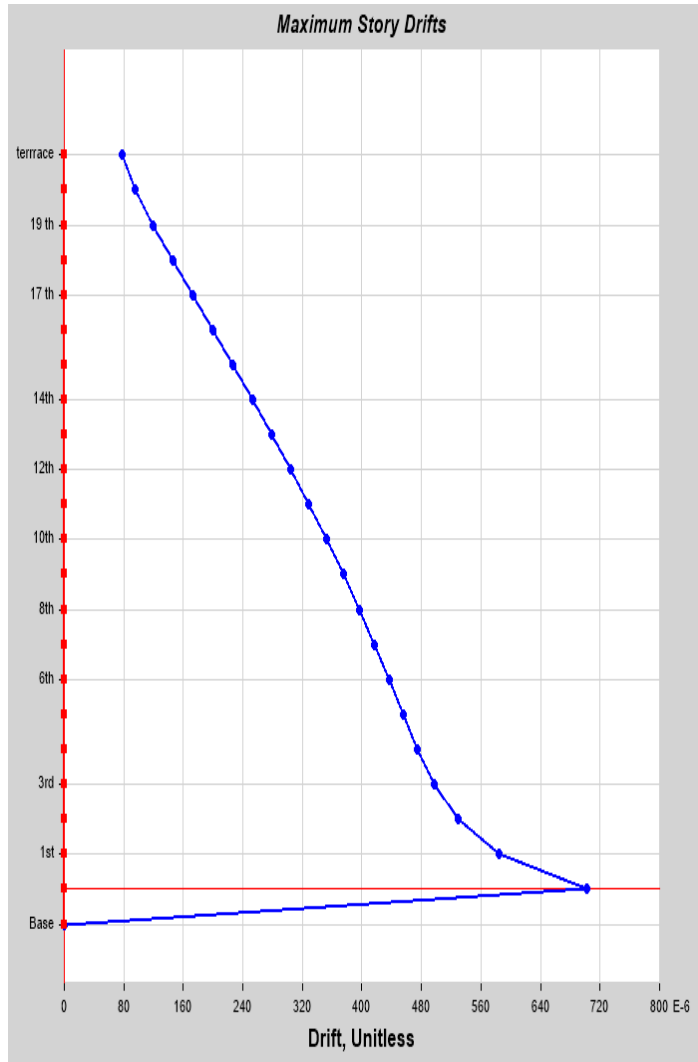


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	104.57
20th	60	312.31
19th	57	518.3
18th	54	722.9
17th	51	926.11
16th	48	1127.24
15th	45	1325.96
14th	42	1521.94
13th	39	1715.54
12th	36	1906.44
11th	33	2095
10th	30	2280.89
9th	27	2461.84
8th	24	2637.91
7th	21	2809.16
6th	18	2976.3
5th	15	3139.68
4th	12	3293.86
3rd	9	3442.05
2nd	6	3587.29
1st	3	3659.91
g.f	0	3659.91
Base	-3	0

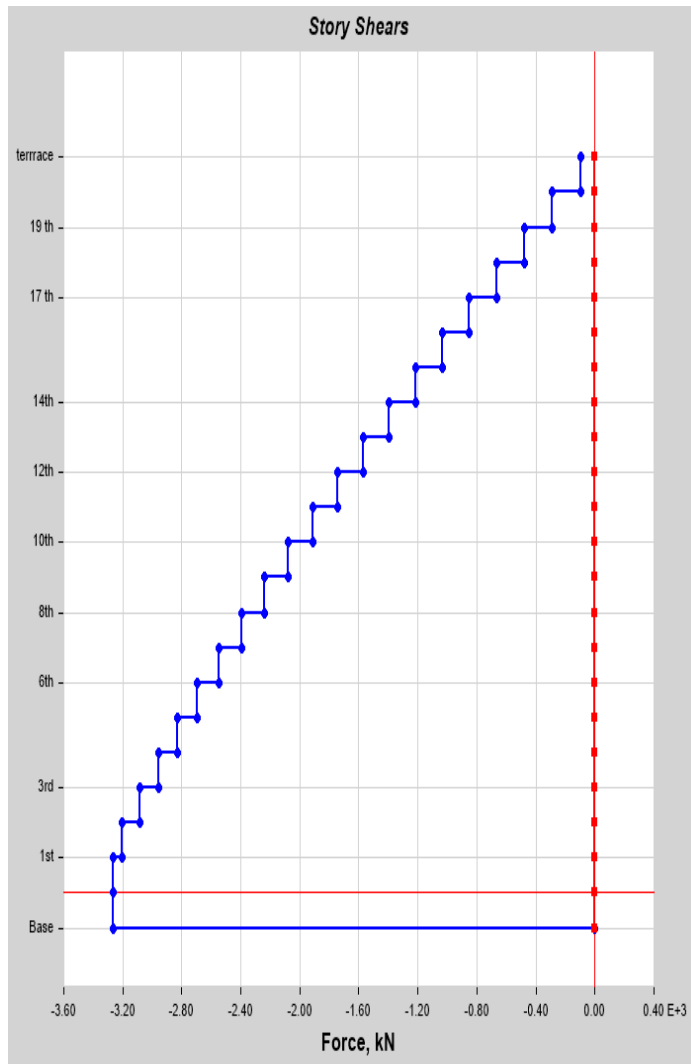
ZONE VI –TERRAIN CATEGORY III



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	22.276
20th	60	22.045
19th	57	21.758
18th	54	21.398
17th	51	20.96
16th	48	20.441
15th	45	19.84
14th	42	19.159
13th	39	18.398
12th	36	17.56
11th	33	16.647
10th	30	15.661
9th	27	14.604
8th	24	13.479
7th	21	12.289
6th	18	11.038
5th	15	9.729
4th	12	8.363
3rd	9	6.94
2nd	6	5.449
1st	3	3.862
g.f	0	2.108
Base	-3	0

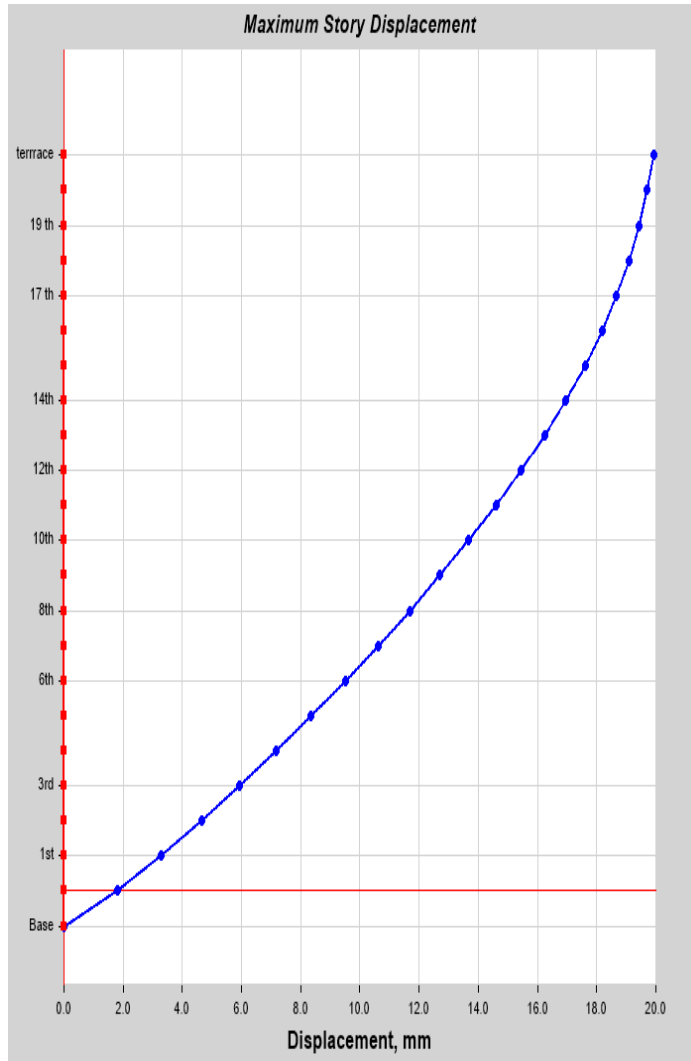


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000077
20th	60	0.000096
19th	57	0.00012
18th	54	0.000146
17th	51	0.000173
16th	48	0.0002
15th	45	0.000227
14th	42	0.000253
13th	39	0.000279
12th	36	0.000304
11th	33	0.000329
10th	30	0.000352
9th	27	0.000375
8th	24	0.000397
7th	21	0.000417
6th	18	0.000436
5th	15	0.000455
4th	12	0.000474
3rd	9	0.000497
2nd	6	0.000529
1st	3	0.000585
g.f	0	0.000703
Base	-3	0

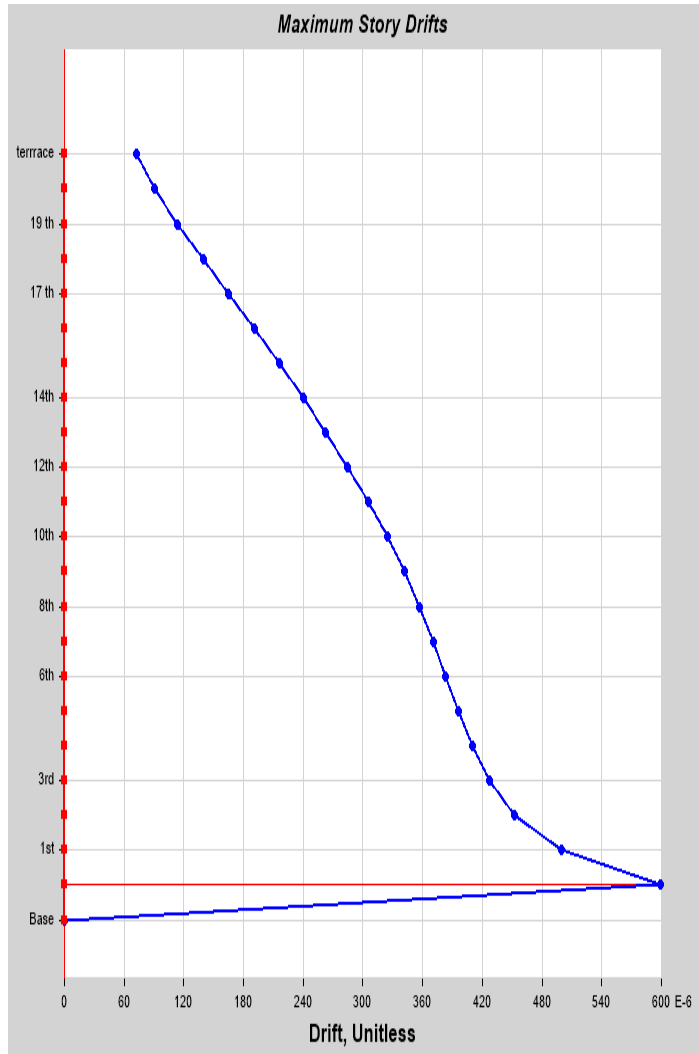


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	96.46
20th	60	287.7
19th	57	477.26
18th	54	665.15
17th	51	851.37
16th	48	1035.27
15th	45	1216.22
14th	42	1394.23
13th	39	1569.33
12th	36	1741.54
11th	33	1910.89
10th	30	2077.4
9th	27	2239.23
8th	24	2396.45
7th	21	2549.12
6th	18	2694.36
5th	15	2830.93
4th	12	2959.1
3rd	9	3081.82
2nd	6	3201.85
1st	3	3261.73
g.f	0	3261.73
Base	-3	0

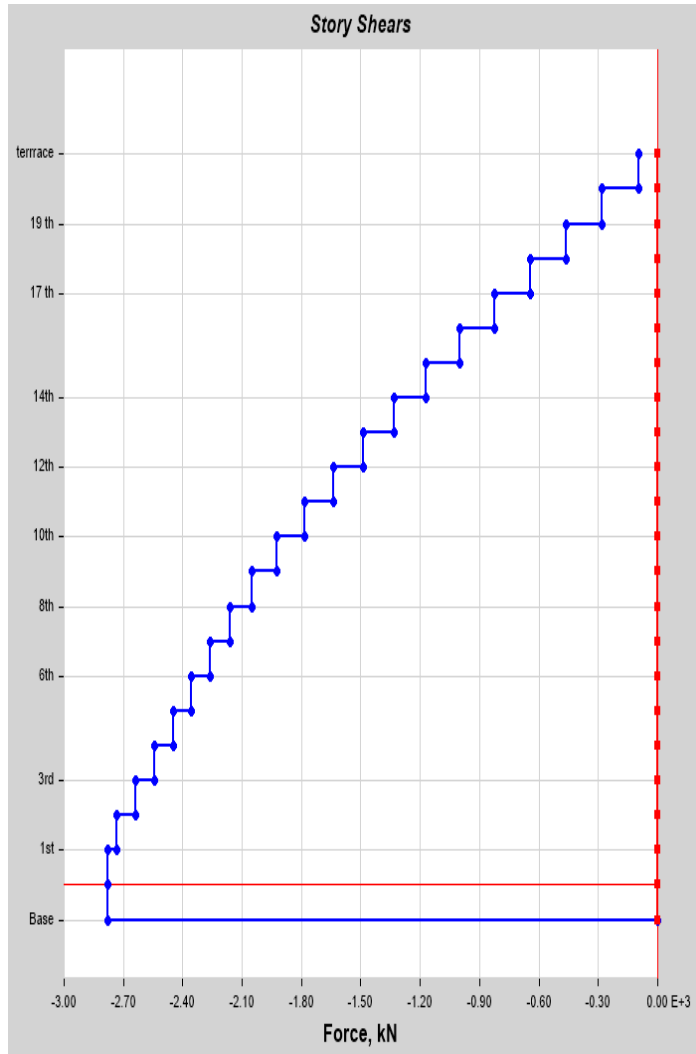
ZONE VI –TERRAIN CATEGORY IV



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	19.923
20th	60	19.705
19th	57	19.433
18th	54	19.091
17th	51	18.673
16th	48	18.178
15th	45	17.605
14th	42	16.958
13th	39	16.238
12th	36	15.45
11th	33	14.596
10th	30	13.681
9th	27	12.708
8th	24	11.684
7th	21	10.613
6th	18	9.502
5th	15	8.352
4th	12	7.164
3rd	9	5.935
2nd	6	4.654
1st	3	3.296
g.f	0	1.798
Base	-3	0



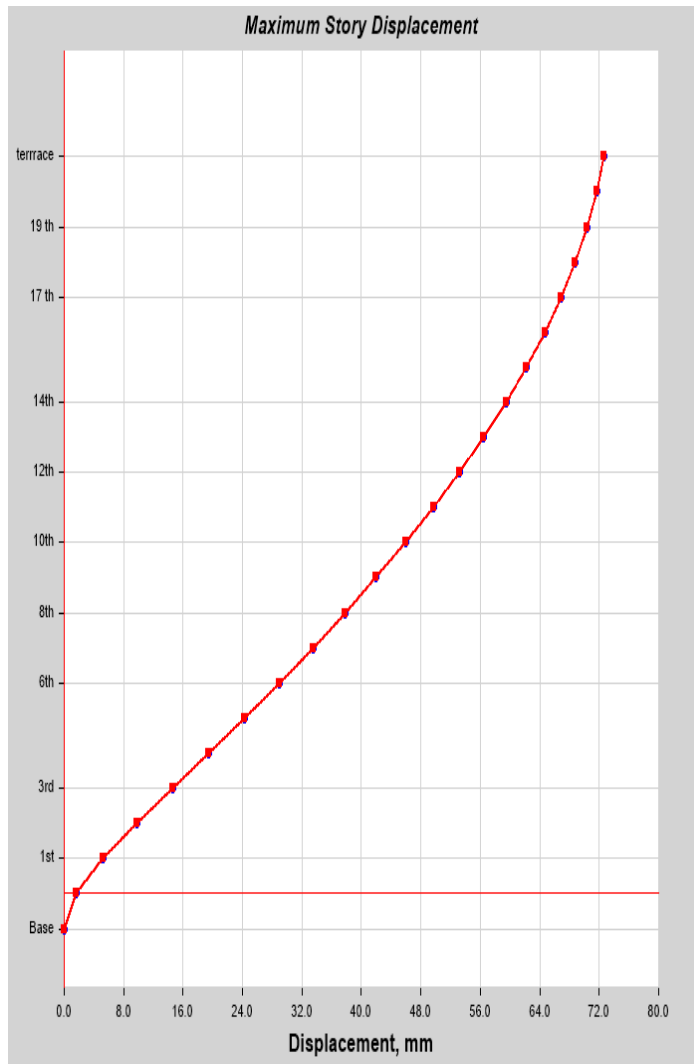
Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000073
20th	60	0.000091
19th	57	0.000114
18th	54	0.000139
17th	51	0.000165
16th	48	0.000191
15th	45	0.000216
14th	42	0.00024
13th	39	0.000263
12th	36	0.000285
11th	33	0.000305
10th	30	0.000324
9th	27	0.000341
8th	24	0.000357
7th	21	0.00037
6th	18	0.000383
5th	15	0.000396
4th	12	0.00041
3rd	9	0.000427
2nd	6	0.000453
1st	3	0.000499
g.f	0	0.000599
Base	-3	0



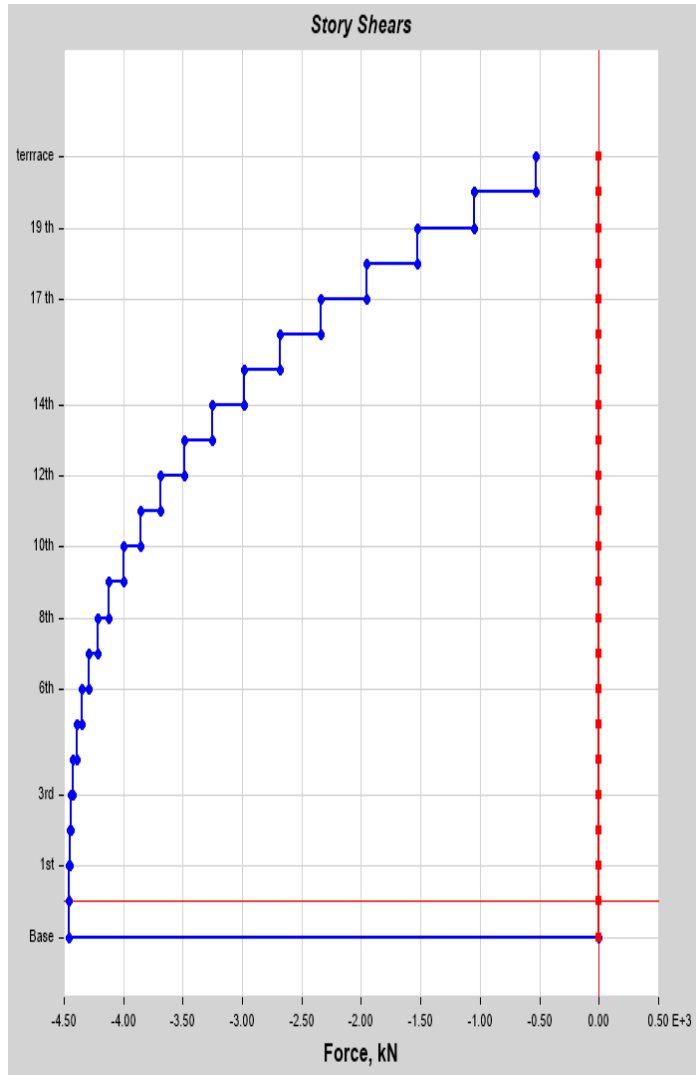
Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	93.94
20th	60	279.83
19th	57	463.73
18th	54	645.66
17th	51	825.66
16th	48	1000.72
15th	45	1169.43
14th	42	1332.19
13th	39	1488.8
12th	36	1639.67
11th	33	1784.62
10th	30	1924.05
9th	27	2049.21
8th	24	2160.86
7th	21	2259.78
6th	18	2354.62
5th	15	2449.46
4th	12	2544.3
3rd	9	2639.14
2nd	6	2731.63
1st	3	2776.71
g.f	0	2776.71
Base	-3	0

SEISMIC ANALYSIS –ZONE V

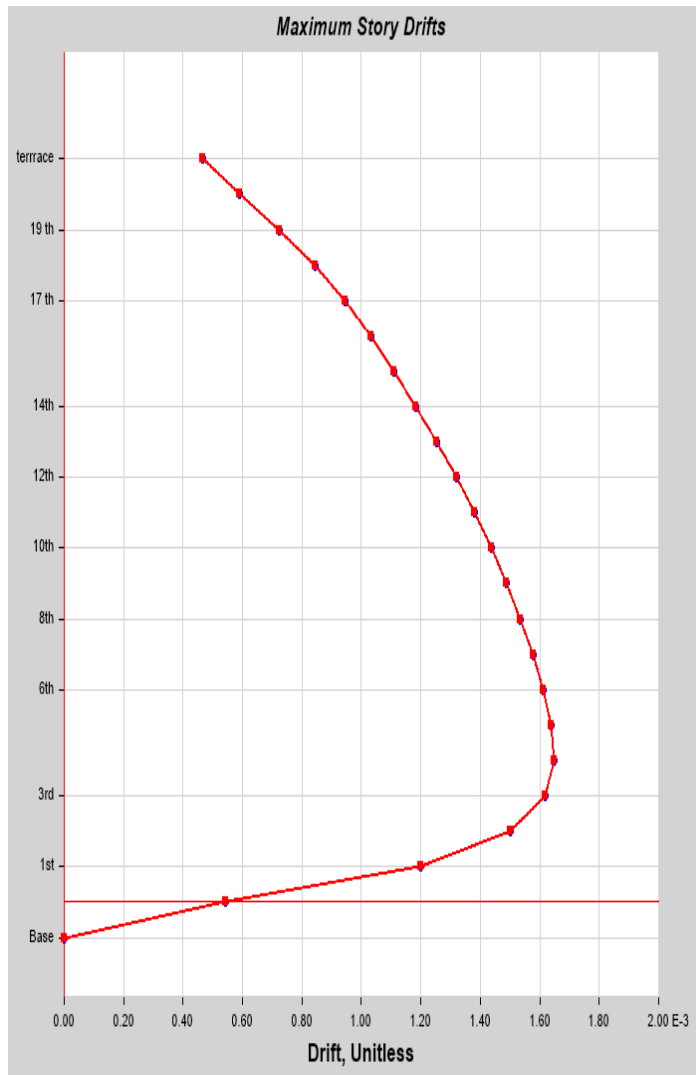
SQUARE



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	72.685
20th	60	71.654
19th	57	70.374
18th	54	68.793
17th	51	66.905
16th	48	64.716
15th	45	62.238
14th	42	59.483
13th	39	56.464
12th	36	53.193
11th	33	49.683
10th	30	45.947
9th	27	41.996
8th	24	37.843
7th	21	33.501
6th	18	28.98
5th	15	24.294
4th	12	19.47
3rd	9	14.569
2nd	6	9.728
1st	3	5.23
g.f	0	1.629
Base	-3	0

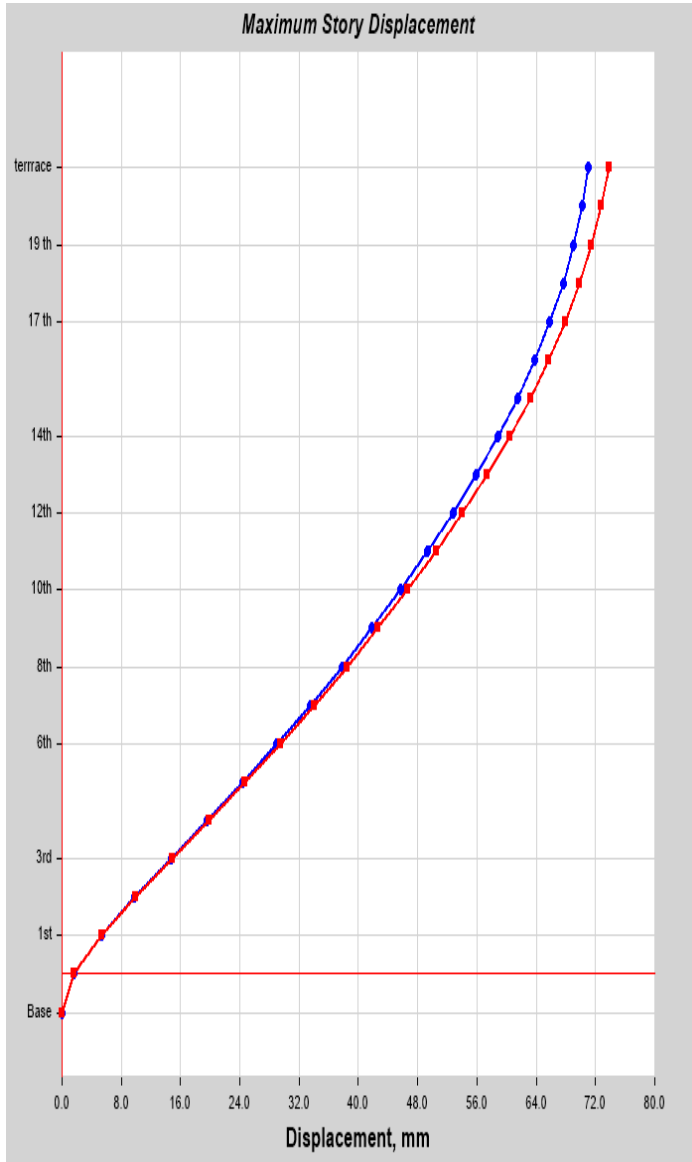


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	526.2923
20th	60	1050.0341
19th	57	1525.0834
18th	54	1953.8154
17th	51	2338.6054
16th	48	2681.8285
15th	45	2985.8601
14th	42	3253.0753
13th	39	3485.8495
12th	36	3686.5578
11th	33	3857.5756
10th	30	4001.278
9th	27	4120.0403
8th	24	4216.2378
7th	21	4292.2457
6th	18	4350.4392
5th	15	4393.1937
4th	12	4422.8842
3rd	9	4441.8862
2nd	6	4452.5748
1st	3	4457.3253
g.f	0	4458.5129
Base	-3	0

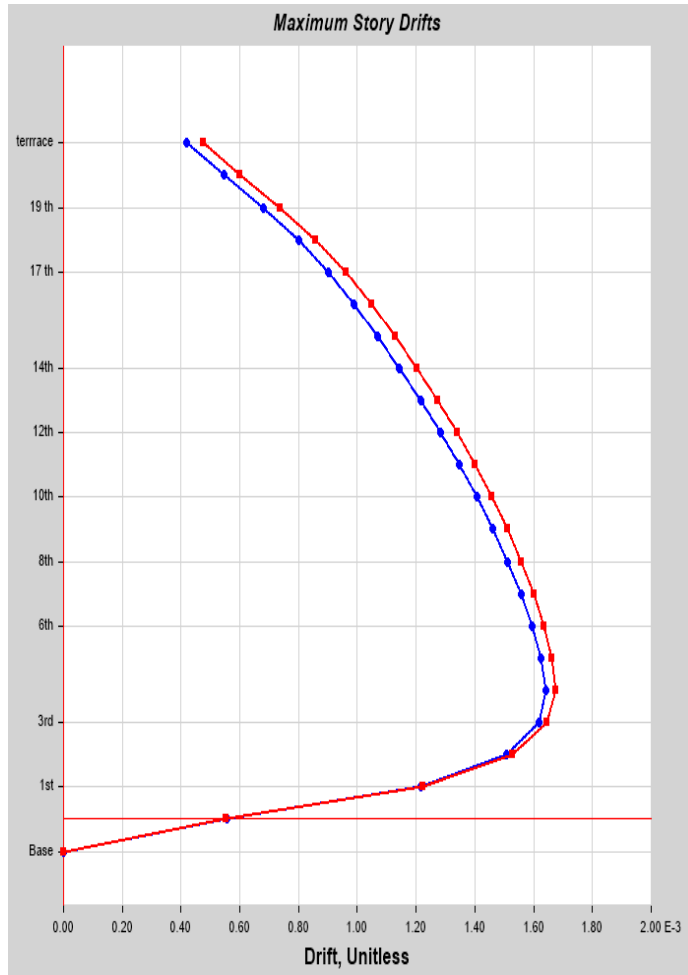


Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000466
20th	60	0.000591
19th	57	0.000725
18th	54	0.000844
17th	51	0.000945
16th	48	0.001031
15th	45	0.00111
14th	42	0.001184
13th	39	0.001253
12th	36	0.001318
11th	33	0.001379
10th	30	0.001436
9th	27	0.001489
8th	24	0.001536
7th	21	0.001577
6th	18	0.001611
5th	15	0.001638
4th	12	0.001648
3rd	9	0.001619
2nd	6	0.001501
1st	3	0.001201
g.f	0	0.000543
Base	-3	0

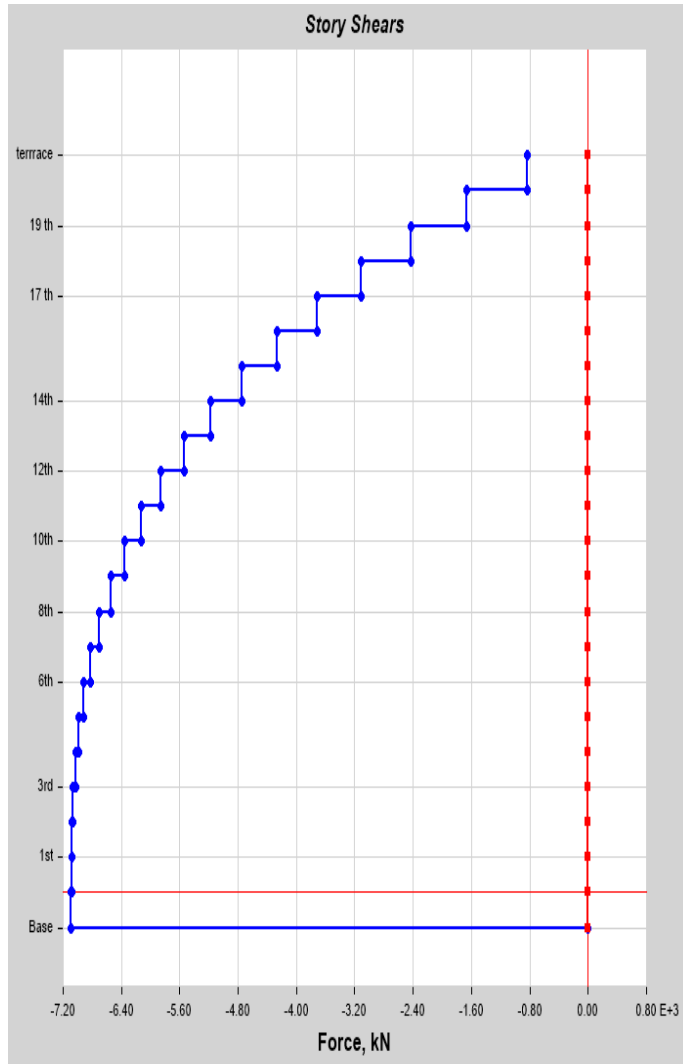
RECTANGLE



Storey response values			
Storey	Elevation (m)	X-Dir (mm)	Y-Dir (mm)
terrace	63	71.083	73.814
20th	60	70.199	72.766
19th	57	69.061	71.464
18th	54	67.617	69.858
17th	51	65.861	67.939
16th	48	63.8	65.715
15th	45	61.445	63.198
14th	42	58.807	60.401
13th	39	55.898	57.335
12th	36	52.731	54.015
11th	33	49.319	50.453
10th	30	45.672	46.662
9th	27	41.804	42.653
8th	24	37.726	38.44
7th	21	33.45	34.034
6th	18	28.986	29.447
5th	15	24.348	24.693
4th	12	19.559	19.798
3rd	9	14.677	14.822
2nd	6	9.835	9.903
1st	3	5.311	5.329
g.f	0	1.664	1.662
Base	-3	0	0

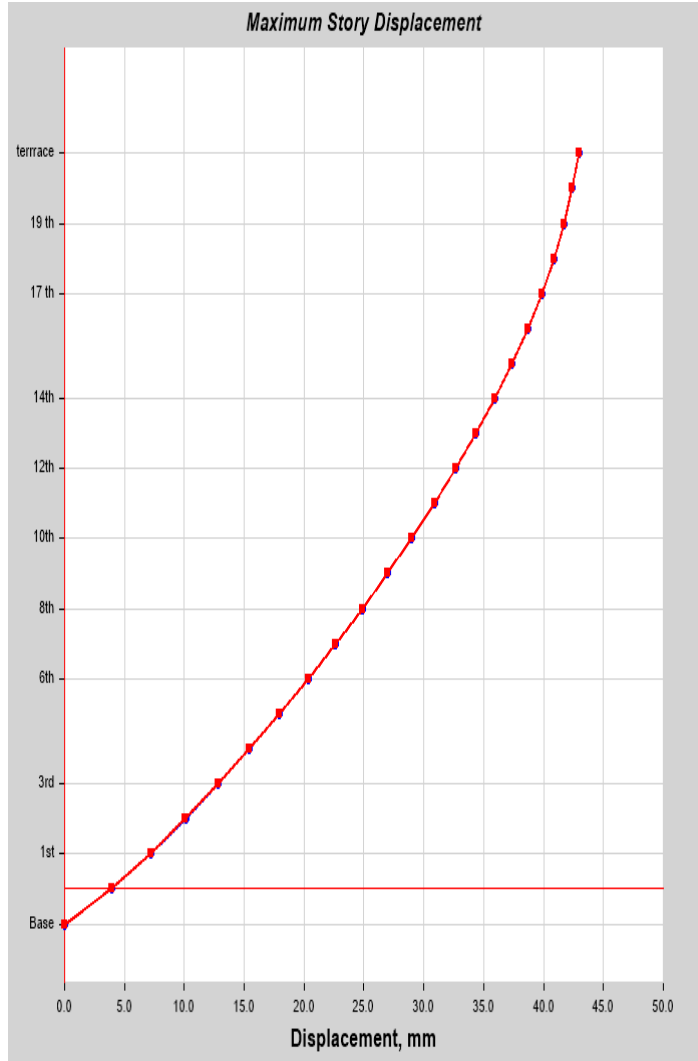


Storey response values			
Storey	Elevation (m)	X-Dir	X-Dir
terrace	63	0.000419	0.000474
20th	60	0.000546	0.000601
19th	57	0.000681	0.000737
18th	54	0.000801	0.000859
17th	51	0.000902	0.000961
16th	48	0.000989	0.001048
15th	45	0.001069	0.001128
14th	42	0.001144	0.001203
13th	39	0.001216	0.001273
12th	36	0.001283	0.001339
11th	33	0.001346	0.0014
10th	30	0.001406	0.001458
9th	27	0.001462	0.001511
8th	24	0.001512	0.001559
7th	21	0.001557	0.0016
6th	18	0.001595	0.001635
5th	15	0.001626	0.001662
4th	12	0.001642	0.001674
3rd	9	0.001619	0.001645
2nd	6	0.001509	0.001526
1st	3	0.001216	0.001223
g.f	0	0.000555	0.000554
Base	-3	0	0

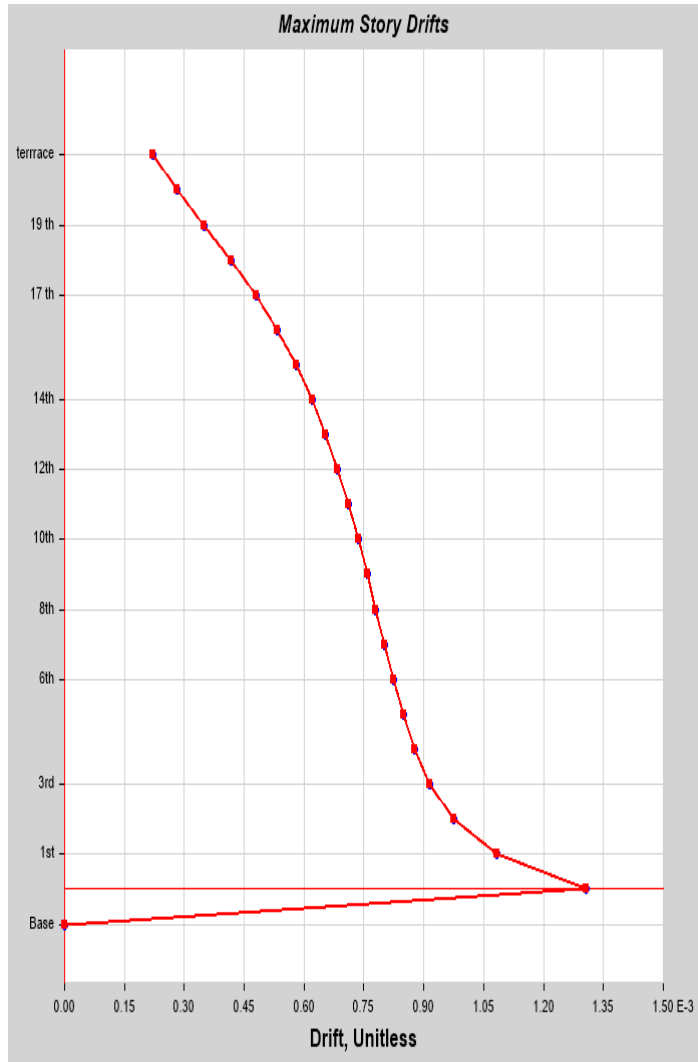


Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	839.308
20th	60	1671.5428
19th	57	2426.4043
18th	54	3107.6668
17th	51	3719.1046
16th	48	4264.492
15th	45	4747.6034
14th	42	5172.213
13th	39	5542.0951
12th	36	5861.0241
11th	33	6132.7742
10th	30	6361.1198
9th	27	6549.8352
8th	24	6702.6947
7th	21	6823.4725
6th	18	6915.9431
5th	15	6983.8806
4th	12	7031.0594
3rd	9	7061.2539
2nd	6	7078.2383
1st	3	7085.7869
g.f	0	7087.674
Base	-3	0

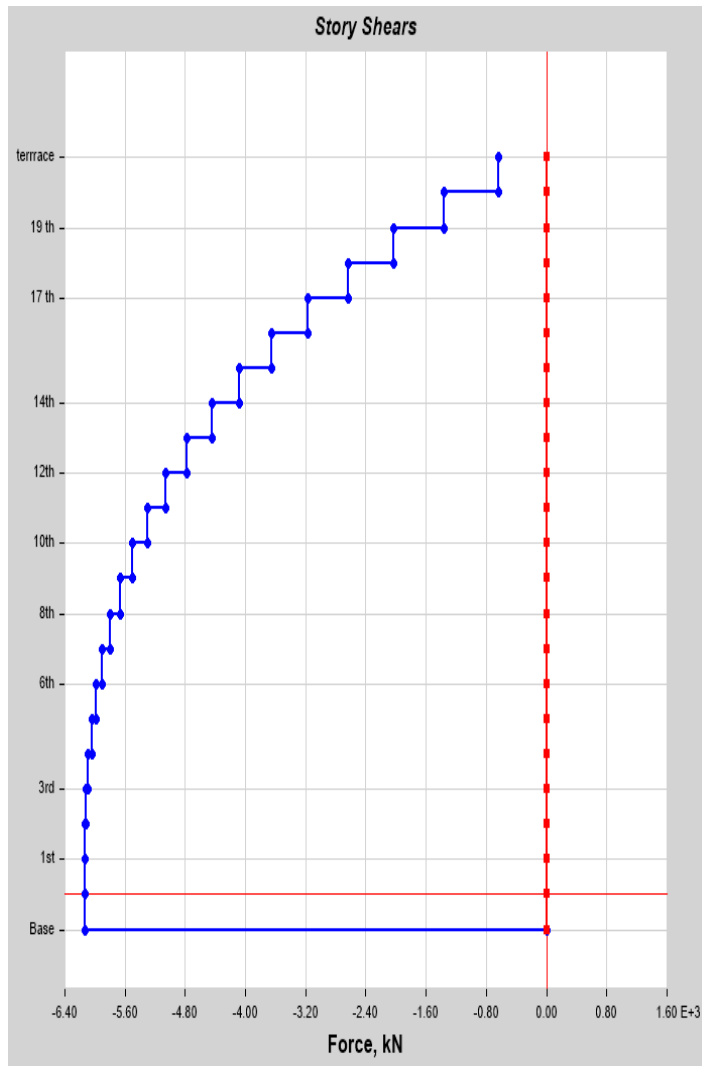
OCTAGONAL



Storey response values		
Storey	Elevation (m)	X-Dir (mm)
terrace	63	42.974
20th	60	42.414
19th	57	41.724
18th	54	40.876
17th	51	39.866
16th	48	38.701
15th	45	37.39
14th	42	35.944
13th	39	34.371
12th	36	32.68
11th	33	30.878
10th	30	28.97
9th	27	26.96
8th	24	24.85
7th	21	22.643
6th	18	20.338
5th	15	17.937
4th	12	15.436
3rd	9	12.829
2nd	6	10.092
1st	3	7.171
g.f	0	3.922
Base	-3	0



Storey response values		
Storey	Elevation (m)	X-Dir
terrace	63	0.000221
20th	60	0.00028
19th	57	0.00035
18th	54	0.000418
17th	51	0.000479
16th	48	0.000533
15th	45	0.00058
14th	42	0.00062
13th	39	0.000655
12th	36	0.000685
11th	33	0.000711
10th	30	0.000735
9th	27	0.000758
8th	24	0.00078
7th	21	0.000802
6th	18	0.000824
5th	15	0.000849
4th	12	0.000878
3rd	9	0.000916
2nd	6	0.000975
1st	3	0.001083
g.f	0	0.001307
Base	-3	0



Storey response values		
Storey	Elevation (m)	X-Dir (kN)
terrace	63	633.4817
20th	60	1366.3554
19th	57	2031.0935
18th	54	2631.0196
17th	51	3169.4574
16th	48	3649.7307
15th	45	4075.1631
14th	42	4449.0782
13th	39	4774.7999
12th	36	5055.6517
11th	33	5294.9574
10th	30	5496.0407
9th	27	5662.2252
8th	24	5796.8347
7th	21	5903.1928
6th	18	5984.6332
5th	15	6044.4496
4th	12	6085.9957
3rd	9	6112.5853
2nd	6	6127.5419
1st	3	6134.1892
g.f	0	6135.8511
Base	-3	0