

Analysis of G+20 RC Tall Building in Different Zones using ETABS

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ABSTRACT: The race towards new heights and architecture has not been without challenges. When the building increases in height, the stiffness of the structure becomes more important. Tall structures have continued to climb higher and higher facing strange loading effects and very high loading values due to dominating lateral loads. The design criteria for tall buildings are strength, serviceability, stability and human comfort. Thus the effects of lateral loads like wind loads, earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. The objectives of the present work is to study the behaviour of a multi storied R C building subjected to earthquake load by adopting Linear static analysis. The present study is limited to reinforced concrete (RC) multi-storied commercial building with FOUR different zones II, III, IV & V. The analysis is Carried out with the help of FEM software's ETABS. The building model in the study has twenty one storey's with constant storey height of 3m. Effect of lateral load on moments, axial forces, shear force, base shear, maximum storey drift and tensile forces on structural system are studied and also comparing the results of zone 2, zone 3, zone 4 and zone 5. Different values of seismic zone factor are taken and their corresponding effects are interpreted in the results.

The parameters, for example, base shear, displacements, storey drifts and storey shear of building model were analyzed and interpreted in this project.

KEYWORDS: G+20 RC tall building, Displacement, Base shear, Storey drift, Storey shear.

I. INTRODUCTION

India is a developing country, huge construction projects are yet to come as undeveloped cities are needed to develop since so many years. In current century, many construction projects all over the world are going, time delay takes place which in turn affects the growth of the construction of huge projects. To avoid time delay and thereby the growth, economic construction methodology should be adopted. To economize the structure, structural optimization techniques should be used.

For large projects, it is necessary to go for structural optimization because it directly affects cost of construction. Many Metropolitan cities are facing vast growth of infrastructure whether it may be in terms of horizontal development or vertical development. Metropolitan cities like Delhi, Bangalore and Mumbai have high population and in forth coming years' land availability problems will increase tremendously which will in turn affect the overall growth of the city, so most of the builders in construction industries prefers vertical development of structures. As we increase number of stories or height of structure, huge lateral forces come into picture which will tend to increase the construction cost of the project in terms of consumption of steel, concrete and such other materials. Hence usually optimization techniques are adopted to economize the structure. New and different approaches to design have become possible through the increased speed of computers and software tools of optimization theory. The optimization exercise commences right from the architectural concept stage. Suggested grid dimensions by architecture usually do not result into most economical structural member sizes and reinforcement consumption. In general optimization includes discretization of a whole structure into a series of sub frames with slab, beams, columns and footings.

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The objectives of the present work is to study the behaviour of a multi storied R C building subjected to earth quake load by adopting Linear or equivalent static analysis. The present study is limited to reinforced concrete (RC) multi-storied commercial building with FOUR different zones II, III, IV & V. The analysis is carried out the help of FEM software's ETABS. The building model in the study has twenty storey's with constant storey height of 3m. Calculation for a high-rise construction manually then it will take extra time in addition to human individual errors possibly will be occurred. Consequently, the use of ETABS (Extended Three-Dimensional Analysis of Building Systems) will make it easy.

Importance of G+20 storey building and its study: Population of India is increasing at alarming rate. This large population not only needs job but also needs housing and infrastructure facilities. With the advent of Industrial Policy most industries are coming in middle level cities and large cities. Hence, large population is migrating to these cities. Thus, the number of structures and buildings required for them is very large in these cities. This massive population increase will put great pressure on agriculture land near big and middle level cities. Medium or high rise would be the only answer to this urbanization. Land will become scarce and therefore, there will be the urgent need to build multi-storey structures in greater number in middle level cities also. At present these cities are expanding horizontally in mix manners but with the scarcity of land there is need for vertical expansion. This is especially needed for saving the agriculture land for growing food items. Hence, the concept of multi-storeyed buildings or high-rise buildings comes into existence.

II. LITERATURE REVIEW

[1] **J.P Annie Sweetlin (2016):** The present day scenario witnesses a series of natural calamities like earthquakes, tsunamis, floods etc. Of these the most damaging and recurrent phenomena is the earthquake. The Effective design and the construction of Earthquake resistant structure has gained greater importance all over the world. In this paper the earthquake resistance of a G+20 multi-storey building is analysed using Equivalent static method with the help of E-TABS 9.7.4 software. The method includes seismic coefficient method as recommended by IS 1893:2002. The parameters studied were displacement, storey drift and storey shear. Seismic analysis was done by using E-TABS software and successfully verified manually as per IS 1893:2002. Drift is within the limits for the building (0.004 times of the height of the storey) $0.004 \times 3.2 = 12.8\text{mm}$. Earthquake Base shear is greater than Wind Base shear. Complete guideline for the use of E-TABS 9.7.4 for seismic coefficient analysis is made available by this paper. [2] **Panchal D.R and Marathi P.M (2011):** The paper involves the comparative study of RCC, steel and composite (G+30) stories structures under the seismic effect. For the analysis equivalent static method has been used and modelling of structures has done by ETABS. From this study they conclude that the steel structures are better than RCC structures for low rise buildings but for high rise buildings the composite option is best suited among all three options. In addition, the reduction in self weight of steel structure is 32% less than RCC structures and the self weight of composite structure is 30% less than RCC structures. And also they suggest that, in steel structure the bending moment of secondary beam increased by average 83.3% and reduced by 48% in composite structure as compare to RCC. [3] **Abhay Guleria (2014):** Abhay Guleria presents the analysis of the multi-storeyed building using ETABS reflected that the storey overturning moment varies inversely with storey height. Moreover, L-shape, I- shape type buildings give almost similar response against the overturning moment. Storey drift displacement increased with storey height up to 6th storey reaching to maximum value and then started decreasing. From dynamic analysis, mode shapes are generated and it can be concluded that asymmetrical plans undergo more deformation than symmetrical plans. Asymmetrical plans should be adopted considering into gap

The above listed literature reviews have mainly discussed the comparison on the effect of earthquake and wind loads on the performance of reinforced concrete buildings and different values of zone factor are taken and their corresponding effects are interpreted in the results and also different values of wind speeds are taken for wind analysis and their corresponding effects of building structure are interpreted in the results. By referring these literature reviews we have made the below mentioned objective of the project.

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Objective: To study the behaviour of a building under the action of seismic loads and wind loads. To compare various analysis results of building under zone II, III, IV and zone V using ETABS Software. To know the base shear, displacement, storey drift and storey shear of the structure.

III.METHODOLOGY

To achieve the objectives of the study that is to modeling and analyze of G+20 RC tall building in different zones using ETABS, which meets the basic requirements such as safety, durability, economy, aesthetic appearance, feasibility, practicability and acceptability. It has been proposed to follow the following methodology.

- Structural planning
- Modeling and analysis in ETABS

Plan Details: An 33m in X direction and 22m in Y direction and a story building is modelled using ETAB Software. The height of each story is kept as 3 m in the structure with the total height of the structure as $21 \times 3 + 1.5 + 0.5 = 65\text{m}$. The building plan in AUTOCAD and centre line diagram in ETABS is shown below,

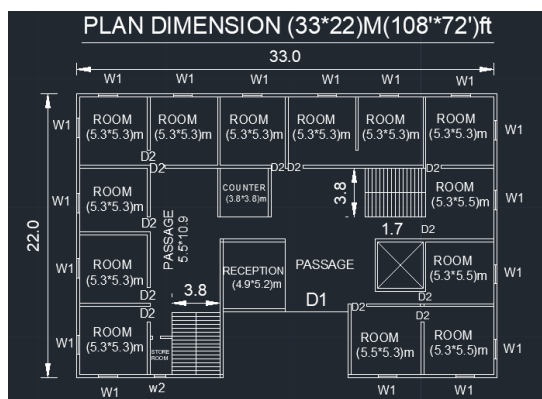


Fig 1: Plan of multistorey building in Autocad.

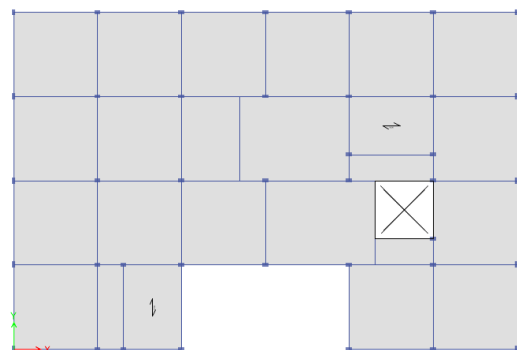


Fig 2: Centre line diagram in Etabs

The 3D view model and rendered view model in ETABS are shown below,

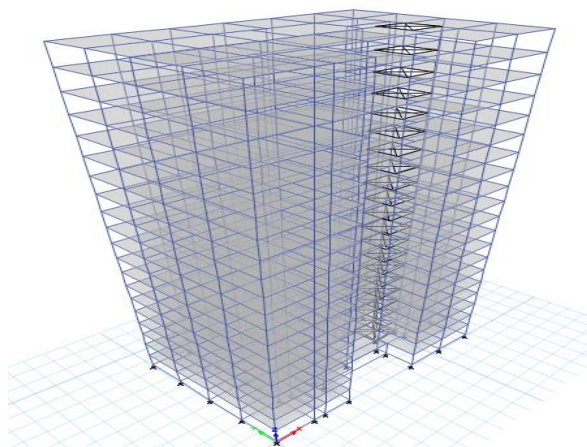


Fig 3:3D model of the structure

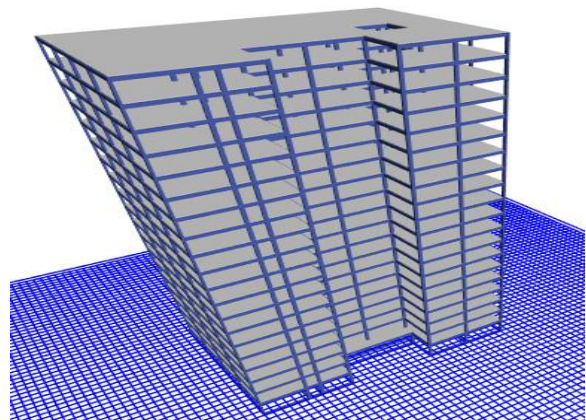


Fig 4: Rendering view of the structure

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MODEL DETAILS:

1. Dead load:

Dead load on floor finishing: 0.8 kN/sq. m. (Table 2 as per IS 875(part1):1987)

2. Live load:

Live load on floor: 5 kN/sq. m. (Table 1 as per IS 875(part2):1987)

Live load on roof: 2 kN/sq. m. (Table 1 as per IS 875(part2):1987)

Wall load: $0.25 \times 1 \times (3-0.6) \times 19 = 12$ kN/m.

Parapet load: $0.15(0.5) \times 19 = 1.425$ kN/m.

3. Seismic load:

Seismic Zone: Zone-II; Zone-III; Zone-IV; Zone-V (As per IS 1893:2002(part1))

Type of structure: Special RC moment-resisting frame (SMR) (Table 7 as per IS 1893:2002(part1))

Seismic Zone factor: 0.16 for Zone II; 0.20 for Zone III; 0.30 for Zone IV; 0.36 for Zone V (Table 2 as per IS 1893:2002(part1))

Importance factor: 1.5 (Table 6 as per IS 1893:2002(part1))

Response reduction factor: 5.0 (Table 7 as per IS 1893:2002(part1))

4. Wind load:

Probability factor or risk co-efficient (K1): 1.05 (clause 3 as per IS 875:1987(part 3))

Terrain, Height and Structure size factor (K2): Terrain category 3 and building class-C (clause 5.3.2.1 as per IS 875:1987(part 3))

Topography factor (K3): 1.0 (clause 5.3.3.1 as per IS 875:1987(part 3))

Design wind speed (Vb): 33 m/s for Zone II; 39 m/s for Zone III; 46 m/s for Zone IV; 50 m/s for Zone V (clause 5.2 as per IS 875:1987(part 3))

5. Building Parameters:

Length x Breadth	33 x 22 m
No. of storeys	21
Storey height	3 m
Beam size	300 x 600 mm
Column size	300 x 900 mm
Slab thickness	140 mm
Staircase slab thickness	140 mm
Plinth beam size	300 x 500 mm
Wall thickness	250 mm
Depth of foundation	1.5 m
No. of columns	798
No. of beams	1176
No. of slabs: 2-way	378
No. of slabs: 1-way	126

Table 1: Building details considered

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IV. RESULTS AND DISCUSSIONS

Seismic analysis of most structures is still carried out on the assumption that the lateral force is equivalent to the actual loading. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves.

[1] Base shear: Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure or the seismic force at base of the building is called the base shear. Earthquake often damages buildings at this level. Weight of the building above cracking is the shear force that broke the building. Typically earthquake damage occurs at base of building.

ZONES	BASE SHEAR (kN)
ZONE II	1231.67
ZONE III	1989.83
ZONE IV	2948.97
ZONE V	4423.61

Table 2: Base shear graph

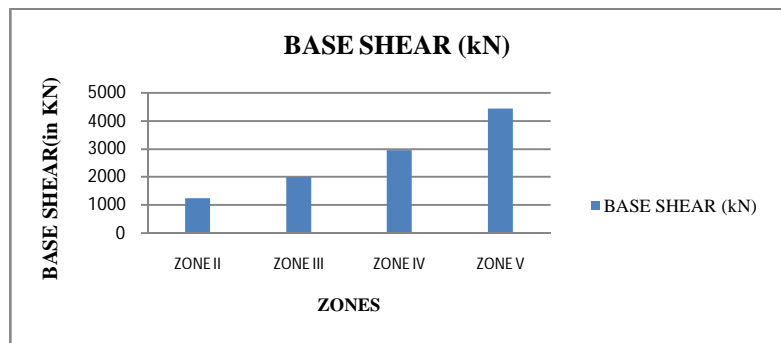


Fig 5: Base shear graph

From the above base shear graph it is clear that, the base shear of structure increases as we go to higher seismic zones. For a similar building the base shear value of ZONE II is 1225.67 KN and ZONE V is 4423.61 KN. This means base shear increases by more than 360% if seismic ZONE changes from II to V.

[2] Displacement for earthquake load: The maximum displacement in the building along X direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQX) and along Y direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQY).

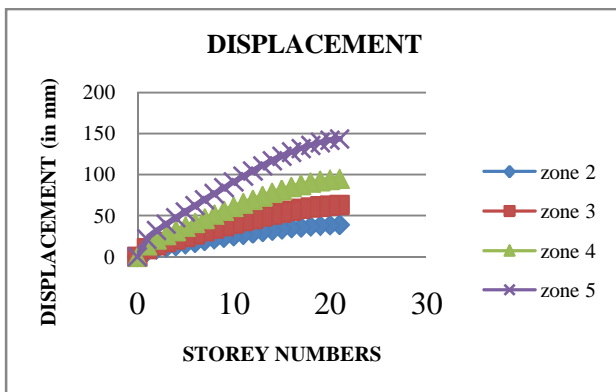


Fig 6: Displacement graph along X direction

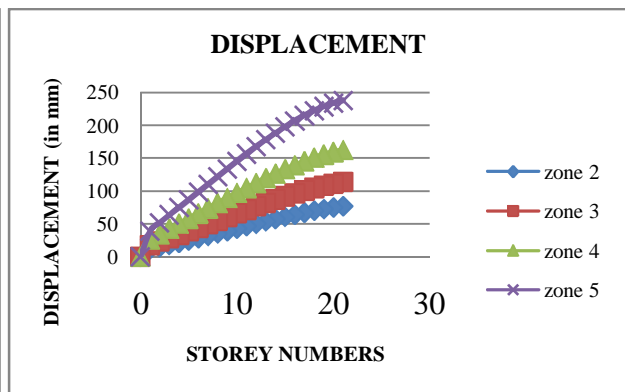


Fig 7: Displacement graph along Y direction

From the above displacement graph (fig 1) it is clear that, the displacement of building models increases with the increasing of seismic Zones. The displacement is very high at roof and very low at the base. The displacement occur at

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the ZONE II is 38.255 mm and ZONE V is 143.337 mm. This means the displacement increases by more than 250% if seismic ZONE changes from II to V.

From the above displacement graph (fig 2) it is clear that, the displacement of building models increases with the increasing of seismic Zones. The displacement is very high at roof and very low at the base. The displacement occur at the ZONE II is 76.32 mm and ZONE V is 237.611 mm. This means the displacement increases by more than 300% if seismic ZONE changes from II to V.

[3] Displacement for wind load: The maximum displacement in the building along X direction is obtained for the wind load combination (1.2DL+1.2LL+1.2WLX) and along Y direction is obtained for the wind load combination (1.2DL+1.2LL+1.2WLY).

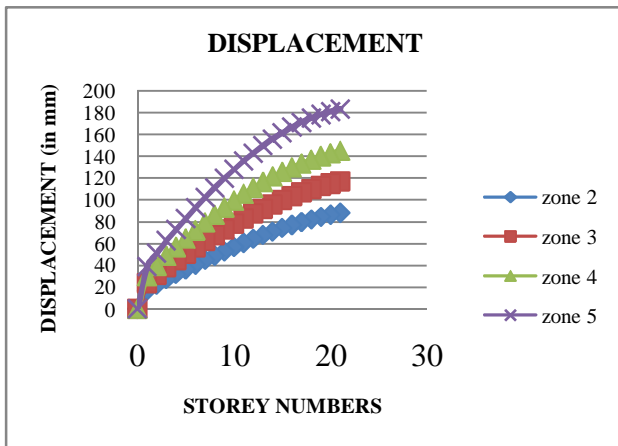


Fig 8: Displacement graph along X direction

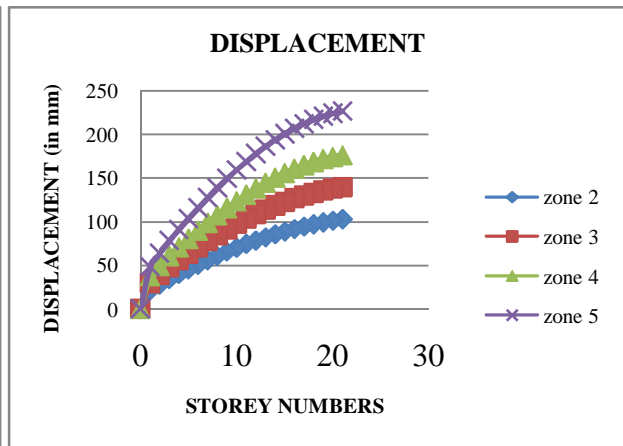


Fig 9: Displacement graph along Y direction

From the above displacement graph (fig 3) it is clear that, the displacement of building models increases with the increasing of seismic Zones. The displacement is very high at roof and very low at the base. The displacement occurs at the wind space 33 m/s is 87.969 mm and at the wind speed 50 m/s is 183.17 mm. This means the displacement is increases by more than 200% from wind speed 33 m/s to 50 m/s.

From the above displacement graph (fig 4) it is clear that, the displacement of building models increases with the increasing of seismic Zones. The displacement is very high at roof and very low at the base. The displacement occurs at the wind space 33 m/s is 102.492 mm and at the wind speed 50 m/s is 226.609 mm. This means the displacement is increases by more than 200% from wind speed 33 m/s to 50 m/s.

[4] Storey drift for earthquake load: The storey drift in the building along X direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQX) and along Y direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQY).

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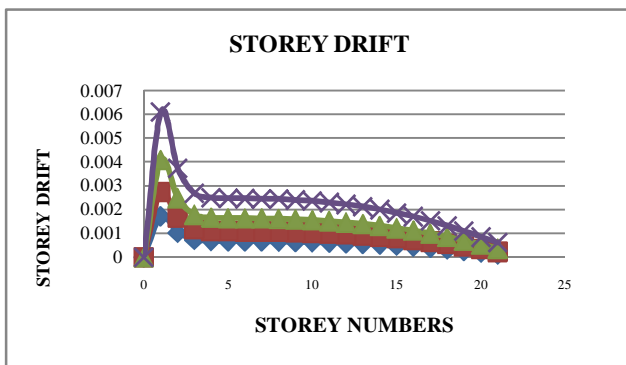


Fig10: Storey drift graph along X direction

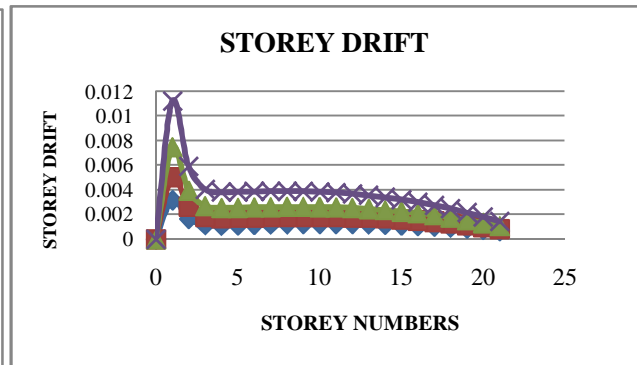


Fig 11: Storey drift graph along Y direction

From the above storey drift graph (fig 5) it is clear that, the storey drift increases with the increasing of seismic zone factor. And the maximum storey drift is available at ZONE V. The storey drift for ZONE II is 0.000117 and storey drift for ZONE V is 0.000606. This means the storey drift is increases by more than 170% when compare to ZONE II to ZONE V.

From the above storey drift graph (fig 6) it is clear that, the storey drift increases with the increasing of seismic zone factor. And the maximum storey drift is available at ZONE V. The storey drift for ZONE II is 0.000652 and storey drift for ZONE V is 0.001441. This means the storey drift is increases by more than 160% when compare to ZONE II to ZONE V.

[5] Storey drift for wind load: The storey drift in the building along X direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2WLX) and along Y direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2WLY).

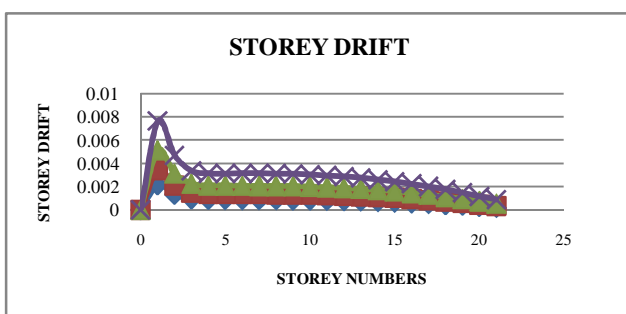


Fig 12: Storey drift graph along X direction

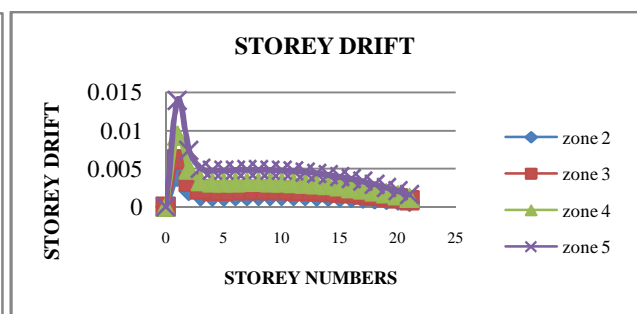


Fig 13: Storey drift graph along Y direction

From the above storey drift graph (fig 7) it is clear that, the storey drift increases with the increasing of wind pressure. And the maximum storey drift is available at ZONE V. The value of storey drift at wind speed 33 m/s is 0.000178 and at high wind speed 50 m/s is 0.000862. This means the storey drift is increases by more than 170%.

From the above storey drift graph (fig 8) it is clear that, the storey drift increases with the increasing of wind pressure. And the maximum storey drift is available at ZONE V. The value of storey drift at wind speed 33 m/s is 0.000642 and at high wind speed 50 m/s is 0.001628. This means the storey drift is increases by more than 190%.

[6] Storey shear for earthquake load: The storey shear in the building along X direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQX) and along Y direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQY).

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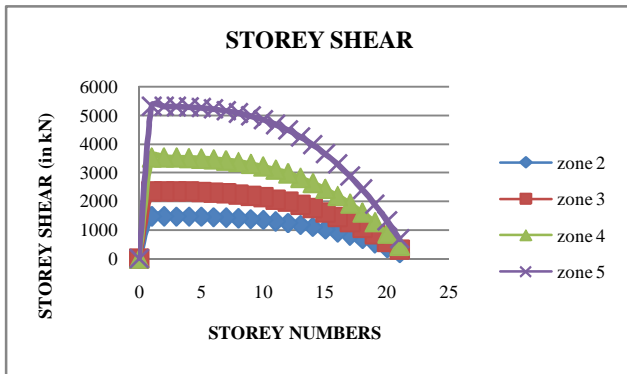


Fig 14: Storey shear graph along X direction

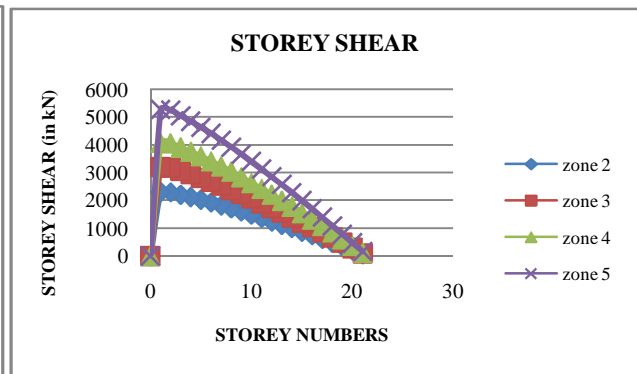


Fig 15: Storey shear graph along Y direction

From the above storey shear graph (fig 9) it is clear that, the Storey Shear is decreased as height of the building increased and reduced at top floor in all the building models. The storey shear is maximum at the base. And the storey shear value for the model in ZONE II is 190.0427 kN and ZONE V is 684.1536 kN. The storey shear is increases by more than 350%.

From the above storey shear graph (fig 10) it is clear that, the Storey Shear is decreased as height of the building increased and reduced at top floor in all the building models. The storey shear is maximum at the base. And the storey shear value for the model in ZONE II is 68.5381 kN and ZONE V is 157.3419 kN. This means the storey shear is increases by more than 200%.

[7] **Storey shear for wind load:** The storey shear in the building along X direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2WLX) and along Y direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2WLY).

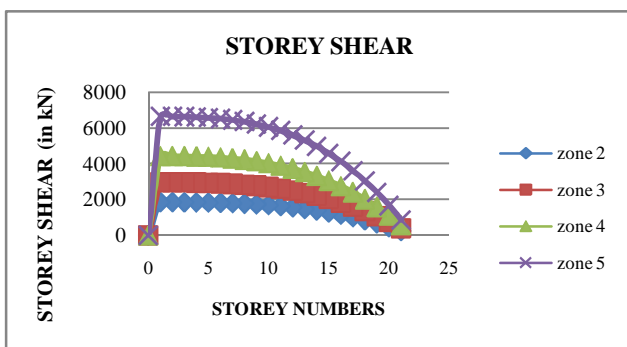


Fig 16: Storey shear graph along X direction

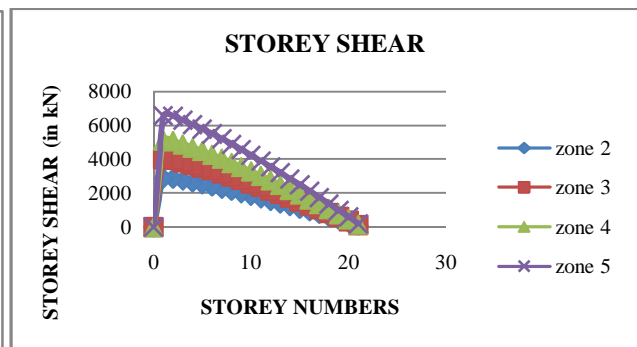


Fig 17: Storey shear graph along Y direction

From the above storey shear graph (fig 11) it is clear that, the Storey Shear is decreased as height of the building increased and reduced at top floor in all the building models. The storey shear is maximum at the base. The value of storey shear at wind speed 33 m/s is 237.5533 kN and at high wind speed 50 m/s is 855.192 kN. This means the storey shear is increases by more than 350%.

From the above storey shear graph (fig 12) it is clear that, the Storey Shear is decreased as height of the building increased and reduced at top floor in all the building models. The storey shear is maximum at the base. The value of storey shear at wind speed 33 m/s is 85.6727 kN and at high wind speed 50 m/s 196.6774 kN. This means the storey shear is increases by more than 200%.

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V. CONCLUSION

The following conclusions are made from the present study:

1. The base shear of structure increases as we go to higher seismic zones. For a same building the base shear value of ZONE II is 1225.67 kN and ZONE V is 4423.61 kN. This means base shear increases by more than 360% if seismic ZONE changes from II to V.
2. The displacement of building models increases with the increasing of seismic Zones. The displacement is very high at roof and very low at the base. The displacement occur at the ZONE II is 38.255 mm and ZONE V is 143.337 mm. This means the displacement increases by more than 250% if seismic ZONE changes from II to V.
3. The displacement of building models increases with the increasing of wind pressure. The displacement is very high at roof and very low at the base. The displacement occurs at the wind space 33 m/s is 87.969 mm and at the wind speed 50 m/s is 183.17 mm. This means the displacement is increases by more than 200%.
4. The storey drift increases with the increasing of seismic zone factor. And the maximum storey drift is available at ZONE V. The storey drift for ZONE II is 0.000117 and storey drift for ZONE V is 0.000606. This means the storey drift is increases by more than 170% when compare to ZONE II to ZONE V.
5. The Storey Shear is decreased as height of the building increased and reduced at top floor in all the building models subjected to seismic loads considered. The storey shear is maximum at the base. And the storey shear value for the model in ZONE II is 68.5381 kN and ZONE V is 157.3419 kN. This means the storey shear is increases by more than 200% when compare to ZONE II to ZONE V.
6. The storey shear is maximum at the base. The value of storey shear at wind speed 33 m/s is 85.6727 kN and at high wind speed 50 m/s 196.6774 kN. This means the storey shear is increases by more than 200% if the wind speed changes low wind speed (33 m/s) to high wind speed (50 m/s).

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