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Response of High-Rise Building Subjected To Earthquake & Wind Load consideration by Using Gust Factor

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Abstract: We have been constructing the building structures for decades, and the development of earthquake-resistant buildings is rising day by day. The current research is mostly focused on the behavior of earthquakes loads by using wind gust factor by ETABS software, I have modeled symmetric and asymmetric tall structures with various geometries, including Rectangle Shape, Square Shape, U-Shape, H-Shape, L-Shape and T-Shape buildings having Ground + 31 floors. The structures are constructed in accordance with Indian codes and regulations. The main objective of this paper is to compare the variation of storey drift and storey displacement in static and dynamic method by using gust factor of various constructions. According to our findings, symmetric buildings perform better than asymmetric buildings during earthquakes.

***Keywords*– Asymmetric building, Gust factor, Storey displacement, Storey drift and Storey displacement.**

I) INTRODUCTION

Infrastructure is a very important part of our life as the number of building construction works is increasing day by day as the population of the country increases. As the number of people living in urban areas increases, infrastructure becomes more and more an important component of our lives. There is a growing demand for tall structures in the market, but there is a scarcity of land. Narrow land is very helpful for construction in case tall structures. The Urbanization and population explosion across the globe has resulted in increased demand for high rise buildings. Wind is the common terminology used for moving air and usually applies to the natural horizontal movement of the atmosphere. Though vertical air movement is important in meteorology, but of less importance near the ground. Wind load and earthquake load are important factor in reinforced tall structure in in dynamic analysis but both are different to design and evaluation the result. If we take both load together as well as earthquake and wind load simultaneously so it increase the structure cost. When the building height's increases then wind pressure is also increase with height of structure. In structural engineering, horizontal air movements, especially slow deceleration of wind speeds and high eddy generated near the ground, are important. Therefore, as the height of the structure increases, it becomes very important to consider lateral loads and other factors. Pressure on its contact surface; it is a force load. The country is divided into zones of similar seismic activity. Earthquake zoning can be defined as a country or region division. The Seismic zoning of a country mainly depend upon the seismic history of region. This means a detailed investigation of past earthquakes, like magnitude, intensity and degree of damage and other characteristics etc. The purpose of structural analysis is to determine how a structure will behave when subjected to a certain action. The weight of things can cause a load to be placed on a structure. There may be an unusual kind of excitement happening nearby, such as an earthquake or intense shaking from a nearby explosion. All of these loads are dynamic, including the self-weight of the structure. At some point in time, these loads were not present. The difference between dynamic and static analysis is based on whether the applied action has more speed compared to the natural frequency of the structure. If a load is applied slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics is a type of structural analysis that looks at how structures respond to dynamic loading (actions that have a high acceleration).

Lingeshwaran et al., 2020 has studied on symmetric and asymmetric structures with different geometry of building with G+10 floors. He has find out the result of storey drift and storey displacement in various structures by applying the seismic load as per zone-4 according to Indian standard codes. The research provided information of storey drift and storey displacement from Software tables. The structure's activity is analyzed by this information. The result obtained suggests that symmetric buildings are efficient in performance when compared to asymmetric structures. Displacement values of symmetric structures are also compared to be lesser than that obtained of asymmetric structures, although when seismic loads are considered, L shaped structures and H shaped structures have almost equal values. (Lingeshwaran et al., 2020)

Sharma and Savita Maru, 2022 has investigated statically and dynamically analysis on Ground + 30 Floors R.C.C. tall structure in seismic zone-2 and zone-3 and compared with the axial force, moment on nodes and beam and Torsion. It was concluded that in dynamic value of displacement and moment of vertical member in beams at different point is maximum in both zone as per compared with Static analysis, value of Axial force is not much difference in “zone-2 and zone-3” for both static and dynamic analysis. (Sharma and Savita Maru, 2022)

Bagheri et al., 2019 studied this paper a 20-storey height up to 90 m structure with plan regular and irregularities is being analyzed i) Statically in seismic zone-1and seismic zone-II ii) Dynamically seismic zone-4 and seismic zone-2 method. And comparison of the results has been scrutinized. It is evaluate that dynamic analysis is better than statics analysis because the displacement of dynamic analysis is less compared to statics and its show the maximum displacement at joints of each floor as compared to center of mass. (Bagheri et al.,2019)

Sultan and Peera, 2015 researched on Ground +15 Floors various building pattern 1) Floor plan of “Rectangular Shape” 2) Floor plan of “L Shape” 3) Floor plan of “C Shape” 4) Floor plan of “H Shape”. The overturning moment varies in opposing proportion to the building height, with the moment produced in rectangular-shaped buildings being higher than in other designs. In all circumstances, the story overturning moment reduces as the story height rises. The comparison of base shear for 1st storey, 5th storey, 10th storey and 15th storey with different shapes of the building has been executed. According to the findings, the storey shear tends to decrease as the storey height rises. In comparison to all other situations, a L shape building has less storeys. The maximum storey displacement rises in tandem with the storey's height. The displacement of a rectangular-shaped building is lower than that of other shapes. Storey drift grows as the floor height increases up to the seventh storey, when it reaches its maximum value, and then it begins to decrease. Mode forms are derived from the dynamic analysis and it is concluded that L, H, and C shape buildings deform more than rectangular buildings. The lower base shear is an L-shaped building and the higher base shear is a rectangular building. Irregularly shaped buildings are more deformed, so regularly shaped buildings should be prioritized. The results show that C-shaped buildings are more vulnerable compared to all other different shapes. (Sultan and Peera, 2015)

Pavan Kumar et al., 2014 investigated the Seismic analysis in Zone-2 for multistory building. The displacement, torsion, different column axial forces and bending moments compared of static or dynamic response spectrum analysis in Ordinary moment resisting frame and Special moment resisting frame. The result was carried out that axial forces are coming equally in both analyses; the torsion value is negative in static and positive in dynamic, in static analysis the moment value is higher than dynamic analysis. (Pavan Kumar et al., 2014)

Guleria, 2014 studied on multi- story building having the 15 floors for different plan configurations like 1) rectangular building plan, 2) C shape building plan, 3) L shape building plan 4) I shape building plan. Carried out the value of structure in the form of maximum i) shear force ii) bending moments iii) story displacement are computed and then compared for all the analyzed cases. Cross-sectional area of the building is 32m x 24m having bays 4m x 4m, 3m clear height and total Loads considered are taken in accordance with the IS-Code. The conclusion was that bending moments of all the shapes is lower as compared with 1) rectangular building plan, for all cases increases of storey height overturning moment is decrease and storey height is increases along the story drift displacement. (Guleria, 2014)

Chauhan, 2020 studied on nonlinear time history analysis is performed by various geometry models are used Rectangular (18m x 24m), Square (18m x 18m) and Circular (18m x 18m) for Shape G+15 Storied find out the behavior of reinforced frame building with regular plan by using “ETABS software”. For dynamic analysis 1) time history method 2) response spectra method can be used. The parameter study which is considered base plinth height 1.5m, floor height 3.2m, Concrete M40 & Reinforcement Fe 500, cross-sectional area of column is 600 mm x 600 mm, cross-sectional area of beam 300mm x 300mm and structure heights is 49.5 m. conclusion was found that in rectangular and circular building maximum moment and maximum stress is more as compared to square building. According to the findings, square RCC geometry is preferred to rectangular and circular geometry for dynamic analysis. (Chauhan, 2020)

Ahesan, 2019 investigates Indian codes comparison with international codes to find out seismic load effect on R.C.C. building various parameter like storey drift and lateral displacement by using major codes and IS-Codes which was used for design the building and structure along the wind load effect i.e. gust factor. The plan area of regular forms such as 1) Square, Rectangular, 2) Elliptical, 3) Circular, 4) Rectangle with two semicircle shapes were maintained the same for the purpose of analysis, as were the frame attributes. The R.C.C. frame building having Ground +19 Floors by using Etabs Software 2016. The result was obtained it explained mathematical equations rather than graphs, the new "IS 875(Part-3): 2015" is more exact than the old Indian standard code "IS 875(Part-3): 1987." Because circular, elliptical, and rectangular buildings with two semicircles form a smaller area perpendicular to the wind direction than square and rectangular buildings, the wind pressure is lower. (Ahesan, 2019)

Ranjitha K. P1, 2014 studied the R.C.C. frame building having Ground +14 Storied on comparison of equivalent static wind load and dynamic analysis based on gust factor in Zone-1 and Zone-IV are performed on the building to check the value of the 1) base shear, 2) storey displacement, 3) storey drift, 4) overturning moment, 5) storey shear. by various shape of geometry structure are used in Square Shape and I- Shape (25m x 25m) are performed in wind Zone-1 and Zone-IV in accordance with IS-Code. The result was obtained by using this method the maximum moment and maximum stress of square plan building is less than rectangular shape and circular building. According to the findings, square RCC geometry is preferred to rectangular and circular geometry for dynamic analysis. The Storey displacement becomes zero and maximum at bottom story or top story. Story height of building increases then the displacement values also increases. For varied shapes of structures, as the wind zone rises, the story displacement increases as well. When compared to the displacements in irregular structures, the story displacements values in regular structures with and without gust factor in zones 1 and 4 are less. (Ranjitha K. P 1, 2014)

III) Objective of work

1. Response of Building in terms of storey displacement, storey, drift and storey shear subjected to seismic loads.
2. To compare the various response of buildings with Rectangular Shape, C-Shape, H-Shape, L-Shape, T-Shape and Square Shape of the building
3. Perform parametric study for different earthquake zones and different soil condition.
4. To comparing the storey displacement, storey drift and storey shear of symmetric and asymmetric structures by design the model in ETABS 2018 Software.
5. To find out the storey displacement and storey drift in seismic zone-4 and comparing the various shape of geometry in different location.

IV) Methodology

The study is carried out for the behavior of structure making different shapes model was designed in ETABS software Ground + 31 storied R.C. C. frame buildings with a regular and irregular plan having 1) Rectangular Shape plan, 2) C-Shape plan , 3) H-Shape plan, 4) L-Shape plan, 5) T-Shape plan, 4) Square Shape plan of the building plan varying geometry. Floor height provided as 3.0 m. And also, properties are defined for the frame structure. The structure was subjected to self-weight, dead load, live load as per considered as per IS 875 (Part-3) 2015. The wind load of by using gust factor is calculated by manually calculation for Zone-4 in different location for Vb=39 m/s, Vb=44 m/s, Vb=47 m/s, Vb=50 m/s. The analysis results will show the seismic response of buildings and wind load by using gust factor in different locations in form of storey shear, storey drift, storey displacement, etc.

Building Property

Building Parameter used for design	
Plan Dimension	36 × 24 m
Grid Size in X-direction	Nos. 09 (each bay 4m)
Grid Size in Y-direction	Nos. 06 (each bay 4m)
Each story height	3.0 m
No of storey	31 Floors
Column dimension	0.50 x 0.50 m

Beam dimension	0.30 x 0.45 m
Slab Thickness	0.125 m
Support Condition	Fixed Supports for all Shapes
Seismic Zone	Zone-4
Grade of Concrete	M-25
Grade of Steel	F_y500 N/mm^2
Density of Concrete	25kN/m^3
Dead Load	1.5kN/m^2
Live Load	1.5kN/m^2
Floor Finish	1.0kN/m^2

This parameter is considered for study to design different type of Structure shapes having Ground + 31 Floors by using the ETABS model for analysis of Static analysis and dynamic analysis under the consideration of seismic response and wind load by using gust factor.

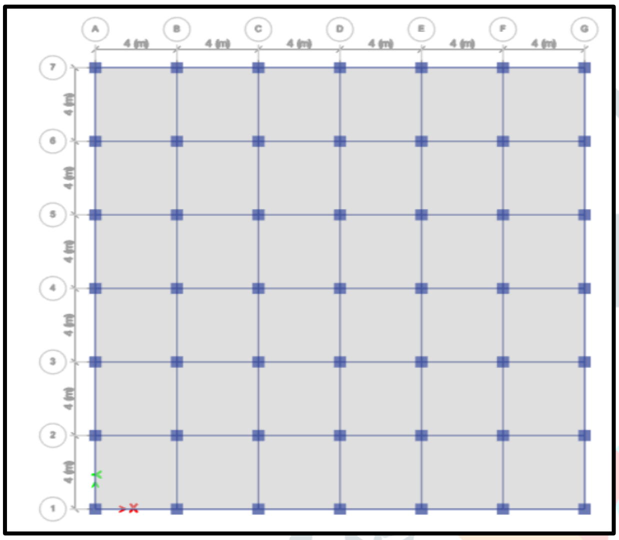

Figure:-1 Plan view of Rectangular Shape

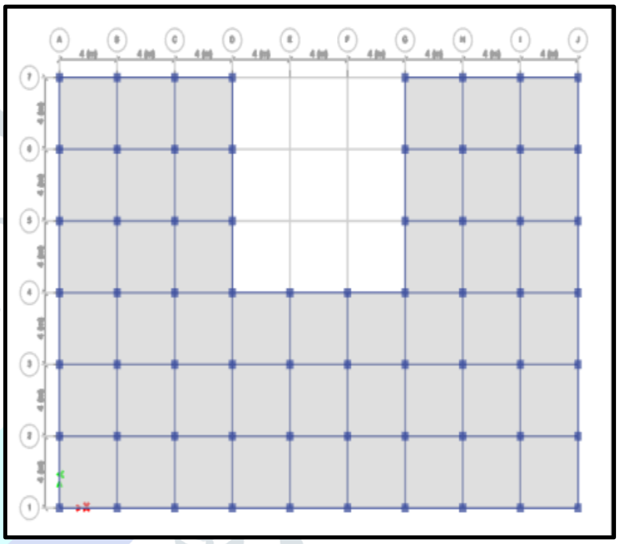

Figure:-2 Plan view of C-Shape

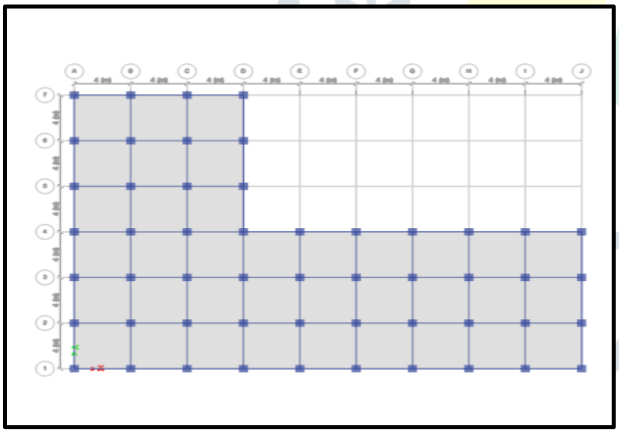

Figure:-3 Plan view of L-Shape

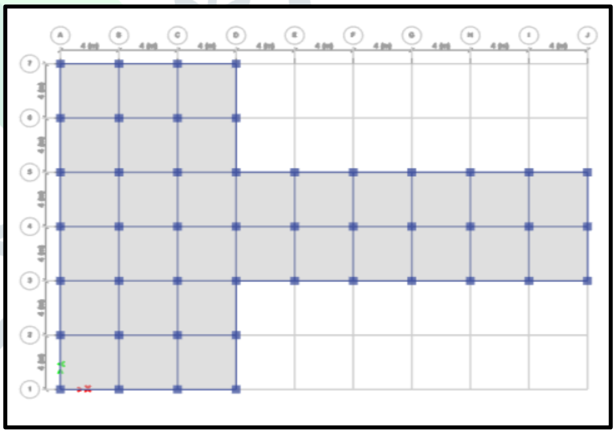

Figure:-4 Plan view of T-Shape

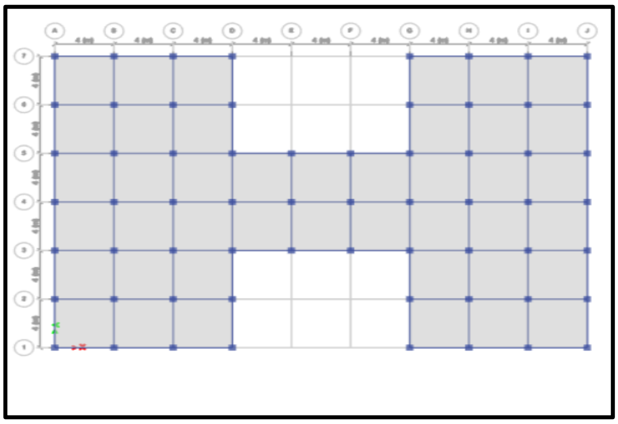

Figure:-5 Plan view of H-Shape

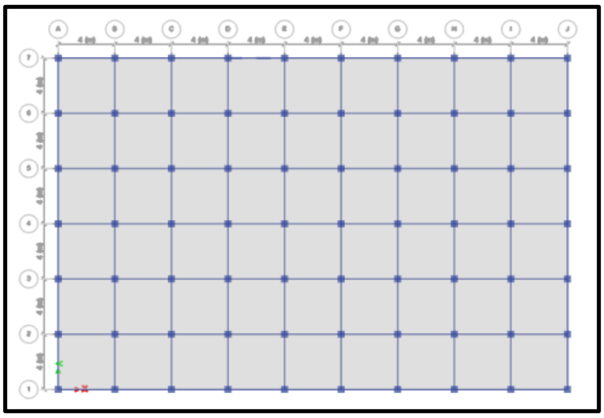

Figure:-6 Plan view of Square Shape

IV) Results

The seismic load results for all the structure at various locations using load combinations for X-direction are display in below figures for 1) Vb=39 m/s, 2) Vb=44 m/s, 3) Vb=47 m/s, and 4) Vb=50 m/s).

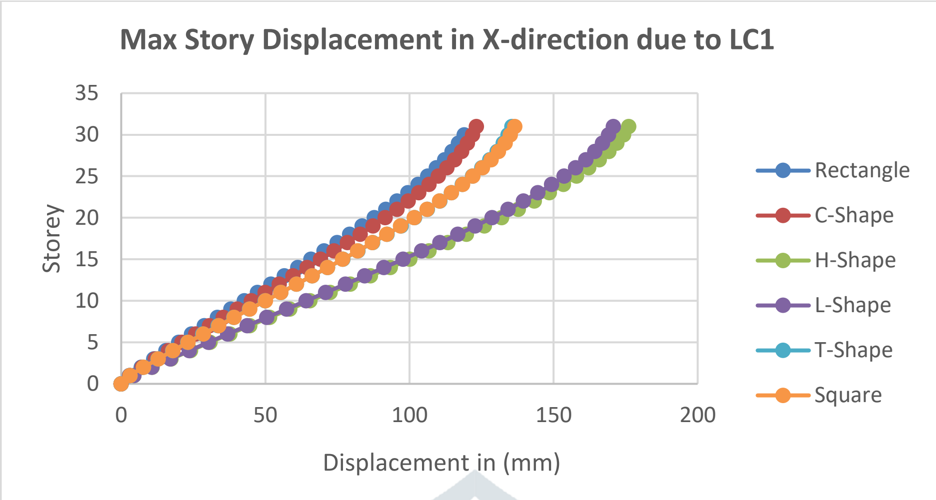

Figure:-7 Storey Displacement in X-Direction

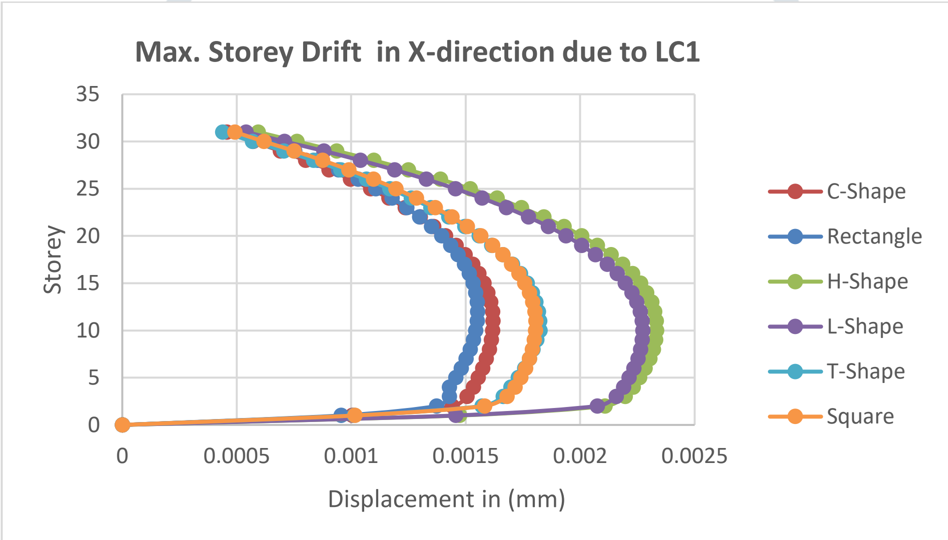

Figure:-8 Storey Drift in X-Direction

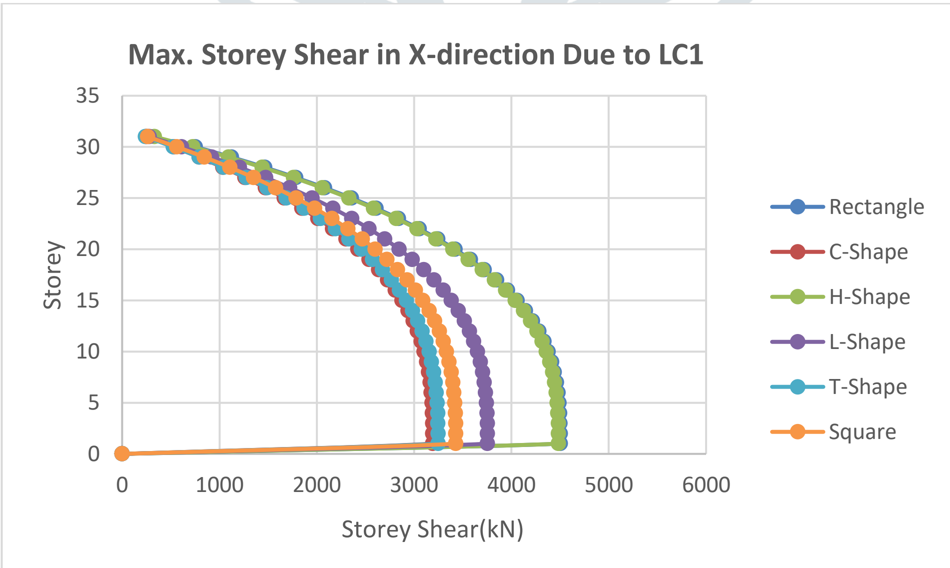

Figure:-9 Storey Drift in X-Direction

The wind load by using gust factor results for all the structure i.e. Rectangular Shape, C-Shape, L-Shape, T-Shape, H-Shape plan and Square Shape at various locations display in below figures for 1) Vb=39 m/s, 2) Vb=44 m/s, 3) Vb=47 m/s, and 4) Vb=50 m/s).

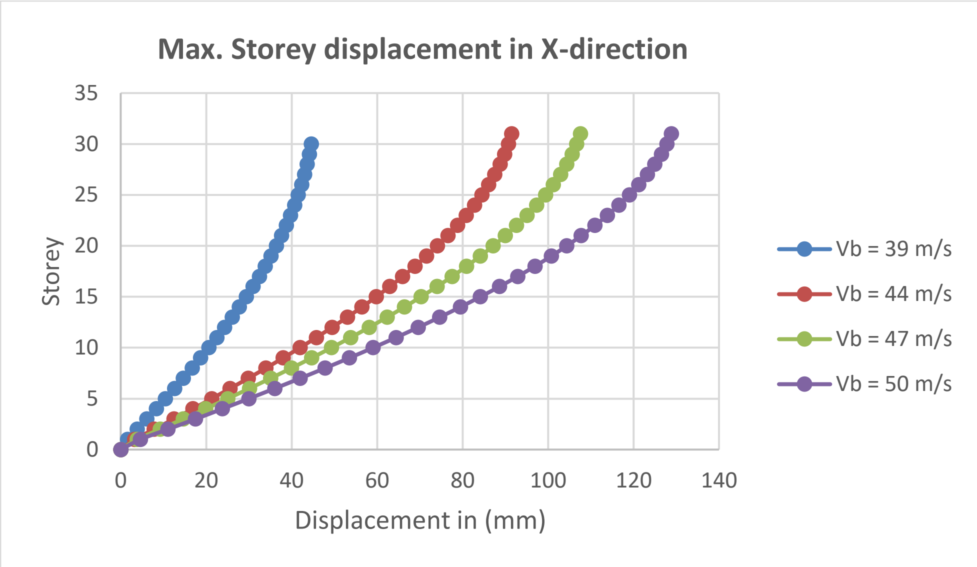

Figure:-10 Storey Displacement of Rectangular Shape in X-direction

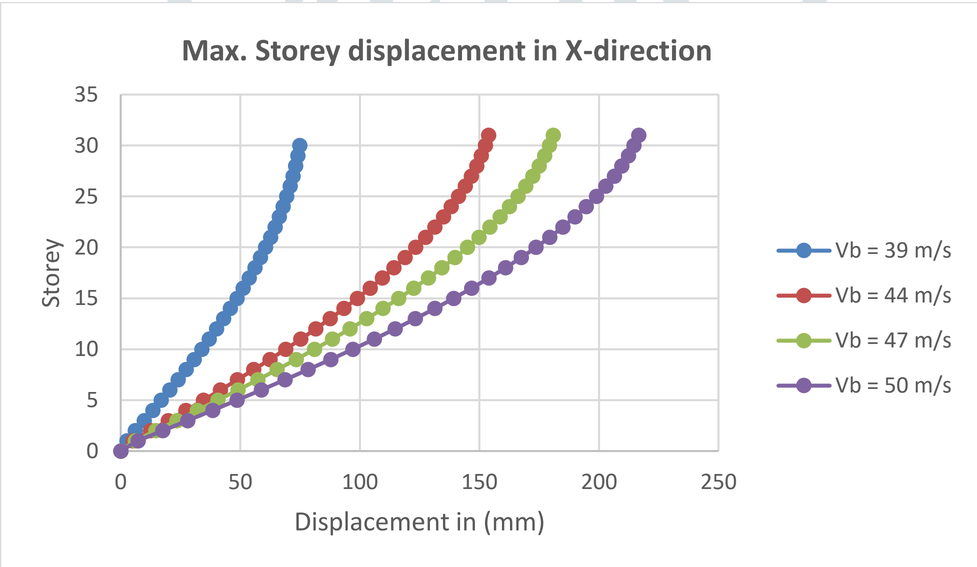

Figure:-11 Storey Displacement of C-Shape in X-direction

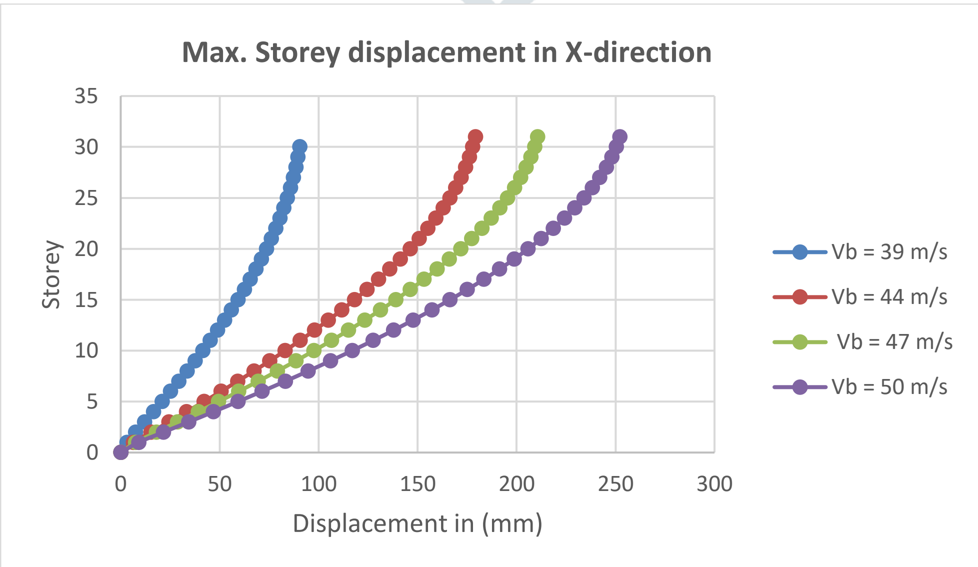

Figure:-12 Storey Displacement of L-Shape in X-direction

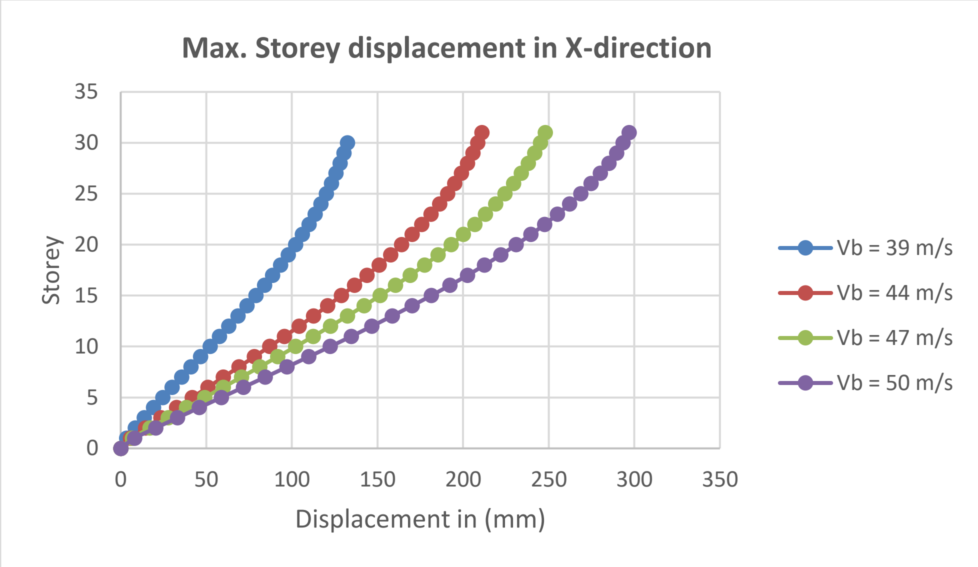

Figure:-13 Storey Displacement of T-Shape in X-direction

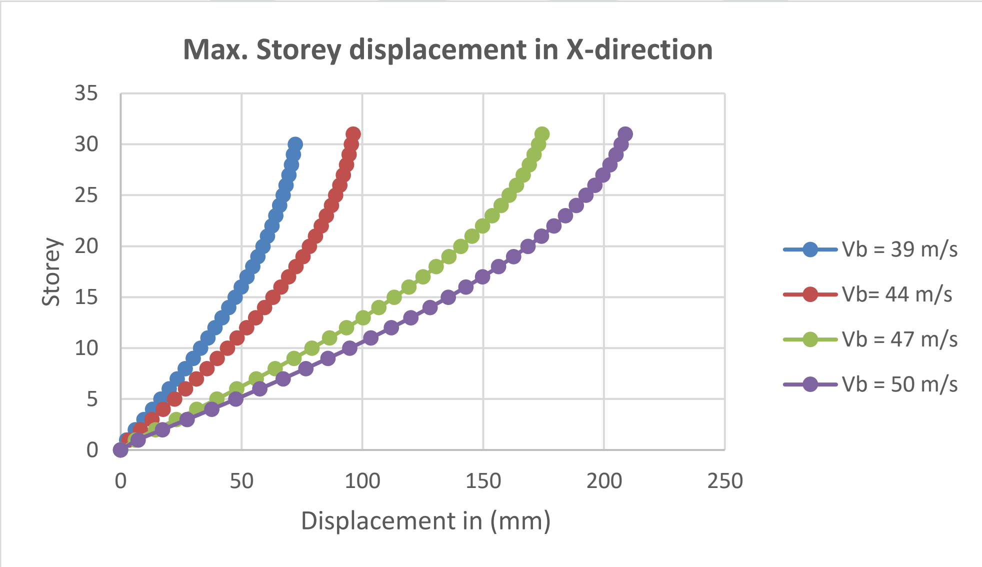

Figure:-14 Storey Displacement of H-Shape in X-direction

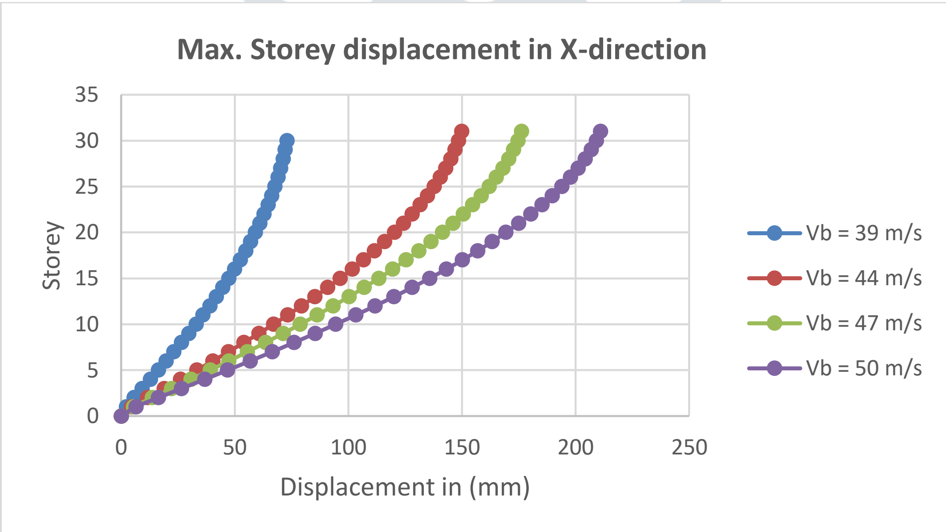

Figure:-15 Storey Displacement of Square Shape in X-direction

V) Conclusion

Through the research, I prepared symmetric and asymmetric models of buildings of rectangular shaped, square shaped, L-shaped, C-shaped, T-shaped and H-shaped for a 31 floor structure with the aid taken for ETABS software. These structures are modeled and designed as per IS 1893 (part 1): 2016 for earthquake forces and wind loads with the inclusion of gust factor, investigated as per IS 875 (part 3): 2015.

1. The Storey Displacement is increases along the storey height for all the Cases
2. For various type of geometry (Regular or irregular) in Locations of V=50 m/s in Zone-4 its shows the highest displacement in different location in X-direction or Y-Direction.
3. For various type of geometry (Regular or irregular) in Locations of V=47 m/s in Zone-4 its shows the Second highest Storey displacement in different location in X-direction or Y-Direction
4. The storey shear is increases along the storey increases for all the cases
5. For various type of geometry in locations of Vb in zone-4 its shows the highest shear in different locations in X or Y direction.
6. For various type of geometry (Regular or irregular) in Locations of V=47 m/s in Zone-4 its shows the Second highest Storey shear in different location in X-direction or Y-Direction
7. The Storey drift is increases along the storey for all the Cases
8. For various type of geometry (Regular or irregular) in Locations of V=50 m/s in Zone-4 its shows the highest drift in different location in X-direction or Y-Direction.
9. For various type of geometry (Regular or irregular) in Locations of V=47 m/s in Zone-4 its shows the Second highest Storey drift in different location in X-direction or Y-Direction.
10. Hence, after all these I concluded that storey displacement, storey shear and storey drift are increases with respect to height and changes with different types of geometry.

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