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TIME HISTORY ANALYSIS OF A COMMERCIAL BUILDING USING ETABS SOFTWARE

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Abstract: Earthquake is the result of sudden release of energy from epicenter in the earth's crust that generates seismic waves action. It has social as well as economic consequences such as causing death and injury of lives especially human beings and damages the buildings and natural environment. Ground shaking and rupture are the major effects generated by earthquakes.In order to take precaution for the loss of life and damage of structures due to the ground motion, it is important to understand the characteristics of the ground motion. The most important dynamic characteristics of earthquake are peak ground acceleration (PGA), duration, and frequency content. These characteristics play dominant rule in studying the responses of structures under seismic loads. The time history analysis begins by selecting an appropriate ground motion record that represents the seismic input to the structure. The ground motion record is typically obtained from historical earthquake data or synthesized based on specific design criteria. Once the ground motion record is obtained, it is applied to the building model as an input motion. The analysis results are then evaluated against performance criteria and design codes to ensure that the building meets the required safety standards. Engineers can use the analysis outputs to assess the structural integrity, identify potential weaknesses, and make necessary design modifications to enhance the building's seismic performance. Time history analysis plays a crucial role in assessing the seismic performance of buildings. It provides valuable insights into the dynamic behavior of structures and aids in designing safer and more resilient buildings.

Keywords: ETABS, Base Shear, Storey Drift, Storey Stiffness.

I. INTRODUCTION

The Multi-Storey buildings are very commonly constructed to shelter large population in small per capita area. These multi-Storey buildings are usually irregularly shaped to give better aesthetic appearance. But irregular multi-Storey buildings are much affected when earthquake occurs and can cause damage to adjacent structures also. And for aesthetic purpose the modelling has been done in ETABS software. Time history analysis (THA) provides a nonlinear evaluation of dynamic structural response of structure under various past earthquake loadings which varies with respect to the specified time function. Hence the present work involves study of seismic response of a different structure by Time history analysis for a given seismic intensity and ensure the structures can resist similar earthquake loads.

II. METHODOLOGY

The structures are modelled using ETABS software, The buildings consist of plan dimension 25mx35m with 5 bays and number of stories as 20, considering bottom storey height as 4.2m and rest above stories height as 3m. The column and beam sizes from 1st to 10th floor is 750mmx750mm and 400mmx500mmm, further above floors from 11th to 20th floor the column and beam sizes are 500mmx500mm and 300mmx400mm respectively.

Then five different types of structures are modelled in Regular and irregular forms, The models are then subjected to three different earthquake intensities in both x & y directions, El Centro earthquake in 1940, Helena Montana earthquake in 1935, Hollister earthquake in 1974.

The analysis encompassed all 30 models, involving a comprehensive evaluation of software-generated outcomes in terms of parametric values such as Base shear, Storey Drift and Storey Stiffness. A comparison between models and their behaviours on different earthquakes were also done.

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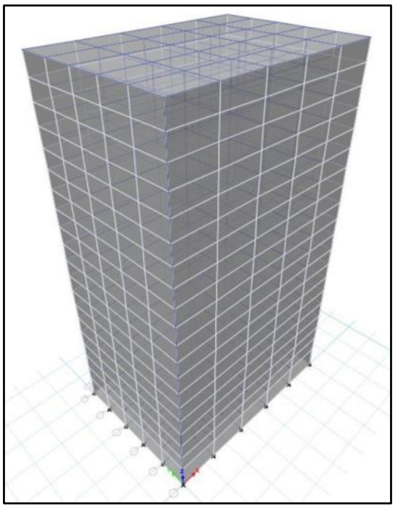
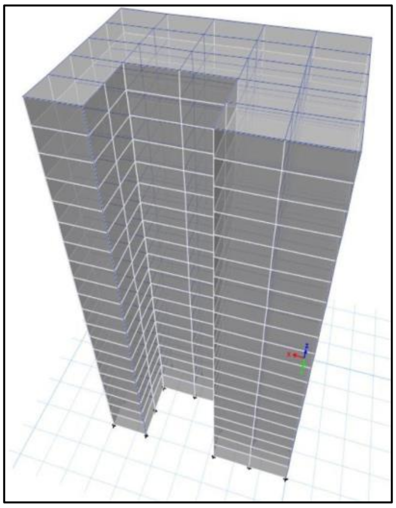
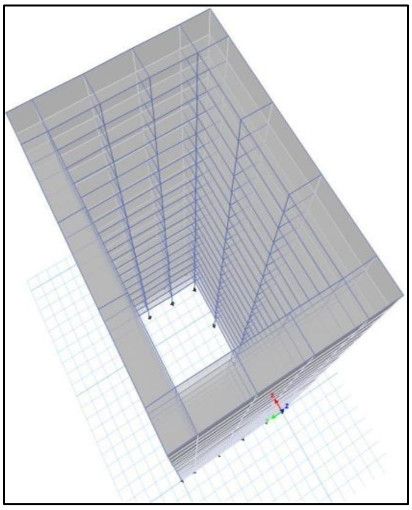
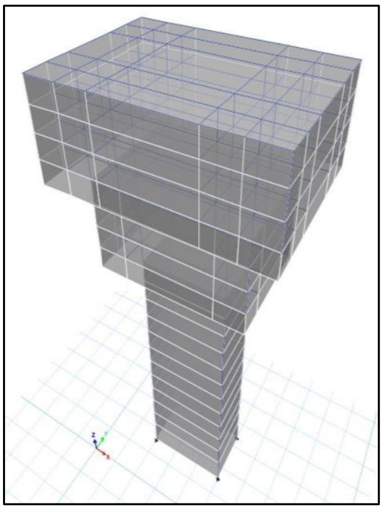
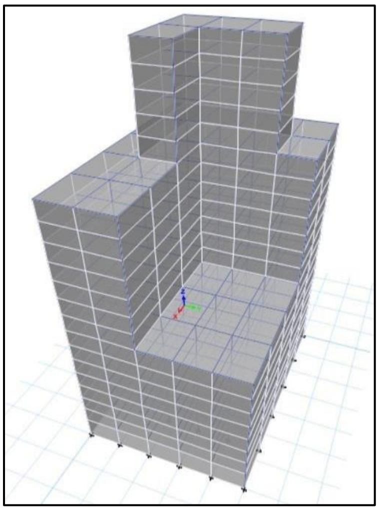




a) Regular model b) U shape (Plan irregular) model c) Hollow shape (Plan irregular) model

d) T shape (Vertical irregular) model e) L shape (Vertical irregular) model

Figure 1: 3D models of five different regular and irregular structures.

III. RESULTS AND DISCUSSIONS

Time history analysis is performed on all the models. Earthquake data used in time history analysis are as mentioned in clause 4.2. The behaviour of models is studied by extracting the results from the analysis in the form of Base Shear, Storey Drift and Storey Stiffness. The results are plotted in a graphical form as shown in following figure below.

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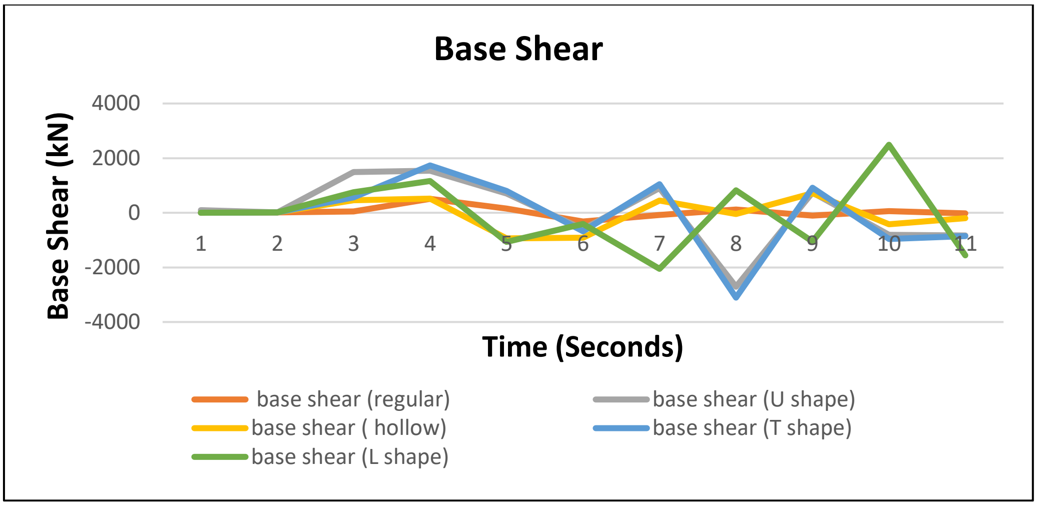

Figure 2: Base Shear of structures due to El Centro 1940 in X direction

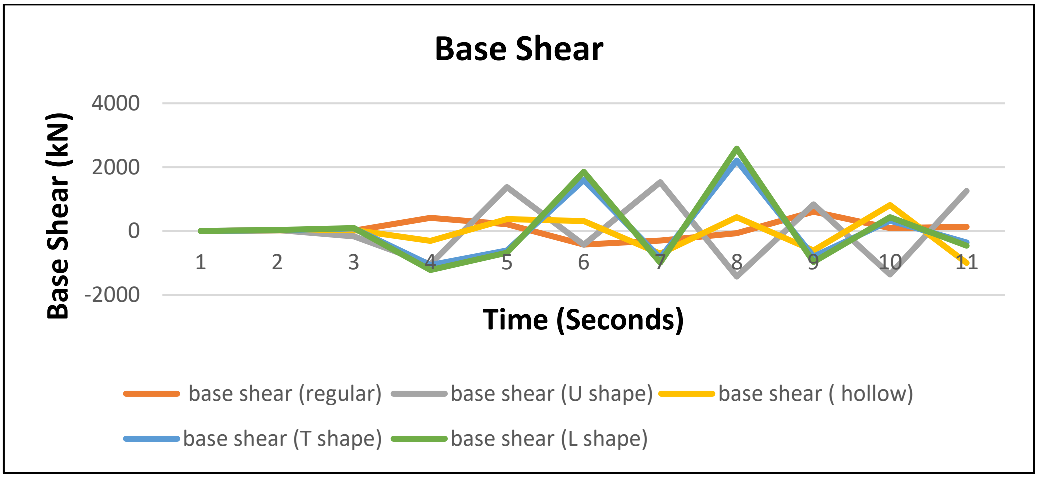

Figure 3: Base Shear of structures due to El Centro 1940 in Y direction

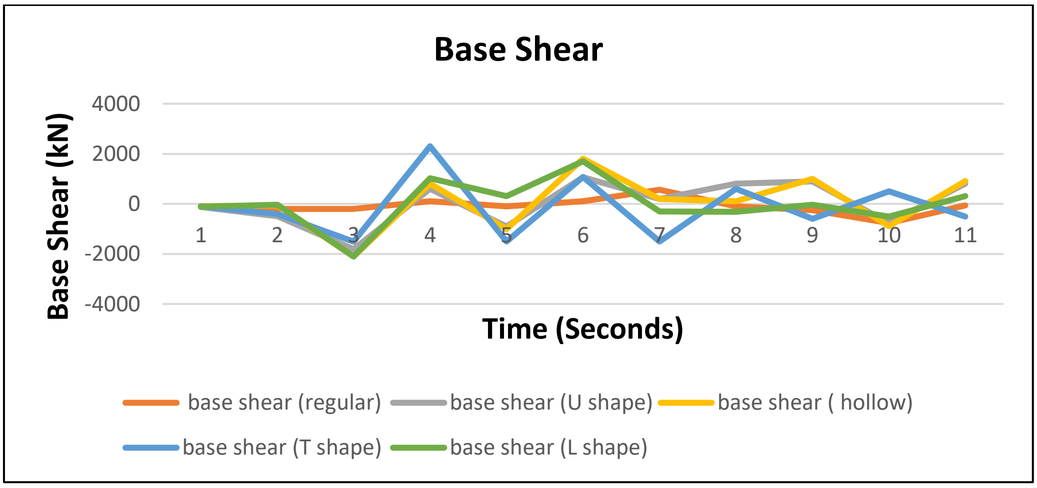

Figure 4: Base Shear of structures due to Helena Montana 1935 in X direction

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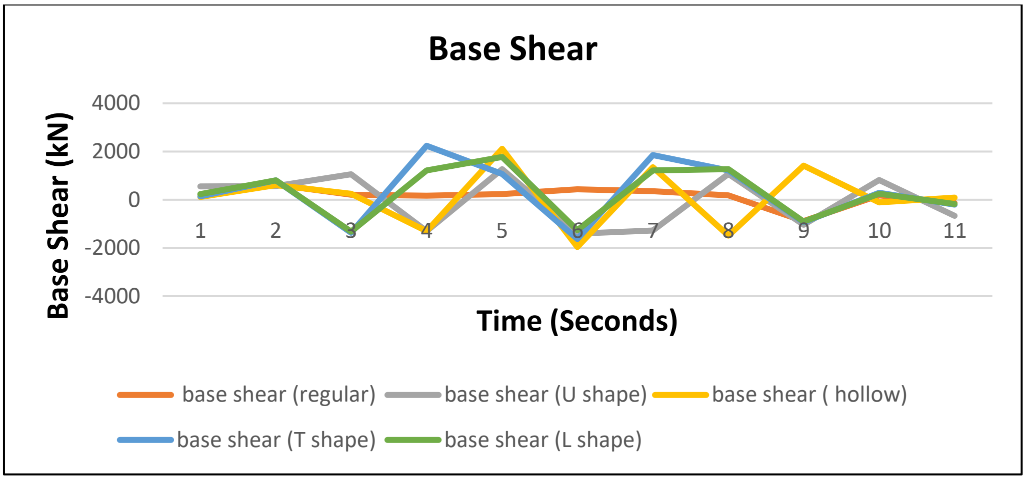

Figure 5: Base Shear of structures due to Helena Montana 1935 in Y direction.

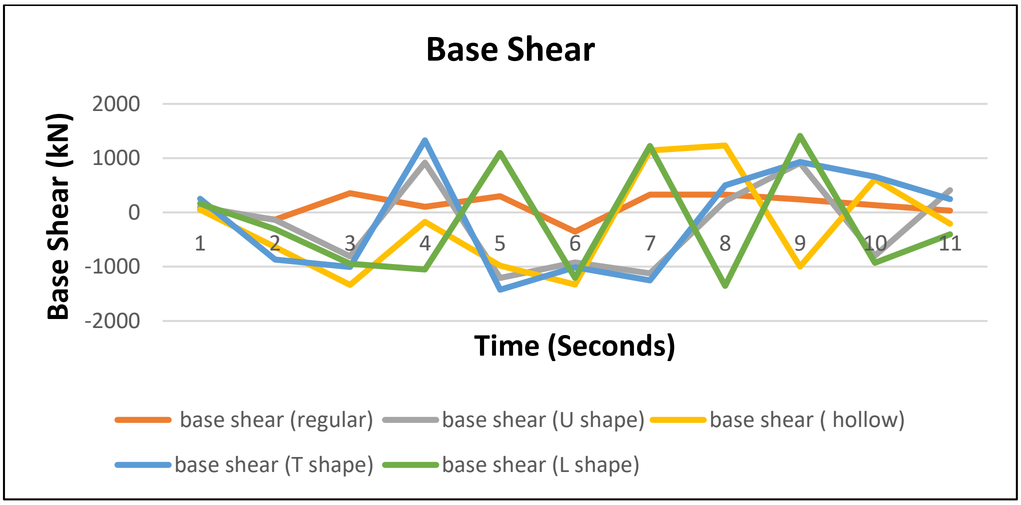

Figure 6: Base Shear of structures due to Hollister 1974 in X direction

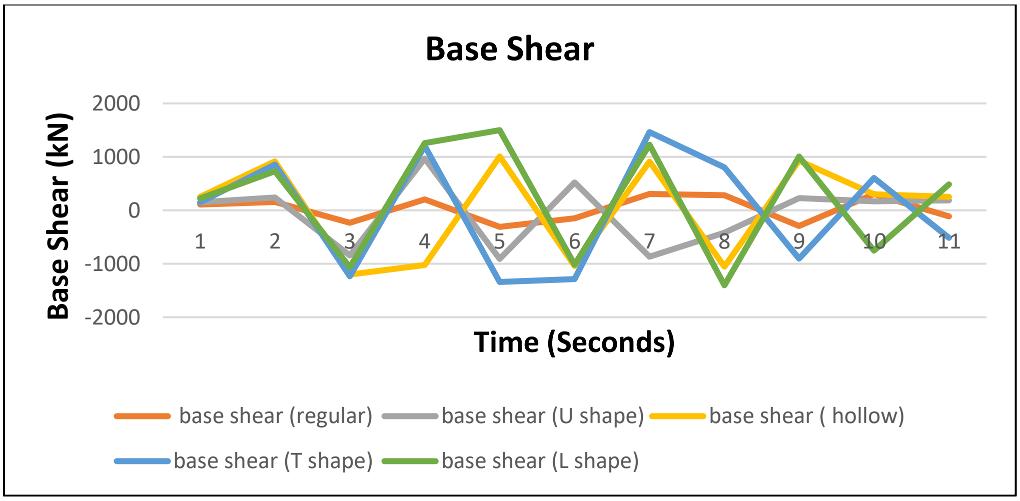

Figure 7: Base Shear of structures due to Hollister 1974 in Y direction.

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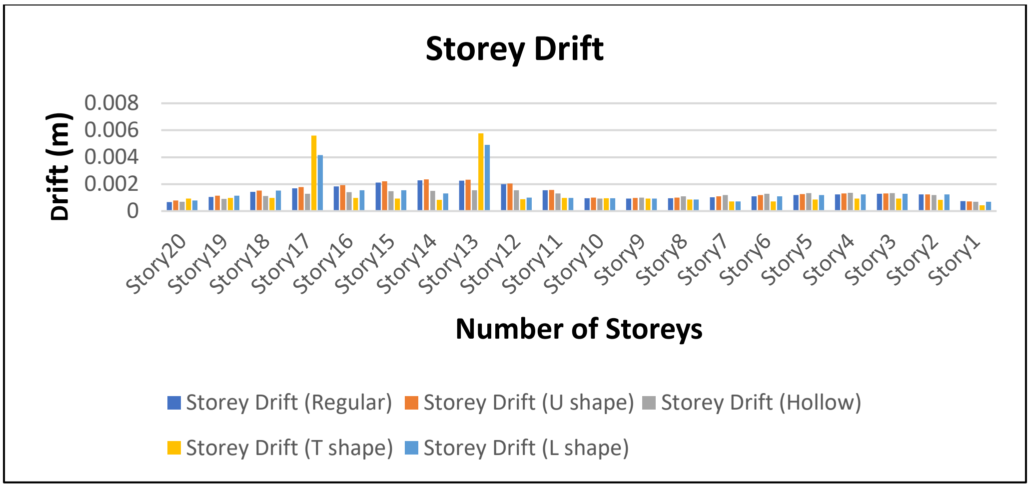

Figure 8: Storey Drift of structures due to El Centro 1940 in X direction

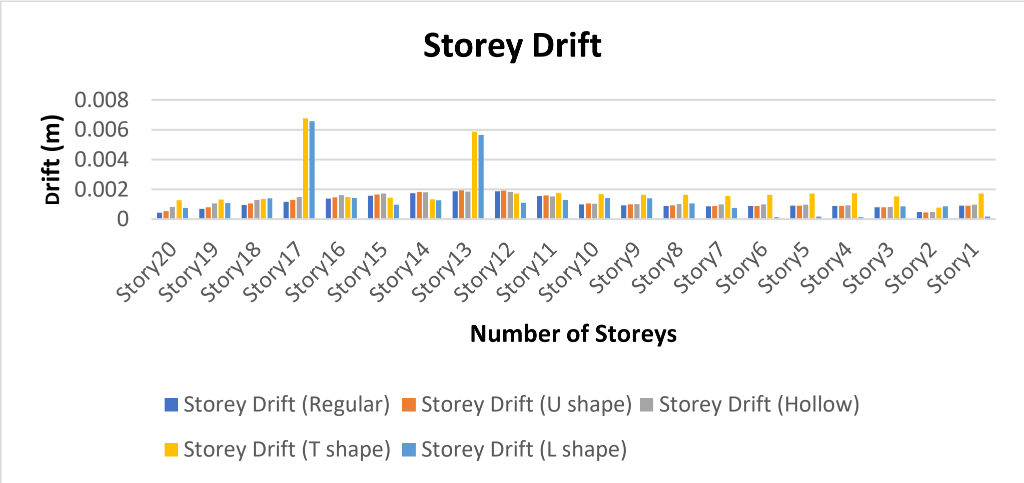

Figure 9: Storey Drift of structures due to El Centro 1940 in Y direction.

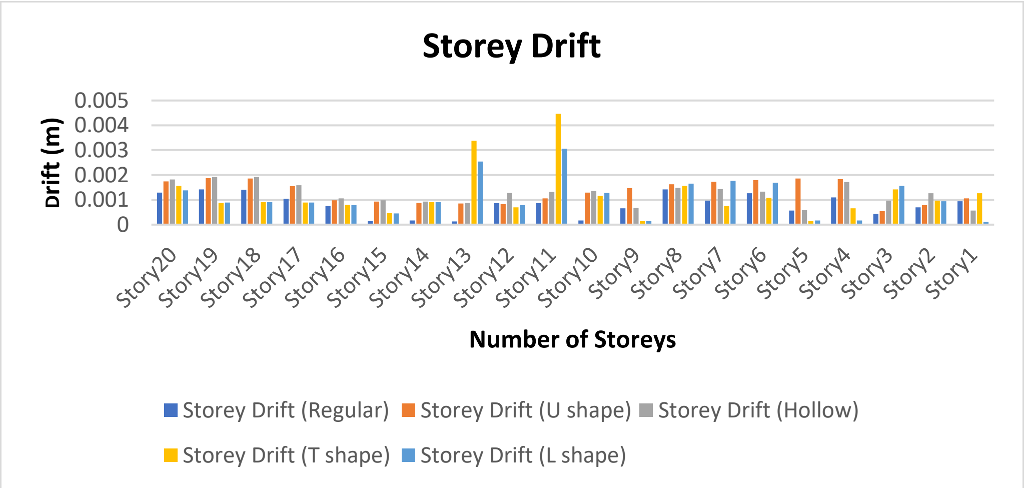

Figure 10: Storey Drift of structures due to Helena Montana 1935 in X direction.

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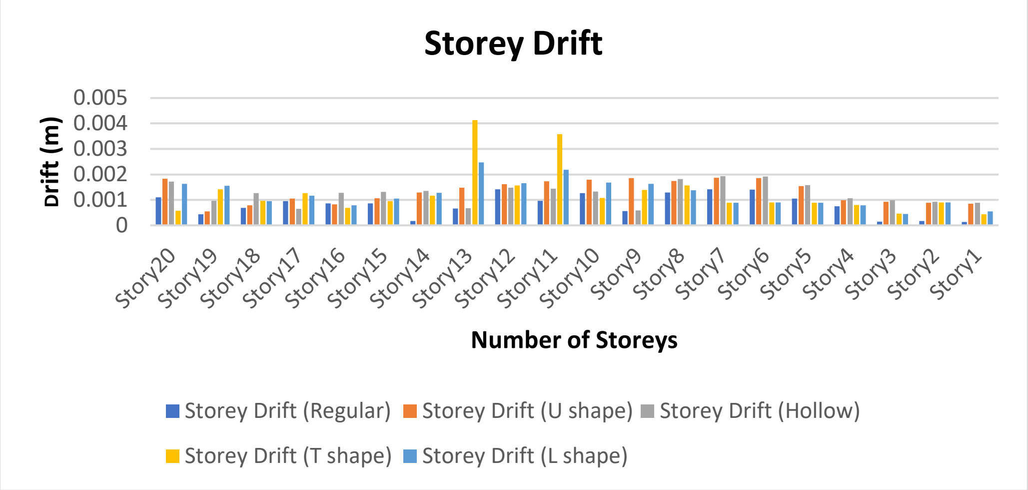

Figure 11: Storey Drift of structures due to Helena Montana 1935 in Y direction.

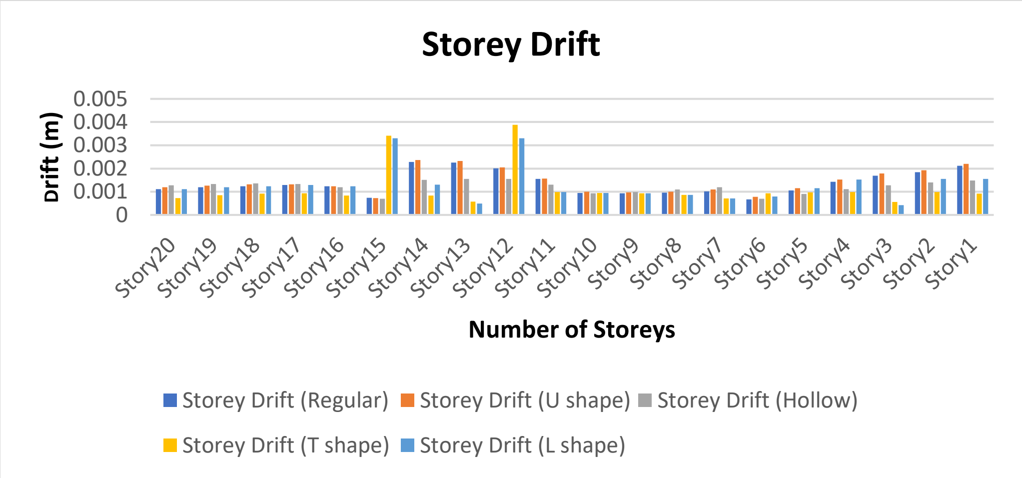

Figure 12: Storey Drift of structures due to Hollister 1974 in X direction

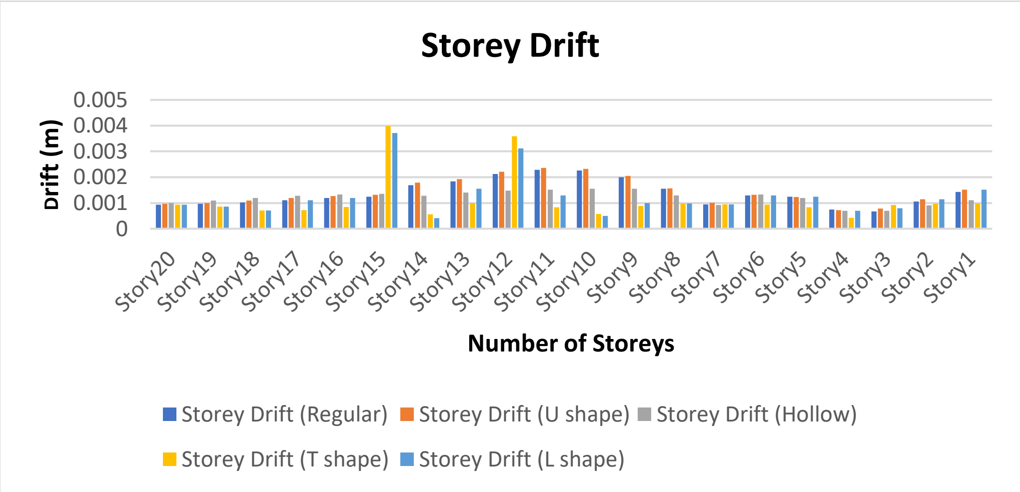

Figure 13: Storey Drift of structures due to Hollister 1974 in Y direction.

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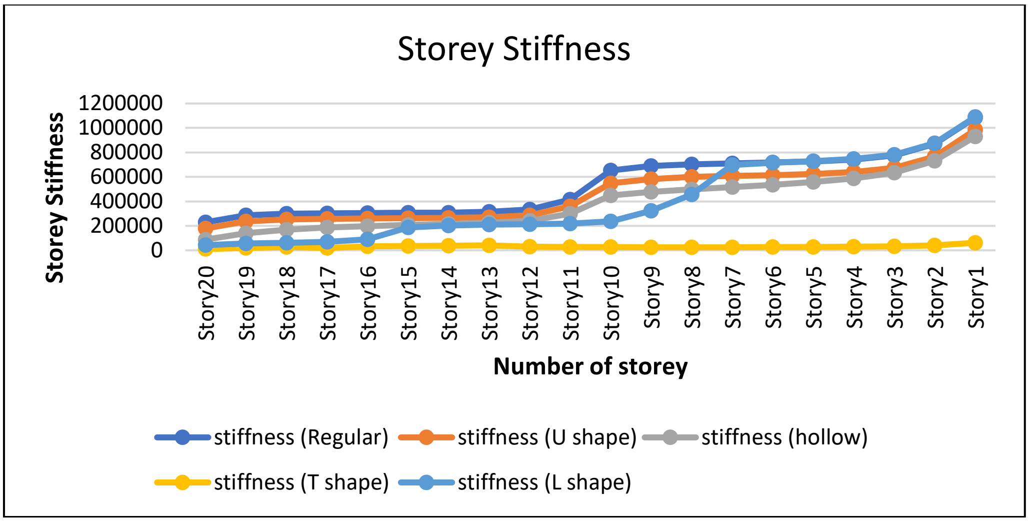

Figure 14: Storey Stiffness of structures due to El Centro 1940 in X direction

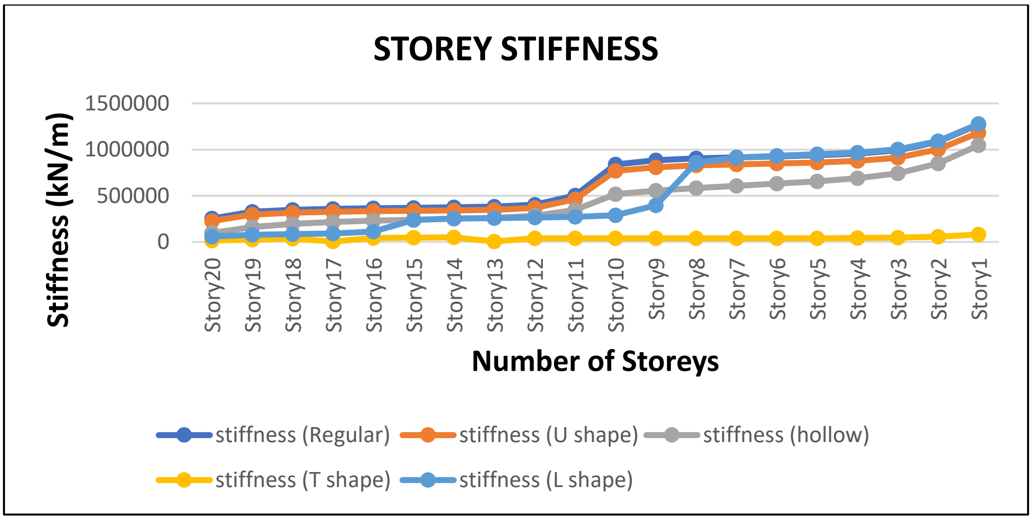

Figure 15: Storey Stiffness of structures due to El Centro 1940 in Y direction

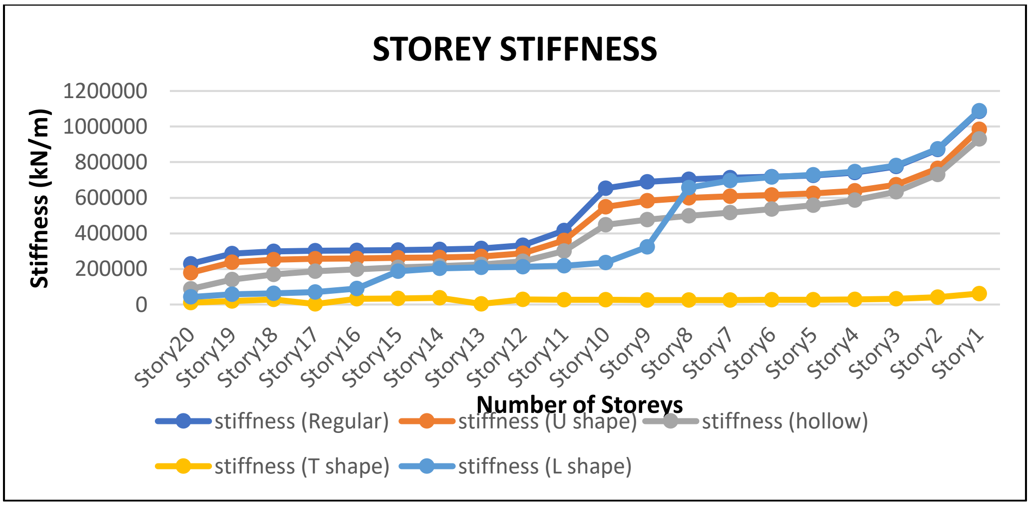

Figure 16: Storey Stiffness of structures due to Helena Montana 1935 in X direction

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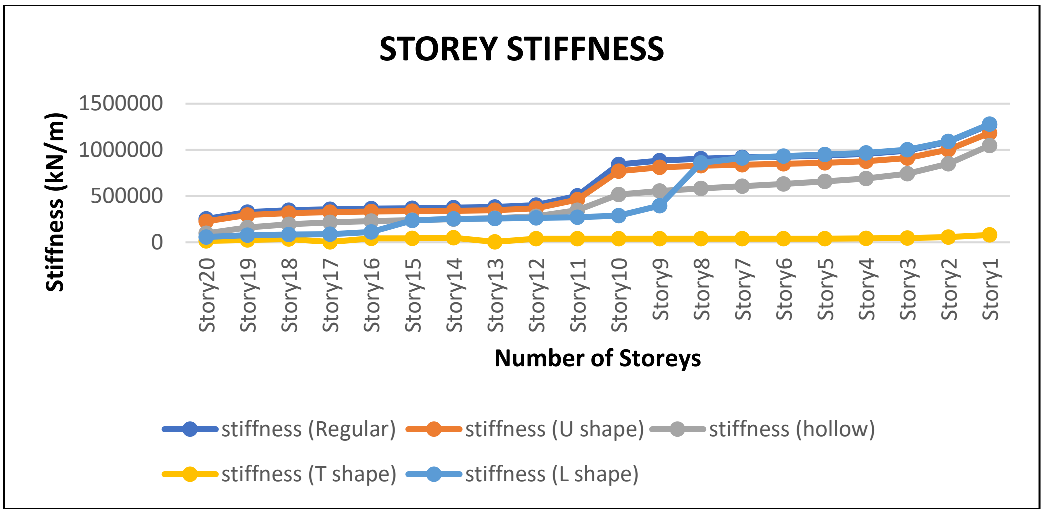

Figure 17: Storey Stiffness of structures due to Helena Montana 1935 in Y direction.

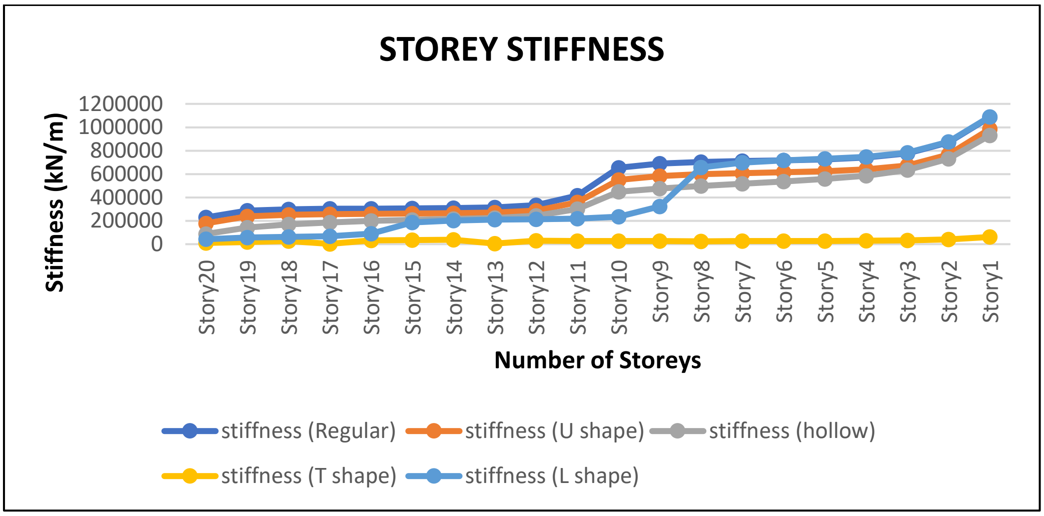

Figure 18: Storey Stiffness of structures due to Hollister 1974 in X direction

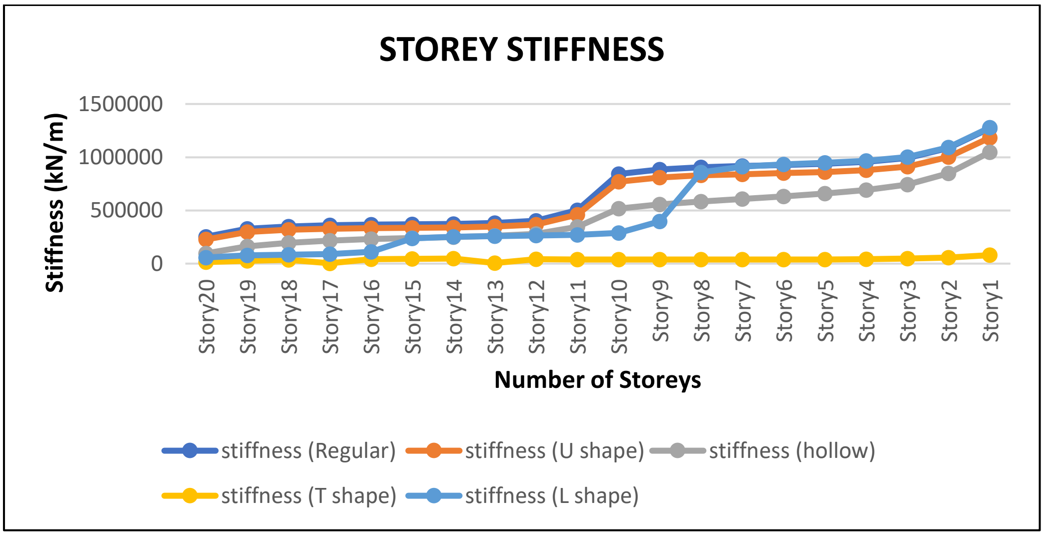

Figure 19: Storey Stiffness of structures due to Hollister 1974 in Y direction.

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From the above graphs the following can be conclusion drawn:

1. Figure 2: It can be observed that the base shear for all five models due to past earthquake data (El Centro 1940 in X direction) is maximum at "L" shape structure i.e., 2500kN @ 10 sec & minimum at "T" shape structure i.e., -3000kN @ 8 sec respectively.

2. Figure 3: It can be observed that the base shear for all five models due to past earthquake data (El Centro 1940 in Y direction) is maximum at "L" shape structure i.e., 2500kN @ 8 sec & minimum at "U" shape structure i.e., -1500kN @ 8 sec respectively.

3. Figure 4: It can be observed that the base shear for all five models due to past earthquake data (El Centro 1940 in X direction) is maximum at "T" shape structure i.e., 2400kN @ 4 sec & minimum at "L" shape structure i.e., -2200kN @ 3 sec respectively.

4. Figure 5: It can be observed that the base shear for all five models due to past earthquake data (El Centro 1940 in X direction) is maximum at "T" shape structure i.e., 2400kN @ 4 sec & minimum at "Hollow" shape structure i.e., -2000kN @ 6 sec respectively.

5. Figure 6: It can be observed that the base shear for all five models due to past earthquake data (El Centro 1940 in X direction) is maximum at "L" shape structure i.e., 1400kN @ 9 sec & minimum at "T" shape structure i.e.,-1500kN @ 5 sec respectively.

6. Figure 7: It can be observed that the base shear for all five models due to past earthquake data (El Centro 1940 in X direction) is maximum at "L" shape structure i.e., 1500kN @ 5 sec & minimum at "L" shape structure i.e.,-1400kN @ 8 sec respectively.

7. Figure 8: It can be observed that the maximum storey drift among all five models due to past earthquake data (El Centro 1940 in X direction) is around 0.0057m @ 13th storey and though it is not exceeding the permissible value of 0.012m, hence it is safer to design.

8. Figure 9: It can be observed that the maximum storey drift among all five models due to past earthquake data (El Centro 1940 in Y direction) is around 0.0067m @ 17th storey and though it is not exceeding the permissible value of 0.012m, hence it is safer to design.

9. Figure 10: It can be observed that the maximum storey drift among all five models due to past earthquake data (Helena Montana 1935 in X direction) is around 0.0044m @ 11th storey and though it is not exceeding the permissible value of 0.012m, hence it is safer to design.

10. Figure 11: It can be observed that the maximum storey drift among all five models due to past earthquake data (Helena Montana 1935 in Y direction) is around 0.0041m @ 13th storey and though it is not exceeding the permissible value of 0.012m, hence it is safer to design.

11. Figure 12: It can be observed that the maximum storey drift among all five models due to past earthquake data (Hollister 1974 in X direction) is around 0.0038m @ 12th storey and though it is not exceeding the permissible value of 0.012m, hence it is safer to design.

12. Figure 13: It can be observed that the maximum storey drift among all five models due to past earthquake data (Hollister 1974 in Y direction) is around 0.0039m @ 15th storey and though it is not exceeding the permissible value of 0.012m, hence it is safer to design.

13. Figure 14: It can be observed that the minimum lateral stiffness percentage among all five models due to past earthquake data (El Centro 1940 in X direction) is around 0.71% @ 13th storey and which is not under the permissible value, hence it is safer to design.

14. Figure 15: It can be observed that the minimum lateral stiffness percentage among all five models due to past earthquake data (El Centro 1940 in X direction) is around 0.74% @ 14th storey and which is not exceeding the permissible value, hence it is safer to design.

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15. Figure 16: It can be observed that the minimum lateral stiffness percentage among all five models due to past earthquake data (Helena Montana 1935 in X direction) is around 0.71% @ 13th storey and which is not exceeding the permissible value, hence it is safer to design.

16. Figure 17: It can be observed that the minimum lateral stiffness percentage among all five models due to past earthquake data (Helena Montana 1935 in Y direction) is around 0.77% @ 13th storey and which is not exceeding the permissible value, hence it is safer to design.

17. Figure 18: It can be observed that the minimum lateral stiffness percentage among all five models due to past earthquake data (Hollister 1974 in X direction) is around 0.77% @ 13th storey and which is not exceeding the permissible value, hence it is safer to design.

18. Figure 19: It can be observed that the minimum lateral stiffness percentage among all five models due to past earthquake data (Hollister 1974 in Y direction) is around 0.84% @ 14th storey and which is not exceeding the permissible value, hence it is safer to design.

IV. CONCLUSIONS

1. The time history analysis using ETABS has provided a comprehensive understanding of how the building responds to dynamic loads, especially during seismic events.

2. Base shear values for irregular structure are more compared to regular structure for all 3 past earthquake data in both x and y direction. Among U shape and Hollow plan irregular structure, U shaped structure depicted higher base shear compared to hollow structure. Among vertical irregular structure, both T shaped and L shaped vertical irregular structures showed higher base shear values.

3. The Storey drift is one of the main factors which influence on the building serviceability. The maximum Storey drift of the models studied does not exceed the permissible value of safety i.e., 0.004 times the storey height (<0.012 of each storey).

4. The stiffness of the structure reduces due to effect of earthquake load. The codal requirement of lateral stiffness in any storey to be greater than 70% of that of the above storey is satisfied in the present study.

5. The results of the models studied subjected to earthquake data in both x and y directions are in permissible limit and do not fall beyond the limiting values.

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