iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: V Month of publication: May 2023

DOI: https://doi.org/10.22214/ijraset.2023.52194

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

Comparative Study of the Performance of the Diagrid System with and without Shear Wall

Darpan Kapre[1], Dr. N. G. Gore[2]
University Department of Civil Engineering, Mahatma Gandhi Mission's College of Engineering and Technology, Kamothe, Navi Mumbai

Abstract: Due to increasing population with every passing year and the land available for use of habitation is the same as it was a decade ago. So, the only solution to the problem is vertical growth. Now this need for the increase in the vertical height of the buildings has made the buildings tall and slender. The Parameters discussed in this study include Storey Displacement, Storey Drift, Base shear, Storey shear and Time period for static and dynamic behaviour of different lateral load resisting configurations. Based on this parametric study, logical and meaningful conclusion is made for future study considering the safety and economy of the buildings.
Keywords: Diagrid building, Shear wall, Story Drift, Base shear, Time period, economy.

I. INTRODUCTION

A. General

As the population is increasing tremendously with every passing year and the land available for use of habilitation is the same as it was a decade ago. There has been seen an increase in the density of population in the urban area. So the only solution to the problem is for vertical growth. Now this need for the increase in the vertical height of the buildings has made the building become long and slender. As tall buildings had always been a showcase of dreams, power and technical advancement. The height of the building has now become the primary point of focus of today's world. Over the decades there have been significant development of high-rise buildings which had taken place considering various architectural features and structure concept hand in hand. Tall structure demand lot of technical support without which its emergence is not possible. As the height of structure is increased the lateral forces acting on the structure also rapidly increases. Hence the lateral load resisting systems plays an important role than structural system that resist gravitational loads. In the modern world there are various lateral load resisting systems have been implemented in aspect of design, shape and economy.

B. Rigid Frame Structure

A rigid frame in structural engineering is the load-resisting skeleton constructed with straight or curved members interconnected by mostly rigid connections which resist movements induced at the joints of members. Its members can take bending moment, shear, and axial loads. The two common assumptions in this building frames are that its beams are free to rotate at their connections and that its members are so connected that when under load, the angel they make with each other does not change. Frame works with connections of intermediate stiffness will be intermediate between these two extremes. Frame works with connections of intermediate stiffness are commonly called semi rigid frames. The AISC specifications recognize three basic frame types: Rigid Frame, simple frame, and partially restrained frame.

C. Diagrid Structure

The Diagrid structural system has unique properties that are both modern and economical. Although the role of a structural system is the same, carrying loads to the foundation and beyond, the Diagrid has components that make this role more efficient. This section will walk you through the similarities and differences between a Diagrid and other structural system.

D. Shear Wall Frame System

Continuous concrete vertical wall serves both architecturally as partition and structurally to carry gravity and lateral loads. Shear walls are used in building to resist lateral force due to wind and earthquakes. Very high plane stiffness and strength makes shear walls ideally suited for tall buildings. Shear wall generally starts at foundation level and are continued throughout the building height.

II. LITERATURE REVIEW

Taranath S. D. et al. (2014) investigated the study of the efficiency of peripheral pentagrid and hexagrid bracing systems compared with the basic model (without bracings) at standard loading conditions. For comparison three tall buildings of 40, 50 and 60 stories with structural forms of rigid frame-slab, shear walls with flat slabs, flat slabs with columns are considered and lateral bracings of pentagrid & hexagrid shape with rigid connections are made to these models by using RC members of 200 x 200 mm. They concluded that construction details need additional care.

Nijil George Philip and Shashidharan (2016) considered a circular regular plan diameter of 40.63 m and modelled 36, 50, 60, 70 and 80 Storey buildings by using ETABS software. They compared buildings configured with a uniform diagonal angle to buildings with non-uniform diagrid angle distribution. Dynamic wind analysis was carried for structural members as per the Gust effect method of IS:875 Part III- 1987. The researchers compared the results in terms of top Storey displacement and maximum forces developed on diagrid member. They concluded that forces on diagrids in a circular building can be reduced by making the use of non-uniform diagrid configurations of specified angles and also material require for building.

Nischay J and M. R. Suresh (2016) analysed three models of different geometry of 30 stories, 45 stories and 60 stories with the diagrid angle of 69.670 by using ETABS software. They compared the shear wall system as an external lateral load resisting system with the diagrids on the exterior of the building and investigated the parameters such as Storey drift, lateral displacement, Storey stiffness, base shear and time period. They concluded that lateral displacement in diagrids model is lesser as compared to that of shear wall models. The study also reveals that base shear values are higher and time periods are less in diagrid model as compare to that of shear wall models. Hence, against seismic vibrations diagrid models are less flexible.

Nandeesh K C and Geetha K (2016) considered a 52 storied hyperbolic circular diagrid steel structure rehabilitated with steel braced frames and shear wall to analyse seismic and wind reaction of the model for zone II and zone III by using ETABS software. They considered two models with centre divider framework and shifting floor zone comprising of diagrid funnel segment at the external fringe of both the models. They concluded that the shear wall system performed better under seismic loading and even against the Storey drift as compare to steel bracing frame system. The study revealed that the shear wall system is very effective against the parameters such as Storey displacement, Storey drift and time period.

Nimisha. P and Namitha Krishnan (2016) analysed a 30, 36, 42, 48, 54, 60, 66 Storey model with a plan of 32m x 32m having Storey height of 3.8m using ETABS 2015 software. Various loading has been taken as per IS 875-1977. They made a comparison between diagrid building and tubular building. The study reveals that the parameter such as Storey drift, displacement, time period and Storey shear are greater in the tubular building as compare to diagrid building. They concluded that while moving to higher model the analyzed result of Diagrid and tubular building decreases. They also concluded that diagrid building is structurally more efficient as compared to the tubular building.

III.PROBLEM FORMULATION

A. General

In present study C shape plan of commercial building has been chosen. Six different building models with Diagrid system and Diagrid with Shear wall system are modelled using ETABS software. The building models are analyzed for seismic action by equivalent static method and response spectrum methods for zone III, zone IV and zone V for special moment-resisting frame. As well as wind analysis is done for three basic wind speed 44 m/s, 47 m/s, 50 m/s. The loadings on the building are considered as per IS 875-2015 and IS 1893- 2016. Storey height shall be kept constant at 3.5 meters for all Storeys and ground floor with 4 meters.

ETABS version 2016 is used for modelling of building frames. The basic three activities which are to be carried out are

1) Model generation (geometry)
2) Assignments of material, stiffness & load properties
3) Analysis (Static, Dynamic and Wind analysis)
4) Extraction & interpretation of results for useful findings

B. Combinations for Models

Based on the literature review and the gaps found in the research, the combinations of model for different Diagrid systems are obtained. The various model combinations are listed below;

1) M1- Diagrid without Shear wall Structure

The model has a Diagrids placed at outer side of the models. The Diagrid structure is considered as a base model for comparison

2) M2- Diagrid with Shear Wall Structure

The model has Diagrid frame with shear wall placed at lift portion in core and at corner of the models.

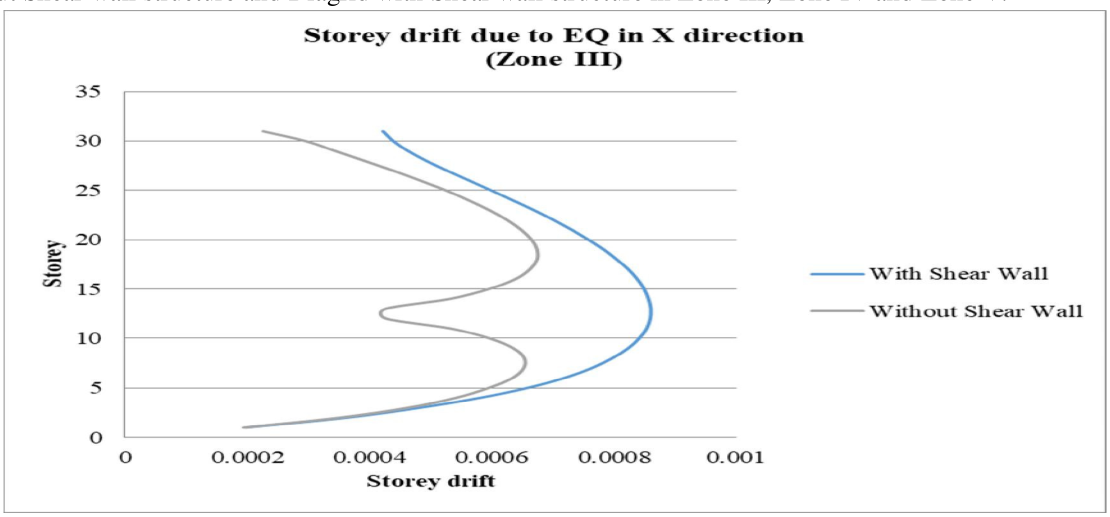
All of above configuration are so decided that the versatile performance of lateral load resisting system can be judged. In addition to this, all of these four configurations mentioned above shall be repeated for three different seismic zones i.e. Mumbai (Zone III & Basic wind speed 44 m/s), Delhi (Zone IV & Basic wind speed 47 m/s) and Guwahati (Zone V & Basic wind speed 50 m/s). So, in all 6 different building models are modelled to capture the effect of different lateral load resisting i.e. Diagrid without Shear Wall Structure and Diagrid with Shear wall structure by varying seismic zones. All the models are subjected to earthquake and wind load as per IS 1893-2016 and IS 875-2015 respectively. Storey height shall be kept constant at 3.5 meters for all Storeys and 4 meters for ground floor. The above building models will be analyzed by for seismic action by Response Spectrum methods for zone III, zone IV and zone V for special moment- resisting frame. As well as wind analysis will be done for three basic wind speed 44 m/s, 47 m/s and 50m/s respectively. After analysis of all the structures; the results of analysis should be compared and conclusion will be drawn for the suitability of the structures for different seismic zones.

IV. RESULTS

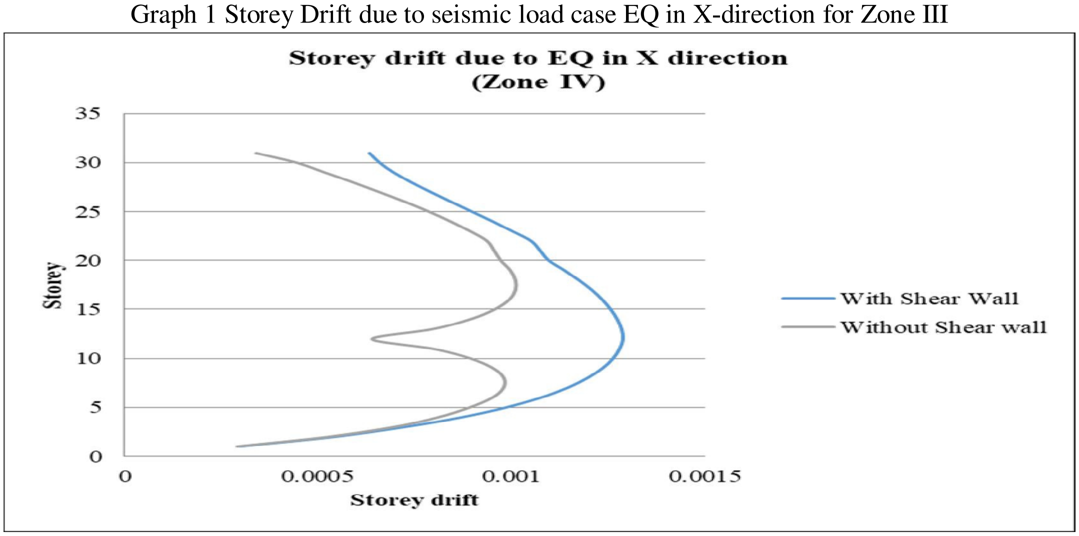
The following results are obtained.

A. Storey Drift due to seismic load case EQ in X-direction

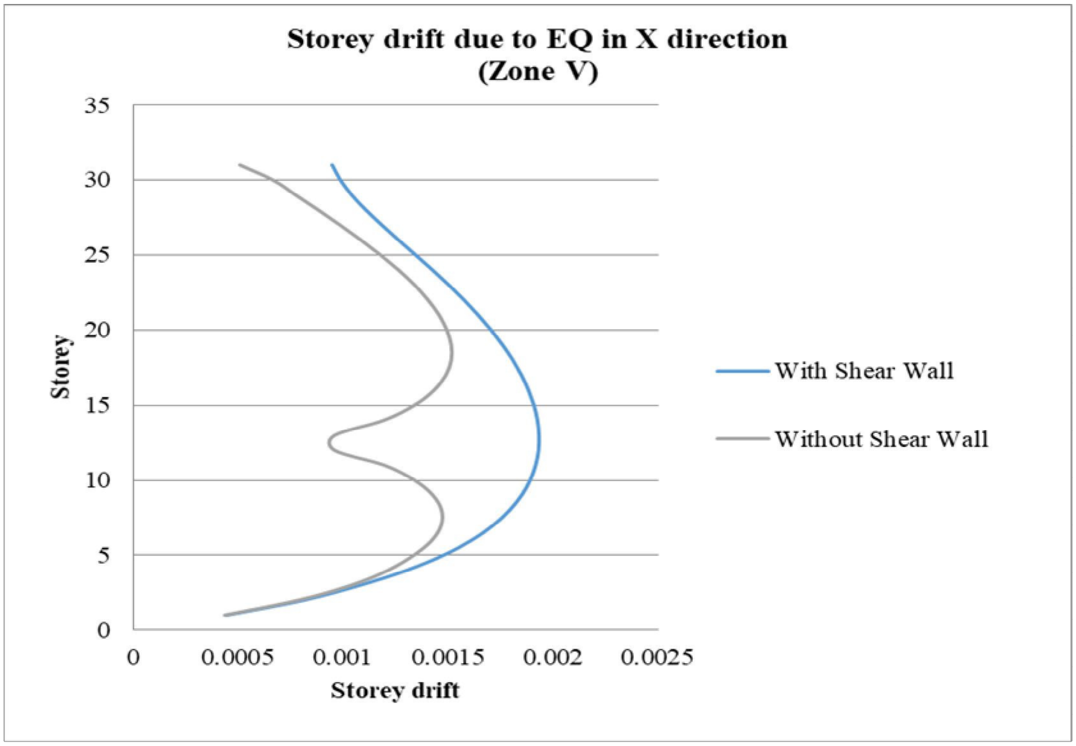
The Graph 1,2 & 3 shows Storey drift due to seismic load case EQ in X direction for different lateral load resisting system i.e. Diagrid without Shear wall structure and Diagrid with Shear wall structure in Zone III, Zone IV and Zone V.



Graph 1 Storey Drift due to seismic load case EQ in X-direction for Zone III



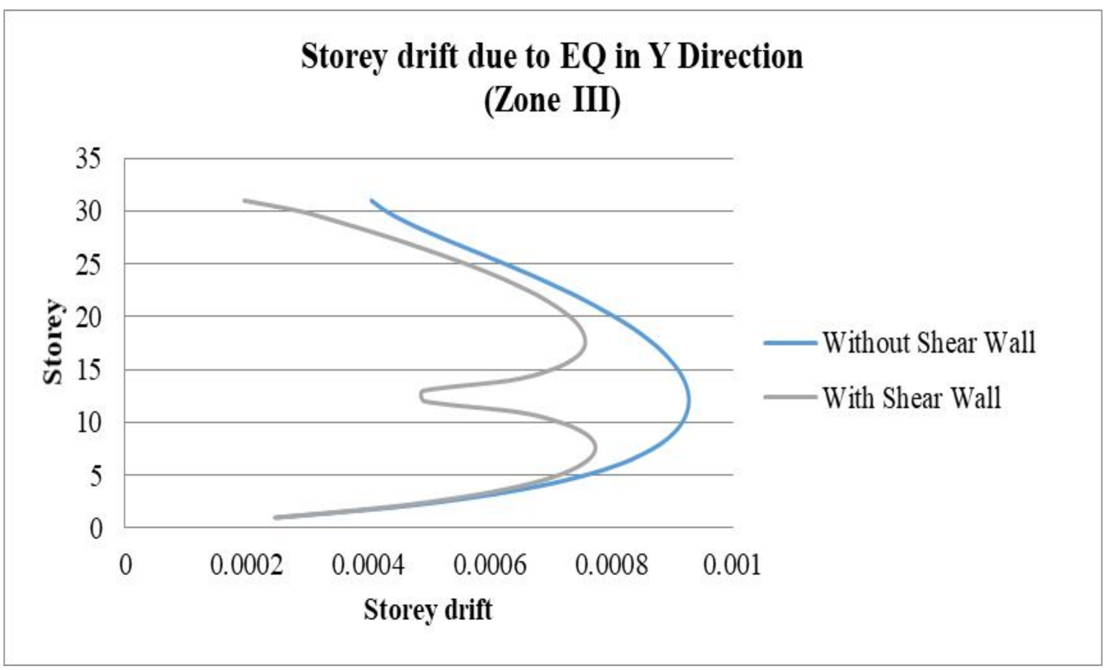
Graph 2 Storey Drift due to seismic load case EQ in X-direction for Zone IV



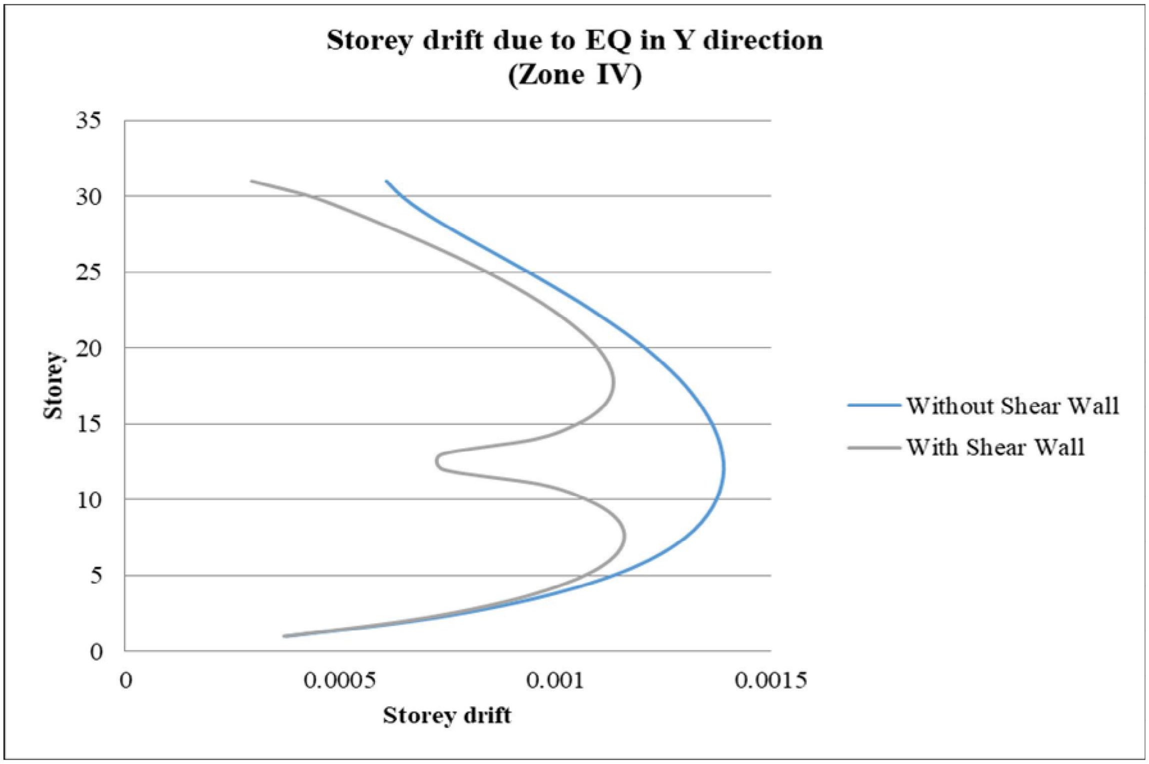
Graph 3 Storey Drift due to seismic load case EQ in X-direction for Zone V

B. Storey Drift due to seismic load case EQ in Y-direction

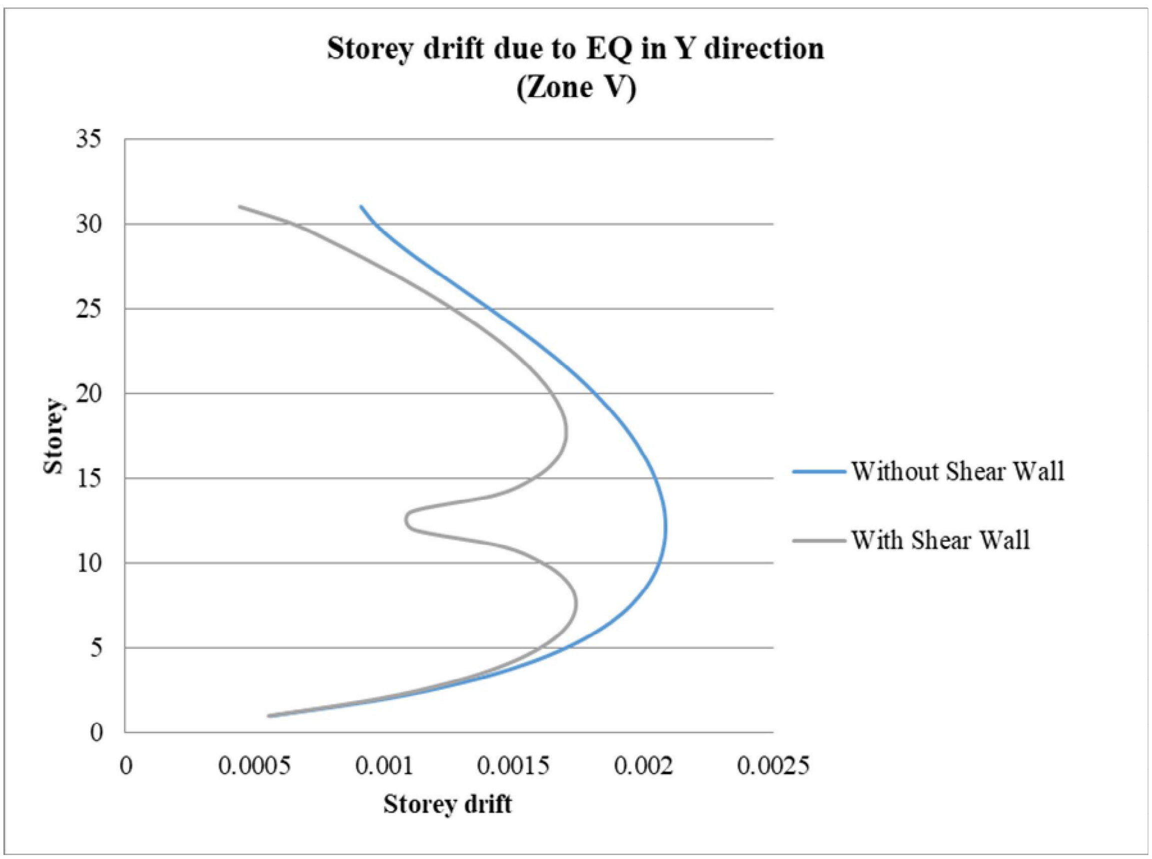
The Graphs 4, 5 & 6 shows storey drift due to seismic load case EQ in Y direction for different lateral load resisting system i.e. Diagrid without Shear wall structure and Diagrid with Shear wall structure in Zone III, Zone IV and Zone V.



Graph 4 Storey Drift due to seismic load case EQ in Y-direction for Zone III



Graph 5 Storey Drift due to seismic load case EQ in Y-direction for Zone IV



Graph 6 Storey Drift due to seismic load case EQ in Y-direction for Zone V

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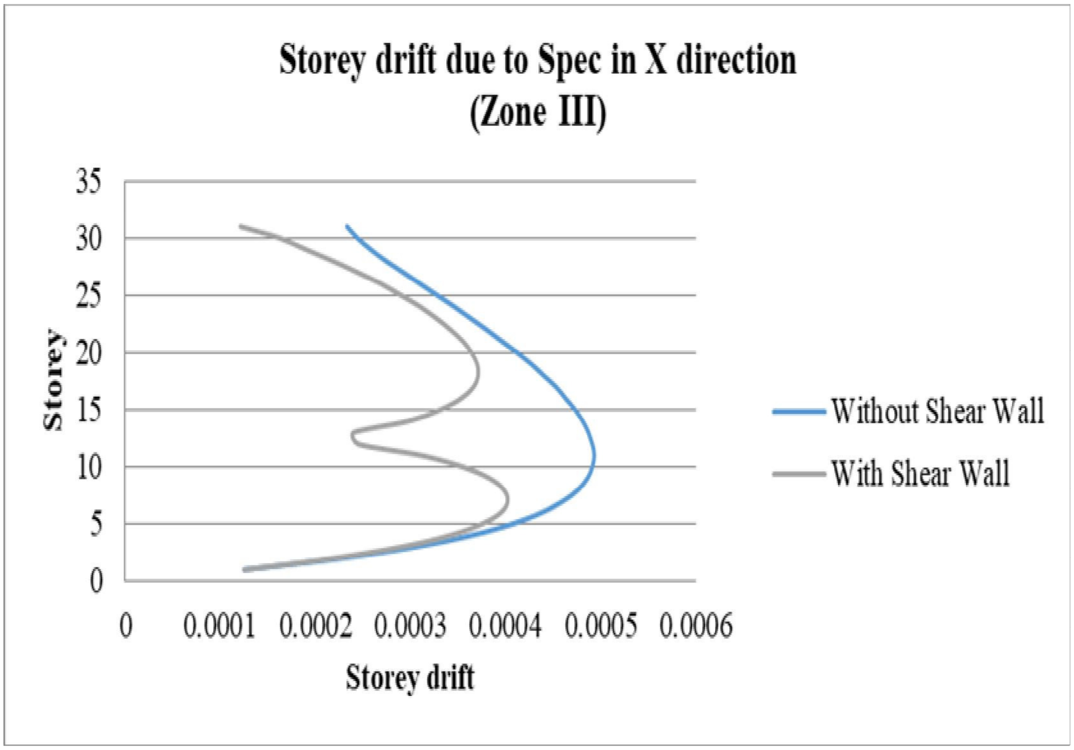
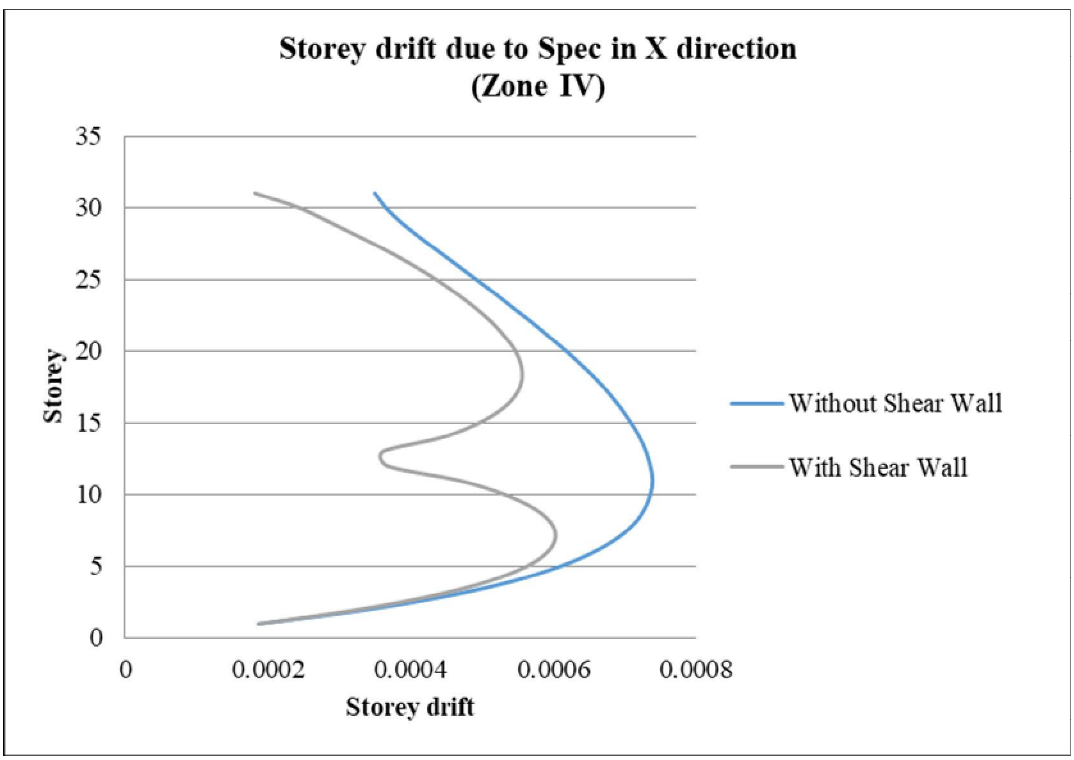
C. Storey Drift due to seismic load case Response Spectrum in X-direction

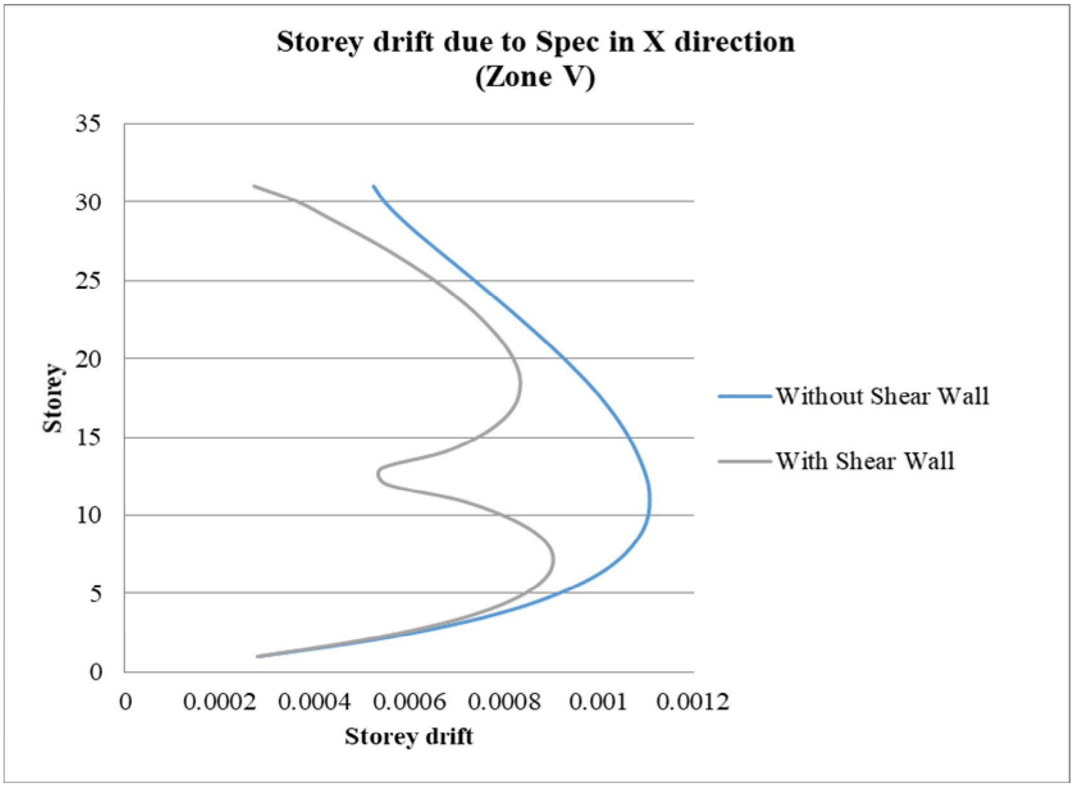
The Graphs 7, 8 & 9 shows Storey drift due to seismic load case response spectrum (Spec) in X direction for different lateral load resisting system i.e. Diagrid without Shear wall structure and Diagrid with Shear wall structure in Zone III, Zone IV and Zone V.



Graph 7 Storey Drift due to seismic load case Response Spectrum in X-direction for Zone III

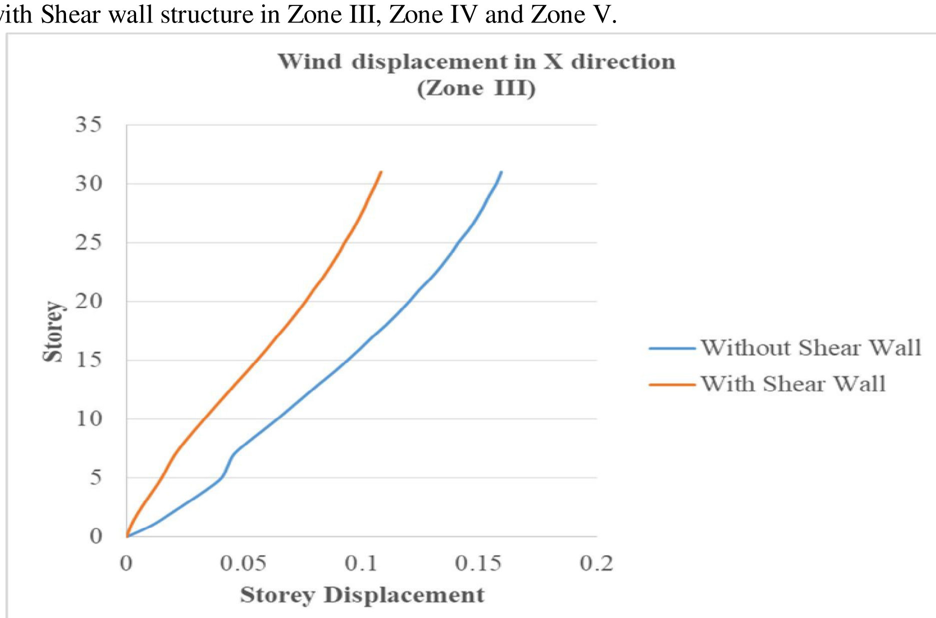


Graph 8 Storey Drift due to seismic load case Response Spectrum in X-direction for Zone IV



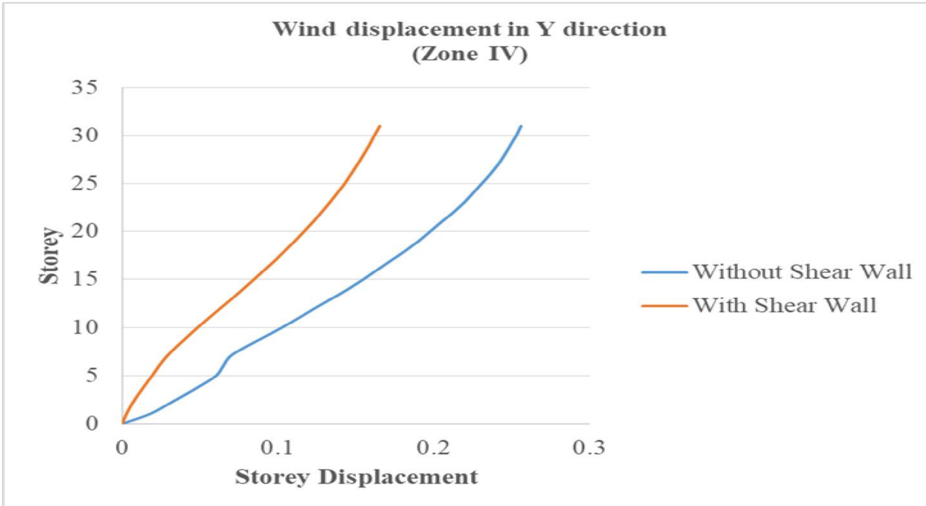
Graph 9 Storey Drift due to seismic load case Response Spectrum in X-direction for Zone V

The Graphs 10 shows wind displacement due to load case Wind in X direction for different lateral load resisting system i.e. Diagrid structure and Diagrid with Shear wall structure in Zone III, Zone IV and Zone V.



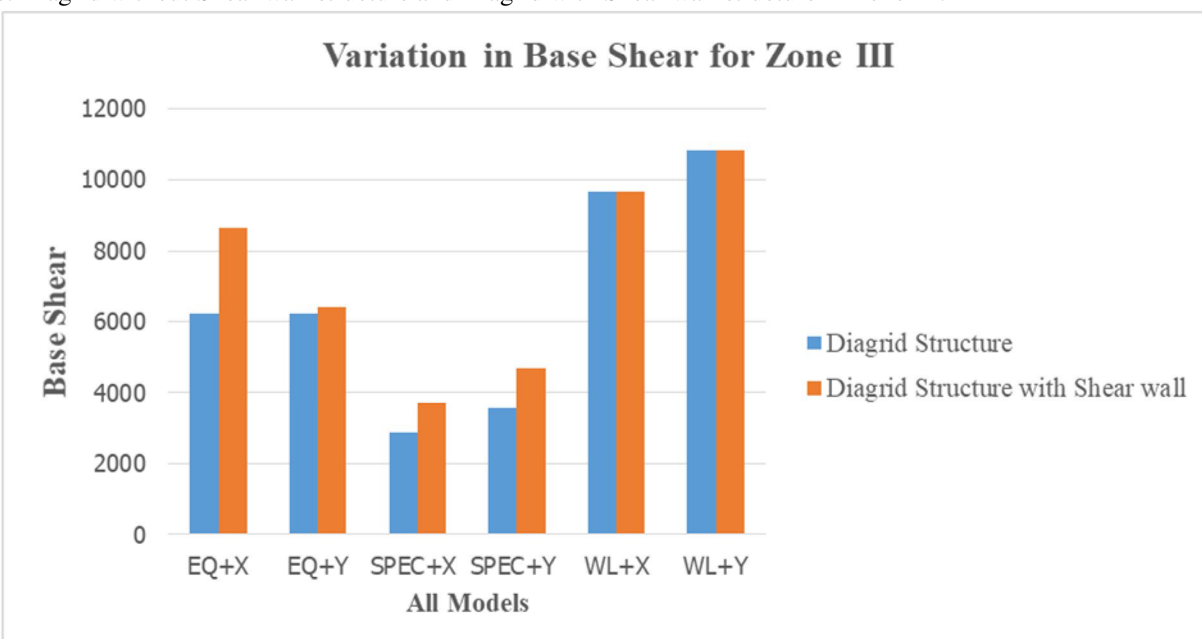
Graph 10 Wind Displacement in X-direction for Zone III

The Graph 11 shows wind displacement due to load case Wind in Y direction for different lateral load resisting system i.e. Diagrid structure and Diagrid with Shear wall structure in Zone IV.



Graph 11 Wind Displacement due to load case Wind in Y-direction for Zone IV

The base shear is majorly due to seismic loads. The Graph 6.31, 6.32, 6.33 shows variation in base shear for lateral load resisting system i.e. Diagrid without Shear wall structure and Diagrid with Shear wall structure in Zone III.



Graph 12 Variation in Base Shear for lateral load resisting system in Equivalent Static, Response Spectrum and Wind analysis for Zone III

V. CONCLUSIONS

The research work is clearly focused on the study of wind and seismic behaviour of geometrically irregular C-shaped (in plan) high-rise structures using ETABS software. Attempts are made in selecting the configurations which are distinct from each other so that a complete picture could be drawn to understand the performance of lateral load resisting system under seismic and wind loads. In order to assess and conclude the behaviour, parameters such as Storey Drift, Earthquake Displacement, Wind Displacement, Base Shear, Time Period are studied in detail. Six various models in three different zones are created and analysed to provide a comprehensive output of different lateral load resisting system i.e. Diagrid without Shear Wall Structure and Diagrid with Shear Wall Structure.

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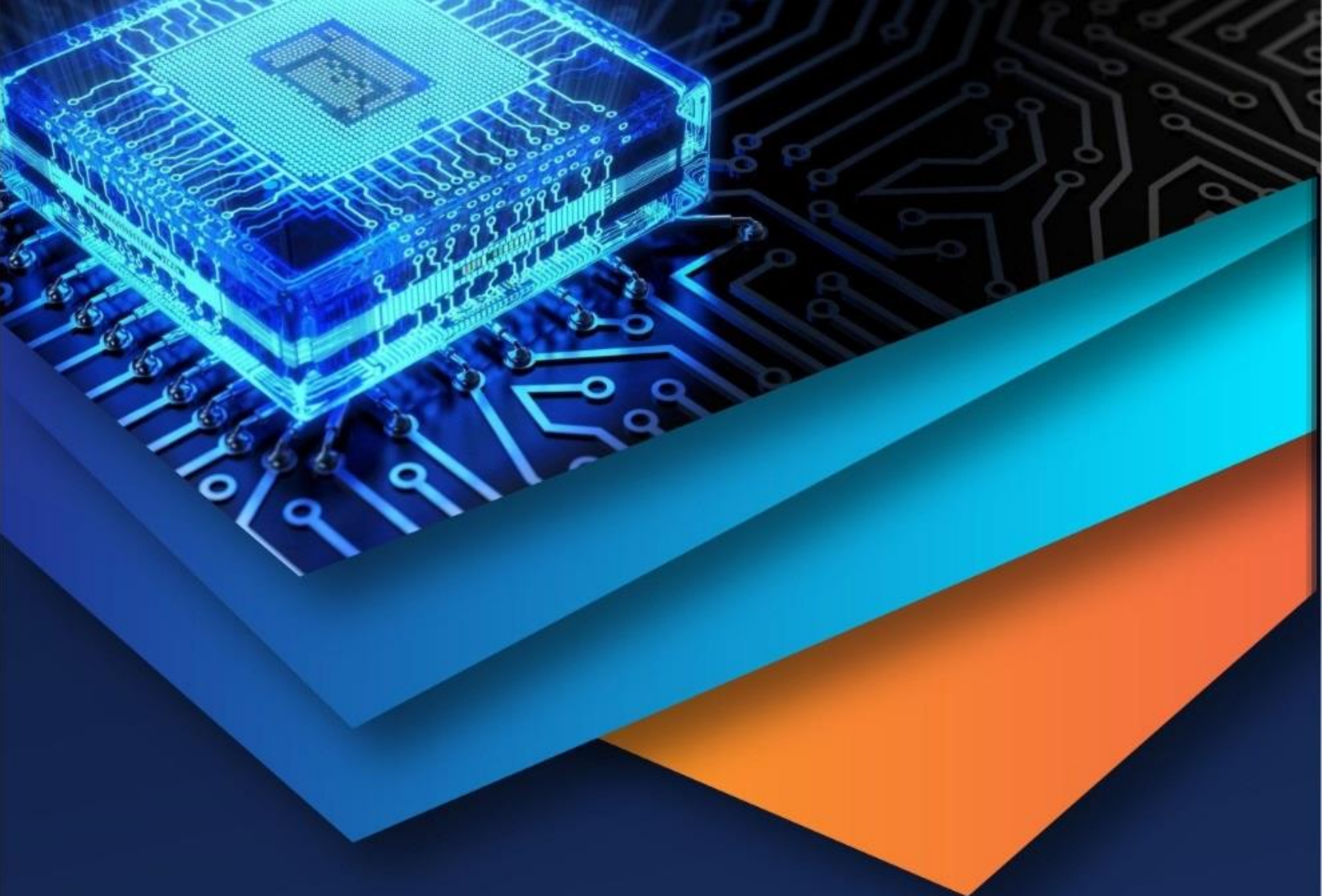

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