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# Structural Analysis of the Performance of the Diagrid System with and without Shear Wall

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***Abstract: The objective of the present work is to study, behaviour and performance of diagrid structural system with and without shear wall under lateral loads i.e. wind and earthquake that may occur during the lifespan of the building. In this present work a particular G+70 storey geometrically irregular C-shaped high-rise Diagrid building with and without Shear wall are modelled using ETABS software. These models are analysed for Static and dynamic behavior in three different zones i.e, Zone III, Zone IV and Zone V with basic wind speed 44 m/s, 47 m/s and 50 m/s respectively. Equivalent Static analysis, Response Spectrum Method (dynamic analysis) and Static Wind analysis is carried out.***
***Keywords: Diagrid building, Shear wall, Story Drift, Base shear, Time period, economy.***

## I. INTRODUCTION

### *A. General*

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. Almost all the conventional vertical columns are eliminated for Diagrid structures. This is possible because the Diagonal members in Diagrid structural systems can carry gravity loads as well as lateral forces because of their triangulated configuration. On the other hand, the Diagonals in conventional braced frame structures carry only lateral loads. The gravity loads in conventional braced frames are carried down to the earth by the vertical members both in the exterior and interior of the building. Diagrid structures are also much more effective in minimizing shear deformation because they carry shear by axial action of the diagonal members, while conventional framed tubular structures carry shear by the bending of the vertical columns.

As the population is increasing the demand and development for high rise building is also increasing. While the selection of construction technology and material should satisfy aspects such as ease of construction and lower cost, it is equally important to ensure sustainability. The steady-growth in the housing requirements has generated the searches for new constructive materials and construction methods to improve life quality, cost-efficiency and ease construction.

Conventional structures are heavy, and most structures are primarily designed for vertical or gravity load with little attention being paid for lateral load resistance – earthquake, wind, etc. this is because such proper detailing leads to increase in cost, and India is still not adaptive to new methods. While the diagrid system and shear wall system are individual lateral load resisting systems. As the height of the buildings are drastically increasing and to ensure
safety and efficiency of the structures it's necessary to provide addition load resisting system to structure.

## II. LITERATURE REVIEW

Sachin Mohare and H Sharada Bai (2017) analyzed 45 storey steel building with a triangular diagrid pattern with a plan area of 36×36m considering a diagrid angle of 63$^{o}$ by using SAP2000 V-15. For comparison purpose, the density of diagrid was taken as 3, 4 and 6 and length of the shear wall of 6m and 12m is considered at the corners along X and Y directions. Various load combinations were taken as per IS provisions and seismic analysis was carried out for Zone V. They observed that at different heights lateral displacement are less in diagrid structure as compare to that of conventional shear walled structures. They concluded that structural parameters such as lateral sway, maximum axial force and bending moment were developed less in the diagrid structure than that of shear walled structure.

Rudrappa P Y and S M Maheshwarappa (2018) analyzed a 12 and 24 Storeyed building to study the behaviour of the structure under lateral loadings by using ETABS software. Various models were analyzed considering conventional building, flat slab building and flat-slab diagrid building with different diagrid angles.

Response spectrum and equivalent static analysis were performed to study the behaviour of flat-slab RC building with and without diagrid at the outer periphery considering parameters like displacement, Storey drift, top Storey, base shear and time period. The results observed were that in the flat slab diagrid building with corner column there was decrease in the top Storey displacement, time period, maximum drift ratio and an increase in the base shear respectively. Hence in the flat slab diagrid building with corner column top Storey displacement, maximum drift ratio increases.

They concluded that higher diagrid member are required for flat-slab building without corner column as compared to that of building with corner column.

Trupti A. Kinjawadekar and Amit C. Kinjawadekar (2018) analysed various numerical models of 18 and 36 Storey structures considering the simple frame and different diagrid angles i.e. 450, 640 and 720 by using SAP-2016. They have compared various models to study the seismic characterization of the diagrid structural system. The parameters such as Storey displacement, Storey drift, time period and base shear are analysed.

They concluded that for 18 Storey structure more stiffness is observed in the region of diagrid angle 450 to 640 and similarly for 36 Storey structure with the region of diagrid angle 640 to 720 which indicates less top Storey displacement. The study reveals that the diagrid angle in the region of 450 to 640 is more efficient as compared to other angles regardless of the consumption of steel. They also concluded that the optimum angle observed was 640 as Storey drift and top Storey displacement is much lesser in these region and joints required are less.

Pattan Venkatesh et al. (2018) considered 60 storied buildings of different geometry considering diagrid and without diagrid and analysed the models using ETABS software. The three models taken for analysis were a conventional rigid-frame building of rectangular plan of size 24m x 24m, circular diagrid building having a plan diameter of 24m and a rectangular diagrid building of plan size 24m x 24m.

The results showed that maximum displacement of the floor is h/250 under seismic loadings. They also concluded that stiffness and lateral displacement of the building are greater along X-direction than that along the Y direction. The research reveals that in terms of performance evaluation such as efficiency and sustainability diagrid system is found to be better and more resistant to the lateral forces.

## III.PROBLEM FORMULATION

### *A. General*

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.

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*B. Typical Floor Plan and Figures of Models*

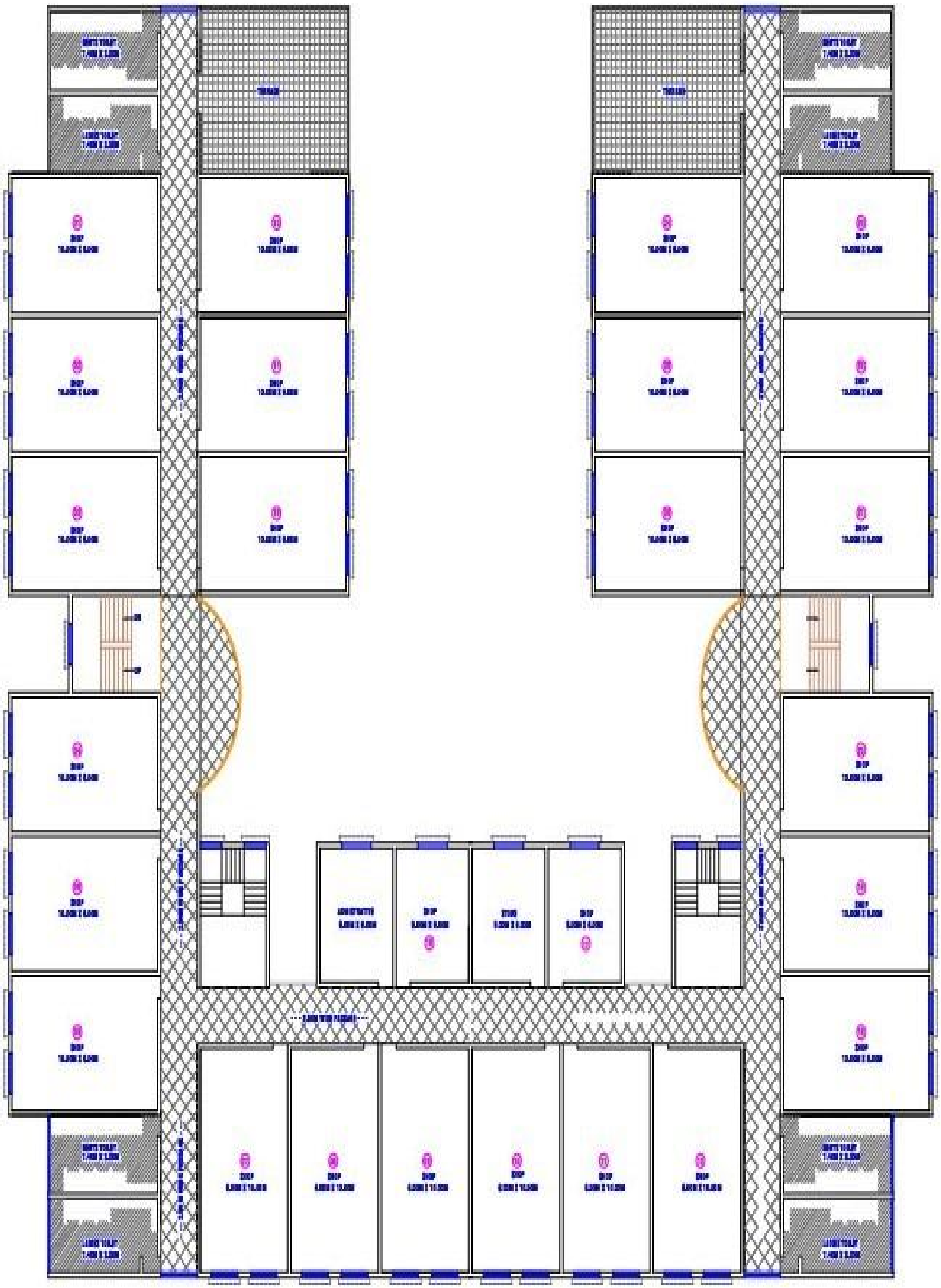

Fig 1 Typical C-Shape Floor Plan
*(Modelled in AutoCAD)*

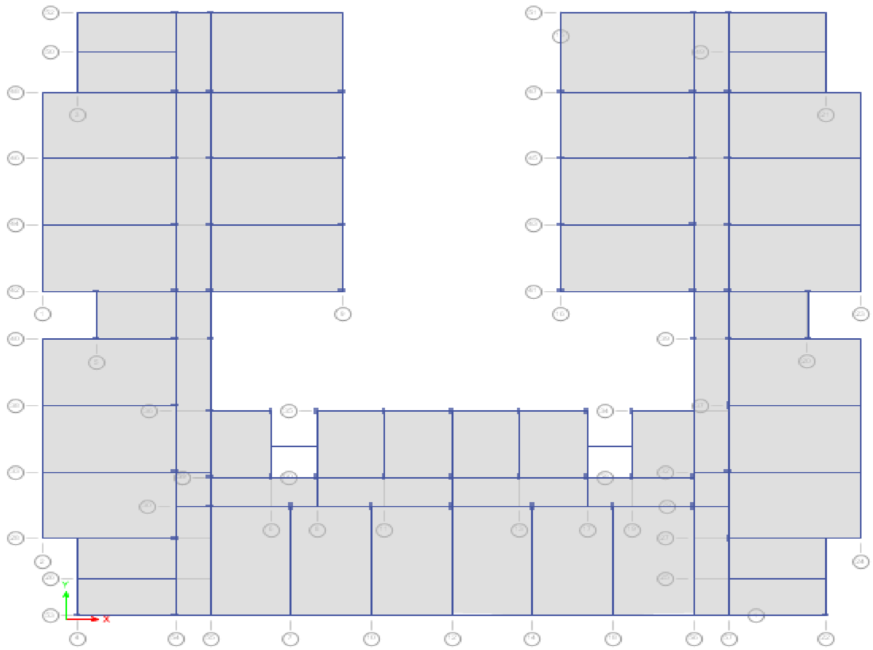

Fig 2 Typical software Plan of Diagrid Structure
*(Modelled in ETABS 2016)*

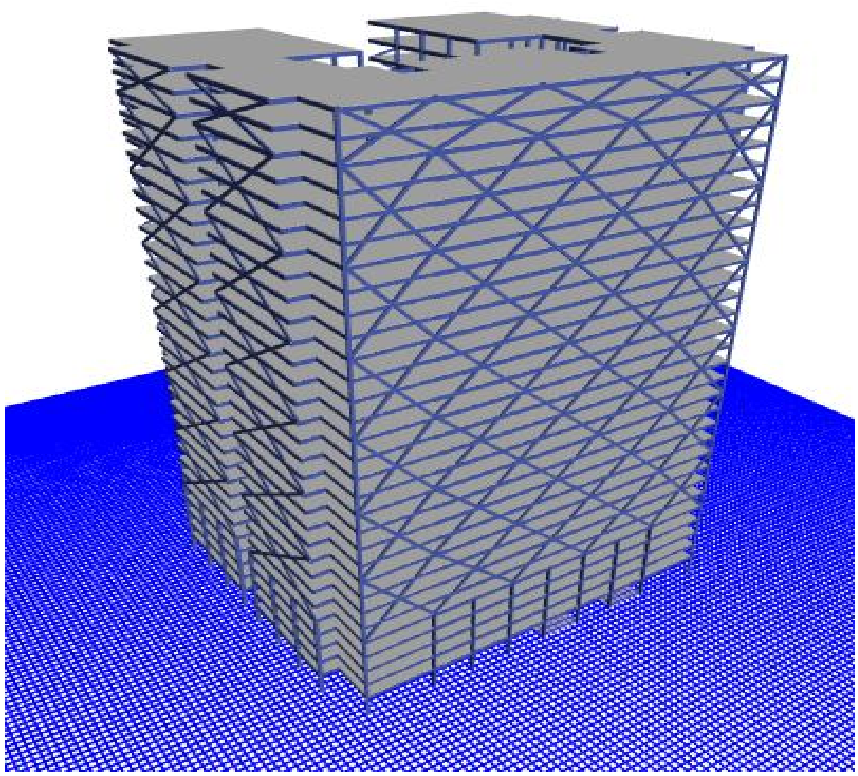

Fig 3 Three-dimensional extruded view of 30 storied Diagrid Structure
(*Modelled in ETABS 2016*)

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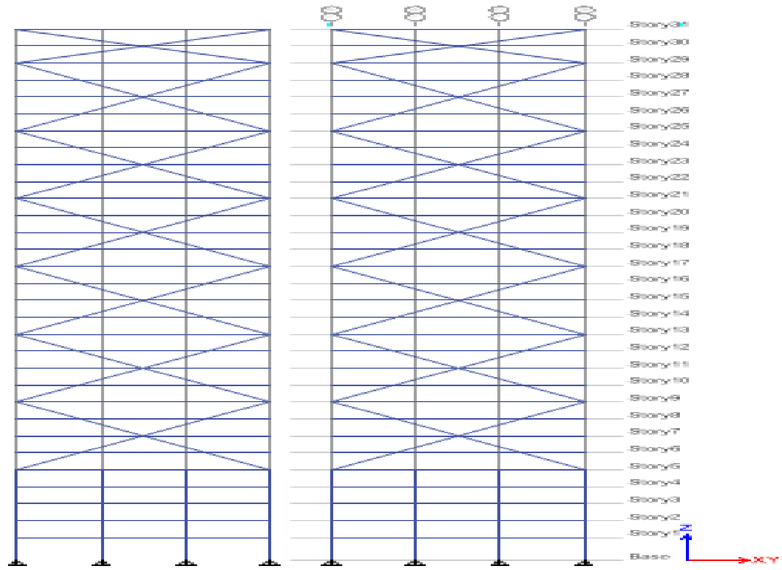

Fig 4 Diagrid Model Elevation
*(Modelled in ETABS 2016)*

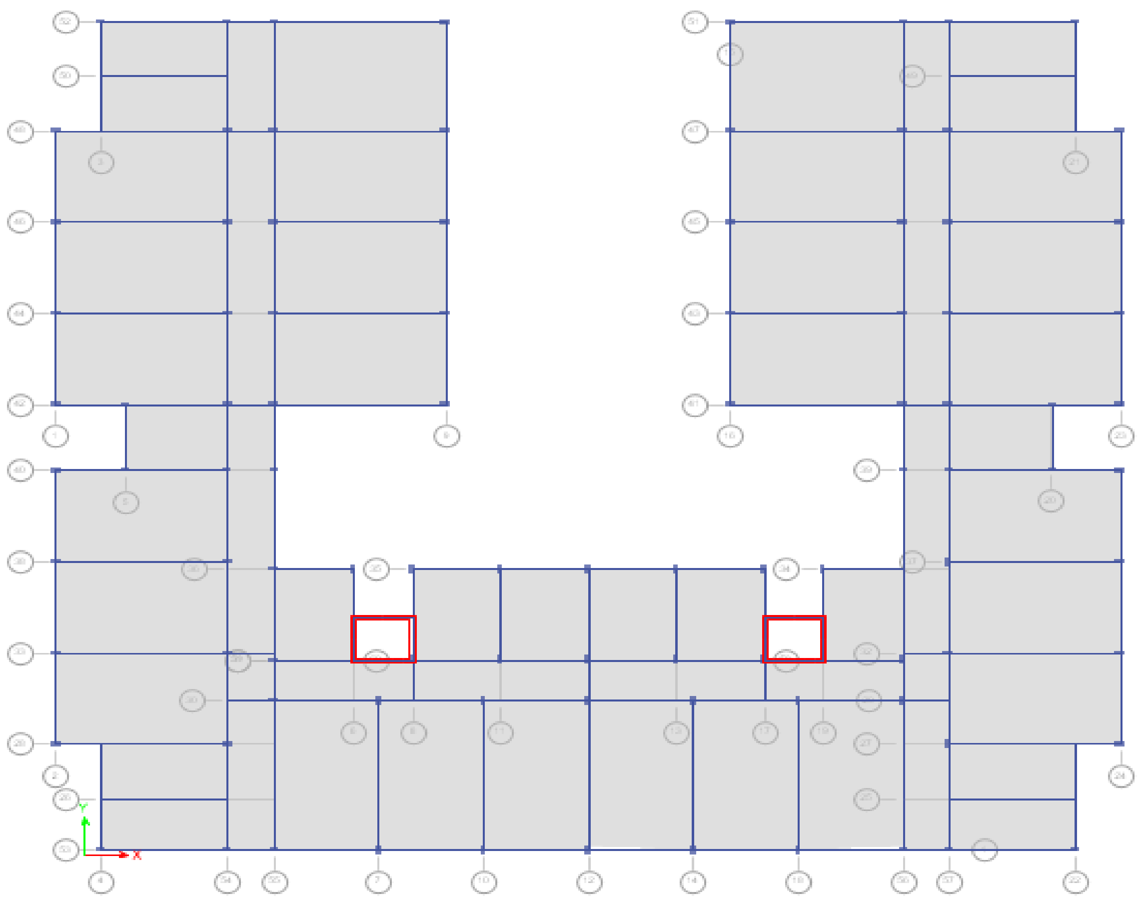

Fig 5 Typical software Plan of Diagrid Structure with Shear wall *(Modelled in ETABS 2016)*

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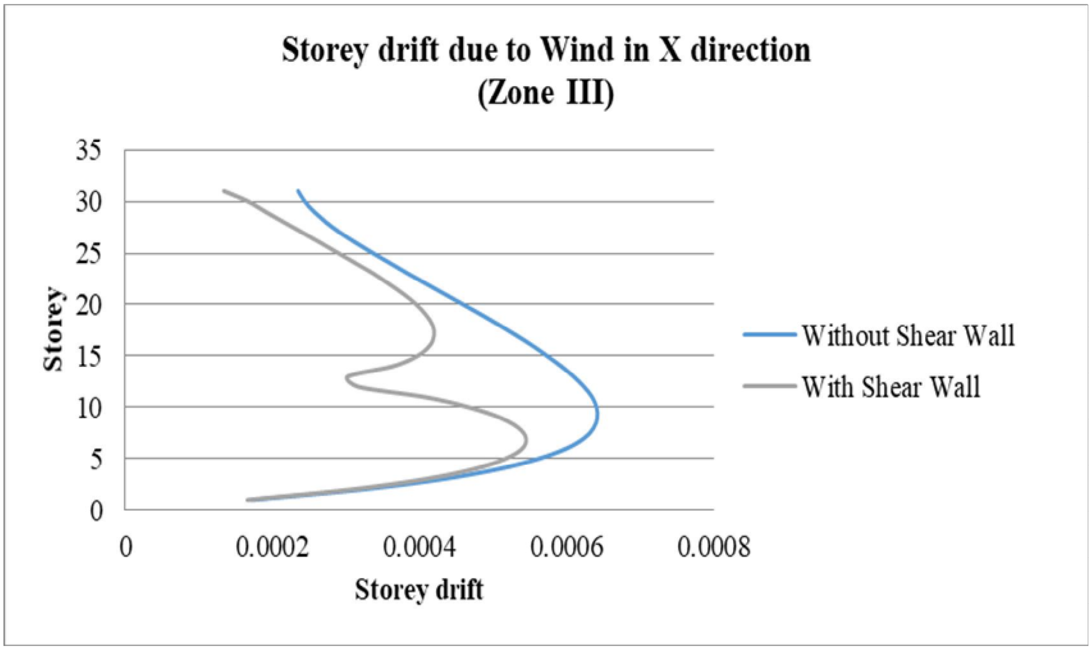
## IV.RESULTS

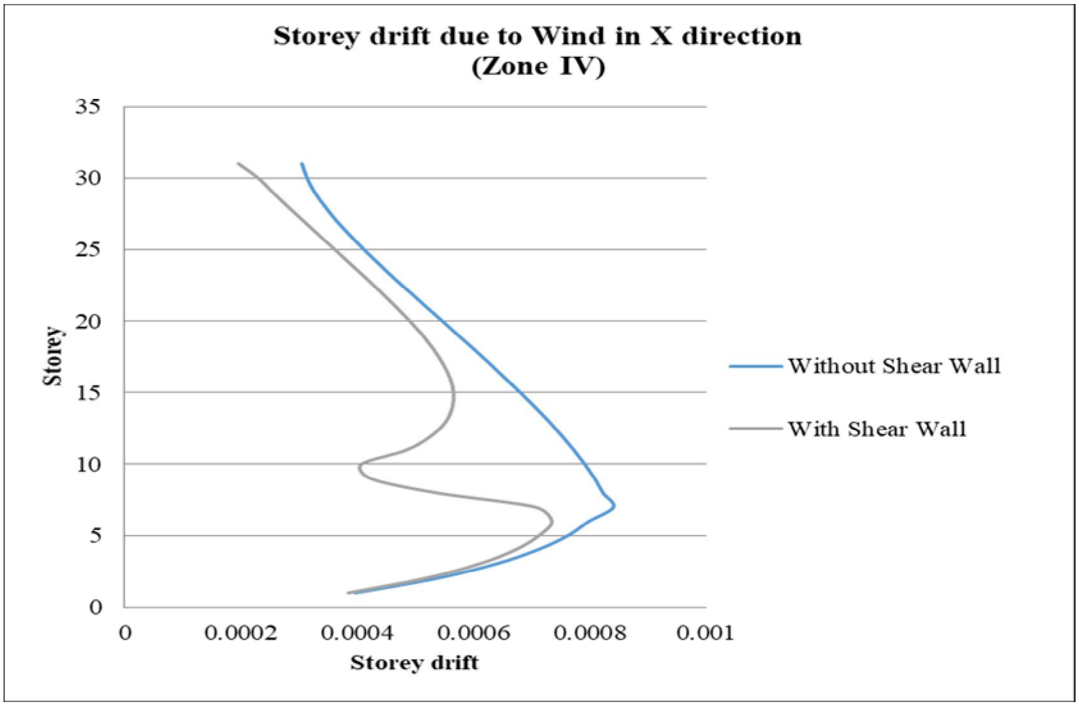
The following results are obtained.

### A. *Storey Drift due to load case Wind in X-direction*

The Graph 6, 7 & 8 shows Storey drift due to load case Wind 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 6 Storey Drift due to load case Wind in X-direction for Zone III




Graph 7 Storey Drift due to load case Wind in X-direction for Zone IV

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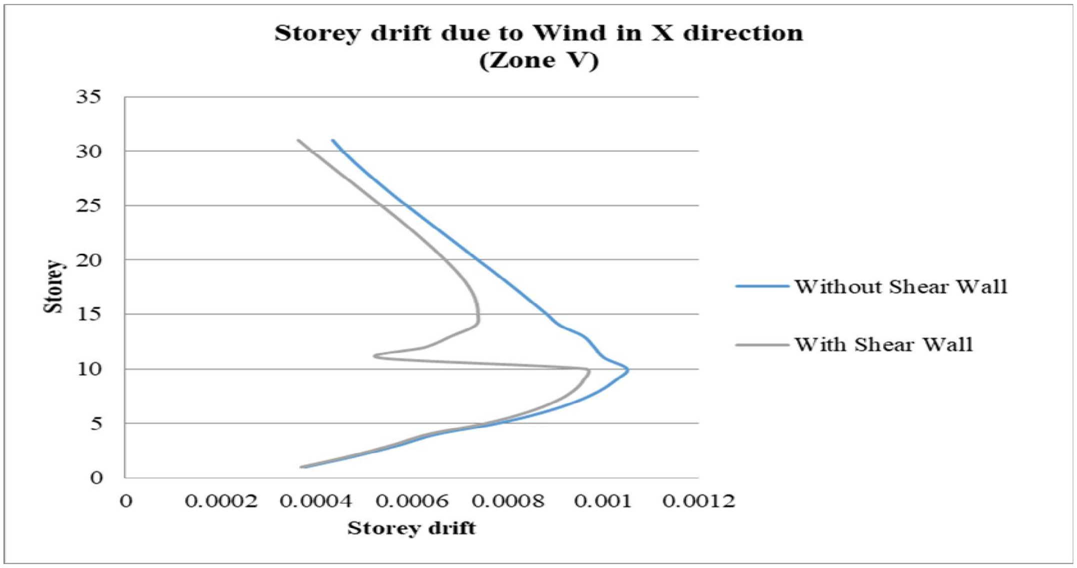
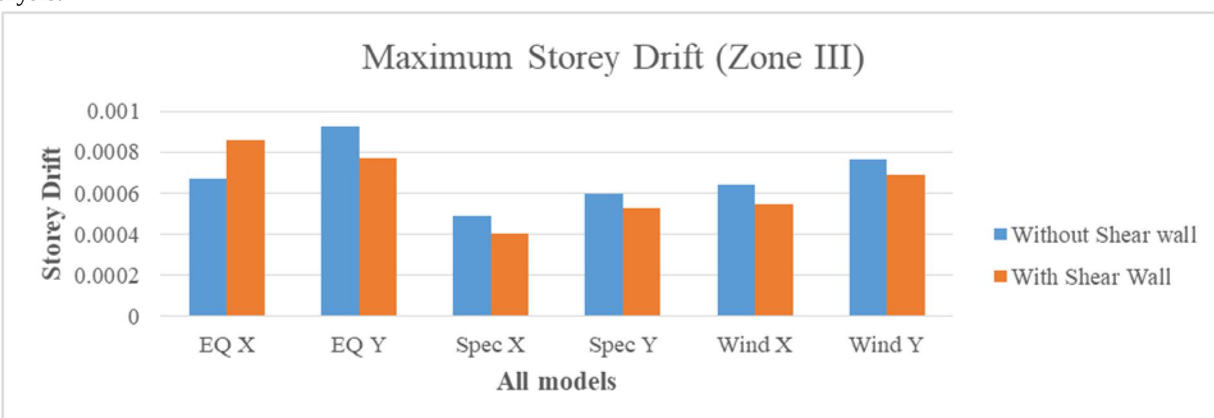



Graph 8 Storey Drift due to load case Wind in X-direction for Zone V

### *B. Maximum Storey Drift in Zone III, Zone IV and Zone V*

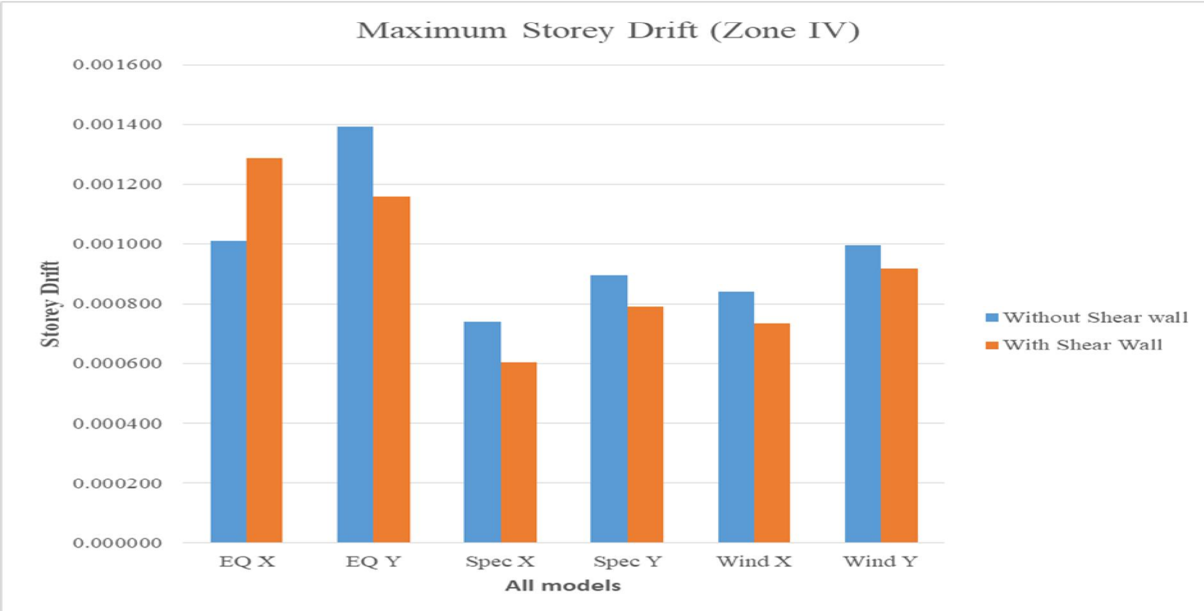
The Graphs 9 & 10 shows maximum drift for different lateral load resisting system i.e. Diagrid without Shear wall structure and Diagrid with Shear wall Structure in Zone III, Zone IV and Zone V by Equivalent Static method, Response spectrum method and Wind analysis.




Graph 9 Variation in Maximum Storey Drift in Zone III for lateral load resisting system in Equivalent Static, Response Spectrum and Wind analysis

Table 1 Percentage Reduction in Maximum Storey Drift in Zone III for lateral load resisting system in Equivalent Static, Response Spectrum and Wind analysis

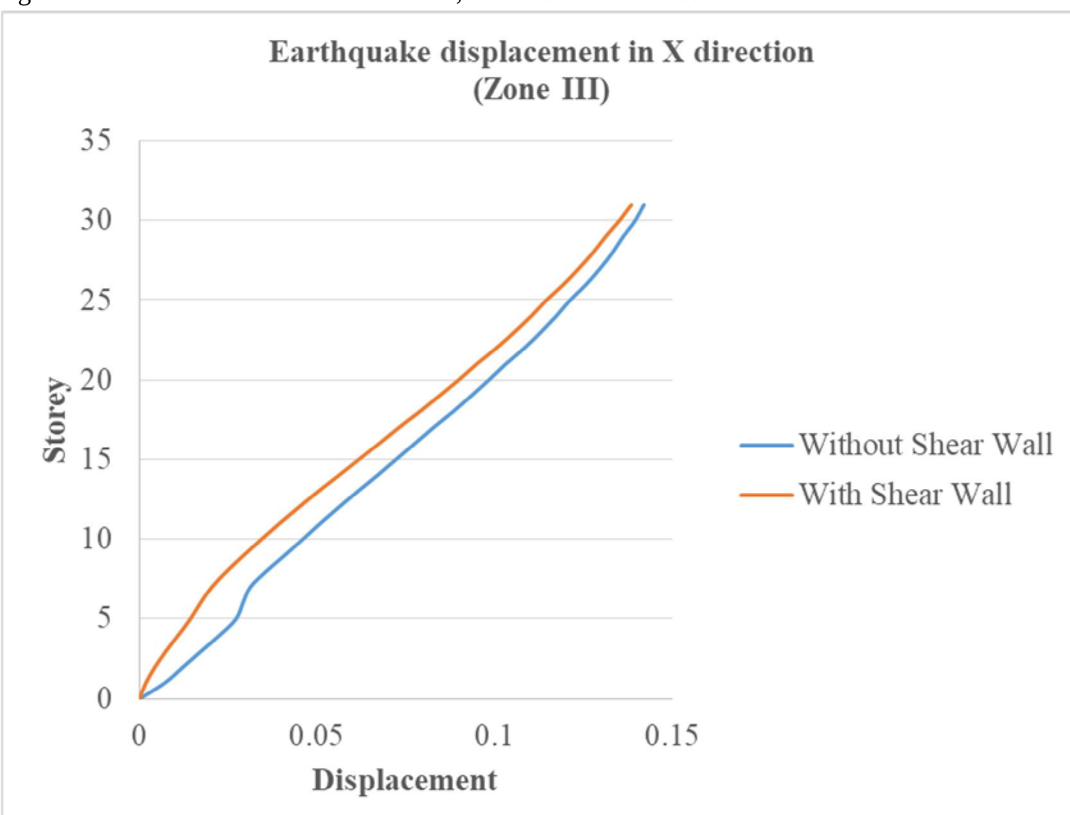
| Maximum Storey Drift (Zone III) | | | |
|---|---|---|---|
| Load Case | Diagrid without Shear wall Structure | Diagrid with Shear Wall Structure | % Reduction in Maximum Storey Drift |
| EQ X | 0.000674 | 0.00086 | 27.60 |
| EQ Y | 0.000927 | 0.000772 | 16.72 |
| Spec X | 0.000493 | 0.000402 | 18.46 |
| Spec Y | 0.000597 | 0.000527 | 11.73 |
| Wind X | 0.000642 | 0.000545 | 15.11 |
| Wind Y | 0.000767 | 0.000692 | 9.78 |



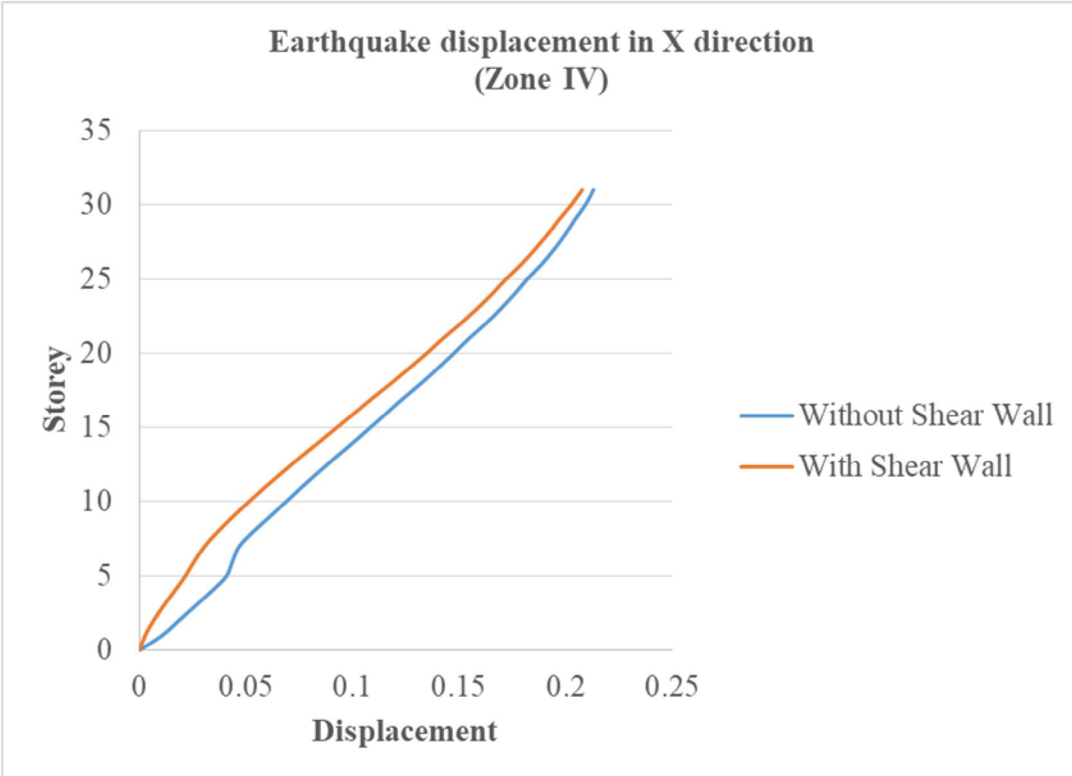

Graph 10 Variation in Maximum Storey Drift in Zone IV for lateral load resisting system in Equivalent Static, Response Spectrum and Wind analysis

### C. Earthquake Displacement in X-direction

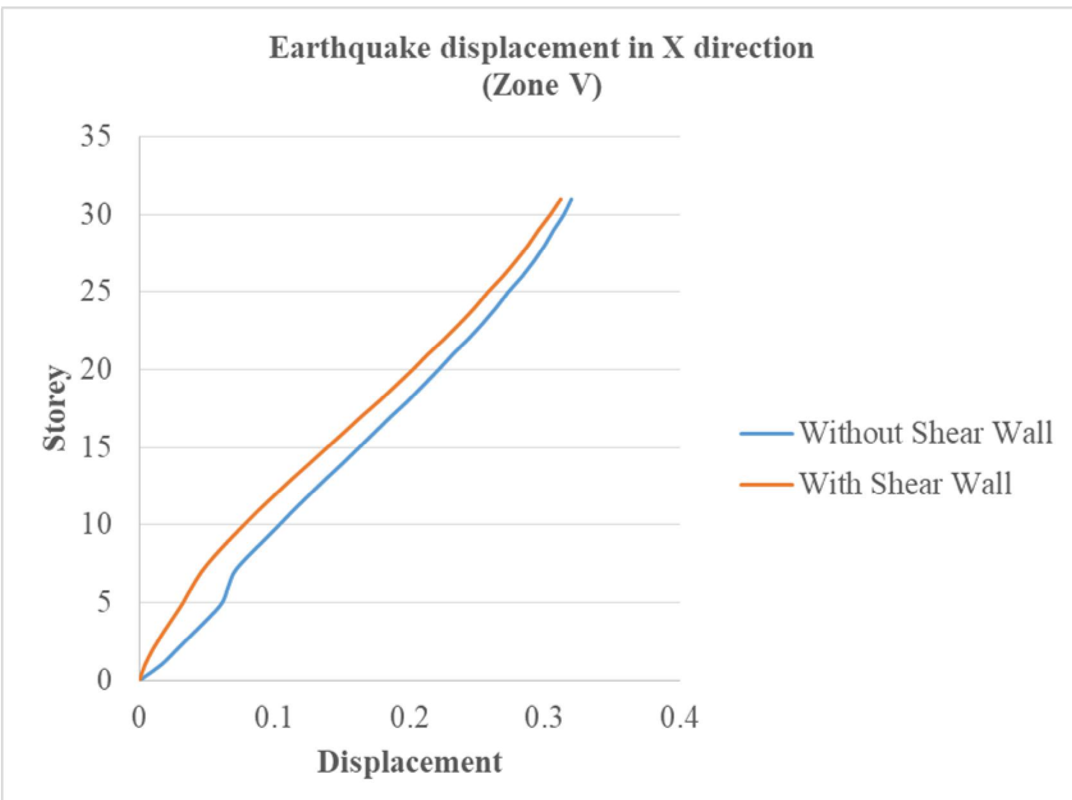
The Graphs 11, 12 & 13 shows Earthquake displacement in X direction for different lateral load resisting system i.e. Diagrid structure and Diagrid with Shear wall structure in Zone III, Zone IV and Zone V.




Graph 11 Earthquake Displacement in X-direction for Zone III

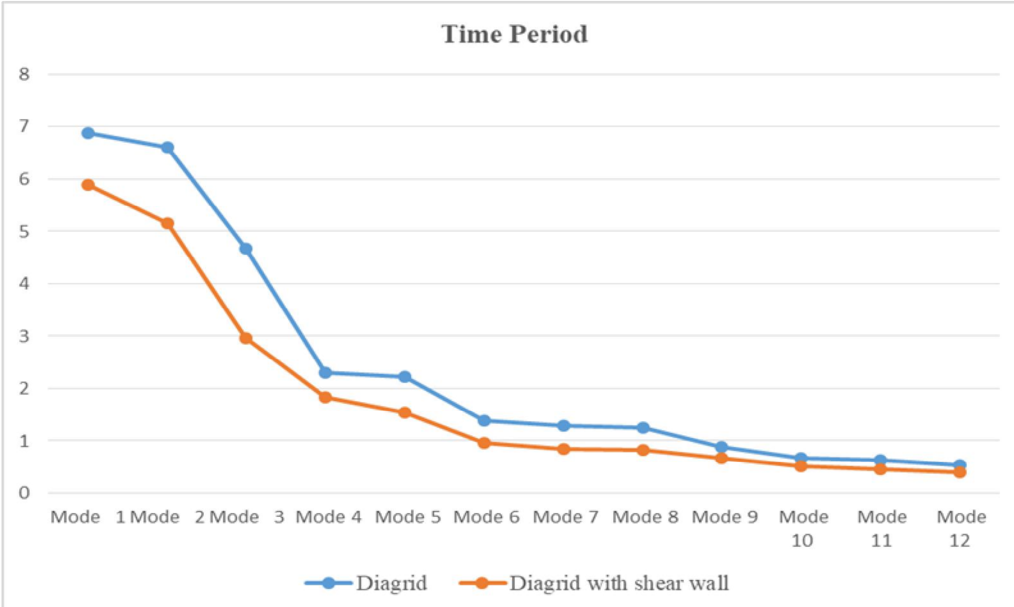



Graph 12 Earthquake Displacement in X-direction for Zone IV




Graph 13 Earthquake Displacement in X-direction for Zone V

The Graph 14 show variation in time period values calculated as per modal analysis for different lateral load resisting system i.e. Bare frame structure, Braced frame structure, Shear wall structure and Outrigger structure.




Graph 14 Variation in Time Period for lateral load resisting configuration in Modal Analysis

From Graph 14, it can be clearly inferred that least values of time period in modal analysis are obtained for Diagrid with shear wall structure with provision of lateral load resisting configurations. Maximum percentage reduction is observed for Diagrid with Shear wall structure which is up to 36.68% at mode 3

## V. CONCLUSIONS

Based on the analysis results obtained following conclusions can be drawn:

1) The use of lateral load resisting system i.e. Shear Walls and Diagrid system in tall structure increases the stiffness and makes the structure more efficient under seismic and wind loading
2) Significant reduction in maximum storey drift is observed for Diagrid with shear wall structure by equivalent static analysis up to 27.60 % and in response spectrum analysis and wind analysis Diagrid without Shear wall structure it up to 18.40 % and 12.60 % in X direction.
3) Maximum top storey displacement is observed for Diagrid without shear wall structure due to earthquake forces in all zones in both the direction i.e. X and Y directions.
4) The earthquake displacement decreases 10 to 15% in Diagrid with Shear wall structure as compare to Diagrid without Shear wall structure for different zones i.e Zone III, Zone IV and Zone V.
5) Maximum top storey displacement is observed for Diagrid without shear wall structure due to wind forces in all zones in both the direction i.e. X and Y directions.
6) The wind displacement with different wind speed decreases 10 to 15% in Diagrid with Shear wall structure as compare to Diagrid without Shear wall structure.
7) In parametric study of base shear maximum values is observed for Diagrid without shear wall structure in all equivalent static, response spectrum and wind analysis.
8) The base shear in X- direction, Diagrid without Shear wall Structure and Diagrid with Shear wall structure base shear is closely spaced, while Diagrid with Shear wall Structure base Shear increase 1.22 times as compare to Diagrid without Shear wall structure.
9) The non-linear Response spectrum load case of earthquake generated lesser base shear then IS code's Equivalent static method.
10) The natural time period of structure are closely spaced, while Diagrid without Shear wall structure time period increased 1.2 times as compare to Diagrid with Shear wall Structure.

## REFERENCES


[1] U. A. Nawale, D. N. Kakade, "Analysis of Diagrid Structural System by E-Tab," International Advanced Research Journal in Science, Engineering and Technology, Volume 4, Issue 6, June 2017.

[2] Sachin Mohare, Dr. H Sharada Bai, "Comparative Behaviour of High Rise Buildings with Diagrids and Shear Wall as Lateral Load Resisting System," International Journal of Advances in Scientific Research and Engineering, Vol.3, Special Issue 1, Aug 2017.

[3] Rudrappa P Y, S M Maheshwarappa, "Comparative Study on High Rise RC Flat -Slab Building Performance for Lateral Loads with and without Diagrid System," International Journal of Engineering Research and Advanced Technology, Volume 4, Issue 8, August 2018.

[4] Trupti A. Kinjawadekar, Amit C. Kinjawadekar, "Comparative study of seismic characteristics of diagrid structural systems in high rise construction," International Journal of Civil Engineering and Technology Volume 9, Issue 6, June 2018.

[5] Pattan Venkatesh, Sujay Deshpande, Shweta Patil, "A Comparative Study on the Structural Analysis of Diagrid Structural Systems with Conventional Structural Systems for different Plan Configurations," International Journal for Research in Applied Science & Engineering Technology, Volume 6, Issue VI, June 2018.

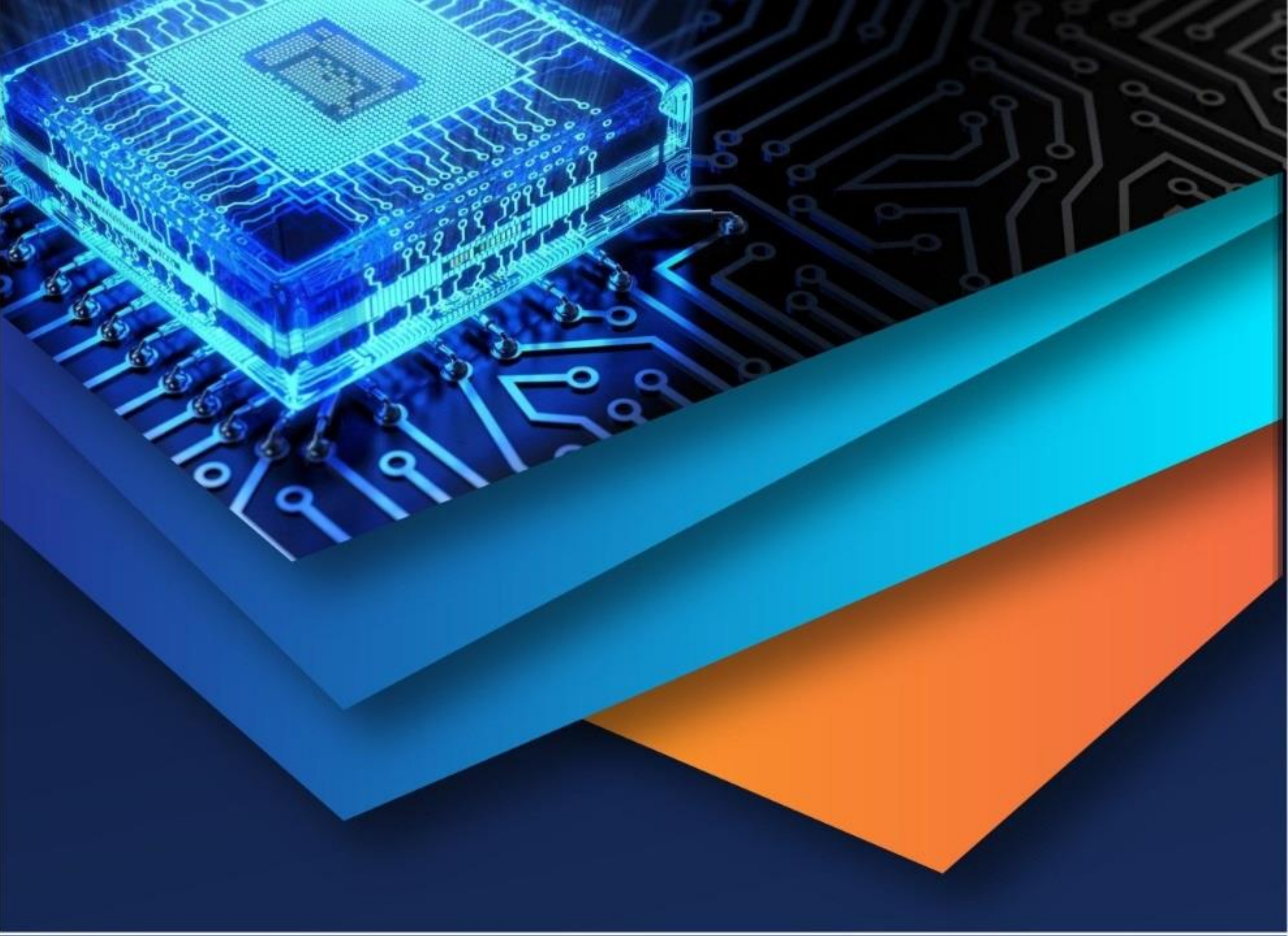
[6] Narsireddy, Vinayak Vijapur, "Some comparative study on steel diagrid structure with conventional steel structure," International Research Journal of Engineering and Technology, Volume:05, Issue 07, July 2018.

[7] Jateen M. Kachchhi, Snehal V. Mevada & Vishal B. Patel, "Comparative study of diagrid structure with other structural systems for tall structures," Global Journal of Engineering Science and Researches, April 2019.

[8] T. R. Somvanshi, P. K. Kolase, V. R. Rathi, "Comparative Analysis and Design of Diagrid structure and Orthogonal structure," International Journal of Engineering Development and Research, Volume 7, Issue 3, 2019.

[9] Jayesh Akhand, Dr. J. N Vyas, "Comparative Study of Different shapes of Diagrid Structure System with Conventional System using Response Spectrum Analysis," International Research Journal of Engineering and Technology, Volume 06, Issue: 04, April 2019.

[10] S. K. Duggal, "Earthquake-Resistant Design of Structures" Second Edition.



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