iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VII **Month of publication:** July 2021

DOI: https://doi.org/10.22214/ijraset.2021.36975

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VII July 2021- Available at www.ijraset.com

Study on Dynamic analysis of Diagrid and Outrigger Structures Subjected to Seismic and Wind Load

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Abstract: A Comparative study of G+30 story regular, diagrid, outrigger structure is presented. A square shaped floor plan of 18 m × 18m size was considered. ETABS 2016 was used in modeling and analysis of structural members. All structural members were designed as per IS456:2000, load combinations such as dead load, live load, earthquake and wind loads were considered for analysis and design of the structure. Later Regular, Diagrid and outrigger structural systems were compared; the key results like Base shear, story displacement and story drift are obtained. It is found that diagrid system is efficient in resisting seismic loads and outrigger system is found efficient in resisting wind loads.

I. INTRODUCTION

The rapid growth of urban population and limitation of available land, the taller structures are preferred now a day. So when the height of structure increases then the consideration of lateral load is very much important. Lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are rigid frame, shear wall, wall frame, braced tube system, outrigger system and tubular system. Recently the diagrid – diagonal grid structural system is widely used for tall buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. Hence the diagrid, for structural effectiveness and aesthetics has created renewed interest from architectural and structural design of tall buildings.

Diagrid structural system is a type of exterior structure which is a framework of diagonally intersecting metal, concrete or wooden beams that is used in the buildings. Recently diagrid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Compared to closely space vertical columns in framed tube, diagrid structure consists of inclined columns on the exterior surface of building. Inclined columns the present lateral loads are resisted due to axial action of the diagonal compared to bending of vertical columns in framed tube structure. Diagrid structures generally do not require core because lateral shear can be carried by the diagonals on the periphery of building.

The difference in exterior - braced conventional frame structural pattern and the diagrid structural pattern is that these buildings do not use conventional vertical columns. The previous earthquakes in India show that not only non-engineered structures but engineered structures need to be designed in such a way that they perform well under seismic loading.

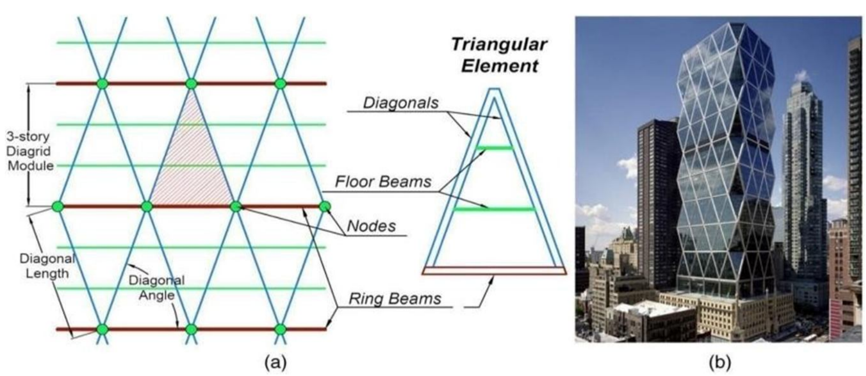

Fig.1. Diagrid structure

Outriggers are deep and stiff beam/truss which join the valuable center to the outside most columns in a frame. This reduces the deflection of the constructing by using preserving all of the columns in their function and making the constructing act as a single unit. This reduces the horizontal movement of middle and makes the structure stiffer. Outriggers and belt trusses collectively and separately are being employed in structures in unique way and hence nameddifferently. These are chosen on the basis of requirement of the structure. These also can be used in mixture for a singlestructure.

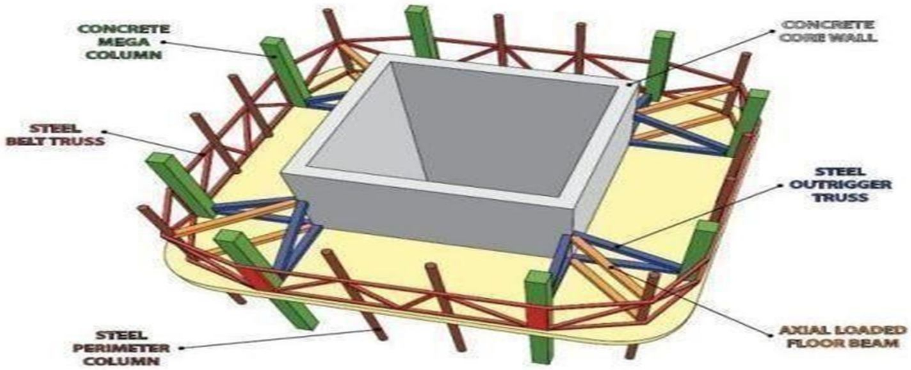

Fig.2. Outrigger structure

II. OBJECTIVE OF PROPOSED STUDY

A. Introduction

In this paper, a comparative study of G+30 storey RC Regular frame structure, diagrid structure and outrigger structural system with same configuration is presented here. A simple floor plan of 18m x 18m size was considered. The analysis was carried out for G+30 storey building with floor height of 3.2m and the results were obtained in terms of Base shear, storey displacement, shear, and storeydrift are presented.

In the present study evaluation of seismic and wind response of the G+30 storey RC frame structure by using diagrid and outrigger system is discussed. A simple computer based modelling in ETABS software was performed for equivalent static method (ESM) subjected to earthquake and wind loading.

B. Objectives

1) To study the behavior of Regular, diagrid and outrigger structures s under the effect of earthquake loads using equivalent static and dynamic time history methods in earth quake zone 2 and zone 5.
2) To study the behavior of Regular, diagrid and outrigger structures under the effect of wind loads using GUST Factor approachas per IS 897 Part-3 2015 in zone 2.
3) To understand the key results like, Time period, Frequency base force, displacement, drift, extracted from the analysis of regular, diagrid and outrigger structures
4) Comparing the key results of regular, diagrid and outrigger structures with respective zones.
5) Conclusions are made from the key results by mentioning the importance considering Lateral load resisting systems in dynamic earthquake and wind analysis.

C. Methodology

1) At First a 30 story Square concrete moment resisting frame is considered, having dimension 18 m x 18 m in X and Y direction. Baysize is 3 m uniform along both the direction. Modelling and analysis is carried out using ETABS ver.16
2) The moment resisting frame is analyzed for Dead, Live, Earth quake and wind load combinations. After the moment resisting framefails for the above combinations the lateral load resisting systems are introduced to the moment resting frame
3) Then the model is analyzed for Dead, Live, Earth quake and wind loads with lateral load resisting systems incorporated in thestructure.
4) Behavior of lateral load resisting system i.e., Diagrid and outrigger systems are studied.
5) Earth quake analysis is carried out with equivalent static method and time history method and wind analysis by GUST factor approach

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III. ANALYSIS OF G+30 STOREY BUILDING

A. *Building Configuration*

Structure	Concrete
Plan dimension	18mX18m in both X and Y direction
No.of Storey	G+30
Height of structure above GL	96m
Storey height	3.2m
Grade of Concrete (fck)	M25,M30
Grade of reinforcement steel	HYSD500
Column	700mmX700mm
Beam	450mmX600mm
Slab	150mm
Diagrid section	450mmX600mm
Outrigger	450mmX600mm
Outrigger belt truss	450mmX600mm
Shear wall	300mm
Wall load (glass panels) 100mm	5.2 KN/m
Floor finish	1.5 KN/m^2
Typical live	3.5 KN/m^2
Roof live	1 KN/m^2
Earth quake zone	Zone 2, Zone 5
Wind zone	Zone 2
Type of Soil	Medium

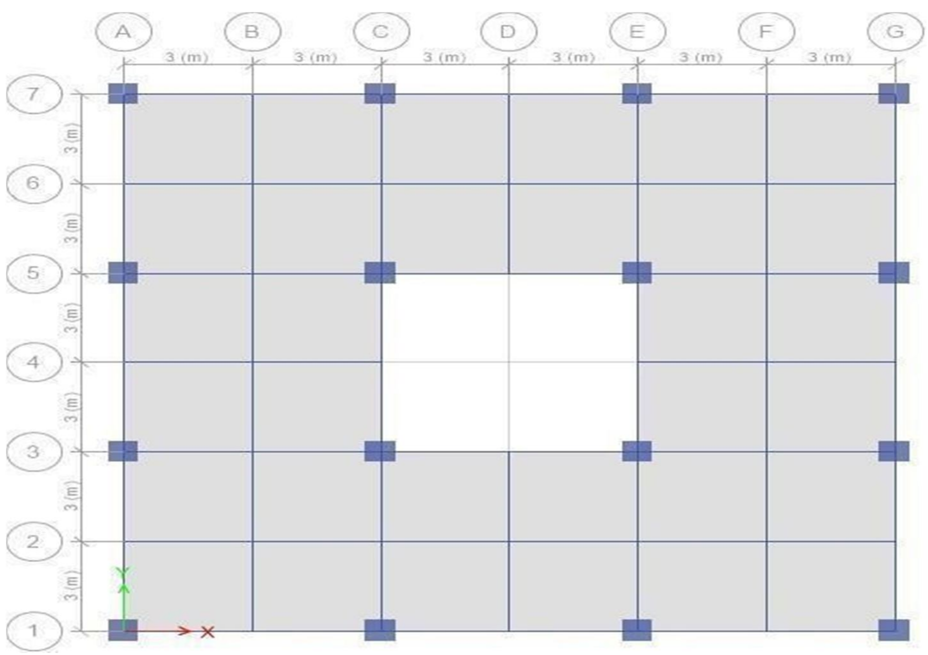


Fig.3 Plan

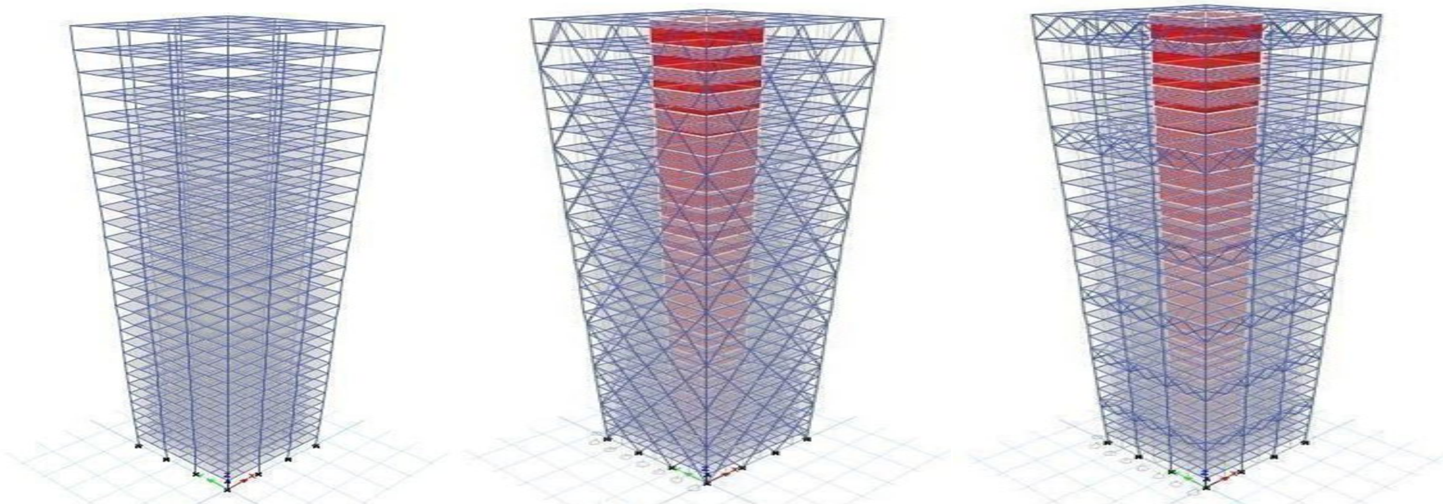


Fig.4-3D view of the Regular, Diagrid and Outrigger structure

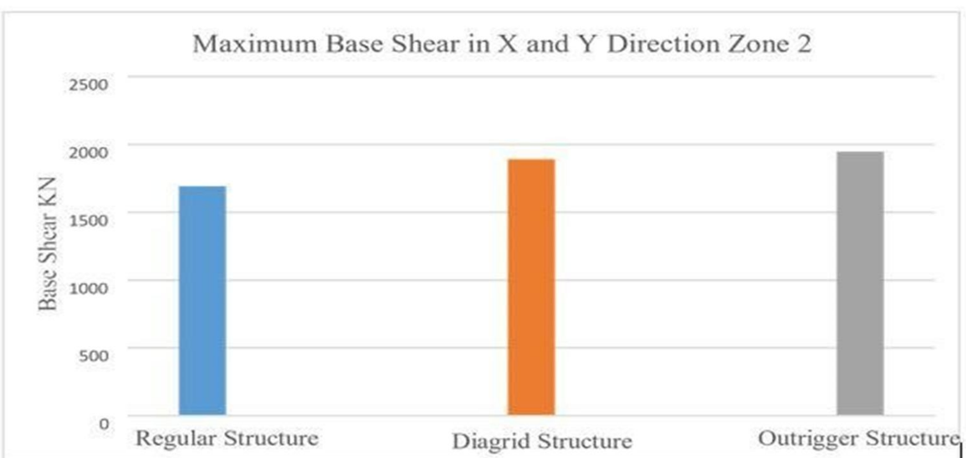
IV. RESULTS AND DISCUSSIONS

Reinforced concrete multi-storied buildings are very complex to model as structural systems for analysis. The current version of the IS 1893(Part 1): 2002 requires that practically all multi-storied buildings be analysed as three-dimensional systems. In the present study the performance evaluation of RC regular diagrid and outrigger. The study as a whole makes an effort to evaluate the effect of diagrid and outrigger on RC buildings, in terms of dynamic characteristics and identifies the influencing parameters which can regulate the effect on Base shear, storey displacement, storey drift.

This paper presents results of seismic analysis and wind analysis carried out on G+30 storied square shaped 3-D RC Regular frame and frame with diagrid and outrigger. The analysis is performed by taking into account of earthquake loads in EQX and EQY directions and wind loads in WIND+X,WIND-X,WIND+Y and WIND –Y. The response obtained from the analysis is Bas shear ,storey displacement, and storey drift. The results presented are discussed in detail with reference to relevant Tables and Figures.

A. *Equivalent Static Analysis*

1) *Base Shear*



Regular Structure	1693.00 KN
Diagrid Structure	1893.11 KN
Outrigger Structure	1947.34 KN

Fig 5. Maximum Base shear in X and Y Direction Zone 2

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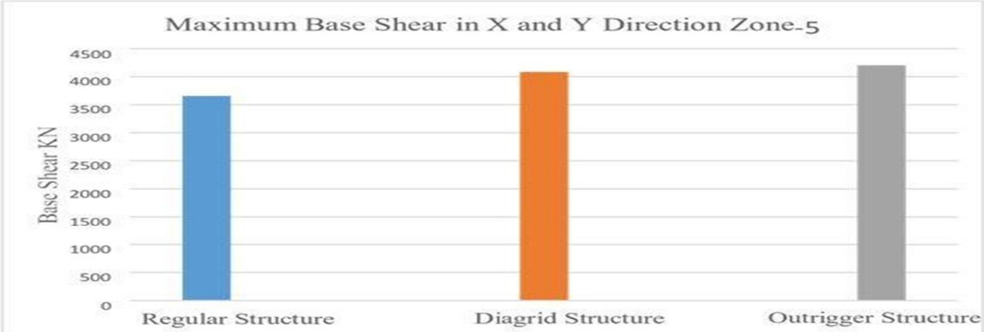


Regular Structure	3656.89 KN
Diagrid Structure	4082.19 KN
Outrigger Structure	4206.26 KN

Fig 6. Maximum Base shear in X and Y Direction Zone 5

2) Storey Displacement

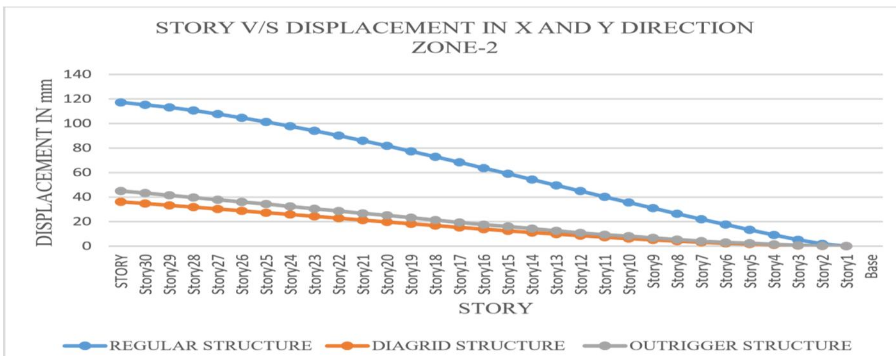


Fig 7. Story v/s Displacement in X and Y Direction Zone 2

Fig 7 shows the story v/s displacement of regular, diagrid and outrigger structure in both X and Y direction of Zone 2. It is found thatdisplacement is reduced by 69.15%using Diagrid structure and 62.66% by using outrigger structure when compared with regular structure.

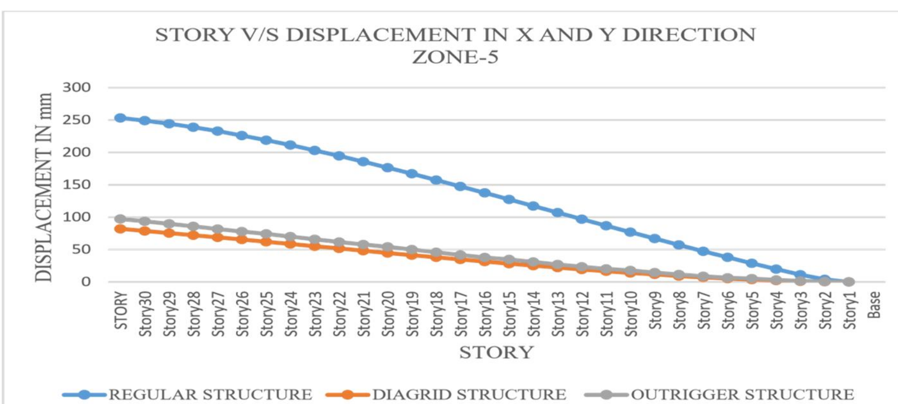


Fig 8. Story v/s Displacement in X and Y Direction Zone 5

Fig 8 shows the story v/s displacement of regular, diagrid and outrigger structure in both X and Y direction of Zone 5. It is found thatdisplacement is reduced by 67.29%using Diagrid structure and 58.49% by using outrigger structure when compared with regular structure.

3) Storey Drift

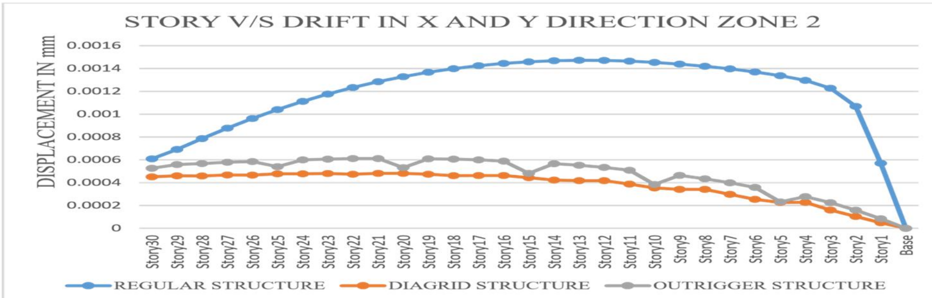


Fig 9. Story v/s Drift in X and Y Direction Zone 2

Fig 9 shows the story v/s drift of regular, diagrid and outrigger structure in both X and Y direction of Zone 2. It is found that displacement is reduced by 67.35%using Diagrid structure and 58.50% by using outrigger structure when compared with regular structure.

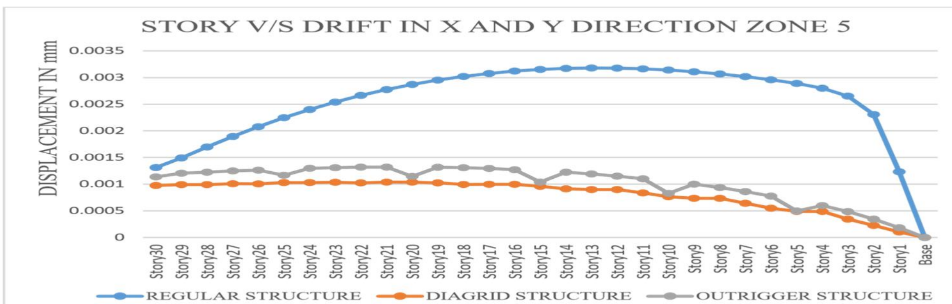


Fig 10. Story v/s Drift in X and Y Direction Zone 5

Fig 10 shows the story v/s drift of regular, diagrid and outrigger structure in both X and Y direction of Zone 5. It is found that displacement is reduced by 67.58%using Diagrid structure and 61.64% by using outrigger structure when compared with regular structure.

B. Time History Analysis

Location- Imperial valley

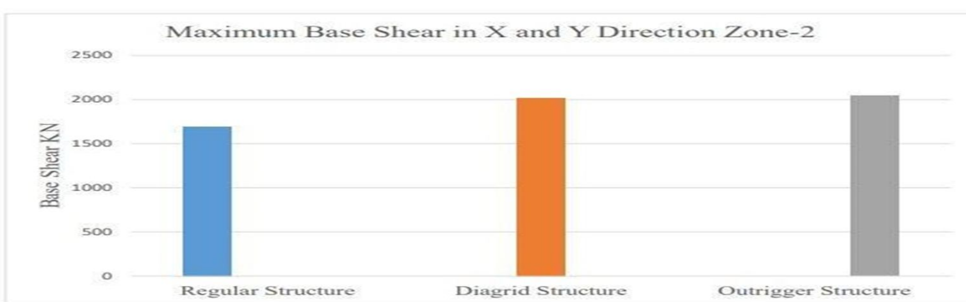
Time- 21:35 Pacific Standard TimeDate- 18 May 1940

Magnitude- 6.9

Depth- 16km

Areas affected- United States, Mexico

1) Base Shear



Regular Structure	1693.00 KN
Diagrid Structure	2019.18 KN
Outrigger Structure	2044.87 KN

Fig 11. Maximum Base Shear X and Y Direction Zone 2

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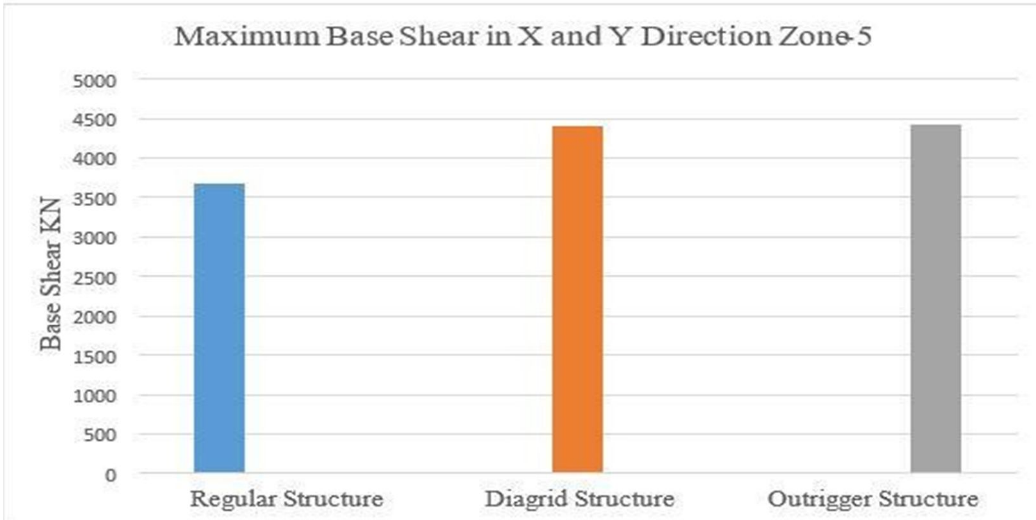

Regular Structure	3656.89 KN
Diagrid Structure	4402.72 KN
Outrigger Structure	4417.08 KN

Fig 12. Maximum Base Shear X and Y Direction Zone 5

2) Storey Displacement

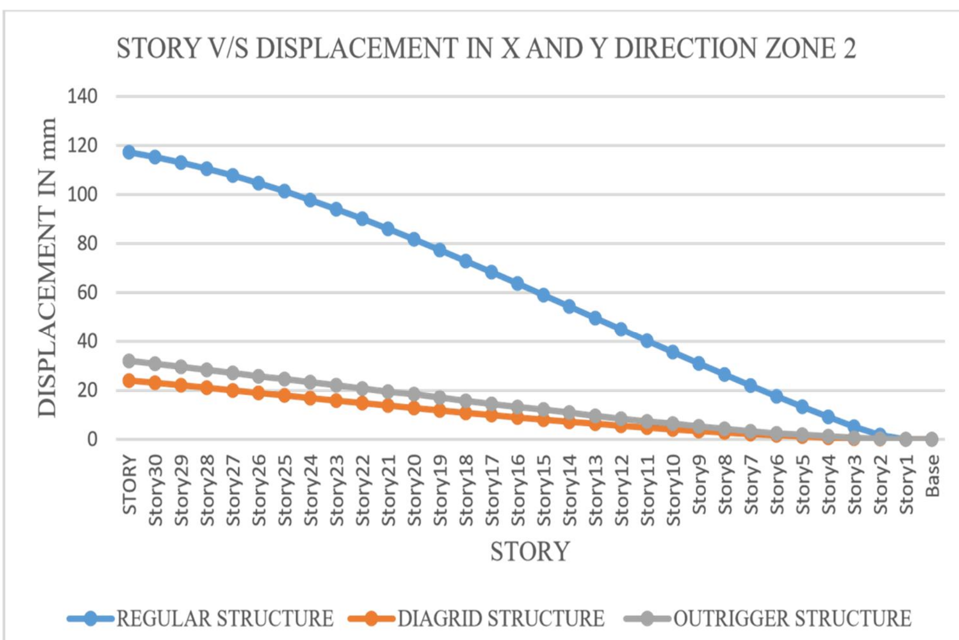

Fig 13. Story v/s Displacement in X and Y Direction Zone 2

Fig 13 shows the story v/s displacement of regular, diagrid and outrigger structure in both X and Y direction of Zone 2. It is found that displacement is reduced by 79.52%using Diagrid structure and 72.72% by using outrigger structure when compared with regular structure.

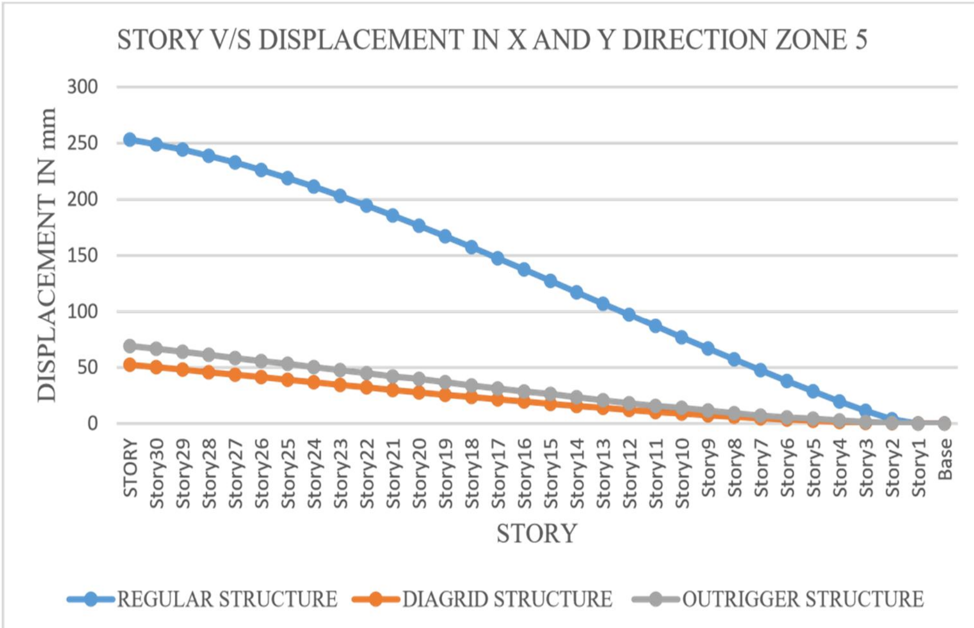

Fig 14. Story v/s Displacement in X and Y Direction Zone 5

Fig 14 shows the story v/s displacement of regular, diagrid and outrigger structure in both X and Y direction of Zone 5. It is found that displacement is reduced by 79.31%using Diagrid structure and 72.68% by using outrigger structure when compared with regular structure.

3) Storey Drift

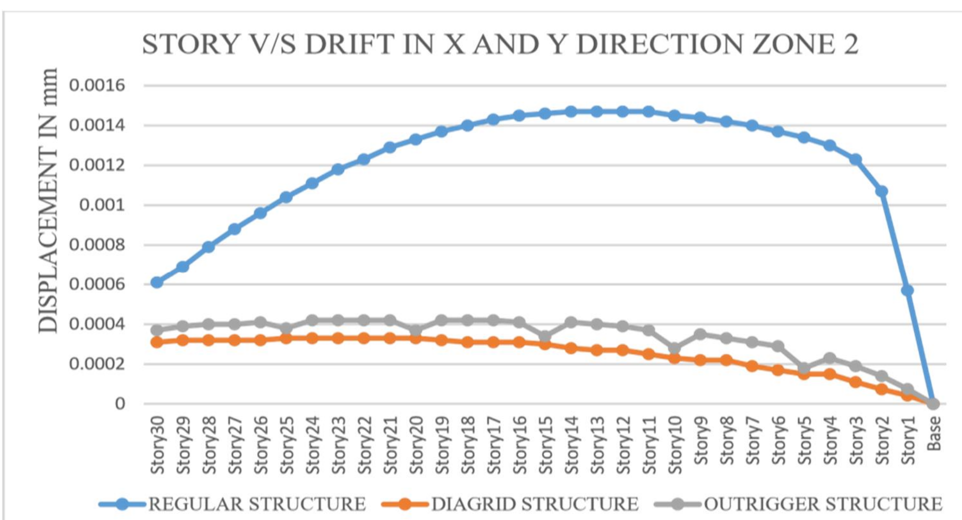

Fig 15. Story v/s Drift in X and Y Direction Zone 2

Fig 15 shows the story v/s drift of regular, diagrid and outrigger structure in both X and Y direction of Zone 2 It is found that displacement is reduced by 79.31%using Diagrid structure and 72.68% by using outrigger structure when compared with regular structure.

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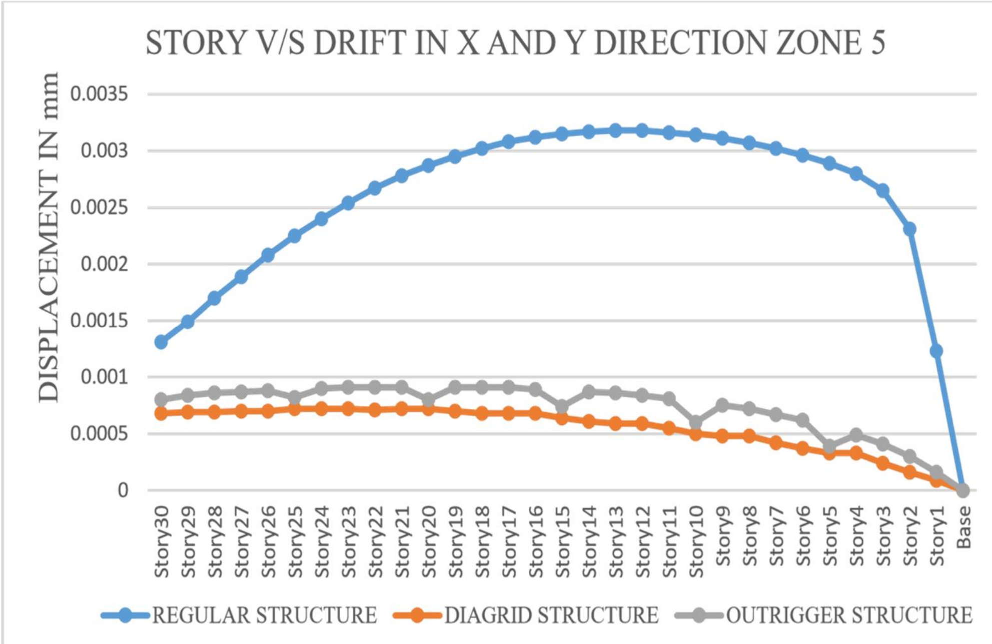


Fig 16. Story v/s Drift in X and Y Direction Zone 5

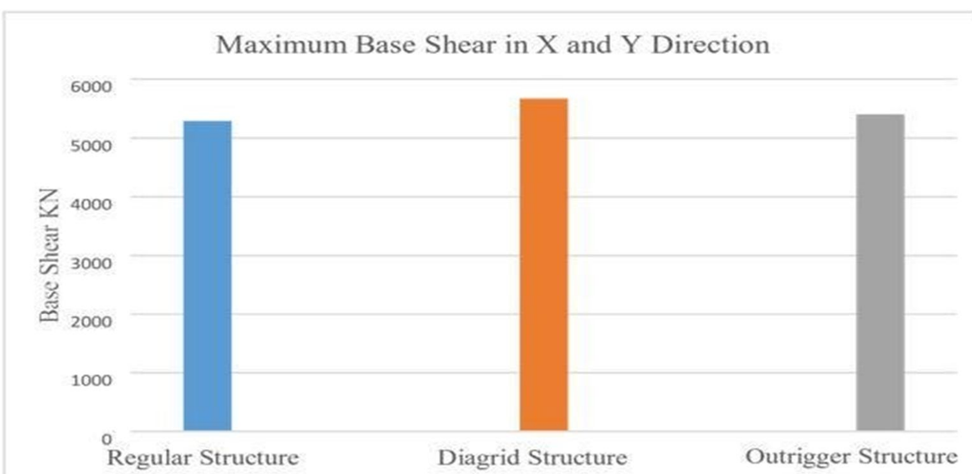
Fig 16 shows the story v/s drift of regular, diagrid and outrigger structure in both X and Y direction of Zone 5. It is found that displacement is reduced by 77.35%using Diagrid structure and 71.38% by using outrigger structure when compared with regular structure.

C. Wind Analysis by GUST Factor Approach

Basic wind speed-33m/sTerrain category -4

Zone -2

1) Base Shear



Regular Structure	5289.95 KN
Diagrid Structure	5670.98 KN
Outrigger Structure	5402.49 KN

Fig 17. Maximum Base Shear in X and Y Direction

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2) Storey Displacement

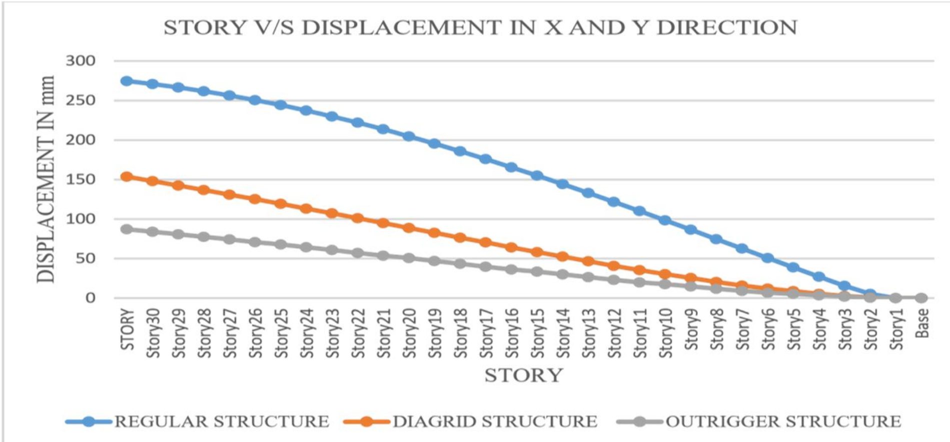

Fig 18. Story v/s Displacement in X and Y Direction

Fig 18 shows the story v/s displacement of regular, diagrid and outrigger structure in both X and Y direction. It is found that displacement is reduced by 44.06%using Diagrid structure and 68.28% by using outrigger structure when compared with regular structure.

3) Storey Drift

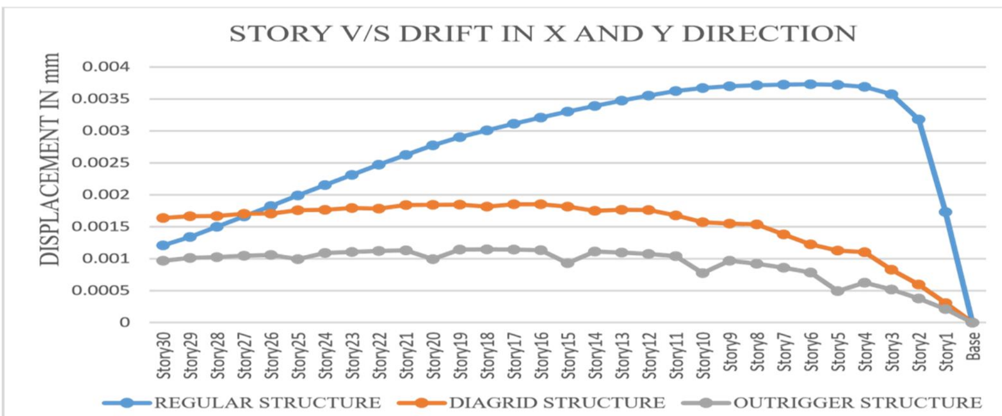

Fig 19. Story v/s Drift in X and Y Direction

V. CONCLUSIONS

A. From the Equivalent static analysis it is concluded that for Zone 2 and Zone 5 the story drift and displacement is reducedmore by using diagrid and less reduction is found by using outrigger when compared with regular structure.

B. From the Time History analysis it is concluded that for Zone 2 and Zone 5 the story drift and displacement is reduced moreby using diagrid and less reduction is found by using outrigger when compared with regular structure.

C. From the earth quake analysis of the structure it is found that diagrid structure is more efficient in reducing the Lateralloads when compared with regular structure.

D. From the Wind analysis using GUST Factor approach it is concluded that the story drift and displacement is reduced moreby using outrigger and less reduction is found by using diagrid when compared with regular structure.

E. From the wind analysis of the structure it is found that outrigger structure is more efficient in reducing the Lateral loads when compared with regular structure.

F. From the above discussion it is observed that diagrid structure is efficient in resisting earth quake load and outrigger structure is efficient in resisting wind load.

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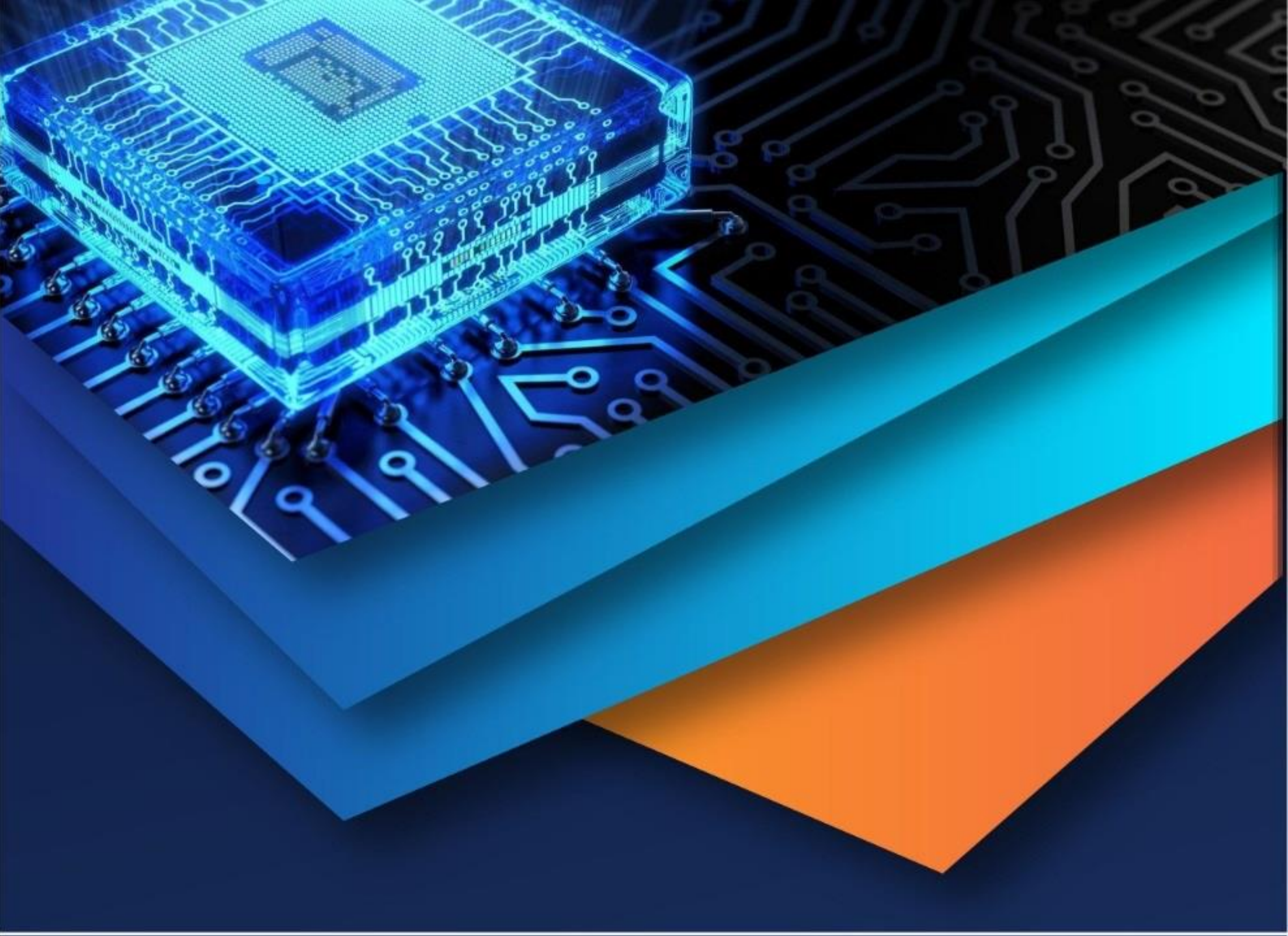

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