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Study on Behaviour of Outrigger System on High Rise Structure by Varying Outrigger Depth

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***Abstract*— Tall building development is rapidly growing almost everywhere in the world acquainting new difficulties that need to be met with, through engineering evaluation. In tall buildings, lateral loads generated by earthquake or wind load are frequently resisted by providing coupled shear walls. But as the height increases, the building becomes taller and the efficiency of the tall building greatly depends on lateral stiffness and resistance capacity. So, a system called outrigger is introduced which improves overturning stiffness and strength by connecting shear wall core to outer columns. In past outriggers were used for small and medium lateral load to minimize the risk of structural and non-structural damage.**

Keywords: Outrigger, Outrigger Depth, High-rise Buildings

I. INTRODUCTION

The outrigger and belt truss system is one of the lateral loads resisting system in which the external columns are tied to the central core wall with very stiff outriggers and belt truss at one or more levels. The belt truss tied the peripheral column of building while the outriggers engage them with main or central shear wall. Outrigger systems are widely used to provide efficient lateral load resistance in tall slender buildings. Outriggers are rigid horizontal structures connecting a building core or spine to distant columns. They improve stiffness against overturning by developing a tension- compression couple in perimeter columns when a central core tries to tilt. Generating a restoring moment acting on the core at the outrigger level. Outrigger system behaviour is simple in principle, but analysis, design, detailing and construction of a complete core-and-outrigger system is complex in practice: being indeterminate, distribution of forces between the core and the outrigger system depends on the relative stiffness of the elements, differential strains between elements and other factors.

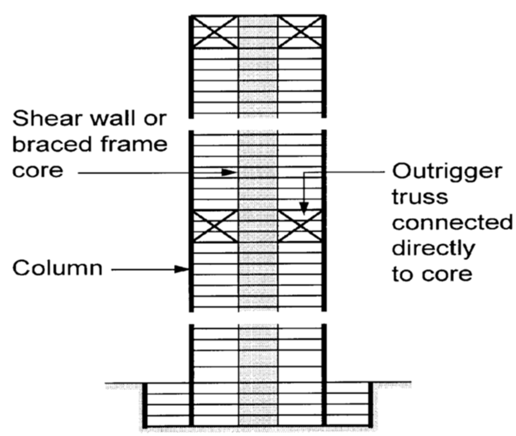


Figure 1 Outrigger Structural System

II. OBJECTIVE

The objective is to study the behaviour of outrigger, analyses of models for main governing factors like earthquake load and wind load with varying of outrigger depth, and optimization of outrigger depth. In present study, 50 storey 3D structures are modelled in ETABS v2015 software. The behaviour of the outrigger with static analysis of the outrigger with the varying depth of outrigger is studied. The structure with shear wall core and structure with outrigger system of varying outrigger depth are compared. The outrigger depth is reduced to 2/3rd, 1/3rd and half of the storey height along with the full storey height. The study of lateral deflection and storey drift comparison for different outrigger depth will be made to get optimum height of outrigger.

III. MODELLING AND ANALYSIS

Model data: Assuming location of building at Rajkot (Gujarat, India) following data is considered.
Plan Dimension = 50 m x 40 m (grid)
No of Storey of Building = 50 Storey
Typical Storey Height = 3 m
Column Details = Breadth – 1800 mm, Width – 900 mm

Beam Details = Breadth – 230 mm, Depth – 450 mm
Slab Details = Thickness – 150 mm
Column to Column Clear Distance = 5 m
Self- weight of the structural element
Floor finishes = 1.5kN/m2
Live load = 3 KN/m2
Shear Wall = Thickness – 300 mm
Concrete Grade = M50, Steel = Fe500.

Model is analyzed for earthquake and wind loading for different outrigger depth in ETABS v2015 software and results are compared.

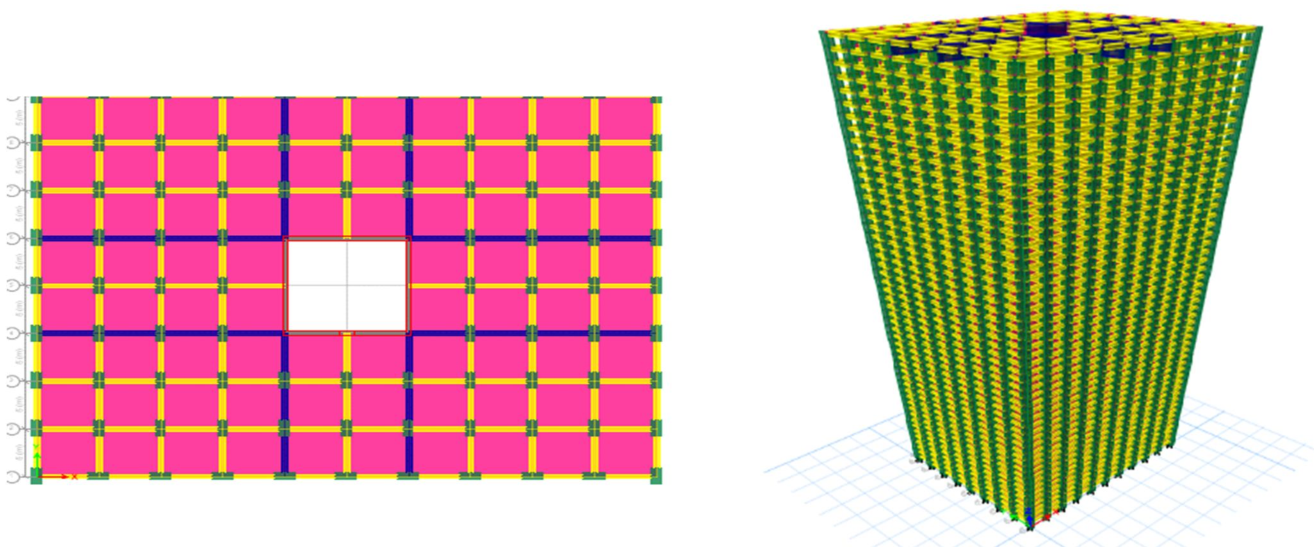
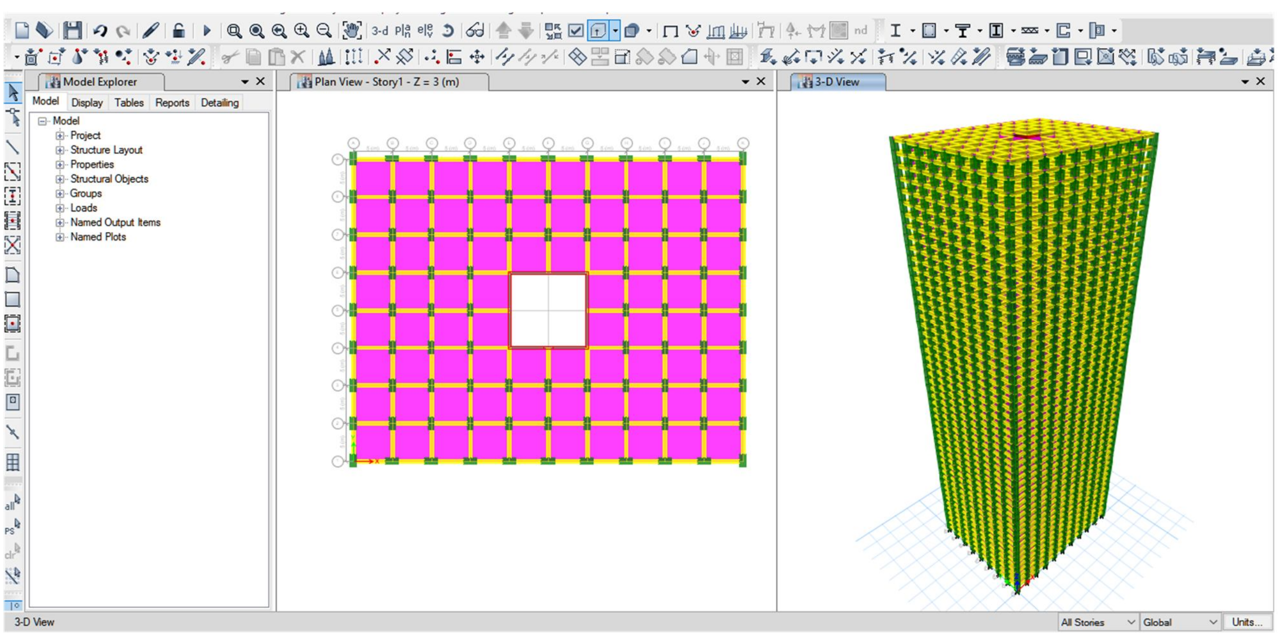


Figure 2 Etabs Model



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IV. RESULT COMPARISON

A. Earthquake Load

1) Storey Displacement

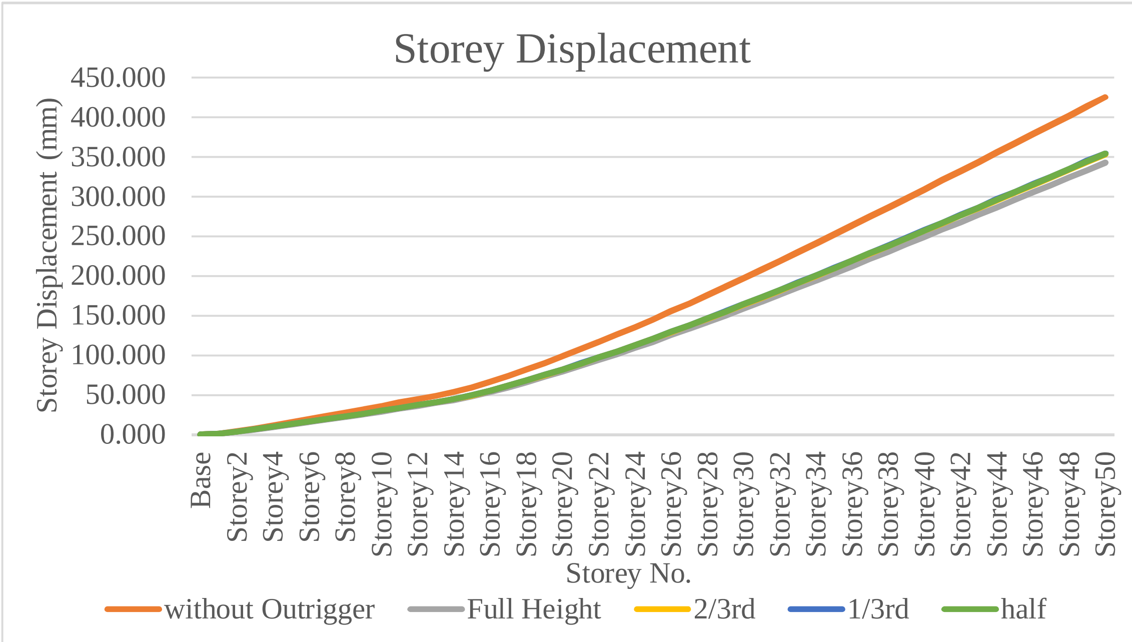

Figure 4 Story Displacement with Varying Outrigger Depth

From fig 3 it is observed that storey displacement linearly increases for base to top storey and there is significant change in storey displacement for building without outrigger and building with outrigger. There is not much difference for building with different outrigger depth.

2) Storey Drift

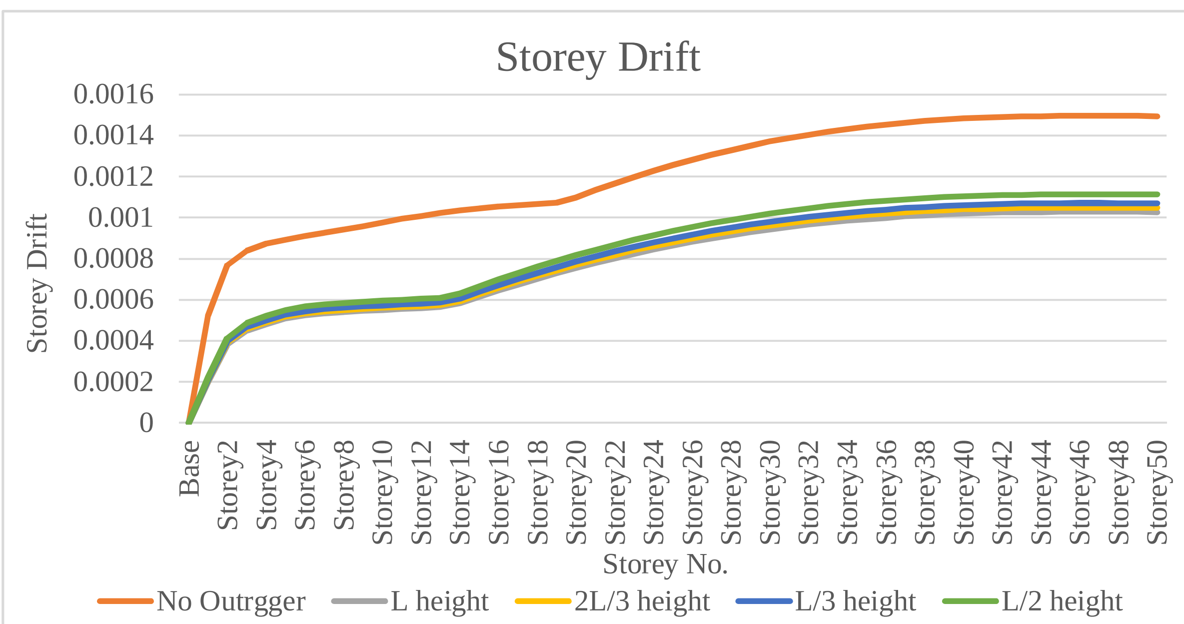

Figure 5 Story Drift with Varying Outrigger Depth

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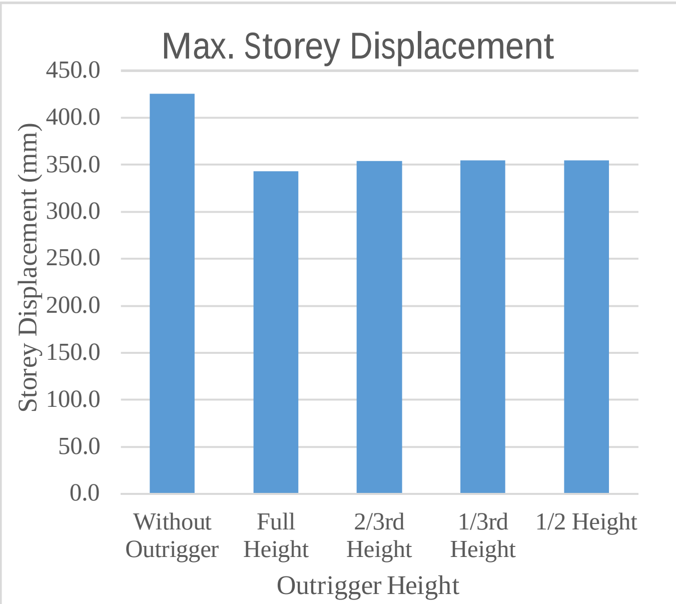
From fig 4 it is observed that storey drift increases from base to storey 5 then is becomes constant up to storey 15 then it linearly increases up to storey 40 and then again it becomes constant up to top. There is not much change in story drift for different outrigger drift.

Following figures shows maximum story displacement and maximum story drift for different outrigger depth for earthquake load.



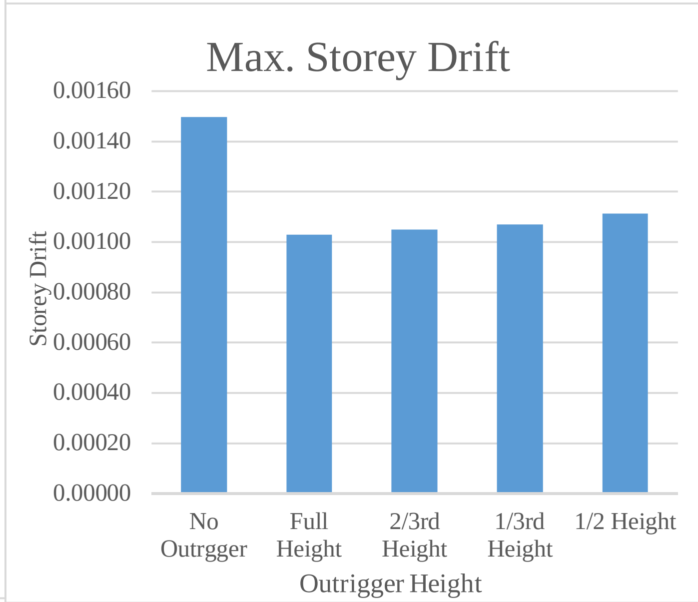


Figure 7 Max. Story Drift

y Displacement

B. Wind Load

1) Story Displacement

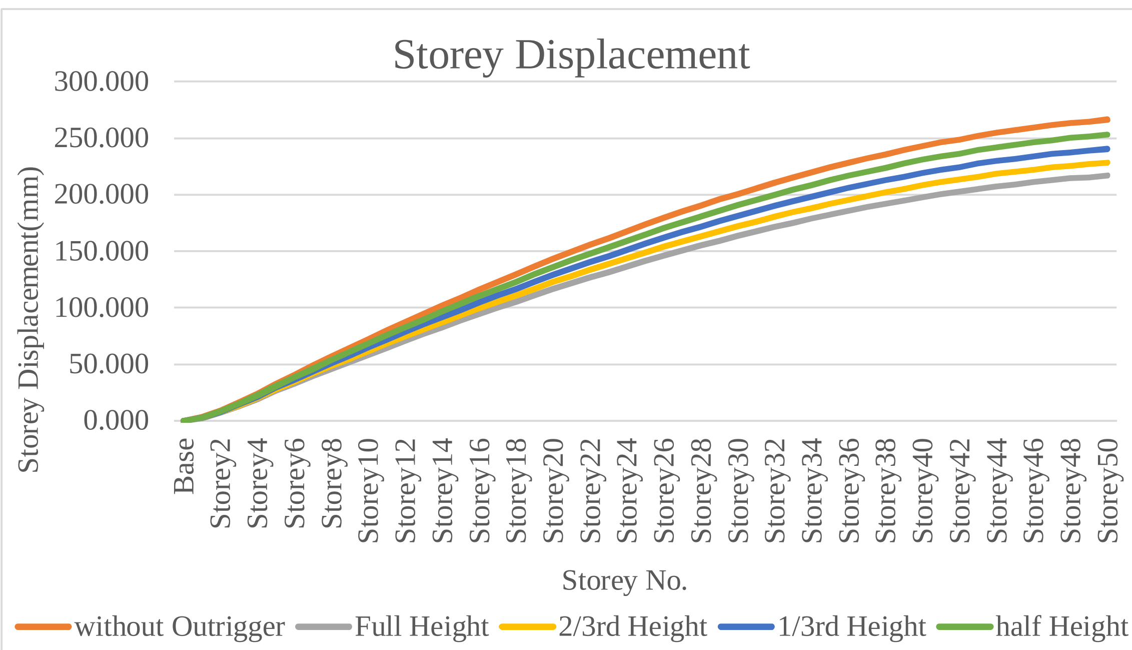


Figure 8 Story Displacement with Varying Outrigger Depth

From fig 7 it is observed that wind load gives same storey displacement graph as earthquake load but has less value. It can be seen that outrigger considerably minimizes the effect of wind load.

2) Story Drift

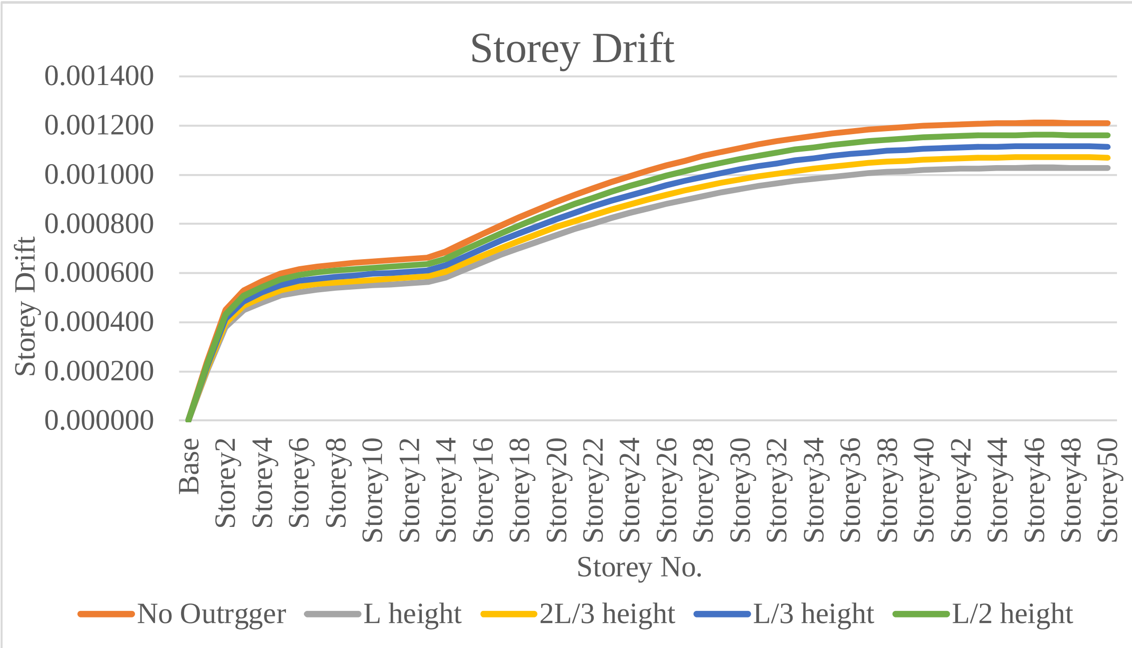


Figure 9 Story Drift with Varying Outrigger Depth

Fig. 9 shows that wind load gives same graph as earthquake load and outrigger system is quite efficient in reducing effect of wind load.
Following figures shows maximum story displacement and maximum story drift for different outrigger depth for wind load.

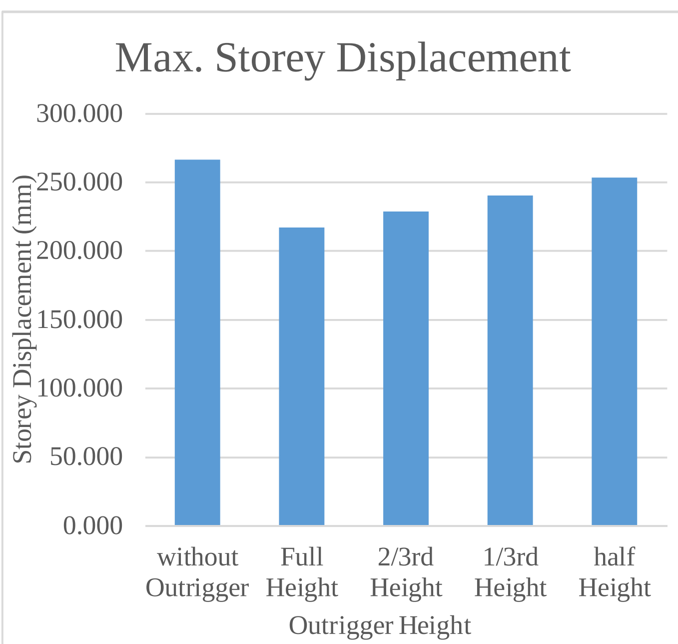


Figure 10 Max. Story Displacement

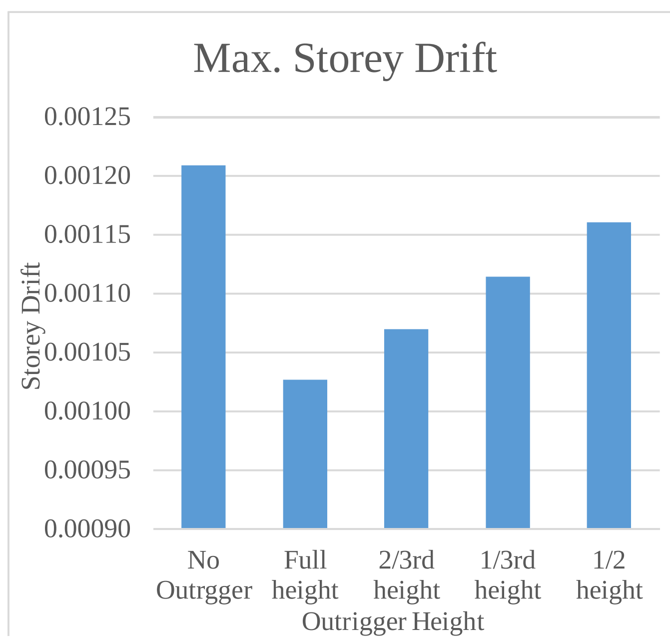


Figure 11 Max. Story Drift

V. CONCLUSIONS

The use of outrigger structural systems in high-rise buildings increases the stiffness and makes the structural more efficient under lateral load. Based on the analysis results obtained following conclusions made:

A. It has been observed that for earthquake analysis of 50 storey building storey displacement and drift is reducing with provision of outrigger of varying height.

B. For 50 storey building with provision of earthquake load, Storey Displacement reduces from 425mm without outrigger to 342mm for outrigger of full storey height at top. Which shows that displacement reduces up to 19.42% for outrigger of full storey height.

C. After providing full storey height outrigger further decrease in height of outrigger storey displacement slightly increases about 4-5%.

D. For 50 storey building decrease in the depth of the outrigger to 2/3rd, 1/3rd and 1/2 of the storey height reduces the percentage reduction of lateral displacement and storey drift up-to 3% – 4% and 5% - 6% respectively in comparison with outrigger depth of full storey height. Hence, Drift increases with reduction of depth of outrigger.

E. For different outrigger depth, there is not much difference in displacement up to some height of the building (up to about 16 storey) then it increases slightly.

F. On application of wind load, Storey Displacement reduces from 266 mm without outrigger to 216 mm for outrigger of full storey height at top. Which shows that displacement reduces up to 18.79% for outrigger of full storey height.

G. Wind load gives same type of graph as earthquake load for storey displacement as well as storey drift, but has less value then earthquake load.

H. The outrigger structural systems not only efficient in controlling the top displacements but also play significant role in reducing the inter storey drifts.

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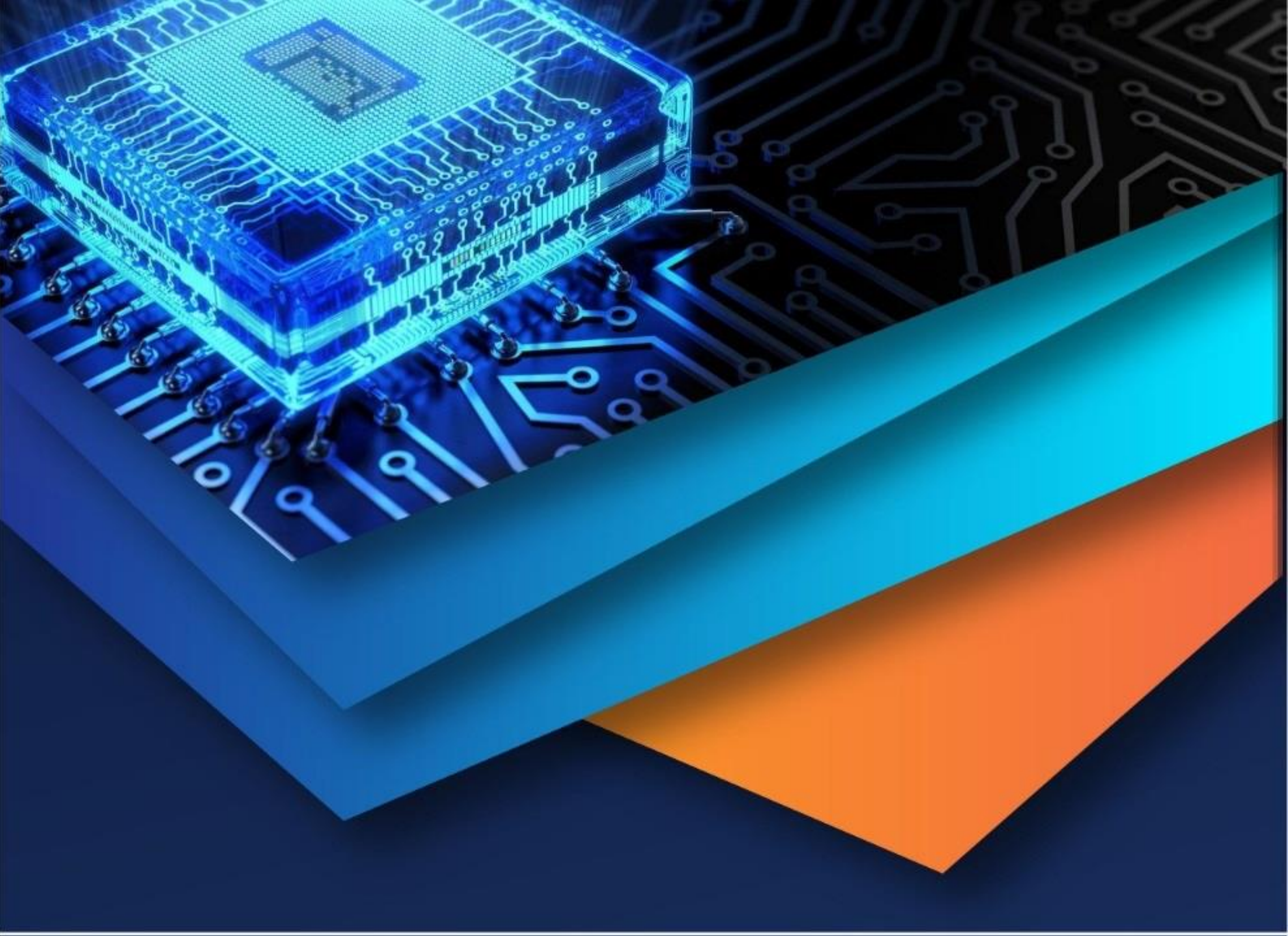

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