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COMPARATIVE STUDY OF OUTRIGGER AND DIAGRID STRUCTURAL SYSTEMS

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Abstract – *The Demand for High Rise structures has become so exponentially high that effective and advanced form of structural systems needs to be studies in detail so as to choose the best suitable structure in a given scenario. This paper attempts to illuminate the behavior of the two most effective and popular structural systems viz. Outrigger and Diagrid Structural systems. In this paper a simple office building with varying height to depth ratios will be analyzed by implying both the outrigger and Diagrid structural systems thus 9 models 3 for each structural system were analyzed and their behavior was compared, It was found that both the outrigger and Diagrid structures were effective in lateral loads but to varying extents. When compared to conventional Moment resisting frame structure with shear walls, Outrigger and Diagrid Systems performs better. Diagrid Structures however outclasses outrigger systems by reducing the storey drift by X percent and Top Storey Deflection by Y percent.*

Key Words: (Size 10 & Bold) Outrigger, Diagrid, Etabs, comparison etc (Minimum 5 to 8 key words)…

1. INTRODUCTION

Tall buildings have essentially become a need of the current populations tends in the world, which led to an increase in the demand of tall structures. High rise buildings have been known to possess a high risk towards lateral loads due to its slender nature which has inspired structural engineers to come up with innovative solutions to these effects. Since then, many structural systems has been developed namely Rigid frame structure, Braced frame structure, Shear wall frame structure, Outrigger structure, Braced tube structure, Bundled tube structure, Diagrid system etc. Out of these structures this thesis focuses on the performance of Outrigger and Diagrid structural systems.

1.1 Diagrid Structure

The Diagrid structural system can be defined as diagonal members formed as a framework made by the intersection of different materials. As diagrids are made up of triangular pattern, they are effective in both gravity and lateral force.

1.2 Outrigger

Outriggers are very stiff horizontal arm like structures that are designed to improve the buildings resistance to overturning and strength by connecting the core to distant columns. The concept of Outrigger is not new to us as Outriggers have been used in sailing vessels in the mast of the sail to improve the stability. Despite being such an old technology it has been recently been introduced in the structural framework of the buildings.

2. Objective and Model Configuration

In this paper, an ordinary office building will be analyzed. Gravity and lateral loads from Indian Codes- IS 456-2000, IS 875- Part 1, 2, 3 IS 1893:2016 IS 13920. Response spectrum analysis and static wind loads given in IS 875 will be applied. Structural model of the plan given in the figure below will be modelled in 9 different models with increasing story numbers i.e. 40 story 60 story and 80 story models. Three models will be Diagrid, three outrigger and three normal moment resisting frames with shear walls. The building chosen is a commercial building with plan dimensions 27 meters X 25.5 meters.

Table -1: Preliminary data for design

Type of Structure	Special RC moment resisting frame (SMRF), Outrigger, Diagrid
Number of stories	G+40, G+60,G+80
Height of storey	3.0m
Thickness of slab	0.150m
Thickness of external wall	0.230m
Thickness of internal wall	0.150m
Grade of reinforcing steel	Fe415
Density of concrete	25kN/m^3
Density of brick	20kN/m^3
Grade of concrete in slab	M30,M40,M50
Grade of concrete in beam & column	M30,M40,M50
Grade of concrete in shear wall	M30,M40,M50
Dead load	Self weight of slab, beam, column, shear wall, brick wall and parapet wall
Live load	For intermediate

	floor=4kN/m^2 For terrace floor=1.5 kN/m^2
Floor finish	For intermediate floor=1kN/m^2 For terrace floor=1.5 kN/m^2
Seismic zone	III,
Soil condition	Medium soil
Wind speed	44
Importance factor	1
Zone factor	0.16
Damping ratio	5%

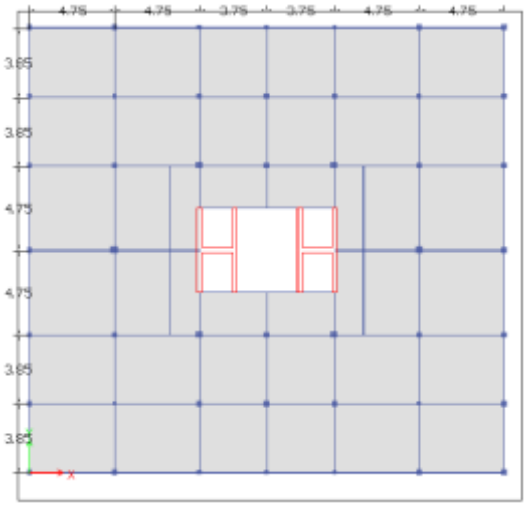

Fig 1 Floor Plan for all Models

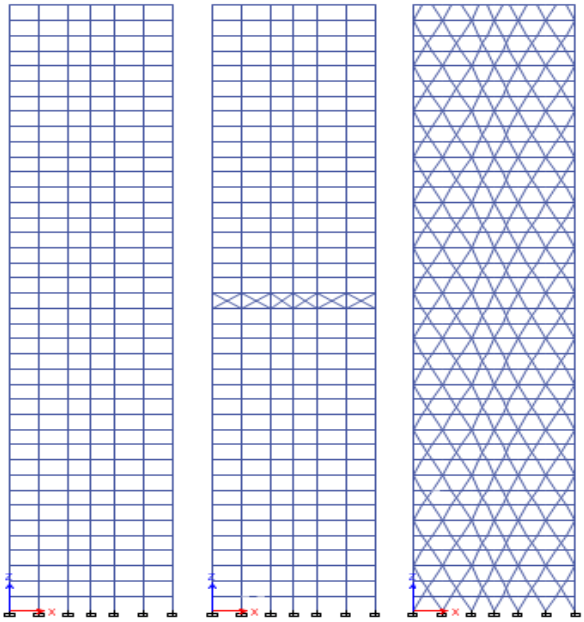

Fig -2: Elevation for all framing systems

3. RESULTS AND DISCUSSION

Nine different models having different structural systems and increasing length to depth ratios of 40,60 and 80 stories were analyzed and the results so obtained are given below is a systemized manner. For the purpose of this study, major factors such as storey drift, top storey displacement and modes shapes have been compared for these structures.

3.1 Storey Drift

Indian Codes suggest the maximum allowable interstory drift in the structure should be limited to 0.004 times the story height. Figures below shows the story drifts in 40, 60 and 80 story models respectively for the different structural system considered.

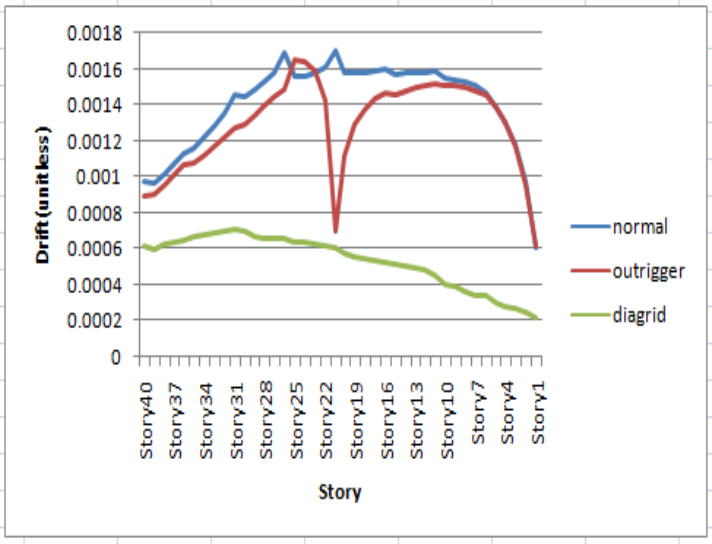

Chart -1: Story Drift in 40 Story models in different structural system

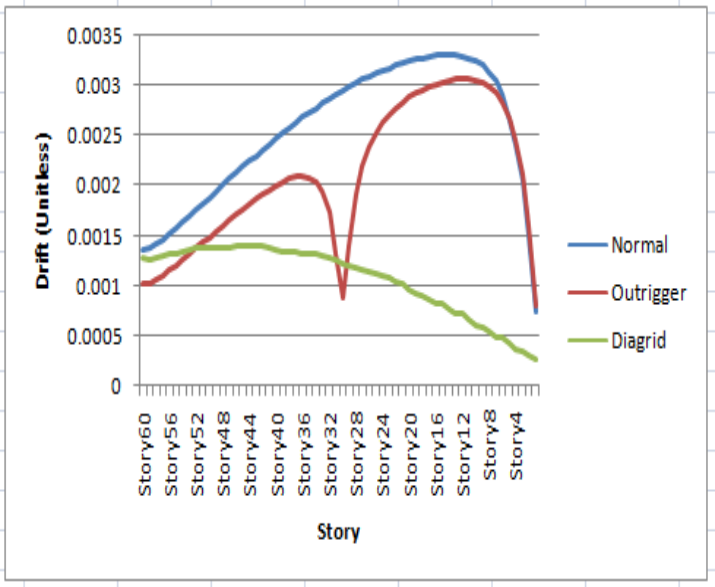

Chart -2: Story Drift in 60 Story models in different structural system

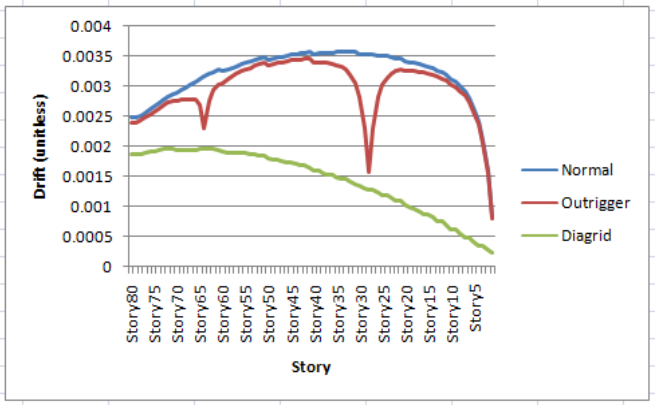

Chart -3: Story Drift in 80 Story models in different structural system

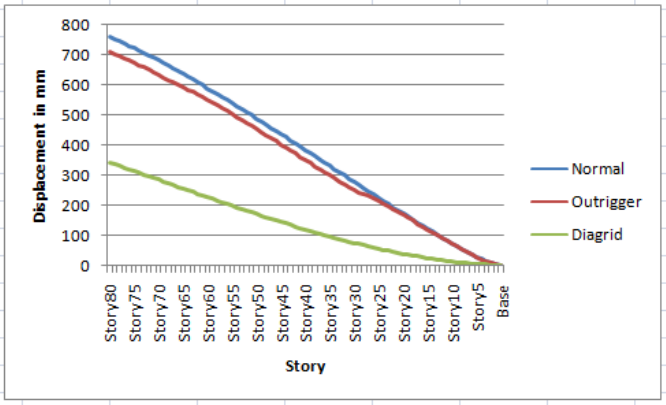

Chart -6: Story Displacement in 80 Story models in different structural system

3.2 Storey Displacement

Story Displacement of different structural systems for 40, 60 and 80 story models have been shown graphically below .The maximum top story displacement to H/500 is a commonly accepted values. The performance of the diagrids has been shown to be adequate in all cases.

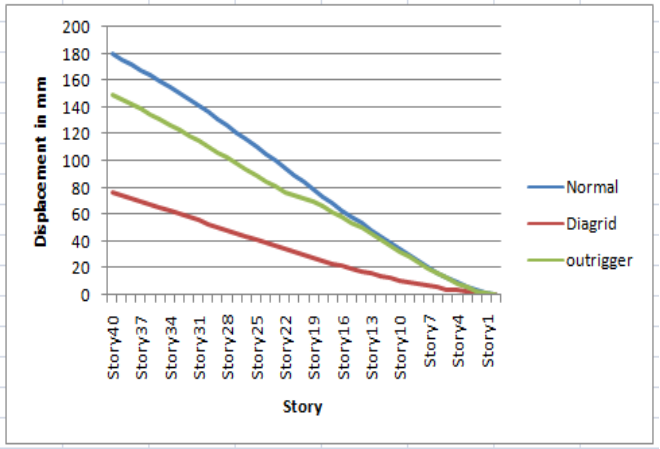

Chart -4: Story Displacement in 40 Story models in different structural system

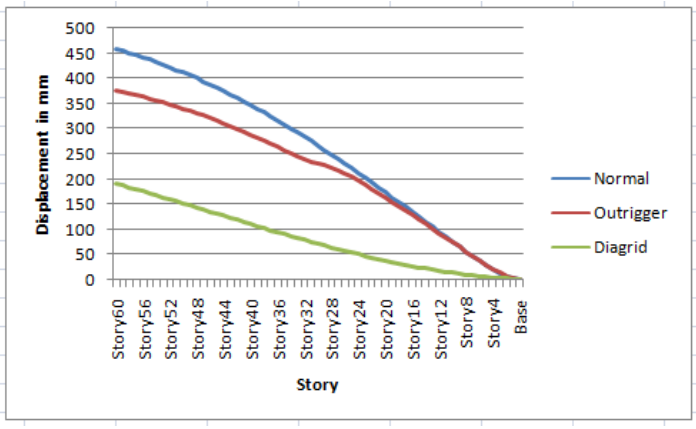

Chart -5: Story Displacement in 60 Story models in different structural system

3.3 Time period

Story Displacement of different structural systems for 40, 60 and 80 story models have been shown graphically below .The maximum top story displacement to H/500 is a commonly accepted values. The performance of the diagrids has been shown to be adequate in all cases.

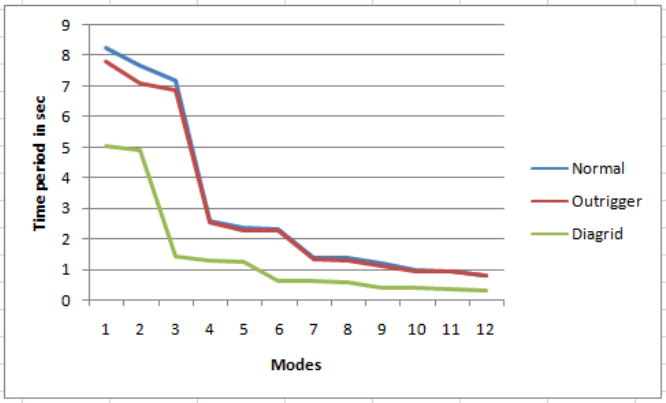

Chart -7: Time Period in 40 story model for first 12 modes

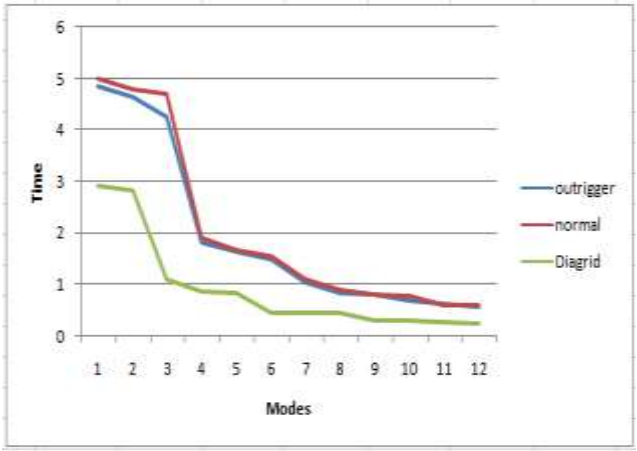

Chart -8: Time Period in 80 story model

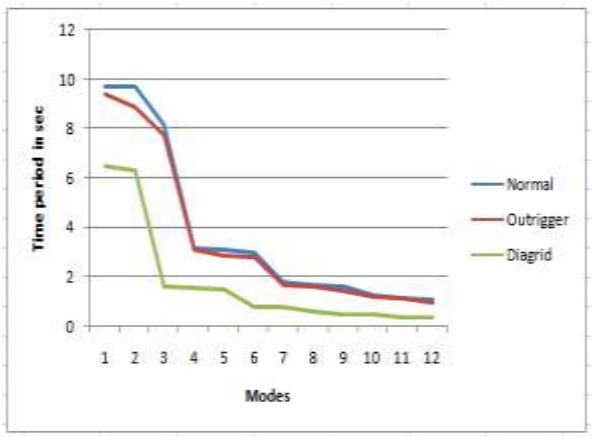

Chart -9: Time Period in 80 story model

4. CONCLUSIONS

The conclusions of this comparative analysis and study have been listed point wise below:

1. As the lever arm for the laterally stiff member is greater for Diagrid structure is greater than the outrigger structure ,it performs better
2. The top story displacement of Diagrid structure in comparison to Outrigger structure was 48%, 49% and 51% related to 40, 60 and 80 story models.
3. Time Period of Diagrid structure in comparison to Outrigger structure was 39%,35% and 30% related to 40, 60 and 80 story models
4. Top Story Drift of Diagrid structure in comparison to Outrigger structure was 31%,-24% and 21% related to 40, 60 and 80 story models
5. It was also concluded that the Resistance to Diagrid structures to torsion in all the three models was more than outrigger and Normal Structures.

Thus the performance of the diagrid structural system is evidently superior to Outrigger and conventional rigid frame with shear wall structural systems.

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