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# Design Analysis of Outrigger and Hexagrid System in High Rise Buildings

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ABSTRACT

The innovation of high strength structural materials as well as the introduction of predominant development methods gave a lift in the development of tall structures. As the height of the structure increases, they become progressively vulnerable to wind load and seismic load. The opposition of tall structures to lateral loads is the fundamental determinant in the formulation of new basic structural frameworks that develop by the constant endeavors of structural engineers to go on increasing the building height while keeping the deflection inside worthy points of confinement and limiting the measure of materials. In this proposed work an analytical study will be consider on such systems like outrigger system with core shear wall and hex grid systems, so as to determine their structural efficiency in transferring the lateral loads safely to the ground.

A comparison of outrigger system with core shear wall and a hex grid system was made on a 15-story building reinforced concrete building by using standard package ETABS by comparing different parameters such as Maximum Storey Displacement, Maximum Storey Drift, Forces, Moment and Storey Shear.

**Keywords :** Structural Analysis, Forces, Deflection, Lateral Forces, Etabs

## I. INTRODUCTION

In the history of structures, maybe nothing is more dazzling than the human goal to make progressively tall structures. Different social and financial factors, for example, migration of people from to urban areas looking for better way of life and openings for work, the increment in land values in urban regions and higher population density, have prompted an incredible increase in the number of tall structures all over the world. As the tall structure is best to land use strategy in present time it can spare a ton of land, hence the horizons of the world's urban areas are ceaselessly being punctured by particular and recognizable tall structures as great as mountain ranges, and achieving more height keeps on being the challenge and goal. However, there are some incredible challenges which are to be looked by the designer every day to make these structures a reality. Out of many challenges, one is that of lateral loads i.e. seismic load and wind load. So there is a need to stabilize the tall buildings against these lateral loads and to provide comfort to the occupants.

In many respects concrete is an ideal building material, combining economy, versatility of form and function, and noteworthy resistance to fire and the ravages of time. The raw materials are available in practically every country, and the manufacturing of cement is relatively simple. It is little wonder that in this century it has become a universal building material. Tall buildings are the most complex built structures since there are many conflicting requirements and complex building systems to integrate. Today's tall buildings are becoming more and more slender, leading to the possibility of more sway in comparison with earlier high-rise buildings. From the first high rise buildings constructed in the late 19$^{th}$century until the modern day skyscrapers, the structure has played an important role in the overall design. Increasing height and slenderness brought about a change in the structural engineers focus from static gravity loads to horizontal dynamic loads generated by wind and earthquakes. Thus the impact of wind and seismic forces acting on them becomes an important aspect of the design. Improving the structural systems of tall buildings can control their dynamic response. With more appropriate structural forms such as shear walls and braced structures, and improved material properties, the maximum height of concrete buildings has increased in recent decades. Therefore, the time dependency of concrete has become another important factor that should be considered in analyses to have a more reasonable and economical design.

In this study we are performing comparative analysis of outrigger and hex grid structure to determine the most suitable type of structure and to design it as per I.S. 456 : 2000. For analysis and design ETABS software is adopted whereas for drafting AutoCAD tool is used.

### *Objectives of the Study*

The main objectives of this study are as follows:

1. To determine outrigger and hexagrid structure system.
2. To Analyze & Design the structure for Stability under lateral pressure.
3. To Analyze the structure using Analysis tool ETABS
4. To determine the stability of structure under lateral forces in terms of Forces, Moment, Deflection and Cost.

## II. LITERATURE REVIEW

**Daliya et. al. (2019)**[9] the research paper introduced an investigation of hexagrid framework directed by utilizing examination and structure programming, ETABS. A standard floor plan 36m x 36m and sporadic floor plans moulded as C, L and T were considered, every basic part was structured according to IS 456:2000. G+30, G+40 and G+50 stories models are considered to look at the exhibition by tallness. Seismic parameters were considered from 1893-2002. Dead and live loads were considered according to Indian Standards. Results expressed that as the stature of the structure expands relocation additionally increments. The exhibition purpose of the T shape and L shape plan inconsistency was closer to one another. Timespan increments with increment in stature of the structure. Base shear was least except the C formed model.

**Manzoor and Singh (2019)**[15] the research paper introduced a logical investigation made on the structural system, for example, the outrigger framework with centre shear divider and hexagrid frameworks, to decide their basic effectiveness in moving the sidelong loads securely to the ground. An examination of outrigger framework with centre shear divider and a hexagrid framework was made on a 38-story building strengthened solid structure by utilizing standard bundle ETABS 2016 by looking at changed parameters, for example, Maximum Story Displacement, Maximum Story Drift and Story Shears. The conclusion expressed that the hexagrid framework is best as it has least sidelong removal and it gives a superior engineering appearance to the structure.

**Kachchhi et. al. (2019)** [5] the research paper consider a parametric comparison of a symmetric building, modelling a 10 storey structure and the analysis of the model was done using ETABS V2017 for structural systems namely Shear walls, Belt Truss, Outrigger, Diagrid, Staggered Truss and a conventional Frame. Structure analysis was done considered Dead load, Live load, Seismic load and Wind load. Static and Response spectrum analysis was done for performing earthquake loads where the model was considered on seismic zone V. The results exhibited that Displacements on every story and story float was less in Diagrid frameworks in X-Direction in contrast with other parallel loads opposing framework. Storey Displacement on every story and story float were less in Staggered Truss frameworks in Y-Direction when contrasted with other parallel burden opposing framework.

## III. METHODOLOGY

**Step-1** First step is collection of data related to outrigger & hexagrid structures considering software implementation.

**Step-2** Modelling of Structure using ETABS

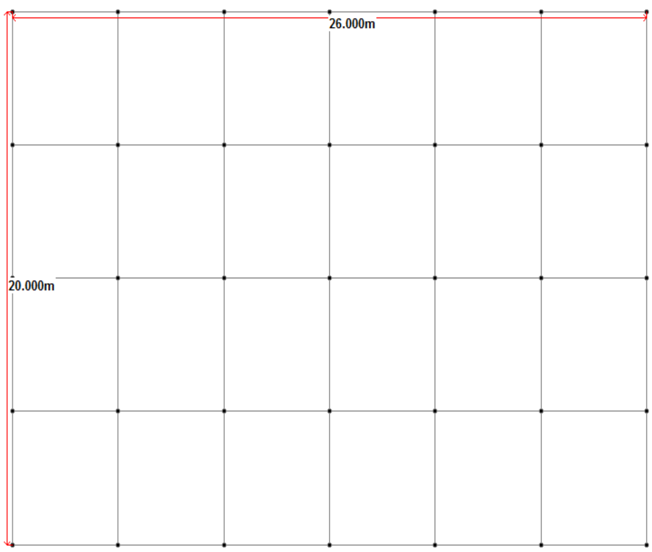


**Figure 1.** Modelling of Structure using ETABS

The dimensions of the structure were designed in both the cases.

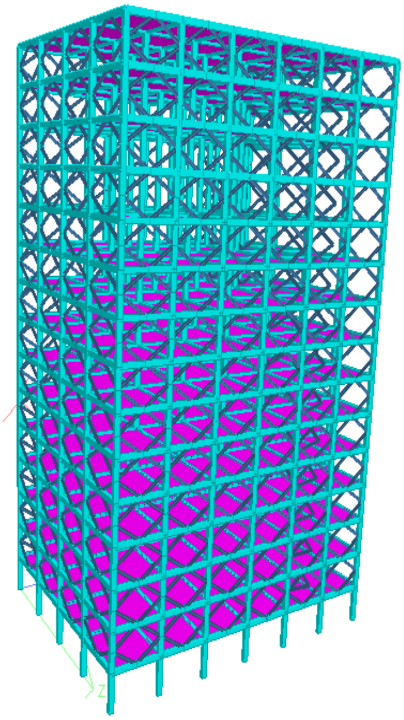

**Figure 2.** Modelling of Hexa-Grid

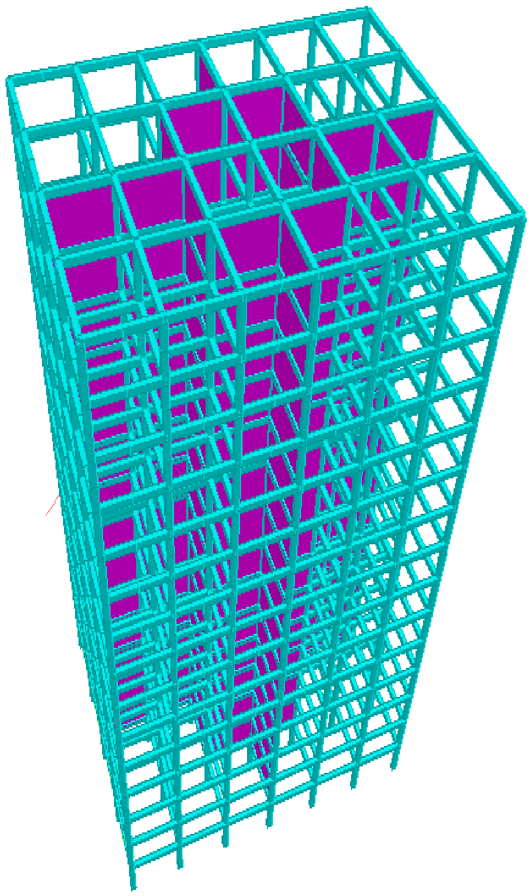

**Figure 3.** Modelling of Outrigger

**Step-3**To assign sectional data and properties

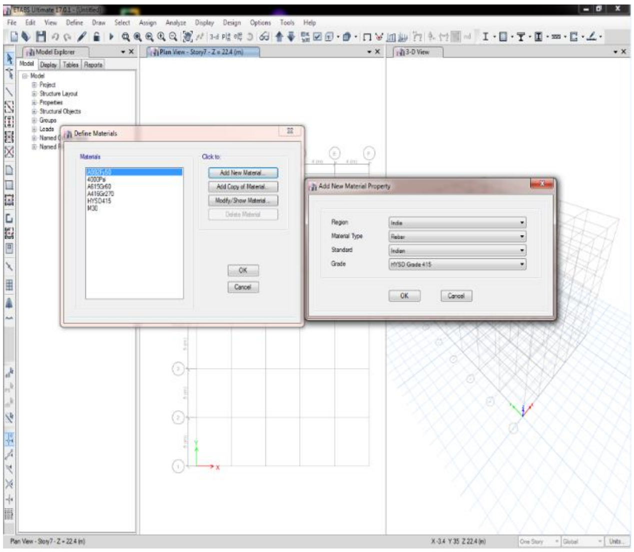

**Figure 4.** Creating material properties in ETABS.

Materials make up the essential components, which all assembling procedures need to work with. Assembling top-notch items easily require itemized information on complex collaborations among an enormous number of variables including item plan necessities, materials and their properties and assembling forms that convert these materials into required structures. Today there is a wide scope of materials and procedures accessible and the assignment of choosing the most ideal material while limiting the expenses of assembling is a significant test. Meeting such a test requires an intensive comprehension of the attributes of materials and forms and the related assembling innovation.

**Step-4** To Assign support conditions.


**Figure 5.** Assigning fixed end support

**Step-5** Formation of load combination (8 load combinations in x & z-direction) and Time History Plot.

**Step-6** To perform finite element analysis and design as per I.S. 456:2000

The Finite Element Analysis (FEA) is the reproduction of some random physical marvel utilizing the numerical procedure called Finite Element Method (FEM). Architects use it to lessen the number of physical models and tries and enhance parts in their structure stage to grow better items, quicker.

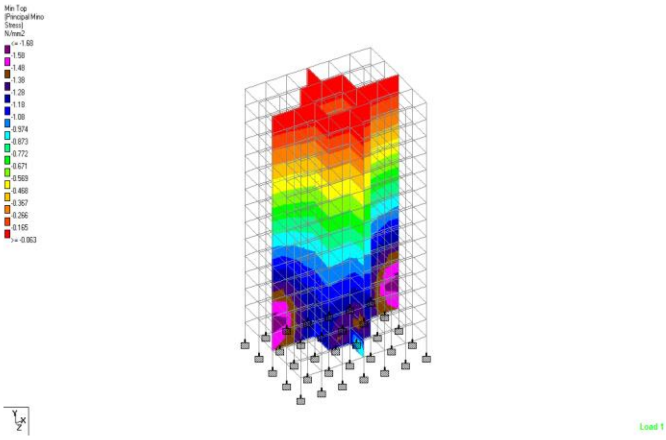

**Figure 6.** Analysis output

**Step-7** To prepare comparative result in M.S. excel

**Step-8** To provide conclusion as per results.

**Table 1 Geometrical properties of the structure**

| | | |
|---|---|---|
| **1** | **Number of Stories** | **Ground + 15 storey** |
| **2** | Height of stilt floor | 3.3 m. |
| **3** | Height of upper stories | 3.3 m. |
| **4** | Depth of foundation | -1.5 m |
| **5.** | Grade of concrete for RCC structure | M 30 |
| **6** | Grade of concrete for Composite structure | M 30 |
| **7** | Steel used for longitudinal | HYSD 500 |

| | | |
|---|---|---|
| | reinforcement | |
| **8** | Steel used for lateral reinforcement | HYSD 415 |
| **9** | Steel Sections | Fe 345 |
| **10** | Time history | Elcentrino |
| **11** | Length & Width | 20 x 26 m |

***Loading conditions***

**Table 2.** Load Assessments and Calculations

| S.No. | Load Type | As per I.S. |
|---|---|---|
| 1 | Self Load | I.S. 875-PART-1 |
| 2 | Live Load | I.S. 875-PART-2 |
| 3 | Time history Analysis | I.S. 1893-PART-1 |

## IV. Analysis Results

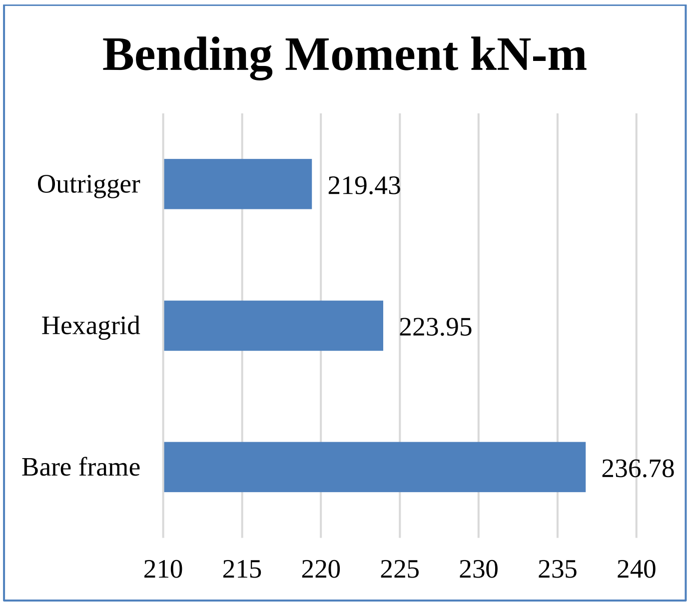


**Fig 7 :** Bending moment in KN-m

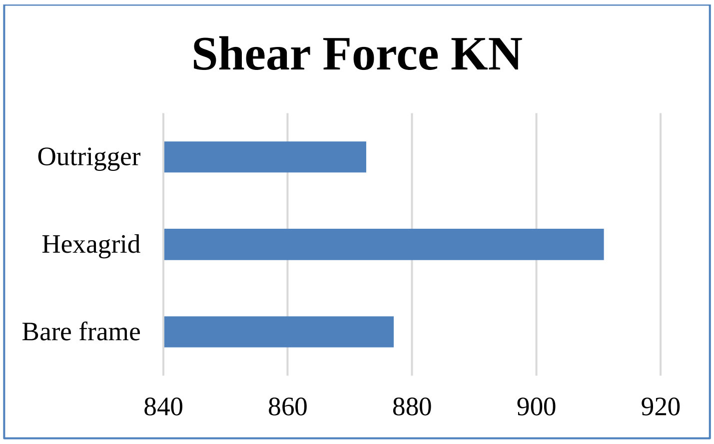


**Fig 8:** Shear Force in KN

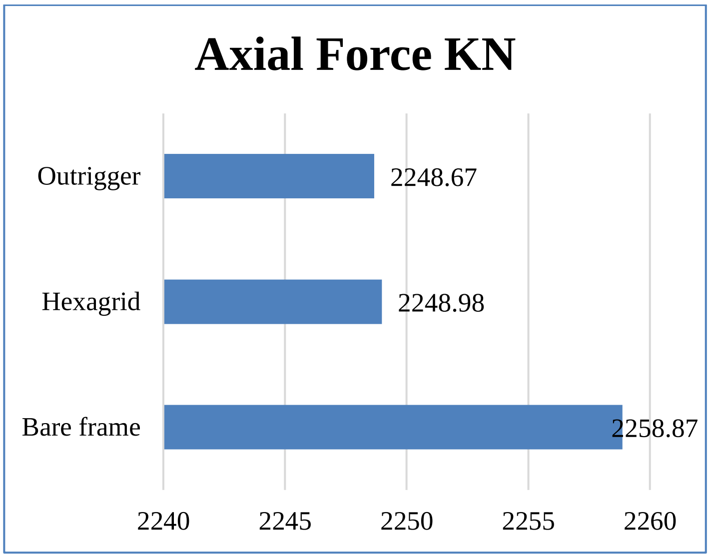


**Fig 9:** Axial Force in KN

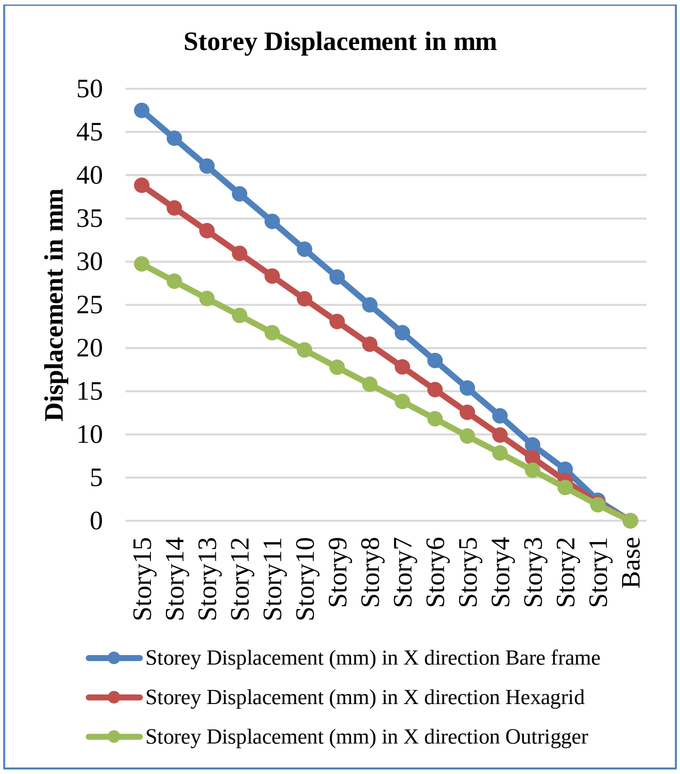

**Fig 10 :** Storey Displacement in mm


**Fig 11 :** Detailling of structure in autocad

**Conclusions:**

A comparison of outrigger system with core shear wall and a hexagrid system was made on a 15-story building reinforced concrete building by using standard package ETABS by comparing different parameters such as Maximum Storey Displacement, Maximum Storey Drift, Forces, Moment and Storey Shear.

And the conclusion derived from the results are as follows:

In the present study it has been found that Outrigger system structure is comparatively showing less moment and can said to be economical one as bending moment observed is 219.43 kN-m in outrigger structure whereas in hexagrid it is 223.95 kN-m and in bare frame it is 236.78 kN-m.

In terms of shear force unbalanced forces are observed maximum in hexagrid structure with value 910.87 KN whereas minimum in outrigger structure with value 872.65 KN which shows the stability of the structure.

Vertical forces are maximum in bare frame structure with value 2258.87 KN whereas in both the cases hexagrid and outrigger value is almost similar i.e. 2248.6 KN.

Storey displacement is occurring due to seismic lateral forces and it is clearly observed that Outrigger structure is comparatively more resisting and stable as maximum displacement observed in outrigger structure is 29.72mm whereas in bare frame value is 47.495 mm

***Future Scope***

1. In the proposed work shows comparison of hexagrid, outrigger and bare frame structure for tall structure whereas in future one can select bracing system or other lateral resisting system for analysis.
2. In this study seismic analysis is considered whereas in future study wind loadcan be consider.
3. In this study analysis is done using etabs whereas in future SAP2000 can be prefer for P-delta analysis to determine the displacement force graph.

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