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# Analysis of Diagrid Structure

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**Abstract:** The curiosity of structural engineers for new ideas in the field of High rise buildings has led to some of the most remarkable inventions. Diagonalized grid structures have emerged as one of the most innovative and adaptable approaches to structuring buildings in this millennium. Structural design of high rise buildings is governed by lateral loads due to wind or earthquake. The vertical columns were only engineered to carry gravity loads and were incapable of providing lateral stability. The diagonal grid was capable of resisting all of the gravity loads as well as providing lateral stability due to its triangular configuration. Compared to closely space vertical columns in framed tube, diagrid structure consists of inclined columns on the exterior surface of building. Due to inclined columns lateral loads are resisted by axial action of the diagonal compared to bending of vertical columns in framed tube structure. A regular floor plan of 42 m × 42 m size is considered. ETABS software is used for modelling and analysis of structural members. This paper presents a simple approach on optimization of diagrid structure for best grid angle.

**Keywords**: Diagonalized grid, High rise building, Structural analysis.

## I. INTRODUCTION

The rapid growths of urban population and consequent pressure on limited space have considerably influenced the residential development of city. In High rise building, as the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. Diagrid is a particular form of space truss. It consists of perimeter grid made up of a series of triangulated truss system. Diagrid is formed by intersecting the diagonal and horizontal components. The famous examples of diagrid structure all around the world are the Swiss Re in London, Hearst Tower in New York, Cyclone Tower in Asian (Korea), Capital Gate Tower in Abu Dhabi and Jinling Tower in China.

## II. MODELLING OF DIAGRID STRUCTURE

*(a) Building configuration:*

A 70-storey diagrid structure of four different angles was modelled and analysed in the E-Tabs software. The Diagrid angle adopted are 66°. The inclined columns are provided at fourteen-meter spacing along the perimeter. Storey height is kept uniform for all floors which is 3.2m. Slab thickness is kept 0.15m which is precast concrete of M30 grade concrete. Building is located in Mumbai having wind speed 44 m/s and comes under ZONE-3 earthquake prone area. The Joints of the diagrid columns are connected to each other by nodes system. These nodes are connected to the core of the building consisting of shear wall of size 14 m × 14 m with the help of beam sections. Thus the position of the beams is determined by the diagrid columns and their connections. Secondary beams are also used in order to support the slab section.

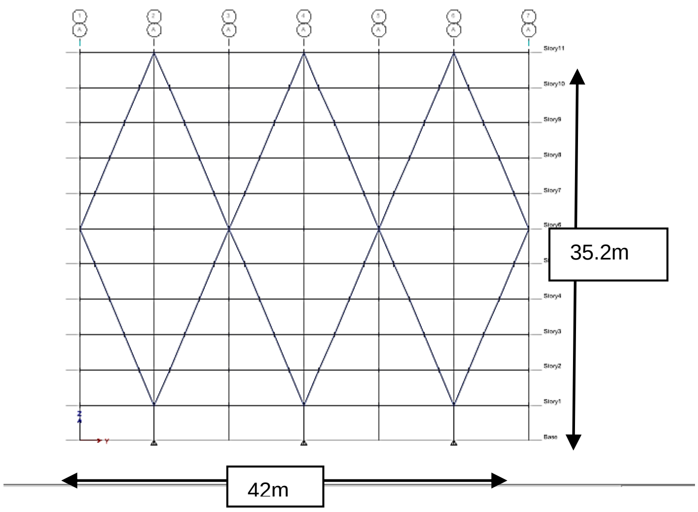


Fig. 1 Elevation view of the diagrid model

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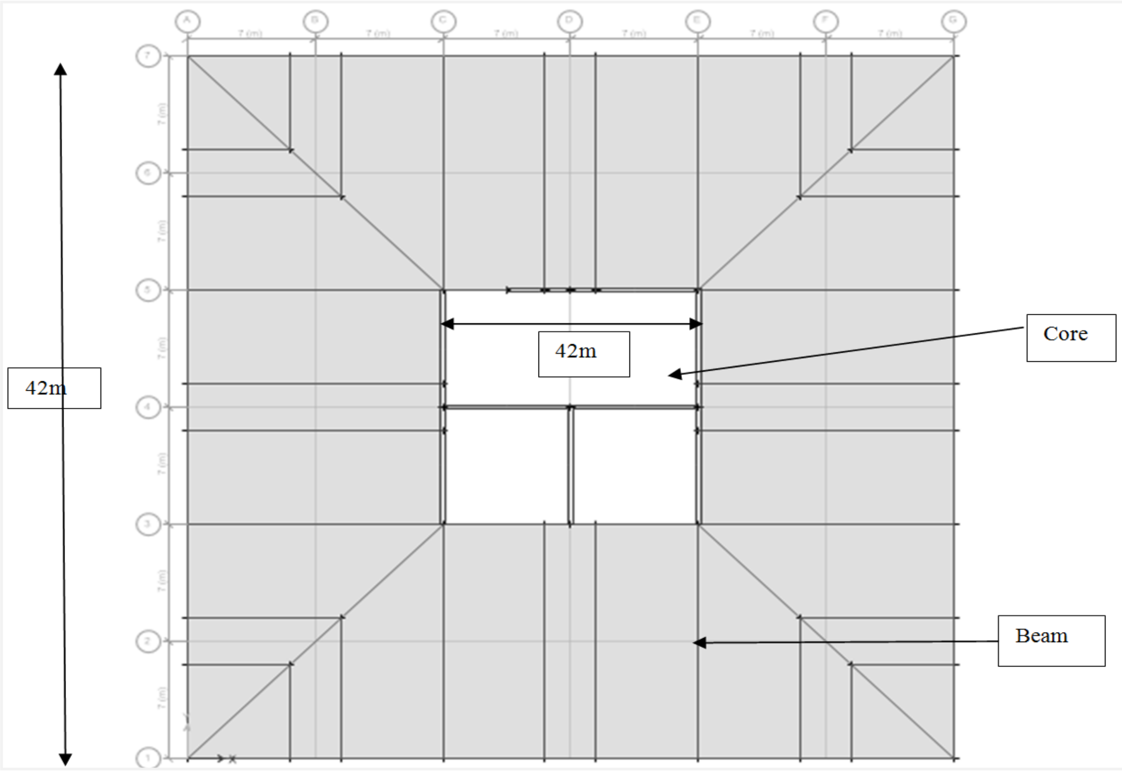


Fig. 1  Plan view of the diagrid structure

*(b)* *Material Properties:*
For beams steel section of Fe415 steel is used, slab section of M30 concrete and shear wall of M35 concrete

(c) *Section Properties:*
For Diagrid columns tubular section of diameter m is used and is connected by nodes system, for beam steel section of ISHB 450 of Fe415 steel is used, slab section consists of precast concrete of M30 grade concrete of size 0.15 m thickness.

(d) *Load Parameters:*
The design dead load and live loads on floor slab are 3 KN/m2 and 2.5 KN/m2 respectively. The dynamic along wind loading is computed based on the basic wind speed of 44 m/sec and terrain category III as per IS:875 (III)-1987 (Gust factor method). The design earthquake load is computed based on the zone factor of 0.16, medium soil, importance factor of 1 and response reduction factor of 5.

## III. ANALYSIS RESULTS

After modelling of the structure on Etabs several loads are assigned and analysis is made to run. Etabs provide a etailed information for the displacement in X- direction and Y-direction. Following are the results displayed storey wise.

TABLE I  DISPLACEMENT OF DIAGRID STRUCTURE IN X-DIRECTION

| | **Displacement** | **In** | X- **Direction** | |
|---|---|---|---|---|
| **Storey** | **Dead** | **Live** | **Wind** | **Seismic** |
| | mm | mm | mm | mm |
| Base | 0.003 | 0.001 | 1.235 | 0.617 |
| Storey10 | 0.298 | 0.133 | 25.963 | 15.115 |
| Storey20 | 1.168 | 0.528 | 73.336 | 45.703 |
| Storey30 | 2.493 | 1.134 | 132.845 | 86.874 |
| Storey40 | 4.171 | 1.902 | 198.767 | 134.902 |
| Storey50 | 6.115 | 2.794 | 267.02 | 186.46 |
| Storey60 | 8.248 | 3.772 | 334.786 | 238.64 |
| Storey70 | 10.472 | 4.792 | 400.593 | 289.35 |
| Top | 10.686 | 4.89 | 407.052 | 294.294 |

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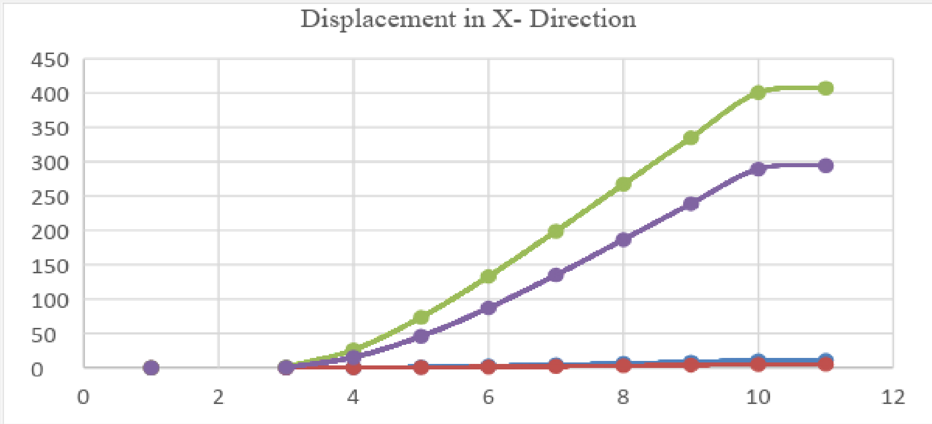

Fig. 1 A Graph showing displacement with respect to storey height X-Direction

TABLE II DISPLACEMENT IN Y-DIRECTION

| | Displacement | In | Y- Direction | |
|---|---|---|---|---|
| Storey | Dead | Live | Wind | Seismic |
| | mm | mm | mm | mm |
| Base | 0.014 | 0.007 | 0.995 | 0.512 |
| Storey10 | 0.863 | 0.428 | 27.638 | 16.311 |
| Storey20 | 2.981 | 1.48 | 78.5 | 49.551 |
| Storey30 | 6.094 | 3.028 | 141.629 | 93.973 |
| Storey40 | 10.009 | 4.975 | 211.174 | 145.7 |
| Storey50 | 14.537 | 7.229 | 282.941 | 201.234 |
| Storey60 | 19.496 | 9.697 | 353.99 | 257.456 |
| Storey70 | 24.711 | 12.293 | 422.773 | 312.083 |
| Top | 25.239 | 12.556 | 429.528 | 317.428 |

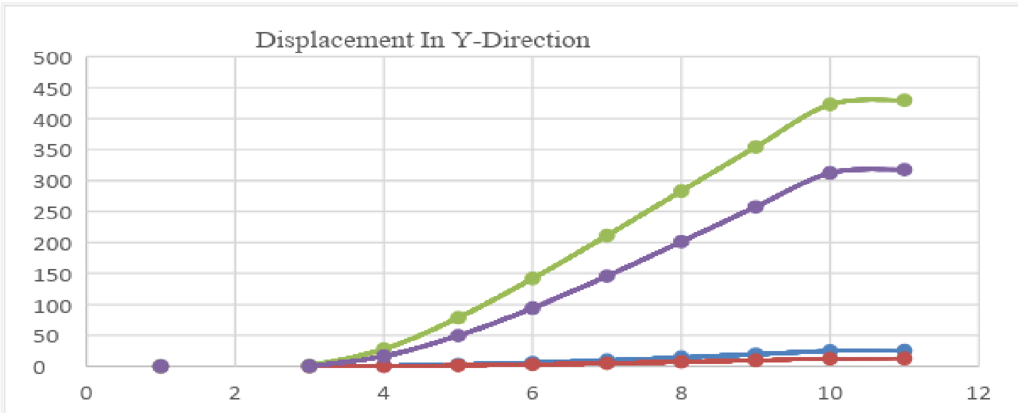

Fig. 1 A Graph showing displacement with respect to storey height Y-Direction

## IV. CONCLUSIONS

In this paper, analysis of 71 storey diagrid steel building is presented in detail. A regular floor plan of 42 m ×42 m size is considered. ETABS software is used for modelling and analysis of structure. From the study it is observed that most of the lateral load is resisted by inclined diagrid columns on the periphery, while gravity load is resisted by both the internal columns and peripheral diagonal columns. So, internal columns need to be designed for vertical load only. Due to increase in lever arm of peripheral diagonal columns, diagrid structural system is more effective in lateral load resistance. Lateral and gravity load are resisted by axial force in diagonal members on periphery of structure, which make system more effective. Diagrid structural system provides more flexibility in planning interior space and facade of the building.The results obtained also states that the displacement by the diagonal grid is just 50% of the permissible limit.

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