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# Optimum Performance of Diagrid Structure

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***Abstract:- Growth of high rise building increases due to development in construction technology and structural system. High rise structure design governs to resist lateral load due to wind or earthquake forces. Generally shear wall core, braced frame etc. used as lateral load resisting system. Recently new trend generated to resist lateral forces using truss system called as diagrid structure. Diagrid structural system adopted to resist lateral load due to its structural efficiency and flexibility of architectural planning. To find out optimum performance of diagrid Steel structure, a 36 storey building with floor plan 35 x 35 m is considered. For modeling and analysis of building ETABS software is used. Five building models are constructed in ETABS software with $50^0$11'24'', $67^0$22'12", $74^0$28'12", $78^0$13'48" and $82^0$5'24" angular orientation of diagrid member. The models are analyzed under earthquake loading by response spectra method. Results are obtained in terms of top storey displacement, Inter storey drift and Modal time period. Optimum angle and optimum performance of diagrid structure are decided by comparing results.***

Keywords Diagrid Structure, Optimum Angle, Storey Drift, ETABS v 2015.

## 1. Introduction

The growths of urban population and consequent pressure on limited space have considerably influenced the residential development of city. The high cost of land, the desire to avoid a continuous urban sprawl, and the need to preserve importance agricultural production have all contributed to drive residential building upward. As the height of building increases, the need of lateral load resisting system also increases. 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 ) system widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by unique geometric configuration. Over the last 1 Decade, diagrid structures have proven to be highly adaptable in structuring a wide range of building types. The diagrid in its purest form is capable of resisting all of the gravity loads and lateral loads on the structure without assistance of a traditional structural core. The term ñdiagridò is a blending of the worlds ñdiagonalò and ñgridò and refers to a structural system that is single-thickness in nature and gains its structural integrity through the use of triangulation. Diagrid is a particular form of space truss. It consists of perimeter grid made up of a series of triangulated truss system. Diagrid are formed by intersecting the diagonal and horizontal components. The diagrid has good appearance and it is easily recognize. The configuration and efficiency of diagrid system reduce the number of structural element required on the façade of the buildings, therefore less obstruction to outside view. Angle of diagrid member is measure in anticlockwise direction with x-axis. The angle at which performance of diagrid structure is improved than other angle, is called Optimum angle. ETABS v 2015 is structural analysis software which is based on finite element method. Storey drift is the displacement of one level relative to the other level above or below.

Elena mele, et.al [1] perform analysis on different diagrid structure. They applied horizontal as well as vertical loading on triangular element of diagrid structure and observe behavior of diagrid structure. R. Deshpande et.al [2] perform comparison between diagrid structure and brace frame with shear wall system. For analysis of structure wind forces considered. They observed material consumption in diagrid structure less than conventional structural system. Khushabu jani et.al [3] perform analysis and design of diagrid structure. They considered five models with varying height i.e. 36, 50, 60, 70, 80. For analysis wind and earthquake force used. B. K. Nguyen et.al [4] explains effect wind forces in geometry. They explained procedure for reduction of wind effect on the structure by using following methods Aerodynamic modification, structural reinforcement and Auxiliary damping devices.

In this paper five diagrid models are constructed by varying diagrid angular orientation i.e. $50^0$11ô24ôô, $67^0$22ô12ò, $74^0$28ô12ò, $78^0$13ô48ò and $82^0$5ô24. All models has similar plan area and

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storey height. Models analyzed in same earthquake situation and observe performance of diagrid structure in terms of storey displacement, storey drift and modal time period.

## 2. Analysis of Diagrid Structure

Five models constructed in ETABS software with varying angular orientation of diagrid member i.e. $50^0$11ô24ôô, $67^0$22ô12ò, $74^0$28ô12ò, $78^0$13ô48ò and $82^0$5ô24. A typical plan and elevation shown in figure 1 and figure 2 respectively. For Analysis of diagrid structure response spectra method is adopted. Following soil condition taken for analysis. Hard soil strata, zone factor 0.36, response reduction factor 5, importance factor 1. The live load on floors 3 $kN/m^2$ and on roof 2 $kN/m^2$. Grade of concrete M 30 and grade of steel Fe 250.

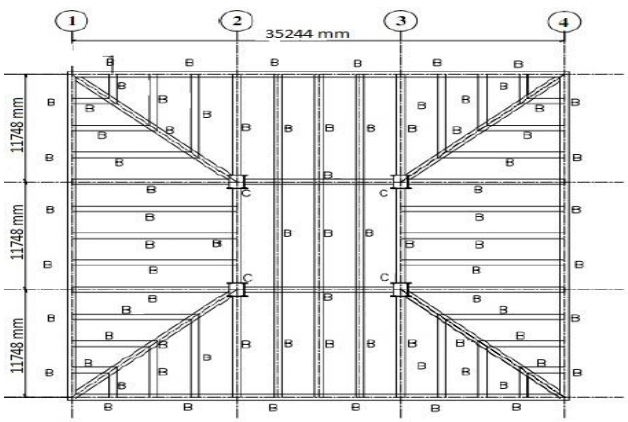



Figure 1. Typical Plan of Diagrid Structure.

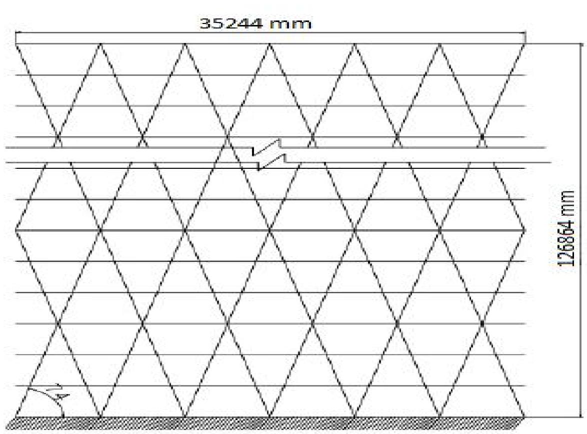
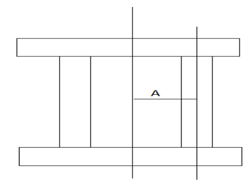



Figure 2. Typical Elevation of Diagrid Structure.

### 2.1. Building Configuration

In the Table 1 geometric configuration of structure is mention below.

Table 1. Description of Structural Member

| Description | Dimension/ figure |
|---|---|
| Plan | 35.244 x 35.244 m |
| Storey height | 3.524 m |
| Beam | Symmetric I section<br>Flange = 180 x 40 mm<br>Web = 430 x 40 mm |
| Column | <br>Flange = 1300 x 50 mm<br>Web = 1410.10 x 50 mm<br>A = 217 mm |
| Diagrid member | Pipe section<br>External diameter = 450 mm<br>Thickness = 25 mm |
| Slab | 130 mm |

## 3. Analysis Results

The analysis results obtained in terms of modal time period, storey displacement and storey drift. In the Figure 3 and Figure 4, the value of storey displacement represent on Y-axis and Number of Storeys on X- axis. The displacement of storey increases with respect to diagrid angle shown in figure. The graph is in red color shows less storey displacement than other graphs. Due to square geometry displacement of storey in X direction and Y direction is nearly same.

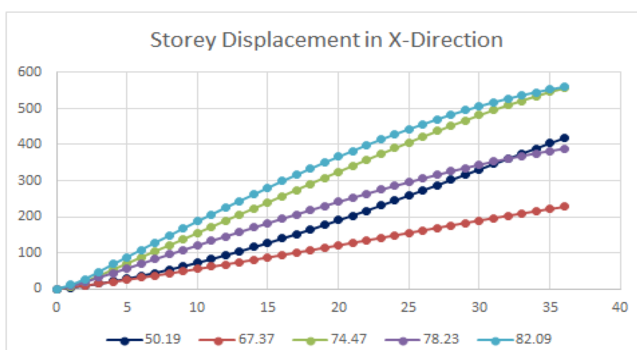



Figure 3. Storey Displacement in X- Direction

Storey drift in x direction and y direction is represented in Figure 5 and Figure 6 respectively. In the graph on X-axis represent Number of Storeys and on Y-axis represent storey drift. The storey drift is increases with respect to increase in diagrid angle. In the figure five graphs represent storey drift of five model of different orientation. At an angle $67^0$22ô12ò storey drift of diagrid structure is minimum.

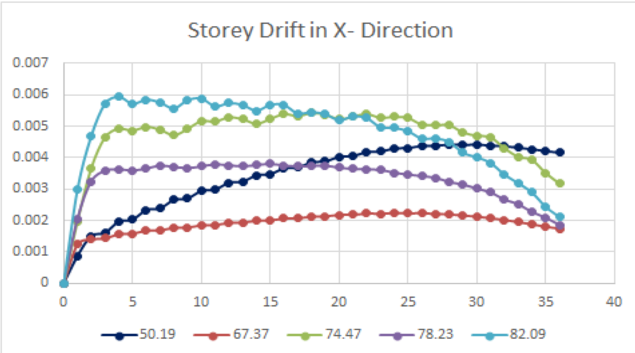



Figure 5. Storey Drift in X-Direction

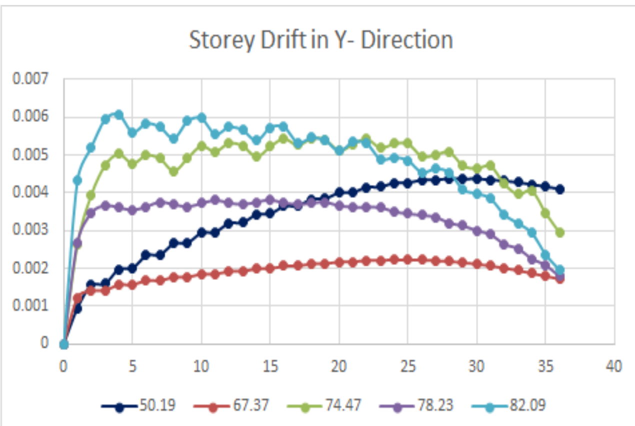



Figure 6. Storey Drift in Y-Direction

The model time period is represent in the Figure 7. In the graph number of mode on X-axis and time period on Y- axis represented. The five graphs represent time period of five diagrid models. The time period of diagrid structure increases with increase in angle of diagrid structure. In the graph minimum model time period is represent at an angle $67^0$22ô12ò .

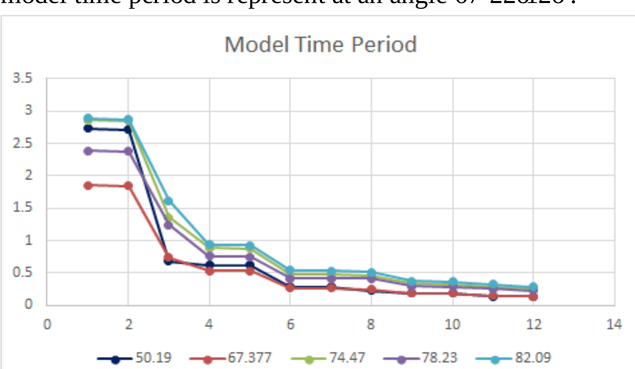



Figure 7. Modal Time Period

## 4. Conclusion

1. Observing above analysis results it can concluded that performance of diagrid structure at an angle $67^0$22ô12ò is better than other angles.

2. On the basis of results it can concluded that performance of structure depends on stiffness of diagrid element. Stiffness of diagrid element depends on angular orientation of member, effective length, area and material. If material, and area of member similar then stiffness of diagrid structure depend on angular orientation and effective length.

3. The optimum performance of diagrid structure gets at an angle $60^0$ to $70^0$.

4. Length of diagrid member should be minimum as possible to get optimum performance of diagrid structure.

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