Performance Assessment of High-Rise Building using Diagrid

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Abstract

In recent trends, the construction development has been rapidly increasing towards tall building structures. Recently different structural system like braced tube structure, space truss, diagrid structural system etc. are adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Diagrid is a particular form of space truss. It consists of a perimeter grid made up of a series of triangulated truss system. Diagrid is formed by intersecting the diagonal and horizontal components. Due to inclined columns lateral loads are resisted by axial action of the diagonal in diagrid structure compared to bending of vertical columns in conventional buildings. Generally for tall building diagrid structure steel is used. Analysis and design of 30 RC building with steel is presented. A regular floor plan of 36 x36 m size is considered. ETABS software is used for modeling and analysis of structural members. All structural members are designed as per IS 456:2000 and IS 800:2007 considering all load combinations. Later the optimum angle for a 30 storey RC building with steel diagrid is found out.

Keywords: Structural System, Diagrid Building, Space Truss

I. INTRODUCTION

The rapid growth of urban population and limitation of available land, the taller structures are preferable now a day. As the height of the building increases, the lateral resisting systems becomes as important as the gravity supporting system. For conventional high rise building, shear wall braced frame, outrigger structures etc. forms the interior system and framed tube, and braced tube etc. forms the exterior system. Diagrid comes under exterior system. The concept of diagrid is not a new one. The term “diagrid” is a combination of words “diagonal” and “grid”. Diagrid structures can be seen as the latest mutation of braced tube structures. For diagrid structures, almost all the conventional vertical columns are eliminated. This is possible because the diagonal members in diagrid system can carry gravity load as well as lateral forces owing to their triangulated configuration. Diagrid carry shear by the axial action of the diagonal members, while the conventional framed tubular structures carry shear by the bending of the vertical columns. Diagrid structures do not need high shear rigidity cores because shear can be carried by the diagrids located on the perimeter. The configuration and efficiency of a diagrid system reduce the number of structural element required on the facade of the building, therefore less obstruction to the outside view. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, therefore allowing significant flexibility with the floor plan. Diagrids can be constructed with steel, concrete or timber. Due to the flexibility of triangulated shape, diagrids can be easily used for modeling any complex shaped buildings.

II. LITERATURE REVIEW

Significant researches were carried out on seismic behaviour of diagrid structural system and a few published works are reviewed in this section. Moon “et al.”, developed a general method for preliminary design od diagrid by adopting a stiffness based design method. Leonard “et al.”, carried out research on shear lag effect in high rise building that adopted diagrid system and concluded that diagrid structure performed three times better than framed tube buildings. Moon studied the performance and constructability issue of diagrid structures employed for complex shaped tall buildings. He proposed extracting regularity from irregular form. Kushbu Jani “et al.”, performed analysis and design of diagrid structure based on IS code specification. Seismic performance evaluation of typical diagrid building was carried out by Kim “et al”. He concluded that diagrid structure shows higher strength and lower ductility compared to tubular structures. The ductility of diagrid structures can be improved by replacing the diagonal members with buckling restrained braces. Nishith B Panchal “et al.”, compared static analysis results of concrete diagrid structures having different diagrid angles and different diagrid member sizes. They concluded that optimum angle of diagrid is in the region of 65 to 75.
III. **FINITE ELEMENT MODELING OF THE TANK**

Modeling and analysis of building is performed in ETABS. The geometric details and the member sizes of the building are provided in Table 1 and 2 respectively. The angle of diagrid is decided on the basis of the storey module. Here, four different storey module is considered, that is 2-storey module, 3-storey module, 4-storey module and 6-storey module.

![Structural Plan](image)

**Fig. 1: Structural Plan**

<table>
<thead>
<tr>
<th>Member</th>
<th>No</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam</td>
<td>B1</td>
<td>300 x 600</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>300 x 1050</td>
</tr>
<tr>
<td>Column</td>
<td>C</td>
<td>1700 x 1700</td>
</tr>
</tbody>
</table>
| Diagrid  | D   | 375mm Pipe sections with 12mm thick (from 16th to 30th storey)
|          |     | 450 mm Pipe sections with 25 mm thickness (from 1st to 16th storey) |

**IV. RESULTS AND DISCUSSIONS**

**A. Linear Static Analysis**

Equivalent static seismic loads were calculated as per IS 1893: 2002 guidelines. Building was assumed to be in seismic zone 3 and soil type was taken as medium. Importance factor 1 and response reduction factor 5 were adopted. Wind speed of 39 m/s was assumed.

The following results were obtained.

1) 3 storey module shows less top storey displacement and storey drift compared to others.
2) Time period is observed to be less for 4 storey module, which reflects more stiffness and less mass of the structure.
B. Nonlinear Static Analysis

Comparing uniform angle diagrids, a diagrid four storey module is found to be showing highest stiffness and moderate ductility.

C. Linear Time History Analysis

Linear time history analysis results shows less storey shear, column force and overturning moment for 4 storey module. Here only one seismic time history was used for simulation. The calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input. Therefore several analysis are required using different ground motion records.
The study of the seismic performance of 30 storey diagrid building is accomplished by analytical methods. Equivalent static analysis, nonlinear static pushover analysis and linear time history analysis were conducted using ETABS analysis package.

1) Equivalent static analysis results show less top storey displacement and drift for 3 storey module. And also time period is less for 4 storey module (67.4).

2) Equivalent static analysis will not give any idea about the ductility of the structure. Therefore nonlinear static pushover analysis results shows high stiffness and moderate ductility for 4 storey module (67.4).

3) Linear time history results shows less overturning moment, storey shear, column force for 4 storey module (67.4).

4) From all the above analysis the optimum angle for a 30 storey RC building with steel diagrid is 67.4°

REFERENCES