COMPARATIVE ANALYSIS OF DIAGRID STRUCTURE WITH VARIOUS INDIAN SEISMIC ZONE

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Abstract - *Diagrid systems are emerging as one of the most structurally efficient and visually appealing tall-building alternatives. Such systems are increasingly being employed in modern construction. The present literature lacks extensive information on their structural behaviour and seismic design criteria to assure optimal performance under various earthquake seismic zones. This research aims to evaluate the seismic dependability of diagrid structural systems and create more efficient performance-based approaches.*

A total of seven models with varying sizes, angles, storey heights, and density with a regular floor plan are studied in E-tabs software for the study of diagrid structural system for tall steel structure subjected to lateral loading for seismic zones II, III, IV, and V. The reaction spectrum analysis for earthquake loading and the gust factor technique for dynamic along wind response are investigated for structure analysis. A comparison of the results with various Indian seismic zones using IS 1893 part 1- 2016 is conducted in terms of time duration, base shear, storey displacement, storey shear, and storey drift.

Key Words: Diagrid, Seismic zone II,III,IV,V, Storey drift, Storey displacement, base shear, IS 4506:2000, IS 1893:2016, IS 800:2007, Seismic analysis, ETAB.

1.INTRODUCTION

Over the last several decades, high-rise structures have shown to be the best solution to the difficulties of land scarcity and rising rates of urbanisation in all areas. Controlling challenges in high-rise building design include earthquake and wind lateral stress, as well as gravitational loads. As structures developed taller and thinner, structural engineers were challenged to meet the needed drift standards while reducing the architectural impact of the structure. Engineers have devised and deployed various unique lateral load resisting structural structures during the last half-century to minimize (bundled-tube, diagrid, outrigger systems, etc.). in many high-rise structures to fulfill safety, serviceability, and aesthetic standards while minimizing material consumption. Previously, structural form modifications were implemented to accommodate changing aesthetic trends in high-rise building design. The diagrid structural system has recently acquired favor for tall steel buildings due to the structural efficacy and aesthetic prospects provided by the system's unusual geometric pattern. In terms of design, (pre)fabrication, and erection operations, it is heavily reliant on steel's capabilities as a structural system. A diagrid project's success is also contingent on the architect, engineer, and steel fabricator/erector working well together.

1.1 WHY USE OF DIAGRID STRUCUTURE?

In last 10 years, diagrid structures have established to be highly adaptable in structuring an extensive range of building types, spans and forms. Diagrid is a specific form of space truss as shown in Fig..1.1, which contain multiple diagonal elements that form a diagonal grid on the fringe of the structure All conventional vertical columns are eliminated in diagrid structural system. Diagrid structural system balance gravity as well as lateral load with the help of diagrid grid on perimeter. With the help of connection of diagonal and horizontal member diagrid structure is modeled.

The structure prepared by this system contain unique aesthetic appearance and can be recognized from the outside. Due to its unique formation and efficiency of structure a diagrid system reduces the number of structural elements necessary on the perimeter of the buildings. Hence, the exterior view from the building has less hindrance compared to the conventional design of structures. The structural efficiency of diagrid system also helps in escaping internal and corner columns, thus, permitting important flexibility with the floor plan. In addition, perimeter diagrid system saves nearly 20 percent of the structural steel weight when equated to a conventional moment-frame structure.

Fig -1: Hearst Tower

2. OBJECTIVE

- To build the 28 model of diagrid structure in ETABS 19.
- To analyse diagrid structural system with pertaining to angle and various seismic zone.
- To study on the variations in the structural response due to the earthquake motions with different Indian seismic zone.
- To determine the different storeys diagrid structures behaviour with all seismic zone of India.
- Best configuration of diagrid system for various seismic zone which results into optimal solution.
- To determine the storey drift and storey displacement of diagrid structure.

3. scope of work

- To perform parametric study of performance of diagrid for lateral loading with different angles, various vertical & horizontal densities with seismic zone Ⅱ , Ⅲ, Ⅳ, Ⅴ.
- To come up with the best configuration for diagrid system that reduces displacement, inter-storey drift, time period, base shear.
- To realise scope of work, 28 models of different storey steel building is to be analysed in Etabs software for dynamic wind load by using gust factor method and non-linear static earthquake load by performing response spectrum analysis for seismic zone Ⅱ , Ⅲ, Ⅳ, Ⅴ.

Chart -1: Structural Anatomy of 28 Models

4. Behaviors of diagrid structure with different loading condition

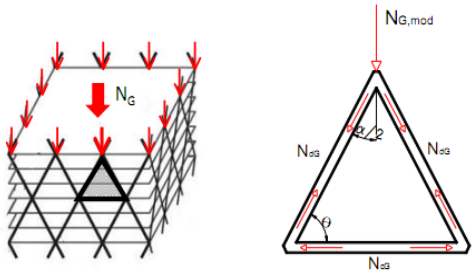


Fig-2: Effect of Gravity Load on Diagrid Module

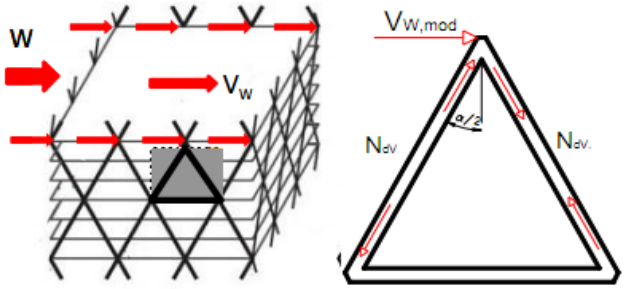


Fig-3: Effect of Shear Force on Diagrid Module

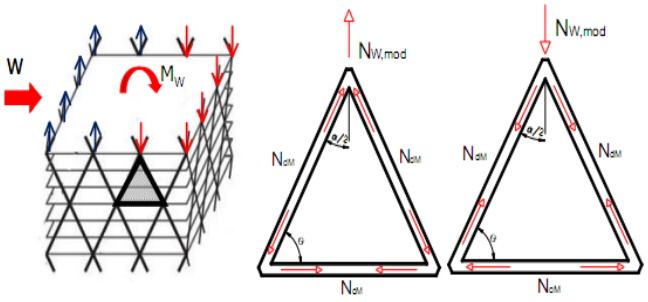


Fig-4: Effect of Shear Force on Diagrid Module

5.Modelling of diagrid structure

In this topic, analysis and design of various storey diagrid structural system is presented. Modeling, analysis and design of diagrid structure is carried out using ETABS software. All structural members are designed using IS 800:2007 considering all load combinations. The static analysis is carried out considering earthquake and wind loads on structures. Important analysis results in terms of time period, top storey displacement and interstorey drift are presented for various seismic zone and results are compared. Further sizes of diagonal members for all buildings are presented.

5.1 Section property

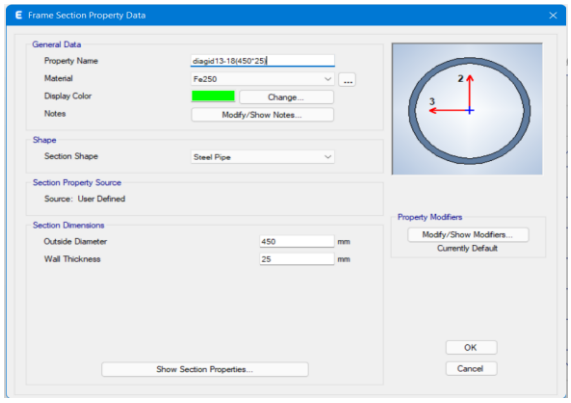


Fig-5.1 Section design of Diagrid Module

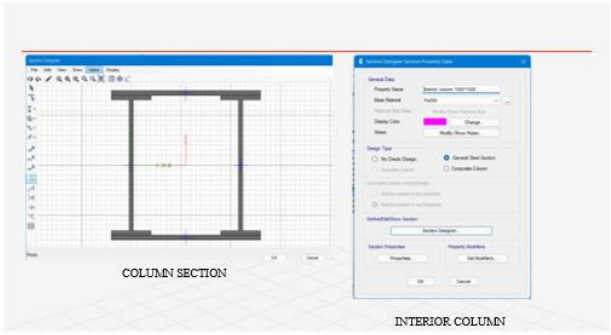


Fig-5.2 Section design of Column section

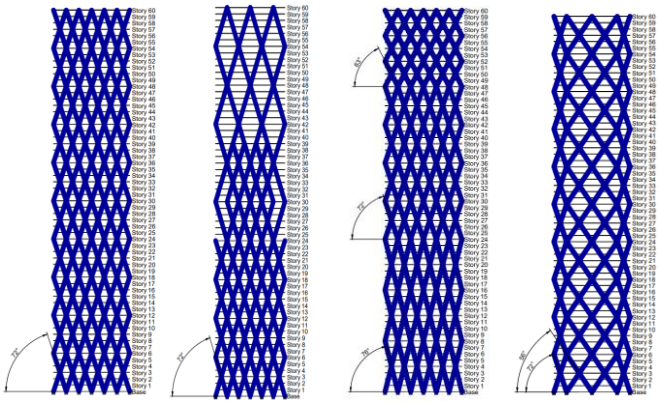


Fig-5.3 Models of Diagrid structure with various Angles

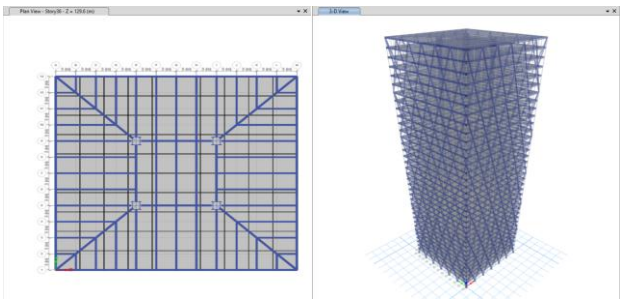


Fig-5.4 Plan view of Diagrid structure

5.2 Loading data

Following loadings are considered for the analysis and design of structure;

Dead Load: Dead load of slab 3.75 kN/m2 + Self-weight of the **structural members.**

Live Load: 2.5 kN/m2

Terrain category: III

Class: C

Wind Load: Static wind loading is calculated as per IS: 875(III)-1987[24]. Dynamic along wind loading is calculated using gust factor method as per IS: 875(III)-1987[24]. Calculation of across wind equivalent static load is presented in Appendix A.

Load Combinations: Load combinations are considered as per IS:800-2007 for design of structure. combinations for the analysis and design of structure as per IS:800-2007.

Earthquake Load: Run model with different seismic zone like II, III, IV & V.

6. CONCLUSIONS

1. The following observations are made based on a comparison of the analysis and results of a 36-story diagrid structural system with a diagrid Angle of 74.75º to analyze the behavior of diagrid structural systems in various seismic zones.
    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift & Srorey displacement increases to 37.7%, 33.08%, & 33.42%.
2. From the comparison of analysis and results of 60 storey diagrid structural system with diagrid Angle of 71.57º to understand the behaviour of diagrid structural system, with various seismic zone following observations are made.
    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift & Srorey displacement increases to 36.42%, 31.12%, & 33.33%.
3. From the comparison of analysis and results of 60 storey diagrid structural system with Shear wall at core and diagrid Angle of 71.57º to understand the behaviour of diagrid structural system, with various seismic zone following observations are made.
    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift &

Srorey displacement increases to 36.42%, 31.12%, & 33.33%.

4. From the comparison of analysis and results of 6 storey diagrid structural system with diagrid Angle of 74.50º to understand the behaviour of diagrid structural system, with various seismic zone following observations are made.

    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift & Srorey displacement increases to 37.20%, 33.25%, & 33.66%.

5. From the comparison of analysis and results of 12 storey diagrid structural system with different vertical density of diagrid Angle up to 4th storey is 70º, 5th to 8th storey is 71º, 9th to 12th 72º to understand the behaviour of diagrid structural system, with various seismic zone following observations are made.

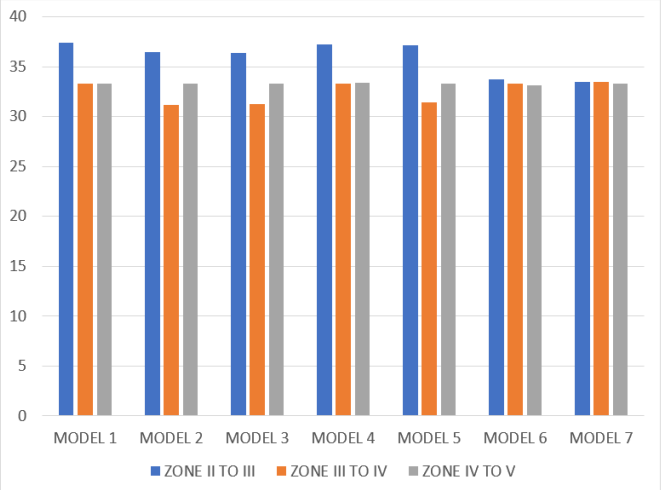
    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift & Srorey displacement increases to 37.38%, 33.40%, & 33.33%.

6. From the comparison of analysis and results of 16 storey diagrid structural system with different vertical density of diagrid Angle up to 5th storey is 55º, 6th to 10th storey is 65º, 12th to 16th 73.47º to understand the behaviour of diagrid structural system, with various seismic zone following observations are made.

    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift & Srorey displacement increases to 37.72%, 33.33%, & 33.13%.

7. From the comparison of analysis and results of 16 storey diagrid structural system with different vertical density of diagrid Angle up to 5th storey is 60º, 6th to 10th storey is 65º, 12th to 16th 71.20º to understand the behaviour of diagrid structural system, with various seismic zone following observations are made.

    - From comparison of analysis results seismic zone II to III to IV & V inter storey drift & Srorey displacement increases to 37.64%, 33.87%, & 33.33%.



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