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ANALYSIS AND COMPARISON OF DIAGRID AND CONVENTIONAL STRUCTURAL SYSTEM

RINJU JOSE

PG student, Department of Civil Engineering, Indhira Gandhi college of Engineering and Technology for Women, Nellikuzhy, Kerala, India

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Abstract - *The rapid growth of urban population and limitation of available land, the taller structures are preferable now a day. So when the height of structure increases then the consideration of lateral load is very much important. For that the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. Recently the diagrid structural system is widely used for tall buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. 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. In my study, analysis of diagrid structural system and conventional structural system for 20storey building is considered. A regular floor plan of 40 m × 40 m size is considered for both structures. ETABS software is used for modelling and analysis of structural members. Comparison of analysis results in terms of storey drift, displacement ,storey shear and also the economical aspect are to be studied.*

Key Words: **Diagrid, Conventional Structural System, E-TABS, Optimum Angle, Diagonals, Tracking Nodes, Axial force.**

1.INTRODUCTION

Tall buildings emerged in the late nineteenth century in the U.S.A. They constituted a so-called "American Building Type," meaning that most important tall buildings were built in the U.S.A. Today, they are a worldwide architectural phenomenon. Many tall buildings are built worldwide, especially in Asian countries, such as China, Korea, Japan, and Malaysia. Based on data available and published in the 1980s, about 49% of the world's tall buildings were located in North America. Diagrid structures represent the most popular and featuring solutions for tall buildings of the new millennium, a sort of signature element of the latest design practice. Both in the case of prismatic, regular buildings, and in the case of complex, non-conventional forms, the diagrid concept offers the structural possibility of combining high efficiency and aesthetic connotation. The high cost of land, the desire to avoid a continuous urban sprawl, and the need to preserve important agricultural production have all contributed to drive residential buildings upward. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. 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 – structural system is widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system.

The diagrid systems are the evolution of braced tube structures, since the perimeter configuration still holds for preserving the maximum bending resistance and rigidity, while, with respect to the braced tube, the mega-diagonal members are diffusely spread over the façade, giving rise to closely spaced diagonal elements and allowing for the complete elimination of the conventional vertical columns. The major difference between a braced tube building and a diagrid building is that, there are no vertical columns present in the perimeter of diagrid building, whereas in braced tube building there are vertical column present in the perimeter of the building. Therefore the diagonal members in diagrid structures act both as inclined columns and as bracing elements, and carry gravity loads as well as lateral forces; due to their triangulated configuration, mainly internal axial forces arise in the members, thus minimizing shear racking effects. The term "diagrid" is a combination of the words "diagonal" and "grid" and refers to a structural system that is single-thickness in nature and gains its structural integrity through the use of triangulation. Diagrid systems can be planar, crystalline or take on multiple curvatures. They often use crystalline forms or curvature to increase their stiffness. Perimeter diagrids normally carry the lateral and gravity loads of the building and are used to support the floor edges.

1.1 OBJECTIVE OF THE STUDY

Safety and minimum damage level of a structure could be the prime requirement of high rise buildings .To meet these requirements, the structure

should have adequate lateral strength & sufficient ductility. In this thesis, I choose two 20 storey buildings, one for diagrid and other for conventional building, in which every storey is of 3m height is taken in both building and analysis values are compared in terms of Shear, Displacement, Drift and also the economical aspect is compared.
The work is to be carried out by conducting-

- Modelling of both the building frames.
- To analyse diagrid and conventional structural systems using ETAB software.
- To compare the performance of the building with diagrid structural system and conventional frame system.
- To obtain the response in terms of parameters such as storey displacement, storey drift, storey shear.
- To study the concept of diagrid structural system.

1.2 SCOPE OF THE PROJECT

Scope of the project includes :

- Attaining more flexibility in planning interior space & façade of building.
- The use of diagrids significantly decreases the maximum shear force and bending moment in internal and perimeter beams.
- Column free structures can be constructed.
- Natural day lighting saves energy consumption.
- Free and clear, unique floor plans are possible.
- Aesthetically dominate and expressive.

2. ANALYSIS OF DIAGRID AND CONVENTIONAL STRUCTURAL SYSTEMS

Two structural models are taken in account for this study, which is diagrid model and conventional structure.

2.1 BUILDING CONFIGURATION

A regular floor plan for diagrid structure and conventional structure is having 40 m x 40 m plan dimension and 60m total height of building (20 storeys). The storey height is 3m for both structures. Size of diagrid is taken 300 mm pipe section with 12mm thickness at an angle of 36.4°. There are two models for comparative study, one is for conventional frame building and another is for diagrid structure. Modeling and analysis and of structures are carried out using ETABS 2013 software.

The physical properties and data of the building considered for the present study is as follows:

Table -1: physical properties and data of the building

Plan area	40 m x 40m
Storey height	3m
Steel sections	Fe 250
Concrete (slabs)	M25
Dead load	3KN/m^2
Live load	2.5 KN/m^2
Slab thickness	120mm
Earthquake load	IS 1893 (part 1):2002
Wind load	IS 875(part 3):1978
Steel design code	IS 800:2007

2.2 DIAGRID BUILDINGS

The structural elements like columns, beams and diagrids are assigned structural steel properties while the slabs are considered of RCC. All sections in buildings are optimized for design sections. For that, all buildings having storeys 20 and above are divided into three parts along the height of the buildings. For the design of diagrids and columns, built-up box sections are used and for the design of beams, Indian Standard I-Sections are used.
Model A = Diagrid structure with X type bracings
Model B = Diagrid structure with V type bracings
Model C = Diagrid structure with I shape bracings
Model D = Conventional structure

2.3 CONVENTIONAL FRAME BUILDINGS

In case of conventional frame, as the height increases, stiffness based design criteria becomes predominant and even if the column sections suffice the strength criteria, maximum lateral displacement exceeds 1/500th of building height. To overcome these excessive member sizes are required as height increases. For the design of columns, built-up box sections are used and for the design of beams, Indian Standard I-Sections are used.

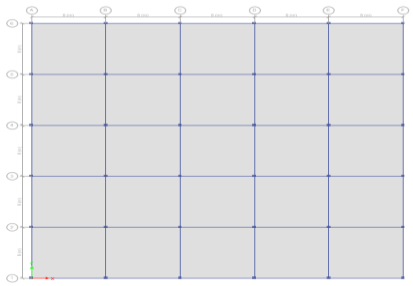


Fig -1: Typical Floor Plan

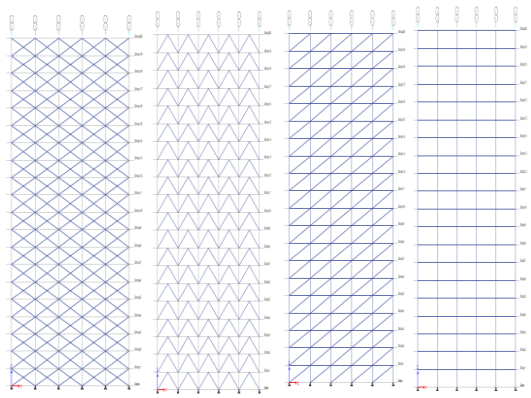


Fig -2: Typical elevation for model A,B,C,D

3. RESULTS COMPARISON AND DISCUSSION

3.1 MAXIMUM STOREY DISPLACEMENT

Chart-1 represent the comparison of the maximum storey displacements for both the systems. The trend of lateral displacements is observed to be similar in both the directions because the building selected in study is symmetrical. It is observed that the pattern of the plot is similar for both systems but the overall displacement values are quite higher for conventional frame. Thus it proves the effectiveness of diagrid structures.

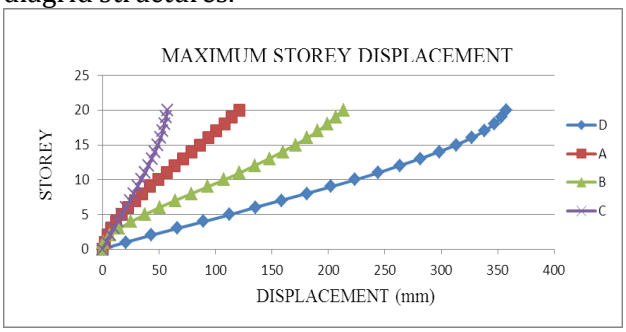


Chart – 1: Comparison of maximum storey displacement

3.2 MAXIMUM STOREY DRIFTS

Uniform storey drift curves are observed in both the cases. But storey drift patterns of conventional frame buildings are observed more uniform while in case of the diagrid buildings highly conservative results are observed. Maximum storey drift are observed at the higher portion of the conventional frame building, while in diagrid buildings sudden variations are observed at storeys where the diagrid sections are changed. As the building is symmetrical, results in both directions are identical.

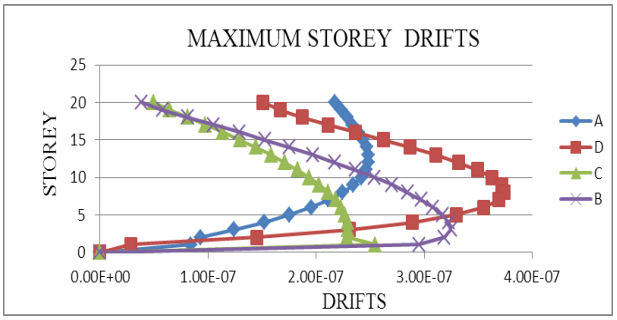
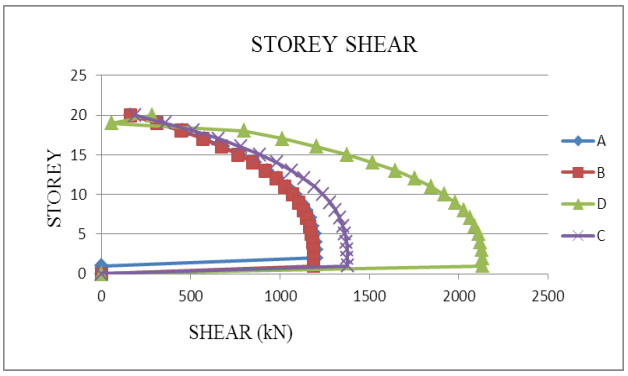


Chart-2: Comparison of Storey drift

3.3 STOREY SHEAR



Chatr-3: Comparison of storey shears

4. CONCLUSIONS

Based on the numerical study carried out in the present research work, following major conclusions can be drawn:

- Displacements on each storey and storey drifts are observed to be less in diagrid systems as compared to conventional frame.
- Diagrid structure provides more efficiency than conventional structure.
- From the study it is observed that diagonal columns are resisted the lateral loads of structure, the top storey displacement is very much less in diagrid structure as compared to the conventional frame building.
- Also, less amount of storey shear is seen in diagrid structure than to the conventional frame structure.

- Diagrid structure gives more aesthetic look and gives more of interior space due to less columns and façade of the building can also be planned more efficiently.

REFERENCES

[1] Dongkyu Lee , Soomi Shin, "Advanced high strength steel tube diagrid using TRIZ and nonlinear pushover analysis", *Journal of Constructional Steel Research* ,January 2014,Vol.6, PP 151-158.
[2] Giovanni Maria Montuori , Elena Mele, Giuseppe Brandonisio, Antonello De Luca," Geometrical patterns for diagrid buildings: Exploring alternative design strategies from the structural point of view", *Engineering Structures,* January 2014, Vol.71, PP 112-127.
[3] Nishith B. Panchal, Vinubhai R. Patel, " diagrid structural system: strategies to reduce lateral forces on high-rise buildings" *, Journal of Research in Engineering and Technology,* April 2014,Vol.3, PP 2319-1163.
[4] G M Montuori , Elena Mele, Giuseppe Brandonisio, Antonello De Luca," Secondary bracing systems for diagrid structures in tall buildings" *Engineering Structures*, June 2014 ,vol. 75 , PP 477–488.
[5] Ravi K Revankar, R.G.Talasadar, "Pushover Analysis of Diagrid Structure" *International Journal of Engineering and Innovative Technology,* September 2014,Vol. 4, Issue 3, PP 168-174.