A Review on Structural Behaviour of Hexagrid & Diagrid Structural Systems in Multi Storey Buildings

Yash Bhardwaj
Research Scholar
Department of Civil Engineering
RKDF, Bhopal, India

Abstract— The advancement of technology and development of economy of the world have brought the new era of tall buildings. The most efficient building system for high rises has been the tube-type structural systems. Now-a-days, a particular structural system called a diagrid system has caught the attention of engineers. In order to improve the efficiency of tube-type structures in tall buildings, as both structural and architectural requirements are provided well, a new structural system, called "Hexagrid", is introduced in this study. It consists of multiple hexagonal grids on the face of the building. However limited academic researchers have been done with focus on the structural behaviour, design criteria and performance assessment of this structural system.

Key words: Hexagrid, Diagrid, Displacements Profile, Structural Systems

I. INTRODUCTION

Tall building development involves various complex factors such as economics, aesthetics look, technology, municipal regulations, and politics. Among these, economics has been the primary governing factor. For a very tall building, its structural design is generally governed by its lateral stiffness. Comparing with conventional orthogonal structures for tall buildings such as framed tubes, diagrid structures carry lateral wind loads much more efficiently by their diagonal member's axial action. A Diagrid structure provides great structural efficiency without vertical columns have also opened new aesthetic potential for tall building architecture. Diagrid has a good appearance and it is easily recognized. The configuration and efficiency of a diagrid system reduces the number of structural element required on the façade of the buildings, therefore less obstruction to the outside view. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, and therefore allowing significant flexibility with the floor plan. "Diagrid" system around perimeter saves approximately 20 percent of the structural steel weight when compared to a conventional moment- frame structure. The diagonal members in diagrid structural systems carry gravity loads as well as lateral forces due to their triangulated configuration. Diagrid can save up to 20% to 30% the amount of structural steel in a high- rise building. 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.

II. LITERATURE REVIEW

Akshat and Gurpreet Singh (2018) reviewed research published on the structural performance of diagrid system. A first step toward a systematic and comprehensive study is that regular patterns are compared to alternative geometrical configurations, obtained by changing the angle of diagonals (variable-angle, VA) as well as by changing the number of diagonal (variable-density, VD) along the building height. Further it discusses about the different diagrid patterns generated and designed for an assumed building; and how the resulting diagrid structures are assessed under gravity and wind loads and various performance parameters are evaluated on the basis of the analyses results. Md. Arman (2018) analysed the performance of high-rise buildings, it is especially important that an effective modelling technique be involved because of the complexity of the real structural behaviour and the difficulties of full scale measurement. The lateral performance of multi-storey buildings under different loading conditions is greatly influenced by various parameters such as structural stiffness and base to height ratio of the building. Optimization and refinement of such performance has become the focus as well as the constraint for structural engineers in their design practice. Avnish Kumar Rai & Rashmi Sakalle (2017) analysed a regular eleven storey RCC building with plan size 16 m × 16 m located in seismic zone V & III is considered for analysis. STAAD. Pro software is used for modelling and analysis of structural. Seismic zone is considered as per IS 1893(Part 1): 2002. The Comparison between the diagrid and conventional building analysis results presented in terms of a node to node displacement, bending moment, storey drift, shear forces, an area of reinforcement, and additionally the economical aspect. Kona Narayana Reddy and Dr. E. Arunakanthi (2017) studied on the Oblique columns of different shapes in high rise building. In this work a high rise building with Normal Columns & with different locations of Oblique columns is considered for analysis. In this paper, response spectrum & Linear Static analysis were executed combined with a Numerical Building Model by this program, which were also compared following the analysis results. The results of the analysis on the Axial forces, Base shear, Time period, Storey drift and Displacements are compared. The results are presented in tabular and graphical form. The results on the displacement are checked with serviceability conditions and are compared and presented in tabular form.

Ravi Sorathiya and Prof. Pradeep Pandey (2017) presented a stiffness-based design methodology for determining preliminary member sizes of RCC diagrid structures for tall buildings. A G+24, G+36, G+48, G+60 storey RCC building with plan size 18 m × 18 m located in surat wind and seismic is considered for analysis.

STAAD.Pro software is used for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 and load combinations of seismic forces are considered as per IS 1893(Part 1): 2002. Comparison of analysis results in terms of beam displacement, Storey Drift, Bending Moment. This cause economical design of diagrid structure compared to conventional structure. Harshada A. Naik (2017) presented the literature review of different authors on behaviour of diagrid structures under wind loading and seismic loading to understand the performance of diagrid structures. This study gives good indications on parameters in terms of time-period, top-storey displacement, inter-storey drift and storey shear. Viraj Baile (2017) analysed a 36-storeyed diagrid building, simple frame building and a building with various bracing systems have been modelled and analysed. The bracing systems are X-type, V-type and Inverted V- type. The positions of the bracings have also been varied. A total of 15 buildings have been modelled and analysed to compare which system performs better a lateral load resisting system. The modelling and analysis has been performed on ETABS. The dynamic analysis is performed by using Response Spectrum Method. All the loadings and the checks are provided as per Indian Standards. Pallavi Bhale and P.J. Salunke (2016) analysed a regular five storey RCC building with plan size 15 m × 15 m located in seismic zone V is considered for analysis. STAAD. Pro software is used for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 and load combinations of seismic forces are considered as per IS 1893(Part 1): 2002. Comparison of analysis results in terms of storey drift, node to node displacement, bending moment, shear forces, area of reinforcement, and also the economical aspect is presented. Drift in diagrid building is approx. half to that obtained in conventional building. Steel consumed in diagrid building is 33.21 % less as compared to conventional frame.

III. Conclusion

From the literatures reviewed it was revealed that:

1) Diagrid performs better across all the criterions of performance evaluation, such as efficiency, expressiveness and sustainability.
2) Diagrid structures have higher stiffness than other structures.
3) Diagrid structures have less deflection as compared to the conventional structures.
4) Weight of the structure gets reduced to a greater extent due to which structure has more resistance to lateral forces.
5) Displacement on each storey, storey drift and storey shear are observed to be less in diagrid structures as compared to conventional structures.
6) Diagrid structure gives more aesthetic look and gives more of interior space. Due to less number of columns, façade of the building can also be planned more efficiently.
7) Greater granularity of structural pattern is more efficient for resisting vertical loads. While for lateral loads, variation of granularity has no significant impact to the structural efficiency, although smaller granularity tends to perform better.
8) Lateral load is resisted by 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.
9) 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.
10) Diagrid structure system provides more economy in terms of consumption of steel as compared to other structural system. So, diagrid structure is cost effective and eco-friendly.

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