A Review of Study About Design And Analysis of Hexagrid And Diagrid Building Structure With Regular Building Structure

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Abstract- *The latest trend in high rise building is diagrid structures because of structural and architectural effectiveness. In the study previous literatures are studied for Flat-slab Building and detailed analysis is carried out to check the behaviour of flat-slab buildings with and without diagrid. It is very important that the selected structural system is such that the structural elements are utilized effectively while satisfying design requirements. Recently diagrid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Structural design of high-rise buildings is governed by lateral loads due to wind or earthquake. Lateral load resistance of the structure is provided by interior structural system or exterior structural system. 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 building. This paper also reviews the studies on the comparison of diagrids with regular configuration and diagrids with varying angles. The analysis and comparison of diagrid and conventional structural system on the basis of consumption of steel, structural weight and displacement are also highlighted.*

Keywords- Diagrid building, conventional building, Tall Buildings, Storey Displacement, Diagrid Structures, Storey Displacement.

I. INTRODUCTION

The structural system of a high-rise building is designed to cope with the vertical gravity loads and lateral loads caused by wind or seismic activity. The structural system consists only of the members designed to carry the loads; all other members are referred to as non-structural. The term structural system or structural frame in structural engineering refers to load-resisting sub-system of a structure. The structural system transfers loads through interconnected structural components or members. Diagrid structure consists of inclined columns on the exterior surface of the building. Due to inclined columns, lateral loads are resisted by axial action of the diagonal compared to bending of vertical columns in framed tube structure. Diagrid structures typically, don't need core because of lateral shear may be carried by the diagonals on the outer boundary of a building. The number of high-rise building is increasing day by day due to urban development and unavailability of land. As the height of the building increases, both lateral load and gravity load becomes important in the design. The structures are classified into interior structures and exterior structures based on the distribution of components of lateral load resisting elements. When major part of the lateral load resisting elements is located within the interior of the building, the system is termed as interior structures whereas if the lateral load resisting elements is located at the building perimeter, they are termed as exterior structures. Shear wall core, braced frame, outrigger structures constitute the interior system and framed tube, braced tube, diagrid constitute the exterior system.

II. CLASSIFICATION OF TALL BUILDING STRUCTURAL SYSTEMS

Structural system in tall buildings can be divided into two broad categories: Interior structures and Exterior structures (Fig. 1). This classification is based on distribution of components of the primary lateral load resisting system over building. An interior structure is when its major part of lateral load resisting system is located within interior of structure and an exterior structure is, if the major part of lateral load resisting system is located at the building perimeter.

Classification of tall building structural system

1. Interior Structures
   - Shear Wall/shear Trusses
   - Core Supported Outrigger structure
   - Moment-Resisting frame (MRF)

2. Exterior Structures:

- Diagrid system
- Bundled Tube
- Braced Tube
- Space Trusses
- Framed Tube System
- Tube-In-Tube

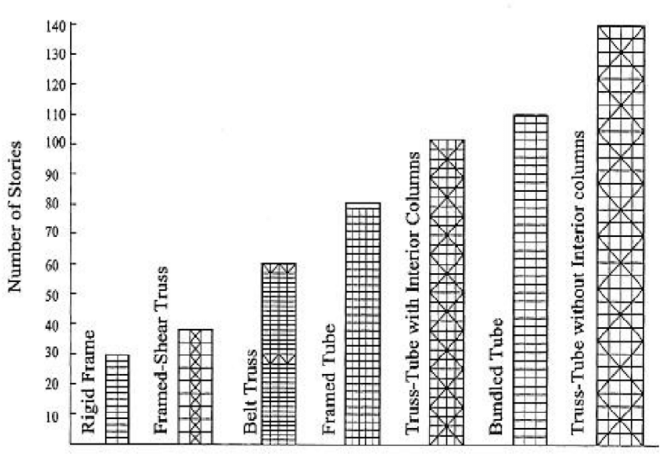

Figure 1. Exterior Structure

III. LITERATURE REVIEW

Jateen M. Kachchhi et. al. (2019) The studied about the most effective and economical system which can resist lateral load such as wind load and seismic load. Based on literature review, carry out comparative study of various lateral load resisting systems such as Shear wall, Belt Truss, Outrigger, Belt Truss + Outrigger, Diagrid, Staggered Truss, Tube in Tube system of 10 story structure with plan dimension of 18m X 18m. Analysis has been carried out using ETABS-2017 for different method of analysis for static earthquake forces, dynamic earthquake forces. and static wind forces as per IS 875 (Part-3)-2015 and design based on IS: 800-2000 and found that storey Displacements and storey drifts are observed to be less in Diagrid systems in X Direction as compared to other lateral load resisting system.

Jayesh Akhand et. al. (2019) Analysed and designed of 16 storey diagrids building with plan of 18 m × 18 m size is considered. Staad professional software system is employed for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 considering all load combinations. Seismic load as Dynamic load as per IS1893-2002 and Wind load as IS 875-part 3 considered for analysis and design of the structure. Load distribution in diagrid system is also studied for 16 storey building. Response spectrum analysis results provides a more realistic behaviour of structure response and diagrid structure is more effective in lateral load resistance Seismic and wind analysis of conventional building with different shapes of diagrid building with equivalent plan area at seismic zone III is carried out.

Safiya Daliya Ahammed et. al. (2019) In order to improve the efficiency of tube-type structures in tall buildings, a new structural system, called "Hexagrid", is introduced in this study. It consists of multiple hexagonal grids on the facade of the building. In hexagrid structural system almost all the conventional columns are eliminated. In the study structural models, the linear static and dynamic analysis is performed to investigate the performance point of the building frame in terms of displacement, Time period, Drift ration and Base shear. The performance point of T shape and L shape plan irregularity is almost nearer to each other. It may be due to same plan area. Time period increases with increase in height of the building.

Yash Bhardwaj (2019) studied about behaviour of hexagrid & diagrid structural system in multi storey buildings. 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. Diagrid performs better across all the criterions of performance evaluation, such as efficiency, expressiveness and sustainability.

Akshat et. al. (2018) the study is made on the basis of lateral load due to earthquake. There are various structural systems for resisting the lateral load but the diagrid structural system is in trends nowadays and adopted for research work. In this paper, a 60-storey tall building of height 216 m is analysed. The plan dimension of the building is 48 m × 48 m. The building is analysed for lateral load due to earthquake in seismic zone IV. Various patterns of the diagrid were used in the dynamic analysis by varying the angles of the diagonal elements. The analysis is performed by using ETABS software.

Deepthi et. al. (2018) The objective of this study is to analyse the behaviour of the outriggers and to choose the appropriate system among the different outrigger structural system. The structural response parameters like base shear, lateral displacement, storey drift and time period are compared. The structural efficiency of each system is studied depending on different configuration adopted based on the considered parameters. The displacement of model 1 without any lateral resisting systems seems to be higher and the model of outrigger with truss core is exhibiting least displacement

compared with other models in Equivalent static analysis. There is reduction of about 23% in displacement compared to Model 1 and Model 3.

Pattan Venkatesh et. al. (2018) This study presented the structural behaviour of three models of 60 storey buildings viz., Conventional rigid framed building with rectangular plan having plan dimensions of 24mx24m, diagrid building with rectangular plan having plan dimensions of 24mx24m and diagrid building with circular plan having a plan diameter of 24m. Modelling and Analysis for all the above buildings is done for gravity, earthquake and wind loads using ETABS software. IS 800:2007 is used for the design of the structural members. All the three models are analysed and compared using the parameters such as base shear, storey displacement, time periods, structural weight and storey drifts.

Sayyed Kamran Altaf et. al. (2018) studied about parametric study of diagrid, pentagrid and hexagrid structural system. Maximum storey displacement in Diagrid structure is less as compare to other structural systems like pentagrid and hexagrid structural system. Maximum storey drift in Diagrid structure is less as compare to other structural systems like pentagrid and hexagrid structural system. Base shear in Diagrid structure is less as compare to other structural systems like pentagrid and hexagrid structural system. Height is main criteria in this kind of buildings, demand for tall buildings has increased because of increase in demand for business and residential space, advances in constructions, high strength structural elements, materials and also various software like Etabs, Staad pro etc these are analysis and design software's have provided growth of high-rise structures.

Yogeesh et. al. (2018) A Comparative study of 8 storey bare frame building and a diagrid building is presented. A 'C' shaped floor plan of 16 m × 16 m size was considered. ETABS was used in modelling and analysis of structural members. All structural members were designed as per IS 456:2000, load combinations such as dead load, live load and design earthquake loads were considered for analysis and design of the structure. Later both bare frame and diagrid structural systems were compared; the comparative study of diagrid structural system shows an increase in the responses like storey shear, storey stiffness and decrease in the responses like storey displacement and storey drift. The Storey displacement and story drift is maximum for RC bare frame and minimum for RC frame with diagrid.

Avnish Kumar Rai et. al. (2017) In present research work, steel diagrid structure at an outer portion of the building at 60 degrees having an inner core of R.C.C columns with R.C.C beam and the slab is analysed and compared with a conventional concrete building. The diagonal member of diagrid structure transferred the lateral loads by axial action compared to bending of vertical columns in the conventional building system. 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. 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.

Divya et. al. (2017) Analysis of 48 storied Steel building with diagrid system and hexagrid system is presented. Modelling and analysis of structural member is done using finite element software ETABS. Loads, load combinations and seismic data are provided according to IS 875:1987and IS 1893:2002 respectively. Comparison of analysis results with conventional system is done in terms storey displacement, storey shear, storey drift and time period. The top storey displacement is very much less in diagrid and hexagrid compared to the conventional system since the diagonal columns resist lateral load of the structure. Both diagrid and hexagrid system promise highly efficient structure.

Gopisiddappa et. al. (2017) Aimed to study the behaviour of tall building without any lateral load resisting system. To examine response of high rise building with diagrid system. The present work consists of analysis of 30 storey linear building and analysis of diagrid systems with different diagonal angles that is 45-degree, 63-degree, 73-degree, 75-degree, 78-degree, 81 degree. The comparison between linear building and diagrid building is carried out. ETABS software is used for modelling and analysis of structure. Analysis results like storey displacement, interstorey drift are presented here.

Reviewed papers have designed different storey structures with different diagrid angles taking regular, variable angle diagrid structures. Comparison is done between terms like storey drift, time period, angle of diagrid, steel and concrete consumption. Results depict that variable angle system are effective than regular diagrid structures and regular diagrid is better than regular frame structure. The diagrid structure reduces column count which provides more rentable space in the same plane area as that of framed system. Results also depict the requirement of the study of the diagrid structural system combined with different cores to increase its effectiveness and height.

IV. CONCLUSION

This paper presents a review on diagrid structural systems for the resistance against lateral loads for tall buildings. The study on load distribution showed that most of the lateral load is resisted by the diagrids in the periphery whereas gravity load is almost equally resisted by internal columns and periphery diagonals. This makes the structure more economical and improves the aesthetics. The comparative analysis of both steel and concrete diagrid structural system with conventional system showed remarkable reduction in responses such as displacement, inter-storey drift.

REFERENCES

[1] Jateen M. Kachchhi, Snehal V. Mevada, Vishal B. Patel, "Comparative Study of Diagrid Structure with Other Structural Systems for Tall Structures", Global Journal of Engineering Science and Researches, vol. 4, 2019.

[2] Jayesh Akhand, J.N Vyas, "Comparative Study of Different shapes of Diagrid Structure System with Conventional System using Response Spectrum Analysis", International Research Journal of Engineering and Technology (IRJET), Volume: 06, Issue: 04, Apr 2019.

[3] Safiya Daliya Ahammed, Shahla C. P, "Seismic Behaviour of Hexagrid Type Structural System", International Journal of Engineering Research & Technology, Vol. 8 Issue 02, February-2019.

[4] Yash Bhardwaj, "A Review on Structural Behaviour of Hexagrid & Diagrid Structural Systems in Multi Storey Buildings", International Journal for Scientific Research & Development, Vol. 6, Issue 11, 2019.

[5] Akshat, Gurpreet Singh, "Dynamic Analysis of Diagrid Structural System in High Rise Steel Buildings", International Journal of Civil Engineering and Technology, Volume 9, Issue 8, August 2018, pp. 71–79.

[6] Deepthi M, Umashankar Patil G H, "Parametric Evaluation of Outrigger Structural System for High Rise Buildings", International Journal of Research in Advent Technology, Special Issue, August 2018.

[7] Pattan Venkatesh, Sujay Deshpande, Shweta Patil, "A Comparative Study on the Structural Analysis of Diagrid Structural Systems with Conventional Structural Systems for different Plan Configurations", International Journal for Research in Applied Science & Engineering Technology, Volume 6 Issue VI, June 2018.

[8] Sayyed Kamran Altaf, "Parametric Study of Diagrid, Pentagrid and Hexagrid Structural System", International Journal of Technical Innovation in Modern Engineering & Science, Volume 4, Issue 8, August-2018.

[9] Yogeesh H.S, V. Devaraj, "A Seismic Study on Diagrid Structure", International Journal for Research in Applied Science & Engineering Technology, Volume 6 Issue VI, June 2018.

[10] Avnish Kumar Rai, Rashmi Sakalle, "Comparative analysis of a high-rise building frame with and without diagrid effects under seismic zones III & V", International journal of engineering sciences & research Technology, 2017.

[11] Divya, B. Saraswathy, "Comparative Analysis of High-Rise Steel Building with Hexagrid, Diagrid and Conventional Structural System", International Research Journal of Engineering and Technology, Volume: 04, Issue: 04, Apr -2017.

[12] Gopisiddappa, M. Divyashree, Sindhuja, "Performance Study of High-Rise Building with Diagrid System Under Dynamic Loading", International Research Journal of Engineering and Technology, Volume: 04 Issue: 06, June -2017.