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A Review Paper on Comparative Analysis of Diagrid Structure with Various Indian Seismic Zone

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Abstract – The need for high-rise structures has grown tremendously, necessitating a thorough examination of effective and modern structural systems to select the most appropriate construction for a specific situation. A tall building's structural system should be designed in such a way that it maximizes structural efficiency. The purpose of this research is to compare the structural systems of diagrids. The analysis is based on a 42 m x 42 m standard floor design. E-tabs software is used to analyse a diagrid structural system for a 40-story steel building subjected to lateral loads in seismic zones II, III, IV, and V. (i.e., Angles for diagrid system and variation in density). For structural analysis, response spectrum analysis for earthquake loading and the gust factor approach for dynamic along wind response are addressed. The top storey displacement, inter-storey drift, and first mode time period are used to compare the analysis results.

***Key Words*: Seismic behaviour, Diagrid structure, Angles for diagrid system, Response spectrum analysis, E-tabs**

1. INTRODUCTION

High-rise buildings have now been proven to be the most appropriate solution to problems of land scarcity and rising rates in all areas of urbanization in the last few decades. Wind and earthquake lateral loading, as well as gravity loading, are governing considerations in the construction of high-rise buildings. As structures have become taller and slender, structural engineers have been put to the test to meet the enforced drift requirements while minimizing the structure's architectural appearance.

Engineers have developed and incorporated several new lateral loads resisting structural systems (bundled-tube, diagrid, outrigger systems, etc.) in many high-rise buildings over the last five decades as technology has progressed, in an attempt to reach the safety, serviceability, and aesthetic criteria while minimizing the material used. In the past, structural form changes have been made in response to new architectural trends in high-rise building design.

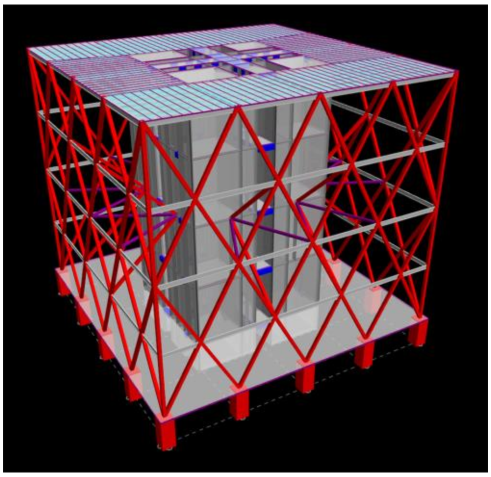

Fig -1.1: Diagrid structural model

Because of its greater structural efficiency and economy in terms of steel tonnage than other structural systems, the diagrid structural system has recently become one of the finest solutions for Tall Concrete-Steel Buildings. As an exterior lateral load resisting system, a diagrid structure comprises inclined diagonal columns on the building's exterior periphery. The axial movement of the diagonal resists lateral loads due to inclined columns.

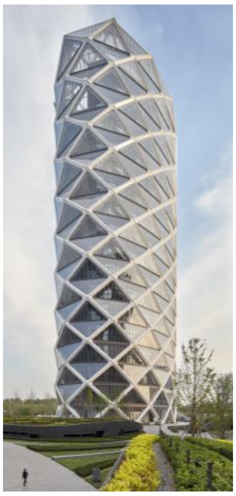

Fig -1.2: Real-life Diagrid structural system

1.1HISTORY OF DIAGRID STRUCTURE:

A diagrid (a portmanteau of the diagonal grid) is a framework for constructing and roof creation made up of diagonally intersecting metal, concrete, or wooden beams. In evaluation to a conventional metal frame, it calls for much less structural metal. Norman Foster's layout for the Hearst Tower in New York City makes use of 21% much less metal than a normal structure. The diagrid removes the requirement for columns and may be applied to create huge roofs with no columns. The diagrid gadget is likewise utilized in another conventional foster construction, 30 St Mary Axe in London, UK, widely regarded as "The Gherkin."

As illustrated in Fig.1.1.1, the 13 IBM Building in Pittsburgh, which was completed in 1963, is an early example of the successful use of the diagrid system. Diagonal bracing members are a remarkably efficient structural element for lateral load resistance. As a result, most high-rise structures have steel frames with diagonal bracing of various configurations, such as X, K, and eccentric, to successfully withstand lateral loads. Diagonal bracings are frequently integrated into the building cores, which are normally found inside the structure.

Fig -1.1.1: IBM Building

1.2OBJECTIVE

- To build a diagrid structural model in ETABS 19.
- To investigate a diagrid structural system with shear and braced core walls for four different angles and densities in four different Indian seismic zones.
- To study the differences in structural reaction caused by earthquake motions in different Indian seismic zones.
- To establish the appropriate diagrid system layout for various seismic zones that results in an ideal solution.

2. Literature Review

Elena Mele, Maurizio Toreno [1] The structural performance of diagrid structural systems in tall buildings was discussed. They discussed the properties of diagrid systems, with a focus on structural behavior under gravity and lateral load, as well as design requirements based on strength and stiffness. They also compared the structural performance of various modern diagrid big buildings, including the Swiss Re building in London, Hearst Headquarters in New York, and Guangzhou's West Tower.

They conclude how an overview of the structural behavior of diagrid structures in tall buildings has been presented after their study and analysis effort. A consideration of the consequences of the building form as well as the diagonal slope has been presented, starting with the evaluation of internal forces arising in the single triangular module under the effects of both gravity and wind loads. The foregoing principles on internal force evaluation were applied to three case studies, namely the Swiss Re building in London, the Hearst Headquarters in New York, and the West Tower in Guangzhou, and the results were compared to equivalent conclusions produced from computer analysis.

C. Rahul and J. K. Lokesh [2] Using E-tabs V.15.2 software, the seismic behavior of Diagrid structures with flat slab (DFS) and Diagrid structures with normal slab (DNS) was discussed. The best diagrid angle is determined using a stiffness-based approach among five distinct angles: 41°, 50°, 56°, 61°, and 64°. In general, diagrid structures handle both gravity and lateral loads, however, four internal columns that carry gravity load are added to improve the structure's efficiency.

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Mangesh Vhanmane and Maheshkumar Bhanuse [3] The modeling of high-rise building structures with diagrid configurations of various angles was studied. Under gravitational and lateral stresses, the behavior of high-rise buildings structures with diagrid configurations is investigated. Furthermore, investigate the behavior of high-rise buildings with diagrid configurations for various parameters such as storey displacement, storey drift, and base shear.

The diagrid angle between 65° and 72° is best suited for height ranges between 120 and 240 m, according to this research.

Merry James and Neeraja Nair[4] The behavior of geometrically uneven buildings with diagrid is investigated, and the diagrid's optimum angle for a regular geometry diagrid is discovered. The focus of this work is seismic analysis. Nonlinear dynamic analysis is recommended since it is the only method that accurately describes the real behavior of a structure during an earthquake. Nonlinear dynamic analysis is advised in the case of diagrids with an incomplete module at the top. The El Centro Earthquake (Imperial Valley event) occurred in southern California in 1940, and the time history function data used in the study procedure came from that earthquake. On the Mercalli intensity scale, it had a moment magnitude of 6.9 and a maximum perceived intensity of X (Extreme).

In terms of maximum displacement and drift, the time history analysis of the symmetric model reveals that the module 2 diagrid structure with an angle of 67.22° outperforms other angles. Module 2 diagrid has reduced maximum displacement and storey drift. As the diagrid angle increases, so does the base shear and structural weight. For structural weight, there is just a slight reduction.

KYOUNG-SUN MOON, JEROME J. CONNOR AND JOHN E. FERNANDEZ [5] The various configurations of the diagrid structure were studied in detail. They are given the shear force, extensional strain, transverse shearing strain, total extensional strain, and other equations to calculate. The optimal angle of the columns for maximum bending stiffness is 90°, and the optimal angle of the diagonals for maximum shear rigidity is around 35°; it is assumed that the optimal angle of the diagonal members of diagrid constructions will be somewhere in between. A collection of 60-story structures with various diagrid angles are planned and evaluated using SAP2000 to test these assumptions as well as to identify the real range of ideal angles. The research is carried out again for buildings with 42 and 20 stories.

The effect of the diagonal angle on the behavior of diagrid-type structures was investigated in this work. The best range of diagrids angle for 60-story diagrid constructions with an aspect ratio of around 7 was discovered to be between 65° and 75°. Because the contribution of bending to total lateral displacement reduces as the building height falls, the range for 42-story buildings with an aspect ratio of roughly 5 is around 10° lower. The optimal angle study results, the simple member sizing methodology, and other topics discussed, such as architectural, constructability, and urban contextual issues, are expected to be extremely useful to both engineers and architects for the preliminary design of diagrid structures, according to the authors.

3. CONCLUSIONS

According to the result of the research, flat slab diagrid structures perform better than standard slab system (i.e., with beam) diagrid structures in terms of storey displacement in case of earthquakes.

Also, this research provided real-world examples of how to take an angle that yielded excellent outcomes in terms of stability. A diagrid angle of 61° to 72° is optimal for heights between 120 and 240 m. However, the diagrid construction with a 67.22° angle surpasses other angles in terms of maximum displacement and drift.

REFERENCES

[1] Elena Mele, Maurizio Toreno*, Giuseppe Brandonisio and Antonello De Luca. “Diagrid structures for tall buildings: case studies and design considerations” [THE STRUCTURAL DESIGN OF TALL AND SPECIAL BUILDINGS Struct. Design Tall Spec. Build. (2012) Published online in Wiley Online Library]

[2] C. Rahul and J. K. Lokesh “Seismic Behavior and Comparison of Different Slab System Diagrid Structure” SPRINGER Nature Singapore Pte Ltd. 2021

[3] Mangesh Vhanmane and Maheshkumar Bhanuse “Study of Behavior of High-Rise Buildings with Diagrid Systems” SPRINGER Nature Singapore Pte Ltd. 2021

[4] Merry James and Neeraja Nair “Seismic Performance Analysis of Vertically Irregular Structures with Diagrid” SPRINGER Nature Singapore AG 2020

[5] KYOUNG-SUN MOON, JEROME J. CONNOR AND JOHN E. FERNANDEZ “Diagrid structural systems for tall buildings: characteristics and methodology for preliminary design” THE STRUCTURAL DESIGN OF TALL AND SPECIAL BUILDINGS Published online in Wiley Interscience.

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