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A REVIEW ON ANALYSIS OF STEEL BUILDINGS WITH DIAGONAL-BRACING STRUCTURAL SYSTEMS

Ashish[1], Sunil Kumar[2]

[1]M.Tech. Scholar, Ganga Institute of Technology and Management, India

[2]Assistant Professor, Ganga Institute of Technology and Management, India

ABSTRACT

Civil engineers have shifted their focus to designing elevated buildings that can withstand lateral earthquake loads. The Diagonal-grid structural system has emerged as an innovative and flexible solution. It utilizes inclined columns arranged in a bordered tube pattern on the building's outer surface, allowing axial action to resist lateral loads. This system offers advantages such as improved organizational efficiency and architectural flexibility. Research is needed to explore its structural characteristics further. In this study, linear dynamic analysis using the response spectrum technique was performed in ETABS to compare the Diagonal-grid system with traditional systems. The analysis considered parameters such as top storey displacement, inter-storey drift, base shear, and time period. The impact of module variation on these parameters was investigated by studying alternative high-elevation constructions with different module sizes vertically and horizontally. Furthermore, the influence of the shear wall core and external corner columns on the Diagonal-grid system's behavior was examined. The Diagonal-grid system has proven effective not only in tall buildings but also in mid-rise steel structures. Despite challenges such as design complexity, node building, and higher construction costs, the system's benefits outweigh the drawbacks. Consequently, further research into this promising system is warranted.

Keywords: elevated buildings, Diagonal-grid system, lateral earthquake loads, structural characteristics, research

1. INTRODUCTION

With the rapid growth of population and limited availability of land, the demand for larger structures has increased, leading to a shift towards vertical expansion. As buildings reach greater heights, the role of wind and seismic resistance systems becomes crucial in ensuring their structural integrity. Among the various types of structures, steel and reinforced concrete systems are commonly employed due to their strength, durability, and ease of construction. In this context, this article explores the different structural systems used in tall buildings. The focus is on the Diagonal-grid system, which has gained popularity for its innovative and adaptable nature. The Diagonal-grid structure consists of inclined columns spread out in a bordered tube configuration, allowing for efficient load distribution and lateral load resistance through axial action. The research aims to analyze and compare the structural characteristics of the Diagonal-grid system with traditional systems. Linear dynamic analysis using the response spectrum technique is performed to evaluate parameters such as top storey displacement, inter-storey drift, base shear, and time period. The impact of module variation on the performance of the Diagonal-grid system is also investigated. Additionally, the study explores the influence of the shear wall core and external corner columns on the behavior of the Diagonal-grid system. Understanding these aspects will provide valuable insights into the design and performance of elevated buildings subjected to tangential earthquake loads. By examining the benefits and limitations of the Diagonal-grid system and studying its behavior under different scenarios, this research aims to contribute to the advancement of structural engineering in the context of tall buildings.

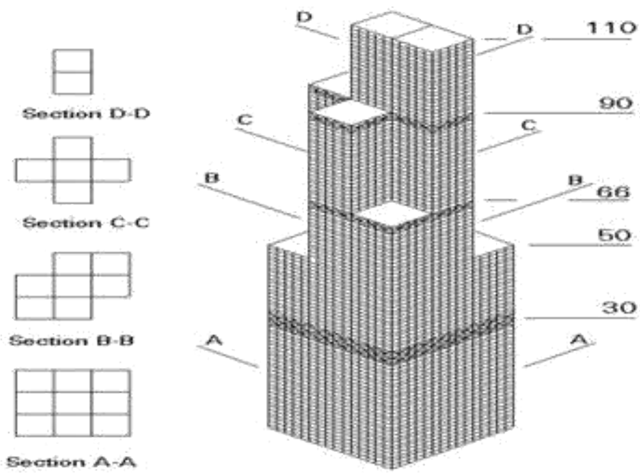

Figure 1: Bundled Tube System

2. METHODOLOGY

The methodology employed in this research focuses on the load transmission mechanism and analysis of the Diagonal-grid structure using the ETABS software. ETABS was selected for its proficiency in modeling building structures and its capabilities in structural analysis. ETABS, an acronym for Extended Three Dimensional Analysis of Building Systems, is an integrated structural analysis program widely used in the building design process.

It utilizes finite element-based analysis techniques and offers advanced features for designing and analyzing building systems. These include 3D object-based modeling, visualization tools, quick linear and nonlinear analysis capabilities, comprehensive design capabilities for a wide range of materials, and informative graphical presentations, reports, and schematic drawings.

For the analysis of Diagonal-grid structures, which are primarily subjected to seismic and wind loads, the seismic design approach is adopted, considering the influence of lateral loading on tall structures. Several earthquake design methods are employed, including static analysis, dynamic study, response spectrum analysis, period antiquity examination, and pushover analysis.

In particular, the response spectrum analysis method is utilized, which involves computing the overall response of a multi-degree-of-freedom (MDOF) system by performing spectral analysis on a single degree of freedom (SDOF). This approach relies on modal analysis and the definition of response spectra to approximate the linear behavior of the structure. A linear dynamic analysis is conducted to evaluate the building's response to seismic loads.

The structural modeling process involves comparing the Diagonal-grid structural system with conventional systems in the first part of the study. The second part investigates the effect of module variation both vertically and horizontally. The third part examines the impact of the shear wall core, and the final part demonstrates the influence of an external corner column in the Diagonal-grid structural system.

By employing this methodology, a comprehensive analysis of the Diagonal-grid structure's behavior and performance under various conditions is conducted, providing valuable insights into its load transmission mechanism and structural characteristics.

3. RESULTS AND DISCUSSION

The comparative study between an ordinary structural system and a Diagonal-grid structural system provides insights into their behavior under dynamic loads. Both structures have the same floor plan, consisting of 30 storeys with a height difference of 3.2 meters between each story. The constructions are designed for Seismic Zone 4 with medium soil conditions.

In the traditional structural system, a reinforced concrete core wall system is located at the plan's midsection, providing stability and resistance to lateral loads. On the other hand, the Diagonal-grid structural system incorporates perimeter structural steel diagonal columns connected to a central reinforced concrete core wall system through perimeter horizontals with optimal angles. This triangulated network allows the Diagonal-grid structure to efficiently resist both lateral and gravity stresses.

The angle of the diagonals in the Diagonal-grid system is set at 70 degrees, resulting in a 6-story module. This module size plays a crucial role in load transmission and overall structural performance. The analysis of both structures under dynamic loads using the ETABS software provides valuable results in terms of structural behavior.

Parameters such as top storey displacement, inter-storey drift, base shear, and time period are evaluated to assess the performance of the structures. The results obtained from the analysis indicate that the Diagonal-grid structural system outperforms the traditional structural system in terms of lateral load resistance.

Due to the triangulated network of diagonal columns, the Diagonal-grid structure exhibits higher rigidity and better load distribution, leading to lower top storey displacement, reduced inter-storey drift, and improved overall stability. The findings also highlight the importance of module variation in the Diagonal-grid system. By varying the module size both vertically and horizontally, the structural response and behavior can be influenced. Further analysis and investigation of different module variations can provide valuable insights into optimizing the performance of Diagonal-grid structures.

Additionally, the impact of the shear wall core and external corner columns in the Diagonal-grid structural system should be considered. These elements play a significant role in load transmission and overall structural stability. By analyzing their effects, design modifications and improvements can be made to enhance the performance of the Diagonal-grid system.

Table 1

Plan Dimension	21.5*21.5 m
Storey Height	3.3 m
Shear Wall core Dimensions	7.2*7.2 m
External to Core Distance	7.2 m

Table 2

Dead loads:	Self-weights of the structures.
Overlaid loadings due to finishes etc:	3.2 KN/m2
Live Loads :	3.2 KN/m2
Seismic loads in X-coordinate:	According to IS 1893:2002
Seismic loads in Y-coordinate:	According to 1893:2002
Wind loadings:	According to IS 875 (Part3)

4. CONCLUSION

- The effect of module size disparity both horizontally and vertically on the structural behaviour of the Diagonal-grid system is studied, as well as the computation of optimal angles for different building heights and module variations.
- In a Diagonal-grid system, the outcome of shear walls core is investigated.
- The Diagonal-grid Structural System is also investigated, both with and without outside c-col.

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