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Dynamic Wind Analysis of Reinforced Concrete Bundled Tube-In-Tube Structure

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Abstract

This research paper investigates the dynamic wind analysis of reinforced concrete bundled tube-in-tube structures. The study focuses on comparing the performance of bundled tube, tube-in-tube, and bundled tube-in-tube structural systems under dynamic wind loading. The analysis is conducted using ETABS software, and the results are evaluated in terms of story displacement, story drift, and base shear. The findings indicate that the bundled tube-in-tube structure exhibits superior performance with reduced displacement and drift compared to the other systems. The study concludes that the addition of internal tubes significantly enhances the structural stability under wind loads.

1. Introduction

1.1 General

The rapid urbanization and population growth have led to the construction of tall buildings, especially in metropolitan areas. High-rise structures are subjected to various lateral loads, including wind and seismic forces, which can significantly affect their stability. The design of tall buildings must account for these lateral loads to ensure structural integrity and safety. This study focuses on the dynamic wind analysis of reinforced concrete bundled tube-in-tube structures, which are known for their efficiency in resisting lateral loads.

1.2 Problem Formulation

The literature review reveals that while several studies have been conducted on various reinforced concrete (RCC) buildings with different tubular systems, there is limited research on the combination of bundled tube and tube-in-tube systems. This study aims to fill this gap by investigating the performance and efficiency of buildings that combine these two structural systems.

1.3 Objectives of Research

The primary objectives of this research are:

1. To formulate the problem statement and develop a methodology for analyzing tube-in-tube, bundled tube, and bundled tube-in-tube structures under dynamic wind loading.
2. To compare the structural performance of these systems in terms of story displacement, story drift, and base shear.
3. To conduct a non-linear analysis of the bundled tube-in-tube structure under dynamic loading.

2. Literature Review

2.1 Introduction

The literature review highlights the advancements in the structural analysis of bundled tube structures and their response to various loading conditions. Several researchers have studied the finite element modeling of bundled tube structures, focusing on their lateral load resistance and stability.

2.2 Gaps in Research Area

Despite the extensive research on tubular systems, there is a lack of studies on the combination of bundled tube and tube-in-tube systems. This study aims to address this gap by analyzing the performance of buildings that integrate these two systems.

3. Methodology

3.1 Finite Element Modeling

The finite element method (FEM) is employed to model and analyze the structures using ETABS software. The structures are subjected to dynamic wind loading, and the results are evaluated in terms of story displacement, story drift, and base shear.

3.2 Structural Systems

Three structural systems are analyzed:

1. **Bundled Tube Structure**: A system consisting of multiple tubes bundled together.
2. **Tube-in-Tube Structure**: A system with an outer tube and an inner core tube.

3. **Bundled Tube-in-Tube Structure**: A combination of the bundled tube and tube-in-tube systems.

3.3 Loading Conditions

The structures are subjected to dynamic wind loading, and the analysis is conducted according to the Indian Standard IS 875 (Part 3) for wind loads.

4. Results and Discussion

4.1 Story Displacement

The results indicate that the bundled tube-in-tube structure exhibits the lowest displacement values in both the X and Y directions. The displacement along the X-direction is 32.45% less than that of the bundled tube structure and 3.91% less than the tube-in-tube structure.

4.2 Story Drift

The story drift values for the bundled tube-in-tube structure are significantly lower than those of the other systems. The drift along the X-direction is 48% less than that of the bundled tube structure and 11.60% less than the tube-in-tube structure.

4.3 Base Shear

The base shear values for the tube-in-tube structure are higher than those of the bundled tube and bundled tube-in-tube structures. However, the shear across the X-direction is similar for all three systems.

4.4 Pushover Analysis

The pushover analysis reveals that the bundled tube-in-tube structure exhibits better performance under lateral loads, with a higher base shear capacity and lower displacement compared to the other systems.

5. Conclusions

5.1 General

The study concludes that the bundled tube-in-tube structure offers superior performance under dynamic wind loading compared to the bundled tube and tube-in-tube structures. The addition of internal tubes significantly reduces the displacement and drift, enhancing the overall stability of the structure.

5.2 Key Findings

1. The bundled tube-in-tube structure exhibits the lowest displacement and drift values, making it the most efficient system for resisting lateral loads.
2. The addition of internal tubes enhances the structural stability by reducing the deflection and story drift under wind loads.
3. The tube-in-tube structure shows higher base shear values, but the bundled tube-in-tube structure offers a better balance between shear capacity and displacement.

5.3 Future Scope

Future research could explore the performance of bundled tube-in-tube structures under seismic loading and investigate the optimization of internal tube configurations for different building heights and geometries.

References

1. IS 875 (Part 3): 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 3: Wind Loads.
2. ETABS User Manual, Computers and Structures, Inc.
3. Various research papers and theses cited in the literature review section.