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Analytical Assessment of Pros and Cons for Prevalent Tall Building System in Comparison with Tube System Using ASCE7-10 Wind Load Specifications

N. Siahpolo*[1], A. Kheyroddin[2], M. Gerami[3]

1- Ph.D Candidate of Earthquake Engineering, Semnan University, Semnan, Iran
2- Professor of Structure Engineering Department, Semnan University, Semnan, Iran
3- Associate Professor of Earthquake Engineering Department, Semnan University, Semnan, Iran

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ABSTRACT

Tall buildings classify as interior and exterior systems regarding to structural system. Important forms of exterior systems are tube, tube-in-tube w/o interior core, tube-in-tube with outrigger, braced tube and bundled tube. In order to evaluate pros and cons of each system, full 3D model implemented by using SAP2000 and seismic performance assessment defined as a major aim of this research. Shear absorption, story drift, inter story drift, shear lag factor (SLF), fundamental period and maximum along-wind displacement and acceleration are evaluated parameters.
The qualitative results showed that using aforementioned led to improve seismic response of building compared with tube system. However, a considerable effect on response reduction observed by using braced system. On the other hand, variation rate of SLF on columns located at tension flange was much uniform. In addition, SLF became one on the upper floors in all cases. Finally, by using braced tube, and maximum along-wind displacement and acceleration calculated with ASCE7-10 meet the comfort criterion of occupants.

KEYWORDS:

Shear Lag, Drift Index, Tall Building, Tube system, Shear Absorption Percentage.

* Corresponding Author, Email: n.siahpolo@mjdkh.ac.ir

1- BRIEF INTRODUCTION

Due to current development in utilities, and improvement in life style quality in the developing and developed countries, the application of high-rise structures are essential. Development of new construction technologies and technical software's in analysis and design of buildings prepare a new field of study and improve the performance of high-rise buildings. The first tall building constructed at the end of 19 century in USA-Chicago was Home Insurance Building. To classify tall building systems two classifications are common. In the first category, which is defined by Fazlor-Khan, three types of structural model are defined with regard to material. Steel moment frame, outrigger, tube and bundled tube are the examples of this category. These systems could be defined for concrete buildings as well.

In a recent ears the new classifications have been proposed by Soon and Mir Ali [1].

In order to evaluate the efficiency of different structural systems, several studies have been conducted. These studies are classified in five groups. In a first group the architectural aspects are considered [1]. In second group, a series of simplified equations have been derived to calculate dynamic characteristics of tall building [2]. In the third branch, the experimental behavior of tall building are evaluated [3]. Fourth group relates to construction management and structural control [4]. Finally, in the last group researchers' work on the pros and cons of tall building system to propose modified systems [5].

Previous studies show that each of structural systems have they on defeats and efficiencies. For example, in the tube systems, the shear lag may lead to nonuniform distribution of axial forces in perimeter columns. Thus, several methods have been developed to overcome these phenomena.

2- METHODOLOGY

In order to investigate the benefits and defeats of modern structural systems of tall buildings, in this paper a 70-story steel tube building has been deigned under gravity and wind loads. Then, a structural system changed to tube-in-tube, tube-in-tube with interior core, braced tube and bundled tube. Then response parameter such as inter-story drift index, shear lag coefficient, shear absorption ratio and change in fundamental period were evaluated. Evaluation of different tall building systems with equal stress ratio in design process is the main innovation of this paper. Also for the first time, the maximum roof displacement and acceleration were considered to control residents' confidence criteria.

3- MAIN CONTRIBUTIONS

After a series of analysis, some of the important achievements of this paper are listed as following:

- The bundled Tube system is the most effective system to control shear lag. The minimum effect on this factor was obtained by Tube-in-Tube system.

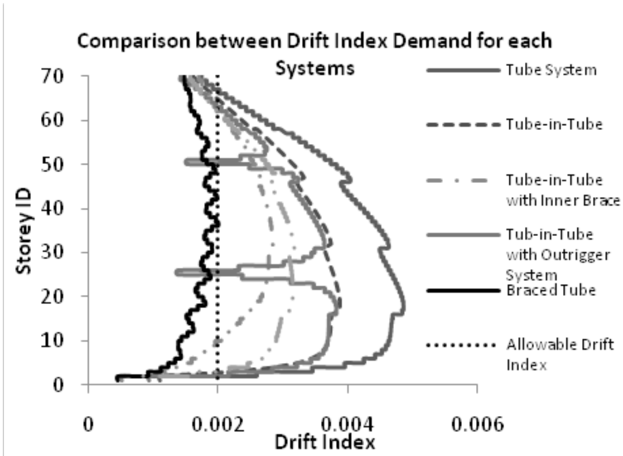

Figure 1. The effect of structural system on the inter-story drift ratios

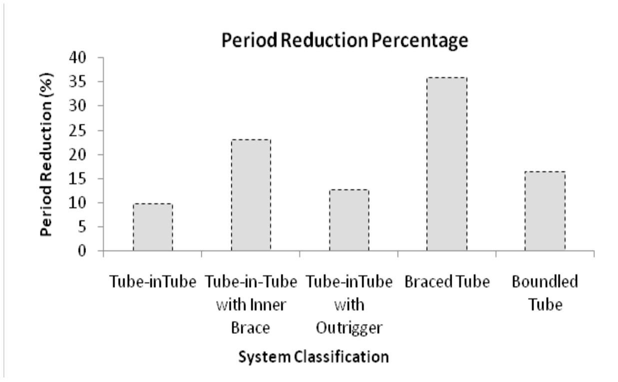

Figure 2. The effect of structural system on the fundamental period

- The reverse shear lag was observed in all structural systems. In this case, the contribution of exterior columns on axial forces are greater than interiors.
- The results showed that the maximum shear force is absorbed by outer tube in Tube-in-Tube system. If the braced core attaches to this system, in the lower stories, the maximum shear force is absorbed by inner tube while in the upper stories; the maximum shear force is absorbed by outer tube. In the braced rube system, the brace absorbs great part of external forces. The tube has the second place.
- Selecting each of lateral system rather than tube system, decrees the inter-story and displacement.

However, braced tube has maximum effect on these demands. Using this system ensures that the maximum roof displacement and acceleration are limited to control residents' confidence criteria (AISC07-10).

- Using braced tube system leads to decrease fundamental period in comparison with other systems. In addition, the tube system has minimum effect on changing vibrational period.

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