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Base Shear Coefficients and Displacement Amplification Factors of Tall Buildings with Tubular and Outrigger Bracing Systems on Flexible Soil

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ABSTRACT: Currently, the framed-tube and outrigger-braced systems are known as two conventional load bearing systems in tall buildings. These structural systems can be used in tall buildings with high efficiency to provide the necessary lateral stiffness and strength against lateral forces due to earthquakes or strong storms. On the other hand, increasing the stiffness of these structures augments the relative importance of flexibility of the underlying soil and the resulting added displacements. This paper aims to study the seismic behavior of framed-tube and outrigger-braced tall buildings on flexible soil in comparison to a rigid base. For this purpose, a range of 10 to 50-storey steel buildings with both structural systems on flexible and rigid bases are analyzed dynamically and the maximum base shear and lateral roof displacement are calculated. Also for comparing the benefit of each system, the total weight of steel used per system in each case is calculated. Results indicated that the design spectrum of Standard 2800 overestimates the response of the studied systems. Overall, the tubular system more economically provides the necessary stiffness and strength of the building system.

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1- Introduction

The tubular and outrigger braced systems are two effective structural systems for design of tall buildings against wind and earthquake [1-6]. In tubular buildings, the lateral resistance is provided by very stiff and strong moment frames located at the perimeter of building [7-13]. Such a placement maximizes also the torsional resistance of a tubular structure and lowers the pace of increase of the structure's weight in taller buildings. On the opposite, in outrigger buildings, the inner core of structure plays the main role in providing the lateral resistance and stiffness of the structural system [14-18]. The central core is connected to the perimeter at certain levels to increase and maximize the required resistance of the building.

In this study, the structural behavior of these two systems compared through studying a vast variety of buildings [19, 20].

2- Systems Under Study

For the purposes of this study, 15, 20, …, 50 story structures having the mentioned lateral resistant systems are explored. For each building, dynamic time history analysis implemented under 10 earthquake records. Maximum base shear and maximum lateral displacement of the roof of each building are determined under each earthquake and averaged between the records. These normalized to the peak ground displacement and weight of the building, respectively, and called the displacement amplification factor and the seismic coefficient. To account for the flexibility of soil, use has been made of soil springs at the foundation level. Spring coefficients calculated for two types of firm and soft soils.

3- Numerical Results

The displacement amplification factor and the seismic coefficient displayed for the selected cases in Figures 1 and 2. It is observed that the two systems perform similarly regarding the lateral strength but the lateral stiffness of the outrigger system somewhat outweighs that of the tubular system.

Flexibility of soil adds to the lateral displacements of the systems uniformly. The displacement amplified up to 50% in certain cases. For the base shear, also a similar trend though to a smaller rate observed. P-Delta effects due to larger lateral displacements can contribute to the changes in the lateral responses.

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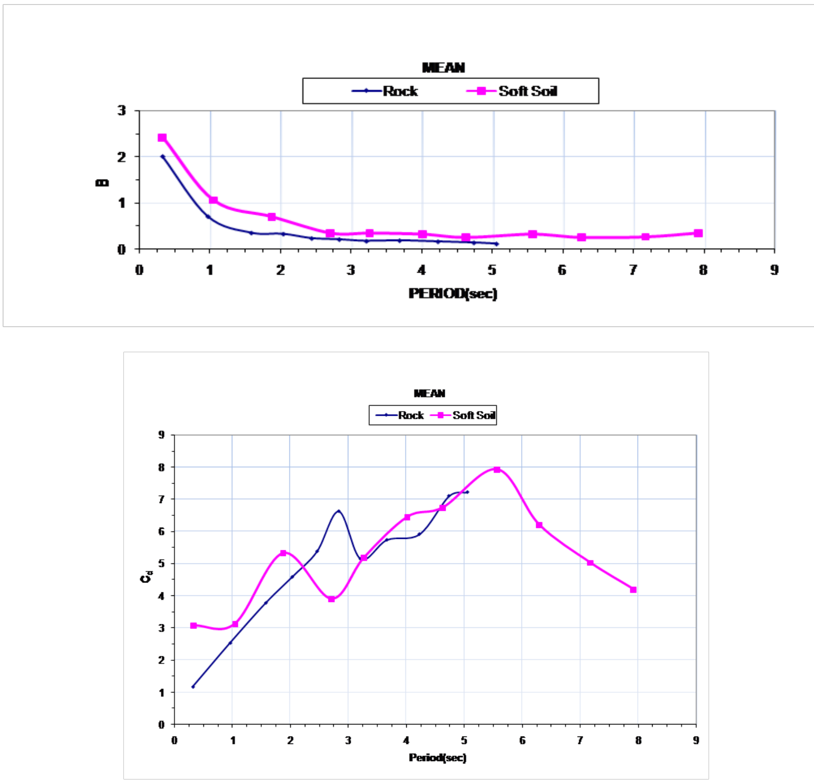

Figure 1. The displacement and force amplification factors for tubular buildings

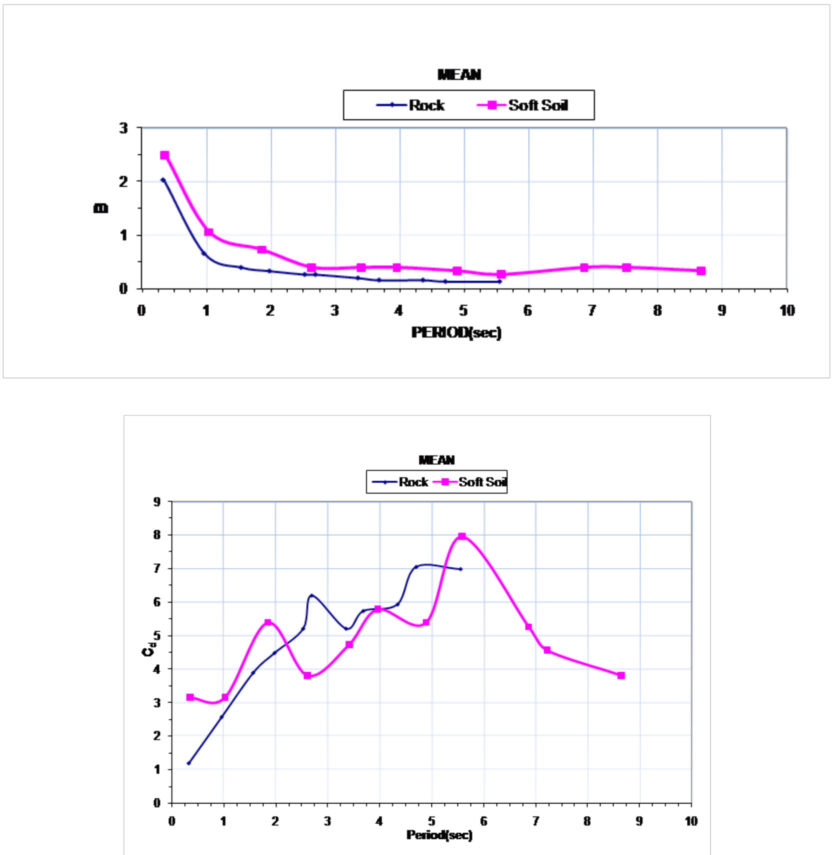

Figure 2. The displacement and force amplification factors for outrigger braced buildings

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