# Quantification of seismic performance factors of Hexagrid, Diagrid and tube structural systems for tall buildings

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**ABSTRACT**

Vertical growth of cities, has become a challenging issue in the building industry, due to the heavy urbanization and population growth. Bracing, is a highly efficient and economical method in order to achieve resistance against lateral loads in a tall building with steel structure. In order to improve the structural efficiency of tube-type skeletons in tall buildings, a new structural system, known as hexagrid, is investigated in this paper. In comparison with the diagrid system, the hexagrid, consists of multiple hexagonal grids on the periphery of the building. This investigation quantifies three seismic performance factors, including over-strength factor ($\Omega_0$), period-based ductility ($\mu_T$) and response modification coefficient (R) for hexagrid, diagrid and tube systems. The present study involves the 30- and 50-story of peripheral hexagrid and diagrid bracing systems compared with the tubular system. The structures were evaluated using nonlinear static and dynamic analyses. According to the results, the hexagrid system has a better response modification coefficient (R). Nonlinear static and IDA analyses are conducted using Open Sees software. The structures' behavior under 7pairs of ground motion records have been investigated by nonlinear time history analysis utilizing PERFORM-3D software. The maximum inter-story drift for the studied models was determined and compared with the "life safety" and "collapse prevention" performance limits, as recommended by FEMA P695.

**Keywords:** Hexagrid systems, Diagrid Systems, High-rise buildings, nonlinear analysis, inter-story drift,

## 1. INTRODUCTION

Construction of high-rise buildings used to be driven by the demand for space in densely populated areas. However, as the height of the building increases, the building becomes a symbol of prominence. Advancements in structural engineering and technology have greatly pushed the height limit. The growth was propelled by the invention of the safety mechanism for vertical elevators by Elisha G. Otis in mid-1800, which made the elevator the fastest and efficient means of vertical transportation in tall buildings. Combined with the improvement in fabrication and construction methods, the construction of skyscrapers not only has become more relevant and feasible; it has pushed the height limit even further.

The most profound advancements in structural engineering is the development of different structural systems that allow for taller buildings. As the height of the building increase, the lateral load resisting system becomes more important than the structural system which resists the gravity loads. The lateral load resisting systems that are widely used are the followings: rigid frames, braced frames, belt and outrigger truss systems and framed tube structures. A core or a system of cores which provides additional stiffness to the structure, is usually present in the building's structural system and uses for utilities such as the elevator shaft. A combination of the lateral load resisting systems or a variation of the concepts such as the braced tube system or the bundled tube system has resulted in emergence of high-rises with aspect ratio of 1:7 or even more.

The most significant trend of tall building configuration constructed in the late 19th century was based on the economic equations by introducing as much natural light as possible to have better