Nature-inspired hexagonal cells: an efficient approach for lateral load resisting skeleton in seismic zones

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ABSTRACT

The structural configuration of a building impose a considerable impact on the design issues with which engineers and architects have to tackle. Nature as a rich source of stability and aesthetic can provide several ways for engineers to design buildings' structures in such a way that the structure would perform better under gravity and lateral loadings.

This paper provides an overview on the hexagrid structural form as a load resisting system in tall buildings. A uniform grid of hexagons and also a fractal replication of hexagons are introduced as the peripheral load resisting system in a 20-story high-rise. Bundled-tube flexural panels were implemented as the interior structure. The computer models were designed and analyzed in SAP 2000 program. The structures were evaluated through nonlinear time history analyses under an ensemble of 3 components of 3 near-field pulse-like ground motion records.

Results indicated that both nature-inspired structures act efficiently under seismic loadings and the fractal structure have shown slightly better performance in reducing the damage imposed to the essential structural elements such as exterior corner columns.

Keywords: nature-inspired structures, fractal structures, hexagrid, tall building

1. INTRODUCTION

There are several ways in which the structural engineers can design an element or a building, such as material or even load resisting system, and benefit from the nature-inspired forms [1]. Hexagonal structures could be found in almost every scene of nature. The most common example of hexagonal structure in nature is the beehive. The beehive is consists of several hexagons, each of which has the same angle and the same chord length. Having considered the efficiency of hexagonal cells upon other polygons, one may refer to the stiffness and strength that the hexagons provide in line with the light weight they have [2].

To the authors' knowledge, Montouri et al. have first made a comprehensive study on the hexagonal tube structures in 2015 [3]. In this research work, different angles of diagonal members for both horizontal and vertical hexagonal cells have been studied, and optimum angles have been achieved by studying the axial and shear stiffness of the hexagons. It is worthwhile to point out here that according to their study, an optimum range of 50-70 and 40-50 is preferred for horizontal and vertical hexagons, respectively.

Kia Darbandsari and Firoozi, have studied the seismic behavior of hexagrid skeleton in two tall buildings of 30 and 50 story, and compared the results with more popular skeletons, framed tube and diagrid structures. It is indicated in this research that buildings with hexagrid as load resisting system, have shown better seismic performance and energy dissipation under near field ground motion record [4].

Memarzadeh Kiani and Firoozi, tried to make use of benefits of both horizontal and vertical hexagonal cells in a tall building. They utilized a transitional story, constructed from pentagrids, to