Dealing with structural patterns based on Voronoi diagram: mechanical efficiency vs. visual complexity

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Abstract

In this paper a discussion on non-conventional patterns for large scale structures is presented, with specific focus to the case of tall buildings. The term "non-conventional patterns" refers to irregular and complex geometrical layouts of structural members, quite different from the rectangular beam-column grids, traditionally adopted in frame structures, as well as from the triangular grid (diagrid), recently adopted in a large number of important buildings [1]. The idea is to explore the mechanical properties of selected non-conventional structural patterns, based on the Voronoi tessellation, in order to assess their applicability in tube configurations for tall buildings, and to compare their potential efficiency to more conventional system (diagrids) [2].

For this aim, a procedure for the parametric generation of Voronoi patterns, which explicitly controls both grid density and irregularity degree, is developed. Next, two alternative approaches are utilized for sizing the structural members of the Voronoi grids, on the basis of a global stiffness design criterion, namely: a classical homogenization-based micromechanical approach [3], and a sizing optimization procedure utilizing mono-objective genetic algorithms.

Different patterns, characterized by both uniform and variable irregularity degree and/or density are generated, designed and optimized for a 90-story building case study, with the aim to compare both the relative efficiency of the patterns and the design strategies. Comparisons in terms of optimization outcomes (unit structural weight, member cross section distribution along elevation), and performance parameters (deformed configuration, lateral displacements, interstory drift ratio, member strength demand to capacity ratio) are carried out. Discussion in terms of structural efficiency, also through the comparison to diagrid solutions developed for the same building case study, is finally presented.

Keywords: **structural patterns, optimization, efficiency**

References

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