# The role of joints in the structural optimization of grid shells

***E. Grande[1], †M. Imbimbo[2], and V. Tomei[3]**

[1]Department of Sustainability Engineering, University Guglielmo Marconi, Roma, Italy.
[2]Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Cassino, Italy
[3]Department of Engineering. University Niccolò Cusano, Roma, Italy

*Presenting author: e.grande@unimarconi.it
†Corresponding author: mimbimbo@unicas.it

## Abstract

Grid shells are a structural typology successfully employed in several fascinating applications of civil engineering thanks to their capacity to cover large spaces with free forms and light solutions. The main peculiarity of grid shells is a mixing of shape and structure which requires to consider together architectural and structural aspects within the design process.
In this context, structural optimization techniques have a key role in terms of efficient supports for achieving enhanced grid shell solutions generally obtained by merging together structural/architectural requirements and goals. The majority of studies available in the current literature focus the attention on optimization approaches mainly based on the structural weight of members, while it completely neglects the role of joints [1, 2]. Differently, only few studies emphasize the role of joints on the structural behaviour of grid shells and, then, on the optimization process itself [3-5].

The paper here presented is a part of a research activity carried out by the authors and concerning the structural optimization of grid shells throughout the combination of design strategies and algorithms which combine design parameters, requirements and structural response. In particular, the aim of the paper is to investigate the role of joints on the structural optimization of grid shells. Then, considering case studies derived from the recent literature, the authors analyse optimized solutions obtained by introducing different restraint conditions at the end of the members composing the grid shell and simulating different possible joint configurations. By using the commercial computer code grasshopper, genetic algorithms are employed with fitness functions related to the global structural weight and, moreover, specific constraint conditions related to both the local behaviour of members (stress level and local buckling) and the global behaviour of the entire grid shell (displacements and global buckling phenomenon). Comparing the different obtained solutions, it has been possible to carry out important considerations on the role of joints and discuss the different proposed strategies.

Keywords: **Grid shells, Joints, Structural optimization, Evolutionary algorithms**

**References**

[1] Richardson J. N., Adriaenssens S., Coelho R. F., Bouillard P. (2014) *Discrete topology optimization. Connectivity for gridshells, Shell Structures and Optimization*. Form Finding and applications, 171-179.
[2] Grande E., Imbimbo M., Tomei V. (2018), Structural Optimization of Grid Shells: Design Parameters and Combined Strategies, J. Archit. Eng. 24.
[3] van der Linden L. (2015), Innovative joints for gridshells - joints designed by topology optimisation and to be produced by additive manufacturing. Master Thesis Building Engineering, Delft university of technology.
[4] Grande E., Imbimbo M., Tomei V. (2018), Role of global buckling in the optimization process of grid shells: Design strategies, *Engineering Structures* 156, 260–270.
[5] Adeli H. and Sarma K. (2006), Cost Optimization of Structures – Fuzzy Logic, Genetic Algorithms, and Parallel Computing, *John Wiley and Sons, West Sussex, United Kingdom*.