Applications of Topology Optimization in Structural Engineering

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ABSTRACT

This study introduces applications of structural topology optimization to buildings and civil engineering structures. Topology optimization problems utilize the firmest mathematical basis, to account for improved weight-to-stiffness ratio and perceived aesthetic appeal of specific structural forms, enabling the solid isotropic material with penalization (SIMP) technique. Structural topology optimization is a technique for finding the optimum number, location and shape of "openings" within a given continua subject to a series of loads and boundary conditions (Bendsoe and Sigmund, 2003). Aerospace and automotive engineers routinely employ topology optimization and have reported significant structural performance gains as a result. Recently designers of buildings and structures have also started investigating the use of topology optimization, for the design of efficient and aesthetically pleasing developments. This paper examines two examples of where topology optimization may be a useful design tool in civil/structural engineering in order to overcome the frontiers between civil engineers and engineers from other disciplines. The first example presents the optimized structural design of a geometrically complex high-rise structure and the optimal design of its architectural building shape. The second one focuses on the optimization and design of a perforated steel I-section beam, since such members are widely used nowadays in the vast majority of steel buildings and structures while they provide a number of advances. Conclusions are drawn regarding the potential benefits and barriers to the more widespread implementation of topology optimization within the civil/structural engineering industry.