DISTRIBUTED LOADS IN TRUSS TOPOLOGY OPTIMIZATION

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ABSTRACT

Structures are often subject to distributed loads such as wind, snow, and inertial forces. In skeletal structures, the distributed loads act along the members that are defined as lines in the structural model. In truss analysis, distributed loads are transformed into equivalent nodal loads, and the effects of bending are neglected. Distributed loads are seldom treated in the literature on truss topology optimization. This is understandable, since incorporating distributed loads into truss topology optimization poses great difficulties for the conventional formulations relying on the ground structure approach. Firstly, if a loaded member is removed, the corresponding equivalent nodal loads must vanish from the equilibrium equations. This condition is difficult to include in the problem formulation for distributed loads not depending on the member cross-section. Secondly, if the ground structure is made denser, the number of loaded nodes increases. As all loaded nodes must be present in the truss and they must be adequately supported, making the ground structure denser leads generally to an increase in the number of members in the optimum truss. The only way of removing nodes under distributed load is to remove the attached members as well, producing gaps in the line (domain) of the distributed load.

In this work, a formulation for incorporating distributed loads into truss topology optimization is presented. The approach is based on binary variables that control the existence of ground structure members and nodes. Overlapping members are added between all nodes subject to the distributed load. Equivalent nodal loads for all of these members are included in the equilibrium equations, and the binary variables are used to switch off the nodal loads of vanishing members. Further constraints ensure sufficient support for the loaded nodes and disallow member overlapping in the optimum structure.

In the case of discrete member cross-sections, a linear mixed-integer formulation is available for truss topology optimization. As all the constraints and terms related to the proposed approach for distributed loads are linear in the binary variables, the linearity of the formulation is preserved. This makes the presented method appealing in conjunction with the mixed-integer formulation.

The proposed approach is illustrated on a roof truss design problem that verifies the applicability of the method for treating distributed loads in truss topology optimization.