Topology and Configuration Optimization of Trusses Based on Virtual Bars Concept

Dariusz Bojczuk[1], **Anna Rębosz-Kurdek**[2]

Faculty of Management and Computer Modelling, Kielce University of Technology, Al. Tysiąclecia Państwa Polskiego 7, 25-314 Kielce, Poland
e-mail: [1]mecdb@eden.tu.kielce.pl , [2]arebosz@tu.kielce.pl

1. Abstract

The algorithms of optimal design of topology, configuration and cross-sectional areas of trusses are considered in this paper. In the basic case, the problem of cost minimization with constraint imposed on global stiffness is analyzed.

The main feature of the presented approach is application of so-called virtual bars, which can join existing nodes so far non-connected. The concept of such bars was introduced earlier in papers by Mróz and Bojczuk (cf. [2]). Here, at first initial structure should be created and it can be chosen as the statically-determinate truss. Next, topological derivative is applied to select virtual bars. It is important to notice, that number of these bars is considerably smaller than the number of additional bars used in ground structure approach even in the case, where in order to reduce number of design variables only connections with neighboring nodes were taken into account (cf. [1]). Moreover, this artificial reduction may cause elimination of some connections which should appear in the optimal design. Such difficulties usually do not occur when using presented here approach.

In this paper two alternative methods of optimal design of trusses are presented. At first, the two-stage (topology and geometry) optimization procedure was presented. Initially, topology optimization is performed. Here, each virtual bar is simulated by self-equilibrated system of forces specified by single design parameter. These design parameters, which can be called topological parameters enable to control statically admissible static fields in order to minimize objective function and modify truss topology. This approach gives possibility for simultaneous generation of many equivalent topologies. Such solutions especially appear for problems, where symmetric systems of bars are expected. In the next stage, configuration optimization is performed for all optimal topologies and the best solution is chosen.

In the second method, optimization is carried on simultaneously with respect to topological parameters, which represent forces in virtual bars and with respect to configuration parameters, which correspond to positions of nodes. Here, analogously as in the first method, cross-sectional areas of bars are determined directly depending on bar forces.

The considerations are illustrated by some numerical examples. They confirm usefulness and efficiency of the presented algorithms. In particular, decrease of number of design parameters significantly reduces computation time required for generation of optimal designs. The results obtained for the both methods were compared with the results available in literature, especially in [1]. Moreover, the presented approach is also successfully applied to the problem of the cost minimization with constraints imposed on stresses and buckling loads.

2. References

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