10th World Congress on Structural and Multidisciplinary Optimization
May 19 - 24, 2013, Florida, USA

Linear Programming Approach to Design of Link Mechanisms of Partially Rigid Frames

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Various approaches have been developed for design and optimization of link mechanisms. Conventionally link mechanisms are designed using unstable units such as mechanical chains. Recently, some optimization and enumeration approaches have been developed utilizing graph theory, mixed integer programming, and nonlinear programming. However, it is still difficult to obtain an unstable mechanism that has one degree of kinematical indeterminacy and undergoes the desired mode of deformation. Furthermore, most of the recently developed methods can be applied to planar mechanism, or a spatial truss mechanism with universally rotatable joints.

The authors have developed a method for finding a retractable structure that deforms from a planar structure to a desired three-dimensional shape [1,2]. The structure consists of beams connected by partially rigid three-dimensional joints; i.e., rotations in specific directions and/or torsion are partially released from a rigidly-jointed frame.

In this study, we present a general approach to design of spatial link mechanism with partially rigid joints. An infinitesimal mechanism that undergoes the desired deformation is obtained by solving a linear programming problem to maximize the load factor under constraints on equilibrium and upper- and lower-bound constraints on the member-end forces. Large-deformation analysis is then carried out to verify the geometrically nonlinear behavior.

It is shown in the numerical examples that various mechanisms can be easily found using the proposed method.

References

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