DESIGN OF DEPLOYABLE STRUCTURES USING STRUCTURAL OPTIMIZATION

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Abstract

Deployable structures are structures that can be transformed from a compact configuration to a stable expanded form with relatively low energy. A major application of such structures is in disaster relief, where the need for rebuilt infrastructure, including bridge crossings and shelters, is urgent and critical to the effectiveness of medical responders. Given the potential lack of available resources in this context, deployable structures must be designed as lightweight and small in folded stated (for ease of transportation to damaged sites), require minimum force and skill to deploy and dismantle (for fast installation and possible relocation and reuse), and be stable during and after the deploying process. Given the challenge of this design problem, prior work in the area of optimal deployable structure design primarily considered fixed topology systems and used sizing or shape optimization, and combinations thereof, to minimize the structural system weight (e.g., [1-5]). This idea is briefly reviewed and extended to the case of topology optimization for developing optimized configurations of deployable structures. Topology optimization includes optimization of member sizes and, more importantly, design of the system mechanisms that enable deployment. Design objectives include minimum weight deployment is simulated using a pseudo-nonlinear analysis algorithm that sufficiently captures deployment mechanics. Design specifications are limited to geometry and system stiffness in the fully deployed state, although extensions to additional design objectives and constraints are also discussed.

[1] C.J. Gantes, P.G. Georgiou, V.K. Koumousis, Optimum design of deployable structures using genetic algorithms, *Structures and Materials*. 4 (1998) 255–264.
[2] T. Buhl, F.V. Jensen, S. Pellegrino, Shape optimization of cover plates for retractable roof structures, *Computers Structures*. 82 (2004) 1227–1236.
[3] J.P. Hanus, Investigation of a deployable military bridge system with a fiber reinforced concrete deck. University of Wisconsin-Madison, PhD dissertation, 2007.
[4] A. Kaveh, S. Shojaee, Optimal Design of Scissor-Link Foldable Structures Using Ant Colony Optimization Algorithm, *Computer-Aided Civil and Infrastructure Engineering*. 22 (2007) 56–64.
[5] A.P. Thrall, M. Zhu, J.K. Guest, I. Paya-Zaforteza, S. Adriaenssens, Structural Optimization of Deploying Structures Comprised of Linkages, *ASCE Journal of Computing in Civil Engineering*. (2013).