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Energy-efficient actuator placement for a convertible bending active structure

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Abstract

The requirements on load-bearing structures regarding their multifunctionality and adaptivity are steadily growing and the significance of ressource- and energy-saving measures is increasing. Recent developments concerning adaptive structures are kinetic bending active structures, which make it possible to use the stored elastic strain energy for transformation processes. The associated large deformations result in bending stresses, which cause a less efficient load transfer. Consequently it can be reasonable to combine this approach with the principles of lightweight construction, in order to enable the generation of material-saving and efficient structures. This can lead to a greater structural stiffness and counteracts the influence of the dimension effect. Another advantage is, that for the actuation of a lighter structure less energy is required. An optimal actuator placement can contribute to saving even more energy, which is why this should already be determined in the design process.

Within the scope of this paper a design method is presented which attempts to accommodate all these requirements using the example of a convertible bending active pavilon. In the digital design process a hybrid structure consisting of bending elements and a kinematic truss was derived from results of structural optimisation methods. In order to facilitate the transformation, sliding mechanisms were integrated. The form findings for the different transformation states were conducted by the method of dynamic relaxation and could be verified with a convertible small-scale prototype. With the means of the finite element method the analysis of the structure was performed. To investigate the improvement potentialities regarding energy efficiency, the sliding mechanisms were fixed and all rods were considered as possible integrated actuators. A complete analysis of all possibilities was performed for the placement of eight actuators. Subsequently, solutions for actuation concepts with a minimal amount of necessary energy were found by means of optimisation algorithms. Additionally, to shorten the computation time, a heuristic algorithm was implemented. The solutions obtained represent energy-efficient alternatives for the initial design, in which the actuation is realised with support displacements.

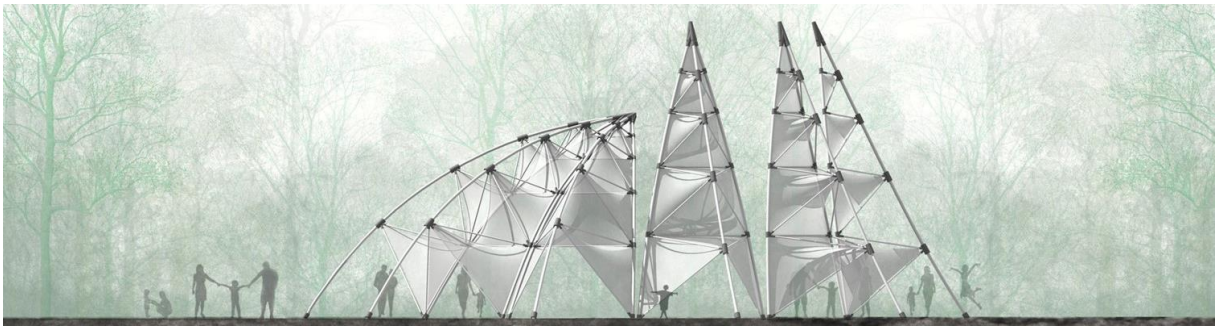

Fig. 1. Initial design of the pavilon with sliding mechanisms and actuation by support displacements