Experimental testing of a small-scale simply supported truss beam that adapts to loads through large shape changes

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ABSTRACT

Adaptive structures can modify shape and internal forces through sensing and actuation in order to maintain optimal performance under changing actions. Previous work has shown that well-conceived adaptive design strategies achieve substantial whole-life energy savings compared with traditional passive designs. The whole-life energy comprises an embodied part in the material and an operational part for structural adaptation. Structural adaptation through controlled large shape changes allows a significant stress redistribution so that the design is not governed by extreme loads with long return periods. This way, material utilization is maximized and thus embodied energy is reduced. A design process based on geometry optimization has been formulated to obtain shapes that are optimal for each load case. The non-linear force method is employed to control the structure into required shapes. This paper presents the experimental testing of a small-scale prototype adaptive structure produced by this design process. The structure is a simply supported planar truss. Shape adaptation is achieved through controlled length changes of turnbuckles that strategically replace some of the structural elements. Geometric reconfiguration through large shape changes is helped by the flexibility of polymer-based nodes fabricated via additive manufacturing. The stress is monitored strain sensors fitted on the truss elements. The node positions (i.e. the shape of the structure) is monitored by an optical tracking system. Experimental results show that stress redistribution through shape adaptation is in good accordance with numerical predictions.