Toews von Riesen, E.

PhD Title: Active Hyperhelical Structures

Abstract

This thesis is motivated by the desire to develop a new hyperhelical active structure that can adapt its shape according to a required task. An active hyperhelix of general geometry is introduced with respect to its active-mechanical behaviour, where the term "active hyperhelix" is used for a successively coiled active rod or strip that possesses the ability to alter its strain, curvature and/or twist, with each successive coiling increasing the order of the hyperhelix by one. Kinematical relationships between the geometry before and after actuation are developed as functions of the active components on the strip level and hierarchical changes in shape are derived for a general geometry and order of a hyperhelix. Following a kinematical analysis, the mechanical behaviour of hyperhelices is addressed in the second half of this work, considering the loading cases of axial force and torque for any hyperhelical order. A variety of special cases is considered throughout this thesis giving guiding rules on the applicability and the use of certain special geometries. In particular, an optimal geometry is considered where "optimal geometry" refers to a geometry that maximises the change in shape for a given actuation level or, in general, provides a desired behaviour. Limitations on possible changes in shape are discussed and approximate solutions are developed where possible. Depending on the cross-section on the fundamental level, beam or shell theory behaviour is assumed. A detailed study on the transitional region between beam and shell theory assumptions is presented and guiding rules are given for the validity of each theory. Left and right-handed coiling is considered for any hyperhelical level and a variety of coiling configurations is analysed with the aim to optimise the behaviour of active hyperhelices. The stability of hyperhelical behaviour is considered in detail and one unstable coiling configuration is presented. To sum up, the thesis provides a full account on active-mechanical behaviour of active hyperhelical structures of general geometry and order.

Toews von Riesen

Eduard Toews von Riesen
Cambridge, May. 2007