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A Constraint Model for Beam Flexure Modules with an Intermediate Semi-Rigid Element

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Abstract

Compliant mechanisms provide guided motion by utilizing the elastic deformation of their constitutive beams. These beams are usually stiffened via an intermediate element to help adjusting the stiffness in the motion as well as the bearing directions. For the sake of simplicity, the rigidity of this intermediate element has always been assumed to be infinite, while in practical situations, it has a finite compliance. So the objective of this paper is to study the nonlinear static load-displacement relationships of beam-based flexure modules with an intermediate semi-rigid element. The principle of virtual work along with nonlinear von-Karman expression of the strain energy is utilized to obtain the differential equations governing the nonlinear static behavior of a flexure beam with intermediate stiffener as well as the corresponded kinematic and natural boundary conditions. These equations are then solved analytically and closed form expressions are provided for the end point displacement of the beam in terms of the end forces and moments applied to the beam. Also a closed form expression is derived for the nonlinear strain energy of the beam in terms of its end point displacements. These expressions are utilized to model the nonlinear load-displacement behavior of a general parallelogram flexure module. The presented models are verified using nonlinear finite element