Simulating the Bending Behavior of Inflatable Drop Stitch Fabric Panels

William G Davids*

* Department of Civil and Environmental Engineering
University of Maine
Orono, ME 04469-5711
e-mail: william.davids@maine.edu, web page: http://www.civil.umaine.edu

ABSTRACT

This presentation details the development of a novel, computationally efficient method for predicting the nonlinear bending behavior of inflated drop-stitch panels using Timoshenko beam elements. In contrast with conventional inflated fabric beams with circular cross-sections, drop-stitch panels have yarns that connect the top and bottom skins and are tensioned by the inflation pressure. The nonlinear beam finite-element modeling strategy presented here incorporates the important response drivers of shear deformations and nonlinearity caused by fabric wrinkling. In addition, the work done by the internal pressure due to deformation-induced volume changes and its effect on panel stiffness and capacity are simulated. Further, the effect of the drop stitch yarns on panel bending response is explicitly incorporated in the element formulation using follower forces. The drop stitch yarns are shown to produce additional nonlinearity by coupling panel internal bending and shear resultants. Neither pressure-volume work due to bending nor the effect of drop yarns has been considered in prior studies on drop stitch panel bending response. Coupon-level fabric tests as well as panel inflation and panel torsion tests used to determine the effective orthotropic moduli of the panel fabric skin are briefly described, as are large displacement bending tests conducted for a range of inflation pressures. Comparisons between model-based and measured panel load-displacement response demonstrate that the model is capable of accurately predicting panel bending behavior for a wide range of deflections and inflation pressures. The model simulations clearly demonstrate the significant impact of pressure-volume work, shear deformations, and drop yarns on panel bending response.