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On Saint-Venant's Problem for an Inhomogeneous, Anisotropic Cylinder—Part II: Cross-Sectional Properties

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Cross-sectional properties of a prismatic inhomogeneous, anisotropic cylinder are determined from Saint-Venant solutions for extension-bending-torsion and flexure, whose method of construction was presented in a previous paper. The coupling of extensional, bending, and twisting deformations due to anisotropy and inhomogeneity leads to some very interesting features. Herein, it is shown that for an inhomogeneous, anisotropic cylinder whose cross-sectional plane is not a material symmetry plane, distinct modulus-weighted and compliance-weighted centroids and distinct principal bending axes are possible. A line of extension-bending centers is given on which an axial force causes extension and bending only but no twist. Two shear centers are given, one using the Griffith-Taylor definition that ignores cross-sectional warpages and the other by stipulating a zero mean rotation over the cross section. The center of twist is discussed, and this property depends on root end fixity conditions that are prescribed in terms of their mean values based on integrals over the cross section rather than by a pointwise specification. While these shear center and center of twist definitions have some rational bases, it is recognized that other definitions are possible, for example those based on modulus or compliance-weighted integrals. Two examples, an angle and a channel, both composed of a two-layer ±30 deg angle-ply composite material, illustrate the procedures for determining these cross-sectional properties.

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