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On Saint-Venant's Problem for an Inhomogeneous, Anisotropic Cylinder—Part III: End Effects

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End effects or displacements and stresses of a self-equilibrated state in an inhomogeneous, anisotropic cylinder are represented by eigendata extracted from an algebraic eigensystem. Such states are typical of traction and/or displacement boundary conditions that do not abide by the distributions according to Saint-Venant's solutions, whose construction were discussed in the first paper of this series of three. This type of analysis of end effects quantitifies Saint-Venant's principle, and the algebraic eigensystem providing the eigendata is based on homogeneous displacement equations of equilibrium with an exponential decaying displacement form. The real parts of the eigenvalues convey information on the inverse decay lengths and their corresponding eigenvectors are displacement distributions of self-equilibrated states. Stress eigenvetors can be formed by appropriate differentiation of the displacement eigenvectors. The eigensystem and its adjoint system provide complete sets of right and left-handed eigenvectors that are interrelated by two bi-orthogonality relations. Displacement and stress end effects can be represented by means of an expansion theorem based on these bi-orthogonality relations or by a least-squares solution. Two examples, a beam with a homogeneous, isotropic cross section and the other of a two layer beam with a ±30 deg angle-ply composite cross section, are given to illustrate the representation of various end effects.

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