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Analytical Computation of the Shear Correction Factor in Layered and Heterogeneous Sections

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The shear correction factor κ is critical for accurate predictions in Timoshenko beam and Mindlin plate theories, especially when accounting for transverse shear deformation. Classical values of κ apply to homogeneous, prismatic sections, but real structures often exhibit material inhomogeneity, internal layering, or orthotropic behavior—necessitating more general formulations. This paper presents an analytical and semi-analytical framework for determining κ\kappaκ in nonhomogeneous, layered, and orthotropic cross-sections. The method relies on the principle of strain energy equivalence, where the actual shear stress field is replaced by an energetically equivalent uniform distribution. The formulation accounts for spatially varying shear modulus $G(x, y)$ and, in the plate case, orthotropic shear stiffness components $G_{xz}(x, y)$ and $G_{yz}(x, y)$. Closed-form expressions are derived for selected layered geometries with piecewise-constant material properties. For continuously graded or microstructurally heterogeneous sections, a numerical integration scheme is proposed, based on pointwise evaluation of stress and stiffness fields. This allows application to composites with dispersed inclusions or stochastic mesostructures. Comparisons with finite element models confirm the accuracy of the proposed approach for both beams and plates. The results highlight the sensitivity of κ\kappaκ to material layout and anisotropy, especially when stiff inclusions or weak layers are located in high-shear regions. The developed methodology provides a versatile and efficient tool for improving shear deformation modeling in complex structural elements, with direct relevance to layered composites, sandwich structures, and advanced timber systems.

Keywords: *shear correction factor, nonhomogeneous cross-section, Reissner-Mindlin plates, Timoshenko beams, layered materials, analytical homogenization*