COMPUTATIONAL ACCURACY OF PLASTICITY CONSTITUTIVE MODELS

Rebecca M. Brannon

Sandia National Laboratories
Albuquerque, New Mexico
rmbrann@sandia.gov

Virtually every structural mechanics code includes a classical model for non-hardening Von Mises plasticity (NHVMP). Most codes also offer enhanced models with one or more additional features such as alternative yield surfaces (Tresca, etc.), plastic hardening (isotropic and kinematic), elastic anisotropy, nonassociativity (ADA non-normality), and thermal/rate/pressure dependence. An expansive literature, dating back many decades, exists for assessing the order of accuracy of various plasticity solution algorithms. Unfortunately, however, most publications of this type assume incorrectly that a converged solution is actually a correct solution, making those convergence rate studies moot. Furthermore, ubiquitous misconceptions exist about the geometrical meaning of the governing equations for even the simplest of plasticity models. Attempts to fit experimental data to wrongly implemented or wrongly interpreted material models often lead researchers to conclude that the material they are working with must require advanced features such as non-normality when, in reality, they don't (or perhaps they do, but the amount is wrong). For non-hardening plastic loading of an arbitrarily anisotropic material, the actual stress rate is a projection of the trial elastic stress rate onto the yield surface. However, the correct projection direction is generally oblique to the yield surface even when the plastic strain rate is directed normal to the yield surface. This result implies that many "closest point" return algorithms will converge, but not to the correct result. For verifying accuracy of NHVMP models, a closed form exact solution will be presented for the case of a constant strain rate (which is useful for verification). For advanced models, a generalization of plastic return algorithms will be presented, and a list will be provided summarizing numerous sources of "phantom non-normality" (i.e., validation situations that make many researchers conclude that non-normality exists when it really doesn't).