Rate Sensitive, Transversely Isotropic Material Model for Large-Scale Computational Geomechanics

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Today's geoscientists have unprecedented capabilities to simulate large-scale mechanical behavior of complex geosystems made possible by the development of massively parallel solution algorithms and teraflops supercomputers. Some major applications areas include reservoir scale modeling of formation compaction caused by pore pressure drawdown during oil or gas production, field-scale modeling of the behavior of earth penetrators, and the simulation of shock-structure interaction of hard and deeply buried targets. For these applications the material strain rates can vary from nearly zero to 10^7 s^{-1}; the porosity can vary from nearly zero to ~40%; and the deformation can be nearly isotropic to transversely isotropic. Large-scale computations are further complicated by the presence of rock joints and other discontinuities. It is imperative therefore that the material models used in these applications provide accurate representations of the complex deformation of the natural behavior of geosystems. A constitutive model for rock, soil, and concrete that is being developed and used at Sandia is capable of describing deformation and failure of such "geomaterials". These materials involve a complex interaction of dilation and compaction occurring simultaneously. The model can include strain rates from quasi-static to the shock regime and can handle transverse isotropy in the elastic and plastic domains. The model has been implemented in the Sandia solid mechanics finite element codes and has been used to make large-scale calculations for defense and energy related programs. This paper summarizes these efforts and gives examples of analyses that have been performed.

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