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Strain-Gradient Plasticity under Conditions of Non-Proportional Loading

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Abstract: In the last few decades substantial attention has been devoted to extensions of the classical theory of elastoplasticity in order to accommodate size-dependent effects. These strain-gradient theories have in many cases been developed by generalizing the classical notions of convex yield surfaces and convex, positively homogeneous dissipation functions, and the resulting variational problems are amenable to complete analysis. It is found, though, that the implementation of these gradient theories can be less straightforward. Thus, for some dissipation functions that are quite simple and obvious extensions of those encountered in the classical theory, it is not straightforward to determine the corresponding convex domains defining the elastic region. Furthermore, numerical experiments appear to indicate counterintuitive behaviour: for simple one-dimensional model problems investigators have reported that the response to a change in direction of loading following proportional straining into the plastic range is initially elastic, while alternative theories predict the expected plastic behaviour. The purpose of this contribution is, first, to present an overview of a model for strain-gradient plasticity and its qualitative properties; and second, using the tools of convex analysis as well as numerical experimentation, to explore and understand some of the unusual features of strain-gradient theories, for specific choices of dissipation function.