Phase-field slip-line theory of plasticity

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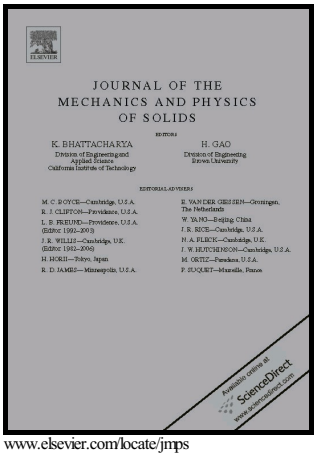

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Abstract

A variational approach to determine the deformation of an ideally plastic substance is proposed by solving a sequence of energy minimization problems under proper conditions to account for the irreversible character of plasticity. The flow is driven by the local transformation of elastic strain energy into plastic work on slip surfaces, once that a certain energetic barrier for slip activation has been overcome. The distinction of the elastic strain energy into spherical and deviatoric parts is used to incorporate in the model the idea of von Mises plasticity and isochoric plastic strain. This is a "phase field model" because the matching condition at the slip interfaces are substituted by the evolution of an auxiliary phase field that, similarly to a damage field, is unitary on the elastic phase and null on the yielded phase. The slip lines diffuse in bands, whose width depends upon a material length-scale parameter.

Numerical experiments on representative problems in plane strain give solutions with noteworthy similarities with the results from classical slip-line field theory, but the proposed model is much richer because, accounting for elastic deformations, it can describe the formation of slip bands at the local level, which can nucleate, propagate, widen and diffuse by

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