A Variational Gradient Plasticity Model Allowing for Shear Band Localization

Maria Chiara Comella*[1], Antonino Favata†[1], Andrea Rodella[1], and Stefano Vidoli[1]

[1]Department of Structural and Geotechnical Engineering, Sapienza University of Rome – Italy

Abstract

This contribution explores a novel approach to gradient plasticity within the variational framework, focusing on a modification of the classical energy functional. Traditional elasto-plastic models combine a quadratic energy term associated with the elastic strain and a dissipation term dependent on the norm of the plastic strain rate. Gradient plasticity models enhance these formulations by introducing regularization terms that smooth plastic strain gradients and prevent localization effects.

In contrast, we propose replacing this regularizing term with a non-quadratic contribution, allowing for threshold effects, that fundamentally alters the model's behavior, by means of the curl of the plastic strain. This terms measures the degree of incompatibility in the plastic strain field, indicating the presence of internal defects or dislocations that prevent smooth, continuous deformation. It is closely related to the dislocation density tensor, providing a measure of the number and distribution of dislocations in the material.

This formulation impacts the plastic threshold and emphasizes dislocation interactions at the tips and curved regions of shear bands, facilitating the formation of highly localized plastic zones. Unlike classical gradient plasticity, this approach does not regularize the solution but instead enables sharper representations of shear bands.

Our analysis examines the implications of this novel term on the energy landscape, threshold conditions, and localization evolution. Results highlight its capacity to model phenomena such as dislocation nucleation and the evolution of curved plastic regions with improved fidelity, providing new insights into material behavior under extreme conditions.

*Speaker

†Corresponding author: antonino.favata@uniroma1.it

sciencesconf.org:esmc2025:603199