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Finite element implementation and detailed comparison of generalised plasticity models

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The lack of an internal length scale parameter in classical continua leads to unrealistic modelling of some phenomena related to the microstructure of the material such as size effect and strain localisation. Generalised plasticity models and their application in modelling of localisation in geomaterials and mechanical behaviour of materials at the micro or nanometer scale (e.g. micro or nano-indentation) [1-2] have increased the interest in generalised continua. In the literature, some generalised plasticity models are proposed. However, there is a lack of comparative studies of the models, their properties and numerical behaviour. This hinders the use of these models by researchers and engineers when classical models fail to predict realistic solutions. The present research work focuses on both the Cosserat and strain-gradient plasticity models and their numerical behaviour in specific problems.
Two-dimensional Cosserat elements (quadrilaterals and triangles) are implemented with several Cosserat plasticity models to determine the numerical behaviour of the elements in the plastic regime. The numerical results show that both the integration scheme and the interpolation of displacement and rotation play an important role. The numerical solutions of Cosserat elastoplastic models are compared, and the effects of material parameters and specific formulations are investigated. Static, rate-independent, small-strain and two-dimensional (plane strain) problems are considered. Cosserat and strain-gradient plasticity models are also implemented to study comparatively their localisation behaviour. The results show that Cosserat and strain-gradient models behave differently considering the same material parameters.

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