World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:16, No:12, 2022



# A Proper Continuum-Based Reformulation of Current Problems in Finite Strain Plasticity

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**Abstract :** Contemporary multiplicative plasticity models assume that the body's intermediate configuration consists of an assembly of locally unloaded neighbourhoods of material particles that cannot be reassembled together to give the overall stress-free intermediate configuration since the neighbourhoods are not necessarily compatible with each other. As a result, the plastic deformation gradient, an inelastic component in the multiplicative split of the deformation gradient, cannot be integrated, and the material particle moves from the initial configuration to the intermediate configuration without a position vector and a plastic displacement field when plastic flow occurs. Such behaviour is incompatible with the continuum theory and the continuum physics of elastoplastic deformations, and the related material models can hardly be denoted as truly continuum-based. The paper presents a proper continuum-based reformulation of current problems in finite strain plasticity. It will be shown that the incompatible neighbourhoods in real material are modelled by the product of the plastic multiplier and the yield surface normal when the plastic flow is defined in the current configuration. The incompatible plastic factor can also model the neighbourhoods as the solution of the system of differential equations whose coefficient matrix is the above product when the plastic flow is defined in the intermediate configuration. The incompatible tensors replace the compatible spatial plastic velocity gradient in the former case or the compatible plastic deformation gradient in the latter case in the definition of the plastic flow rule. They act as local imperfections but have the same position vector as the compatible plastic velocity gradient or the compatible plastic deformation gradient in the definitions of the related plastic flow rules. The unstressed intermediate configuration, the unloaded configuration after the plastic flow, where the residual stresses have been removed, can always be calculated by integrating either the compatible plastic velocity gradient or the compatible plastic deformation gradient. However, the corresponding plastic displacement field becomes permanent with both elastic and plastic components. The residual strains and stresses originate from the difference between the compatible plastic/permanent displacement field gradient and the prescribed incompatible second-order tensor characterizing the plastic flow in the definition of the plastic flow rule, which becomes an assignment statement rather than an equilibrium equation. The above also means that the elastic and plastic factors in the multiplicative split of the deformation gradient are, in reality, gradients and that there is no problem with the continuum physics of elastoplastic deformations. The formulation is demonstrated in a numerical example using the regularized Mooney-Rivlin material model and modified equilibrium statements where the intermediate configuration is calculated, whose analysis results are compared with the identical material model using the current equilibrium statements. The advantages and disadvantages of each formulation, including their relationship with multiplicative plasticity, are also discussed.

**Keywords :** finite strain plasticity, continuum formulation, regularized Mooney-Rivlin material model, compatibility
**Conference Title :** ICACSM 2022 : International Conference on Advances in Computational Structural Mechanics
**Conference Location :** Amsterdam, Netherlands
**Conference Dates :** December 02-03, 2022