A hemivariational granular-chain model with elasticity, damage and impenetrability constraints

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Abstract

A granular-chain model is proposed taking into account damageable elastic links between the grains, as well as impenetrability conditions represented by inequality constraints. The modelling approach is hemivariational: it is formulated as a variational inequality based on virtual powers defined on the set of admissible kinematics. This approach is adapted from recent research efforts in formulating hemivariational models for elasticity, damage and plasticity in granular materials. More specifically, the presented work is developed within the framework of a recent masonry model (see for example Tran & Barchiesi 2023), and intended as an intermediate step to homogenising said model.
The modelling approach used in the presented work is an extension of the one in Tran et al. 2024: time-dependence is taken into account (although the model remains quasi-static), and inequality constraints have been added to account for the impenetrability of the grains. The solving process is illustrated analytically for undamaged evolutions, and numerically in damaged elasticity.
References:

Tran, C. A., & Barchiesi, E. (2023). A new block-based approach for the analysis of damage in masonries undergoing large deformations. Continuum Mechanics and Thermodynamics, 35(4), 1625-1654.
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