Smooth Plasticity and Damage Model for the Material Point Method

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ABSTRACT

The Material Point Method (MPM) is an extension of particle in cell methods (PIC) for solid mechanics problems. The structure is discretized into a set of material points that hold all the state variables of the system [1] such as stress, strain, velocities etc. A background grid is employed and the variables are mapped to the nodes of the grid. The momentum conservation equations with energy and mass conservation considerations are solved at the grid nodes and the updated state variables are again mapped back to the material points updating their positions and velocities. The background grid is used only to solve the governing equations at the end of each computational step and then it is reset back to its original undeformed configuration. It is used only as a scratchpad for calculations and thus mesh distortion that constitutes a problem in Finite Element simulations is avoided.

In this work the explicit formulation of the MPM is employed. According to the strain decomposition rule the strains are uncoupled into an elastic and an inelastic part. The constitutive law follows a Bouc-Wen [3] type formulation and provides a smooth transition to the inelastic regime. In the same manner a damage driving variable is introduced as a function of the total strain. The incremental damage behavior is smoothed similarly to the plasticity formulation following their common mathematical structure [2]. The above formulation is incorporated in the expression of the tangent modulus of elasticity as Heaviside type functions that control the inelastic behavior and damage at elemental level. Results are presented that validate and verify the proposed formulation in the context of the Material Point Method.

REFERENCES

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