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ON POD BASED REDUCTION-ORDER MODELING IN MULTI-SCALE MATERIAL FAILURE SIMULATION

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The present work addresses the problematic of reducing the computational time of multi-scale framework by solving, at each point of the structural scale, the Representative Volume Element (RVE) equilibrium problem using Reduce-Basis approximations. A specific methodology is proposed in order to tackle non-smooth fields. Therefore, the framework can find its applications into quasi-brittle heterogeneous materials, such as cementitious ones, and aims at performing crack propagation computations at a structural level.

The model is based on the Finite Element Method at both scales linked by weak coupling (FE2). The macro-strain acts as a loading parameter on the RVE whereas the macro-stress is the resulting homogenization of the micro-stress. The degradation mechanisms are modeled by the Continuum Strong Discontinuity Approach (CSDA) which lead to kinematic of the macroscopic crack defined in a small dimensional space.

The basis used for the reduction are constructed with a partitioned version of the Proper Orthogonal Decomposition of a set of a pre-computed snapshots, allowing us to consider distinctly the different regime of the solution (elastic, hardening or softening). Then, in addition to the projection of the solution (strains) onto a reduced basis, the interpolation of the off-line terms (stresses) is also made in a reduced-order space. To avoid the resulting ill-posed formulation, an expansion of the approximation space is made. Finally, based on both precision and stability considerations, a point-selecting algorithm (greedy) is perform in order to reduce the number of integration points.

The specificity of the method in regards with the potentially non-smooth solutions comes from a decomposition of the fields between elastic and inelastic domains of the RVE thus increasing the efficiency of the greedy algorithm. Such a decomposition is possible thanks to the CSDA that allows us to fully express the RVE formulation in terms of strains.