Optimization of TFA homogenization based on data-driven approach

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Abstract

Composite materials are increasingly used in various fields of engineering. A large number of composite materials exhibit nonlinear behaviour due to the intrinsic mechanical response of the constituents and the topological complexity of the internal periodic structures at the micro level. The mechanical behaviour at the micro level can be determined by studying the Representative Volume Element (RVE) using appropriate constitutive models. However, the computational effort usually associated with the RVE study by the Finite Element (FE) method is very high.
An effective approach that can significantly reduce the computational effort is Transformation Field Analysis (TFA), introduced by Dvorak (1). TFA is based on the idea that it is possible to divide the RVE into subdomains or clusters within which a uniform distribution of microscopic strain fields is assumed. Such an assumption drastically reduces the number of internal variables required to solve the micromechanical problem and consequently the computational time. Accordingly, in TFA, the total macroscopic strain prescribed on the RVE is mapped onto each cluster by elastic and inelastic strain localisation tensors, which are generally a function of the position within the cluster. Uniform localisation tensors are obtained during the offline stage by averaging the localisation tensors within each cluster.

This paper presents an optimisation procedure based on a data-driven approach that leads to the evaluation of strain localisation tensors. The choice of uniform localisation tensors is obtained through a training stage consisting of a two-step optimisation process aimed at minimising a total stress error measure between TFA and an FE reference solution during some pre-analyses. Such a training stage is performed during the offline stage so that it does not affect the computation time of the online TFA procedure. Several benchmark strain histories are used during the online stage as a verification test to validate the optimised strain localisation tensors. The results show that the total strain errors are reduced by at least two orders of magnitude in all cases considered.

References
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