Modelling of elastic-viscoplastic composites by the additive Mori-Tanaka scheme based on a modified tangent linearization

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Abstract

When phases have non-linear elasto-viscoplastic behaviour, mean-field modelling based on the Eshelby inclusion problem presents certain challenges. One challenge is the long-term memory effect, which results from presence of time derivatives of different orders in the local constitutive response. The additive interaction law is one potential solution to this issue (1). Due to its appealing simplicity associated with fairly good accuracy, the model is well suited to be employed as a material model in large scale finite element calculations (2). However, while alternative variational approaches take into account the second moments of stresses and strains, this mean field approach based on the additive interaction law typically just adopts the mean values of stress and strain fields in each phase. It is clear that methods developed in (2) by taking account of stress fluctuation within the phases enhance model predictions. On the other hand, the variational homogenization framework is not efficient for non-proportional loadings and large-scale finite element due to their complexity. Therefore, in this work, we propose to include second moments in homogenisation models based on the additive interaction law.

The current study discusses how to formulate the additive Mori-Tanaka model of two-phase elastic-viscoplastic material by including the second moments of stresses (3). Following (5), the Hill-Mandel's lemma is adopted to capture the evolution law of second moments of stresses. With these modifications, a modified tangent linearization of the viscoplastic law is suggested. The outcomes of the model are compared with full-field fast Fourier transform numerical calculations of (4). In order to demonstrate the model accuracy, predictions are compared to those of other models accounting for stress fluctuations found in the literature (5). These benchmarks show that the improved tangent linearization performs well for both monotonic and non-monotonic loading responses.

Acknowledgements

The research of K. Kowalczyk-Gajewska was partially supported by the project 2021/41/B/ST8/03345 of the National Science Centre, Poland. S. Berbenni and S. Mercier acknowledge the support of the National Research Agency (ANR), France, under the project ANOHONA (ANR-23-CE51-0047)

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