APPLICATION OF A STOCHASTIC TRANSFORMATION FIELD THEORY TO THE INELASTIC RESPONSE OF COMPOSITES

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As the structural application of composites materials becomes more commonplace it is increasingly important to utilize material models capable of accurately predicting the inelastic response of such materials. Most composite materials have microstructures that exhibit some level of statistical variation. The extremes in these variations typically initiate and propagate history-dependent and failure behavior at both the local and bulk length scales in these materials. Therefore, since deterministic models can not hope to successfully capture the effects of statistical extremes, successfully predicting the history-dependent behavior of such materials requires the use of stochastic material models capable of incorporating general inelastic models for the phases' behaviors.

In the current work a combination of both deterministic models and a new stochastic model based on a stochastic transformation field analysis (STFA) ([1] and [2]) are used to consider the influence of these statistical extremes on the history-dependent behavior of composites. The STFA develops general equations governing the behavior of the concentration tensors in the presence of arbitrary variations in these tensors as well as other fields (such as the stress, strain, and eigenfields). These equations, in conjunction with the probability density functions (PDFs) for the concentration tensors, predict the local and bulk behavior of the composite. The deterministic modeling component (for example that given in [2]) is utilized to assist in generating the probability density functions (PDFs) for the concentration tensors required by the stochastic models. The proposed modeling approach represents a departure from the current state of the art in stochastic material modeling which typically assumes a distribution function for the spatial arrangements of the material microstructure and subsequently utilized a given homogenization method to predict the material behavior. One advantage of the approach utilized in the current work as opposed to more traditional approaches is that the statistics of the concentration tensors are independent of the constitutitve theory for the inelastic behavior of the constituent materials.

Example problems for the viscoplastic and viscoelastic response of both continuous fiber and particulate composites are considered. In particular the issue of how much statistical information is required to correctly predict the inelastic response of such materials is addressed.

References

[1] T.O. Williams, "A General, Stochastic Transformation Field Theory", *J. Eng. Mech.*, (in press), 2006.
[2] T.O. Williams and S.C.Baxter, "A Framework for Stochastic Mechanics", *Prob. Eng. Mech.*, (in press), 2006.

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