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Virtual Testing Architecture for Prediction of Effective Properties of Particulate Composites

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Particulate composites comprise of filler material (often spherical in shape) and a matrix medium. These type of composites are widely useful in many structural applications. It is crucial that comprehensive understanding of the three dimensional mechanical response of particulate composites are developed. Traditionally, laboratory-level experiments have been used to determine the mechanical response but such experiments are limited by cost, complexity and inability to replicate certain experiments. Therefore, in the last two decades, a drive towards virtual testing schemes has become popular in academic literature. These virtual testing schemes employ a completely numerical approach to determine a holistic set of mechanical responses for a given test material. In order to predict accurately, these virtual tests employ robust geometric models of the test material, with realistic material models, adequate boundary conditions and a robust homogenization strategy. It is believed that in the near future, virtual tests will replace a significant number of traditional laboratory experiments. In spite of the practical importance of particulate composites, there is a limited range of mechanical data of its three dimensional response especially using a computational approach. There are no existing virtual testing schemes for particulate composites. There is therefore a need to develop a robust virtual testing architecture for prediction of effective properties of particulate composites. Such a framework should be scalable for prediction of nonlinear constitutive responses of a given particulate composite.

This study has developed a computational virtual testing architecture for predicting effective properties of particulate composites. A particulate composite made up of SiC filler in an alumina matrix was used in this work. The test composite was modelled first by considering perfect bonding between the matrix and filler constituents and subsequently the effect of interphase region was assessed too. The role of different boundary conditions types (namely Dirichlet, Neumann and Periodic Boundary Conditions) were investigated as a parametric study of the applicability of the virtual testbed for the particulate composite. The virtual testbed was found to be a representative architecture for prediction, using micromechanical modelling approach, the holistic range of 3D effective properties of particulate composites. The paper concludes by presenting parametric studies on mesh dependency, critical RVE size for representative prediction of all effective properties of the composite, etc.

Key works: virtual testing, particulate, predictive modelling, periodic boundary conditions, representative volume element, Monte Carlo approach