Accelerated Multiscale Modelling of Large-scale Composite Structures Using a Material Knowledge System Generated by Artificial Neural Network

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ABSTRACT

The high computational cost is a significant challenge for modelling the progressive damage behavior of large-scale composite structures. This is due to the fine description in finite element (FE) modelling for the materials, i.e. with each unidirectional layer defined as required by the applicability of composite failure criteria. In this work, we propose a method to accelerate the nonlinear FE analysis by using homogenized materials (at macroscale) defined by a pre-computed material knowledge system. The material knowledge system represents the nonlinear strain/stress relationship as well as the possible failure mode information. Developed using artificial neural network (ANN) algorithms, the knowledge system is first trained with a vast number of data obtained from simulations of a mesoscale unit cell FE model and then used for prediction. The prediction accuracy of the knowledge system is examined by comparing with the results of conventional FE modelling and good agreement is observed. The presented method enables accelerated progressive damage analysis of large-scale composite structures, with significant savings of the computational cost. Lastly, the knowledge system is only based on material designs and is reusable for other structures with the same material.

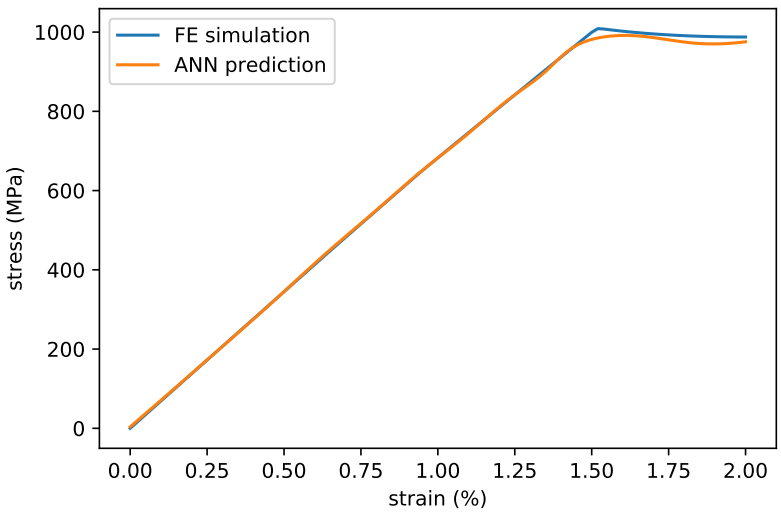

Figure 1: Comparison of ANN predicted and FE simulated nonlinear material constitutive curve for a tensile load case.