Micromechanics-Based Structural Analysis (FEAMAC) and Multiscale Visualization within Abaqus/CAE Environment

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Abstract: A unified framework is presented that enables coupled multiscale analysis of composite structures and associated graphical pre and post processing within the Abaqus/CAE environment. The recently developed, free, Finite Element Analysis - Micromechanics Analysis Code (FEAMAC) software couples NASA's Micromechanics Analysis Code with Generalized Method of Cells (MAC/GMC) with Abaqus/Standard and /Explicit to perform micromechanics based FEA such that the nonlinear composite material response at each integration point is modeled at each increment by MAC/GMC. The Graphical User Interfaces (FEAMAC-Pre and FEAMAC-Post), developed through collaboration between SIMULIA Erie and NASA Glenn Research Center, enable users to employ a new FEAMAC module within Abaqus/CAE that provides access to the composite microscale. FEAMAC-Pre is used to define and store constituent material properties, set up and store composite repeating unit cells, and assign composite materials as sections with all data being stored within the CAE database. Likewise FEAMAC-Post enables multiscale field quantity visualization (contour plots, X-Y plots), with point and click access to the microscale (i.e., fiber and matrix fields).

Keywords: Failure, Composite, Micromechanics, Viscoplasticity, Abaqus/CAE, Multiscale, FEAMAC, MAC/GMC, User Material, SDVs.

1. Introduction

The use of advanced composites (PMCs, MMCs, CMCs) provides benefits in the design of advanced lightweight, high temperature, structural systems because they provide increased specific properties (e.g., strength to density ratio) in comparison to their monolithic counterparts. To fully realize the benefits offered by these materials, however, experimentally verified, computationally efficient, multiscale design and analysis tools must be developed for the advanced multiphased materials of interest. Furthermore, in order to assist both the structural analyst in designing **with** these materials and the materials scientist in designing/developing **the** materials[1], these tools must encompass the various levels of scale for composite analysis, see Fig. 1.

[1] The structural engineer perspective relates to the design of structures with given materials whereas the materials scientist perspective is how to design a material for a given application. Clearly, the two perspectives are not mutually exclusive.