Abstract:

The role of composite materials has become more important in the last decades, since they are important in areas in which lightweight structures are used. An important class of composites consists of two materials, namely a fiber with excellent tensile strength and stiffness properties and a matrix with poor mechanical properties.

The aim of this paper is to describe the constitutive behavior of composite materials. For this purpose, a user subroutine UMAT for the commercial finite element software ABAQUS is written, which takes into account anisotropy and brittle damage behavior as well as irreversible strains remaining after unloading. Therefore a plasticity model, which considers plastic strain only under transversal compression and shear, was coupled with a brittle damage model.

The implemented mechanical model is formulated in terms of plane stress. The strength of a material is characterized by six mechanical parameters: tension resp. compression strength in fiber direction, tension resp. compression in matrix direction, longitudinal and transversal shear strength. Four different failure modes are considered; the four corresponding failure initiation criteria are based on Hashin's criteria and formulated in terms of effective stress. After exceeding a failure criterion, the material stiffness begins to degrade. The evolution of damage depends only on the fracture energy. To avoid convergence problems and mesh dependent solutions, a viscous regularization scheme is introduced.

The plasticity model distinguishes between two different yield modes: yielding under transverse compression and yielding under shear. In order to keep the needed material parameters small, the implementation is kept as simple as possible. To keep the computational effort low, interactions between the two yield modes are not taken into account.

The implemented models have been verified. For this purpose, the implemented model has been compared to the damage model implemented in ABAQUS. Single element tests have been made as well as mesh dependence tests; the standard plate-with-a-hole benchmark test has been calculated as well as an industrial model of the Boeing-777 winglet.