Altair® Multiscale Designer™
Simulation of Multiscale Material Models

Altair® Multiscale Designer is an accurate and efficient tool for the development of multiscale material models and simulation of parts manufactured from any heterogeneous material, such as continuous and chopped fiber composites, honeycomb cores, lattice structures, reinforced concrete, soil and bones. Applications include multiscale material modeling for design, ultimate failure assessment, statistical-based material allowables, creep, fatigue, fracture, and impact simulations. It also provides user material plugins to commercial FEA solvers Altair® OptiStruct™, Altair® Radioss™, LS-DYNA, and Abaqus.

Product Highlights:

- Multiscale material models for
- continuous, long, and short reinforced composites
- Built-in parametric & external unit cell modeling
- Accurate, efficient simulation of inelastic effects to ultimate failure
- Fiber-orientation mapping for injection molding
- Virtual material allowables for standard specimens
- Plugins for Altair® OptiStruct, Altair® Radioss, LS-DYNA, and Abaqus

Benefits
While many multiscale modeling frameworks exist, Altair® Multiscale Designer provides an unmatched combination of ease of use, computational efficiency, predictive accuracy, and versatility.

Ease of Use
Altair® Multiscale Designer has well defined methodologies, including experimental test matrix protocols, for the development of multiscale material models of continuous and chopped materials. Users can design unidirectional and woven continuous materials and both short and long chopped reinforced products made from carbon, glass, or Kevlar with thermoplastic and thermoset polymer matrices. The process required to develop a multiscale material model is captured in 4 steps within the Altair® Multiscale Designer user interface:

- Unit Cell Model Definition
- Linear Material Characterization
- Reduced Order Model Computation
- Nonlinear Material Characterizatio Validated multiscale material models are easily included in any macro model

simulation via the Macro Solver Integration GUI and provided user material plugins (DLLs) to Altair® OptiStruct, Altair® Radioss, LSDyna, and Abaqus.

Computational Efficiency
Instead of implementing direct homogenization, which is accurate but computationally inefficient, or some other classical homogenization method, which is computationally efficient but inaccurate, Altair® Multiscale Designer utilizes 3D FEA Unit Cells with a Reduced Order Model (ROM) technique that allows for both predictive accuracy and computational efficiency. The ROM performs a one–time solution of the unit cell which stores all required heterogeneous material behavior of the elastic and inelastic regime into a "material database". Upon subsequent macro model simulation, each macro element calls into this database via the user material plugins (DLLs) to perform matrix algebraic calculations for the homogenized stiffnesses and de–homogenized phase stresses and strains to achieve high accuracy and efficieny.
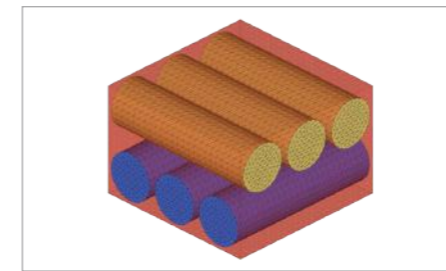
Definition of external unit cells in Altair® HyperMesh™
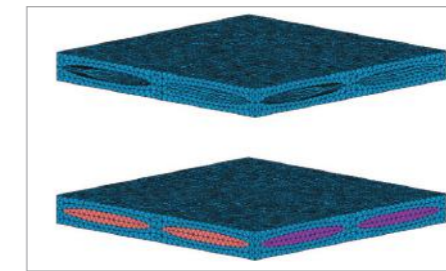
Matrix phase and homogenous plain weave unit cell

Laminate from stack of homogenous plain weave unit cells of multiple orientations

Predictive Accuracy
Altair® Multiscale Designer implements advanced damage and plasticity laws which account for the fundamental physical behavior of various phase materials. Each phase material of the 3D FEA unit cell is assigned a nonlinear material law. The nonlinear material laws within Altair® Multiscale Designer include damage models for brittle materials like carbon and glass fibers, plasticity models for ductile materials, advanced hybrid damage, plasticity models, brittle, and ductile behavior. Characterization of the material parameters for all Altair® Multiscale Designer nonlinear material laws have well defined experimental test matrices and procedures with minimal experimental tests required. In addition, Altair® Multiscale Designer material models for various product forms (Unidirectional, Woven, and Chopped) have been validated against several experimental datasets for predictive accuracy.

Versatility
Altair® Multiscale Designer includes a built– in FEA macro solver which allows for automatic parametric multiscale simulations of several standard coupon specimens (unnotched, notched, shear, and bend) directly within Altair® Multiscale Designer. The stochastics module

of Altair® Multiscale Designer couples the built– in parametric multiscale simulation capability with the ability to perform Monte Carlo and Sparse Grid stochastics multiscale simulations. Each multiscale material model parameter can be given a Probability Distribution Function (PDF) via mean, standard deviation, and distribution type parameter input. The output of the stochastic multiscale simulation is a PDF which is used directly to calculate A– and B– Basis material allowables for "Virtual Allowables" assessments.

Capabilities
**Altair® Multiscale Designer – Mechanical**
Altair® Multiscale Designer – Mechanical provides a well–established methodology for the development of fully nonlinear multiscale material models. These models are subsequently used in linear or nonlinear macro analysis to resolve micro–scale fields (stresses and strains within each phase material of the unit cell) at a computational cost comparable to that of macro– scale modeling. Both the forward homogenization approach, where micro–scale properties are known prior, and the inverse optimization approach, where micro– scale properties are determined from known macro– scale homogenized properties, are available.

Altair® Multiscale Designer — Stochastics
Altair® Multiscale Designer – Stochastics provides a forward homogenization stochasticsimulation process which computes a Probability Distribution Function (PDF) for the homogenized macro– scale properties given the variability of the micro– scale geometry and constitutive properties. Altair® Multiscale Designer – Stochastics automatically calculates A– and B– basis material allowables directly from the output PDFs via a virtual allowables supported by test methodology.
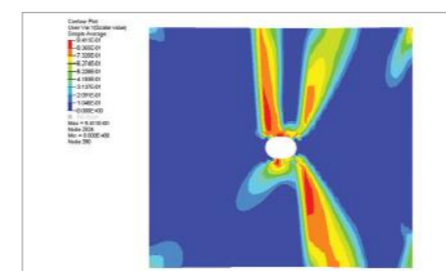
Multiscale analysis of open hole tension specimen – matrix phase damage
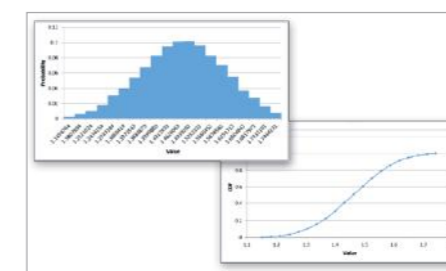
Probabilistic determination of virtual allowables
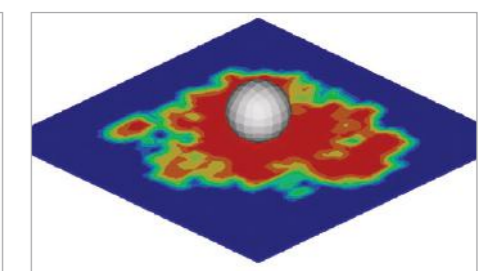
Multiscale analysis of low velocity impact - matrix phase damage