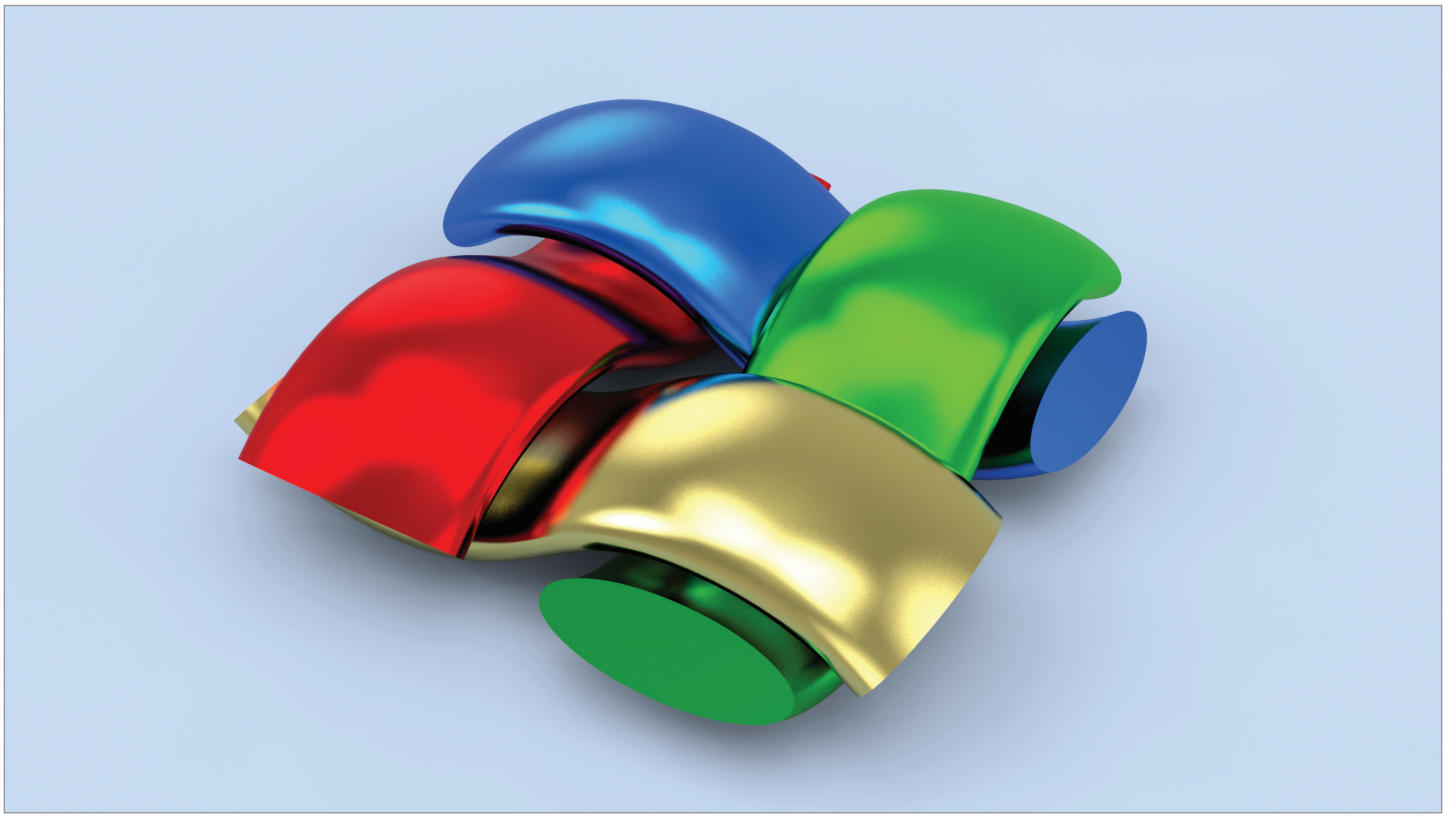
# Multiscale Designer™

Altair | HyperWorks®



Multiscale Designer is an efficient tool for development and simulation of multiscale material models of continuous, woven, and/or chopped fiber composites, honeycomb cores, reinforced concrete, soil, bones, and various other heterogeneous materials. Applications include multiscale material modeling for design, ultimate failure, statistical-based material allowables, fatigue, fracture, impact, crash, environmental degradation, and multiphysics simulations and provides plugins to commercial FEA solvers; Optistruct, RADIOSS, LS-DYNA, and Abaqus.

## Product Highlights

- Develop multiscale material models using forward homogenization and inverse optimization technologies
- Built-in parametric unit cells for unidirectional, woven, chopped, and particulate fiber composites
- Simulate nonlinear material behavior including ultimate failure at the micro-scale
- Obtain virtual material allowables supported by test and perform fatigue analysis
- Efficient plugins to commercial FEA codes OptiStruct®, RADIOSS®, LS-DYNA, and Abaqus

Learn more:
**altairhyperworks.com/multiscale**

## Benefits

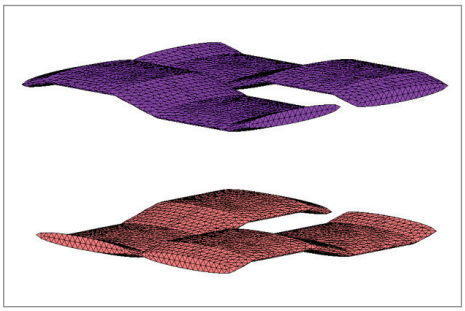
While a number of multiscale modeling frameworks exist, Multiscale Designer provides unmatched combination of practicality, mathematical rigor, validation, and versatility.

### Practicality

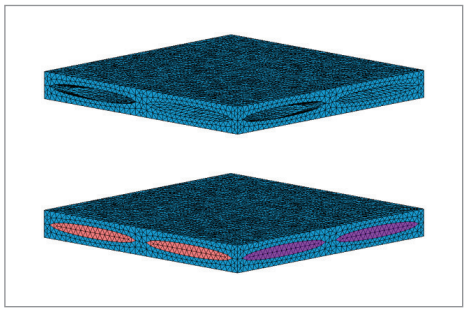
Multiscale Designer is equipped with a systematic model reduction technology that simplifies complex unit cells, having hundreds of thousands of finite elements, to a manageable number of deformation modes and state variables. The optimal kinematics (modes and state variables) are automatically selected to provide the desired level of accuracy for quantities of interest. Multiscale Designer is equipped with a built-in parametric library of unit cell models that permit optimization and stochastic simulations. The current parametric library of unit cell models includes; continuous fiber, woven fabrics, short and long chopped fiber, ordered particles, and random particle microstructures. This eliminates the overhead of generating complex unit cell models and their linkage to macro-scale FEA solvers. In addition to the parametric library of unit cells, user defined unit cell models (CAD and/or FEA mesh) can be imported and/or generated entirely within Multiscale Designer.

### Mathematical Rigor

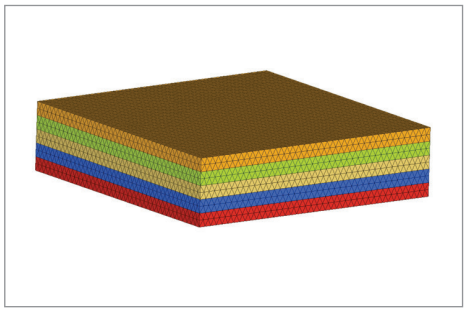
Multiscale Designer is free of scale separation and provides mesh insensitive results inherent to competing multiscale products. The characteristic material length scale is automatically identified by Multiscale Designer based on user-specified experimental data at the coupon-level. In addition, Multiscale Designer is equipped with stochastic multiscale capabilities that translate geometrical and material uncertainties into macro-scale component uncertainties.



*Warp and fill phases of plain weave unit cell*



*Matrix phase and homogeneous plain weave unit cell*



*Laminate from stack of homogeneous plain weave unit cells of multiple orientations*

**Validation**
Multiscale Designer is integrated with an experimental material database and a multi-step optimization engine that identifies model parameters having a high degree of uncertainty (such as void content, micro-cracks, interface/interphase properties).

**Versatility**
Advanced Multiscale Designer features include; generation of A- and B-basis material allowables with minimum testing and high accuracy, microstructural optimization, multiscale fatigue, and multiscale multiphysics simulation capabilities.

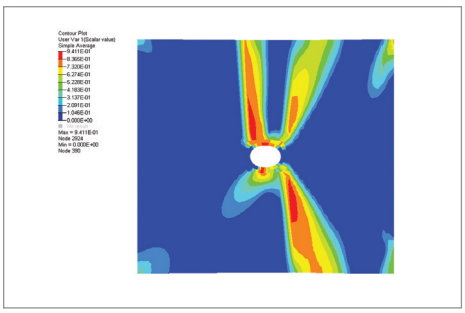
## Capabilities

**Mechanical**
Multiscale Designer - Mechanical computes linear and nonlinear material models which are subsequently used in a nonlinear analysis to resolve micro-scale fields (stresses and strains at the micro-scale) 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. Multiscale Designer - Mechanical is based on a micromechanical approach that possesses a minimal number of internal variables representing inelastic deformation of the micro-phases and has been validated against more than 50 benchmark problems of various composite product forms at the coupon and component levels.

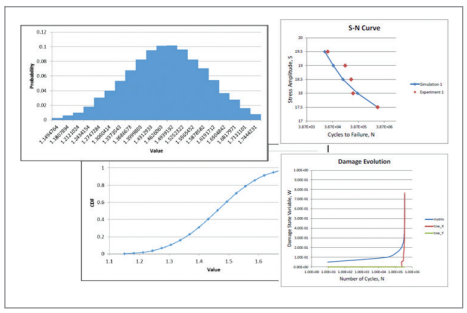
**Stochastics**
Multiscale Designer - Stochastics also provides forward homogenization and inverse optimization stochastic simulation capabilities. The forward homogenization stochastic simulation process computes a probability distribution function for the homogenized macro-scale properties given the variability of the micro-scale geometry and constitutive properties. The inverse optimization stochastic simulation process reverse engineers the probability distribution function of the micro-scale constitutive properties based on the variability of the experimental data at a macro-scale (coupon) level. Multiscale Designer – Stochastics provides the data necessary for the calculation of A- and B-basis material allowables via a virtual allowables supported by test methodology.

**Fatigue**
Multiscale Designer - Fatigue is based on the two-scale asymptotic homogenization approach in time, and reduced order homogenization in space, that can be effectively applied to any material architecture and any constitutive equations of micro-phases. Multiscale Designer - Fatigue has been validated for chemical vapor Infiltrated (CVI), melt Infiltrated (MI) ceramic composites, and PMR-15 and MVK-14 reinforced carbon fiber composites.

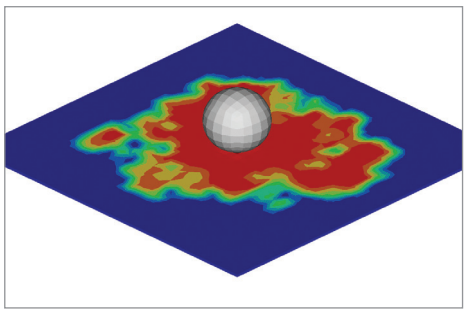
**Multiphysics**
Multiscale Designer - Multiphysics is based on the unified coupled multiscale mechano-diffusion-reaction model of environmental degradation of polymer and ceramic matrix composites. Mulitscale Designer - Mulitphysics couples multiple physical processes at multiple scales, including oxygen and/or moisture diffusion, reaction, and deformation. The salient feature of Multiscale Designer - Multiphysics is its computational efficiency accomplished through model reduction for multiple physical processes.



*Multiscale analysis of open hole tension specimen – matrix phase damage*




*Virtual allowables supported by test and fatigue simulation results*



*Multiscale analysis of low velocity impact – matrix phase damage*