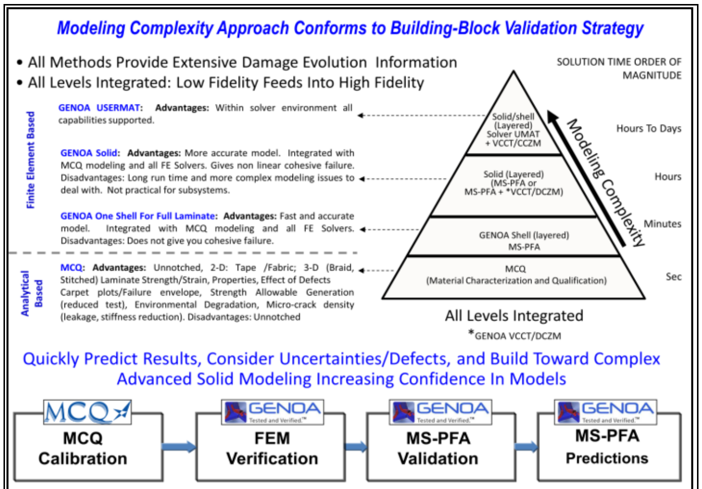
Aircraft Components Under Static Service Loading Using GENOA with and without UMAT

Challenge

Designers of composite structures need accurate computer codes for cost effective and light-weight design of structures. In addition to accuracy, computational costs in relation to time required for analysis is also a significant factor in assessing the viability and applicability of a computer code to a specific problem. In a recent program, the United States Air Force attempted to assess the predictive capabilities of several commercial codes. Invited participants were asked to predict the behavior of a series of notched and un-notched laminates subject to static loads. Numerous codes participated in the event. AlphaSTAR used the opportunity to compare solutions associated with GENOA and GENOA User Defined Material (UMAT) input in other commercially available Finite Element codes.

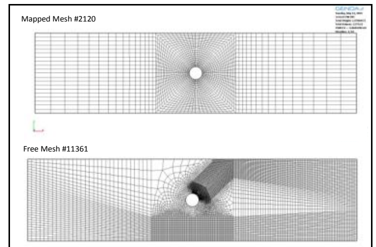


Functionality and Module Responsibilities

Solution

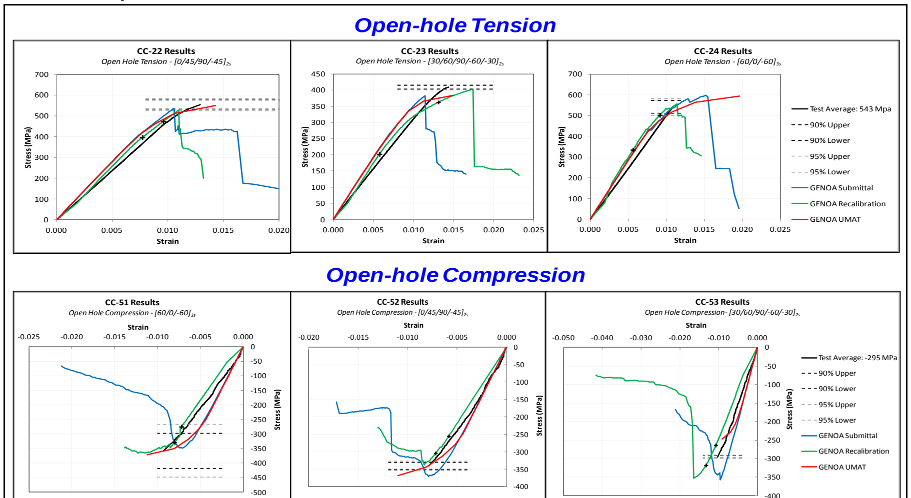
AlphaSTAR's GENOA software is capable of D&DT, life, and reliability predictions by means of Multi-Scale Progressive Failure Analysis (MS-PFA). The software augments the output of commercial FEM analysis to provide engineers with predictive technology to characterize and qualify advanced composites materials and structures considering manufacturing anomalies, effects of defects, and scatter for "as-built/as-is" states of composite material and structure. The innovation associated with GENOA is the integration of composite constituent micromechanics level progressive failure simulation with finite element structural analysis in a common building block strategy.

In the current study, the benefits of multi-scale progressive failure analysis and GENOA were utilized in two approaches. In the first approach, GENOA led the analysis and called on the services of and FEA solver to generate displacements and strains. In the second approach, a commercial FEA code led the analysis and called GENOA in its material subroutine. In both cases, material input was addressed by MCQ Composites, which accepted the results of 5 standard ASTM tests for in-plane material behavior, reverse engineered in situ constituent properties for fiber and matrix, assessed matrix non-linearity and recognized the effect of defects and other manufacturing anomalies on material performance. The material model was also validated against both 3 point bend and DCB test.



Two mesh schemes chosen for analysis

Next, two meshes were defined for the analysis of varying layout and resolution to confirm that convergence and mesh alignment were not an issues. The mapped mesh consisted of 2120 elements and the free mesh consisted of 11,361 elements.



GENOA with FEA Solver and GENOA UMAT

During the course of Air Force the project, the use of GENOA calling a commercial solver, was chosen to avoid convergence problems due to material degradation inside the solver implicit analysis. Post project, the analysis was revisited and other commercial FE codes using GENOA as a material subroutine was evaluated for speed and accuracy. The corresponding stress strain curves confirm that both approaches provided similar results with regard to accuracy. However there was a significant difference in computational cost. GENOA inside other FE codes as a material subroutine resulted in an analysis that took about 60 seconds to complete. In contrast, GENOA calling a commercial solver required 1700 seconds on average to complete an analysis.

Results & Conclusion

- Both GENOA approaches produced equivalent results.
- GENOA UMAT was almost 30x faster.
- Issues of mesh alignment and convergence were not a factor.

Key Highlights & Benefits
Product: GENOA, UMAT
Industry: Aerospace, Automotive, Manufacturing
Application: Blind Prediction
Benefits: Consistent Accuracy, Dramatically increased speed

Related Publication

Damage Tolerant Composite Design Principles for Aircraft Components under Static Service Loading Using Multi-Scale Progressive Failure Analysis. Journal of Composite Materials, vol. 51, 10: pp. 1393-1419.