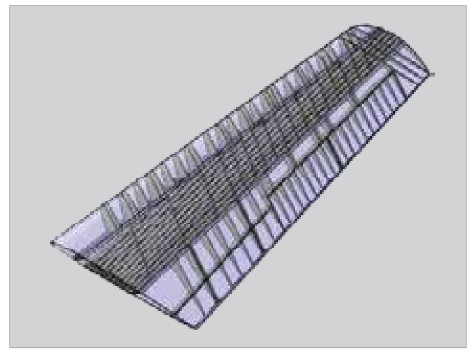
Case Study

OptiStruct Plays a Key Role in the Air Wing Design for a Multi-Disciplinary, Collaborative University Capstone Design Project

Overview

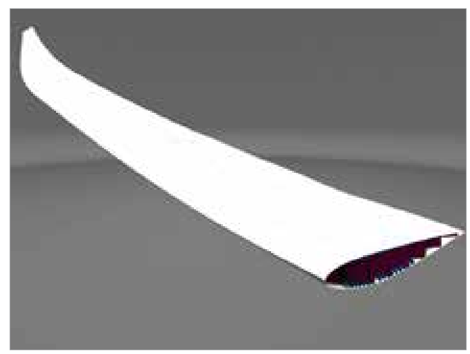
Engineers working in the industry are increasingly being required to work collaboratively and in multi-disciplinary design teams. Why is a similar trend not visible in engineering education? In order to address this issue, the Georgia Institute of Technology (Georgia Tech) took the lead in collaborating with five U.S. universities to develop a senior-level capstone design course that would give engineering students collaborative design experience using state-of-the-art computational tools. The multi-disciplinary course was completed over two semesters. Students, under the direction of university professors and industrial mentors, completed a fixed-wing aircraft design.



Aircraft Fixed Wing Design

Business Profile

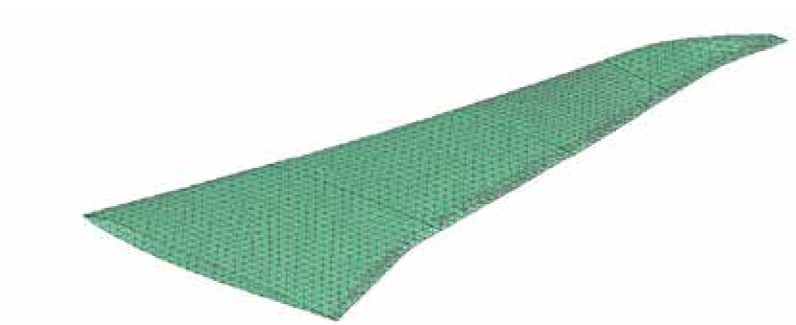
Georgia Tech in Atlanta, GA is a premier research university that provides students, faculty, and research staff with exceptional opportunities for intellectual, personal, and professional growth. The Georgia Tech College of Engineering is consistently ranked in the country's top ten engineering schools. It's graduate program in Aerospace Engineering is ranked in the top 5 programs. It's Aerospace Systems Design Laboratory, under the direction of Dr. Dimitri Mavris, and the Center of Excellence in Rotorcraft Technology, under the direction of Dr. Daniel Schrage, both provide a comprehensive, advanced design and systems engineering methods curriculum that enables students to become proficient in collaborative aerospace engineering projects.



Wing Skin

Challenge

The challenge of the senior-level capstone project was to re-design the fixed wing of a commercial aircraft using computer-aided-design (CAD) and computer-aided-engineering (CAE) tools that facilitate data sharing and collaboration among five United States engineering universities. Conceptual, preliminary, and detailed design of the wing structure, based on application of aluminum and laminated carbon-fiber composite materials, were required to be completed over the course of two semesters.



Wing Skin Finite Element Mesh

"Altair provided the capstone design student team with a tremendous amount of support through teaching optimization methods during two on-line webinars and consulting at their regional office in Boethel, WA."

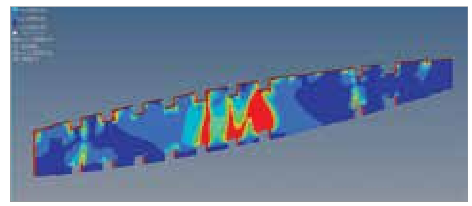
Dr. Daniel Schrage
Professor of Aerospace Engineering
Georgia Institute of Technology

Solution

Among several CAD and CAE simulation programs selected to complete the project, Altair OptiStruct was utilized to complete an optimized design for the aluminum wing ribs and the multi-ply laminate composite wing skin of a large passenger aircraft. The topology and shape optimization capabilities of OptiStruct were applied to design each of these structural components.

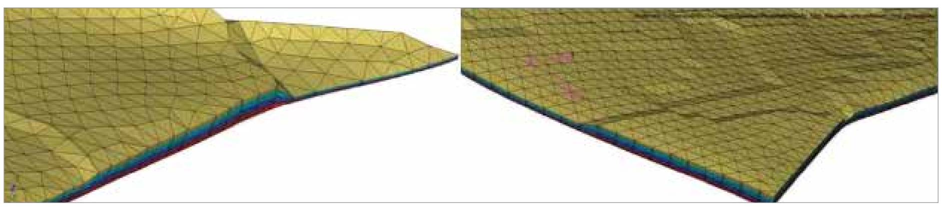
Web Topology Optimization Results

OptiStruct topology and free-size optimization methodologies were applied to eliminate aluminum material in non-critical rib stressed areas and reduce rib wall thickness. Topology optimization results gave a clear representation of the rib structural load paths, based on a rib thickness of 2.0 mm. Subsequent free-size optimization studies reduced the thickness to 0.15 mm.



Web Free-Size Optimization Results

For the lower wing skin design, a two-step optimization process was completed: an initial free-size optimization study that produced a set of ply shapes that correspond to the stiffest design for a given weight, followed by a sizing step that optimized laminate thickness. A maximum of 314 plies, corresponding to a total thickness of 60 mm, were used in strength-critical design areas.



Tip (Left) and Root (Right) of Optimized Composite Wing Skin

Optimization Model for Composite Skin

Results/Benefits

The application of Altair OptiStruct allowed the project design objectives to be met in a timely manner. Working collaboratively, the students gained valuable, real-world working experience by sharing CAD and CAE design data needed to complete the optimization analyses. More specifically:

- Free-size optimization results for the aluminum wing rib structure produced alight-weight design with varying web thickness.
- Free-size and size optimization for the laminated composite material wing skin determined which ply shapes and laminate lay-ups were best suited to maximize the stiffness for a cantilever wing subjected to surface pressure loads.

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