AA599C (to become AA534) Integrity of composite aircraft structures

Winter 2009 - Aeronautics and Astronautics, University of Washington

Class Schedule: MWF tbd, **Room:** LOWE (EDGE)
Instruction: Jan. to Mar.

Outline

Instructor: Prof. Paolo Feraboli, Ph.D.
Office: Gugg. 311D Tel. 206.543.2170 E-mail: feraboli@aa.washington.edu
Office Hours: anytime after class or by appointment

Class Website:
www.aa.washington.edu/people/faculty

Objective: Learn the tools to understand the most advanced concepts in composite structures and materials. Particular focus will be made on composite failure initiation and propagation, bolted and bonded joints, and damage resistance and tolerance, leading to considerations on regulatory agency requirements. Discussion has a very strong and applied emphasis to aircraft structures but is of applicable to all high-performance, lightweight structures. The emphasis of the course will be industry practices.

Recommended (but not required) pre-requisites:
Fundamental theory of Laminated Composites (for example AA432, AA532, ME450, Course I UW/ Boeing certificate program, or equivalent)
Metal Fatigue and/or Fracture Mechanics (for example AA531 or equivalent).

Textbook:
Composite Materials Handbook CMH-17 (formerly MIL-HDBK-17)
Rev. F (2002) Vol. 1 and 3 only - available through http://www.cmh17.org/resources.aspx

Other recommended book:
Composite Materials in Aircraft Structures, 2nd Edition - A.A. Baker, S. Dutton, D. Kelly - AIAA Education Series - available through the AIAA website for $116.95+S&H. AIAA members take advantage of the reduced rate ($79.95 +S&H).

Grading Distribution:

Homeworks	(3x10%)	30%
Laboratory experiments	(2x15%)	30%
Take-home Final		40%

Final exam will be open book/ notes.

Syllabus

Building block approach
Building block rationale and assumptions.
Case study Boeing 777 Empennage.
Lamina- and laminate-based strength. Allowables.
Practical Laminate design.
Elastic and failure analysis of composite sections (I-stiffener).

Stress Concentration
Metal vs. Composite generalities.
Point stress criterion. Critical dimension.
Mar-Lin equation.
Laminate tests.
Element tests.

Bonded Joints.
Closed form Analysis Methods.
FEM analysis.
ASTM standard test methods.
Surface preparation, Manufacturing and Adhesives
Design considerations

Bolted Joints.
Principles and failure modes.
Load share analysis.
Bearing and bypass interaction.
Design considerations.

Damage Resistance and Tolerance
Definitions and problems
Impact damage. Impact testing. Damage initiation.
Residual Strength. Semi-empirical, reduced stiffness, soft inclusion
Methods of compliance. Regulatory agency requirements. FAA FARs and ACs.

Supportability
Non-destructive evaluation techniques. Maintenance.
Repair types, materials and joints.
Analysis and design of repairs: bonded repairs.

Applications
Composite Fuselage. ATCAS Program. Boeing 787.
Cargo floor gusset case study

Hands-on experiments
EXP1. Supply pre-molded plates. Machine, tab, test specimens (UNT, UNC, OHT and OHC)
EXP2. Damage resistance: lightning strike. C-scan and micrographic inspection. Residual strength measurement.

Instructor's Bio-sketch

Paolo Feraboli joined the Department of Aeronautics and Astronautics of the University of Washington in the summer of 2005, as Assistant Professor in Aerospace Structures and Materials. Since then he has been collaborating with The Boeing Co., Federal Aviation Administration (FAA), and Automobili Lamborghini S.p.A. on various research projects related to the development of analytical and experimental techniques for composite materials. He is particularly interested in composites safety and certification initiatives, in particular in the area of damage resistance and tolerance, lightning strike protection, and crashworthiness.

He has authored over 50 publications between peer-reviewed journals and internationally acclaimed conferences. He is Chair of the CMH-17 Working Group on Crashworthiness (former MIL-HDBK-17), Chair of the Durability and Damage Tolerance Technical Division of ASC, and member of the AIAA Materials Technical Committee. He is also an active member of SAMPE.

Since June 2007 he has been actively involved with the technology development of the composite-intensive Boeing 787 Dreamliner.

Before joining the faculty at UW, Paolo was visiting researcher at NASA Langley Research Center, in the Mechanics and Durability Branch. He earned his Ph.D. from the University of California at Santa Barbara under the supervision of Dr. Keith Kedward, and holds previous degrees in Mechanical Engineering from the University of Bologna, Italy. Prior to moving to the States, Dr. Feraboli worked for Automobili Lamborghini S.p.A. in Sant'Agata Bolognese, where he was involved with the development of primary composite structures for the Murcièlago line-up.