Course E-6
Composite Joint Design & Analysis

Course Summary

This course is designed for engineers who wish to better understand the unique requirements for mechanically fastened composite structures, and how to design adhesively bonded joints for full load transfer and longevity.

Introduction

This course is engineering-oriented and quite mathematical in nature, but develops the practical requirements for good, sound joint design in composite structures. The course is best suited for degree-qualified engineers with at least 2 years experience and a degree in mechanical, civil, aerospace structures, or material science technologies. Unlike metals structures, the requirements for geometric sizing of a composite mechanically fastened joint are more critical, particularly when the joint is bearing primary loads. In adhesively bonded joint design the free ends of the joint are the critical condition where particular care must be taken to ensure peeling stresses are kept low. The question often asked is whether to use mechanical fasteners or adhesive bond a structural joint. This question will be clearly answered during the workshop. Design and analysis of composite structures allows participants to develop the preliminary design sizing of composite joints. This is later developed into detailed designs using non-linear and closed formed solution computer programs. Although the workshop is engineering-oriented and quite mathematical in nature, it is very much practical in output. Numerical analysis and design calculations are performed on PC based programs. (No more than two students per computer.) Optimization of design parameters to meet structural and geometric limitations is quickly identified. Hands-on structural testing is used to reinforce issues of quality control, adhesive preparation and surface conditioning prior to bonding. Preparation of mechanically fastened joints, the effects of induced damage, sizing and ply orientation changes are also considered.

Topics

Key Lecture Topics:

Introduction:

- Principles of joint technology.
- Types of joining methods.
- Advantages and disadvantages.
- Joint configurations.
- Mechanical fastener types.
- Adhesives technology.
- Fundamentals of stress analysis.
- Material properties.

Adhesive Bonded Joint Analysis::

- Introduction.
- Failure modes.
- Single - lap joint.
- Double-lap joint.
- Scarf joints.
- Stepped - lap joints.
- In-plane shear joints.
- Thermal mismatch and stiffness imbalance.
- Peel stresses.
- Design equation summary.
- Design guidelines.
- Computer programs.
- Damage tolerance.
- Fabrication methods.
- Quality control and assurance.

Mechanically Fastened Joint Analysis:

- Introduction.
- Failure modes.
- Single fastener analysis.
- Multiple fastener analysis (single row).
- Multi-row fastener analysis.
- Multi-row fastener preliminary loads estimation.
- Joint design guidelines.
- Computer programs for joint stress analysis.
- Lug joint analysis.
- Tension joints.

Bonded-Bolted Joints

- Discussion.

Workshop Exercises:

- Participants perform composite structural joint numerical analysis and design calculations using PC based programs.
- Optimization of design parameters is performed to meet structural and geometric limitations with the computer programs.
- Experimental testing of several joints is demonstrated during the course. These tests will clearly demonstrate the influence of mechanically fastened joints sizing changes, and the variations in adhesive bonded joint design parameters, including ply orientation. The impact of surface preparation is also illustrated in the experimental phase of the course.

Course Benefits

Attendees will learn best practices for design and analysis of advanced composite structural joints.

Prerequisites

E-5 Composite Structural Design course or equivalent engineering experience with composite structures design.

Teaching Method

Active classroom lecture and workshop exercises

CEU

3.6