Course ES-1
Composite Essentials for Engineers and Managers

Course Summary

ES-1 has been developed to provide engineers and technical managers with a broad, but comprehensive understanding of composite materials and manufacturing techniques used in component development, design, and in-service operation. The course covers the major considerations for the application of composite materials with an emphasis on cost, weight, and structural requirements, material usage, manufacturing techniques, vacuum bagging, and cure cycles. The ES-1 course also covers the fundamentals of composite analysis, bonded joints, and bolted joints. The course incorporates the classroom lecture into the hands-on fabrication of fiberglass and carbon fiber prepreg solid laminate and honeycomb core panels. These panels are both bonded and bolted together and then mechanically tested to evaluate their performance and failure with the classroom analysis. ES-1 is a recommended prerequisite for all the Engineering Structures (ES) courses to ensure that the students have a sufficient understanding of composite materials and processes before they begin the learning process on more in-depth composite analysis techniques. Only engineers with extensive composite materials and process experience from OJT, or other formal training, such as Abaris' Aerospace Repair Analysis and Substantiation (ER-1) or Advanced Composite Structures: Fabrication & Damage Repair - Phase 1 (M-1/R-1) course should consider omitting this course as a prerequisite.

Introduction

ES-1 consists of 40% materials and processes, 40% analysis, and 20% hands-on and material testing. It compares various manufacturing processes, outlining the differences that each process offers, in terms of component quality and structural performance. A full spectrum of fiberglass and carbon fiber, solid laminate and sandwich panels are fabricated and assembled with both bonded and bolted joints to demonstrate significant fabrication, processing, and assembly effects. Specific component design details such as holes, joints, ply drop-offs, etc. are incorporated and examined from a behavioral point of view. The course includes a review of in-service issues such as damage and defects, repairability, environmental influences, manufacturing quality requirements, certification standards, and health and safety concerns.

The analysis in ES-1 presents the in-plane stiffness calculations using matrix math to determine laminate modulus values as well as evaluate the applied loads and stresses to calculate the resulting strains.The laminate calculations are also applied to bonded and bolted joint analysis to evaluate the strength of the assembled test panels made during the course.

Overall, ES-1 allows attendees to better understand the issues facing composite designers, engineers, and fabricators as they develop and implement composite materials into new components and structures. This understanding will greatly improve the effective and efficient use of composite materials into their product. Participants in the course will be provided with a comprehensive set of course notes and other related documents.

Topics

Key Lecture Topics:

- Introduction to composite capabilities and global properties by explaining the fundamental behavior and performance issues that are unique to composite materials and structures.
- Health and safety concerns are presented where aspect of occupational health and safety are discussed, with the need to protect the working and the environment emphasized.
- Constituent material properties and effects are presented with an in-depth discussion of fiber and resin properties, resin content, and fiber volume with their individual impact on composite structures.
- Composite manufacturing is explained with the many methods available to fabricate composite structures. These methods will be discussed with consideration given to the facility requirements, product quality, and structural performance.
- Nondestructive Inspection is discussed with the role of visual and instrumented nondestructive inspection in manufacturing and maintaining composite structures.
- Composite mechanical testing and test standard are presented with many ASTM methods used in composite material property evaluation. These methods range from Quality Assurance testing to mechanical property determination. The significance of testing is emphasized.
- Composite Bond tooling, Assembly fixtures, mechanical fastening, and adhesive bonding.
- Maintenance and repair of composites is presented with a discussion of in-service damage types, and the requirements for maintenance and repair activities are introduced as an important part of the life-cycle approach to design and development.
- The properties of a single layer (ply) are explained without the mathematic rigor, but with sufficient detail to understand the complexity of composite material engineering mechanics.
- Laminate properties are developed from single plies using classical laminate plate theory to enable the application of loads and stresses.
- Environmental considerations such as galvanic corrosion, lightning strike, EMI, moisture ingression, and fluids contamination is presented which affect the in-service performance of composites structures.
- Operational issues concerning temperature and moisture is discussed to understand the materials selection requirements early in the development of composite structures and components.

Workshop Exercises:

- Fiberglass and carbon fiber, solid laminate and sandwich panel layups.
- Vacuum bag preparation and installation.
- Elevated temperature curing.
- Bonded and bolted panel assembly.
- Mechanical testing for composites.

Course Benefits

Attendees will receive a comprehensive understanding of composite materials and specific issues related to the use of composites in structures and component design, manufacture, and “in-service” operation.

Prerequisites

None

Teaching Method

Active classroom lecture and workshop exercises

CEU

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