AEROSPACE
SHORT COURSES

Stress Analysis for Aerospace Structures (AERO0480)

Instructor: Dennis C. Philpot

Course Description

This course is designed for the practicing engineer who has an interest in the various aspects of stress analysis in aerospace structural-mechanical design and would like to enhance his or her expertise in this important field. The approach taken in this course is to start with a strong theoretical foundation and then build upon that foundation with practical applications that can be immediately put into practice in the workplace. In this manner, both the theory and practice of classical "hand" analysis techniques are presented as well as the more modern (numerical/computational) methods used in the industry. The subject-matter difficulty level is intermediate.

Course Highlights

- The big picture: Solid Mechanics
- Engineering mechanics review
- Two- and three-dimensional theory of elasticity
- Generalized Hook's Law
- Airy stress functions
- Linear elastic fracture mechanics (LEFM)
- Energy methods in mechanical analysis
- The finite element method
- Failure prevention of engineering materials
- Fundamentals of deterministic stress analysis
- Analysis of bolted joints
- Fatigue analysis in mechanical design
- Numerical optimization
- Five common errors in stress analysis practice

Who Should Attend?

- Design engineers who would like to become more familiar with the techniques and modern practices of stress analysis to help them be more efficient and productive in their work.
- Mechanical engineers who have been out of college for a while and need to become more knowledgeable in the area of stress analysis due to a particular job assignment or new career opportunity that requires expertise in analyzing structures.

- Department managers whose staff are involved in stress analysis work.

Learning Objectives

Upon completing this course, participants should be able to:

- Identify and correct problematic designs based on stress analysis results
- Calculate margins of safety due to various types of loading conditions
- Assess structures based on material strength, brittle fracture and fatigue criteria
- Analyze bolted joints under preload, tension, shear and combined loading
- Understand the theory behind the analysis processes
- Optimize designs for greater efficiency and/or durability
- Speak knowledgeably about structural integrity to customers and management

Course Outline

Day One

Introduction

- Why Structures Fail
- Structural Integrity Focus
- Design Synthesis
- Analysis in the Design Environment
- Vectorial and Analytical Mechanics
- Key Design Engineering Processes
- Product Specifications and Design Criteria
- Point Design and Parametric Analysis
- The Product of the Stress Analyst
- The Value of Early Analysis

Engineering Mechanics Review

- Free Body Diagrams
- Introduction to Solid Mechanics
- Constitutive Relations
- Two-Dimensional Theory of Elasticity
- Equations of Compatibility
- The Airy Stress Function
- Moment and Shear Diagrams
- Properties of Plane Areas
- Calculating Stresses in Beams
- Analyzing Non-Symmetric Beams
- Stability of Columns

Day Two

Energy Methods in Mechanical Analysis

- The Usefulness of Energy Methods
- Momentum and Kinetic Energy
- Strain Energy in Structural Elements
- Rayleigh Ritz Method
- Types of Finite Elements

- d'Alembert's Principle
- Lagrange's Equations of Motion
- How Finite Elements are Derived
- Computation of Deflections
- Computation of Stresses

Failure Prevention of Engineering Materials

- The Stress Analyst's Primary Task
- Design Feasibility
- Structural Integrity Processes
- Structural Integrity is Essential
- Aircraft Structural Integrity Program (ASIP)
- Factors of Safety and Margins of Safety
- Important Failure Modes
- Material Distortion
- Ductile Rupture
- Fracture of Brittle Materials
- Stability Failure
- Progressive Fracture due to Fatigue

Day Three

Deterministic Stress Analysis in Mechanical Design

- Definition of stress
- Generalized Hook's Law
- Equilibrium of a 2-D stress element
- Derivation of the principal stresses
- Mohr's circle of stress
- Static failure theories
- Introduction to Fracture Mechanics
- Historical Failures Involving LEFM
- The Column Analogy
- Two Distinct Approaches to LEFM
- Calculation of Stress Intensity

Analysis of Bolted Joints

- Bolt and Material Stiffness
- Tensile and Shear Areas for Standard Bolts
- Modified Interaction Equation
- Analysis of Bolts Loaded in Tension
- Analysis of Bolts Loaded in Shear
- Analysis of Bolts under Combined Loading
- Determining the Proper Preload
- Strength of Threads in Shear
- Joints involving Multiple Fasteners
- Use of Fitting Factors in Bolted Joints

Day Four

Dynamic Loading

- What is Meant by “Quasi-Static Loads”
- Mode Shapes, Boundary Conditions and Natural Frequencies
- Equations of Motion for Second-Order Systems
- Harmonic Loading of Second-Order Systems
- Shock Loading of Second-Order Systems
- Introduction to Random Vibration
- Linear System Response to Random Vibration
- Random Vibration in Mechanical Design

Fatigue Analysis in Mechanical Design

- The Three Phases of Fatigue Failure
- Complicating Factors in Fatigue Analysis
- The Modified Goodman Diagram Approach to Fatigue Life Analysis
- Alternative Failure Criteria in Fatigue Life Analysis
- Endurance Limit Modifying Factors
- Fatigue Analysis Using MMPDS Data
- Cumulative Damage Theory

Day Five

Numerical Optimization

- The Optimization Problem
- Unconstrained Design Problems
- Constrained Design Problems
- General Purpose Optimization Software
- The Finite Element Method
- Multidisciplinary Design Optimization (MDO)

Practical in-Depth Examples and Sample Problems

- Castigliano’s Theorems and Examples of Castigliano’s Second Theorem
- Optimization of a Space Truss
- Five Common Errors Committed by Structural Analysts
- Duhamel’s Integral
- d’Alembert’s Principle and Inertia Relief Practice
- Theoretical/First Principles vs. Computer Software

Classroom hours / CEUs

31.50 classroom hours
3.15 CEUs

Certificate Track

Aircraft Design, Aircraft Structures

Course Fees

Early registration course fee: $2,595 if you register and pay by the early registration deadline (45 days out).
Regular registration course fee: $2,795 if you register and pay after the early registration deadline.

Course Materials
Course materials, including outlines, presentation copies, and supplementary materials, will be accessible through Canvas, KU's online learning system. Instructions to access Canvas will be provided upon completed registration. Students are required to bring a computer or other electronic device with PDF-viewing capabilities with them to class each day. If you require accommodation contact us at professionalprograms@ku.edu and we will work with you on an accessible solution.

U.S. Federal Employee Discount
This course is available to U.S. federal employees at 10% off the registration fee. To receive the federal employee discount, you must enter the code **FGVT116** during the checkout process. Please note that you must validate your eligibility to receive this discount by entering your U.S. government email address (ending in .gov or .mil) when creating your online registration profile. This discount is available for both the early registration and regular registration fees.

Canada Department of National Defence Discount
This course is available to Canada DND employees at 10% off the registration fee. Please contact the DND Procurement Authority (DAP 2-3) for details. Please note that you cannot register using our online system when requesting this discount. This discount is available for both the early registration and regular registration fees.

Instructor Bio

As a Northrop Grumman Defense Systems Sector Technical Fellow, Mr. Philpot is the Advanced Weapons Division technical lead for aerodynamics, mechanical design and structural and thermal analysis for missile products and advanced programs and has played a key role in diverse programs, which include the Advanced Anti-Radiation Guided Missile (AARGM), Multi-Stage Supersonic Target (MSST), the Jordan Light Gunship (JLG), as well as many others. He also serves as the test director for many of the environmental tests (thermal, vibration, acoustic, shock, etc.) that are conducted for the purpose of hardware development, acceptance and qualification.

Having had a keen interest in teaching for many years, Mr. Philpot began developing course material back in the early 1990's to pass on his theoretical and experiential knowledge to the aerospace engineering community. The two courses he teaches through the University of Kansas, Aerospace Short Courses KU Lifelong & Professional Education include *Dynamics for Aerospace Structures* and *Stress Analysis for Aerospace Structures.* It is his sincere hope that these courses will greatly benefit each course participant and the companies they serve.

This class is available for delivery at your company.
Your company can realize substantial savings by bringing an aerospace short course to your workplace. On-site delivery is ideal for organizations that need to train 10 or more employees on a specific topic. For more information on on-site course delivery, or to request a cost proposal, please contact us at ProfessionalPrograms@ku.edu.

CONTACT US:

KU Jayhawk Global
Aerospace Short Course Program
1515 St. Andrews Dr.
Lawrence, KS 66047
Email: jayhawkglobal@ku.edu
Phone: 785-864-6779 (Registration)