Stability and integrity of aerospace structures

Academic Year: (2019 / 2020) **Review date: 07-05-2020**

Department assigned to the subject: Bioengineering and Aeroespace Engineering Department
Coordinating teacher: CINI , ANDREA
Type: Electives ECTS Credits : 6.0
Year : 3 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Advanced Mathematics
Aerospace Materials I and II
Introduction to Structural Analysis
Aerospace Structures

OBJECTIVES

- Understanding of the concept of instability and the loading conditions in which it appears.
- Ability to calculate the onset of instability in aerospace structures.
- Understanding the effects that cycling loading, stress level and geometric configuration have on the life of structural members.
- Understanding the mechanism by which cracks grow and variables that affect their growth rate.
- Ability to calculate when aerospace structures will fail when subjected to cycling loading.
- Knowledge of design concepts and inspection methods that will safeguard aerospace structures from catastrophic failure.

DESCRIPTION OF CONTENTS: PROGRAMME

1) Stress Analysis of Aircraft Components
- Structural Idealization
- Wing spar and box beams
- Wings
- Fuselage

2) Structural Stability
- Columns:
Elastic buckling of ideal columns. Euler Curve. Inelastic buckling of columns. Euler-Engesser Curve. Real effects on column stability: Imperfections. Local Buckling and Crippling. The Johnson-Euler curve.
- Plates:
Elastic buckling of plates (compression, bending, shear and combined loading). Plastic effects in plate buckling. Effect of panel curvature. Panel failure: compression and shear panels. Diagonal Tension.

3) Structural Integrity:
- Constant and variable amplitude fatigue:
SN Curves. Stress concentrations. Cycle counting. Cumulative damage rules. Residual stresses. Design Criteria.
- Linear Elastic Fracture Mechanics:
Energy release rate and Stress Intensity Factors. Plastic zone size. Fracture Toughness and failure prediction. Thickness effects on Fracture Toughness. The plane strain Fracture Toughness test.
- Fatigue Crack Growth:
Fatigue crack growth rate curve. Stress ratio effects. Paris Law and other analytical representations.
- Damage Tolerance Analysis:
Life prediction. Closed form integration for constant Beta and Paris Law. Retardation effects. Design Criteria.

LEARNING ACTIVITIES AND METHODOLOGY

Theory sessions.
Problem sessions working individually and in groups.
Experimental and numerical Lab-sessions.

ASSESSMENT SYSTEM

End-of-term exam (60%)
Midterm test (10%)
Lab sessions - projects (30%)

In order to pass the subject the following two conditions must be met:

1) A minimum grade of 5.0 (End-of-term + continuous evaluation) must be obtained,
AND
2) A minimum grade of 4.0 in the end-of-term exam must be obtained.

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- Anderson, T. L. Fracture Mechanics: Fundamentals and Applications, CRC Press, 1995
- Megson Aircraft Structures for Engineering Students, Elsevier, 2012
- Ralph I. Stephens, et. al. Metal Fatigue in Engineering, Wiley, 2001
- Timoshenko & Gere Theory of Elastic Stability, McGraw Hill, 1985

ADDITIONAL BIBLIOGRAPHY

- Broek, David The practical use of fracture mechanics, Springer, 1989
- Bruhn, E.F. Analysis and design of flight vehicle structures, Jacobs, 1973
- James Gere and Stephen Timoshenko Mechanics of Materials, PWS Publishing, 1990 (or newer).
- Jan R. Wrigth Introduction to Aircraft Stability and Loads, John Wiley & Sons, 2007
- John M. Barsom and Stanley T. Rolfe Fracture and Fatigue Control in Structures, ASTM, 1999