# AIRCRAFT STRUCTURES

# for engineering students

Second Edition T.H.G. MEGSON

Edward Arnold A division of Hodder & Stoughton LONDON MELBOURNE AUCKLAND

# Preface

Preface to Second Edition

# PART 1 ELASTICITY

#### Chapter 1 Basic Elasticity

1.1 Stress 1.2 Notation for forces and stresses 1.3 Equations of equilibrium 1.4 Plane stress 1.5 Boundary conditions
1.6 Determination of stresses on inclined planes 1.7 Principal stresses
1.8 Mohr's circle of stress 1.9 Strain 1.10 Compatibility equations
1.11 Plane strain 1.12 Determination of strains on inclined planes
1.13 Principal strains 1.14 Mohr's circle of strain 1.15 Stress-strain relationships 1.16 Experimental measurement of surface strains

#### Chapter 2 Two-dimensional Problems in Elasticity

2.1 Two-dimensional problems 2.2 Stress functions 2.3 Inverse and semi-inverse methods 2.4 St Venant's principle 2.5 Displacements 2.6 Bending of an end-loaded cantilever

#### **Chapter 3** Torsion of Solid Sections

3.1 Prandtl stress function solution 3.2 St Venant warping function solution 3.3 The membrane analogy 3.4 Torsion of a narrow rectangular strip

# Chapter 4 Energy Methods of Structural Analysis

4.1 Strain energy and complementary energy
4.2 Total potential energy
4.3 Principle of virtual work
4.4 The principle of the stationary value of the total potential energy
4.5 The principle of the stationary value of the

65

ix

xi

1

48

33

#### vi Contents

total complementary energy 4.6 Application to deflection problems 4.7 Application to the solution of statically indeterminate systems 4.8 Unit load method 4.9 Principle of superposition 4.10 The reciprocal theorem 4.11 Temperature effects

#### Chapter 5 Bending of Thin Plates

5.1 Pure bending of thin plates 5.2 Plates subjected to bending and twisting 5.3 Plates subjected to a distributed transverse load 5.4 Combined bending and in-plane loading of a thin rectangular plate 5.5 Bending of thin plates having a small initial curvature 5.6 Energy method for the bending of thin plates

#### Chapter 6 Structural Instability

6.1 Euler buckling of columns 6.2 Inelastic buckling 6.3 Effect of initial imperfections 6.4 Stability of beams under transverse and axial loads 6.5 Energy method for the calculation of buckling loads in columns 6.6 Buckling of thin plates 6.7 Inelastic buckling of plates 6.8 Experimental determination of critical load for a flat plate 6.9 Local instability 6.10 Instability of stiffened panels 6.11 Failure stress in plates and stiffened panels 6.12 Flexural-torsional buckling of thin-walled columns 6.13 Tension field beams

# PART II ANALYSIS OF AIRCRAFT STRUCTURES

#### Chapter 7 Principles of Stressed Skin Construction

7.1 Materials of aircraft construction 7.2 Loads on structural components 7.3 Function of structural components 7.4 Fabrication of structural components

#### Chapter 8 Bending, Shear and Torsion of Open and Closed, **Thin-walled Beams**

8.1 Bending of open and closed section beams 8.2 General stress, strain and displacement relationships for open and single cell closed section thin-walled beams 8.3 Shear of open section beams 8.4 Shear of closed section beams 8.5 Torsion of closed section beams 8.6 Torsion of open section beams 8.7 Analysis of combined open and closed sections 8.8 Structural idealization 8.9 Effect of idealization on the analysis of open and closed section beams 8.10 Deflection of open and closed section beams

147

203

#### 117

# Chapter 9 Stress Analysis of Aircraft Components

9.1 Tapered beams 9.2 Fuselages 9.3 Wings 9.4 Fuselage frames and wing ribs 9.5 Cut-outs in wings and fuselages 9.6 Laminated composite structures

# Chapter 10 Structural Constraint

10.1 General aspects of structural constraint 10.2 Shear stress distribution at a built-in end of a closed section beam 10.3 Thin-walled rectangular section beam subjected to torsion 10.4 Shear lag 10.5 Constraint of open section beams

# Chapter 11 Matrix Methods of Structural Analysis

11.1 Notation 11.2 Stiffness matrix for an elastic spring 11.3 Stiffness matrix for two elastic springs in line 11.4 Matrix analysis of pin-jointed frameworks 11.5 Application to statically indeterminate frameworks 11.6 Matrix analysis of space frames 11.7 Stiffness matrix for a uniform beam 11.8 Finite element method for continuum structures

# PART III AIRWORTHINESS AND AEROELASTICITY

#### Chapter 12 Airworthiness

12.1 Factors of safety—flight envelope 12.2 Load factor determination 12.3 Symmetric manoeuvre loads 12.4 Normal accelerations associated with various types of manoeuvre 12.5 Gust loads 12.6 Fatigue

#### Chapter 13 Elementary Aeroelasticity

13.1 Load distribution and divergence 13.2 Control effectiveness and reversal 13.3 Structural vibration 13.4 Introduction to flutter

# Index

563

520

## Ca

312

390

441

482