

Table of Contents

- 1 INTRODUCTION – WHAT IS “MECHANICS OF SOLIDS?”
 - 1.1 Units of Measurement
 - 1.2 Convention used in this book
- 2 TYPES OF SOLIDS – A SYSTEMS VIEW OR SEQUENCE OF IDEALIZATIONS
 - 2.1 2D Components (of the 3D)
 - 2.1.1 The Plane Frame
 - 2.1.2 The Plane Truss
 - 2.2 1D Components (of the 2D)
 - 2.2.1 The Continuous Beam and Column
 - 2.2.2 The Strut and Tie
 - 2.3 0D Components (of the 1D)
 - 2.3.1 The Cross-Section of Infinitesimal Length
 - 2.3.2 Geometrical Properties of Sections
 - 2.3.2.1 The Centroid or Centre of Area
 - 2.3.2.2 The Moment of Inertia, Section Modulus, Radius of Gyration
 - 2.3.2.2.1 The Subtraction Method
 - 2.3.2.2.2 The Parallel Axis Theorem Method
 - 2.3.2.2.3 Section Modulus
 - 2.3.2.2.4 Radius of Gyration
 - 2.4 The Supports and Joints – Where Components Meet
 - 2.4.1 Types of Supports in 2D
 - 2.4.1.1 The Roller Support
 - 2.4.1.2 The Pinned Support
 - 2.4.1.3 The Fixed Support
 - 2.4.2 Types of Joints in 2D
 - 2.4.2.1 The Rigid Joint
 - 2.4.2.2 The Pinned Joint
 - 2.4.2.3 The Free Joint
- 3 FORCES AND STATIC EQUILIBRIUM
 - 3.1 “The forces are external; the stresses/deformations internal”
 - 3.2 Forces – Resultants and Equilibrants
 - 3.2.1 Equilibrium of Concurrent Forces
 - 3.2.1.1 Resultants by Vector Addition
 - 3.2.1.2 Components of a Force
 - 3.2.1.3 Resultants by Trigonometry
 - 3.2.1.4 Conditions of Static Equilibrium for Concurrent Forces
 - 3.2.2 Equilibrium of Non-Concurrent Forces

- 3.2.2.1 Position and Moment of a Force
- 3.2.2.2 A Moment as a Couple
- 3.3 Statical Determinacy and Geometric Instability
 - 3.3.1 Determinacy of Plane Trusses
 - 3.3.2 Determinacy of Beams
 - 3.3.3 Geometric Instability
- 4 STATICALLY DETERMINATE TRUSSES – “REACTIONS THEN JOINTS, THEN SECTIONS”
 - 4.1 Finding the Internal Forces (in Planar Trusses) by Joint Equilibrium
 - 4.1.1 The Graphical Method
 - 4.1.1.1 Bow’s Notation and the Force Polygon for the External Forces
 - 4.1.1.2 The Force-Polygons at the Joints
 - 4.1.2 The Algebraic Method: ($\sum H = 0$; $\sum V = 0$)
 - 4.2 Finding the Internal Forces (in Planar Trusses) by the Method of Sections
 - 4.3 Finding the Internal Forces (in 3D Trusses) by the Method of Tension Coefficients
- 5 STATICALLY DETERMINATE BEAMS – “REACTIONS THEN SECTIONS”
 - 5.1 Shear Force (V) and Bending Moment (M)
 - 5.1.1 Sign Convention for V and M
 - 5.2 SFD and BMD at Section x by the Graphical Method
 - 5.2.1 Equilibrium of an Infinitesimal Beam Length
 - 5.2.2 The Shear Force Distribution ($V_x = - \sum \text{forces } q \text{ to left of } x$)
 - 5.2.3 The Bending Moment Distribution ($M_x = \text{Area of SFD to the left of } x$)
 - 5.3 SFD and BMD at Section x by the Algebraic Method
- 6 STRESS, STRAIN IN TIES AND STRUTS CROSS-SECTIONS
 - 6.1 Direct Stress and Axial Strain
 - 6.2 The Constitutive Relation of Ties/Struts
 - 6.3 Axial Stress-Strain Behaviour
 - 6.4 Allowable Stress
 - 6.5 Direct Stress in Statically Determinate Systems
 - 6.5.1 Stress in a Rod Considering Self-Weight
 - 6.5.2 Profile of a Constant Stress Member
 - 6.5.3 Thin-Walled Cylinder Under Pressure
 - 6.6 Direct Stress in Statically Indeterminate Systems
 - 6.6.1 Stress in a Composite (Compound) Bar
 - 6.6.1.1 Without Temperature Effects
 - 6.6.1.2 With Temperature Effects
- 7 STRESS, STRAIN IN HOMOGENEOUS BEAM CROSS-SECTIONS (ENGINEER’S BEAM THEORY)
 - 7.1 Shear Force V, and Bending Moment M, as Stress Resultants

- 7.2 The Constitutive Relation of Beams in Pure Bending
- 7.3 Bending Strain and Bending Stress
- 7.4 The Moment of Resistance of Beams
- 8 STRESS IN COMPOSITE BEAM CROSS-SECTIONS
 - 8.2 Composite Beams with Symmetrical Arrangement of the Layers
 - 8.2 Composite Beams with Unsymmetrical Arrangement of the Layers
 - 8.2.1 The Transformed Section
 - 8.2.1.1 Stresses at the Interface
 - 8.2.1.2 Moment at the Section
 - 8.2.2 Procedure for Calculating the Stresses
 - 8.3 The Moment of Resistance of Composite Beams
 - 8.3.1 Symmetrical Sections
 - 8.3.2 Unsymmetrical Sections
- 9 COMBINED AXIAL AND BENDING STRESS
 - 9.1 Sections with Uniaxial Bending
 - 9.2 Sections with Biaxial Bending
- 10 DEFLECTION, SLOPE OF BEAM CROSS-SECTIONS
 - 10.1 The Moment-Curvature Relationship
 - 10.2 Double Integration Method
 - 10.3 Standard Cases
 - 10.3.1 Case 1: Point Load Distance “a” From Left End
 - 10.3.2 Case 2: UDL Load Starting Distance “a” From Left End
 - 10.4 Macaulay Method
- 11 TORQUE OF SHAFTS WITH CLOSED-END SECTIONS
 - 11.1 The Constitutive Relation for Shafts
 - 11.2 Concentric Shafts
 - 11.3 Shafts in Series
 - 11.4 Efficiency of Shafts
 - 11.5 The Power-Torque Relationship
- 12 STRESS, STRAIN IN 3D “BULK MASS” SOLIDS
 - 12.1 3D Strain and Plane (2D) Strain
 - 12.2 2D Strain Transformation
 - 12.2.1 Matrix Method of Calculation
 - 12.2.2 Mohr’s Circle Graphical Method of Calculation
 - 12.2.3 Principal Strains and Maximum Shear Strain
 - 12.3 Strain Gauge Rosettes
 - 12.4 Theory of 3D Stress and Plane (2D) Stress
 - 12.5 2D Stress Transformation
 - 12.5.1 Matrix Method of Calculation

- 12.5.2 Mohr's Circle Graphical Method of Calculation
- 12.5.3 Principal Stresses and Maximum Shear Stress
- 12.6 The Plane Stress Constitutive Relation of a Homogeneous Isotropic Material
- 12.7 Introduction to Failure Theory
 - 12.7.1 Maximum Principal Stress Theory
 - 12.7.2 Maximum Shear Stress Theory
 - 12.7.3 Maximum Shear Strain Energy Theory