



Table of Contents

Preface v

1	Basic Concepts in Strength of Materials	1
1-1	Objective of this Book-to Ensure Safety	4
1-2	Objectives of this Chapter	6
1-3	Problem-Solving Procedure	7
1-4	Basic Unit Systems	8
1-5	Relationship Among Mass, Force, and Weight	9
1-6	The Concept of Stress	11
1-7	Direct Normal Stress	12
1-8	Stress Elements for Direct Normal Stresses	14
1-9	Direct Shear Stress	15
1-10	Stress Elements for Shear Stresses	20
1-11	Bearing Stress	20
1-12	The Concept of Strain	24
1-13	Poisson's Ratio	25
1-14	Shearing Strain	26
1-15	Modulus of Elasticity	26
1-16	Modulus of Elasticity in Shear	27
1-17	Preferred Sizes and Standard Shapes	27
1-18	Experimental and Computational Stress Analysis	33
	References	38
	Problems	38

2 Design Properties of Materials 48

2-1	Objectives of this Chapter	50
2-2	Metals in Mechanical and Structural Design	50
2-3	Steel	57

2-4	Cast Iron	62
2-5	Aluminum	63
2-6	Copper, Brass, and Bronze	65
2-7	Zinc, Magnesium, and Titanium	66
2-8	Nonmetals in Engineering Design	66
2-9	Wood	67
2-10	Concrete	67
2-11	Plastics	68
2-12	Composites	69
	References	80
	Problems	80
3	Design of Members under Direct Stresses	83
3-1	Objectives of this Chapter	85
3-2	Design of Members under Direct Tension or Compression	85
3-3	Design Normal Stresses	86
3-4	Design Factor	87
3-5	Design Approaches and Guidelines for Design Factors	89
3-6	Methods of Computing Design Stress	92
3-7	Design Shear Stress	98
3-8	Design Bearing Stress	102
3-9	Stress Concentration Factors	108
	References	112
	Problems	112
4	Axial Deformation and Thermal Stress	128
4-1	Objectives of this Chapter	130
4-2	Elastic Deformation in Tension and Compression Members	130
4-3	Deformation Due to Temperature Changes	136
4-4	Thermal Stress	140
4-5	Members Made of More Than One Material	143
	Problems	146
5	Torsional Shear Stress and Torsional Deformation	153
5-1	Objectives of this Chapter	156
5-2	Torque, Power, and Rotational Speed	156
5-3	Torsional Shear Stress in Members with Circular Cross Sections	159
5-4	Development of the Torsional Shear Stress Formula	162
5-5	Polar Moment of Inertia for Solid Circular Bars	163
5-6	Torsional Shear Stress and Polar Moment of Inertia for Hollow Circular Bars	164

5-7	Design of Circular Members under Torsion	166
5-g	Comparison of Solid and Hollow Circular Members	169
5-9	Stress Concentrations in Torsionally Loaded Members	173
5-10	Twisting-Elastic Torsional Deformation	180
5-11	Torsion in Noncircular Sections	190
	References	195
	Problems	196
	Computer Assignments	201
6	Shearing Forces and Bending Moments in Beams	203
6-1	Objectives of this Chapter	205
6-2	Beam Loading, Supports, and Types of Beams	206
6-3	Reactions at Supports	213
6-4	Shearing Forces and Bending Moments for Concentrated Loads	217
6-5	Guidelines for Drawing Beam Diagrams for Concentrated Loads	224
6-6	Shearing Forces and Bending Moments for Distributed Loads	231
6-7	General Shapes Found in Bending Moment Diagrams	237
6-8	Shearing Forces and Bending Moments for Cantilever Beams	238
6-9	Beams with Linearly Varying Distributed Loads	240
6-10	Free-Body Diagrams of Parts of Structures	242
6-11	Mathematical Analysis of Beam Diagrams	246
	Problems	257
7	Centroids and Moments of Inertia of Areas	268
7-1	Objectives of this Chapter	269
7-2	The Concept of Centroid-Simple Shapes	270
7-3	Centroid of Complex Shapes	270
7-4	The Concept of Moment of Inertia	275
7-5	Moment of Inertia of Composite Shapes whose Parts have the Same Centroidal Axis	277
7-6	Moment of Inertia for Composite Shapes-General Case-Use of the Parallel Axis Theorem	279
7-7	Mathematical Definition of Moment of Inertia	282
7-8	Composite Sections Made from Commercially Available Shapes	283
7-9	Moment of Inertia for Shapes with all Rectangular Parts	287
7-10	Radius of Gyration	288
	References	292
	Problems	293
	Computer Assignments	300
8	Stress Due to Bending	301
8-1	Objectives of this Chapter	305

8-2	The Flexure Formula	305
8-3	Conditions on the Use of the Flexure Formula	308
8-4	Stress Distribution on a Cross Section of a Beam	311
8-5	Derivation of the Flexure Formula	312
8-6	Applications-Beam Analysis	313
8-7	Applications-Beam Design and Design Stresses	316
8-8	Section Modulus and Design Procedures	318
8-9	Stress Concentrations	324
8-10	Flexural Center or Shear Center	330
8-11	Preferred Shapes for Beam Cross Sections	333
8-12	Design of Beams to be Made from Composite Materials	337
	References	338
	Problems	339
	Computer Assignments	357

9 Shearing Stresses in Beams 358

9-1	Objectives of this Chapter	360
9-2	Importance of Shearing Stresses in Beams	362
9-3	The General Shear Formula	363
9-4	Distribution of Shearing Stress in Beams	369
9-5	Development of the General Shear Formula	376
9-6	Special Shear Formulas	378
9-7	Design Shear Stress	382
9-8	Shear Flow	383
	References	386
	Problems	386

10 Special Cases of Combined Stresses 395

10-1	Objectives of this Chapter	399
10-2	The Stress Element	399
10-3	Stress Distribution Created by Basic Stresses	401
10-4	Combined Normal Stresses	402
10-5	Combined Normal and Shear Stresses	412
	References	417
	Problems	417

11 The General Case of Combined Stress and Mohr's Circle 428

11-1	Objectives of this Chapter	429
11-2	Creating the Initial Stress Element	430
11-3	Equations for Stresses in Any Direction	432
11-4	Principal Stresses	436

11-5	Maximum Shear Stress	437
11-6	Mohr's Circle for Stress	438
11-7	Examples of the Use of Mohr's Circle	445
11-S	Stress Condition on Selected Planes	452
11-9	Special Case in which Both Principal Stresses have the Same Sign	455
11-10	The Maximum Shear Stress Theory of Failure	459
11-11	Use of Strain-Gage Rosettes to Determine Principal Stresses	460
	References	467
	Problems	467
	Computer Assignments	469
12	Deflection of Beams	470
12-1	Objectives of this Chapter	473
12-2	The Need for Considering Beam Deflections	473
12-3	Definition of Terms	475
12-4	Beam Deflections Using the Formula Method	478
12-5	Superposition Using Deflection Formulas	482
12-6	Basic Principles for Beam Deflection by Successive Integration Method	486
12-7	Beam Deflections-Successive Integration Method-General Approach	488
12-8	Beam Deflections-Moment-Area Method	497
12-9	Applications of the Moment-Area Method	501
12-10	Beams with Distributed Loads-Moment-Area Method	514
	References	516
	Problems	516
	Computer Assignments	522
13	Statically Indeterminate Beams	523
13-1	Objectives of this Chapter	526
13-2	Formulas for Statically Indeterminate Beams	527
13-3	Superposition Method	534
13-4	Continuous Beams-Theorem of Three Moments	539
	Problems	543
	Computer Assignments	547
14	Columns	548
14-1	Objectives of this Chapter	552
14-2	Slenderness Ratio	553
14-3	Transition Slenderness Ratio	556
14-4	The Euler Formula for Long Columns	557
14-5	The J. B. Johnson Formula for Short Columns	558
14-6	Summary-Buckling Formulas	558

14-7	Design Factors for Columns and Allowable Load	561
14-8	Summary-Method of Analyzing Columns	561
14-9	Column Analysis Spreadsheet	565
14-10	Efficient Shapes for Column Cross Sections	567
14-11	Specifications of the AISC	567
14-12	Specifications of the Aluminum Association	569
14-13	Non-Centrally Loaded Columns	570
	References	576
	Problems	576
15	Pressure Vessels	583
15-1	Objectives of this Chapter	585
15-2	Distinction Between Thin-Walled and Thick-Walled Pressure Vessels	585
15-3	Thin-Walled Spheres	587
15-4	Thin-Walled Cylinders	589
15-5	Thick-Walled Cylinders and Spheres	592
15-6	Procedure for Analyzing and Designing Spherical and Cylindrical Pressure Vessels	593
15-7	Shearing Stress in Cylinders and Spheres	599
15-S	Other Design Considerations for Pressure Vessels	603
15-9	Composite Pressure Vessels	604
15-10	Spreadsheet Aid for Analyzing Thick-Walled Spheres and Cylinders	605
	References	606
	Problems	606
	Computer Assignments	608
16	Connections	609
16-1	Objectives of this Chapter	610
16-2	Modes of Failure	611
16-3	Riveted Connections	613
16-4	Bolted Connections	614
16-5	Allowable Stresses for Bolted and Riveted Connections	615
16-6	Example Problems-Riveted and Bolted Joints	615
16-7	Eccentrically Loaded Riveted and Bolted Joints	618
16-8	Welded Joints with Concentric Loads	622
	References	625
	Problems	626
	Appendix	631
	Answers to Selected Problems	685
	Index	699