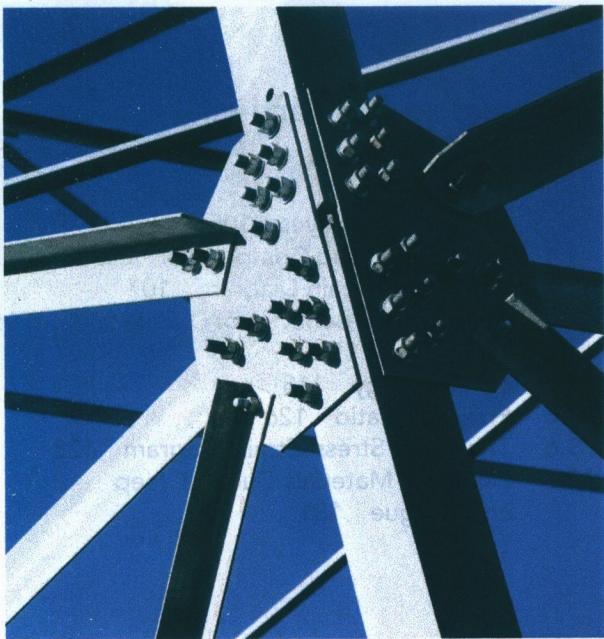


# CONTENTS



## 1 Stress 27

Chapter Objectives 27

- 1.1 Introduction 27
- 1.2 Equilibrium of a Deformable Body 28
- 1.3 Stress 45
- 1.4 Average Normal Stress in an Axially Loaded Bar 47
- 1.5 Average Shear Stress 55
- 1.6 Allowable Stress Design 68
- 1.7 Limit State Design 70

## 2 Strain 89

Chapter Objectives 89

- 2.1 Deformation 89
- 2.2 Strain 90

- 2.3 Deformation and Strain 90
- 2.4 Strain Components 90
- 2.5 Strain Components in Three Dimensions 91
- 2.6 Strain Components in Three Dimensions 92
- 2.7 Strain Components in Three Dimensions 93
- 2.8 Strain Components in Three Dimensions 94
- 2.9 Strain Components in Three Dimensions 95
- 2.10 Strain Components in Three Dimensions 96



### 3

## Mechanical Properties of Materials 105

- Chapter Objectives 105
- 3.1** The Tension and Compression Test 105
- 3.2** The Stress–Strain Diagram 107
- 3.3** Stress–Strain Behavior of Ductile and Brittle Materials 111
- 3.4** Strain Energy 115
- 3.5** Poisson’s Ratio 126
- 3.6** The Shear Stress–Strain Diagram 128
- \*3.7** Failure of Materials Due to Creep and Fatigue 131



### 4

## Axial Load 143

- Chapter Objectives 143
- 4.1** Saint-Venant’s Principle 143
- 4.2** Elastic Displacement of an Axially Loaded Member 145
- 4.3** Principle of Superposition 160
- 4.4** Statically Indeterminate Axially Loaded Members 160
- 4.5** The Force Method of Analysis for Axially Loaded Members 167
- 4.6** Thermal Stress 175
- 4.7** Stress Concentrations 182
- \*4.8** Inelastic Axial Deformation 185
- \*4.9** Residual Stress 187



## 5 Torsion 201

Chapter Objectives 201  
5.1 Torsional Deformation of a Circular Shaft 201  
5.2 The Torsion Formula 204  
5.3 Power Transmission 212  
5.4 Angle of Twist 224  
5.5 Statically Indeterminate Torque-Loaded Members 240  
\*5.6 Solid Noncircular Shafts 247  
\*5.7 Thin-Walled Tubes Having Closed Cross Sections 250  
5.8 Stress Concentration 260  
\*5.9 Inelastic Torsion 263  
\*5.10 Residual Stress 265



## 6 Bending 281

6.1 Chapter Objectives 281  
6.1 Internal Loading as a Function of Position 281  
6.2 Graphical Method for Constructing Shear and Moment Diagrams 288  
6.3 Bending Deformation of a Straight Member 306  
6.4 The Flexure Formula 310  
6.5 Unsymmetric Bending 326  
\*6.6 Composite Beams 336  
\*6.7 Reinforced Concrete Beams 339  
\*6.8 Curved Beams 343  
6.9 Stress Concentrations 350  
\*6.10 Inelastic Bending 360



## 7

### Transverse Shear 383

Chaps	2.1
Torsion	2.2
Shear	2.3
The N	2.4
Power	2.5
Augu	2.6
Stress	2.7
Membr	2.8
Solid	2.9
Thin-w	2.10
Coos	2.11
Stress	2.12
Impa	2.13
*2.10 Repla	2.14



## 8

### Combined Loadings 429

Chaps	3.1
Inlet	3.2
Funct	3.3
Gash	3.4
Sand	3.5
Bendi	3.6
Stress	3.7
The P	3.8
Unsym	3.9
Comb	3.10
Reinfor	3.11
Cure	3.12
Stress	3.13
*3.10 Inversic Persi	3.14



## 7

### Transverse Shear 383

Chapter Objectives	383
<b>7.1</b>	<b>Shear in Straight Members</b> 383
<b>7.2</b>	<b>The Shear Formula</b> 384
<b>7.3</b>	<b>Shear Flow in Built-Up Members</b> 402
<b>7.4</b>	<b>Shear Flow in Thin-Walled Members</b> 411
<b>*7.5</b>	<b>Shear Center for Open Thin-Walled Members</b> 416

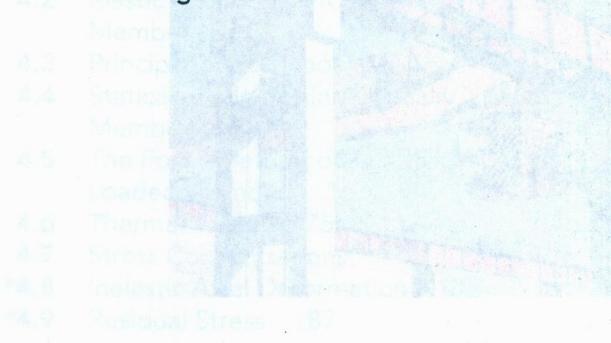
The Shear Stress-Strain Relation	383
Failure of Materials Due to Shear and Fatigue	384



## 8

### Combined Loadings 429

Chapter Objectives	429
<b>8.1</b>	<b>Thin-Walled Pressure Vessels</b> 429
<b>8.2</b>	<b>State of Stress Caused by Combined Loadings</b> 436





Design of Beams  
and Shafts See  
Chapter 9



Design of Plates  
See Chapter 10

## 9

# Stress Transformation

## 459

Chapter Objectives 459

**9.1** Plane Stress Transformation 459

**9.2** General Equations of Plane Stress Transformation 464

**9.3** Principal Stresses and Maximum In-Plane Shear Stress 467

**9.4** Mohr's Circle—Plane Stress 483

**9.5** Absolute Maximum Shear Stress 495

Concepts Pending 713

\***10.7** Design for Columns for  
Bending 721

## 10

# Strain Transformation

## 507

Chapter Objectives 507

**10.1** Plane Strain 507

**10.2** General Equations of Plane Strain Transformation 508

**10.3** Mohr's Circle—Plane Strain 516

\***10.4** Absolute Maximum Shear Strain 524

**10.5** Strain Rosettes 526

**10.6** Material Property Relationships 530

\***10.7** Theories of Failure 542

Applied to Beams 733

\***10.8** Castigliano's Theorem 733

\***10.9** Casagrande's Theorem Applied to Trusses 795

\***10.10** Castigliano's Theorem Applied to Beams 798



483	Morph's Cleat—Pine Series	4.0
485	Asporotelyx maximum Series	2.0

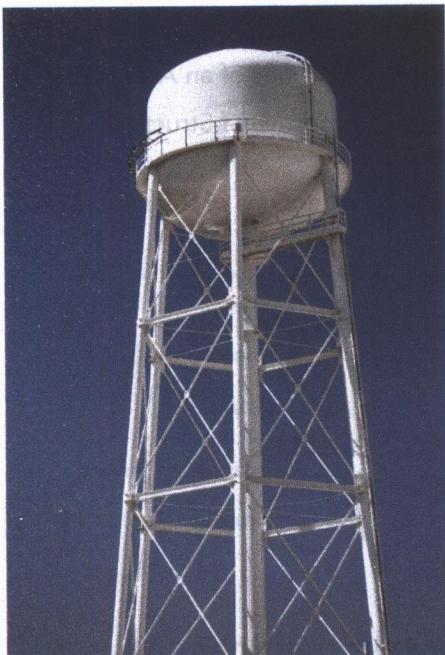


## 11 Design of Beams and Shafts 559

11.1	Chapter Objectives	559
11.1	Basis for Beam Design	559
11.2	Prismatic Beam Design	562
*11.3	Fully Stressed Beams	576
*11.4	Shaft Design	580

## 12 Deflection of Beams and Shafts 591

12.1	Chapter Objectives	591
12.2	The Elastic Curve	591
12.2	Slope and Displacement by Integration	595
*12.3	Discontinuity Functions	613
*12.4	Slope and Displacement by the Moment-Area Method	625
12.5	Method of Superposition	640
12.6	Statically Indeterminate Beams and Shafts	648
12.7	Statically Indeterminate Beams and Shafts—Method of Integration	649
*12.8	Statically Indeterminate Beams and Shafts—Moment-Area Method	654
12.9	Statically Indeterminate Beams and Shafts—Method of Superposition	660



## 13 Buckling of Columns 679

13.1	Chapter Objectives	679
13.2	Critical Load	679
13.3	Ideal Column with Pin Supports	682
13.3	Columns Having Various Types of Supports	688
*13.4	The Secant Formula	700
*13.5	Inelastic Buckling	706
*13.6	Design of Columns for Concentric Loading	714
*13.7	Design of Columns for Eccentric Loading	724

14 Energy Methods 737

14.1	Chapter Objectives	737
14.2	External Work and Strain Energy	737
14.3	Elastic Strain Energy for Various Types of Loading	742
14.4	Conservation of Energy	755
14.5	Impact Loading	762
*14.6	Principle of Virtual Work	773
*14.6	Method of Virtual Forces Applied to Trusses	776
*14.7	Method of Virtual Forces Applied to Beams	784
*14.8	Castigliano's Theorem	793
*14.9	Castigliano's Theorem Applied to Trusses	795
*14.10	Castigliano's Theorem Applied to Beams	798

## Appendices

- A Geometric Properties of an Area 806
- B Geometric Properties of Structural Shapes 820
- C Slopes and Deflections of Beams 824

## Fundamental Problems Partial Solutions and Answers 827

## Answers to Selected Problems 849

## Index 867

## Fundamental Equations of Mechanics of Materials 888

Chap	
12.1	The Free Body Diagram
12.2	Free Body Diagrams
12.3	Free Body Diagrams
12.4	Free Body Diagrams
12.5	Free Body Diagrams
12.6	Free Body Diagrams
12.7	Free Body Diagrams
12.8	Free Body Diagrams
12.9	Free Body Diagrams
12.10	Free Body Diagrams

