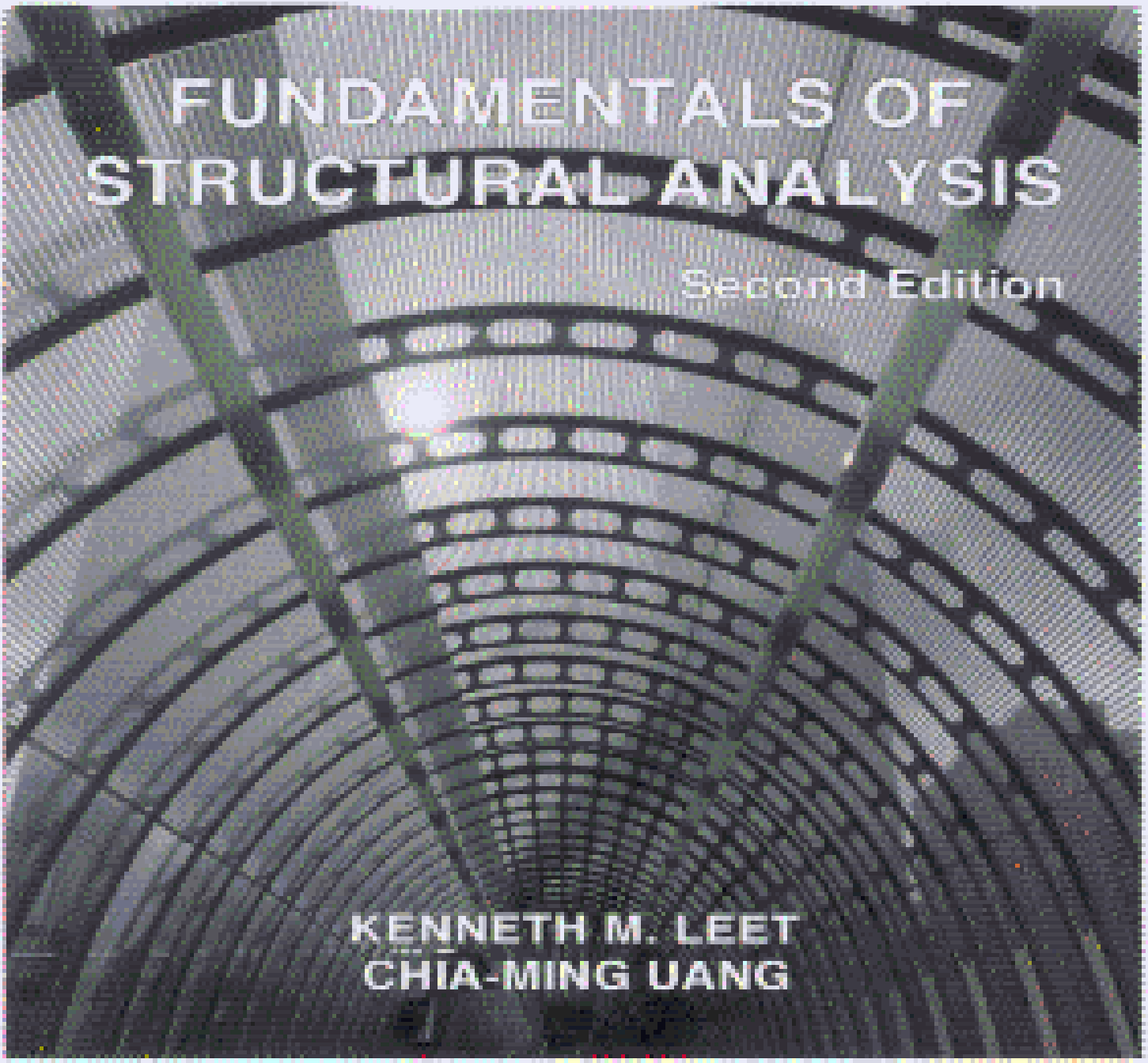

McGraw-Hill International Edition

TABLE OF CONTENTS

Preface			xv
Chapter 1	**Introduction**		**3**
	1.1	Overview of the Text	3
	1.2	The Design Process: Relationship of Analysis to Design	5
	1.3	Strength and Serviceability	7
	1.4	Historical Development of Structural Systems	8
	1.5	Basic Structural Elements	11
	1.6	Assembling Basic Elements to Form a Stable Structural System	20
	1.7	Analyzing by Computer	23
	1.8	Preparation of Computations	24
	Summary		25
Chapter 2	**Design Loads**		**27**
	2.1	Building and Design Code	27
	2.2	Loads	28
	2.3	Dead Loads	28
	2.4	Live Loads	36
	2.5	Wind Loads	43
	2.6	Earthquake Forces	59
	2.7	Other Loads	64
	2.8	Load Combinations	65
	Summary		66
Chapter 3	**Statics of Structures—Reactions**		**73**
	3.1	Introduction	73
	3.2	Forces	74
	3.3	Supports	81
	3.4	Idealizing Structures	85
	3.5	Free-Body Diagrams	86
	3.6	Equations of Static Equilibrium	88
	3.7	Equations of Condition	94
	3.8	Influence of Reactions on Stability and Determinacy of Structures	97

	3.9	Classifying Structures	105
	3.10	Comparison Between Determinate and Indeterminate Structures	110
	Summary		112
Chapter 4	**Trusses**		**121**
	4.1	Introduction	121
	4.2	Types of Trusses	124
	4.3	Analysis of Trusses	125
	4.4	Method of Joints	126
	4.5	Zero Bars	130
	4.6	Method of Sections	131
	4.7	Determinacy and Stability	139
	4.8	Computer Analysis of Trusses	145
	Summary		148
Chapter 5	**Beams and Frames**		**163**
	5.1	Introduction	163
	5.2	Scope of Chapter	168
	5.3	Equations for Shear and Moment	169
	5.4	Shear and Moment Curves	176
	5.5	Principle of Superposition	194
	5.6	Sketching the Deflected Shape of a Beam or Frame	198
	5.7	Degree of Indeterminacy	203
	Summary		206
Chapter 6	**Cables**		**221**
	6.1	Introduction	221
	6.2	Characteristics of Cables	222
	6.3	Variation of Cable Force	223
	6.4	Analysis of a Cable Supporting Gravity (Vertical) Loads	224
	6.5	General Cable Theorem	225
	6.6	Establishing the Funicular Shape of an Arch	228
	Summary		231
Chapter 7	**Arches**		**235**
	7.1	Introduction	235
	7.2	Types of Arches	235
	7.3	Three-Hinged Arches	237
	7.4	Funicular Shape for an Arch That Supports a Uniformly Distributed Load	239
	Summary		244

Chapter 8 **Live Load Forces: Influence Lines for Determinate Structures** **249**
8.1 Introduction 249
8.2 Influence Lines 249
8.3 Construction of an Influence Line 250
8.4 The Müller–Breslau Principle 258
8.5 Use of Influence Lines 261
8.6 Influence Lines for Girders Supporting Floor Systems 264
8.7 Influence Lines for Trusses 271
8.8 Live Loads for Highway and Railroad Bridges 277
8.9 Increase–Decrease Method 280
8.10 Absolute Maximum Live Load Moment 285
8.11 Maximum Shear 288
Summary 290

Chapter 9 **Deflections of Beams and Frames** **301**
9.1 Introduction 301
9.2 Double Integration Method 301
9.3 Moment-Area Method 307
9.4 Elastic Load Method 326
9.5 Conjugate Beam Method 331
9.6 Design Aids for Beams 339
Summary 341

Chapter 10 **Work-Energy Methods for Computing Deflections** **353**
10.1 Introduction 353
10.2 Work 354
10.3 Strain Energy 356
10.4 Deflections by the Work-Energy Method (Real Work) 358
10.5 Virtual Work: Trusses 360
10.6 Virtual Work: Beams and Frames 376
10.7 Finite Summation 388
10.8 Bernoulli's Principle of Virtual Displacements 390
10.9 Maxwell-Betti Law of Reciprocal Deflections 393
Summary 396

Chapter 11 **Analysis of Indeterminate Structures by the Flexibility Method** **409**
11.1 Introduction 409
11.2 Concept of a Redundant 409
11.3 Fundamentals of the Flexibility Method 410
11.4 Alternative View of the Flexibility Method (Closing a Gap) 414
11.5 Analysis Using Internal Releases 423
11.6 Support Settlements, Temperature Change, and Fabrication Errors 431
11.7 Analysis of Structures with Several Degrees of Indeterminacy 435
11.8 Beam on Elastic Supports 443
Summary 446

Chapter 12 **Analysis of Indeterminate Beams and Frames by the Slope-Deflection Method** **455**
12.1 Introduction 455
12.2 Illustration of the Slope-Deflection Method 455
12.3 Derivation of the Slope-Deflection Equation 457
12.4 Analysis of Structures by the Slope-Deflection Method 463
12.5 Analysis of Structures That Are Free to Sidesway 477
12.6 Kinematic Indeterminacy 486
Summary 487

Chapter 13 **Moment Distribution** **497**
13.1 Introduction 497
13.2 Development of the Moment Distribution Method 498
13.3 Summary of the Moment Distribution Method with No Joint Translation 503
13.4 Analysis of Beams by Moment Distribution 504
13.5 Modification of Member Stiffness 511
13.6 Analysis of Frames That Are Free to Sidesway 526
13.7 Analysis of an Unbraced Frame for General Loading 530

13.8 Analysis of Multistory Frames 535
13.9 Nonprismatic Members 537
Summary 546

Chapter 14 **Indeterminate Structures: Influence Lines** **555**
14.1 Introduction 555
14.2 Construction of Influence Lines Using Moment Distribution 556
14.3 Müller–Breslau Principle 559
14.4 Qualitative Influence Lines for Beams 561
14.5 Live Load Patterns to Maximize Forces in Multistory Buildings 569
Summary 578

Chapter 15 **Approximate Analysis of Indeterminate Structures** **581**
15.1 Introduction 581
15.2 Approximate Analysis of a Continuous Beam for Gravity Load 582
15.3 Approximate Analysis of a Rigid Frame for Vertical Load 589
15.4 Approximate Analysis of a Continuous Truss 592
15.5 Estimating Deflections of Trusses 598
15.6 Trusses with Double Diagonals 599
15.7 Approximate Analysis of a Multistory Rigid Frame for Gravity Load 602
15.8 Analysis of Unbraced Frames for Lateral Load 610
15.9 Portal Method 613
15.10 Cantilever Method 620
Summary 625

Chapter 16 **Introduction to the General Stiffness Method** **633**
16.1 Introduction 633
16.2 Comparison Between Flexibility and Stiffness Methods 634
16.3 Analysis of an Indeterminate Beam by the General Stiffness Method 639
Summary 651

Chapter 17 **Matrix Analysis of Trusses by the Direct Stiffness Method** **655**
17.1 Introduction 655
17.2 Member and Structure Stiffness Matrices 660
17.3 Construction of a Member Stiffness Matrix for an Individual Truss Bar 660
17.4 Assembly of the Structure Stiffness Matrix 662
17.5 Solution of the Direct Stiffness Method 665
17.6 Member Stiffness Matrix of an Inclined Truss Bar 667
17.7 Coordinate Transformation of a Member Stiffness Matrix 678
Summary 679

Chapter 18 **Matrix Analysis of Beams and Frames by the Direct Stiffness Method** **683**
18.1 Introduction 683
18.2 Structure Stiffness Matrix 685
18.3 The 2 × 2 Rotational Stiffness Matrix for a Flexural Member 686
18.4 The 4 × 4 Member Stiffness Matrix in Local Coordinates 695
18.5 The 6 × 6 Member Stiffness Matrix in Local Coordinates 705
18.6 The 6 × 6 Member Stiffness Matrix in Global Coordinates 713
18.7 Assembly of a Structure Stiffness Matrix—Direct Stiffness Method 716
Summary 718

Appendix Review of Basic Matrix Operations 721
Glossary 733
Answers to Odd-Numbered Problems 737
Credits 742
Index 743