

Contents

	PREF	ACE	viii
			xiii
	CON	VERSION FACTORS	xvii
CHAPTER 1	INTR	ODUCTION	1
	1.1	Structural Design 1	
	1.2	Principles of Design 1	
	1.3	Historical Background of Steel Structures 3	
	1.4	Loads 3	
	1.5	Types of Structural Steel Members 12	
	1.6	Steel Structures 16	
	1.7	Specifications and Building Codes 20	
	1.8	Philosophies of Design 20	
	1.9	Factors For Safety—ASD and LRFD Compared 24	
	1.10	Why Should LRFD Be Used? 29	
	1.11	Analysis of the Structure 29	
		Selected References 30	
CHAPTER 2	STEE	LS AND PROPERTIES	33
	2.1	Structural Steels 33	
	2.2	Fastener Steels 39	
	2.3	Weld Electrode and Filler Material 40	
	2.4	Stress-Strain Behavior (Tension Test) at Atmospheric Temperatures 41	
	2.5	Material Toughness 42	
	2.6	Yield Strength for Multiaxial States of Stress 44	
	2.7	High Temperature Behavior 45	

	2.9	Brittle Fracture 48	
	2.10	Lamellar Tearing 52	
	2.11	Fatigue Strength 53	
	2.12	Corrosion Resistance and Weathering Steels 55	
		Selected References 56	
CHAPTER 3	TENS	SION MEMBERS	58
	3.1	Introduction 58	
	3.2	Nominal Strength 59	
	3.3	Net Area 60	
	3.4	Effect of Staggered Holes on Net Area 61	
	3.5	Effective Net Area 65	
	3.6	Block Shear Strength 68	
	3.7	Stiffness as a Design Criterion 69	
	3.8	Load Transfer at Connections 70	
	3.9	Load and Resistance Factor Design–Tension Members 71	
	3.10	Tension Rods 77	
	3.11	Allowable Strength Design-Tension Members 80	
		Selected References 83	
		Problems 84	
CHAPTER 4	STRU	ICTURAL BOLTS	87
	4.1	Types of Bolts 87	
	4.2	Historical Background of High-Strength Bolts 89	
	4.3	Causes of Rivet Obsolescence 90	
	4.4	Details of High-Strength Bolts 91	
	4.5	Installation Procedures 93	
	4.6	Nominal Strength of Individual Fasteners 95	
	4.7	Load and Resistance Factor Design—Bolts 99	
	4.8	Examples—Tension Member Bearing-Type Connections—LRFD 105	
	4.9	Slip-Critical Joints 110	
	4.10	Allowable Strength Design—Bolts 114	
	4.11	Examples—Tension Members Using Allowable Strength Design 115	
	4.12	Eccentric Shear 117	
	4.13	Fasteners Acting in Axial Tension 135	
	4.14	Combined Shear and Tension 139	
	4.15	Shear and Tension From Eccentric Loading 148	
		Selected References 154	
		Problems 155	

Cold Work and Strain Hardening 47

2.8

CHAPTER 5	WELDING		161
	5.1	Introduction and Historical Development 161	
	5.2	Basic Processes 162	
	5.3	Weldability of Structural Steel 167	
	5.4	Types of Joints 168	
	5.5	Types of Welds 170	
	5.6	Welding Symbols 172	
	5.7	Factors Affecting the Quality of Welded Connections 175	
	5.8	Possible Defects in Welds 178	
	5.9	Inspection and Control 180	
	5.10	Economics of Welded Built-up Members and Connections 181	
	5.11	Size and Length Limitations for Fillet Welds 182	
	5.12	Effective Areas of Welds 185	
	5.13	Nominal Strength of Welds 186	
	5.14	Load and Resistance Factor Design—Welds 189	
	5.15	Allowable Strength Design—Welds 196	
	5.16	Welds Connecting Members Subject to Direct Axial Load 197	
	5.17	Eccentric Shear Connections—Strength Analysis 209	
	5.18	Eccentric Shear Connections—Elastic (Vector) Analysis 216	
	5.19	Loads Applied Eccentric to the Plane of Welds 223	
		Selected References 227	
		Problems 229	
CHAPTER 6	СОМ	PRESSION MEMBERS	236
	PAR1	TI: COLUMNS	<i>236</i>
	6.1	General 236	
	6.2	Euler Elastic Buckling and Historical Background 236	
	6.3	Basic Column Strength 238	
	6.4	Inelastic Buckling 239	-
	6.5	Residual Stress 243	
	6.6	Development of Column Strength Curves Including Residual Stress 245	
	6.7	Structural Stability Research Council (SSRC) Strength Curves 253	
	6.8	Load and Resistance Factor Design 256	
	6.9	Effective Length 261	
	6.10	Load and Resistance Factor Design of Rolled Shapes (W, S, and M) Subject to Axial Compression 268	
	6.11	Allowable Strength Design 274	

	6.13	Design of Latticed Members 278	
	PAR1	II: PLATES	283
	6.14	Introduction to Stability of Plates 283	
	6.15	Strength of Plates Under Uniform Edge Compression 290	
	6.16	AISC Width/Thickness Limits λ_r to Achieve Yield Stress Without Local Plate Buckling 293	
	6.17	AISC Width/Thickness Limit λ_p to Achieve Significant Plastic Deformation 297	
	6.18	AISC Provisions to Account for the Buckling and Post- Buckling Strengths of Plate Elements 299	
	6.19	Design of Compression Members as Affected by Local Buckling Provisions 305	
		Selected References 313	
		Problems 316	
CHAPTER 7	BEA!	MS: LATERALLY SUPPORTED	321
	7.1	Introduction 321	
	7.2	Simple Bending of Symmetrical Shapes 321	
	7.3	Behavior of Laterally Stable Beams 322	
	7.4	Laterally Supported Beams—Load and Resistance Factor Design 325	
	7.5	Laterally Supported Beams—AISC-ASD Method 331	
	7.6	Serviceability of Beams 332	
	7.7	Shear on Rolled Beams 337	
	7 . 8	Concentrated Loads Applied to Rolled Beams 343	
	7.9	Holes in Beams 348	
	7.10	General Flexural Theory 349	
	7.11	Biaxial Bending of Symmetric Sections 356	
		Selected References 359	
		Problems 361	
CHAPTER 8	TOR	SION	365
	8.1	Introduction 365	
	8.2	Pure Torsion of Homogeneous Sections 366	
	8.3	Shear Stresses Due to Bending of Thin-Wall Open Cross-Sections 369	
	8.4	Shear Center 370	
	8.5	Torsional Stresses in I-Shaped Steel Sections 373	
	8.6	Analogy Between Torsion and Plane Bending 383	
	8.7	Practical Situations of Torsional Loading 388	

Shear Effect 275

6.12

	8.8	Load and Resistance Factor Design for Torsion— Laterally Stable Beams 391	
	8.9	Allowable Strength Design for Torsion—Laterally Stable Beams 396	
	8.10	Torsion in Closed Thin-Wall Sections 397	
	8.11	Torsion in Sections with Open and Closed Parts 400	
	8.12	Torsional Buckling 400	
		Selected References 406	
		Problems 408	
CHAPTER 9	LATE	RAL-TORSIONAL BUCKLING OF BEAMS	413
	9.1	Rational Analogy to Pure Columns 413	
	9.2	Lateral Support 414	
	9.3	Strength of I-Shaped Beams Under Uniform Moment 416	
	9.4	Elastic Lateral-Torsional Buckling 417	
	9.5	Inelastic Lateral-Torsional Buckling 422	
	9.6	Load and Resistance Factor Design—I-Shaped Beams Subjected to Strong-Axis Bending 424	
	9.7	Allowable Strength Design Method—I-Shaped Beams Subjected to Strong-Axis Bending 431	
	9.8	Effective Laterally Unbraced Length 432	
	9.9	Examples: Load and Resistance Factor Design 433	
	9.10	Examples: Allowable Strength Design 447	
	9.11	Weak-Axis Bending of I-Shaped Sections 451	
	9.12	Lateral Buckling of Channels, Zees, Monosymmetric I-Shaped Sections, and Tees 452	
	9.13	Lateral Bracing Design 460	
	9.14	Biaxial Bending of Doubly Symmetric I-Shaped Sections 472	
		Selected References 476	
		Problems 478	
CHAPTER 10	CON	TINUOUS BEAMS	484
	10.1	Introduction 484	
	10.2	Plastic Strength of a Statically Indeterminate Beam 484	
	10.3	Plastic Analysis—Load and Resistance Factor Design Examples 493	
	10.4	Elastic Analysis—AISC LRFD Method 507	
	10.5	Elastic Analysis—Allowable Strength Design 509	
	10.6	Splices 511	
		Selected References 513	
		Problems 513	

CHAPTER 11	PLATE	GIRDERS	516
	11.1	Introduction and Historical Development 516	
	11.2	Difference Between Beam and Plate Girder 518	
	11.3	Vertical Flange Buckling Limit State 520	
	11.4	Nominal Moment Strength—AISC Design 523	
	11.5	Moment Strength Reduction Due to Bend-Buckling of the Web 528	
	11.6	Nominal Moment Strength—Hybrid Girders 534	
	11.7	Nominal Shear Strength—Elastic and Inelastic Buckling 536	
	11.8	Nominal Shear Strength—Including Tension-Field Action 540	
	11.9	Strength in Combined Bending and Shear 549	
	11.10	Intermediate Transverse Stiffeners 551	
	11.11	Bearing Stiffener Design 556	
	11.12	Longitudinal Web Stiffeners 557	
	11.13	Proportioning the Section 559	
	11.14	Plate Girder Design Example—LRFD 565	
		Selected References 585	
		Problems 586	
CHAPTER 12	СОМЕ	BINED BENDING AND AXIAL LOAD	591
	12.1	Introduction 591	
	12.2	Differential Equation for Axial Compression and Bending 592	
	12.3	Moment Magnification—Simplified Treatment for Members in Single Curvature Without End Translation 596	
	12.4	Moment Magnification—Members Subject to End Moments Only; No Joint Translation 599	
	12.5	Moment Magnification—Members with Sidesway Possible 602	
	12.6	Nominal Strength—Instability in the Plane of Bending 603	
	12.7	Nominal Strength—Failure by Combined Bending and Torsion 604	
	12.8	Nominal Strength—Interaction Equations 605	
	12.9	Biaxial Bending 607	
	12.10	AISC Design Criteria 609	
	12.11	Unbraced Frame—AISC Design 614	
	12.12	Design Procedure—AISC LRFD Method 626	
	12.13	Examples—AISC LRFD Method 628	
		Selected References 646	
		Problems 648	

CHAPTER 13	CONN	IECTIONS	<i>655</i>
	13.1	Types of Connections 655	
	13.2	Simple Shear Connections 658	
	13.3	Seated Beam Connections—Unstiffened 674	
	13.4	Stiffened Seat Connections 681	
	13.5	Triangular Bracket Plates 687	
	13.6	Continuous Beam-to-Column Connections 691	
	13.7	Continuous Beam-to-Beam Connections 721	
	13.8	Rigid-Frame Knees 722	
	13.9	Column Base Plates 728	
	13.10	Beam Splices 735	
		Selected References 739	
		Problems 743	
CHAPTER 14	FRAIV	IES-BRACED AND UNBRACED	748
	14.1	General 748	
	14.2	Elastic Buckling of Frames 751	
	14.3	General Procedure for Effective Length 759	
	14.4	Stability of Frames Under Primary Bending	
		Moments 759	
	14.5	Bracing Requirements—Braced Frame 764	
	14.6	Overall Stability When Plastic Hinges Form 771	
		Selected References 772	
CHAPTER 15	DESIG	GN OF RIGID FRAMES	774
	15.1	Introduction 774	
	15.2	Plastic Analysis of One-Story Frames 774	
	15.3	AISC LRFD Method—One-Story Frames 785	
	15.4	Multistory Frames 801	
		Selected References 802	
		Problems 802	
CHAPTER 16	сомі	POSITE STEEL-CONCRETE CONSTRUCTION	804
	16.1	Historical Background 804	
	16.2	Composite Action 806	
	16.3	Advantages and Disadvantages 808	
	16.4	Effective Width 808	
	16.5	Computation of Elastic Section Properties 810	
	16.6	Service Load Stresses with and Without Shoring 813	
	16.7	Nominal Moment Strength of Fully Composite Sections 815	
	16.8	Shear Connectors 819	
	16.9	Composite Flexural Members Containing Formed Steel Deck 828	

16.10	Design Procedure—AISC LRFD and ASD
	Methods 829
16.11	AISC Examples—Simply Supported Beams 829
16.12	ASD Example—Simply Supported Beam 836
16.13	Deflections 837
16.14	Continuous Beams 840
16.15	Composite Columns 843
	Selected References 845
	Problems 847

APPENDIX 849

TABLE A1 APPROXIMATE RADIUS OF GYRATION 850

TABLE A2 TORSIONAL PROPERTIES 851

INDEX 853