
Contents

Preface..... xiii
Author xv

SECTION I *Design Loads*

Chapter 1 Design Criteria 3

 Classification of Buildings 3

 Building Codes 3

 Standard Unit Loads..... 3

 Tributary Area..... 3

 Working Stress Design, Strength Design, and Unified Design of Structures 7

 Elastic and Plastic Designs..... 10

 Elastic Moment Capacity..... 12

 Plastic Moment Capacity..... 12

 Combinations of Loads 14

 Other Loads..... 15

 Continuous Load Path for Structural Integrity 18

 Problems..... 18

Chapter 2 Primary Loads: Dead Loads and Live Loads 23

 Dead Loads..... 23

 Live Loads..... 24

 Floor Live Loads 24

 Basic Design Live Load, L_o 24

 Effective Area Reduction Factor 24

 Other Provisions for Floor Live Loads..... 26

 Multiple Floors Reductions 27

 Roof Live Loads, L_r 28

 Tributary Area Reduction Factor, R_1 28

 Slope Reduction Factor..... 28

 Problems..... 29

Chapter 3 Snow Loads 31

 Introduction 31

 Minimum Snow Load for Low-Slope Roofs..... 31

 Balanced Snow Load..... 34

 Importance Factor 34

 Thermal Factor, C_t 34

 Exposure Factor, C_e 35

 Roof Slope Factor, C_s 35

Rain-on-Snow Surcharge	36
Partial Loading of the Balanced Snow Load	37
Unbalanced across the Ridge Snow Load	38
Snow Drift from a Higher to a Lower Roof	40
Leeward Snow Drift on Lower Roof of Attached Structure	40
Windward Snow Drift on Lower Roof of Attached Structure	41
Leeward Snow Drift on Lower Roof of Separated Structure	42
Windward Snow Drift on Lower Roof of Separated Structure	42
Sliding Snow Load on Lower Roof	44
Sliding Snow Load on Separated Structures	46
Problems	46
Chapter 4 Wind Loads	49
Introduction	49
Definition of Terms	49
Procedures for MWFRS	50
Simplified Procedure for MWFRS for Low-Rise Buildings	50
Horizontal Pressure Zones for MWFRS	57
Vertical Pressure Zones for MWFRS	61
Minimum Pressure for MWFRS	61
Procedures for Components and Cladding	66
Simplified Procedure for Components and Cladding for Low-Rise Buildings	66
Minimum Pressures for Components and Cladding	70
Problems	72
Chapter 5 Earthquake Loads	75
Seismic Forces	75
Seismic Design Procedures	75
Definitions	76
Structural Height	76
Stories above Base and Grade Plane	76
Fundamental Period of Structure	77
Ground Motion Response Accelerations	77
Mapped MCE_R Spectral Response Acceleration Parameters	78
Adjustments to Spectral Response Acceleration Parameters for Site Class Effects	78
Design Spectral Acceleration Parameters	78
Design Response Spectrum	78
Importance Factor, I	88
Seismic Design Categories	88
Exemptions from Seismic Designs	90
Equivalent Lateral Force Procedure to Determine Seismic Force	90
Effective Weight of Structure, W	90
Seismic Response Coefficient, C_s	90
Response Modification Factor or Coefficient, R	91
Distribution of Seismic Forces	92
Distribution of Seismic Forces on Vertical Wall Elements	92
Distribution of Seismic Forces on Horizontal Elements (Diaphragms)	93

Design Earthquake Load..... 94

Soil–Structure Interaction 98

Problems..... 99

SECTION II Wood Structures

Chapter 6 Wood Specifications..... 105

 Engineering Properties of Sawn Lumber..... 105

 Reference Design Values for Sawn Lumber..... 105

 Adjustments to the Reference Design Values for Sawn Lumber..... 106

 Time Effect Factor, λ 107

 Size Factor, C_F 107

 Size Factor, C_F , for Dimension Lumber..... 108

 Size Factor, C_F , for Timber 108

 Repetitive Member Factor, C_r 108

 Flat Use Factor, C_{fu} 108

 Buckling Stiffness Factor, C_T 108

 Bearing Area Factor, C_b 108

 Format Conversion Factor, K_F 109

 Resistance Factor, ϕ 109

 Load Resistance Factor Design with Wood 109

 Structural Glued Laminated Timber..... 114

 Reference Design Values for Glued Laminated Timber 115

 Adjustment Factors for Glued Laminated Timber 116

 Flat Use Factor for Glued Laminated Timber, C_{FU} 116

 Volume Factor for Glued Laminated Timber, C_v 116

 Curvature Factor for Glued Laminated Timber, C_c 116

 Stress Interaction Factor, C_I 118

 Shear Reduction Factor, C_{VR} 118

 Structural Composite Lumber..... 120

 Summary of Adjustment Factors..... 121

 Problems..... 123

Chapter 7 Flexure and Axially Loaded Wood Structures 125

 Introduction 125

 Design of Beams 125

 Bending Criteria of Design 125

 Beam Stability Factor, C_L 127

 Effective Unbraced Length..... 128

 Shear Criteria 129

 Deflection Criteria..... 131

 Creep Deflection..... 132

 Bearing at Supports..... 136

 Bearing Area Factor, C_b 137

 Design of Axial Tension Members..... 138

 Design of Columns..... 140

 Column Stability Factor, C_p 141

 Design for Combined Bending and Compression 143

 Problems..... 147

Chapter 8	Wood Connections	153
	Types of Connections and Fasteners	153
	Dowel-Type Fasteners (Nails, Screws, Bolts, Pins)	153
	Yield Limit Theory for Laterally Loaded Fasteners	154
	Yield Mechanisms and Yield Limit Equations	155
	Reference Design Values for Lateral Loads (Shear Connections)	157
	Reference Design Values for Withdrawal Loads	157
	Adjustments of the Reference Design Values	157
	Wet Service Factor, C_M	158
	Temperature Factor, C_t	158
	Group Action Factor, C_g	158
	Geometry Factor, C_Δ	158
	End Grain Factor, C_{eg}	161
	Diaphragm Factor, C_{di}	161
	Toenail Factor, C_{tn}	161
	Nail and Screw Connections	164
	Common, Box, and Sinker Nails	164
	Post-Frame Ring Shank Nails	164
	Wood Screws	165
	Bolt and Lag Screw Connections	166
	Bolts	167
	Lag Screws	167
	Problems	168

SECTION III Steel Structures

Chapter 9	Tension Steel Members	175
	Properties of Steel	175
	Provisions to Design Steel Structures	175
	Unified Design Specifications	176
	Limit States of Design	176
	Design of Tension Members	177
	Tensile Strength of Elements	177
	Net Area, A_n	178
	Effective Net Area, A_e	179
	Block Shear Strength	182
	Design Procedure for Tension Members	184
	Problems	186
Chapter 10	Compression Steel Members	191
	Strength of Compression Members or Columns	191
	Local Buckling Criteria	193
	Flexural Buckling Criteria	194
	Effective Length Factor for Slenderness Ratio	194
	Limit States for Compression Design	197
	Nonslender Members	197
	Flexural Buckling of Nonslender Members in Elastic and Inelastic Regions	197

Inelastic Buckling.....	198
Elastic Buckling.....	198
Torsional and Flexural-Torsional Buckling of Nonslender Members.....	198
Single-Angle Members.....	200
Built-Up Members.....	200
Slender Compression Members.....	200
Use of the Compression Tables.....	200
Problems.....	203
Chapter 11 Flexural Steel Members	209
Basis of Design.....	209
Nominal Strength of Steel in Flexure	209
Lateral Unsupported Length.....	209
Fully Plastic Zone with Adequate Lateral Support.....	211
Inelastic Lateral Torsional Buckling Zone.....	211
Modification Factor C_b	211
Elastic Lateral Torsional Buckling Zone.....	212
Noncompact and Slender Beam Sections for Flexure.....	212
Compact Full Plastic Limit	213
Noncompact Flange Local Buckling.....	213
Slender Flange Local Buckling.....	214
Summary of Beam Relations	214
Design Aids.....	215
Shear Strength of Steel.....	218
Beam Deflection Limitations	220
Problems.....	222
Chapter 12 Combined Forces on Steel Members.....	225
Design Approach to Combined Forces	225
Combination of Tensile and Flexure Forces.....	225
Combination of Compression and Flexure Forces: The Beam-Column Members.....	227
Members without Sidesway.....	227
Members with Sidesway.....	227
Magnification Factor B_1	229
Moment Modification Factor, C_M	229
K Values for Braced Frames.....	231
Braced Frame Design.....	231
Magnification Factor for Sway, B_2	235
K Values for Unbraced Frames	235
Unbraced Frame Design.....	237
Open-Web Steel Joists	240
Joist Girders.....	243
Problems.....	245
Chapter 13 Steel Connections	251
Types of Connections and Joints.....	251
Bolted Connections	251

Specifications for Spacing of Bolts and Edge Distance	254
Bearing-Type Connections	255
Slip-Critical Connections	259
Tensile Load on Bolts	261
Combined Shear and Tensile Forces on Bolts	263
Combined Shear and Tension on Bearing-Type Connections	263
Combined Shear and Tension on Slip-Critical Connections	265
Welded Connections	267
Groove Welds	267
Effective Area of Groove Weld	267
Fillet Welds	267
Effective Area of Fillet Weld	267
Minimum Size of Fillet Weld	267
Maximum Size of Fillet Weld	268
Length of Fillet Weld	268
Strength of Weld	268
Complete Joint Penetration Groove Welds	268
Partial Joint Penetration Welds and Fillet Welds	268
Frame Connections	271
Shear or Simple Connection for Frames	272
Single-Plate Shear Connection or Shear Tab	272
Framed-Beam Connection	272
Seated-Beam Connection	272
End-Plate Connection	272
Single-Plate Shear Connection for Frames	274
Moment-Resisting Connection for Frames	277
Problems	279

SECTION IV Reinforced Concrete Structures

Chapter 14 Flexural Reinforced Concrete Members	289
Properties of Reinforced Concrete	289
Compression Strength of Concrete	289
Design Strength of Concrete	290
Strength of Reinforcing Steel	291
Load Resistance Factor Design Basis of Concrete	291
Reinforced Concrete Beams	292
Derivation of the Beam Relations	292
Strain Diagram and Modes of Failure	294
Balanced and Recommended Steel Percentages	295
Minimum Percentage of Steel	295
Strength Reduction Factor for Concrete	296
Specifications for Beams	296
Analysis of Beams	297
Design of Beams	299
Design for Reinforcement Only	299
Design of Beam Section and Reinforcement	300

One-Way Slab.....	303
Specifications for Slabs	303
Analysis of One-Way Slab.....	304
Design of One-Way Slab	305
Problems.....	306
Chapter 15 Doubly and T Reinforced Concrete Beams.....	311
Doubly Reinforced Concrete Beams.....	311
Analysis of Doubly Reinforced Beams	313
Design of Doubly Reinforced Beams.....	316
Monolithic Slab and Beam (T Beams).....	317
Analysis of T Beams	318
Design of T Beams.....	320
Problems.....	323
Chapter 16 Shear and Torsion in Reinforced Concrete	327
Stress Distribution in Beam	327
Diagonal Cracking of Concrete.....	329
Strength of Web (Shear) Reinforced Beam.....	329
Shear Contribution of Concrete.....	331
Shear Contribution of Web Reinforcement.....	331
Specifications for Web (Shear) Reinforcement	332
Analysis for Shear Capacity	333
Design for Shear Capacity.....	335
Torsion in Concrete	338
Provision for Torsional Reinforcement.....	339
Problems.....	341
Chapter 17 Compression and Combined Forces Reinforced Concrete Members	347
Types of Columns.....	347
Pedestals	347
Columns with Axial Loads.....	347
Short Columns with Combined Loads	347
Large or Slender Columns with Combined Loads	347
Axially Loaded Columns	348
Strength of Spirals.....	349
Specifications for Columns	350
Analysis of Axially Loaded Columns.....	351
Design of Axially Loaded Columns.....	353
Short Columns with Combined Loads.....	355
Effects of Moment on Short Columns.....	357
Only Axial Load Acting.....	357
Large Axial Load and Small Moment (Small Eccentricity)	357
Large Axial Load and Moment Larger than Case 2 Section	358
Large Axial Load and Moment Larger than Case 3 Section	358
Balanced Axial Load and Moment	358

Small Axial Load and Large Moment.....	359
No Appreciable Axial Load and Large Moment.....	359
Characteristics of the Interaction Diagram.....	359
Application of the Interaction Diagram	361
Analysis of Short Columns for Combined Loading.....	361
Design of Short Columns for Combined Loading	362
Long or Slender Columns.....	364
Problems.....	364
Bibliography	369
Appendix A	371
Appendix B	377
Appendix C	431
Appendix D	483
Index.....	505