Contents

Chapter	1. Basic Concepts of Structural Analysis	1
1.1	Introduction 1	
1.2	Types of Framed Structures 1	
1.3	Deformations in Framed Structures 4	
1.4	Actions and Displacements 7	
1.5	Equilibrium 13	
1.6	Compatibility 13	
1.7	Static and Kinematic Indeterminacy 14	
1.8	Structural Mobilities 20	
1.9	Principle of Superposition 21	
1.10	Action and Displacement Equations 24	
1.11	Flexibility and Stiffness Matrices 30	
1.12	Equivalent Joint Loads 35	
1.13	Energy Concepts 37	
1.14	Virtual Work 43	
	Problems 47	
Chapter	2. Fundamentals of the Flexibility Method	53
2.1	Introduction 53	
2.2	Flexibility Method 54	
2.3	Examples 61	
2.4	Temperature Changes, Prestrains, and Support	
	Displacements 73	
2.5	Joint Displacements, Member End-Actions,	
	and Support Reactions 78	
2.6	Flexibilities of Prismatic Members 84	
2.7	Formalization of the Flexibility Method 90	
	Problems 105	
Chapter	3. Fundamentals of the Stiffness Method	113
3.1	Introduction 113	
3.2	Stiffness Method 113	
3.3	Examples 125	
3.4	Temperature Changes, Prestrains, and Support	
	Displacements 145	
3.5	Stiffnesses of Prismatic Members 148	
3.6	Formalization of the Stiffness Method 152 Problems 164	

x Contents

Chapter	4. Computer-oriented Direct Stiffness Method	174
4.1	Introduction 174	
4.2	Direct Stiffness Method 174	
4.3	Complete Member Stiffness Matrices 177	
4.4	Formation of Joint Stiffness Matrix 185	
4.5	Formation of Load Vector 186	
4.6	Rearrangement of Stiffness and Load Arrays	189
4.7	Calculation of Results 191	
4.8	Analysis of Continuous Beams 192	
4.9	Example 203	
4.10	Plane Truss Member Stiffnesses 208	
4.11	Analysis of Plane Trusses 212	
4.12	Example 221	
4.13	Rotation of Axes in Two Dimensions 226	
4.14	Application to Plane Truss Members 228	
4.15	Rotation of Axes in Three Dimensions 232	
4.16	Plane Frame Member Stiffnesses 234	
4.17	Analysis of Plane Frames 238	
4.18	Example 243	
4.19	Grid Member Stiffnesses 247	
4.20	Analysis of Grids 251	
4.21	Space Truss Member Stiffnesses 254	
4.22	Selection of Space Truss Member Axes 256	
4.23	Analysis of Space Trusses 260	
4.24	Space Frame Member Stiffnesses 263	
4.25	Analysis of Space Frames 270	
	Problems 274	
Chapter	5. Computer Programs for Framed Structures	282
5.1	Introduction 282	
5.2		282
5.3	Program Notation 289	
5.4	Preparation of Data 291	
5.5	Description of Programs 297	
5.6	Continuous Beam Program 300	
5.7	Plane Truss Program 316	
5.8	Plane Frame Program 321	
5.9	Grid Program 331	
5.10	Space Truss Program 336	

c'ontents xi

5.11	Space Frame Program 344					
5.12	Combined Program for Framed Structures	359				
Chapter	6. Additional Topics for the Stiffness Method	364				
6.1	Introduction 364					
6.2	Rectangular Framing 365					
6.3	Symmetric Structures 369					
6.4	Loads Between Joints 372					
6.5	Automatic Dead Load Analysis 375					
6.6	Temperature Changes and Prestrains 377					
6.7	Support Displacements 377					
6.8	Oblique Supports 378					
6.9	Elastic Supports 380					
6.10	Translation of Axes 383					
6.11						
	from Flexibilities 385					
6.12	Nonprismatic Members 391					
6.13	Curved Members 398					
6.14	Discontinuities in Members 403					
6.15	Flastic Connections 408					
6.16	Shearing Deformations 411					
6.17	Offset Connections 413					
6.18	Axial-Flexural Interaction 417					
Selected	References	421				
Notation		423				
Appendix	x A. Displacements of Framed Structures	428				
	A.1 Stresses and Deformations in Slender					
	Members 428					
	A.2 Displacements by the Unit-Load Method 437					
	A.3 Displacements of Beams 445					
	A.4 Integrals of Products for Computing					
	Displacements 447					
Appendix	x B. End-Actions for Restrained Members	450				

xii Contents

Appendix (<i>C</i> .	Properties of Sections		457
Appendix I	D.	Computer Routines for S	olving Equations	459
D.	1	Factorization Method fo	r Symmetric	
		Matrices 459		
D.	2	Subprogram FACTOR	465	
D.	3 (Subprogram SOLVER	467	
D.	4	Subprogram BANFAC	467	
D.	5	Subprogram BANSOL	471	
Appendix l	Ε.	Solution without Rearran	gement	473
Answers to l	Pro	blems		476
Index				487