



Eastern
Economy
Edition

MATRIX METHODS OF STRUCTURAL ANALYSIS



P.N. GODBOLE
R.S. SONPAROTE
S.U. DHOTE

Matrix Methods of Structural Analysis

MATRIX METHODS OF STRUCTURAL ANALYSIS

P.N. GODBOLE

Former Professor

Department of Civil Engineering
Indian Institute of Technology Roorkee

R.S. SONPAROTE

Associate Professor

Department of Applied Mechanics
Visvesvaraya National Institute of Technology, Nagpur

S.U. DHOTE

Assistant Professor

Department of Civil Engineering
Yeshwantrao Chavan College of Engineering, Nagpur

PHI Learning Private Limited

Delhi-110092

2014

MATRIX METHODS OF STRUCTURAL ANALYSIS (with CD-ROM)

P.N. Godbole, R.S. Sonparote, and S.U. Dhote

© 2014 by PHI Learning Private Limited, Delhi. All rights reserved. No part of this book may be reproduced in any form, by mimeograph or any other means, without permission in writing from the publisher.

The authors and the publisher make no warranty of any kind, expressed or implied, with regard to programs contained in this companion CD. The authors and publisher shall not be liable in any event for incidental or consequential damages in connection with, or arising out of, the furnishing, performance, or use of these programs.

ISBN-978-81-203-4984-1

The export rights of this book are vested solely with the publisher.

Published by Asoke K. Ghosh, PHI Learning Private Limited, Rimjhim House, 111, Patparganj Industrial Estate, Delhi-110092 and Printed by Rajkamal Electric Press, Plot No. 2, Phase IV, HSIDC, Kundli-131028, Sonapat, Haryana.

CONTENTS

Preface xi

1. INTRODUCTION 1–12

- 1.1 Why Matrix Methods 1
 - 1.2 Types of Framed Structures 2
 - 1.3 Forces and Displacements 3
 - 1.4 Basic Structural Principles 4
 - 1.4.1 Condition of Equilibrium 5
 - 1.4.2 Compatibility of Deformations 6
 - 1.5 Static and Kinematic Indeterminacy 6
 - 1.5.1 Static Indeterminacy 6
 - 1.5.2 Kinematic Indeterminacy 9
 - 1.6 Flexibility and Stiffness Methods of Analysis 10
 - 1.7 Stiffness vs Flexibility Method 11
- Problems 12*

Part 1—Basics

2. MATRIX ALGEBRA 15–24

- 2.1 Introduction 15
- 2.2 Definitions 15
- 2.3 Matrix Operations 17
 - 2.3.1 Addition and Subtraction 17
 - 2.3.2 Multiplication 17
 - 2.3.3 Transpose of Matrix 18
 - 2.3.4 Determinant of Matrix 19
 - 2.3.5 Inverse of Matrix 19
 - 2.3.6 Orthogonal Matrix 20
 - 2.3.7 Differentiating a Matrix 20
 - 2.3.8 Integrating a Matrix 20

- 2.4 Some Typical Matrix Operations 20
 - 2.4.1 Multiplication of Two Column Vectors (Matrices) 20
 - 2.4.2 Transpose of Product of Two Matrices 21
 - 2.4.3 Differentiating Expression of Quadratic Form 21
 - 2.4.4 Differentiating Product of Two Vectors 22
 - 2.4.5 Partitioning of Matrices 23

Problems 23

3. SOLUTION OF EQUATIONS **25–40**

- 3.1 Introduction 25
- 3.2 Assembly and Storage of Equations 25
 - 3.2.1 Band Storage 26
 - 3.2.2 Skyline or Profile Storage 29
- 3.3 Application of Boundary Condition 29
 - 3.3.1 First Method 29
 - 3.3.2 Second Method 30
 - 3.3.3 Third Method (Penalty Method) 31
- 3.4 Solution of Equations 32
 - 3.4.1 Method of Gauss Elimination 33
 - 3.4.2 Cholesky's Method (Crout's Reduction) 35
- 3.5 Frontal Method of Solution 38
- 3.6 Closure 39

Problems 39

References 40

4. STIFFNESS AND FLEXIBILITY **41–54**

- 4.1 Introduction 41
- 4.2 Stiffness and Flexibility 41
 - 4.2.1 The Elastic Spring 41
 - 4.2.2 A Bar Subjected to Axial Force 42
 - 4.2.3 A Cantilever Beam 42
- 4.3 Flexibility Matrix and Stiffness Matrix Methods 45
 - 4.3.1 A Propped Cantilever Beam 46
 - 4.3.2 Structure with more than One Indeterminacy 48

Problems 53

Part 2—Structure (System) Approach

5. FLEXIBILITY MATRIX METHOD **57–81**

- 5.1 Introduction 57
- 5.2 Description of the Method 57
- 5.3 Evaluation of Flexibility Coefficients 59
- 5.4 Steps in the Analysis 59

5.5	Examples	59
5.5.1	Analysis of Beams	60
5.5.2	Analysis of Plane Frames	69
5.5.3	Analysis of Pin-Jointed Plane Truss	74
5.5.4	Analysis of Truss for Lack of Fit/Temperature Changes	77
5.6	Conclusions	78
	<i>Problems</i>	79

6. STIFFNESS MATRIX METHOD 82–106

6.1	Introduction	82
6.2	Description of the Method	83
6.3	Steps in the Analysis	88
6.4	Examples	88
6.4.1	Analysis of Beams	88
6.4.2	Analysis of Plane Frame	95
6.4.3	Analysis of Pin-Jointed Plane Truss	100
6.5	Conclusions	103
	<i>Problems</i>	104

Part 3—Stiffness Matrix Method—Member Approach

7. BASIC STEPS OF STIFFNESS METHOD 109–121

7.1	Introduction	109
7.2	Stiffness Matrix: The Elastic Spring	110
7.3	Spring Assemblage	111
7.4	Some Properties of Stiffness Matrix	113
7.5	Assembly of $[K]$ by Superposition (Direct Method)	114
7.6	Method of Solution	115
7.6.1	Force in the Spring	115
7.7	Stiffness Matrix of a Bar Member	116
7.8	Steps in the Analysis	119
7.9	Closure	120
	<i>Problems</i>	121

8. BEAMS 122–143

8.1	Introduction	122
8.2	Stiffness Matrix of a Beam Member	123
8.3	Equivalent Nodal Load Vector	125
8.4	Steps in the Analysis	126
8.5	Examples	127
	<i>Problems</i>	142

9. PLANE TRUSS	144–175
9.1 Introduction 144	
9.1.1 Global Coordinate System 144	
9.1.2 Local Coordinate System 144	
9.1.3 Transformation Matrix or Rotation Matrix 145	
9.2 Stiffness Matrix of Plane Truss Member 145	
9.2.1 Stiffness Matrix of Truss Member: Local Axis 145	
9.2.2 Transformation Matrix 147	
9.2.3 Stiffness Matrix of Truss Member: Global Axis 148	
9.2.4 Force in the Member 149	
9.3 Steps in the Analysis 150	
9.4 Examples 151	
9.5 Some Important Features of Stiffness Matrix Method 167	
Problems 174	
10. PLANE FRAMES	176–200
10.1 Introduction 176	
10.2 Stiffness Matrix of a Plane Frame Member 176	
10.2.1 Stiffness Matrix in Local Axis 177	
10.2.2 Transformation Matrix 178	
10.2.3 Stiffness Matrix and Nodal Force Vector with Respect to Global Axis 179	
10.3 Steps in the Analysis 180	
10.4 Examples 181	
Problems 200	
11. GRIDS	201–213
11.1 Introduction 201	
11.2 Behaviour of Grid Member 201	
11.3 Stiffness Matrix of a Grid Member 202	
11.3.1 Stiffness Matrix of a Member in Torsion 202	
11.3.2 Stiffness Matrix of a Grid Member in Local Axis 204	
11.3.3 Transformation Matrix 205	
11.3.4 Stiffness Matrix in Global Axis 207	
11.3.5 Equivalent Nodal Loads 207	
11.4 Steps in the Analysis 207	
11.5 Comparison between Grid and Plane Frame 212	
Problems 212	
12. SPACE TRUSSES AND SPACE FRAMES	214–230
12.1 Introduction 214	
12.2 Space Trusses 214	
12.2.1 Stiffness Matrix of Member: Local Axis 215	
12.2.2 Transformation Matrix (Rotation Matrix) 216	
12.2.3 Stiffness Matrix of Member in Global Axis 217	
12.2.4 Steps in the Analysis 218	

12.3	Space Frames	221
12.3.1	Stiffness Matrix and Load Vector in Local Axis	222
12.3.2	Transformation Matrix (Rotation Matrix)	224
12.3.3	Stiffness Matrix and Load Vector in Global Axis	225
12.3.4	Equivalent Nodal Force Vector	225
12.3.5	Determination of Transformation Matrix $[T]$ of a Member	225
12.3.6	Steps in the Analysis	227
12.4	Conclusions	229
	<i>Problems</i>	229

13. ADDITIONAL TOPICS **231–258**

13.1	Use of Symmetry and Anti-Symmetry	231
13.2	Inclined Supports (Oblique Supports)	235
13.3	Beams with Shearing Deformations	245
13.3.1	Deformation in Beam due to Shear	245
13.3.2	Stiffness Matrix of Beam with Shearing Deformation	246
13.4	Member end Releases in Beams and Frames	248
13.4.1	Moment Discontinuity (Moment Release in the Form of Hinge)	248
13.5	Temperature Changes and Prestrains	251
	<i>Problems</i>	256

Part 4—Educational Program

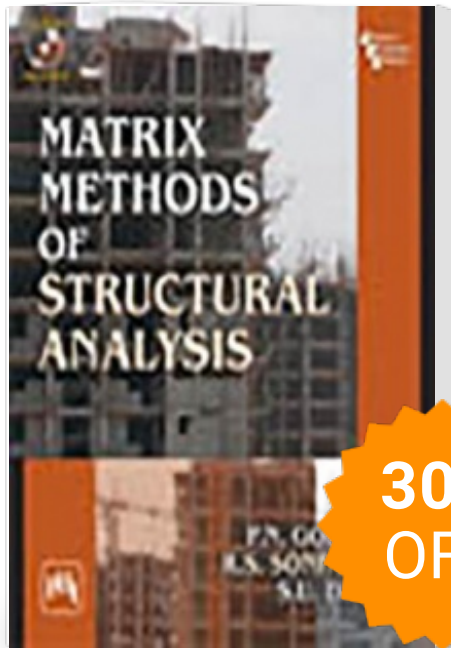
14. COMPUTER PROGRAM AND ILLUSTRATIVE EXAMPLES **261–284**

14.1	Introduction	261
14.2	Structure of the Program	262
14.3	Important Variables in the Program	264
14.4	Explanation of Subroutines/Functions	265
14.5	FORTRAN Program	265
14.5.1	Guide to Input Data	266
14.5.2	Illustrative Examples	267
14.6	C Program	281
14.6.1	Guide to Input Data	281
14.6.2	Illustrative Examples	282

Appendices

A.	<i>Methods to Find Deflections</i>	287–297
B.	<i>Slopes and Deflections in Beams</i>	298–299
C.	<i>Fixed End Forces in Beams</i>	300–301
D.	<i>Properties of Plane Areas</i>	302–303
	INDEX	305–309

Matrix Methods Of Structural Analysis



Publisher : PHI Learning

ISBN : 9788120349841

Author : GODBOLE, P.N. ,
SONPAROTE, R.S., DHOTE,
S.U.

Type the URL : <http://www.kopykitab.com/product/7611>



Get this eBook