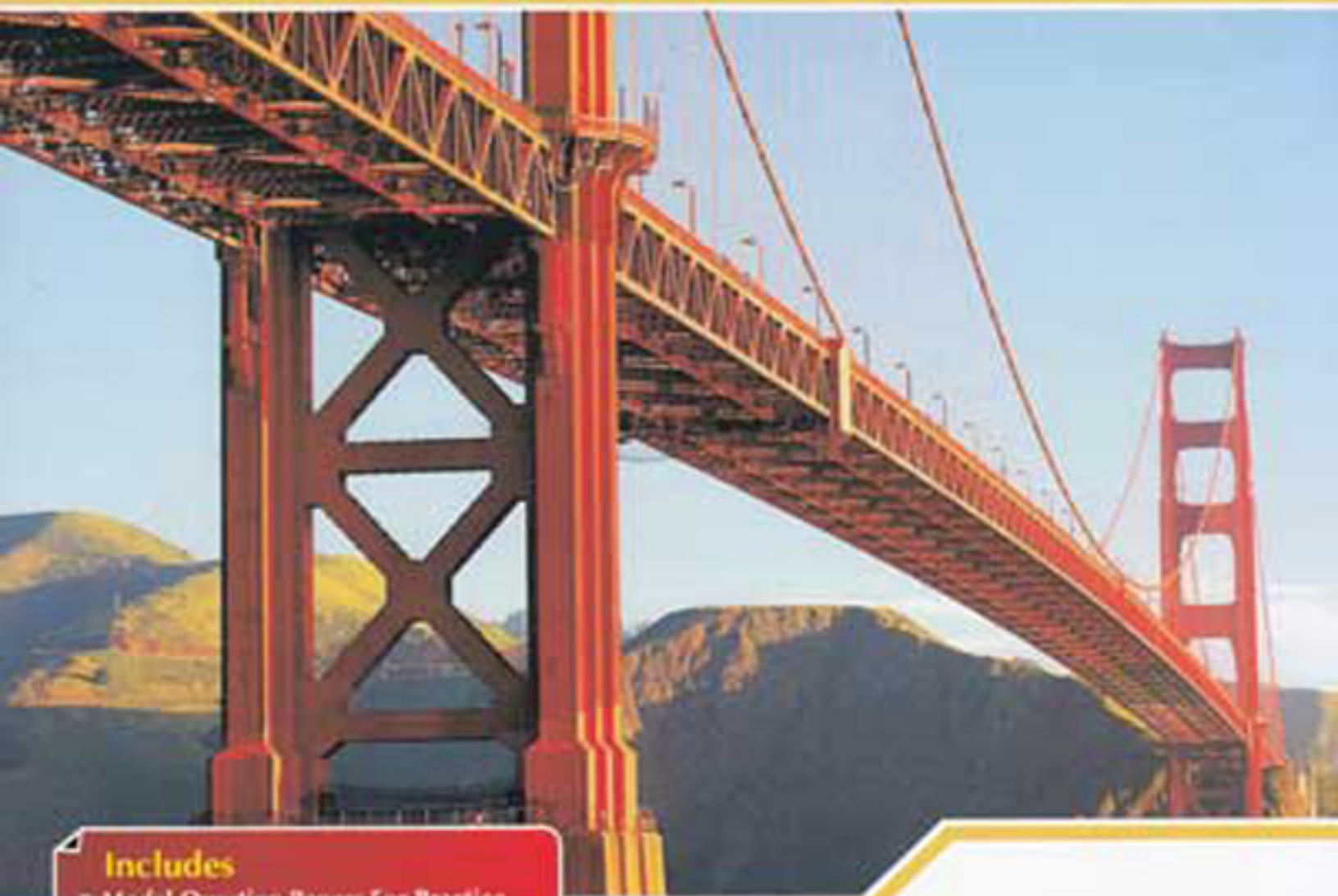


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Third Year Degree Course In
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FOR
SEMESTER – I
THIRD YEAR DEGREE COURSE IN CIVIL ENGINEERING
Strictly According to New Revised Credit System Syllabus
of Savitribai Phule Pune University
(w.e.f June 2017)

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Dedicated to ...

Our Students

...Authors

PREFACE

It gives us great pleasure to present the book '**Structural Analysis - II**' for the students of Third Year Degree Course in Civil Engineering of the Savitribai Phule Pune University. This book is strictly as per the new revised syllabus 2015 Pattern with effect from the Academic Year (2017-18).

As per New Revised Examination Scheme which has been implemented from this academic year, In-semester assessment carries 30 marks over first three units and End Semester Examination carries 70 marks over entire syllabus out of which first three units will carry 20 marks and units 4, 5, 6 will carry 50 marks. The theory course will have 4 credits.

The book is written such that all the basic concepts are explained in simplified manner. It is presented in a more conceptual manner rather than mathematical, as required by the new examination system. It is our objective to keep the presentation systematic, consistent, intensive and clear through explanatory notes and figures. Main feature of this book is, **Complete Coverage** of the New Credit System Syllabus with large number of Worked (Solved) Programs, Examples, Exercises and **Model Question Papers of In Sem and End Sem Exams**.

We are sure that this book will cater to all needs of students for this subject.

We would like to extend our sincere thanks to **Management** and **Dr. D.S. Bormane** (Principal, AISSPM'S COE. Pune) and Colleagues, (Civil Dept. AISSPM'S COE.) for their untiring support in our work.

We also take this opportunity to express my sincere thanks to Shri. Dineshbhai Furia, Shri. Jignesh Furia, Mrs. Nirali Verma, Shri. M. P. Munde and entire team of Nirali Prakashan namely Mrs. Deepali Lachake (Co-ordinator), who really have taken keen interest and untiring efforts in publishing this text.

The advice and suggestions of our esteemed readers to improve the text are most welcomed, and will be highly appreciated.

Pune

Authors

SYLLABUS

Unit I (08 hours)

- (a) Slope-deflection method of analysis: Slope-deflection equations, equilibrium equation of Slope deflection method, application to beams with and without joint translation and rotation, yielding of support, application to non-sway rigid jointed rectangular portal frames, shear force and bending moment diagram.
- (b) Sway analysis of rigid jointed rectangular portal frames using slope-deflection method (Involving not more than three unknowns)

Unit II (08 hours)

- (a) Moment distribution method of analysis: Stiffness factor, carry over factor, distribution factor, application to beams with and without joint translation and yielding of support, application to non sway rigid jointed rectangular portal frames, shear force and bending moment diagram.
- (b) Sway analysis of rigid jointed rectangular single bay single storey portal frames using moment distribution method (Involving not more than three unknowns).

Unit III (08 hours)

- (a) Fundamental concepts of flexibility method of analysis, formulation of flexibility matrix, application to pin jointed plane trusses (Involving not more than three unknowns).
- (b) Application of flexibility method to beams and rigid jointed rectangular portal frames (Involving not more than three unknowns).

Unit IV (08 hours)

- (a) Fundamental concepts of stiffness method of analysis, formulation of stiffness matrix, application to trusses by member approach. Application to beams by structure approach only, (Involving not more than three unknowns).
- (b) Application to rigid jointed rectangular portal frames by structure approach only (Involving not more than three unknowns).

Unit V (08 hours)

- (a) Finite Difference Method – Introduction, application to deflection problems of determinate beams by central difference method
- (b) Approximate methods of analysis of multi-storied multi-bay 2 - D rigid jointed frames by substitute frame method, cantilever method and portal method.

Unit VI (08 hours)

- (a) Finite element method: Introduction, discretization, types of elements-1D, 2D, 3D, isoparametric and axisymmetric, convergence criteria, Pascals triangle, direct stiffness method, principal of minimum potential energy, principal of virtual work. (No numerical)
- (b) Shape functions: CST elements by using polynomials, 1D, 2D elements by using Lagrange's method

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UNIT I

Chapter 1

SLOPE-DEFLECTION METHOD

1.1 INTRODUCTION OF SLOPE-DEFLECTION METHOD

SD method is basically a displacement method i.e. stiffness method (i.e. equilibrium method). Unlike other methods, SD method is based on (a) compatibility of joint displacements including support points, (b) moment - equilibrium of joints and force - equilibrium of a structure also called shear-equilibrium and (c) relations between member-end moments and member-end displacements. The method mainly involves slopes and deflections of the member at its joints and hence it is named as SD method.

SD method begins with the compatible joint displacements and it ends with the equilibrium equations called simultaneous equations. Therefore, SD method is the method of simultaneous solution of equations. The basic unknowns in SD method are the non-zero joint displacements of a structure. The number of such non-zero joint displacements is the degree of kinematic indeterminacy of a structure or degree of freedom. Therefore, kinematically, indeterminate structures are analysed by SD method. Rigidity of a joint implies one single rotation at the joint. Selecting the appropriate unknown joint displacements, the compatibility is indirectly satisfied.

Member end displacements are the same as its joint displacements and called as slope and deflection. For every member of a structure, member-end moments are related to (a) member-end slopes and deflections, and (b) loading on the member by slope-deflection equations of the member, to be denoted hereafter by SD equations.

Using SD equations of all members of a structure, moment-equilibrium equations for the joints and shear-equilibrium equations for the structure are formulated in terms of unknown joint displacements. It should be noted that number of equilibrium equations must be same as the number of unknown joint displacements. The equilibrium equations are solved to obtain unknown joint displacements.

Knowing the joint displacements, member-end moments are found from SD equations of the members and rest of the analysis is completed by laws of statics.

Thus, the SD method is pivoted on the SD equations and it is the member approach.

1.2 REFERENCE SYSTEM AND SIGN CONVENTIONS

Member and its two end joints are the basic components of SD method. To represent a member with its two ends, following reference system is suitable. One of the ends is taken as the origin. Member axis is considered as the x-axis. The y-axis, perpendicular to the member,

is so chosen that the right hand of Cartesian coordinates is formed as shown in Fig. 1.1. Accordingly, for horizontal member, left end of the member as the origin, x-axis along the member and y-axis normal to the member will be the reference system. For vertical member, bottom end of the member as the origin x-axis along the member and y-axis normal to the member, become the reference system.

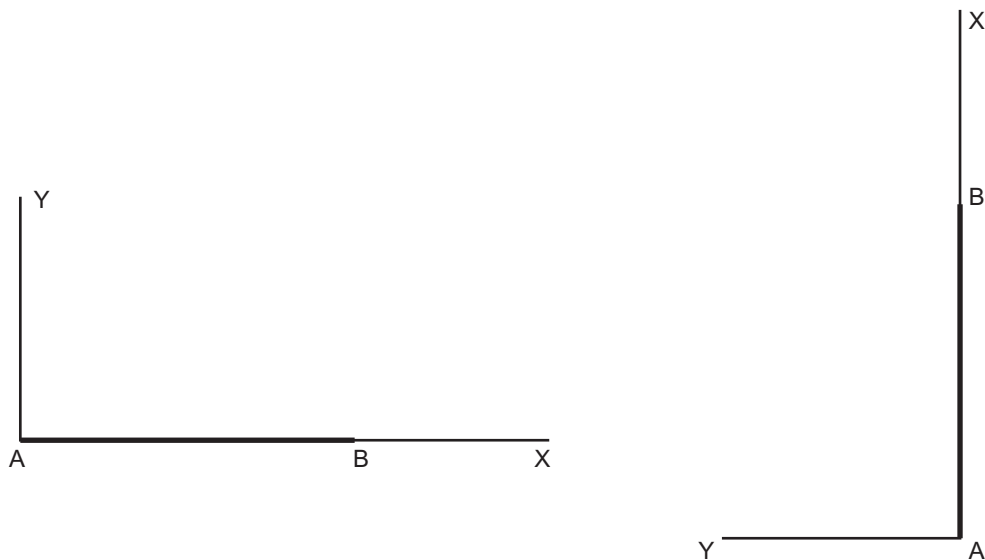


Fig. 1.1 : Frame of reference

Basic quantities of SD method are (a) member-end moment, (b) member-end slope or joint rotation, (c) member-end deflection or joint translation. Consistent with the reference system, following sign conventions are adopted for the basic quantities as shown in Fig. 1.2.

A member-end moment in anticlockwise direction is considered as positive. It is negative if clockwise.

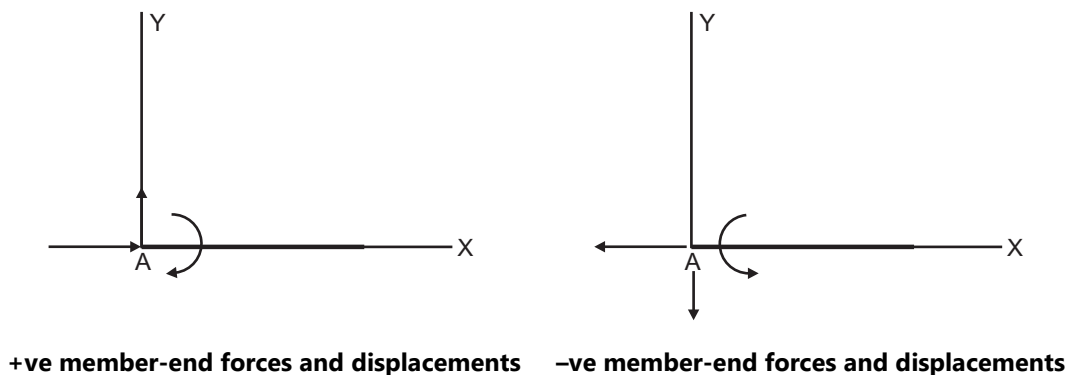


Fig. 1.2 : Sign convention for member-end moments and forces

A member end slope or a joint rotation in anticlockwise direction is considered as positive. It is taken negative if clockwise. A member-end deflection or a joint translation is considered positive if it is in positive y direction. It is taken negative in negative y direction.

Other member-end forces i.e. axial force and shear force are considered positive if they are in positive direction of x and y axes and negative in negative direction of axes.

Sign conventions for bending moment (BM), shear force (SF) and axial force (AF) at a section of a member of a structure are different and should not be mixed with that of member-end moments and forces.

Sagging bending moment is considered as positive and hogging bending moment is negative. When member-end moment is considered as a bending moment, the sign convention of bending moment is applicable. Shear force to the left of the section, in positive y-axis of a member, is considered as positive. Shear force to the right of the section, in negative axis of a member, is taken as negative.

Pull i.e. tensile axial force is treated as positive and push or thrust i.e. compressive axial force is taken as negative.

1.3 SD EQUATIONS

A member of a structure is bounded by two rigid joints at its ends. When a structure is loaded, member deforms, joints are displaced and internal forces are developed. The member-end moments can be expressed in terms of (a) the fixed-end moments of the member due to transverse loads on the member, (b) the member end-slopes or the joint rotations and (c) the member-end deflections or the joint translations. These expressions are called SD equations of the member.

There are two SD equations for a member of a structure, corresponding to the member-end moment at two ends i.e. joints. SD equations are the primary requirements of SD method. SD equations for a rigid jointed prismatic member are derived systematically from the superposition of the member-end moments caused by the following sequential operations.

- (i) Restraining the member-end displacements i.e. locking the member-end joints and considering the fixed member-end moments due to the applied transverse loading on the member.
- (ii) Releasing the restrained member for its end joint displacements one at a time and obtaining the member-end moments due to the released displacement, such an operation is carried out sequentially for all the four displacements, two at each end i.e. slope and deflection.

During these operations, to obtain member-end moment separately due to each cause, the following fundamental principles of analysis are applied.

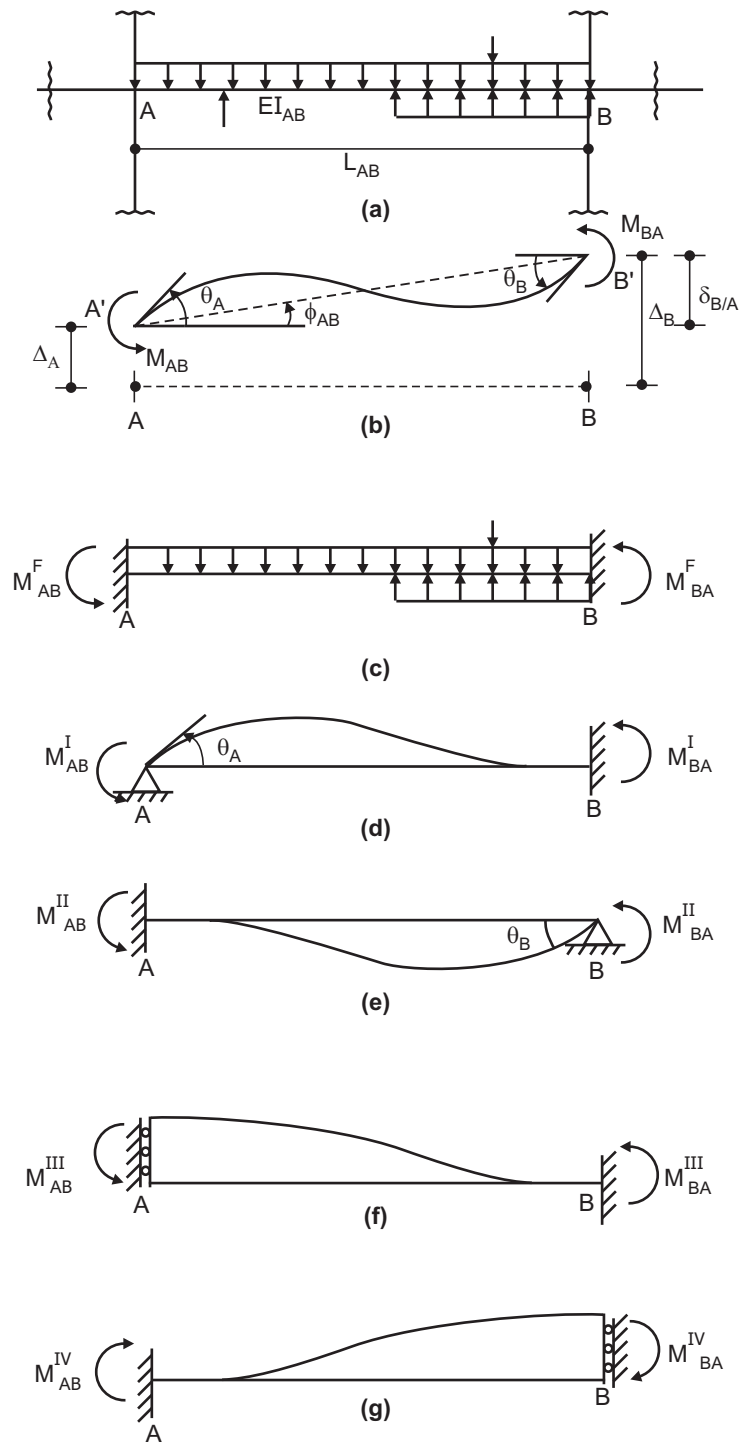
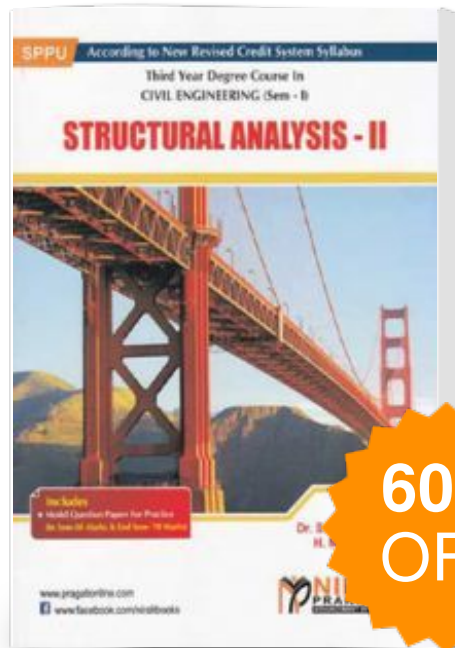


Fig. 1.3 : Development of SD equations by superposition

Structural Analysis - II



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