STPE-02: FINITE ELEMENT METHODS

L-3, T-0, P-0

Introduction

Brief History, Role the Computer, General Steps of the Finite Element Method, Applications of the Finite Element Method, Advantages of the Finite Element Method, Computer Programs for the Finite Element, Methods for Solution of Simultaneous Linear Equations, Banded-Symmetric Matrices, Bandwidth, Skyline, and Wavefront Methods

Introduction to the Stiffness Method

Definition of the Stiffness Matrix, Derivation of the Stiffness Matrix for a Spring Element Assembling the Total Stiffness Matrix by Superposition, Boundary Conditions, Potential Energy Approach to Derive Spring Element Equations

Trusses

Derivation of the Stiffness Matrix for a Bar Element in Local Coordinates, Selecting Approximation Functions for Displacements, Transformation of Vectors in Two Dimensions, Global Stiffness Matrix, Computation of Stress for a Bar in the x-y Plane, Solution of a Plane Truss, Transformation Matrix and Stiffness Matrix for a Bar in Three-Dimensional Space, Use of Symmetry in Structure Inclined or Skewed Supports, Potential Energy Approach to Derive Bar Element Equations, Comparison of Finite Element Solution to Exact Solution for Bar, Galerkin's Residual Method and Its Use to Derive the One-Dimensional Bar Element Equations

Beams

Beam Stiffness, Assemblage of Beam Stiffness Matrices, Beam Analysis Using the Direct Stiffness Method, Distributed Loading, Comparison of the Finite Element Solution to the Exact Solution for a Beam, Beam Element with Nodal Hinge, Potential Energy Approach to Derive Beam Element Equations, Galerkin's Method for Deriving Beam Element Equations

Frames and Grids

Two-Dimensional Arbitrarily Oriented Beam Element, Rigid Plane Frame Examples, Inclined or Skewed Supports – Frame Element, Grid Equations, Beam Element Arbitrarily Oriented in Space, Concept of Substructure Analysis

Plates with Plane Stress and Plane Strain

Basic Concepts of Plane Stress and Plane Strain, Derivation of the Constant-Strain Triangular Element Stiffness Matrix and Equations, Treatment of Body and Surface Forces, Explicit Expression for the Constant-Strain Triangle Stiffness Matrix

Practical Considerations in Modelling and Result Interpretation

Finite Element Modelling, Equilibrium and Compatibility of Finite Element Results, Convergence of Solution, Interpretation of Stresses, Static Condensation, Flowchart for the Solution of Plane Stress/Strain Problems, Computer Program Assisted Step-by-Step Solution, Other Models, and Results for Plane Stress/Strain Problems

Axisymmetric Elements

Derivation of the Stiffness Matrix, Solution of an Axisymmetric Pressure Vessel, Applications of Axisymmetric Elements

Isoparametric Formulation

Isoparametric Formulation of the Bar Element Stiffness Matrix, Rectangular Plane Stress Element, Isoparametric Formulation of the Plane Element Stiffness Matrix, Gaussian and Newton-Cotes Quadrature, Evaluation of the Stiffness Matrix and Stress Matrix by Gaussian Quadrature, Higher-Order Shape Functions

Three-Dimensional Stress Analysis

Three-Dimensional Stress and Strain, Tetrahedral Element, Isoparametric Formulation

Plate Bending Element

Basic Concept of Plate Bending, Derivation of a Plate Bending Element Stiffness Matrix and Equations, Computer Solution for a Plate Bending Problem

References

1. A First Course in the Finite Element Method by Logan D. L. ; (Cengage Learning)
2. Elementary Finite Element Method by Desai C.S. ; (Prentice Hall of India)
3. Introduction to Finite Elements in Engineering by Chandrupatla T.R. & Belegundu A.D. ; (Prentice Hall of India)
4. Finite Element Procedures in Engineering Analysis by Bathe K.J ; (Prentice Hall of India)
5. Finite Element Analysis: Fundamentals by Gallaghar R.H ; (Prentice Hall Inc.)
6. Finite Element Analysis in Engineering Design by Rajasekaran S. ; (Wheeler Pub.)
7. Finite Element Analysis - Theory and Programming by Krishnamoorthy C. S. ; (Tata McGraw Hill)
8. The Finite Element Method, Vol I & II by Zienkiewics O.C. & Taylor R.L. ; (McGraw Hill)
9. Finite Element Analysis by Bhavikatti S. S. ; (New Age International Publishers)