SHORT TERM COURSE ON

FINITE ELEMENT ANALYSIS:
NONLINEAR DYNAMIC RESPONSE AND SOIL-STRUCTURE INTERACTION

[Supported by SPARC]

Instructors

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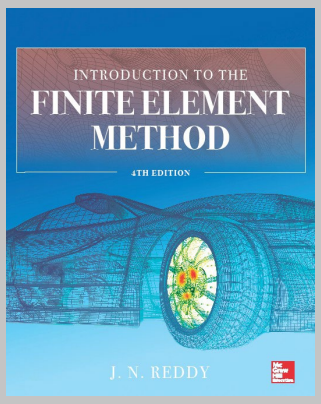

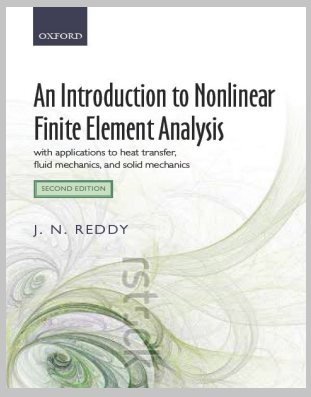

Course date and venue:
15-19 July 2024,
Dept. of Civil Engineering,
IISc Bangalore, India

ABOUT THE COURSE

This course is intended to provide engineers/scientists working in academia as well as in engineering industries with the theory of the finite element method and its use in the solution of linear and nonlinear problems from solid and structural mechanics. The present course is designed to bridge the gap between the theoretical finite element knowledge and its industrial applications by providing sufficient insights into the relationship between the physical problem and associated finite element model (e.g., loads, boundary conditions, constitutive behavior, element selection, mesh design, imposition of boundary conditions, interpretation of results, and so on). The course is not intended to discuss or solve specific industrial problems or their solution by commercial codes.

PROFILE OF PARTICIPANTS

The course is aimed at engineers/scientists who are working with modeling of problems in structural mechanics and who intend to use commercially available finite element packages to analyze their engineering problems. The course will enable participants to understand numerical modeling aspects of physical problems and the workings of the FEM, so that they are confident of their numerical model development, and have the ability to interpret the results. Participants are assumed to have knowledge of the basic courses in heat transfer, fluid mechanics and structural mechanics. Some knowledge of the linear finite elements is an advantage, but not essential.

BENEFITS OF ATTENDING THE COURSE

Persons who have attended the course and followed the material should benefit in strengthening their background in the following areas:

- A clear understanding of the formulative steps involved in the linear and nonlinear finite element models of problems of solid and structural mechanics (beams, plane elasticity, plates, and shells).
- Generation of finite element data (e.g., selection of elements and mesh, computation of nodal forces), imposition of boundary conditions, post-computation of stresses and strains, etc.), exploitation of problem symmetries, and interpretation and evaluation of the results.

- Applications to model problems to illustrate the workings of the FEM, evaluation of results, and use of the results in decision making.
- The knowledge to teach the finite element analysis procedures to others.

COURSE MATERIAL AND REFERENCE BOOKS

1. J. N. Reddy, An Introduction to the Finite Element Method, 4th ed., McGraw-Hill, New York, 2019.
2. J. N. Reddy, An Introduction to Nonlinear Finite Element Analysis, Oxford University Press, UK, 2004.

[A copy of the overheads used in the presentation of the course will be provided as a part of the course Material; participants may purchase the Indian editions of the above books from the local vendors]

Course Outline

The basic concepts in FEM – one-dimensional problems

- Strong and weak forms
- Essential vs. natural boundary conditions
- Integral statements (Principle of the minimum potential energy)
- Finite element approximation functions (linear, quadratic, and cubic elements)
- Illustrative examples from model field problems (e.g., groundwater flow) and discussion of results

Analysis of Euler-Bernoulli and Timoshenko beams

- Governing equations of Euler-Bernoulli beams
- Finite element models
- Examples of application
- Timoshenko beam theory
- Finite element models and shear locking
- Applications
- Plane trusses and frames

Eigenvalue and Time-Dependent problems

- Free vibration of elastic systems
- Transient Analysis

Two-dimensional problems

- Groundwater, membrane, and torsion problems involving a single unknown
- 2D Elements types (triangular and quadrilateral elements)
- Computational examples

Numerical/computational issues

- Subparametric, isoparametric, and superparametric formulations
- Numerical integration
- General modeling considerations

Plane Elasticity Problems

- Governing equations of plane elasticity problems
- Elements types (triangular and quadrilateral elements)
- Examples

Axisymmetric and Three-dimensional problems

- Axisymmetric problems
- 3-D Elasticity problems
- Types of 3-D Finite elements (interpolation functions)

Plate Bending Problems

- Theories of plates
- Classical plate bending elements
- Shear deformation plate elements and shear locking

Introduction to Non-linear Problems

- Geometric and material non-linearity
- 1-D Nonlinear problems (beams)
- Solution algorithms for non-linear equations
- Tangent stiffness calculations

Non-linear Problems in 2-D

- Material non-linearity
- 2-D Nonlinear problems (heat transfer)
- Solution algorithms for non-linear equations
- Tangent stiffness calculations

Nonlinear Formulations of Plate Bending Problems

- Shear deformation plate elements
- Membrane locking
- Tangent stiffness calculations
- Post-computation of strains and stresses

Modeling of soil-structure interactions

- Introduction to the problems of soil-structure interactions
- Computational modeling of soil behavior Including the effect of pore water - changes to governing equations, boundary conditions, addition of new degrees of freedom, and other numerical aspects.
- Plasticity models for soils to include pressure-dependent material behavior and plastic volume change
- Special boundary conditions for truncating the infinite soil domain into a finite domain for static and dynamic scenarios
- Contact definition between soil and structure
- Examples of soil-structure interactions in bridge structures

Course fees:

- **Graduate students: INR 5000.00 + 18% GST**
- **Faculty from Academia: INR 10000.00 + 18% GST**
- **Researchers/Practitioners from R&D labs and industry: INR 20000.00 + 18% GST**

Registration

http://cce.iisc.ac.in/ssp-stc.html

The course fee includes expenses towards course material, refreshments and lunch during the course and does not include expenses towards travel, accommodation, breakfast, and dinner. Limited on campus accommodations at the Hoysala Guesthouse are available (on payment basis) and these will be provided by the Centre for Continuing Education on first come first served basis

About the speakers

Dr J N Reddy

Dr. Reddy is a Distinguished Professor, Regents' Professor, and the holder of the O'Donnell Foundation Chair IV in Mechanical Engineering at Texas A&M University, College Station, Texas. Dr. Reddy, an ISI highly-cited researcher, is known for his significant contributions to the field of applied mechanics through the authorship of a large number of text-books (25) and journal papers (>800). His pioneering works on the development of shear deformation theories (that bear his name in the literature as the Reddy third-order plate theory and the Reddy layerwise theory) have had a major impact and have led to new research developments and applications. Some of the ideas on shear deformation theories and penalty finite element models of fluid flows have been implemented into commercial finite element computer programs like ABAQUS, NISA, and HyperXtrude. In recent years, Reddy's research has focused on the development of locking-free shell finite elements and nonlocal and non-classical continuum mechanics problems dealing with architected materials and structures and damage and failures in solids.

Dr. Reddy has received numerous honors and awards. Most recent ones include: 2023 Leonaro da Vinci Award from the European Academy of Sciences, 2023 Michael Païdoussis Medal from the Royal Society of Canada, 2022 IACM Congress (Gauss-Newton) Medal from the International Association of Computational Mechanics, the 2019 SP Timoshenko Medal from American Society of Mechanical Engineers, the 2018 Theodore von Karman Medal from the American Society of Civil Engineers, the 2017 John von Neumann Medal from the U.S. Association of Computational Mechanics, the 2016 Prager Medal from the Society of Engineering Science, and 2016 ASME Medal from American Society of Mechanical Engineers. He is a member eight national academies, including the US National Academy of Engineering, and foreign fellow of Indian National Academy of Engineering, the Canadian Academy of Engineering, the Brazilian National Academy of Engineering, the Chinese Academy of Engineering, the Royal Engineering Academy of Spain, the European Academy of Sciences, and the European Academy of Sciences and Arts.

Dr Swetha Veeraraghavan

Dr Swetha Veeraraghavan is an Assistant Professor at the Civil Engineering Department at IISc Bangalore. She obtained her B. Tech in Naval Architecture and Ocean Engineering from IIT Madras, and M.S. and Ph.D. in Civil Engineering from California Institute of Technology, USA. Prior to joining IISc, she worked as a computational scientist at the Idaho National Laboratory on developing open-source finite element tools that can model realistic earthquake fault rupture scenarios, and simultaneously simulate the response of critical buildings to the generated seismic wavefields. Her research group at IISc is focusing on structure specific wave interaction mechanisms and on using these to improve the seismic safety of large structures such as dams and tunnels.

CONTACT US

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