NAFEMS India

Agenda

Welcome & Introduction

Dr. Elangovan Kariappan, *NAFEMS India*

Finite Element Modeling for Engineering Analysis

Dr. H.V. Lakshminarayana, *Dayananda Sagar College of Engineering*

Q & A Session

Profile of Speakers

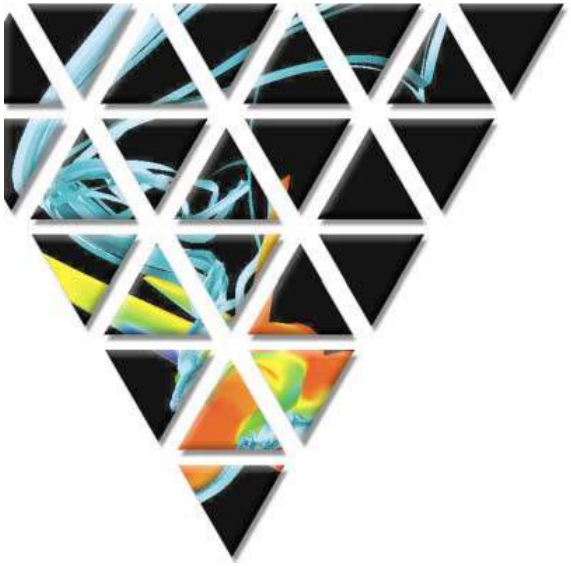
Dr. H.V. Lakshminarayana
Professor, Dept. of Mech. Engg.,
Dayananda Sagar College of Engg.,
Bangalore

Qualification : Ph.D (IISc, Bangalore)

Experience :

- **About 30 years experience in FE Modeling for Engineering Analysis**

  Served as Scientist and Asst. Director, NAL, Bangalore and Materials Laboratory, Air Force Wright Aeronautical Laboratories, Wright Patterson Air Force Base, Dayton, Ohio, USA
- **Composite Structures : Analysis & Design**
- **Fracture Mechanics : Computational**



NAFEMS

NAFEMS INDIA WEBINAR
On
Finite Element Modeling for Engineering Analysis: Theory, Benchmarks, CaseStudies

Presented by
Dr. H V Lakshminarayana
Professor, Dayanda Sagar College of Engineering
Bengaluru
INDIA

Finite Element Modeling for Engineering Analysis

Contents

- Background
- FEModeling for structural dynamic analysis
- FEModeling for Nonlinear analysis of solids and structures
- FEModeling for stress and progressive failure analysis of composite structures
- FEModeling for computational fracture mechanics
- FEModeling for structural design optimization
- FEModeling for simulation of sheet metal forming process
- FEModeling for analysis of threaded Fasteners
- FEModeling for thermal, structural and coupled thermal-structural analysis
- FEModeling for computational fluid dynamics
- FEModeling for coupled field analysis

Finite Element Modeling for Engineering Analysis

Background

- Engineering analysis is the backbone of computer applications in design
- The finite element method in general and general purpose finite element analysis programs in particular implemented on a computer offers a universal procedure for engineering analysis
- The objective of this webinar is to present the contents of a upcoming publication titled “FINITE ELEMENT MODELING FOR ENGINEERING ANALYSIS: THEORY,BENCHMARKS,CASESTUDIES”
- The contributors to each chapter of this edited volume are experts in the field
- Finite element modeling is defined here as the analyst’s choice of material models, finite elements, meshes, constraints, solution methods and pre- and post-processing options available in a chosen commercial FEA software for the intended analysis
- Benchmarks are standard test problems with known target solutions to validate finite element models

FEModeling for structural dynamic analysis

Contributed by Dr G V Rao

Modal analysis

- Mathematical preliminaries
- Hamiltons principal
- Specific finite element formulations
- Governing matrix equation
- Eigen value extraction methods
- Natural frequencies and mode shapes
- Benchmarks
- Casestudy: Aircraft fuselage shell structure

FEModeling for structural dynamic analysis

Contributed by Dr G V Rao

Harmonic response analysis

- Stiffness, damping, mass and applied load idealization
- Equations of motion
- Solution methods
- Amplitude VS Frequency curves
- Benchmarks
- Casestudy: A plane frame

FEModeling for structural dynamic analysis

Contributed by Dr G V Rao

Transient response analysis

- Equations of motion
- Force-Time history input
- Governing matrix equations
- Solution methods
  - Mode superposition method
  - Implicit time integration methods
  - Explicit time integration methods
- Response VS Time graphs
- Benchmarks
- Casestudy: A plane frame

FEModeling for structural dynamic analysis

Contributed by Dr G V Rao

Impact dynamics analysis

- Involves combined geometric, material and contact nonlinearities
- Need for fluid structure coupling
- Nonlinear continuum mechanics background
- Material models
- Specific finite element formulations
- Governing matrix equations
- Specialized solution methods
- Benchmarks
- Casestudy:
  - Hard body impact
  - Soft body impact

FEModeling for structural dynamic analysis

Contributed by Dr G V Rao

Rotor dynamics analysis

- Includes centrifugal force and gyroscopic couple effects
- Specific finite element formulations
- Governing matrix equations
- Specialized solution methods
- Benchmarks
- Casestudy: Turbo charger (compressor rotor, turbine rotor, shaft and bearings)

FEModeling for structural dynamic analysis

Contributed by Dr G V Rao

Aero elastic analysis

- Involves coupling between structural dynamics and unsteady aero dynamics
- Mathematical preliminaries
- Multi-disciplinary finite element analysis
- Divergence and flutter
- Benchmarks
- Casestudy

FEModeling for Nonlinear analysis of solids and structures

Contributed by Dr H V Lakshminarayana

- Historical developments
- Total Lagrangian formulation
- Updated Lagrangian formulation
- Eulerian formulation
- Arbitrary Lagrangian Eulerian formulation
- Nonlinear continuum mechanics background
  - Motion and defermation
  - Strain measures
  - Stress measures
  - Conservation laws
- Constitutive equations – material models
  - Linear elasticity
  - Nonlinear elasticity
  - Hypoelastic
  - Hyperelastic
  - Multiy axial plasticity
  - viscoelasticity
- Nonlinear finite elements for continua
- Nonlinear finite elements for structures

FEModeling for Nonlinear analysis of solids and structures

Contributed by Dr H V Lakshminarayana

- Solution of equations of motion
  - Explicit time integration methods
  - Implicit time integration methods
- Solution of equlibriam equations
  - Newton-Raphson method
  - Modified Newton-Raphson method
- Stability of numerical solution
- NAFEMS Benchmarks
- Casestudies:
  - Lee frame buckling
  - Notched beam bending
  - NLFEA prevents leakage in a steam turbine exhaust casing
  - NLFEA simulates deep drawing process

FEModeling for stress and progressive failure analysis of composite structures

Contributed by Dr Vijayakumar R and Dr H V Lakshminarayana

- Mechanics of composite lamina
  - Lamina stress strain relations
  - Lamina failure criteria
  - Modifications to include hygro-thermal expansions
- Mechanics of composite laminate
  - Classical lamination theory
  - Shear deformation theory
  - Improved shear deformation theory
  - Modifications to include hygro-thermal expansions
  - Residual stresses
- Progressive failure analysis
  - First ply failure to Last ply failure
  - Ply failure criteria
  - Ply failure mode identification
  - Ply stiffness degradation models
  - Step by Step loading

FEModeling for stress and progressive failure analysis of composite structures

Contributed by Dr Vijayakumar R and Dr H V Lakshminarayana

- Benchmarks
  - Stress concentration around a circular cutout in a laminate
  - Stress concentration around an elliptical cutout in a laminate
  - Annular disc under diametrical compression
- Casestudies:
  - Rotating annular composite disc
  - Composite cylindrical shell with an elliptical cutout
  - FWFRP pressure vessel with a metallic liner

FEModeling for computational fracture mechanics

Contributed by Keerthan L J and Shivashankar R S

- Fracture mechanics parameters
  - Stress intensity factor (K)
  - Energy release rate (G)
  - Path independent integral (J)
  - Crack tip opening displacement (CTOD)
- CFM objectives: to determine (K/G/J/CTOD) as function of component/structure geometry, applied loads, crack type, size, location and orientation
- Finite elements for modeling cracked structures/components
  - QUAD8
  - TRIA6
  - STRIA6
  - HEXA20
  - PENTA15
  - SPENTA15
- Pre processing commands

FEModeling for computational fracture mechanics

Contributed by Keerthan L J and Shivashankar R S

- Post processing sub programs
  - 3MBSIF (mixed mode membrane and bending stress intensity factors)
  - SIF123 (mixed mode stress intensity factors)
  - G values
  - J values
  - CTOD values
- Benchmarks
- Casestudies:
  - Arbitrarily oriented crack in a cylindrical shell subjected to axial force, internal pressure and torsional moment
  - Meridional crack in a spherical pressure vessel
  - Arbitrarily oriented crack in a conical shell
  - Cylindrical pressure vessel with torispherical end closures with arbitrarily located and oriented crack
  - Surface crack problems in bars, plates and cylinders

FEModeling for structural design optimization

Contributed by Dr. S Shamasundar

- Analytical methods
- Introduction to Optimisation techniques (GA, SA, NLQSP etc.)
- Hybrid techniques
- Size, shape, topology and parametric optimization
- Linking of CAx tools to optimization
- Case studies (with structural, coupled analysis, manufacturing examples)
  - Weight reduction in long member of SUV
  - Optimization of composite wing of air craft
  - Optimization of hydro forming process
  - Design of Ignition coils

FEModeling for simulation of sheet metal forming process

Contributed by Dr Badrinath Ambati

- Introduction
- Sheet metal forming and blanking
  - Manufacturing and Processing of Sheet Metal
  - Basic Deformation Modes in Stamping
  - Defects in Stamping
  - Test of Formability
    - Failure Analysis with Forming Limit Diagrams (FLD)
    - Basis of the forming limit curve (FLC)
    - Strain paths and forming modes on the FLD
    - Factors influencing the FLC
  - Basics of Draw Die Development
  - Hydro forming

FEModeling for simulation of sheet metal forming process

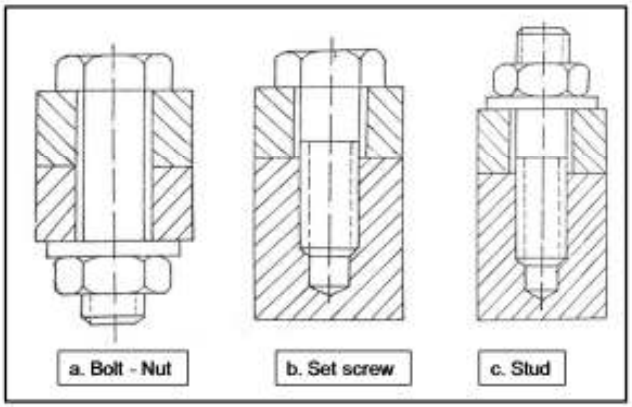
Contributed by Dr Badrinath Ambati

- Computer Analysis of Forming Processes
  - Roll of CAE in Manufacturing
  - Simulation methods
  - Inverse or one-step method, incremental method
  - Geometry cleanup, auto meshing, mesh Quality
  - Model Preparation
  - Results analysis
  - Spring back
  - Multi-Stage Manager
  - Blank Optimizer

FEModeling for analysis of threaded Fasteners

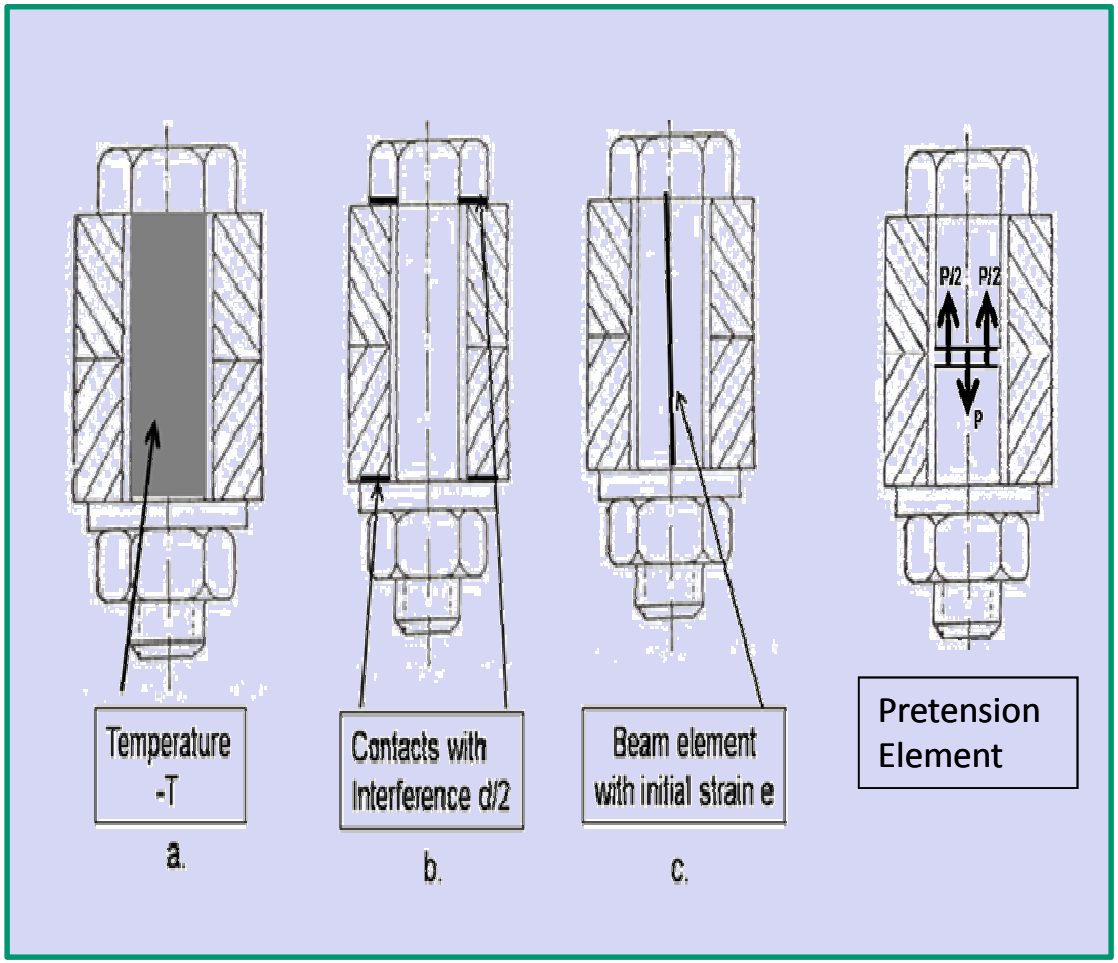
Contributed by Dr K S Raghavan

- CONTENTS :
- .. Basics of Bolted Joints – Types, Design Philosophy, Role of Preload.
- .. Finite Element Method - The “NEED” for Rigorous Analysis
- .. Advanced Features in Modern FEA Packages that Facilitate Exact Simulation – Contact Technology.
- .. Methods of Simulating Preload – Four Approaches Relative Merits and Demerits..
- .. A Simple Example Problem to Illustrate the Concepts
- .. Modelling Approaches, Recommendations on Choice.
- .. Case Studies to Understand Modeling and Interpretation of the Results.
- .. Design Considerations including Fatigue and Creep.



FEModeling for analysis of threaded Fasteners

Contributed by Dr K S Raghavan

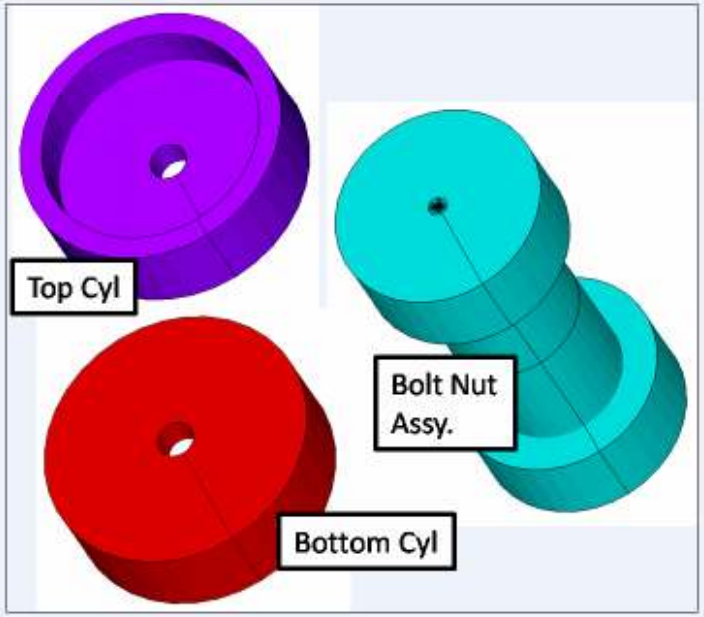


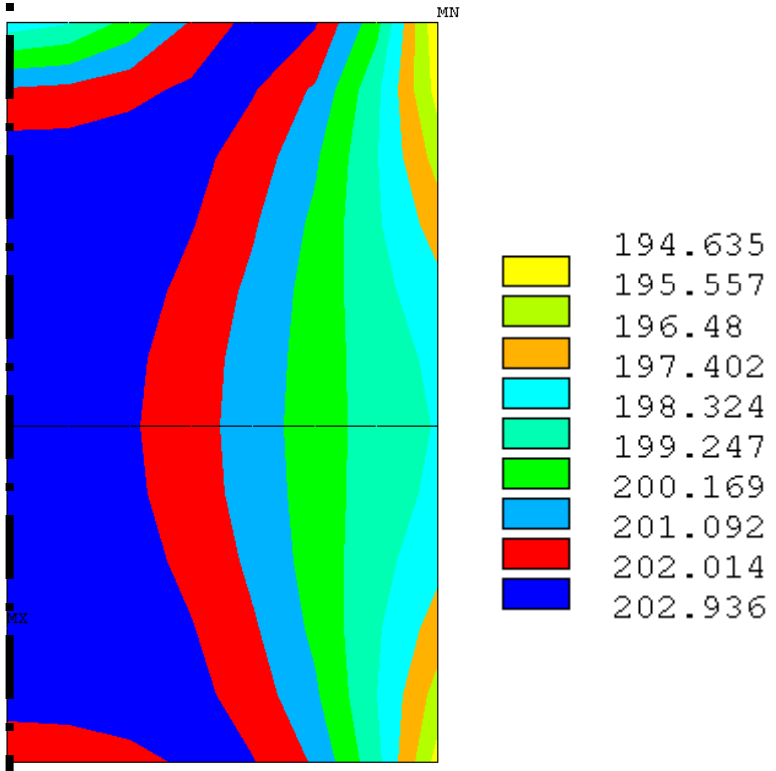
PRELOAD SIMULATION

FEModeling for analysis of threaded Fasteners

Contributed by Dr K S Raghavan

- Illustrative Example
- AN AXISYMMETRIC JOINT





Axial Stress in the Bolt Shank

FEModeling for thermal, structural and coupled thermal-structural analysis

Contributed by Dr H V Lakshminarayana and Shivashankar R S

- Heat transfer processes
- Governing differential equations
- Prescribed temperature, conduction heat flux, convection heat flux and radiation heat flux boundary conditions
- Galerkin weighted residual weak statement
- Specific finite element formulations
- Governing matrix equations for
  - Linear steady state problems
  - Non linear steady state problems
  - Linear transient problems
  - Non linear transient problems
- Solution methods
- Benchmarks
- Casestudy: FEModeling of a pipe joint using Abacus
  - Thermal analysis
  - Structural analysis
  - Coupled thermal-structural analysis

Finite Element Modeling for CFD

Contributed by Viswanath Ramakkagari

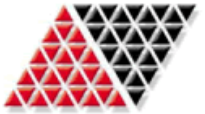
Topics

- Introduction
- Conservation Laws governing Fluid Motion
- Convection-Diffusion Equations
  - Weak Formulation
  - Finite Element Formulation
  - Stabilization Schemes
- Incompressible Flows
  - Weak Formulation
  - Finite Element Formulation
  - Stabilization Schemes
  - Time Integration Schemes
- Numerical Examples
- Summary
- Exercises

FEModeling for coupled field analysis

Contributed by Kiran Kumar B S

- Introduction to Coupled Field Analysis
  - Definition of coupled field analysis
  - Applications and industries
  - Types of coupled filed analysis
  - How ANSYS handles coupled field problems
- Piezoelectric analysis
  - Introduction to piezoelectric analysis
  - Analysis Procedure
  - Case Study: Electric damping of a piezoelectric plate
  - Verification problems
- Electromagnetic analysis
  - Brief history
  - Applications and industries
  - Need for electromagnetic analysis
  - Classification and type of analysis
  - Coupled Physics Circuit Simulation
  - Practical examples solved using ANSYS electromagnetic



Thank You