Finite Element Analysis and Constitutive Modelling in Geomechanics

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IIT Madras

PRE-REQUISITES : Exposure to Mechanics courses & Shear strength of soils

INTENDED AUDIENCE : Senior level UG Civil Engineering & all PG level Civil Engineering students in geotechnical engineering stream

INDUSTRY SUPPORT : Most design companies working in Geotechnical Engineering like L&T ECC, AFCONS, HCC, Keller, Golder Associates, etc

COURSE OUTLINE :

The course will introduce the students to both theoretical and practical aspects of finite element methods applicable to geotechnical engineering. The course will start from the fundamental aspects of matrix structural analysis and move into finite element techniques through variational principles. Special focus of this course will be on topics related to geotechnical problems like modelling of infinite soil media, construction and excavation sequences, jointed mass, and nonlinear analysis techniques. Fundamentals of different topics of isoparametric computations and nonlinear & elastic plastic analysis are explained through simple to use computer programs and detailed flow-charts.

ABOUT INSTRUCTOR :

Prof. K. Rajagopal joined as an Adjunct Professor at Andhra University, Visakhapatnam after retirement from the services of IIT Madras (Department of Civil Engineering). He has more than 25 years of experience with teaching and research in geosynthetics and reinforced soil structures.

COURSE PLAN :

Week 1: Introduction to course, introduction to matrix algebra, concepts of finite element analysis through prismatic elements (spring, bar & beam elements) and matrix structural analysis
Week 2: Variational principles & Rayleigh-Ritz procedures in structural mechanics as a prelude to finite element techniques
Week 3: Continuum, stress & strain states, equations of equilibrium, compatibility & linear elastic constitutive equations, derivation of equilibrium equations for continuum, Plane stress, plane strain and axisymmetric and 3-d stress states
Week 4: Generalized Coordinate methods for deriving shape functions, Lagrange methods for shape functions 3-node CST element for finite element analysis and some simple calculations using this element
Week 5: Numerical integration techniques, Isoparametric transformations, shape functions in isoparametric space, Patch test & convergence
Week 6: Isoparametric element calculations - numerical examples & computer programs for different computations like stiffness matrix, load vector due to self-weight, stresses, etc.
Week 7: In situ stress states in soil medium, Simulation of construction and excavation sequences in finite element analysis, Joint elements for simulating discontinuities in geologic medium
Week 8: Infinite elements for simulating semi-infinite soil domains subjected to static and dynamic loading
Week 9: Stress and strain tensors & invariants,Introduction to nonlinear finite element techniquesDifferent types of constitutive models
Week 10: Nonlinear constitutive models like variable moduli models, Hyperbolic models,>Mohr Coulomb model, stress correction methods & numerical procedures
Week 11: Elastic-Plastic constitutive models Simulation of dilation of soils Hardening soil models for excavation problems
Week 12: Undrained and drained response of soils Consolidation analysis of soils Introduction to simulation of impact and dynamic loading
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