GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code 3724301
Semester – II
Subject Name: Finite Element Methods in Geotechnical Engineering

Type of course: PE-III

Prerequisite: Numerical Methods in Civil Engineering, Theoretical Soil Mechanics and Foundation Engineering.

Rationale: Finite element methods is now used in many field of engineering practice and is now very widely used for analysing geotechnical problems. Using FEM many complex and specific geotechnical issues can be resolved. The understanding of assumptions and approximations in FEA, to describe constitutive models related to soil behaviour either in linear or non-linear form including elastic and elasto-plastic models, modeling various flow problems, deformations, soil parameters for various geotechnical applications are the basic aims of this subject. The course on *Finite Element Methods in Geotechnical Engg* provides the students necessary skills to model various geotechnical problems viz. standard laboratory & field tests, analysis of tunnels, earth retaining structures, cut slopes, embankments and foundations using software's PLAXIS, ANSYS etc..

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE(E)	PA (M)	ESE (V)	PA(I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Concepts of FDM, limitations of FDM, introduction to FEM, Steps involved in Finite Element Analysis Procedure, Merits and Demerits. Principles of Elasticity: Equations of equilibrium and compatibility, stress-strain relations, plane stress and plane strain and axi-symmetric problems	05
2	Element Properties: Concept of an element, various element shapes, Displacement models, Generalized coordinates, Shape functions, Convergent and Compatibility requirements, Geometric invariance, Natural coordinate system - area and volume coordinates.	07
3	Generation of Element Stiffness and Nodal Load Matrices, Isoparametric Formulation: Concept, Different isoparametric elements for 1D-Bar element, 2D analysis-CST & Quadrilateral, formulation of 4-noded isoparametric quadrilateral elements, Lagrangian elements, Serendipity elements.	08
4	Assemblage of Elements: Discretization of a structure, numbering systems, Aspect ratio its effects, Assemblage, Direct Stiffness method.	07

5	Techniques of nonlinear analysis, constitutive modeling for soils, determination of soil parameters for such analysis, related applications.	06
6	Introduction to Artificial Intelligence in GE: Expert systems, Artificial Neural Network (ANN), Fuzzy Logic, Genetic Algorithm	05
7	Variational Calculus: Euler–Lagrange method, Galerkin's method, Ritz method, Kantorovich's method	04
8	Application of FEM/Modelling of problems using FEM based software's like PLAXIS, ANSYS, etc. to solve various geotechnical problems. **(Only During Laboratory Hours)**	---

Reference Books:

1. Krishnamoorthy, C. K., "Finite element analysis theory and programming, Tata McGraw Hill Publishing Cop., 1987.
2. Desai C. S. And Abel, J. F., Introduction to finite element method, Affilialed East-West Press Pub. Ltd.
3. Gauri Dhatt an Gilbert, Tauzot, The Finite Element Method Displayed, John Wiley & Sons.
4. Bathe, Wilson -Finite Elements Procedures in Engineering analysis
5. Chandrupatla, R.T. & Belegundu, A.D -. Introduction to Finite Elements in Engineering
6. J. N. Reddy, Int. to FEM, McGraw Hill, 2nd Edition, 1993.
7. David M Potts and Lidija Zdravkovic, 'Finite Element analysis in Geotechnical engineering – Theory', Thomas Telford, 1999.
8. Programming the Finite Element Method with application to Geomechanics by Smith, I.M., John Wiley and Sons, New Delhi, 2000.

Course Outcomes: Students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	The course provides good background to basics of finite difference and finite element methods of analysis.	10
CO-2	The course would help in application of FEM for performance evaluation of various geotechnical engineering problems, which involves complex geometry and loading conditions.	30
CO-3	The course would also provide insight into various FEM based software's, which can be utilized for simulation of various geotechnical engineering problems.	20
CO-4	The course will also provide an understanding of various nonlinear analysis techniques including constitutive modeling for soil, which will be useful to evaluate the response of soil to various loading conditions.	25
CO-5	The course will provide an insight to artificial intelligence as a tool to analyse various geotechnical engineering applications	15

List of Experiments/Tutorials:

FEA for various linear and non-linear materials, constitutive models, tunnels, earth retaining structures, shallow foundations, embankments. Maximum no of problems may be equal to 5-7.

Apart from above tutorials/experiments a group of students has to undertake one open ended problem/modelling problem based on any one applications of geotechnical engineering using any one software. Few examples of the same are given below:

1. Modelling soil parameters based on stress analysis.
2. Modelling elastic constitutive models – linear and non-linear.
3. Modelling Non-linear materials – Mohr-Coulomb soil.
4. FEM for seepage and consolidation problems.
5. Use of AI tools for pile analysis, soil classification.

List of Open Source Software/learning website:

1. http://nptel.ac.in/
2. http://ocw.mit.edu/courses/civil-and-environmental-engineering/