

**Course Name:**

Numerical Methods in Geotechnical Engineering

**Course Number:**

20408

**Credit:**

3

**Course Content (outline):****1. Preliminaries and Basic Concepts**

- 1.1 What is Modelling?
- 1.2 Mathematical, Physical, and Numerical Modellings and their Relationship
- 1.3 Main Differential Equations in Civil Engineering Mitigation of Seismic Hazards
- 1.4 Numerical Solution of Differential Equations - Spatial and Temporal Discretization

**2. Finite Difference Method (FDM)**

- 2.1 Taylor Series Expansion as the Mathematical Base of the FDM
- 2.2 FDM Solution of Ordinary Differential Equations
- 2.3 FDM Solution of Parabolic PD Equations
- 2.4 FDM Solution of Hyperbolic PD Equations
- 2.5 FDM Solution of Elliptic PD Equations
- 2.6 Stability and Accuracy of Numerical Schemes - Lax Theorem

**3. Finite Element Method (FEM)**

- 3.1 Differences between FDM and FEM
- 3.2 Transforming the Differential Equations to Integral Equations
- 3.3 Interpolation (Shape) Functions for 1 and 2 Dimensional Elements
- 3.4 Iso-Parametric, Sub-Parametric and Super-Parametric Elements
- 3.5 Transforming Differential Form of the Equilibrium Equation to Integral Form
- 3.6 Numerical Integration
- 3.7 Transforming the Integral Form of the Equilibrium Equation to System of Algebraic Equations

3.8 Solving Solid Mechanics Problems Using FEM

3.9 Solving Seepage Problems Using FEM

#### **4. Numerical Modelling of Common Geotechnical Problems Using FEM**

4.1 Geotechnical Problems Class A, B, and C

4.2 Modeling In-Situ Stresses in Geotechnical Problems

4.3 Modeling Construction Sequence in Geotechnical Problems

4.4 Numerical Modeling of Shallow Foundations

4.5 Numerical Modeling of Deep Foundations

4.6 Numerical Modeling of Retaining Walls

4.7 Numerical Modeling of Excavations

4.8 Numerical Modeling of Embankments

4.9 Numerical Modeling of Drained/Undrained Loading Conditions of Saturated Strata

4.10 Numerical Modeling Considering Non-linear Elastic Soil Behavior

#### **References:**

Cook, Malkus and Plesha, "Concepts and Applications of Finite Element Analysis", (1989) John Wiley

Bathe, K.J., "Finite Element Procedures in Engineering Analysis", (1996), Prentice Hall

Zienkiewicz & Taylor, "The Finite Element Method", vol. 1, 4<sup>th</sup> Edition, (1989), McGraw Hill

Smith, I.M., & Griffith, D.C., "Programming the Finite Element Method", 2<sup>nd</sup> Edition (1992), John Wiley & Sons

Reddy, J.N., An Introduction to the Finite Element Method, McGraw-Hill, 1993