Computational Geotechnics

Continuum Mechanics in Computational Geotechnics. Simple numerical methods: Slope stability and Stabilization with the method of slices. Introduction to the finite element and finite difference methods for the solution of boundary value problems in Geotechnical Engineering. Finite Difference Analysis of the nonlinear response of piles to lateral loading. Inverse analysis and optimization methods in the design of pile foundations. Constitutive models of soil behaviour. Application of the Finite Element method in engineering practice. Simulation of laboratory tests, bearing capacity and settlement of foundations, groundwater flow, deep excavations and retaining structures, tunneling, static soil-structure interaction.

- Semester 8
- Teaching hours 4
- Website http://users.ntua.gr/gerolymo/index_files/page0006.htm
- Instructors N. Gerolimos

Prerequisite Knowledge

Basic knowledge in the following Areas (Courses): Soil Mechanics I, Soil Mechanics II, Foundation Engineering and Matrix Structural Analysis

Course Units

	Title	Description	Hours
1	Introduction: Numerical Methods in Geotechnical Engineering-Case Studies	The use of the finite element and finite difference methods in geotechnical engineering. Discussion of case studies.	4
2	Slope Stability and Stabilization with the Method of Slices	Numerical analysis of slope stability with the method of slices. The methods of Fellenius, Bishop and Janbu. Tutorial for use of dedicated PC software of slope stability analysis. Application examples involving dam slopes and road embankments. Probabilistic methods of analysis. Slope stabilization methods (e.g. piles, grouted anchors, retaining walls, embankments, dewatering etc.): Examples and analysis with the use of suitable software.	16
3	The Finite Difference Method: Application to Laterally Loaded Piles	The finite difference method for solving ordinary and nonlinear differential equations. Spreadsheet applications in the analysis of laterally loaded piles. Numerical methods for solving systems of nonlinear algebraic equations: The Euler, Newton-Raphson and Modified Newton-Raphson methods. Application to the lateral response of piles in nonlinear soil. Demonstration of multi-objective (serviceability and cost effective-based) optimization processes for pile-group design.	16

	Title	Description	Hours
		Programming with MATLAB. Introduction to inverse methods of analysis for soil parameters identification.	
4	Introduction to the Finite Element Method	Elements of the finite element method. Tutorial for use of the finite element code PLAXIS in geotechnical analysis and design. Numerical simulation techniques for solving boundary value problems.	4
5	Simple Constitutive Models of Soil Behaviour	Impact of soil constitutive modelling on the numerical analysis of geotechnical problems. Simple constitutive stress-strain relations for nonlinear soil behaviour (Mohr Coulomb, Duncan and Chang, Hardening Soil Model). Numerical modelling of laboratory load tests (triaxial and oedometer) focusing on the calibration of model parameters.	4
6	Numerical Modelling in Geotechnical Engineering	Applications of the finite element method in geotechnical engineering. Numerical analysis of (1) the excavation and temporary support of a metro station, (2) slope stability and (3) shield tunnelling.	16

Learning Objectives

After the successful completion of the course, the students will be able to:

1. Know the main limitations, advantages and field of application of the used numerical method of analysis,
2. Realize the capabilities of numerical modelling as a design Tool in geotechnical engineering.
3. Understand the necessity of using numerical methods for solving Geotechnical Engineering problems.
4. Develop and use simple numerical models, and
5. Analysing real case studies with the use of dedicated PC codes.

Teaching Methods

Teaching methods	In class lectures, Solving of examples and applications in class, Discussion of case studies.
Teaching media	Blackboard presentations, Power Point Slide Projection, Calculations in PC using spreadsheets and dedicated software of analysis (e.g. Matlab, PLAXIS).
Computer and software use	Tutorials for use of dedicated PC software.

Problems - Applications	One or two deliverable homework sets for which solving by hands is mandatory and verification by the use of dedicated PC software is optional.
Assignments (projects, reports)	Students begin to work in class, independently or in teams of 2 to 3, on 2 term projects and submit technical reports, which are graded according to certain criteria, and returned before the final exam.

Student Assessment

- Final written exam: 60%
- Assignments (projects, reports): 40%
- Problems - Applications: 10% Θετική

Textbooks - Bibliography

1. Potts D.M., Zdravkovic (1999). Finite Element Analysis in Geotechnical Engineering. I: Theory, Thomas Telford Publishing, ISBN-10: 0727727532
2. Potts D.M., Zdravkovic (1999). Finite Element Analysis in Geotechnical Engineering. II: Applications, Thomas Telford Publishing, ISBN-10: 0727727834.
3. Wood D.M. (2004). Geotechnical Modelling, Spon Press, Taylor and Francis Group, ISBN: 0-203-78621-1.
4. Lees A. (2016). Geotechnical Finite Element Analysis: A practical Guide, ICE Publishing, Thomas Telford Ltd, ISBN: 0727760874.
5. Comodromos Em. (2009). Computational Geotechnical Engineering: Soil-Structure Interaction, Klidarithmos Editions, ISBN-13: 9789604612017.
6. Computational Geotechnics Notes (in Greek): http://users.ntua.gr/gerolymo/COMPUTATIONAL-GEOTECHNICS-BOOK.pdf

Lecture Time - Place: Friday, 11:45 – 15:30, Rooms: Ζ. Κτ. 1 Πολ., Αιθ. 15