UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

GEOTECHNICS

Enrollment year	2019/2020
Academic year	2021/2022
Regulations	DM270
Academic discipline	ICAR/07 (GEOTECHNICS)
Department	DEPARTMENT OF CIVIL ENGINEERING AND ARCHITECTURE
Course	CIVIL AND ENVIRONMENTAL ENGINEERING
Curriculum	PERCORSO COMUNE
Year of study	3°
Period	2nd semester (07/03/2022 - 17/06/2022)
ECTS	9
Lesson hours	80 lesson hours
Language	Italian
Activity type	WRITTEN TEST
Teacher	LAI CARLO GIOVANNI (titolare) - 9 ECTS
Prerequisites	Basics of Hydraulics and Mechanics of Deformable Body.
Learning outcomes	Scope of the course is to provide students with the theoretical foundations on the hydro-mechanical behaviour of soils which is propaedeutic to the solution of the main problems associated to geotechnical engineering like design of a shallow foundation and the assessment of stability of a natural slope. The study of soil mechanics is framed starting from the experimental evidence and the observation of the behaviour of real structures and continues through physical-mathematical modeling. During the course, particular emphasis is placed on the notion of stress-path and its effectiveness in solving geotechnical problems. The subject of geotechnical characterization of soil deposits and definition of geotechnical model of the subsoil through in-situ and laboratory tests is also thoroughly discussed. This topic is of particular importance as it is preparatory to the geotechnical design of real systems.

The course will comprise lecturing classes dedicated to the illustration of the theoretical topics, exercising classes dedicated to problem-solving and/or deepening some of the themes treated during the lectures and finally tutoring classes dedicated to the interactive solution of the assignments. The course subdivision in didactic modules with lecturing hours (L), exercising hours (E) and tutoring hours (T) is illustrated in the following.

Course contents

First didactic module (6L+4E+2T)) – Origin, description, fabric and classification of soils.
Origin of soils and macro-structural characters of natural deposits. Phase relations. Clay minerals and chemism of clays. Identification and systems of classification of soils. Grain size distribution curves. Atterberg limits. Casagrande plasticity chart. Initial state soil parameters. Interaction between fluid phase and solid skeleton. Intrinsic properties of clays and Burland intrinsic compressibility curve.

Second didactic module (6L+4E+4T) – The porous medium: peculiarities and initial state of natural deposits.
Particulate nature of soils. Limits of applicability of the continuous model. Principle of effective stresses and its physical significance. Total and effective geostatic stresses, pore water pressures. Partially saturated and saturated soil deposits. Phenomena of capillarity. Geologic history and stress history. The notion of pre-consolidation pressure. The at-rest coefficient of lateral earth pressure. Normally-consolidated and over-consolidated soils. Pre-consolidation caused by oscillation of water table. Pre-consolidation from diagenetic and post-depositional aging processes.

Third didactic module (6L+4E+4T) – Seepage in porous media under steady state conditions.
Kinematical aspects of fluid motion. Review of the fundamental equations of fluid mechanics. Forms of energy and Bernoulli’s equation. Flow of water in porous media. Darcy’s law. Equilibrium conditions under the presence of seepage forces. Hydrodynamic pressure and critical hydraulic gradient. The problems of seepage and piping. Assessment of safety conditions of an excavation. Steady state flow. Derivation of Laplace’s equation. Graphical and analytical solutions of boundary value problems associated to Laplace’s equation. Experimental tests for measuring the hydraulic conductivity.

Fourth didactic module (8L+4E+4T) – Seepage in porous media under transient conditions. Theory of consolidation.
Terzaghi one-dimensional consolidation equation. Structure and formal analogy with heat equation. Analytical and numerical solution of Terzaghi equation. Consolidation/oedometer test. Determination of pre-consolidation pressure. Deformability parameters under oedometric conditions: the constrained modulus. Primary and secondary (aging) compression. Experimental determination of the coefficient of consolidation. Influence of sampling disturbance on the results of oedometer testing. Limits of applicability of the Terzaghi one-dimensional consolidation theory. Introduction to radial consolidation. Vertical drains. Skempton pore pressure parameters.

Application to undisturbed sampling.

Fifth didactic module (12L+4E+4T) – Experimental evidences and mathematical modeling of the hydro-mechanical behaviour of soils. Representation of states of stress and of stress and strain paths through the Mohr circle. Representation through the t-s plane, the triaxial plane and the q-p plane. Drainage conditions. Stability analyses under drained and undrained conditions. Mohr-Coulomb failure criterion. Mechanical behaviour of fine-grained soils. Shear resistance and deformability of NC and OC clays. Main laboratory equipments: triaxial apparatus, direct and simple shear shear apparatus. Peak and residual shear strength. Consolidated undrained and unconsolidated undrained triaxial tests. Undrained shear strength. In-situ shear vane test. Plane strain apparatus. Mechanical behaviour of coarse-grained soils. Dilatancy and its implications. Introduction to critical state theory. Deformability parameters. Elastic moduli decaying curves. Engineering approach to constitutive modeling of soils. Advanced approach. Introduction to the theory of elasto-plasticity. The yielding condition and plastic surface. Plastic potential. Associated and non-associated flow-rule. Strain-hardening behaviour of soils. Introduction to the Cam-Clay model.

Sixth didactic module (4L+2E+2T) – Field site investigation and geotechnical model of the subsoil.
Exploration programme, objectives and extension of the survey. Geotechnical characterization of soil deposits and definition of geotechnical model of the subsoil. Harmonization between geologic and geotechnical models. Boreholes and sampling techniques. Undisturbed sampling. In-situ geotechnical tests. Static CPT and dynamic SPT penetration tests. Dilatometer and pressiometer tests. Empirical correlations for the interpretation of CPT and SPT test results. Field measurement of pore water pressure. Installation of piezometers. Introduction to geophysical seismic testing. Cross-hole and down-hole tests.

Seventh didactic module (10L+4E+4T) – Analysis of geotechnical problems at the engineering scale.
Methods of analysis to solve stability problems. Limit analyses and global limit equilibrium methods. Stability of natural slopes and excavation fronts. Equilibrium of an undefined slope. Stability of a slope with the slice method. Bishop and semplified Janbu methods. Overview of earth-retaining structures. Earth thrust. Computation of active and passive earth pressures according to the classical theories of Coulomb and Rankine. Effects of water pressure and of surcharge live loads. Drainage systems. Typologies of foundations. Shallow and deep foundations. Limit bearing capacity of shallow foundations. Geotechnical and structural failure mechanisms. Terzaghi and Brinch-Hansen bearing capacity formulas under drained and undrained conditions. A brief introduction to Italian building code (D.M. 17/01/2018).

Teaching methods

Lectures (hours/year in lecture theatre): 52
Practical classes (hours/year in lecture theatre): 26
Tutoring classes (hours/year in lecture theatre): 24

Reccomended or required readings

Lecture notes, scientific articles and other didactic material will be distributed during classes. The following monographs are recommended:

Lancellotta, R. (2012). Geotecnica (4th edition). Zanichelli, pp. 530. Recommended basic textbook. (In Italian).

Berardi, R. (2021). Fondamenti di Geotecnica (4nd edition). Città Studi, pp.602. Basic textbook. Practical and of easy understanding. (In Italian).

Atkinson, J. (1997). Geotecnica - Meccanica delle Terre e Fondazioni. Mc Graw Hill, pp.452. Reference textbook. It treats both soil mechanics and design of foundations and earth-retaining structures though at a basic level. (In Italian).

Holtz, R.D. & Kovacs, W.D. (1981). An Introduction to Geotechnical Engineering. Prentice-Hall, pp.733. Excellent book to deepen the study on the hydro-mechanical behaviour of soils. Pragmatic and of easy comprehension.

Lambe, T.W. (1991). Soil Testing for Engineers. BiTech Publishers, pp. 165. Reference monograph for geotechnical laboratory tests.

Lambe, T. W. & Whitman, R. V. (1990). Soil Mechanics. John Wiley & Sons, pp. 576. Classical textbook to deepen the study of soil mechanics.

Nova, R. (2002). Fondamenti di Meccanica delle Terre. Mc Graw Hill, pp.373. Reference monograph to deepen the study on the hydro-mechanical behaviour of soils and of soil constitutive modeling. Advanced theoretical approach. (In Italian).

Wood, D.M. (1990). Soil Behaviour and Critical State Soil Mechanics. Cambridge University Press, pp. 462. Reference monograph to deepen the study on the hydro-mechanical behaviour of soils and of soil constitutive modeling. Advanced theoretical approach.

Mitchell, J.K. & Soga, K. (2005). Fundamentals of Soil Behavior. Wiley and Sons, pp. 592. Reference monograph to deepen the study on the chemism of clays and on the interaction between solid and fluid phases of the porous medium.

Salgado, R. (2006). The Engineering of Foundations. McGraw-Hill, 928 pp. Reference monograph to deepen the study on the engineering of foundations.

Viggiani, C. (1999). Fondazioni. Hevelius, 568 pp. Reference monograph to deepen the study on the engineering of foundations. (In Italian).

Assessment methods

Problems and/or reading assignments will be handed over during the course but they will not be collected. However, at the final exam students will be asked to turn in their work for an evaluation. Students are strongly recommended to attempt all the assigned homeworks in order to have a positive outcome at the final examination.

The final exam consists of a three hours written assessment. The test is split in two parts: the first based on theoretical questions while the second on problem-solving. The final grade will be the arithmetic mean of the two parts each of which should be successfully passed with a score greater or equal to 18/30. The test format is closed-book. An equation sheet will be provided during the test.

Further information

Didactic material is posted at the KIRO web site reachable at the link https://elearning.unipv.it/

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