CVEN 7718 Engineering Properties of Soils

Course Syllabus and Schedule

General Information

Professor: John S. McCartney, Ph.D.
Office: ECOT 541
Office hours: By appointment (no HW questions 1 day before due date)
E-mail: john.mccartney@colorado.edu

Class: Time: Spring 2012, Tuesday-Thursday 11:00am - 12:15am
Room: ECCE 1B47

Lab: Time: TBD
Room: ECCE 1B59

Textbook: No textbook is required for this class. Handouts and reference articles will be posted on CULearn throughout the semester. Optional reference texts that you may want to consult are:
Shear Strength of Cohesive Soils (1960). Boulder, CO. ASCE.
Duncan and Wright (2005). Soil Strength and Slope Stability. Wiley.
Terzaghi Peck and Mesri (2005) Soil Mechanics in Eng. Practice. Wiley.
Mitchell and Soga (2005). Fundamentals of Soil Behavior. Wiley.

Course Description:

This is an introductory graduate course covering the stress-strain and strength properties of saturated and unsaturated soils. The purpose of this course is to provide you with a broad understanding of these topics and their history, which will prove useful in other courses, your individual research, reading of the literature, and engineering practice. Information in this class can be applied to the design of earth retaining structures, slope stability, foundation engineering, landfill design, and earth dams. A detailed outline of course topics is attached. We will rely primarily on lectures and laboratory work to develop your understanding of these principles. You will be expected to read and think about material outside class, and to take part actively in class discussions. These discussions will enhance the learning process, allow sharing of experiences, and hopefully make this course more interesting.

Course Topics (30 lectures total)

1. ***Introduction to Engineering Soil Properties*** (1 lecture)
   a. Soil properties and inter-relationships
   b. Categorization of soils from the perspective of shear strength
   c. Undergraduate Soil Mechanics Review
      i. Total and effective stress
      ii. Friction
      iii. Mohr-Coulomb failure envelopes
      iv. Mohr's circles of stress and strain

2. ***Soil Mechanics Concepts Pertinent to Shear Strength of Soils*** (4 lectures)
   a. Laboratory measurement of the shear strength of soils
      i. Direct shear test and interpretation of results
      ii. Triaxial equipment and testing philosophies (Unconsolidated undrained test, Consolidated drained test, Consolidated undrained test)
   b. States of stress in geotechnical engineering (isotropic, K_0 conditions, normal- and over-consolidation, compression, extension, pure shear, plane strain)
   c. Alternative Mohr's diagrams (p-q, t-s, σ_3 vs. σ_1-σ_3) and shear strength parameters
   d. Skempton's A and B pore water pressure parameters
   e. Total and effective stress paths in typical laboratory tests (DS, UU, CU, CD)
   f. Failure criteria (Stress-path tangency and principal stress difference)
   g. Energy corrections for distortional and hydrostatic deformation
3. ***Shearing Properties of Dry and Saturated Sands*** (4 lectures)
   a. Failure envelope and normal stress effects
   b. Effects of variables (density/porosity, confining stress, particle crushing, grain shape, grain size, etc.)
   c. Stress-strain properties (including volumetric and axial strains)
   d. Critical void ratio and critical state
   e. Cyclic loading and pore water pressure generation
   f. Comparisons between triaxial compression, triaxial extension, and plane strain
   g. Field inference of sand shear strength
      i. SPT and CPT correlations for sands
      ii. Shear wave velocity correlations
4. ***Shearing Properties of Saturated Clays*** (6 lectures)
   a. Normally consolidated clay
      i. Stress-strain relationships
      ii. Pore pressure relationships
      iii. Failure envelopes and stress paths
   b. Over-consolidated clay
      i. Stress-strain relationships
      ii. Pore pressure relationships
      iii. Failure envelopes and stress paths
      iv. Sampling effects and SHANSEP
   c. c/p ratio and anisotropy (Ladd and Foote, Edgers and Ladd)
   d. Strength-water content relationships (Rutledge)
   e. Correlations with index properties
   f. Effects of variables (Mineralogy, diffuse double layer effects, sensitivity, compaction water content, cementation, creep, rate of loading, anisotropy)
   g. Residual shear strength and slickensides
   h. Field Measurement of Clay Strength
      i. Vane shear test for clays
      ii. Block sampling and in-situ shear tests
5. ***Estimation of Soil Parameters for Numerical Modeling using Experimentally-Derived Stress-Strain Curves*** (3 lectures)
   a. Duncan and Chang model to model nonlinear stress-strain curves
   b. Tangent and secant moduli from triaxial testing
   c. Effect of strain level on the magnitudes of shear and compression modulus
   d. Poisson's ratio

6. ***Experimental Validation of the Cam Clay Model*** *(4 lectures)*
   a. Review of framework and theoretical basis
   b. Predicted behavior of NC and OC clays
   c. Experimental verification
7. ***Shear Strength of Unsaturated Soils*** (5 lectures)
   a. Soil water retention curve of unsaturated soils
   b. Measurement and control of suction and degree of saturation in triaxial testing
   c. Independent stress state variables and extended effective stress concepts
      i. Fredlund and Morgenstern (1977)
      ii. Khalili and Khabbaz (1998), Lu and Likos (2006), Lu et al. (2010)
   d. Shear strength of unsaturated soils
      i. Independent stress state variables: Vanapalli et al. (1996)
      ii. Single effective stress: Lu et al. (2010)
   e. Constitutive modeling: Barcelona Basic Model and the Wheeler Model
   f. Relative importance of strength, compressibility, and small-strain modulus
8. ***Thermal Behavior of Soils*** (3 lectures)
   a. Impact of temperature on soil properties (compression indices, critical state line)
   b. Thermally induced volume change and modifications to the Cam-Clay model
   c. Impact of temperature on the preconsolidation stress of NC and OC clays
   d. Thermal softening of the yield surface

Laboratory Exercises:

1. Introduction to laboratory testing and equipment (fittings, seals, etc.) (no report)
2. Direct shear tests (loose and dense sands)
3. Unconsolidated undrained triaxial test (compacted clay)
4. Consolidated undrained test with pore water pressure measurement (OC clay)

Course Grade Distribution

Homework	20%
Lab Reports	20%
Exam 1	20%
Exam 2	20%
Exam 3	20%
Total	100%

Course Schedule

- I will occasionally have to miss a class to attend conferences and other professional activities. It is vital that you check your e-mail frequently for updates to the course schedule and other pertinent information. Lectures will be made-up in lab.

Homework

- All homework assignments should be turned in before class begins. Prepare your homework in a professional manner and **show all steps and all calculations** on engineering paper. Data plots and other figures may be generated with a computer following the format of figures in ASCE Journal of Geotech. And Geoenv. Engineering. Provide labels and make sure that plots are to scale. Any homework which is sloppy or difficult to understand will be returned and may receive a reduced grade.
- Students may consult with each other about homework assignments. However, each student is responsible for preparing their own homework and displaying their understanding of the principles behind the homework solution.

Exams

- Exams will consist of a mixture between discussion and technical questions to evaluate your comprehension of the material. No "formulas" will be provided on the exams, however, design charts and similar materials will be given when needed. In addition, you should bring a straight edge and calculator to the exams.

Attendance

- Class attendance is in accordance with the published university course schedule, although a time for laboratory exercises will be selected based on the schedules of students enrolled for the class.
- Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. If an absence is necessary, please notify the professor in advance so that alternative plans may be made. You are responsible for material identified in the readings and covered in class, even if absent from class for authorized activities. Homework will be considered as late after an absence unless that absence is coordinated with the professor in advance. See details at http://www.colorado.edu/policies/fac_relig.html.

Academic Honesty

- The engineering profession does not need, and should not tolerate, dishonesty.
- All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html.

Disability Policy

- If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and http://www.Colorado.EDU/disabilityservices.

Classroom Behavior

- Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. See policies at http://www.colorado.edu/policies/classbehavior.html.
- The University of Colorado at Boulder policy on Discrimination and Harassment, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships apply to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH, the above referenced policies and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh.