Department of Civil and Environmental Engineering
Colorado State University

# CIVE 654 – Experimental Soil Mechanics

## GENERAL INFORMATION:

**Course Reference Number:** 65033 (Lab: 65034)
**Semester:** Fall 2009
**Credit:** (2-1-0)
**Prerequisite:** CIVE 355 (Introduction to Geotechnical Engineering or equivalent)

## SEMESTER SPECIFIC INFORMATION:

**Location:** Engineering B105 (Lab: Engineering A9)
**Time:** M, W: 10:00 – 10:50 am (Lectures); M: 12:00 – 2:50 pm (Lab)
**Instructor:** Dr. Antonio Carraro
**Office:** Engineering A219
**E-mail:** carraro@colostate.edu
**Phone:** (970) 491-4660
**Office Hours:** M, W and F: 9:00 – 9:50 am.

**COURSE DESCRIPTION:** Experimental Soil Mechanics (CIVE 654) combines your knowledge of soil behavior (the material you learned in your introductory soil mechanics course) with additional topics from physics, mechanics, statistics, experimental design, instrumentation and advanced geomaterial testing. In general, the course focuses on the experimental measurement of soil properties. Specific topics include: experimental design; sensor, instrumentation and data acquisition; soil sampling and fabric studies; expansive soil testing; isotropic and anisotropic consolidation; drained and undrained static triaxial compression response; soil liquefaction; unsaturated static triaxial compression response; experimental assessment of soil stiffness and nondestructive, compression and shear wave velocity techniques; effect of principal stress rotation and intermediate principal stress on soil response; and advanced triaxial and hollow cylinder testing.

**COURSE OBJECTIVES:** Upon completion of this class, students should be able to:

a) Calibrate and develop instrumentation typically used in geotechnical laboratories.
b) Set up a data acquisition system.
c) Carry out several experimental protocols for mechanical testing of soils.
d) Measure a variety of soil properties required in modern geotechnical analyses.
e) Construct a conventional triaxial testing device.
f) Make recommendations on the type, amount and scope of laboratory testing required (a) in practical geotechnical applications (e.g. foundation design, liquefaction susceptibility), and (b) for calibration of constitutive models and theoretical frameworks of soil behavior.

**TEXTBOOK AND ADDITIONAL REFERENCES:** There is not a single up-to-date textbook that contains all the topics that will be covered in this course. Thus, a variety of references will be used and provided during the semester. Nevertheless, the following resources may be helpful at various stages of the course:

a) "Soil Laboratory Testing – Vol. 3 – Effective Stress Tests", by K. H. Head, 1998, (John Wiley & Sons).
b) "Fundamentals of Soil Behavior", by J. K. Mitchell and K. Soga, 2005 (Wiley).

**CLASS ATTENDANCE:** Students should attend all classes to obtain maximum educational benefits. Absence or lateness does not excuse students from required course work. Students must inform the instructor prior to the anticipated absence and take the initiative to make up missed work in a timely fashion.

**READING ASSIGNMENTS:** Students are expected to read all materials (i.e., journal and conference papers, ASTM standards, etc.) that will be provided throughout the semester.

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**GRADING:** The final course grade will consist of one final exam, one technical paper (and presentation), and laboratory reports. Lab organization and care during the experiments will account for 10% of the final grade. The grade distribution will be as follows (the +/- system for grading will be used):

| | |
|---|---|
| Final Exam | 20 % |
| Technical Paper | 10 % |
| Technical Paper Presentation | 10 % |
| Lab Reports | 50 % |
| Lab Organization | 10 % |
| Total | 100 % |

**EXAMS:** According to the University Schedule, the final exam will be given on December 18, 2009 (7:00 am - 9:00 am) and will be comprehensive. You must take the exam on the date scheduled by the university; no excuses will be accepted except for an incapacitating illness or a death in the immediate family. For these last two excuses, a signed medical note from a doctor (including address and phone number) will be required. Failure to take an exam on the assigned date without prior approval of the instructor will result in a score of zero.

**LABORATORY REPORTS:** Laboratory projects will be assigned for most lab sessions. A due date for each laboratory project report will be established at the time the assignment is distributed. Reports are due at the beginning of the lab session on the due date. Late reports will neither be graded nor collected. Professional writing and publishing must be used, and all diagrams and calculations must be clearly presented to receive credit (a sample laboratory report will be provided at the beginning of the semester and can be used as a reference). Students will work in groups of 2-3 individuals. Only one report per group should be submitted. Peer evaluations will be used to determine if each group member is performing to standard and will be used to adjust individual grades given for group work. Teams and team members should be identified by the end of the second week of classes.

**TECHNICAL PAPER:** You are asked to write and submit a technical paper on a topic of your choice. Any topic covered in the course (see Course Description) is appropriate, but you are welcome to discuss with me about potential topics. About the middle of the semester, detailed instructions will be provided for this assignment and a list will be compiled with the topics and the name of the presenters. In addition to the paper submission, you will have the opportunity to present your paper to the entire class at the end of the semester. The technical paper and presentation will account for 20% of your final course grade.

**QUIZZES:** Pop quizzes may be given at any time during the semester. Quiz scores will be averaged along with the scores for the laboratory reports to count as 60% of your total course grade.

**GRIEVANCES:** You may contest lab report, quiz and exam grades in writing only. For quiz and lab reports, you should submit a complaint by the next class from the date the quiz/report is returned to you, indicating the item about which you believe a grading error was made. Please note that all grades reflect not only the correctness of the solutions but also organization and clarity of presentation.

**ACADEMIC INTEGRITY:** While I do not anticipate problems of this nature, please be advised that there are penalties and other serious consequences, as described in the Colorado State University Regulations whenever a student is involved in academic dishonesty. For further details on this issue please review the University rules on the following website:

<http://www.conflictresolution.colostate.edu/>

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## TENTATIVE COURSE OUTLINE:

| Week | Topic | Lab Session |
|---|---|---|
| 1 | Course Introduction | Introduction to Experimental Techniques |
| 2 | Experimental Design; Probability/Statistical Theories | Statistical Design of Experiments |
| | **Lab teams should be formed by the end of the 2nd week of classes** | |
| 3 | Soil Sampling | Specimen Reconstitution Techniques |
| 4 | Soil Fabric/Structure | Scanning Electron Microscopy (SEM) |
| 5 | Sensors, Instrumentation and Data Acquisition | Calibration, Data Logging and Management |
| 6 | Expansive Soil Behavior | Swell Potential |
| 7 | Isotropic and Anisotropic Consolidation | $K_0$ and Triaxial Consolidation |
| 8 | Drained Response of Sands | Drained Static Triaxial Testing |
| 9 | Undrained Response of Clays | Undrained Static Triaxial Testing |
| 10 | Liquefaction of Sands with Fines | Undrained Cyclic Triaxial Testing |
| 11 | Shear Wave Velocity/Stiffness Degradation | Bender Elements/Hollow Cylinder Testing (I) |
| 12 | Principal Stress Rotation | Hollow Cylinder Testing (II) |
| 13 | Intermediate Principal Stress | Hollow Cylinder Testing (III) |
| 14 | **Thanksgiving Break** | |
| 15 | Unsaturated Soil Response | Unsaturated Triaxial Testing |
| 16 | Technical Paper Presentations | |
| 17 | **Final Exam** | |