

CVEN 5688 Environmental Geotechnics

Course Syllabus and Schedule

General Information

Professor: John S. McCartney, Ph.D.

Office: ECOT 541

Office hours: By appointment

E-mail: john.mccartney@colorado.edu

Class: Time: Fall 2011, Tuesday-Thursday 2:00am - 3:15am
Room: ECCR 110

Lab: Time: Periodical (Tuesdays 12:00-1:30)
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:

Koerner, R.M. (2005). *Designing with Geosynthetics*. Fifth Edition. Prentice Hall, New Jersey, 2005. (on reserve in library)

Daniel, D.E. (1993). *Geotechnical Practice for Waste Disposal*. Chapman and Hall, London (will soon be on reserve in library)

Course Description:

This course will focus on geotechnical aspects in the disposal of waste materials and the remediation of environmentally contaminated sites. Disposal of waste generated by people and industrial processes is an important issue in our society. In the U.S. alone, we produce more than 7 billion tons of waste annually. If this waste is not managed in a safe and reliable manner, then human health and the environment are at risk. Waste containment facilities (or landfills) are one of the most commonly used means for waste disposal. There are approximately 5,000 municipal waste and 250 hazardous waste landfills operating in the U.S. today. In addition, there are about 500,000 older sites where waste was not disposed safely and it has contaminated soil and groundwater. More than one trillion dollars will be spent over the next 30 years in remediation of these sites in the U.S. alone.

We will explore material properties, technical principles, and practical issues related to the design and operation of landfills and remediation systems. Many of the topics that are discussed in this course are relevant to other fields of geotechnical engineering. A detailed outline of course topics is attached. We will rely primarily on lectures and laboratory work to develop your understanding of these principles. However, this course is not intended simply to throw information at you. 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 Outline

- A. Introduction to waste disposal field
 - 1. Origin of regulations
 - 2. Implications of regulations on engineering design and geotechnical engineering
 - 3. Landfill Components and Functions
- B. Materials in Waste Containment Systems
 - 1. Waste
 - i. Constituents of Hazardous and Solid Waste
 - ii. Physical and Chemical Characteristics (Index Properties, Strength, Decomposition)
 - 2. Soils
 - i. Soil Types and Functions
 - ii. Clay Mineralogy
 - iii. Soil-Water-Electrolyte Interactions and Chemical Effects on Soil Properties
 - 3. Geosynthetics
 - i. Geosynthetic Types and Functions
 - ii. Durability and Chemical Resistance
- C. Flow through Landfill Liners
 - 1. Single phase flow
 - 2. Advection/diffusion of contaminants with retardation
- D. Flow through Landfill Covers
 - 1. Flow of water in unsaturated soils
 - 2. Infiltration
 - 3. Gas flow
- E. Multiphase Flow of Non-Aqueous Phase Liquids
 - 1. Flow processes
 - 2. Partitioning
- F. Design of Liner Systems
 - 1. Compacted clay liners
 - 2. Composite liners
- G. Design of Drainage Systems
 - 1. Capacity and filtration
 - 2. Performance issues (normal stress, biological and mineral clogging)
- H. Design of Cover Systems
 - 1. Water balance and evapotranspirative covers
 - 2. Capillary barriers
 - 3. Instrumentation for cover systems
- I. Landfill Stability (3 Lectures)
 - 1. Material Properties and Testing Approaches
 - 2. Design and Analysis of Slope Stability
- J. Geotechnical Aspects of In Situ Remediation Technology
 - 1. Pump and Treat
 - 2. Soil-Vapor Extraction
 - 3. Reactive Zones and Bioremediation

Course Outcomes

Upon completion of this course, students will be able to:

- A. Introduction to waste disposal field
 - Understand the important characteristics of the waste containment and remediation industry, the responsibilities of a geotechnical engineer in this field, and the potential areas for improvement
 - Know the relevant governmental regulations and engineering design requirements
- B. Materials in Waste Containment Systems
 - Understand the difference between hazardous and solid waste
 - Plan the lifecycle of a waste containment facility
 - Evaluate the impact of contaminants on the properties of soils and geosynthetics
- C. Fluid and Contaminant Transport
 - Plan and perform an experiment to evaluate the hydraulic conductivity of a saturated soil
 - Analyze flow through soil layers
 - Plan and perform an experiment to evaluate the SWRC of an unsaturated soil
 - Analyze flow through unsaturated soils
 - Partition mass of contaminants into air-water-solid phases
 - Calculate rates of diffusion and advection through soils and geosynthetics
- D. Geotechnical Aspects of In Situ Remediation Technology
 - Calculate the conditions necessary to use vacuum collection of VOCs
- E. Soil Barriers
 - Develop a compaction specification for a clay liner
 - Check the compaction quality using field tests
 - Evaluate the success of clay liner installation
- F. Geomembrane Barriers
 - Analyze flow through a geomembrane defect
 - Evaluate difference in flow through geomembranes and composite liners
 - Understand basics of leak detection and seam testing
- G. Drainage Systems
 - Design a drainage system to reach regulatory requirements
 - Evaluate the difference between soil and geosynthetic drains
- H. Landfill Cover Systems
 - Interpret hydraulic performance of alternative landfill covers given different climatic conditions
 - Calculate rates of gas flow through soil covers
- I. Landfill Stability
 - Evaluate the suitability of different testing approaches for interface strength
 - Analyze the stability of a landfill liner and cover

Course Grade Distribution

Participation in in-class discussions	20%
Homework	15%
Exam 1	15%
Exam 2	15%
Exam 3	15%
<u>Final Paper</u>	<u>20%</u>
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. Students will be asked for a convenient time to make up these lectures.

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>.