CE 387R.4

Earth Retaining Structures

	Class Lectures:
Days:	Monday, Wednesday, Friday
Time:	10:00 a.m. - 10:50 a.m.
Building:	Ernest Cockrell, Jr.
Room:	ECJ 7.202

	Instructor:
	Dr. Jorge G. Zornberg
Office:	ECJ 9.227G
Phone:	(512) 232 - 3595
E-mail:	zornberg@mail.utexas.edu
Office Hours:	Mon, Wed 2:00 p.m. - 3:00 p.m.

References:

Tanyu,B.F., Sabatini, P.J., and Berg, R.R. (2005) "Earth Retaining Structures." Publication no. FHWA NHI-05-046, National Highway Institute, US Department of Transportation.

The electronic version of this reference will be available in Blackboard. However, please note that this is just a reference and not a textbook. In addition, I suggest the following books, which should be available in the library:

Elias, V., Christopher, B.R., and Berg, R.R. (2001). *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes*. Publication Number FHWA NH-00-043, March 2001, NHI-FHWA.

Koerner, R.B. (2005). *Designing with Geosynthetics*. Fifth Edition. Prentice Hall.

Das, B.M. (1999). *Principles of Foundation Engineering*, Fourth ed., Brooks/Cole Publishing.

Holtz, R.D., Christopher, B.R., and Berg, R.R. (1997). *Geosynthetic Engineering*. Bitech Publishers Ltd.

Course material:

Handouts will be distributed in class about the lecture for the day to facilitate note taking during the lecture. I will try my best to have consistency between the class notes and slides used in class. However, I often make last-minute updates to the slides, so you will need to take good, complete notes in the lecture. That is, class handouts are distributed to facilitate your note taking, not instead of your note taking.

Reading assignments and additional course material will be posted in Blackboard. The documents will be posted in electronic version (pdf format). The contents will be updated frequently, so you should check periodically for new material.

The articles posted as reading assignments have technical and/or historical significance to the current state of practice. You are expected to read these articles critically and be prepared to discuss them in class. Complementary articles that are not part of the required reading assignments will also be posted as they are useful for future reference or in-depth understanding.

Course Prerequisites:

While there are no prerequisites for this course, a background in geotechnical engineering (at least one or two undergraduate classes) is recommended. Please see me if you have questions about the appropriateness of your background.

Course Objectives:

The overall objective of this course is to provide students the fundamentals and working tools needed for the design and analysis of earth retention systems. Specifically, this course covers the selection, design, and performance of earth retaining structures used for support of fills and excavations. The theory regarding earth pressures and soil-reinforcement interaction are covered in detail. Class discussions will also include case histories illustrating the selection, design and performance of various earth retaining structures. Upon completion of the course, the student should be able to:

- Identify the types, advantages, and disadvantages of the different earth retaining systems (e.g. gravity structures, geosynthetic-reinforced soil structures, earth anchored systems, soil nailing).
- Quantify the lateral earth pressures associated with different earth retaining systems.
- Evaluate the mechanical properties of geosynthetics used for soil reinforcement, including aspects related to time-dependent response, long-term performance, and cost-effectiveness.
- Select the most technically appropriate and cost-effective type of retaining wall for a given project based on a clear understanding of the many available systems.
- Complete the design of fill walls using appropriate design methods, factors of safety, and field verification methods.
- Complete the design of cut walls using appropriate design methods, factors of safety, earth pressure diagrams and field verification methods.
- Be knowledgeable of current US guidelines regarding the design of earth retaining structures.
- Master the use of design tools for the analysis of both external and internal stability, including the use of hand calculations as well as state-of-the-practice computer programs.

Schedule:

The class will meet for three lectures each week. A tentative schedule and outline of the lecture topics is attached. Because of various national and international committees, meetings and conference, I will have to travel on university-sanctioned business during this semester. I plan to cover these periods by rescheduling lectures or by scheduling activities (e.g. presentations, field trips) during the semester. Your help in scheduling these activities is sincerely appreciated.

Attendance:
Students are expected to attend all class periods. Since the course text will provide only supplementary information, the lectures are clearly the main source of information to be covered in the homework assignments and exams.

Examinations:
There will be a midterm exam, given during the regularly scheduled class time, and a *comprehensive* final examination. Make-up examinations will not be given. Students who miss a midterm exam will receive a grade of zero for that exam. Exceptions to this rule will be made only on a carefully considered basis, and only if the student contacts me *before* the exam.

All exams will be closed-book, closed-notes. However, you are permitted to bring sheets (8.5 x 11 inch) written on one side only, of your *own handwritten* equations to each exam. One sheet will be permitted for the first exam, and two sheets will be allowed for the final exam. This way, the new sheet you prepare for the first exam will be used again for the comprehensive exam. You may write only equations (no notes, no graphs) on one side of these sheets. Some equations will also be given on the exams. All design charts and similar materials will be provided for during the exam. The organizational effort required to create your equation sheets is an effective means of reviewing the course content before an exam. Use of cell phones in not allowed during the exams. You need to bring a straight edge and calculator to the exams.

The final examination will cover all of the material from the semester. According to the university schedule, the final exam will be held from 9:00 a.m. to 12:00 noon on Monday, May 17, 2010.

Homework Assignments:
Homework problems will be assigned on a regular basis. Extra copies of the assignments, as well as other class handouts, will be placed in the class box outside of ECJ 9.227. Completed assignments are due at the *beginning of class* on the date specified; late assignments will not be accepted for grading.

Homework is intended principally as a means of helping you to learn and understand the course material, rather than as a means of assigning points which directly determine your final grade. The assignments also are aimed at developing your engineering skills. As much as possible, your assignments will reflect real-world engineering practice where one must work with limited data, deal with uncertainty over site conditions, and compile engineering recommendations.

Each assignment must be submitted with a cover memorandum. A professional engineer's work entails much more than analysis. Hence, all assignments in this class must be submitted with a cover memorandum that briefly discusses your analysis. The cover memo should be typed, addressed to the instructor, and no more than one page long. The text of your memo should:

- Briefly state the purpose of your work (remind the reader of what was requested and what you did).
- Describe the data, material properties, and other information used to solve the problem, including any assumptions you may have used.
- Review important aspects of the problem and your solution.

- Refer to any attached drawings, plots, and other figures and identify the significant information they contain.
- Summarize important results, conclusions, and recommendations.

Attach your calculations, plots, and drawings behind the cover memo. Write your cover memo as if you were submitting your results to a professional client.

Report:

A ***term project*** will be assigned, which involves preparation of a written report and its presentation in a seminar. The written report will be compiled throughout the term. The term project represents a significant portion of the grade, so you should dedicate adequate time during the semester rather than leaving the work towards the end of the term. Details regarding the scope and schedule of the different aspects of the final project will be provided separately.

Grading Policy:

Your final letter grade will be determined by your performance relative to others in the class. Divisions between grade levels, as well as a likely "class curve", are not pre-determined. Participation in class is explicitly considered in your final grade. In borderline cases your participation and attendance in class will also be considered. Your final score for this course will be computed using the following weights:

- Homeworks and term project: 25%;
- Class participation: 5%;
- Midterm examination: 30%;
- Final examination: 40%.

University Policies and Deadlines:

Dropping the Course:

- From the 1st through the 4th class day, graduate students can drop or add a course on Rose or TEX. Beginning with the 5th class day, graduate students must initiate any adds or drops in their department.
- Graduate students can drop a class until the last class day with permission from the departmental Graduate Advisor and the Dean.
- Graduate students with GRA/TA/Grader positions or with Fellowships may not drop below 9 hours in a long session.

Course Evaluation: A course/instructor evaluation will be conducted in class near the end of the semester. The standard form and procedure from The University of Texas Measurement and Evaluation Center (MEC) will be used.

Religious Observances: A student who is absent from a class or examination for the observance of a religious holyday may complete the work missed within a reasonable time after the absence, provided the student has notified the instructor in writing before the absence and not later than the 15^{th} class day.

Students with Disabilities: The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities. Any student with a documented

disability (physical or cognitive) who requires academic accommodations should contact the Services for Students with Disabilities area of the Office of the Dean of Students at 471-6259 as soon as possible to request an official letter outlining authorized accommodations. For more information, contact that Office at 471-6259, TTY at 471-4641, or the College of Engineering Director of Students with Disabilities at 471-4321.

Course Outline:

The tentative outline of lecture topics for the course is as follows:

- **Introduction**
- **Types of earth retaining systems**
  - Classification
  - Overview of fill wall systems
  - Overview of cut wall systems
  - Wall selection
- **Earth pressure theory**
  - Mohr's circle
  - At rest, active, and passive earth pressures
  - Rankine theory. Influence of movement on earth pressures
  - Earth pressure from surcharge loads
  - Coulomb theory
  - Earth pressures from seismic forces
- **Design of externally stabilized fill walls**
  - External stability
  - Design of CIP gravity and semi-gravity walls
  - Design of modular gravity walls
- **Reinforcing elements**
  - Functions and types of geosynthetics
  - Polymers
  - Fundamentals of soil-reinforcement interaction
  - Mechanical properties of metallic and polymeric reinforcements
- **Design of internally stabilized fill walls**
  - Internal stability
  - Design of mechanically stabilized earth (MSE) walls
  - Design of reinforced steep slopes
- **Design of internally stabilized cut walls**
  - Design of soil nail walls
  - Other systems
- **Design of externally stabilized cut walls**
  - Design of sheet pile walls
  - Design of anchored walls
  - Other systems
- **Advances in earth retention systems**
  - Construction aspects
  - Deformability analysis of earth retention systems
  - Performance monitoring of retaining structures
  - Bridge abutments
  - LRFD
- **Advances in soil reinforcement**
  - Embankments over soft foundations
  - Reinforcements overlying voids: reinforced covers, reinforced pavements

- New concepts in soil reinforcement

Case histories will be presented to illustrate the different concepts.