Application of Geosynthetics

Professor:	**Kuo-Hsin Yang, Ph.D. (楊國鑫博士)**	
	Office:	CEB 306
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Class:	Time:	Wed 6 and Fri 3, 4
	Room:	Room 402, General Classroom Bldg. (綜402)
Textbook:	Elias, V., Christopher B.R., and Berg, R.R. (2001). Mechanically Stabilized Earth Walls and Reinforced Soil Slopes. FHWA NH-00-043, March 2001, NHI-FHWA	
Reference	▪ FHWA(2005), Earth Retaining Structures, FHWA NHI-05-046, National Highway Institute, US Department of Transportation. ▪ Koerner (2005), Designing with Geosynthetics, 5th ed, Prentice Hall. ▪ Holtz, Christopher and Berg (1997), Geosynthetic Engineering, Bitech Publishers Ltd. ▪ Zornberg and Christopher (2006), Chapter 37: Geosynthetics, In: The Handbook of Groundwater Engineering, Delleur (Editor-in-Chief), CRC Press, Inc.	

COURSE MATERIAL

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

COURSE DESCRIPTION

The overall objective of this course is to introduce the types, and functions, of geosynthetics and their engineering applications. Specifically, this course focuses on the soil reinforcement and provide students the fundamentals and tools needed for design, analysis, and performance evaluation of geosynthetic-reinforced soil (GRS) structures including both walls and slopes. Class also discusses construction, monitoring, maintenance, case histories as well as current state-of-art applications of GRS structures against various natural disasters.

Upon completion of the course, the students should be able to:

- Identify the types, advantages and disadvantages of different earth retaining systems.
- Select the most technically appropriate and cost-effective type of earth retaining wall for the application from a thorough knowledge of available system.
- Quantify the lateral earth pressures within retaining earth structures.
- Be familiar with the types, functions, and engineering applications of geosynthetics.
- Evaluate the index, hydraulic, mechanical, and environmental properties of geosynthetics based on the standard test methods.
- Be knowledge of current US and Taiwan guidelines regarding the design of GRS structures.

- Complete the design of GRS structures using appropriate design methods, factors of safety, design charts and field verification methods.
- Master the design of GRS structures considering both external and internal stability using hand calculations as well as numerical tools.
- Learn the theory and assumption in various limit equilibrium methods for slope stability analyses of reinforced soil slopes.

HOMEWORK ASSIGNMENTS

Homework problems will be assigned on a regular basis. Assignments will be distributed on class and can be downloaded from CEIBA. Completed assignments are due at the *beginning* of class on the date specified; late assignments will not be accepted. 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.

About 5~7 projects will be assigned to students through the semester. Students will utilize selected numerical methods and constitutive models to analyze geotechnical problems. Students will work in 2~3 people groups to complete the projects and may consult with other groups about homework assignments. The project reports should be concise but clear. Groups will be required to present their findings for some of the assignments. Students may consult with each other about homework assignments. However, each student is responsible for understanding of the principles behind the homework solution. Homework solution keys will be placed using CEIBA system (assess on the Internet via https://ceiba.ntu.edu.tw).

You will quickly learn after college that most practicing engineers spend more time and effort communicating their ideas, analyses, and results than they do performing technical calculations. To encourage the development of these vital professional skills, your homework assignments may require a written response, and not just a simple numerical answer. Hence, *each assignment must be submitted with a cover memorandum* that briefly discusses your analysis. Write your cover memo as if you were submitting your results to a professional client. 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. Prepare your homework in a professional manner and *show all steps and all calculations.* Data plots and other figures must be generated with a computer following the format of figures in ASCE Journal of Geotechnical and Geoenvironmental Engineering. Provide labels and make sure that plots are to scale. Any homework which is sloppy or difficult to understand will be returned without grades. Follows are several tips for writing your assignment.

- Work neatly, do not crowd your work.
- Sketch and label with given data as appropriate
- State any assumption you make
- Work vertically, do not string equations horizontally
- Show all major steps in your calculations or reasoning, so it is clear how you proceed
- Box the final answer and be sure to give proper units
- Do not tear pages out of books or manuals. If a problem involves completing a figure, photocopy the figure and attach it onto your solution sheets.

TERM PROJECT

The term project involves design of a reinforced earth structure. Students are first asked to design a reinforced wall based on provided soil and reinforcement materials. Students should write a formal design report and submit to their instructor. The content of the design report should include material property testing, stability analysis and final design layout. Afterward, students are asked to build a miniature reinforced earth (MSE) retaining wall using paper reinforcement taped to a poster-paper wall facing. This MSE wall competition is to use the least area of paper strips and sustain a larger “footing” load. The term project is graded based on the design report and results of MSE wall competition.

FIELD TRIP

A field trip to a construction site of reinforced earth structures, geosynthetics manufactory, and geosynthetic test laboratory will be arranged during the semester.

EXAMINATIONS

Exams will consist of a mixture between discussion and technical questions to evaluate your comprehension of the material. Formula sheets, design charts and similar materials will be given on the exams when needed. In addition, you should bring a straight edge and calculator to the exams.

Also as engineers, you should inherently be neat and organized. You should certainly strive for neat work because you will probably have to return to design calculations at a variety of times in your careers and if you cannot figure out your own work you could be in severe difficulty. On exams, I will not give credit for answers I cannot read and will not change grading based on subsequent verbal explanations. It is your responsibility to communicate effectively with me on exams.

COURSE GRADE DISTRIBUTION

Participation in in-class discussions	10%
Assignment (Around 5~7 times)	20%
Presentation	10%
Term Project (Reinforced Structures Design Competition)	20%
Midterm Exam	20%
Final Exam	20%
Total	100%

*The final grade will be failed if absences from class are over 5 times without justifiable reasons

FINAL COMMENT

Good luck to all of you in this course. 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. Do not hesitate to ask questions in class, or if necessary, to see your instructor outside of class. Regularly after class discussion is expected. Please do not be afraid of your teacher, I am here to help you. I want to be your friend. Any specific comments that students have on how the course might be improved are particularly welcomed.

ACADEMIC HONESTY

The engineering profession does not need, and should not tolerate, dishonesty. All students of the National Taiwan University 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 (Student Affair) Council. 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).

COURSE OUTLINE

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

1. **Introduction** (1wk)

2. **Types of earth retaining systems** (1wk)
   - Classification
   - Overview of fill wall systems
   - Overview of cut wall systems

3. **Earth pressure theory** (1wks)
   - Mohr's circle
   - At rest, active, and passive earth pressures
   - Influence of movement on earth pressures
   - Earth pressure from surcharge loads and due to compaction
   - Dynamic earth pressures

4. **Geosynthetics** (3wks)
   - Function and types of geosynthetics
   - Polymers
   - Fundamentals and mechanisms of soil-reinforcement interaction

5. **Properties and test methods of geosynthetics** (3wks)
   - Index properties
   - Hydraulic and mechanical properties
   - Environmental properties

6. **Design of mechanically stabilized earth walls** (4wks)
   - Construction aspects
   - Internal stability analysis
   - External stability analysis
   - Seismic analysis
   - Deformability analysis
   - Performance, instrumentation and monitoring

7. **Special lecture** (1wk)
   - Applications of GRS structures against various natural disasters
   - Failure investigation of GRS structures subjected to rainfall

8. **Design of reinforced soil slopes** (3wks)
   - Limit equilibrium procedures for unreinforced soil slopes
   - Definition of factor of safety
   - Limit equilibrium analysis of reinforced soil slopes
   - Design charts for reinforced soil slopes
   - Design against rainfall based on the framework of unsaturated soil mechanics

EXAMPLE COVER MEMORANDUM FOR ASSIGNMENTS

MEMORANDUM

To: Prof. Kuo-Hsin Yang

From: *Your name*

Date:

Subject: Design of Braced Excavation
Plaza of the International Building, Taipei, Taiwan

Attached are our design recommendations for the braced excavation at your site in Taipei. Our design earth –pressure diagram, shown on page 5, indicates a uniform horizontal pressure of 600kPa. If three rows of struts (4m vertical spacing) are placed on every solider pile (5m horizontal spacing), each strut should be designed to carry 12MN of axial compression. The factor of safety against bottom heave is estimated to be 1.2.

The solider piles should be driven into the firm soil below the clay layer. Care should be taken to avoid excessive settlements in the sands during driving of these piles. In addition, an earth berm should not be relied upon to support the excavation in the clay. Other consolidations and problems that should be addressed included:

(1) Timely placement of struts and lagging as the excavation progresses will be critical to minimizing ground movements.
(2) In the first 10m of the excavation, it may be difficult to prevent sloughing of sand into the excavation before the lagging can be placed. It will be necessary to have the lagging closely follow the excavation work in this zone to prevent excessive settlements behind the wall.
(3) The upper sands will have to be dewatered to prevent flooding of the excavation, which will result in a time-dependent consolidation of the deeper clays.

Movements adjacent to the excavation will be mostly due to movements within the clay layer. As indicated on page 8, a vertical settlement of 15cm and a horizontal movement of 25cm should be expected in this area. The expected settlement profile shown on page 9 indicates that settlements are likely to be observed at distances up to 30m from the side of the excavation. Settlements in excess of 15cm may occur due to the loss of the upper sandy soils into the excavation during construction, and consolidation of the clay due to dewatering.

If you need additional information, or have further questions, please do not hesitate to contact me.

EXAMPLE OF FORMAL FORMAT FOR PRESENTING TABLE AND FIGURE

Table 2. Characteristics of Centrifuge Geotextile-Reinforced Slope Models

	Model B18	Model B12	Model D12	Model S9
Number of reinforcement layers	18	12	12	9
Vertical spacing (mm)	12.70	19.05	19.05	25.40
Reinforcement type	weak	weak	weak	strong
Reinforcement tensile strength (kN/m)	0.123	0.123	0.123	0.183
Relative density of sand (%)	55	55	75	55
Sand peak friction angle	35°	35°	37.5°	35°
g level at failure (N_f)	76.5	60	66	52.5
Elapsed time until failure (min)	53	43	60	39
Failure type	catastrophic	catastrophic	catastrophic	progressive

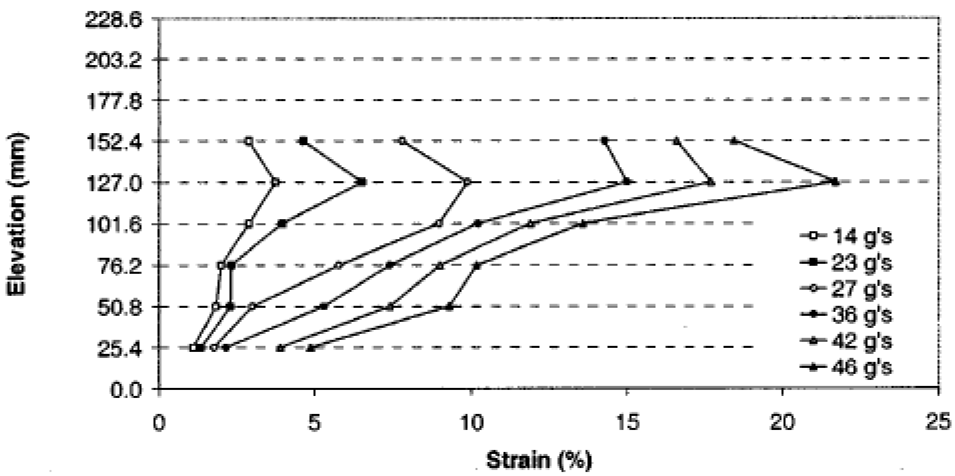

Fig. 10. Reinforcement peak strain distribution: Model S9

EXAMPLE OF FORMAL FORMAT FOR WRITING EMAIL