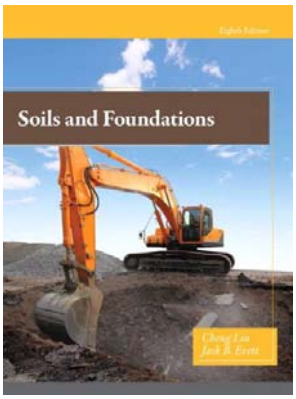

CE 4339/CE 4375/CE4376 – Geostructural Design

Instructor: Soheil Nazarian
A-207, 747-6911

Class Time: TR 10:30 -11:50 Classroom Building C204

Office Hours: Students are always welcome.

Textbook: Soils and Foundations, 8th Edition, by Liu and Evett, Pearson

Introduction

This course is concerned with Geostructural Design. The term "Geostructural Design" is used to describe the design of foundations for buildings and other structures, such as retaining walls. It also includes the design of natural slopes, the dewatering of soils, and mechanical and chemical stabilization of soils, and pavement design.

Geostructural Design must be based on, and make use of, the principles of Soil Mechanics and Geotechnical Engineering. However, it also requires knowledge of geology and involves numerous considerations that might be called "practical," e.g., those based on the availability of suitable construction equipment and personnel. We will spend a significant part of our time on the mechanistic types of problems. But we will spend time discussing practical types of problems because they are the main problems of interest in engineering practice.

The topics covered primarily include:

1. Calculating stability and design of retaining walls
2. Foundation design and bearing capacity for shallow and deep foundations
3. Consolidation and differential settlement of Foundations
4. Slope stability analysis of fills, embankments, cuts, dams
5. Soil stabilization mechanically, with chemical additives, and with geosynthetics
6. Pavement system design

Assuming that you already learned them in the Geotechnical Engineering course, we will also review the following items:

1. Geology
2. Index properties and soil classifications
3. Phase relations (air-water-solid)
4. Laboratory and field tests
5. Effective stress (buoyancy)
6. Shear strength

Most of the students interested in Geostructural Design are also interested in structural design. Structural designers generally have well-developed codes which they are expected to follow. No comparable codes exist in the area of Geostructural Design. In structures, the properties of materials are reasonably well defined because they are manufactured. In Geostructural Design, a major problem exists with trying to define the properties of the soil materials at a site. Structural members are relatively simple in shape. Strata of soil are often discontinuous and the success of a "design" may hinge on whether or not a soil exploration program results in the discovery of critical strata. For the range of stresses usually used, structural materials are subject to small strains, and may often be taken as linearly elastic. Soils are often stressed to large strains, and are almost always inelastic and have nonlinear stress-strain curves. Even if you choose not to engage in the practice of Geostructural Design, there is a high probability that you will work with geotechnical engineers or read their reports in your work. Therefore, an understanding of how

they work and think can be very beneficial. This course is a mixture of theory and practice, and is intended to help you make an easier transition from university classes to engineering practice.

Schedule

A tentative lecture schedule is attached and the reading assignments are indicated. ***You must read the appropriate sections for each topic before the lecture.*** For each topic, I will provide a broad lecture on the subject while I will ask questions from you as we progress. We will work the homework problems in the class as much as possible so that you can ask questions about topics that are complicated.

Grading

Handing in homework problems on time and class participation will count a maximum of 20% toward your grade. Quizzes will count as 50% of your grade. A comprehensive final examination will count as 30%.

Homework

All homework problems are assigned for the semester below. The homework problems will be collected but not graded. The solutions are posted in Room M-105 between 8:00 AM and 5:00 PM except weekends. You can view the solutions by providing your I.D. But you will not be able to check them out to copy in any form or shape (including using your cell phone camera). You will lose this privilege if you do not follow these rules.

Homework is assigned to help you learn the material, not as a means to generate grades. Homework will not be graded mainly to encourage you to do the work. It is acceptable to work with others when discussing methods of attack, but your written work should always be your own.

Homework problems are due at 5:00 PM on Friday the following week. Therefore, you will always have a weekend to work on your problems. Late homework is not accepted. ***If you miss two homework assignments, you will be dropped from the course.***

Past experience clearly shows that a student's grade is strongly dependent on the effort that is put into working and understanding the homework. Although the homework does not directly count towards your grade, in practice it is the most important factor that will affect your grade. Homework solutions will be available on due dates. We encourage that you team up with your other classmates for this activity.

Quizzes

There will be a 20 minute or longer quiz almost every week for a given topic. The problems will be similar to the end of the chapter problems or the examples in the textbook.

Examination

Final examination, which is comprehensive, will last 3 hours. In accordance with University regulations, students who miss examinations will receive grades of zero. Exceptions to this rule will be made only on a carefully considered individual basis and only if the student contacts the instructor before the exam. If you know in advance that you are going to miss an exam, it is your responsibility to inform the instructor before the exam.

Neatness and Organization

You will present homeworks completed in a neat and orderly fashion. On an examination, your work must be easy to follow. However, if you use a calculator and put nothing down on a page but an equation and the answer, you will get no credit. Calculations spread all over an examination page, with an answer suddenly appearing out of nowhere, will also be graded down.

Class Attendance

Students are expected to attend all class periods. Those who fail to attend class regularly are inviting scholastic difficulty and, with the approval of the Dean of the College of Engineering, may be dropped from the course with a grade of F for repeated (5 or more) unexcused absences.

Cell Phones

It is a very good manner to turn off your cell phones during the class lectures and lab sessions. However, please make sure that you do not have a cell phone or any other electronic item with you during the exam and quizzes.

Policy on Cheating

Students are expected to be above reproach in all scholastic activities. Students who engage in scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and dismissal from the university. Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student, or the attempt to commit such acts (Regents' Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22). Scholastic dishonesty harms the individual, all students, and the integrity of the university. Policies on scholastic dishonesty will be strictly enforced.

Final Comment

Good luck to all of you in this course. Please do not hesitate to ask questions in class, or, if necessary, to see me outside of class. Any specific comments that students may have on how the course might be improved are particularly welcome.

Lecture Topics

Lecture Topic 1. Soil Exploration (HW: 3-1, 3-3, 3-5, 3-7)

- 3-1 Introduction
- 3-2 Reconnaissance
- 3-3 Steps of Soil Exploration
  - Boring
  - Sampling
  - Testing
- 3-4 Groundwater Table
- 3-5 Standard Penetration Test (ASTM D 1586)
- 3-6 Cone Penetration Test (ASTM D3441 AND D 5778)
- 3-7 Vane Test
- 3-8 Pressuremeter Test (ASTM D 4719)
- 3-9 Dilatometer Test
- 3-10 Geophysical Methods of Soil Exploration
  - Seismic Refraction Method
  - Electrical Resistivity Method
- 3-11 Record of Soil Exploration

Lecture Topic 2. Subsurface Stresses in Soils (HW: 6-3, 6-5, 6-7, 6-9, 6-11, 6-14)

- 6-1 Introduction
- 6-2 Subsurface Stresses Caused by Overlying Soil Masses
- 6-3 Subsurface Stresses Caused by Surface Loadings
- 6-4 Vertical Pressure below a Concentrated Load
  - Westergaard Equation
  - Boussinesq Equation
- 6-5 Vertical Pressure below a Loaded Surface Area (Uniform Load)
  - Approximate Method
  - Method Based on Elastic Theory

Lecture Topic 3. Consolidation of Soil and Settlement of Structures (HW: 7-1, 7-3, 7-5, 7-7, 7-11, 7-13, 7-15)

- 7-1 Introduction
- 7-2 Immediate Settlement of Loads on Clay
- 7-3 Consolidation Test
- 7-4 Normally Consolidated Clay and Over Consolidated Clay
- 7-5 Field Consolidation Line
- 7-6 Settlement of Loads on Clay Due to Primary Consolidation
- 7-7 Time Rate of Settlement Due to Primary Consolidation
- 7-8 Settlement of Loads on Clay Due to Secondary Compression
- 7-9 Settlement of Loads on Sand
  - Bazaraa Method
  - Schmertmann Method

Lecture Topic 4. Shallow Foundations (HW: 9-2, 9-4, 9-6, 9-8, 9-10, 9-12, 9-15, 9-17)

- 9-1 Introduction
- 9-2 Loads on Foundations
  - Dead Load
  - Live Load
  - Wind Load
  - Snow Load
  - Earth Pressure
  - Water Pressure
  - Earthquake Forces
- 9-3 Depth and Location of Foundations
  - Frost Action
  - Significant Soli Volume Change
  - Adjacent Structures and Property
  - Groundwater
  - Underground Defects
- 9-4 Bearing Capacity Analysis
  - Effect of Water Table on Bearing Capacity
  - Inclined Load
  - Eccentric Load
  - Footings on Slopes
- 9-5 Size of Footings
- 9-6 Contact Pressure
- 9-7 Total and Differential Settlement
- 9-8 Structural Design of Footings

Lecture Topic 5. Deep Foundations (HW: 10-2, 10-4, 10-6, 10-8, 10-10, 10-12, 10-14, 10-16, 10-18, 10-20,10-22)

- 10-1 Introduction
- 10-3 Types of Piles
- 10-4 Length of Piles
- 10-5 Pile Capacity
  - Pile Capacity as Evaluated by the Structural Strength of the Pile
  - Pile Capacity as Evaluated by the Supporting Strength of the Soil
- 10-6 Pile-Driving Formulas
- 10-7 Pile Load Tests
- 10-8 Negative Skin Friction (Down Drag)
- 10-9 Pile Groups and Spacing of Piles
- 10-10 Efficiency of Pile Groups
- 10-11 Distribution of Loads in Pile Groups
- 10-12 Settlement of Pile Foundations
  - Settlement of End-Bearing Piles on Bedrock
  - Settlement of Piles in Sand
  - Settlement of Piles in Clay
- 10-13 Construction of Pile Foundations
- 10-14 Introduction to Drilled Shaft Foundations
- 10-15 Bearing Capacity of Drilled Shafts
  - Drilled Shafts in Cohesive Soils
  - Drilled Shafts in Cohesion less Soils
- 10-16 Settlement of Drilled Shafts
- 10-17 Construction and Inspection of Drilled Shafts

Lecture Topic 6. Lateral Earth Pressure (HW: 11-1, 11-4, 11-6, 11-8, 11-10)

11-1 Introduction
11-2 Earth Pressure at Rest
11-3 Rankine Earth Pressures
11-4 Coulomb Earth Pressures
11-5 Effects of a Surcharge Load upon Active Thrust
11-6 Culmann's Graphic Solution
11-7 Lateral Earth Pressure on Braced Sheetings

Lecture Topic 7. Retaining Structures (HW: 12-1, 12-4, 12-6)

12-1 Introduction
12-2 Retaining Walls
12-3 Design Considerations for Retaining Walls
12-4 Stability Analysis
12-5 Backfill Drainage
12-6 Settlement and Tilting
12-7 Reinforced Earth Walls
12-8 Slurry Trench Walls
12-9 Anchored Bulkheads

Lecture Topic 8. Stability Analysis of Slopes (HW: 13-2, 13-4, 13-6, 13-8)

13-1 Introduction
13-2 Analysis of a Mass Resting on an Inclined Layer of Impermeable Soil
13-3 Slopes in Homogeneous Cohesion less Soils ($c = 0$, $\phi > 0$)
13-4 Slopes in Homogeneous Soils Possessing Cohesion ($c > 0$, $\phi = 0$, and $c > 0$, $\phi > 0$)
    Culmann Method
    Stability Number Method
13-5 Method of Slices
    Bishop's Simplified Method of Slices

Lecture Topic 9. Pavement Design (Homework problems and Lecture notes will be provided)

Introduction
Pavement Types
    Flexible Pavements
    Rigid Pavements
Pavement System Design: Principles for Flexible Pavements
Traditional AASHTO Flexible-Pavement Design Procedure
    Serviceability Concept
    Flexible-Pavement Design Equation
    Structural Number
Pavement System Design: Principles for Rigid Pavements
Traditional AASHTO Rigid-Pavement Design Procedure
Measuring Pavement Quality and Performance
International Roughness Index
Friction Measurements
Rut Depth
Cracking
Faulting
Punchouts
Mechanistic-Empirical Pavement Design

Review Topics

Review Topic a. Formation of Natural Soil Deposits (Study on your own; no homework)

1-1 Introduction
1-2 Rocks-The Sources of Soils
    Igneous Rocks
    Sedimentary Rocks
    Metamorphic Rocks
1-3 Rock Weathering and Soil Formation
1-4 Soil Deposits
    Residual Soils
    Transported Soils

Review Topic b. Engineering Properties of Soils (HW: 2-2,2-4,2-6,2-9,2-11,2-13,2-17,2-19,2-21)

2-1 Soil Types
2-2 Grain-Size Analysis
2-3 Soil Consistency-Atterberg Limits
2-4 Soil Classification Systems
    AASHTO Classification System (AASHTO M-145)
    Unified Soil Classification System (ASTM D 2487)
2-5 Components of Soils
2-6 Weight/Mass and Volume Relationships
2-7 Permeability, Capillarity, and Frost Heave
2-8 Compressibility
2-9 Shear Strength
2-10 Compaction-Improving Engineering Properties of Soil
2-11 Compactness-Relative Density

Review Topic c. Soil Compaction and Stabilization (HW: 4-1, 4-3, 4-5, 4-7)

4-1 Definition and Purpose of Compaction
4-2 Laboratory Compaction Tests (ASTM D 69B and D 1557)
4-3 Factors Affecting Compaction of Soil
4-4 Field Compaction
4-5 Vibroflotation
4-6 Dynamic Compaction
4-7 In-Place Soil Unit Weight Test
4-B Field Control of Compaction
4-9 Soil Stabilization
    Preloading
    Mechanical Stabilization
    Chemical Stabilization
    Geosynthetics

Review Topic d. Water in Soil (HW: 5-1, 5-3, 5-5, 5-7, 5-9, 5-11, 5-13)

5-1 Introduction
5-2 Flow of Water in Soils
- Bernoulli's Theorem
- Darcy's Law
- Laboratory Tests for Coefficient of Permeability
- Field Tests for Coefficient of Permeability
- Empirical Relationships for Coefficient of Permeability
- Permeability in Stratified Soils

5-3 Capillary Rise in Soils
5-4 Frost Action in Soils
5-5 Flow Nets and Seepage
- Construction of Flow Nets
- Calculation of Seepage Flow
- Uplift Pressure

5-6 Dewatering of Subsurface Soils
- Dewatering on a Temporary Basis
- Dewatering on a Permanent Basis

Review Topic e. Shear Strength of Soil (HW: 8-2, 8-4, 8-5, 8-8, 8-10)

8-1 Introduction
8-2 Methods of Investigating Shear Strength
Laboratory Methods for Investigating Shear Strength
In Situ (Field) Methods for Investigating Shear Strength
8-3 Characteristics of the Failure Plane
8-4 Shear Strength of Cohesion less Soils
8-5 Shear Strength of Cohesive Soils
- Normally Consolidated Clay
- Over Consolidated Clay
- Sensitivity

Tentative Lecture Schedule

Week of	Tuesday	Thursday
1/15	Introduction	Lecture Topic 1
1/22	Review Topic b*	Lecture Topic 2
1/29	Review Topic c	Lecture Topic 3
2/5	Lecture Topic 3	Review Topic d
2/12	Lecture Topic 4	Review Topic e
2/19	Review Topic e	Lecture Topic 4
2/26	Lecture Topic 4	Lecture Topic 4
3/5	***Spring Break***	
3/12	Lecture Topic 5	Lecture Topic 5
3/19	Lecture Topic 5	Lecture Topic 6
3/26	Lecture Topic 6	Lecture Topic 7
4/2	Lecture Topic 7	Lecture Topic 7
4/9	Lecture Topic 8	Lecture Topic 8
4/16	Lecture Topic 8	Lecture Topic 9
4/23	Lecture Topic 9	Lecture Topic 9
4/30	Review	Review

* Review Topics are shaded in yellow. You have already studied them in Geotechnical Engineering. We will not lecture them.