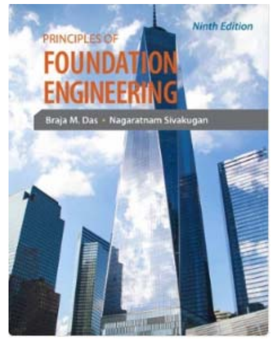
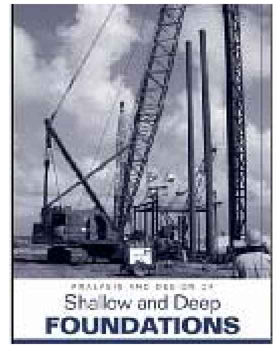
CE 5359 – Foundation Design I





Instructor: Soheil Nazarian
A-207, 747-6911

Class Time: TR 4:30 -6:00 PM
Classroom Building C304

Office Hours: Students are always welcome.

Textbook: Principles of Foundation Engineering, 9th Edition, by Braja Das, Cengage Learning

Suggested Reference Book: Analysis and Design of Shallow and Deep Foundations, by Reese, Isenhower and Wang, ENSOFT, Inc.

Introduction: This course is concerned with foundation engineering. The term "foundation engineering" is used to describe the design of foundations for buildings and other structures, such as retaining walls, tunnels, and coffer and earth dams. It also includes the design of natural slopes, the dewatering of soils, and stabilization of soils, mechanically and chemically.

Foundation design must be based on, and make use of, the principles of mechanics. 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 part of our time on the mechanistic types of problems, in part because they lend themselves better to university-type instruction. But we will spend time discussing practical types of problems that do not lend themselves to homework problems, exams, and grading because they are the main problems of interest in engineering practice.

An important part of the material will be transmitted via lectures. Consequently, you are strongly advised to attend every class period and take extensive notes. Experience shows that students who miss class are likely to encounter questions on exams that they do not understand because the material was covered in their absence.

Some of the students interested in foundation engineering 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 geotechnical engineering. In structures, the properties of materials are reasonably well defined because they are manufactured. In geotechnical engineering, 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. As a result of these conditions, students should realize that the term "design" carries with it different connotations in geotechnical engineering that in some other branches of civil engineering. Even if you choose not to engage in the practice of geotechnical engineering, 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.

Most undergraduate science, mathematics, and engineering courses taken by civil engineers involve problem solving. Problems are always well defined; little, if any, judgment is used in solving them; and there is a single correct answer. Students tend to become *dualistic* (the term intended to indicate that answers to problems are either right or wrong). In a dualistic system, it is assumed that the professor knows (or should know) the answer to every question and that the student is to act as a sponge, simply absorbing as much knowledge as possible. The dualistic stage is an important one because it provides students with the tools of their trade.

Engineering practice, however, tends to be relativistic. In a relativistic system, the problems tend to be ill defined or the problem may be changing as the solution is developing. Important information may be missing or be known only approximately, and the engineer is not likely to possess all of the technical skills needed for a refined solution. In spite of such problems, the designer must develop an acceptable solution. For a relativistic problem, there is likely to be a range of solutions, some better than others, but none that can be considered "right".

In the context of a university course, relativism implies that there are ranges for answers to many exam questions, that answers depend on conditions of the specific problem (hence, the response "Well, it depends" to a question), and that there will not be "correct" answers to some problems. The problem, then, is to develop informed judgments and appropriate thought processes. Some students find interest and challenge in relativism. Others find relativism a great frustration and long for courses with unique answers. This course is a mixture of dualism and relativism, and is intended to help students make an easier transition from deterministic university classes to engineering practice.

Schedule: We will use a self-guided approach in this course. A tentative lecture schedule is attached and the reading assignments are indicated. ***You must read the appropriate sections for each topic before the lecture. You can also use MindTap (see last page of this syllabus) to improve your skills.***

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 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 30% of your grade. The comprehensive final examination will count as 30%. Other class projects and participation will constitute 20% of your grade.

Homework: All homework problems are assigned in MindTap. Homework is assigned to help you learn the material, not as a means to generate grades. It is acceptable to work with others when discussing methods of attack, but your written work should always be your own. The homework problems will be graded automatically. You can try as many times as you wish until you earn a perfect score. ***The homework grade will be based on the grade you earn in the quizzes.***

Homework problems are due at 11:59 PM on Sunday the following week. Therefore, you will always have at least 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 upon 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 single 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: ***A quiz will be assigned on Thursdays after the homework is handed in for a given topic.*** The quiz will be similar to either the homework problems from the previous week or the examples solved in the class or the examples in the textbook.

Case Studies: We will focus on solving problems on most Thursdays. These problems will start from examples in the book followed by a few other problems.

Examination: Final examination, which is comprehensive, will last three 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.

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. Introduction and Review

1.1 Introduction (Handout)

1.1.1 Types of Foundation
1.1.2 Performance Requirement
1.1.3 Design Loads
1.1.4 Strength Requirements
1.1.5 Serviceability Requirements
1.1.6 Constructability Requirements
1.1.7 Economic Requirements

1.2 Geotechnical Properties of Soil (Chapter 2)

1.2.1 Grain-Size Distribution
1.2.2 Size Limits for Soils
1.2.3 Weight-Volume Relationships
1.2.4 Relative Density
1.2.5 Atterberg Limits
1.2.6 Liquidity Index
1.2.7 Activity
1.2.8 Soil Classification Systems
1.2.9 Effective Stress
1.2.10 Consolidation
1.2.11 Calculation of Primary Consolidation Settlement
1.2.12 Time Rate of Consolidation
1.2.13 Shear Strength
1.2.14 Sensitivity

Lecture Topic 2. Natural Soil Deposits and Subsoil Exploration

2.1. Natural Soil Deposits (Chapter 3, no lecturer on this topic)

2.1.1. Soil Origin
2.1.2. Residual Soil
2.1.3. Gravity Transported Soil
2.1.4. Alluvial Deposits
2.1.5. Lacustrine Deposits
2.1.6. Glacial Deposits
2.1.7. Aeolian Soil Deposits
2.1.8. Organic Soil
2.1.9. Some Local Terms for Soils

2.2. Subsurface Exploration (Chapter 3)

2.2.1. Purpose of Subsurface Exploration
2.2.2. Subsurface Exploration Program
2.2.3. Exploratory Borings in the Field
2.2.4. Procedures for Sampling Soil
2.2.5. Split-Spoon Sampling
2.2.6. Sampling with a Scrapper Bucket
2.2.7. Sampling with Thin-Walled Table
2.2.8. Sampling with a Piston Sampler
2.2.9. Observation of Water Tables
2.2.10. Vane Shear Test
2.2.11. Cone Penetration Test
2.2.12. Pressuremeter Test (PMT)
2.2.13. Dilatometer Test
2.2.14. Coring of Rocks

2.2.15. Preparation of Boring Logs
2.2.16. Geophysical Exploration
2.2.17. Subsoil Exploration Report

Lecture Topic 3. Shallow Foundations

3.1. Ultimate Bearing Capacity: General Concept (Chapter 6)

3.1.1. General Concept
3.1.2. Terzaghi's Bearing Capacity Theory
3.1.3. Factor of Safety
3.1.4. Modification of Bearing Capacity Equations for Water Table
3.1.5. General Bearing Capacity Equation
3.1.6. Effect of Soil Compressibility
3.1.7. Eccentrically Loaded Foundations
3.1.8. Ultimate Bearing Capacity under Eccentric Loading - One-Way Eccentricity
3.1.9. Bearing Capacity with Two-Way Eccentricity
3.1.10. Bearing Capacity of a Continuous Foundation Subjected to Eccentric Inclined Loading

3.2. Ultimate Bearing Capacity: Special Cases (Chapter 7)

3.2.1. Foundation Supported by a Soil with a Rigid Base at Shallow Depth
3.2.2. Bearing Capacity of Layered Soils: Stronger Soil Underlain by Weaker Soil
3.2.3. Bearing Capacity of Layered Soil: Weaker Soil Underlain by Stronger Soil
3.2.4. Closely Spaced Foundations - Effect on Ultimate Bearing Capacity
3.2.5. Bearing Capacity of Foundations on Top of a Slope
3.2.6. Bearing Capacity of Foundations on a Slope
3.2.7. Foundations on a Rock
3.2.8. Uplift Capacity Foundations

Lecture Topic 4. Allowable Bearing Capacity and Settlement

4.1. Vertical Stress Increase in a Soil Mass Caused by Foundation Load (Chapter 8)

4.1.1. Stress Due to a Concentrated Load
4.1.2. Stress Due to a Circularly Loaded Area
4.1.3. Stress below a Rectangular Area
4.1.4. Average Vertical Stress Increase Due to a Rectangular Loaded Area
4.1.5. Stress Increase under an Embankment
4.1.6. Westergaard's Solution for Vertical Stress Due to a Point Load
4.1.7. Stress Distribution for Westergaard Material

4.2. Elastic Settlement (Chapter 9):

4.2.1. Elastic Settlement of Foundations on Saturated Clay
4.2.2. Settlement Based on the Theory of Elasticity
4.2.3. Improved Equation for Elastic Settlement
4.2.4. Settlement of Sandy Soil: Use of Strain Influence Factor
4.2.5. Settlement of Foundation on Sand Based on Standard Penetration Resistance
4.2.6. Settlement in Granular Soil Based on Pressuremeter Test (PMT)

4.3. Consolidation Settlement (Chapter 9):

4.3.1. Primary Consolidation Settlement Relationships
4.3.2. Three-Dimensional Effect on Primary Consolidation Settlement

Lecture Topic 5. Mat Foundations (Chapter 10)

5.1. Combined Footings

5.2. Common Types of Mat Foundations

5.2.1. Bearing Capacity of Mat Foundations
5.2.2. Differential Settlement of Mats

5.3. Field Settlement Observations for Mat Foundations

5.4. Compensated Foundation

Lecture Topic 6. Pile Foundations (Chapter 12)

6.1. Types of Piles and Their Structural Characteristics

6.2. Estimating Pile Length

6.3. Installation of Piles

6.4. Load Transfer Mechanism

6.5. Equations for Estimating Pile Capacity

6.5.1. Meyerhof's Method for Estimating Qp
6.5.2. Vesic's Method for Estimating Qp
6.5.3. Coyle and Castello's Method for Estimating Qp in Sand
6.5.4. Correlations for Calculating Qp with SPT and CPT Results
6.5.5. Frictional Resistance (Qp) in Sand
6.5.6. Frictional (Skin) Resistance in Clay
6.5.7. Point-Bearing Capacity of Piles Resting on Rock

6.6. Pile Load Tests

6.7. Elastic Settlement of Piles

6.8. Laterally Loaded Piles

6.9. Pile-Driving Formulas

6.10. Negative Skin Friction

6.11. Group Piles

6.11.1. Group Efficiency
6.11.2. Ultimate Capacity of Group Piles in Saturated Clay
6.11.3. Elastic Settlement of Group Piles
6.11.4. Consolidation Settlement of Group Piles

Lecture Topic 7. Drilled-Shaft Foundations (Chapter 13)

7.1. Types of Drilled Shafts

7.2. Construction Procedures

7.3. Other Design Considerations

7.4. Load Transfer Mechanism

7.5. Estimation of Load-Bearing Capacity

7.5.1. Drilled Shafts in Granular Soil: Load-Bearing Capacity
7.5.2. Load-Bearing Capacity Based on Settlement
7.5.3. Drilled Shafts in Clay: Load-Bearing Capacity
7.5.4. Load-Bearing Capacity Based on Settlement

7.6. Settlement of Drilled Shafts at Working Load

7.7. Lateral Load-Carrying Capacity - Characteristic Load and Moment Method

Lecture Topic 8. Foundations on Difficult Soils (Chapter 15)

8.1. Collapsible Soils

8.1.1. Definition and Types of Collapsible Soil
8.1.2. Physical Parameters for Identification
8.1.3. Procedure for Calculating Collapse Settlement
8.1.4. Foundation Design in Soils Not Susceptible to Wetting
8.1.5. Foundation Design in Soils Susceptible to Wetting

8.2. Expansive Soils

8.2.1. General Nature of Expansive Soils
8.2.2. Unrestrained Swell Test Swelling Pressure Test
8.2.3. Classification of Expansive Soil on the Basis of Index Tests
8.2.4. Foundation Considerations for Expansive Soils
8.2.5. Construction on Expansive Soils

Lecture Topic 9. Soil Improvement and Ground Modification (Chapter 5 time permits)

9.1. General Principles of Compaction

9.2. Field Compaction

9.2.1. Compaction Control for Clay Hydraulic Barriers
9.2.2. Vibroflotation
9.2.3. Blasting
9.2.4. Precompression
9.2.5. Sand Drains
9.2.6. Prefabricated Vertical Drains
9.2.7. Lime Stabilization
9.2.8. Cement Stabilization
9.2.9. Fly-Ash Stabilization
9.2.10. Stone Columns
9.2.11. Sand Compaction Piles
9.2.12. Dynamic Compaction
9.2.13. Jet Grouting

Tentative Lecture Schedule

Week of	Tuesday	Thursday	Quiz on Wednesday
1/21		Topic 1.1	
1/28	Topic 1.1	Topic 1.2	**Lecture Topic 1 Quiz**
2/4	Topics 2.2	Topic 2.2	
2/11	Topic 3.1	Topic 3.1	**Lecture Topic 2 Quiz**
2/18	Topic 3.2	Topic 3.2	
2/25	Topic 4.1	Topic 4.2	**Lecture Topic 3 Quiz**
3/4	Topic 4.3	Topics 5.1-5.2	
3/11	Topics 5.3-5.4	Topics 6.1-6.2	**Lecture Topic 4 Quiz**
3/18	Spring Break		
3/25	Topics 6.3-6.4	Topic 6.5	**Lecture Topic 5 Quiz**
4/1	Topics 6.6-6.8	Topics 6.9-6.10	
4/8	Topic 6.11-6.12	Topics 7.1-7.2	
4/15	Topics 7.3-7.4	Topic 7.5-7.6	**Lecture Topic 6 Quiz**
4/22	Topic 7.7	Topic 8.1	
4/29	Topic 8.2	Topic 9	**Lecture Topic 7 Quiz**
5/6	Topic 9	Topic 9	