CVEN 4728/5728 Foundation Engineering
Course Syllabus and Schedule

Professor: **John S. McCartney, Ph.D., P.E.**
Office: ECOT 541
Office hours: Tuesday-Thursday 9:30-12 and 12-3:00 (or by appointment)
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Class: Time: Fall 2012, Tuesday-Thursday 12:30-1:45 pm
Room: ECCR 1B47

Reference: Coduto, D. "Foundation Design: Principles and Practices." 2nd Edition. Prentice Hall.

Course Description:
Focuses on geotechnical design of shallow and deep foundations, including spread footings, mats, driven piles, and drilled piers. Coverage includes bearing capacity, settlement, group effects, and lateral load capacity of the various foundation types. Additional topics include subsurface exploration, construction of deep foundations, and analysis of pile behavior using wave equation and dynamic monitoring methods. Prereqs., CVEN 3718 or instructor consent. Same as CVEN 5728.

Course Scope:
From the 1930's to the 1960's, the current field of geotechnical engineering was referred to as "soil mechanics and foundation engineering". Everything not considered to be mechanics or material properties was classified as foundation engineering. Thus, foundation engineering referred to everything that involved soils and engineering practice. The term foundation engineering is now evolving more toward the analysis and evaluation of foundations for structures (where the word structures includes buildings, bridges, retaining walls, tanks, offshore structures, and sometimes even highway pavements). In this class we will be concerned mainly with the ultimate capacity, settlement, and structural design of both shallow and deep foundations.

By the very nature of the activity, foundation design involves the need to consider uncertainties while still coming up with acceptable solutions to problems. Although analysis is important, failures often do not result from inability to analyze the problem but rather occur because the designer analyzed the wrong problem, missed some important point, didn't understand what was happening, or was just blindly following policy or codes. Although we will spend a significant amount of time on analysis, our goal is less to develop analytical skills to develop our judgment and attitude for practical work and design. Experience does not necessarily come from years of practical work; experience involves an appropriate blend of understanding of material properties, analytical methods, and practical observations.

Course Outline:
1. Introduction to Foundation Design
   a. Motivation for using Different Foundation Types
   b. LRFD vs. ASD
   c. Issues to Consider in Design
2. Shear Strength of Soils, and Application to Foundation Analysis
3. Subsurface Sampling and Characterization Methods, and Application to Foundation Design
4. Bearing Capacity Analysis of Shallow and Deep Foundations
   a. Concept of upper and lower bound solutions
   b. Undrained analyses (simple circular arc, theories of Prandl and Reissner)
   c. Drained analyses (Terzaghi's theory)
   d. Special factors (Skempton, Brinch-Hansen, Vesic, and Meyerhof factors for depth, slope, inclined load, shape, layered soils, anisotropy)
   e. Knowledge gained from case histories of bearing capacitry
5. Design of Shallow Foundations
   a. Structural design of shallow foundations
   b. Settlement analysis of shallow foundations on clay and sand
   c. Balancing bearing capacity and settlement in design
   d. Strategies to mitigate the effects of expansive soils on foundations
6. Fundamentals of Deep Foundations
   a. Pile Foundations
      i. Pile types and deterioration issues
      ii. Pile driving and allowable stresses

iii. Construction, inspection, specifications and case histories
iv. Structural issues and design

b. Drilled Shaft Foundations
i. Construction, inspection, specifications and case histories
ii. Structural issues and design

c. Other types of foundations (micropiles, helical anchors, anchors, soil nails etc.)

7. Static Capacity Design of Deep Foundations
   a. Load testing of deep foundations
   b. Static analyses of piles and drilled shafts in clay
   c. Static analyses of piles and drilled shafts in sand
   d. Time dependency of capacities
8. Field Load Testing of Foundations
9. Soil-Structure Interaction for Deep Foundations
   a. Axial loading of deep foundations
   b. Lateral Loading of deep foundations
   c. Thermal-mechanical behavior of energy foundations
10. Dynamic Analysis of Deep Foundations and Applications to Design
    a. Pile driving formulas
    b. Wave equation analyses

Course Objectives

In this course, you will learn how to plan a site investigation, how to classify and characterize soils for foundation design, how to estimate the capacity of foundations, and how to estimate the settlement of the soil under the foundation load. You will also learn the principles that govern flow of water in soils, settlement and heave of soils, and shear strength of soils. Students will have to present convincing written arguments to define foundation types and testing to solve specific foundation engineering problems. We will discuss actual field problems during the semester and show you how the concepts that are taught in class can be applied to solve real engineering problems. The course objectives listed below are based on the desired program outcomes identified for engineering education by the Accreditation Board for Engineering and Technology (ABET). For each course objective, the related ABET outcome(s) is listed. Upon completion of this course, students will be able to:

a. Material behavior and site characterization:
   Plan a subsurface exploration (maps to ABET outcomes b, c, g, k)
   Select appropriate drilling, sampling and field property measurement tools for different soil profiles (maps to ABET outcomes a, b, c, g, k)
   Specify necessary laboratory tests to understand the site-specific behavior of foundations (maps to ABET outcomes a, b, c, g, k)
   Evaluate laboratory and field data to select appropriate shear strength values to use in foundation analysis (maps to ABET outcomes a, b, g, k)

b. Design and Analysis of Shallow Foundations:
   Apply the concept of Load-Resistance Factored Design to design foundations (maps to ABET outcomes e, j, k)
   Idealize a soil profile for analysis and design (maps to ABET outcomes a, c, e)
   Apply bearing capacity equations in the correct manner (maps to ABET outcomes a, c)
   Evaluate appropriate bearing capacity correction factors to use in design (maps to ABET outcomes a, c, e)
   Evaluate effects of water and layered soil systems on foundation performance (maps to ABET outcomes a and c)
   Estimate time-rate of foundation settlement for different soil types (maps to ABET outcomes a, c, k, e)
   Identify strategies to mitigate the effects of expansive soils on foundations (maps to ABET outcomes "a", "b", "d" and "g")

c. Design and Analysis of Deep Foundations
   Identify the appropriate deep foundation type for different soil profiles (maps to ABET outcomes a, c, e, g)
   Identify the phenomena which may affect foundation settlement and capacity (maps to ABET outcomes a, c, e, k)
   Calculate side and tip capacity of driven piles in clay (maps to outcomes a, c, e, k)
   Calculate side and tip capacity of driven piles in sand (maps to outcomes a, c, e, k)
   Specify pile material types for various applications (maps to outcomes a, b, c, e, k)
   Evaluate pile capacity in the field using load tests, pile driving equations, and wave equation analysis (maps to ABET outcomes a, c, e, k)
   Apply soil-structure interaction concepts to predict the load-settlement curve and lateral load capacity of deep foundations (maps to ABET outcomes a, c, e, k)

Accreditation through ABET

The Accreditation Board for Engineering and Technology (ABET) is a professional accrediting organization that accredits specific academic programs to assure quality in education. Accreditation is a voluntary, non-governmental process of peer review. It requires an educational program to meet certain defined standards or criteria. More information on ABET and accreditation can be found on the ABET website at http://www.abet.org. As part of the accreditation process, ABET sets general criteria for students, faculty, facilities, educational objectives, and institutional support, as well as program criteria for specific engineering disciplines. One major criterion established by ABET is a set of desired program outcomes, the so-called "a-k" outcomes. These are listed in their entirety below. Specific objectives for individual courses in the CEAE Department are mapped to these ABET outcomes. Engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Mapping of objectives in CVEN 4728/5728 (Foundation Engineering) against ABET outcomes:

	a	b	c	d	e	f	g	h	i	j	k
a	x	x	x		x		x				x
b	x	x	x		x					x	x
c	x	x	x		x		x				x

Website references:

An introduction to drilling and sampling in geotechnical practice, Jason T. DeJong & Ross W. Boulanger, 2nd Edition (2000) http://cee.engr.ucdavis.edu/faculty/boulanger/video/DrillingAndSampling.mpg
Geotechnical News (USA and Canada) http://www.bitech.ca/news.htm
Ground Engineering (UK) http://www.geplus.co.uk/
Association of Drilled Shaft Contractors http://www.adsc-iafd.com/i4a/pages/index.cfm?pageid=1
American Pile Driving Equipment http://www.apevibro.com/asp/glossary.asp?letter=s
Vulcan Hammer http://www.vulcanhammer.net/
U.S. Department of Transportation http://www.fhwa.dot.gov/infrastructure/tccc/tutorial/shafts/index.htm
FHWA Pier and Pile Insp. Tutorials http://www.fhwa.dot.gov/infrastructure/tccc/tutorial/piles/index.htm
Deep foundation Institute http://www.dfi.org/
GRL Engineers http://www.pile.com/
United Facilities Criteria (UFC) http://www.wbdg.org/ccb/DOD/UFC/ufc_3_220_01n.pdf
Procedures for Foundation Design of Buildings and Structures Soil Mechanics Design Manual 7.01
http://www.geotechnicaldirectory.com/publications/Dm701.pdf
Naval Facilities Engineering Command Foundations and Earth Structures Design Manual 7.02
http://www.ce.washington.edu/~geotech/courses/cee523/manuals/NAVFAC72.pdf
Pile Driving Contractors Association http://piledrivers.org/
Dakota Drilling, Denver Colorado http://www.dakotadrilling.com/

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.

Course Grade Distribution

Participation in in-class discussions	10%
Homework	40%
Midterm Exam	25%
Final Exam	25%
Total	100%

Note: Students taking this course for graduate credit must also complete a semester project which will be considered as part of the homework category. Details about the project will be discussed later in the semester.

Neatness

- 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.

Attendance

- Class attendance is in accordance with the published university course schedule.
- 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.