GEO Geotechnical Engineering

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Masters Degree Requirements

There are four options under which a student may complete a master's degree

1. The M.S.E. "Thesis Option" requires at least 30 hours of credit, including:

* 12 to 18 hours in the major focus area,

* 6 to 12 hours in minor focus areas, and

* 6 hours for thesis research and writing. Requires a second professor to serve as a thesis reader.

2. The M.S.E. "Report Option" requires at least 30 hours of credit, including:

* 15 to 21 hours in the major focus area

* 6 to 12 hours in minor focus areas, and

* 3-credit-hour report to the Graduate School or 3-credit-hour report to the CAEE Department. Requires a second professor to serve as a report reader.

3. The M.S.E. "Course-only Option with Independent Study" requires at least 30 hours of credit, including:

* 15 to 21 hours in the major focus area

* 6 to 12 hours in minor focus areas, and

* 3-credit-hour Special Studies (Independent Study) class does not require a second professor to serve as a reader.

4. The M.S.E. "Course-only Option" requires at least 30 hours of credit, including:

* 15 to 24 hours in the major focus area, and

* 6 to 15 hours in minor focus areas.

Students not supported on sponsored research projects or a University fellowship may elect any of the four options. Most Master's students, especially those holding University fellowships or research assistantships, are encouraged to complete Option 1. Students with research assistantships generally write a thesis that also serves as a report to the research sponsor. Options 2 and 3 are appropriate for students interested in a broader education and thus take more courses in related minor focus areas. Master's students are supervised by one member of the Geotechnical engineering faculty, with at least one other professor serving as the thesis or report reader.

One-Year M.S.E. Degree

Students interested in graduating with a master's degree in one year may choose option 3 (course-only with independent study) or 4 (course-only). We offer at least three graduate Geotechnical courses each Fall and Spring Semesters, with an additional Engineering Geology course in the Summer. Students wanting to graduate with the Master's coursework option in one year (Fall+Spring+Summer) usually enroll in these seven courses and one additional course per semester outside Geotechnical engineering, supporting their major and minor focus areas, thus securing 30 credit hours in one year.

Doctoral Requirements

The Ph.D. program has no formal course requirements. We generally expect students to complete a minimum of 16 graduate courses, including courses taken elsewhere and courses taken for the Master's degree. The appropriate courses to complete are selected in consultation with the student's advisor and supervising committee, and should include some coursework in a supporting area outside of Geotechnical engineering. Successful candidates must demonstrate proficiency in written English and pass three examinations:

(1) English Proficiency
The objective of the English proficiency requirement is to ensure that all Ph.D. candidates possess the writing skills necessary for effective technical communication before embarking on the dissertation writing process. English proficiency should be demonstrated in one of three ways:

- By submitting a GRE analytical writing score of 4.0 or greater at the time of application;
- By retaking the GRE and achieving an analytical writing score of 4.0 or greater; or
- By passing an approved technical writing course.

Students who cannot demonstrate proficiency on the basis of their GRE analytical writing score must either retake the GRE or enroll in an approved technical writing course in their first semester as a Ph.D. student. CE397 Advanced Communication Skill for International Students; CE389C Advanced Engineering Communication; or an acceptable Graduate School (GRS) course are the only technical writing courses approved at this time.

(2) Qualifying Examination
This oral examination is administered by a committee of three faculty members, including one from outside of geotechnical engineering. The Qualifying Exam is used to evaluate capabilities and to help the student select appropriate courses. This exam also serves to identify those few students who clearly are not qualified to complete our degree requirements. The qualifying exam should be taken in the first semester of Ph.D. study.

(3) Comprehensive Examination
This second examination involves an extensive discussion of the proposed dissertation work but also tests the candidate's knowledge in geotechnical engineering. The exam typically includes a written description of the proposed dissertation research with an oral presentation to the student's supervising committee. This serves to define the dissertation topic in a public forum. The Comprehensive Exam is typically taken about one to two years into the program when most of the course work has been completed, but before completing the bulk of the dissertation research.

(4) Dissertation Defense
The third and final exam is the defense of the dissertation presented to the student's supervising committee. The defense is held at the end of the program.

The doctoral supervising committee consists of at least five professors, including the student's advisor and at least one professor from outside of Civil Engineering.

Courses

We offer a variety of courses, which cover nearly all aspects of geotechnical engineering.

Undergraduate Courses

Students may take some undergraduate courses as part of their coursework for an advanced degree. The advanced undergraduate courses in geotechnical engineering are:

- **CE 357 - Geotechnical Engineering**
  Index properties and classification of soils; soil permeability and pore water movement; stresses in soil and the effective stress concept; soil compressibility, consolidation, and settlements; shear strength of soil; engineering soil properties and their measurement. Fall and Spring semesters.
- **CE 360K - Foundation Engineering**
  Effect of geotechnical conditions on the behavior, proportioning, and choice of foundation type; design of shallow and deep foundations; study of foundation case histories. Fall and Spring semesters.
- **CE 375 - Earth Slopes & Retaining Structures**
  Earth fills, excavations, and dams; soil compaction, ground improvement, and slope stability; seepage and dewatering; study of earth-pressure theories; design of earth-retaining structures. Spring semesters.

Syllabi for undergraduate courses may be found by searching The University's course syllabi and instructor CV system.

Graduate Courses

The graduate academic program in geotechnical engineering consists of formal courses, seminars, special problems courses, and occasional special courses offered by internationally recognized scholars. Students may enter the graduate program at the start of any semester during the year (Fall, Spring, or Summer semesters). The courses and the faculty members who generally teach the course are listed below.

- **CE 387C - Geoenvironmental Engineering**
  This course covers geotechnical aspects for the containment and remediation of waste. Topics include fluid flow through porous media, including saturated, unsaturated, multiphase and gas flow; contaminant transport across soil barriers; clay mineralogy and chemical interactions with soil liners; field performance of compacted soil liners and composite liners; drainage layer design and performance; water balance evaluations for covers; and interface shear resistance for geosynthetics and soils. The course contains a laboratory. Laboratory experiments include hydraulic conductivity, surface tension, capillarity, chemical interactions with soils and geosynthetics, transmissivity and permittivity of geosynthetics; vapor diffusion through geomembranes, and interface shear resistance between geosynthetics.

- **CE 387L.1 - Strength and Shear Properties of Soil**
  This course provides a thorough discussion of shearing properties of soils, including use of effective versus total stresses, effects of drainage, use of modified failure envelopes, failure and yield criteria, properties of both saturated and unsaturated soils, sensitivity, and thixotropy, and critical state soil mechanics. Lectures cover the interpretation of laboratory measurements, while the lab allows students to perform direct shear and triaxial shear tests.

- **CE 387L.2 - Foundation Engineering**
  This course explores the technical principles and practical issues related to the design, construction, and performance of foundations for structures. Both shallow foundations, which include footings, mats, and rafts, and deep foundations, which include driven piles and drilled shafts, are considered. The emphasis is on the fundamental principles and concepts that will provide the basis and framework for sound engineering judgment in foundation design.
- **CE 387M.1 - Stability of Earth Slopes**
  This course covers the principles of slope stability and the application of these principles to the analysis and design of earth slopes. Different types of analysis, from stability charts to different limit equilibrium solutions, are presented. We consider the analysis of natural slopes, cut slopes, and embankment fills (including dams) under different loading conditions.

- **CE 387M.2 - Seepage and Earth Dams**
  Principles of water flow in soils, hydraulic conductivity, and graphical and numerical techniques for solving seepage problems are covered in the first part of this course. The second part focuses on earth dams and applications of many of the principles covered in the first part of the course. Coverage of earth dams includes preparation and treatment of foundations, selection and design of embankment cross-sections, slope protection

and field measurements. The class performs numerical (finite element) analyses to compute both seepage and stress/deformation patterns for a typical earth dam.

- **CE 387R.1 - Consolidation and Settlement**
  The course begins with a review of classical methods of settlement analysis for wide embankments and of the Terzaghi method of analysis for time rates. These methods are then extended to cover a variety of more realistic conditions including time dependent loading, dewatering, and radial flow involving use of wicks. The behavior of structures is discussed in terms of limit states. Stress distribution theories are discussed and various methods of analysis of behavior of shallow footings, including mats, are discussed. Study of case histories and extensive laboratory observations are used to gain insight into the real performance of soils, and numerical methods of analysis are developed to analyze realistic problems. A laboratory involves the performance of consolidation tests.

- **CE 387R.2 - Soil and Rock Dynamics**
  This course deals with the response of soil, rock, and soil-structure systems under low-amplitude dynamic loading such as that generated by machinery, vehicular traffic, and conventional blasting. Field and laboratory methods used to evaluate dynamic soil properties are discussed. Measurements of dynamic material properties are performed in the field using seismic techniques, and in the laboratory using resonant and transient techniques. Analytical methods used to design surface, embedded, and pile-supported foundations undergoing transient or steady-state vibration are studied. Problems associated with vibration transmission and isolation in soil and rock are also discussed.

- **CE 387R.4 - Earth Retaining Structures**
  Analysis and design are covered for such earth retention systems as retaining walls, free-standing sheet-pile walls, braced excavations, slurry walls, tied-back retention systems, reinforced earth, frozen soil walls, anchored bulkheads, and cellular cofferdams. The problems involved with the interaction of the structures with the soil are studied. Both classical and more refined methods of analyses are included and considerable attention is directed toward field observations. Soft-ground tunneling may also be included.

- **CE 387R.5 - Geotechnical Earthquake Engineering**
  This course is concerned with the application of soil dynamics to earthquake engineering and the study of the geotechnical aspects of earthquakes. Earthquake mechanisms, earthquake ground motions, and the influence of soil conditions on ground motion characteristics are discussed. The evaluation of site response using wave propagation techniques is presented. Soil liquefaction, lateral spreading, the seismic response of earth structures, and seismic-deformation procedures for slopes are considered. Case studies from previous earthquakes and group projects that deal with data from previous earthquakes are used to give students a better understanding of the geotechnical phenomena associated with earthquakes.

- **CE 387G - Engineering Geology**
  This course presents the fundamentals of geology in a way that is relevant to Civil Engineers. The course focuses on geologic materials, earth processes, and landforms, all of which evolve through the vast amounts of geologic time to produce the global conditions that we see today. The three-way interactions among materials, landforms, and processes provide challenges to Civil Engineers in their work siting, designing, and maintaining structures and facilities.
  Although the overall scope of the course is be global, a major emphasis will focus on the Austin area and nearby localities. Most laboratory sessions will be conducted in the field.

- **CE 394M - Adv Analysis of Geotechnical Engineering**
  The primary focus of this course is the application of the finite element method to problems in geotechnical engineering. The finite element method is introduced and various constitutive laws for modeling soil behavior are presented. Specifically, linear elastic, nonlinear elastic (hyperbolic), linear elastic-perfectly plastic, and nonlinear elasto-plastic (Cam clay) models are discussed. The critical state framework for modeling soil response is studied. Students use computer programs to perform static analyses of earth structures and develop recommendations regarding realistic consulting projects. Other analytical procedures, such as the finite difference method and discontinuous deformation analysis, are also discussed.

- **CE 397.7 - Decision, Risk and Reliability**
  This course focuses on modeling uncertainty in geotechnical design and decision-making. Topics include spatial variability in soil properties uncertainty in performance models, decision and risk analysis, and reliability evaluation for components and systems.

- **CE 397 - Scientific Machine Learning**
  This course introduces engineers to scientific machine learning (SciML), a rapidly emerging field that combines the best of machine learning and traditional scientific computation to tackle complex scientific problems. Students will learn to apply machine learning techniques in engineering applications, including numerical simulations, data-driven modeling, and uncertainty quantification. This course covers foundational concepts, techniques, and algorithms, as well as practical implementation in PyTorch and Jax.

Related Courses

Graduate students in geotechnical engineering can choose from an extensive array of classes at The University of Texas at Austin to fulfill the requirements for coursework in supporting areas. A partial list of suitable courses is given here. Students are encouraged to investigate the University's undergraduate and graduate course catalogs for other classes to broaden their graduate education.

- CE 367P Pavement Design and Performance
- CE 374L Groundwater Hydrology
- CE 381P Computer Methods in Structural Analysis
- CE 381R The Finite Element Method
- CE 381T Numerical Modeling of Physical Systems
- CE 385J Hazardous Waste Management
- CE 385R Land Treatment of Waste
- CE 391P Highway and Airport Pavement Systems
- CE 394K.1 Groundwater Pollution and Transport
- CE 397.20 Computer Methods for Civil Engineers
- CE 397.78 Design of Offshore Structures
- ASE 369K Measurements and Instrumentation
- EM 380 Theory of Plasticity
- EM 381 Advanced Dynamics

- EM 382 Nonlinear Analysis
- EM 384K Continuum Mechanics
- EM 388 Solid Mechanics
- EM 392R Random Vibrations
- EM 393N Numerical Methods for Flow and Transport Problems
- EM 394F Finite Element Methods
- EM 394G Computational Techniques in Finite Elements
- EM 394H Advanced Theory of Finite Element Methods
- EM 394V Wave Propagation
- EE 332 Computer Graphics
- ME 335 Probability and Statistics for Engineers
- ME 352K Engineering Computer Graphics
- ME 368J Computer-Aided Design
- PGE 383.29 Rock Fracture Mechanics
- PGE 383.45 Geomechanics of Subsurface Rocks and Fluids
- PGE 383.54 Fundamentals of Rock Mechanics
- PGE 386K Advanced Fluid Flow in Porous Media
- GEO 320L Introductory Field Geology
- GEO 428 Structural Geology
- GEO 346C Introduction to Physical and Chemical Hydrology
- GEO 465K Exploration Geophysics
- GEO 365N Geophysical Data Processing
- GEO 476K Groundwater Hydrology
- GEO380F Introduction to Seismology, Earthquakes, and Earth Structure
- GEO 383C Geology and Hydrology
- GEO 393G Geochemistry of Sedimentary Rocks
- GEO 384M Geophysical Data Modeling and Inversion