

# Civil Engineering

## College of Engineering

The Department of Civil Engineering offers the Master of Science in Civil Engineering (Plan A and Plan B available), and Ph.D. with specialization in the following areas:

Civil Engineering Materials  
Construction Engineering and Management  
Environmental Engineering  
Geotechnical Engineering  
Hydraulics Engineering  
Structural Engineering  
Transportation Engineering  
Water Resources Engineering

These areas utilize courses from other departments and such inter-departmental programs are encouraged. Mechanical Engineering, Chemical Engineering, Agricultural Engineering, Mining Engineering, Mathematics, Computer Science, Geology, Biology, and Chemistry are some of the departments whose offerings contribute to the programs in Civil Engineering.

For the Master of Science in Civil Engineering (M.S.C.E.) degree Plan A, 24 credit hours of course work and a thesis are required to fulfill degree requirements. For the Master of Science in Civil Engineering (M.S.C.E.) degree Plan B, a minimum of 30 credit hours of graduate work are required, including at least 3 credit hours of independent work. The requirement for independent work may be satisfied by either taking an approved curriculum of courses which contain integral independent study components totaling a minimum of 3 credit hours, or by completing at least three credit hours of CE 790 and/or CE 791.

Students who wish to complete the independent work requirement by choosing from an approved curriculum of courses containing integral independent study components, shall present a plan of study which satisfies this requirement, and all other Graduate School requirements, to the Director of Graduate Studies for approval before the completion of 12 credit hours of graduate course work. Preferably this should occur no later than the end of the first semester of graduate residence. The requirement for all independent work must be satisfied under the direction of one faculty member (for students choosing a CE 790 and/or CE 791), or several faculty members (for students following an approved curriculum of courses), who will assign, monitor, and evaluate the student's work as part of the specific course. Written reports will usually represent the work product to be evaluated.

All students must pass a Final Examination as specified by the rules of the Graduate School. The contents and style of the examination, and the evaluation of the student's performance, are the responsibility of a Graduate Faculty committee appointed by the Dean of the Graduate School. The Ph.D. degree has no formal course requirement, but students must pass the Qualifying Examination before entering candidacy. There is no language requirement for the M.S.C.E. and Ph.D. degrees in Civil Engineering.

### Admission Requirements

In addition to satisfying general Graduate School and College of Engineering admissions requirements (a GPA of 2.8/4.0 on all undergraduate work is normally required), applicants for admission to the M.S.C.E., and Ph.D. degree programs in Civil Engineering must have been awarded a Bachelor of Science degree

from an engineering program accredited by the Accrediting Board for Engineering and Technology (ABET). This requirement may be waived for applicants who have been awarded bachelor's degrees other than in engineering or from unaccredited engineering programs (including those offered by foreign institutions) if the applicant has received an acceptable score on the Graduate Record Examination (GRE).

Students with undergraduate majors not in engineering must also take a certain number of undergraduate remedial courses. Neither the M.S.C.E. degree nor the Ph.D. degree in Civil Engineering will be conferred unless the candidates have successfully completed, during their undergraduate and/or graduate careers, at least one basic course in at least four of the following seven areas: civil engineering materials, construction engineering and management, environmental engineering, geotechnical engineering, hydraulics and water resources engineering, structural engineering, and transportation engineering.

Another admission requirement is a minimum combined verbal and quantitative scores of GRE as follows: 1000 (300: New GRE), and 1100 (330: New GRE) for Master's and Ph.D. degree applicants, respectively. Scores on the analytical portion are not considered. Foreign applicants whose native language is other than English must take the Test of English as a Foreign Language (TOEFL) and score at least 550 (Computer Based TOEFL: 213, iBT TOEFL: 80).

The Department of Civil Engineering has many well-equipped laboratories with active research programs in most areas. The research programs provide financial assistance for graduate students. In addition, financial assistance is available through teaching assistantships, fellowships, and scholarships.

Information about the graduate program in Civil Engineering can be obtained by writing the Director of Graduate Studies, Department of Civil Engineering.

## Graduate Courses

CE 461G	Hydrology	(3)
CE 471G	Soil Mechanics	(4)
CE 486G	Reinforced Concrete Structures	(3)
CE 487G	Steel Structures	(3)
CE 508	Design And Optimization Of Construction Operations	(3)
CE509	Control Of The Construction Project	(3)
CE517	Boundary Location Principles	(3)
CE 525	CE Applications Of Geographic Information Systems	(3)
CE 531	Transportation Facilities Design And Operations	(3)
CE 533	Railroad Facilities Design And Analysis	(3)
CE 534	Pavement Design, Construction And Management	(3)
CE 539	Transportation Systems Design	(3)
CE 541	Intermediate Fluid Mechanics (Same As BAE 541)	(3)
CE 542	Introduction To Stream Restoration (Same As BAE 532)	(3)
CE 546	Fluvial Hydraulics (Same As BAE 536)	(3)
CE 547	Watershed Sedimentation (Same As BAE 547)	(3)
CE 549	Engineering Hydraulics(Same As BAE 545)	(3)
CE 551	Water And Wastewater Treatment Engineering	(3)
CE 553	Environmental Consequences Of Energy Production (Same As EGR 553)	(3)
CE 555	Microbial Aspects Of Environmental Engineering	(3)
CE 568	GIS Applications For Water Resources (Same As BAE 538)	(3)
CE 579	Geotechnical Engineering	(3)
CE 581	Civil Engineering Materials Ii	(3)

CE 582	Advanced Structural Mechanics	(3)
CE 584	Design Of Timber And Masonry Structures	(3)
CE 585	Civil Engineering Failure	(3)
CE 586	Prestressed Concrete	(3)
CE 589	Design Of Structural Systems	(3)
CE 599	Topics In Civil Engineering (Subtitle Required)	(1-4)
CE 602	Construction Project Management	(3)
CE 605	New Engineering Enterprises	(3)
CE 621	Introduction To Finite Element Analysis	(3)
CE 631	Urban Transportation Planning	(3)
CE 633	Air Transport Engineering	(3)
CE 634	Traffic Characteristics	(3)
CE 635	Highway Safety	(3)
CE 642	Open Channel Flow (Same As BAE 642)	(3)
CE 643	Mechanics Of Sediment Transport	(3)
CE 651	Fundamentals Of Water Quality Control I	(3)
CE 652	Fundamentals Of Water Quality Control Ii	(3)
CE 653	Water Quality In Surface Waters (Same As BAE 653)	(3)
CE 655	Water Sanitation And Health	(3)
CE 662	Stochastic Hydrology (Same As BAE 667)	(3)
CE 664	Watershed Management	(3)
CE 665	Water Resources Systems	(3)
CE 667	Stormwater Modeling	(3)
CE 671	Advanced Soil Mechanics	(3)
CE 672	Landfill Design	(3)
CE 673	Stability Of Earth Slopes	(3)
CE 676	Groundwater And Seepage	(3)
CE 679	Geotechnical Earthquake Engineering	(3)
CE 681	Advanced Civil Engineering Materials	(3)
CE 682	Advanced Structural Analysis	(3)
CE 684	Slab And Folded Plate Structures	(3)
CE 686	Advanced Reinforced Concrete Theory	(3)
CE 687	Advanced Metal Structures	(3)
CE 699	Topics In Civil Engineering (Subtitle Required)	(1-4)
CE 748	Master's Thesis Research	(0)
CE 749	Dissertation Research	(0)
CE 767	Dissertation Residency Credit	(2)
CE 768	Residence Credit For Master's Degree	(1-6)
CE 769	Residence Credit For Doctor's Degree	(0-12)
CE 779	Advanced Geotechnical Engineering	(3)
CE 782	Dynamics Of Structures	(3)
CE 783	Structural Finite Element Analysis	(3)
CE 784	Shell Structures	(3)
CE 790	Special Research Problems In Civil Engineering	(1-6)
CE 791	Special Design Problems In Civil Engineering	(1-6)

## Course Descriptions

### CE 507 CONSTRUCTION SAFETY AND HEALTH. (3)

The course will develop an understanding of safety and health; cost and human impact; hazard and risk analyses; psychological facts of organizational culture and climate; design safe work procedures for the execution of particular types of work; and individual versus management level improvement in safety and health procedures in the construction process. Prereq: Engineering standing and CE 303 or consent of instructor.

### CE 508 DESIGN AND OPTIMIZATION OF CONSTRUCTION OPERATIONS. (3)

The course critically examines repetitive operations that occur from project to project and the deterministic approaches used to design and optimize their effectiveness. Scientific techniques used to field measure the efficiency of construction operations are also examined. The primary metrics used to optimization include cost, schedule, and sustainability. Prereq: C in CE 303, C in CE 381, and engineering standing or graduate standing.

### CE 509 CONTROL OF THE CONSTRUCTION PROJECT. (3)

This course investigates the principles and practices for the control of budget and schedule for construction projects. Topics studied include: estimating construction costs and developing a project budget, planning construction operations and developing a project schedule, documenting and reporting of project progress and spending, and the management of change of contract amount, contract time, and contract scope work. Prereq or coreq: CE 508 or consent of instructor.

### CE 517 BOUNDARY LOCATION PRINCIPLES. (3)

Procedures for locating or relocating the boundaries of real property; records searching, technical aspects of field work, preparation of descriptions and survey reports, land data systems, legal aspects, special problems. Prereq: C in CE 211, engineering standing, or consent of instructor.

### CE 525 CIVIL ENGINEERING APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. (3)

CE 525 focuses on GIS as a tool in Civil Engineering. The terms and concepts related to Geographic Information Systems are introduced. The management of spatial databases, particularly those related to Civil Engineering, is covered. Students will collect data using a Global Positioning System (GPS). Students will be required to use the GIS ArcInfo to solve a specific individual spatial problem that they propose based on several Civil Engineering databases available to them. Lecture, two hours; laboratory, three hours per week. Prereq: Engineering standing and one of the following: C in CE 331, C in CE 341, or CE 471G.

### CE 531 GEOMETRIC DESIGN AND OPERATIONS OF ROADWAYS. (3)

Analysis of transportation facilities through a diagnostic study of transportation systems with emphasis on design, capacity and safety. Engineering practice oriented toward open-ended design solutions, mostly focused on roadway design. Prereq: C in CE 331, and engineering standing.

### CE 533 RAILROAD FACILITIES DESIGN AND ANALYSIS. (3)

Principles of railroad location, construction, rehabilitation, maintenance, and operation with emphasis on track structure design and analysis, bridges and bridge loading, drainage considerations, track geometry effects, and operating systems analysis. Coreq or prereq: CE 471G or graduate standing or consent of instructor.

### CE 534 PAVEMENT DESIGN, CONSTRUCTION AND MANAGEMENT. (3)

Design, analysis, construction, and management of flexible and rigid pavements. Stresses and strains, pave-

ment materials, subgrade soil stabilization, bases and subbases, quality control, drainage, pavement-type selection, and pavement management. Prereq: C in CE 381; prereq or concur: CE 471G, and engineering standing.

#### CE 539 TRANSPORTATION SYSTEMS DESIGN. (3)

This course focuses on the design of urban intersections and the procedures used to evaluate the operational level of urban roadway systems. First, a review of urban intersection design principles and aspects is presented. Second, traffic signal timing techniques are reviewed and students are required to use two software packages for evaluation of traffic operation of urban roadway systems. The focal point of the course is a group design project where solutions to accommodate all transportation modes and their issues along a corridor in Lexington are sought. Fieldwork and data collection are part of this course. Lecture, two hours; laboratory, one hour. Prereq: C in CE 331; CE 531 prereq or concur.

#### CE 541 INTERMEDIATE FLUID MECHANICS. (3)

Application of basic fluid mechanics to problems of importance to civil engineering practice. This includes flow measuring, closed conduit flow and pipe networks, open channel flow, turbomachinery (pumps), hydraulic structures, culvert flow. Prereq: CE 341, CS programming course, and engineering standing or consent of instructor. (Same as BAE 541.)

#### CE 542 INTRODUCTION TO STREAM RESTORATION. (3)

Introduction to principles of fluvial geomorphology for application in restoring impaired streams. Topics include channel formation processes (hydrology/hydraulics), stream assessment, sediment transport, in-stream structures, erosion control, habitat, and monitoring. Prereq: CE 341 (or equivalent) and engineering standing or consent of instructor. (Same as BAE 532.)

#### CE 546 FLUVIAL HYDRAULICS. (3)

Rainfall physics, principles of erosion on upland areas and construction sites, stable channel design in alluvial material, mechanics of sediment transport, river mechanics, reservoir sedimentation. Prereq: CE 341 or ME 330 and engineering standing. (Same as BAE 536.)

#### CE 547 WATERSHED SEDIMENTATION. (3)

The course objective is to gain an understanding of watershed sedimentation including: (1) erosion and sediment transport processes in a watershed and the mechanisms by which the processes are initiated, developed, and worked towards equilibrium; (2) measurement of the sediment budget for a watershed using sediment fingerprinting and sediment loading data; and (3) prediction of sediment loading in watersheds with different human disturbances using hydrologic-based modeling tools. Specific emphasis will be placed on the use of natural carbon and nitrogen isotopic tracer measurements within sediment fingerprinting as a data-driven approach to measure sediment loading from different sources in a watershed. In order to fulfill the course objective, the instructor will use traditional classroom learning as well as field and laboratory components of the course in order that students can participate in hands-on learning. Prereq: CE 461G (Pre- or Co-requisite or equivalent). (Same as BAE 547.)

#### CE 549 ENGINEERING HYDRAULICS. (3)

Analysis and Design of flow in closed conduits and natural and artificial open channels. Design of hydraulic structures. Prereq: CE 461G and engineering standing, or consent of instructor. (Same as BAE 545.)

#### CE 551 WATER AND WASTEWATER TREATMENT ENGINEERING. (3)

This course examines the scientific and engineering aspects of water and wastewater treatment. Conventional water treatment processes such as rapid mixing, flocculation, sedimentation, filtration, and disinfection as well as biological processes for wastewater treatment are analyzed. Sustainable alternative treatment



techniques are also discussed. Prereq: C in CE 341, C in CE 351, and engineering standing or consent of instructor.

**CE 553 ENVIRONMENTAL CONSEQUENCES OF ENERGY PRODUCTION. (3)**

This course will introduce the relationship of energy, pollution control technology, and the environment. The scientific and engineering aspects of energy production are examined and the associated environmental problems and control technologies are discussed. Prereq: CHE 105, MA 214, and engineering standing or consent of instructor. (Same as EGR 553.)

**CE 555 MICROBIAL ASPECTS OF ENVIRONMENTAL ENGINEERING. (3)**

Environmental microbiology for engineering students with emphasis on microbially mediated chemical cycles, microbial ecology, and industrial microbiology. Prereq: C in CE 351, engineering standing, graduate status or consent of instructor.

**CE 568 GIS APPLICATIONS FOR WATER RESOURCES. (3)**

This course studies the principles, methodology and analysis of geographic information systems and spatially-referenced data unique to water resources and hydrologic modeling. Lectures will explore the latest GIS concepts, hydrologic modeling relationships and data sources and be complimented with computer-based laboratory exercises. Prereq: BAE 437, CE 461G, or consent of instructor. (Same as BAE 538.)

**CE 579 GEOTECHNICAL ENGINEERING. (3)**

Application of the principles of soil mechanics and structural mechanics to the design of retaining walls, bracing for excavations, footings, mat and pile foundations and to the analysis of the stability of earth slopes. Prereq: CE 471G and engineering standing.

**CE 581 CIVIL ENGINEERING MATERIALS II. (3)**

Design, evaluation, and construction of portland cement concrete and hot mix asphalt (HMA). Advanced topics related to high performance concrete and asphalt materials are covered in this course. Prereq: C in CE 381 and engineering standing.

**CE 584 DESIGN OF TIMBER AND MASONRY STRUCTURES. (3)**

Current and historic design methods of buildings and their components using wood, wood products, bricks, and concrete blocks. Prereq: Courses in steel and reinforced concrete design at the senior level, or consent of instructor. (Same as ARC 584.)

**CE 585 CIVIL ENGINEERING FAILURES. (3)**

Fundamentals of failure investigation and forensic engineering; Failure types and mechanisms; Case studies and discussions on various constructed facilities. Prereq: CE 382 or consent of instructor, and engineering standing.

**CE 586 PRESTRESSED CONCRETE. (3)**

Fundamental basis and underlying principles for the analysis and design of prestressed concrete. Working stress and ultimate strength design methods, full and partial prestressing. Design for shear and torsion, deflection, crack control, and long-term effects, and prestress losses. Composite beams, continuous beams, slabs, short and slender columns, precast structures and their connections. Prereq: CE 486G and engineering standing.

**CE 589 DESIGN OF STRUCTURAL SYSTEMS. (3)**

Building codes, design loads, computerized structural analysis and design, gravity and lateral system design, structural system descriptions

and selection considerations, and structural contract documents. Prereq: CE 486G and CE 487G, engineering standing or consent of instructor.

#### CE 595 INDEPENDENT WORK IN CE. (1-4)

Individual work on some selected problem in the field of civil engineering. May be repeated for a maximum of six credits. Prereq: Consent of department chairperson and the instructor; with engineering standing.

#### CE 599 TOPICS IN CIVIL ENGINEERING (Subtitle required). (1-4)

A detailed investigation of a topic of current significance in civil engineering such as: design of small earth dams, man and the environment, drilling and blasting, scheduling construction operations, construction equipment and methods, traffic safety, optimum structural design, environmental impact analysis, systems analysis in civil engineering, motor vehicle noise and its control. May be repeated to a maximum of eight credits, but only four credits can be earned under the same title. A particular topic may be offered at most twice under the CE 599 number. Prereq: Variable; given when topic is identified; plus engineering standing.

**PREREQUISITE FOR GRADUATE WORK:** Students desiring to take any of the following courses should have a thorough working knowledge of chemistry, physics and mathematics. For major work, a candidate must hold a bachelor's degree in civil engineering or its equivalent.

#### CE 602 CONSTRUCTION PROJECT MANAGEMENT. (3)

Management of construction projects: planning, estimating, scheduling and control; organization; site management; material management; safety management; quality management; construction labor relations; productivity management; claims. Prereq: Engineering Standing, graduate status, or consent of instructor.

#### CE 605 NEW ENGINEERING ENTERPRISES. (3)

The course covers the theory and actual practices of organization, management and operation of engineering companies. Primary emphasis on construction companies; however, the principles apply to most service oriented engineering companies. Students will be required to do several independent exercises related to establishing an engineering company. Prereq: Graduate standing in engineering or consent of instructor.

#### CE 608 BUILDING INFORMATION MODELING FOR CONSTRUCTION. (3)

The course focuses on advanced information systems used to control and predict project performance (cost and schedule) in construction. Building Information Modeling is examined as a systems approach of integrating design and construction for the benefit of developing construction work packages, 4D simulations, clash detection, trade coordination, and status visualization. Prereq: CE 509 and enrollment in the Graduate School or consent of the instructor.

#### CE 621 INTRODUCTION TO FINITE ELEMENT ANALYSIS. (3)

Theoretical, conceptual, and computational aspects of the finite element method are developed. Development of the element relationships, element calculations, and assembly of the finite element equations are covered. Both one- and two-dimensional finite element problems are considered. One-dimensional problem areas include elastic deformation, heat conduction, fluid flow, electrostatics, groundwater flow, mass transport, beams on elastic foundations, etc. Two-dimensional problem areas include Poisson's equation, viscous incompressible flow, plane elasticity, and bending of elastic plates. Prereq: MA 432G, MA 537 or consent of instructor. (Same as ME 601.)

**CE 631 URBAN TRANSPORTATION PLANNING. (3)**

A detailed review of the transportation planning process; inventory methodologies; trip generation, distribution and assignment with associated mathematical models and theories; prediction of future travel; land and use models; modal split; developing and testing proposed systems; simulation. Prereq: CE 531 or equivalent and STA 381, or 681 or equivalent statistics course. (Same as GEO 643.)

**CE 633 AIR TRANSPORT ENGINEERING. (3)**

Planning location and design of airports, STOL ports, and heliports. Air traffic operations, performance and control as related to facility requirements. Role of governmental agencies. Prereq: CE 531 or consent of instructor.

**CE 634 TRAFFIC CHARACTERISTICS. (3)**

Vehicle operating characteristics; driver, pedestrian and roadway characteristics as they individually, and collectively as traffic stream characteristics, are related to the planning design and operation of highway facilities.

**CE 635 HIGHWAY SAFETY. (3)**

A detailed review of the impacts of safety considerations on highway design and planning, focusing on the highway environment, its users (both vehicles and drivers) and their interactions. The role of special interest groups (tracking industry, insurance agencies) is also examined. Prereq: CE 539 or consent of instructor.

**CE 641 MECHANICS OF LIQUID FLOW IN PIPES. (3)**

Steady and unsteady one-dimensional pipe flow. Water hammer and surge tank analysis. Steady two-dimensional pipe flow. Digital and analog computer applications. Prereq: CE 549.

**CE 642 OPEN CHANNEL FLOW. (3)**

The study of open channel flow fundamentals and concepts. Topics include uniform flow, varied flow, steady and unsteady flow, energy dissipators, flow transitions, controls, analytical and numerical solutions in 1D and 2D applications. Prereq: CE 541 or consent of instructor.(Same as BAE 642.)

**CE 643 MECHANICS OF SEDIMENT TRANSPORT. (3)**

Fundamentals of turbulence in rivers and sediment transport will be taught including recent theory, derivation of governing equations, experimental methods, modeling, and design based on sediment thresholds. Prereq: CE 341 or consent of instructor. (Same as BAE 643.)

**CE 652 BIOLOGICAL PROCESSES FOR WATER QUALITY CONTROL. (3)**

Principles and applications of environmental biotechnology for water quality control. Process microbiology and kinetics for various water and wastewater treatment processes. Prereq: CE 351 or consent of instructor. (Same as BAE 652.)

**CE 653 WATER QUALITY IN SURFACE WATERS. (3)**

Principles of surface water quality modeling and control. Analysis of dispersion, advection, natural aeration, biological oxidation and photosynthesis; their effects on the physical, chemical, and biological quality of waters in streams, lakes, reservoirs, estuaries and other surface waters. Prereq: CE 351 or consent of instructor. (Same as BAE 653.)

**CE 655 WATER SANITATION AND HEALTH. (3)**

Prevention of water-related diseases by appropriate supply and sanitation practices with designs applicable to small systems and rural areas of developing nations. (Same as CPH 790.)



### CE 662 STOCHASTIC HYDROLOGY. (3)

Hydrologic random variables and probability distributions. Statistical measures, development and use of Monte Carlo simulations in the generation of precipitation fields. Statistical tests of hydrologic data. Point frequency and regional frequency analysis. Analysis of hydrologic time series. Long-term trend, harmonic analysis of periodicity, autocorrelation, spectral analysis. Correlation and regression analysis. Linear stochastic models. Introduction to stochastic processes in hydrology, real-time hydrologic forecast (Kalman filter), pattern recognition, and stochastic differential equations. Prereq: MA 214, CE 461G or equivalent. (Same as BAE 662.)

### CE 664 WATERSHED MANAGEMENT. (3)

This course provides an overview of the scientific principles and management strategies used to effectively manage the physical, chemical, biological and social resources within a watershed so as to improve and sustain the integrity of the watershed system. The course will examine watershed management from both a scientific/engineering perspective as well as from a social science/policy perspective. Examples of effective watershed management will be drawn from cases studies in Kentucky and the United States. Students will be provided with an introduction to those spatial data sets, computer software, and methods currently used in watershed management practice. Prereq: BAE 437 or CE 461G or an equivalent course in hydrology, or consent of instructor. (Same as BAE 664.)

### CE 665 WATER RESOURCES SYSTEMS. (3)

Application of systems analysis, mathematic modeling, and optimization in water resources management and design. Solution of engineering problems found in water supply, water quality, urban drainage, and river basin development and management by use of linear, nonlinear, and dynamic programming models. Prereq: Consent of instructor. (Same as BAE 665.)

### CE 667 STORMWATER MODELING. (3)

Introduction to deterministic and parametric modeling approaches for mathematically simulating stormwater runoff and quality. Emphasis on modeling concepts and model formulation. Analysis of deterministic component models and their linkage. Formulation of existing parametric models. Presentation of methods for parameter optimization and regionalization. Demonstration of linkage between the two approaches with illustrative examples. Prereq: CE 341 and CE 461G, or consent of instructor. (Same as BAE 667.)

### CE 671 ADVANCED SOIL MECHANICS. (3)

Detailed study of soil behavior. Specific topics include soil classification and structure, strength and deformational behavior, compaction, consolidation, and stress distribution in earth masses. Prereq: CE 471G or consent of instructor.

### CE 672 LANDFILL DESIGN. (3)

This course deals with the geotechnical aspects of the design of landfills for the disposal of municipal solid waste. Since landfill design is driven by state and federal regulations, time is taken to review these regulations. Landfills are evaluated as engineered systems consisting of multiple components. Each component is investigated individually, and methods are developed to predict and quantify the performance of these components so that appropriate materials, design criteria, and construction methods can be selected to assure that the landfill will function with minimal environmental impact. Prereq: CE 471G. (Same as BAE 672.)

### CE 673 STABILITY OF EARTH SLOPES. (3)

Review of shear strength principle including laboratory and field tests for shear strength and shear strength of unsaturated soils; theoretical and practical aspects of infinite slopes, block analysis, method of slices, effective and total stress analysis, analysis of unsaturated slopes,

commercial software packages for slope stability analysis, probabilistic analysis of slope stability problems, rapid drawdown, and slope failure mitigation.

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**CE 676 GROUNDWATER AND SEEPAGE. (3)**

Permeability and capillary flow in soils, mathematical theory of flow through porous media. Flow through anisotropic, stratified and composite sections. Solution by flow net, conformal mapping and numerical methods. Seepage toward wells. Dewatering and drainage of soils. Prereq: CE 471G or consent of instructor.

**CE 679 GEOTECHNICAL EARTHQUAKE ENGINEERING. (3)**

Introduction to seismology. Dynamic and earthquake response of soils using standard analysis. Liquefaction of soils under cyclic loading. Measurements of dynamic properties of soils. Earthquake resistant design of retaining walls, foundations, slopes, and earth dams. Soil improvement methods for seismic resistant design. Current state-of-the-art techniques in geotechnical earthquake engineering. Prereq: CE 579.

**CE 681 ADVANCED CIVIL ENGINEERING MATERIALS. (3)**

Fundamental aspects of mechanical behavior of civil engineering materials. Rheology and fracture of asphalt and Portland cement concrete materials. Prereq: CE 381.

**CE 682 ADVANCED STRUCTURAL ANALYSIS. (3)**

Theory and application of energy principles for plane and space frames; shear wall structures; geometric and material nonlinear formations; and nonlinear solution strategies. Solution techniques for the analysis of large complex structures. Introduction to plane stress/strain, axisymmetric and plate bending finite element analysis.

**CE 684 SLAB AND FOLDED PLATE STRUCTURES. (3)**

Design and analysis of reinforced concrete floor slabs and folded plate roofs. Elastic and inelastic methods.

**CE 686 ADVANCED REINFORCED CONCRETE THEORY. (3)**

Background and origin of modern reinforced concrete design procedures and codes. Comparison of American and foreign methods of analysis. Review of current research and projection to anticipated future changes in design and construction practices. Prereq: CE 486G or consent of instructor.

**CE 687 ADVANCED STEEL DESIGN. (3)**

Strength of structural steel columns, including asymmetry and slender compression elements. Flexural strength of slender plate girders. Shear strength with and without post-buckling strength. Frame stability. Steel connections. Floor vibration serviceability. Prereq: CE 487G or consent of instructor.

**CE 699 TOPICS IN CIVIL ENGINEERING (Subtitle required). (1-4)**

An advanced level presentation of a topic from one of the major areas of civil engineering such as hydraulics, geotechnics, structures, transportation, surveying, or water resources. Course with a given subtitle may be offered not more than twice under this number. Prereq: Variable; given when topic identified; graduate standing.

**CE 748 MASTER'S THESIS RESEARCH. (0)**

Half-time to full-time work on thesis. May be repeated to a maximum of six semesters. Prereq: All course work toward the degree must be completed.

**CE 749 DISSERTATION RESEARCH. (0)**

Half-time to full-time work on dissertation. May be repeated to a maximum of six semesters. Prereq:

Registration for two full-time semesters of 769 residence credit following the successful completion of the qualifying exams.

**CE 767 DISSERTATION RESIDENCY CREDIT. (2)**

Residency credit for dissertation research after the qualifying examination. Students may register for this course in the semester of the qualifying examination. A minimum of two semesters are required as well as continuous enrollment (Fall and Spring) until the dissertation is completed and defended.

**CE 768 RESIDENCE CREDIT FOR MASTER'S DEGREE. (1-6)**

May be repeated to a maximum of 12 hours.

**CE 769 RESIDENCE CREDIT FOR DOCTOR'S DEGREE. (0-12)**

**CE 779 ADVANCED GEOTECHNICAL ENGINEERING. (3)**

Application of the principles of soil mechanics to the design and analysis of foundations and earth structures. Prereq: CE 579 and CE 671 or consent of instructor.

**CE 782 DYNAMICS OF STRUCTURES. (3)**

Review of methods of analysis of simple structural systems. Effects of wind, earthquake, traffic and machinery loads. Matrix methods for complex dynamic structural systems, random vibrations of structures.

**CE 784 SHELL STRUCTURES. (3)**

Design and analysis of reinforced concrete shell structures, including domes, barrel shells, hyperbolic paraboloids and cylindrical tanks. Prereq: CE 684 or consent of instructor.

**CE 790 SPECIAL RESEARCH PROBLEMS IN CIVIL ENGINEERING. (1-6)**

Individual work on some selected problems in one of the various fields of civil engineering. Laboratory, six hours. May be repeated to a maximum of nine credits. Prereq: Consent of the chairperson of the department.

**CE 791 SPECIAL DESIGN PROBLEMS IN CIVIL ENGINEERING. (1-6)**

Individual work on some selected problems in one of the various fields of civil engineering. Laboratory, six hours. May be repeated to a maximum of nine credits. Prereq: Consent of the chairperson of the department.