

# Civil Engineering (CE)

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## **CE 214 Engineering Mechanics-Statics** (3 credit hours)

Basic force concepts and equilibrium analysis; distributed forces; centroids; moments of inertia; application to structural elements. Credit will not be given for both CE 214 and MAE 206.

Grade of C or better in PY 205 and MA 241; Co-requisite: MA 242.

*Typically offered in Fall, Spring, and Summer*

## **CE 225 Mechanics of Solids** (3 credit hours)

Elementary analysis of deformable solids subjected to force systems. Concepts of stress and strain; one, two and three-dimensional stress-strain relationships for the linear elastic solid. Statically determinate and indeterminate axial force, torsion and bending members. Stress transformations, pressure vessels, combined loadings. Introduction to column buckling.

Grade of C- or better in CE 214; MA 242.

*Typically offered in Fall, Spring, and Summer*

## **CE 250 Introduction to Sustainable Infrastructure** (3 credit hours)

History and future of civil infrastructure; engineering problem solving; environmental sustainability and life-cycle assessment; social sustainability; engineering economics; problem-driven, sustainability-focused case studies related to different aspects of civil infrastructure.

Corequisite: CSC 111 and CE 214

*Typically offered in Fall and Spring*

## **CE 263 Introduction to Construction Engineering** (3 credit hours)

Introduction to fundamental concepts in Construction Engineering and Management including principles of project management and organization; engineering economics; cost estimation and basic productivities; project scheduling using the critical path method; professional aspects of construction; construction sustainability; and basic construction equipment and safety.

Corequisite: CSC 111 and CE 214

*Typically offered in Fall only*

## **CE 282 Hydraulics** (3 credit hours)

Fluid properties; mass, energy and momentum conservation laws; dimensional analysis and modeling; laminar and turbulent flows; surface and form resistance; flow in pipes and open channels; elementary hydrodynamics; fluid measurements; characteristics of hydraulic machines. Credit will not be given for both CE 282 and MAE 308.

Prerequisite: C- or better in CE 214; Corequisites: MA 341 or MA 305 or ST 370

*Typically offered in Fall, Spring, and Summer*

## **CE 297 Current Topics in Civil Engineering** (1-4 credit hours)

Presentation of material not normally available in regular course offerings, or offering of new courses on a trial basis. Credits and content determined by faculty member in consultation with Department Head.

*Typically offered in Fall, Spring, and Summer*

## **CE 301 Civil Engineering Surveying and Geomatics** (3 credit hours)

Plane surveying, topographical surveying, horizontal and vertical curves, topographic surveys, construction surveys, earthwork, route surveying. Data collection using sight-based, laser-based, and global positioning system equipment. Methods for analysis and presentation of surveying and positioning data, including dealing with errors. Use and applications of GPS information. Credit will not be given for both BAE 325 and CE 301.

Prerequisite: CE 225; Corequisite ST370.; Credit will not be given for both BAE 325 and CE 301.

*Typically offered in Fall and Spring*

## **CE 305 Introduction to Transportation Systems** (3 credit hours)

Integrated approach to planning, design, and operation of transportation systems with an emphasis on highway and street systems. Roadway design, traffic operations and performance, and control systems.

Prerequisite: C- or better in CE 250 or C- or better in CE 263;

Corequisite: ST 370

*Typically offered in Fall and Spring*

## **CE 325 Structural Analysis I** (3 credit hours)

Analysis of determinate and indeterminate bars, trusses, beams and frames using the matrix displacement method. Qualitative deflected shapes and shear and bending moment diagrams. Implementation of analysis procedures through computer programming and commercial structural analysis software.

CSC 111 and C- or better in CE 225.

*Typically offered in Fall and Spring*

## **CE 327 Reinforced Concrete Design** (3 credit hours)

Behavior, strength, and design of reinforced concrete members subjected to moment, shear, and axial forces. Introduction to the design of reinforced concrete structures.

Prerequisite: C- or better in CE 225

*Typically offered in Fall and Spring*

## **CE 332 Civil Engineering Materials** (4 credit hours)

Fundamental characteristics that govern material behavior. Properties of metals, ceramics, polymers, fiber reinforced composites, aggregates, portland cement concrete, and asphalt concrete. Portland cement concrete and asphalt concrete mixture designs. Materials testing according to established standards.

MSE 200 and C- or better in CE 225.

*Typically offered in Fall and Spring*

## **CE 339 Civil Engineering Systems** (3 credit hours)

A broad perspective, systematic approach to civil planning, analysis, evaluation and design for large scale projects in construction, structures, transportation, water resources and other civil engineering areas.

CSC 111 and (MA 341 or MA 305); Junior or Senior standing.

*Typically offered in Spring only*

**CE 342 Engineering Behavior of Soils and Foundations** (4 credit hours)

Description, identification, and engineering classification of soils. The basic principles and mechanics of flow of water through soils, deformation and strength of soils, and the processes of consolidation and compaction. Effective stress concepts, stress and settlement analyses, and evaluation of shear strength. Methods of analysis and geotechnical engineering design concepts.

C- or better in CE 225 and CE 282.

*Typically offered in Fall and Spring*

**CE 365 Construction Equipment and Methods** (3 credit hours)

Study of construction operations as dynamic production processes. Utilization of equipment and other resources to achieve highest levels of productivity, safety, and quality. Covers a wide range of traditional and state-of-the-art construction methods.

Corequisite: CE 214 and ST 370

*Typically offered in Spring only*

**CE 367 Mechanical and Electrical Systems in Buildings** (3 credit hours)

Introduction to mechanical and electrical systems in building construction. Includes HVAC, lighting and electrical systems, focusing on design concepts, equipment application, design of the construction process, and coordination using BIM, for modern building systems.

C- or better in CE 282.

*Typically offered in Spring only*

**CE 373 Fundamentals of Environmental Engineering** (3 credit hours)

Concepts of sustainability and green engineering; energy and climate; overview of contaminants in water, air and terrestrial environments; introduction to water and wastewater treatment, air pollution control, and solid waste management.

Corequisite: (CE 250 or CE 263) and (CHE 205 or CE 282)

*Typically offered in Fall and Spring*

**CE 378 Environmental Chemistry and Microbiology** (4 credit hours)

Principles of Environmental Chemistry and Microbiology, experimental techniques for assessing water and air quality; sampling; statistical interpretation of data.

Prerequisite: Junior standing in Environmental Engineering, MEA 323 or SSC 442, and C- or better in CE 250 and CE 373; Corequisite: ST 370.

*Typically offered in Fall only*

**CE 381 Hydraulics Systems Measurements Lab** (1 credit hours)

Introduction to experimental techniques for the analysis of hydraulic systems; measurement of viscosity, fluid pressures, velocity distributions, flow rates; investigations into the friction, momentum transfer, and turbulence on fluid flow.

Corequisite: CE 282

*Typically offered in Fall and Spring*

**CE 383 Hydrology and Urban Water Systems** (3 credit hours)

Study of engineering hydrology and design of elements of urban stormwater systems. Commonly encountered applications in urban stormwater management, flood control and groundwater engineering. Familiarization with effects of watershed development on quantity and quality of streamflow.

C- or better in CE 282; Corequisite: ST 370; CE, ENE, and CON Majors.

*Typically offered in Fall and Spring*

**CE 397 Current Topics in Civil Engineering** (1-4 credit hours)

Presentation of material not normally available in regular course offerings, or offering of new courses on a trial basis. Credits and content determined by faculty member in consultation with Department Head.

*Typically offered in Fall, Spring, and Summer*

**CE 401/CE 501 Transportation Systems Engineering** (3 credit hours)

Multi-modal transportation systems; railroads, airports, highways, and other modes. Planning, analysis, and design. Fundamental concepts; supply, demand, flows, impacts, and network optimization.

Prerequisite: C- or better in CE 305

*Typically offered in Fall only*

**CE 402/CE 502 Traffic Operations** (3 credit hours)

Highway capacity; traffic control systems; intelligent vehicle/highway systems; and other advanced topics. Credit for both CE 402 and CE 502 is not allowed.

Prerequisite: C- or better in CE 305

*Typically offered in Fall only*

**CE 403/CE 503 Highway Design** (3 credit hours)

Corridor selection; highway alignment; design of roadsides, intersections, and interchanges. Completion of research paper for students taking course for graduate credit. Credit will not be given for both CE 403 and CE 503.

Prerequisite: C- or better in CE 305

*Typically offered in Spring and Summer*

*This course is offered alternate odd years*

**CE 405/CE 505 Railroad System Planning, Design, and Operation** (3 credit hours)

Students will learn about railroad technology and how to plan, design, and operate rail systems especially the design of alignments, track, and terminals; and the operation of freight and passenger services (ranging from transit through commuter rail to intercity and high speed rail). Field trips are involved during non-scheduled class time. Students must be able, if necessary, to provide their own transportation.

Prerequisite: CE 305

*Typically offered in Spring only*

**CE 413 Principles of Pavement Design** (3 credit hours)

Basic principles of analysis, design and performance of highway and airport pavements with critical evaluation of current design and maintenance strategies.

CE 332 and CE 342

*Typically offered in Fall only*

**CE 420 Structural Engineering Project** (3 credit hours)

Planning, analysis and design of complete structural systems composed of steel and reinforced concrete. Professional topics in structural engineering practice.

C- or better in CE 325 and CE 327 and CE 342 and CE 426.

*Typically offered in Fall and Spring*

**CE 426 Structural Steel Design** (3 credit hours)

Design and behavior of structural steel members and their connections subjected to moment, shear, and axial forces. Introduction to the design of steel structures.

C- or better in CE 225.

*Typically offered in Fall, Spring, and Summer*

**CE 435 Engineering Geology** (3 credit hours)

Application of both geology and geotechnical engineering to engineering projects. Illustrations of relevant materials properties and techniques utilized in describing subsurface conditions.

Prerequisite: C- or better in CE 342

*Typically offered in Fall and Spring*

**CE 437 Civil Engineering Computing** (3 credit hours)

Computational approaches to modeling with applications in construction, structures, transportation, water resources and other civil engineering areas; matrix computations, digital terrain modeling, network applications and algorithms, heuristic optimization.

Senior standing; CSC 111 and (MA 341 or MA 305).

*Typically offered in Fall only*

**CE 443 Seepage, Earth Embankments and Retaining Structures** (3 credit hours)

Review of shear strength concepts; ground water hydraulics; slope stability; lateral earth pressure problems; placement of fills.

Prerequisite: C- or better in CE 342

*Typically offered in Fall and Spring*

**CE 444 An Introduction to Foundation Engineering** (3 credit hours)

This course will cover the basics of subsurface analysis and foundation design. Subsurface analysis includes the planning and interpretation of site investigation programs, including insitu testing and sampling, and laboratory testing and data interpretation. Foundation design will include the study of shallow and deep foundations subject to a combination of vertical and lateral loads.

C- or better in CE 342.

*Typically offered in Fall and Spring*

*This course is offered alternate even years*

**CE 450 Civil Engineering Project** (3 credit hours)

Integrated multi-disciplinary team approach to large-scale civil engineering design including topics from geotechnical engineering, land development, transportation engineering, and water resources engineering. Professional topics in civil engineering practice and ethics.

Prerequisite: CE 305 and CE 342 and CE 383; Corequisite: one of (CE 402, CE 403, CE 413, CE 435, CE 444, or CE 488)

*Typically offered in Fall and Spring*

**CE 463 Construction Estimating, Planning, and Control** (3 credit hours)

Overview of the construction industry; life cycle of construction projects, work breakdown structure, activity cost and time estimation, computerized planning and scheduling methods, resource leveling, time-cost tradeoff; computerized cost estimating, bidding and negotiation strategies; and cost/schedule control systems.

Prerequisite: C- or better in CE 263; CE 365 and TDE 220

*Typically offered in Fall only*

**CE 464/CE 564 Legal Aspects of Contracting** (3 credit hours)

Legal aspects of contract documents, drawings and specifications; owner-engineer-constructor relationships and responsibilities; bids and contract performance, Labor laws; governmental administrative and regulatory agencies; torts; business organizations; ethics and professionalism.

Prerequisite: CE 463; Corequisite: CE 365

*Typically offered in Spring only*

**CE 466 Building Construction Engineering** (3 credit hours)

Construction processes for buildings and other structures including codes and standards, structural and architectural components and systems, form work and bracing design, erection and assembly methods.

Corequisite: CE 327

*Typically offered in Fall only*

**CE 469 Construction Engineering Project** (3 credit hours)

Capstone course involving integrated team approach in the design of the construction process, utilizing computerized tools for cost estimation, planning, scheduling, process design, and management of two construction projects. Each student also selects an individual project. Lecture topics include: ethics, professionalism, marketing, bid presentations, business planning, finance, and other appropriate topics by guest speakers from industry.

Prerequisite: CE 463 Co-requisite: CE 464

*Typically offered in Spring only*

**CE 475/CE 575 Renewable Energy and the Grid** (3 credit hours)

Renewable energy technologies such as wind and solar power make up a growing share of the generation mix. Students develop skills in renewable resource assessment, technical design of renewable energy systems, economic assessment of these technologies, and evaluation of relevant policies. We explore fundamentals and practical aspects of commonly used renewable energy models and extensive energy and resource data sets.

Prerequisite: Senior standing and CE 250 or ISE 311 (or equivalent)

*Typically offered in Spring only*

**CE 476 Air Pollution Control** (3 credit hours)

Introduction to air pollution control fundamentals and design. Fundamentals include the physics, chemistry and thermodynamics of pollutant formation, prevention and control. Design will include gas treatment, process modification, and feedstock modification. Pollutants to be addressed include sulfur dioxide, nitrogen oxides, particulate matter, volatile organic compounds, hydrocarbons, and air toxics. Credit for both CE 476 and CE 576 will not be given.

CE 373 and MAE 201; Corequisite: ST 370 or CHE 450 (CHE majors)

*Typically offered in Fall only*

**CE 477 Principles of Solid Waste Engineering** (3 credit hours)

Solid waste management including generation, storage, transportation, processing, land disposal and regulation. Processing alternatives including incineration and composting. Integration of policy alternatives with evaluation of engineering decisions.

CE 250, CE 282 and CE 373.

*Typically offered in Spring only*

**CE 478/CE 578 Energy and Climate** (3 credit hours)

Interdisciplinary analysis of energy technology, natural resources, and the impact on anthropogenic climate change. Topics include basic climate science, energetics of natural and human systems, energy in fossil-fueled civilization, the impact of greenhouse gas emissions on climate, and technology and public policy options for addressing the climate challenge. The course is quantitative with a strong emphasis on engineering and science.

Prerequisite: Senior standing

*Typically offered in Fall only*

**CE 479/MEA 479 Air Quality** (3 credit hours)

Introduction to: risk assessment, health effects, and regulation of air pollutants; air pollution statistics; estimation of emissions; air quality meteorology; dispersion modeling for non-reactive pollutants; chemistry and models for tropospheric ozone formation; aqueous-phase chemistry, including the "acid rain: problem; integrated assessment of air quality problems; and the fundamentals and practical aspects of commonly used air quality models. Credit is allowed only for one of CE/MEA 479 or CE/MEA 579.

CE 282 and CE 373; or CHE 311(CHE Majors); or MEA 421 (MEA Majors); Corequisite: ST 370; or ST 380 (MEA Majors)

*Typically offered in Spring only*

**CE 481 Environmental Engineering Project** (3 credit hours)

Engineering design of selected projects in environmental engineering involving interactions with other scientific and engineering disciplines. Discussion of ethical conduct and professional engineering practice.

Prerequisite: CE 378, 383 Corequisite: CE 484 and two of: CE 476, 477, 479, 488

*Typically offered in Spring only*

**CE 484 Water Supply and Waste Water Systems** (3 credit hours)

Elements of the design of water supply and wastewater disposal systems.

CE 282 and CE 373.

*Typically offered in Fall only*

**CE 487 Introduction to Coastal and Ocean Engineering** (3 credit hours)

Introduction to the analysis of civil engineering projects in the ocean and along the coastline. Basic wave mechanics, tides, and ocean dynamics as applied to the understanding of coastal erosion control and other marine problems. An optional two-day field trip to the North Carolina Outer Banks at a nominal student expense is a regular feature of the course.

Senior standing and CE 282.

*Typically offered in Spring only*

**CE 488/CE 588 Water Resources Engineering** (3 credit hours)

Extension of the concepts of fluid mechanics and hydraulics to applications in water supply, water transmission, water distribution networks and open channels to include water-supply reservoirs, pump and pipe selection, determinate and indeterminate pipe networks, and analysis of open channels with appurtenances.

Prerequisite: CE 339 and CE 383

*Typically offered in Fall only*

**CE 493 Independent Study in Civil Engineering** (1-4 credit hours)

Independent study of a topic in Civil Engineering. Topic and mode of study determined by faculty member(s) and student(s). Individualized/Independent Study and Research courses require a "Course Agreement for Students Enrolled in Non-Standard Courses" be completed by the student and faculty member prior to registration by the department.

*Typically offered in Fall, Spring, and Summer*

**CE 497 Current Topics in Civil Engineering** (1-4 credit hours)

Presentation of material not normally available in regular course offerings or offering of new courses on a trial basis. Credits and content determined by faculty member in consultation with the Department Head.

*Typically offered in Fall, Spring, and Summer*

**CE 498 Special Problems in Civil Engineering** (1-4 credit hours)

Directed reading in the literature of civil engineering, introduction to research methodology, seminar discussion dealing with special civil engineering topics of current interest.

Prerequisite: Senior standing

*Typically offered in Fall and Spring*

**CE 499 Undergraduate Research Thesis in Civil, Construction and Environmental Engineering** (1-3 credit hours)

Faculty mentored research related to civil, construction or environmental engineering. A plan of work is required describing the independent research culminating in a thesis. Presentation at the NC State Undergraduate Research Symposium, or other similar venue, may be included. The student must identify a research advisor from within the CCEE faculty. Departmental approval is required.

Senior standing. Departmental Approval Required.

*Typically offered in Fall, Spring, and Summer*

**CE 501/CE 401 Transportation Systems Engineering** (3 credit hours)

Multi-modal transportation systems; railroads, airports, highways, and other modes. Planning, analysis, and design. Fundamental concepts; supply, demand, flows, impacts, and network optimization.

Prerequisite: C- or better in CE 305

*Typically offered in Fall only*

**CE 502/CE 402 Traffic Operations** (3 credit hours)

Highway capacity; traffic control systems; intelligent vehicle/highway systems; and other advanced topics. Credit for both CE 402 and CE 502 is not allowed.

Prerequisite: C- or better in CE 305

*Typically offered in Fall only*

**CE 503/CE 403 Highway Design** (3 credit hours)

Corridor selection; highway alignment; design of roadsides, intersections, and interchanges. Completion of research paper for students taking course for graduate credit. Credit will not be given for both CE 403 and CE 503.

Prerequisite: C- or better in CE 305

*Typically offered in Spring and Summer*

*This course is offered alternate odd years*

**CE 504 Airport Planning and Design** (3 credit hours)

Analysis, planning and design of air transportation facilities.

Prerequisite: C- or better in CE 305

*Typically offered in Fall only*

*This course is offered alternate even years*

**CE 505/CE 405 Railroad System Planning, Design, and Operation** (3 credit hours)

Students will learn about railroad technology and how to plan, design, and operate rail systems especially the design of alignments, track, and terminals; and the operation of freight and passenger services (ranging from transit through commuter rail to intercity and high speed rail). Field trips are involved during non-scheduled class time. Students must be able, if necessary, to provide their own transportation.

Prerequisite: CE 305

*Typically offered in Spring only*

**CE 507 Sensors, Instrumentation, and Data Analytics for Transportation Networks** (3 credit hours)

Students will learn about the use of sensors, instrumentation, and big data analysis in transportation systems to observe, monitor, and evaluate performance. This includes the technology employed, the deployment strategies, the challenges associated with obtaining high-quality data, the fusion of data from independent sources, the imputation of missing data elements, and evaluation of performance based on the data assembled. The highway mode is the principal focus, including analyses of travel times, delays, queue dynamics, and spatial and temporal demand patterns.

*Typically offered in Spring only*

**CE 508 Transportation Systems Management** (3 credit hours)

Transportation systems management; application of monitoring, communications and information dissemination technologies to transportation systems. Traffic management for freeway and arterial systems. Traveler information and public transportation systems. Management of automated vehicles. Evaluation methods and models.

Restriction: Graduate standing in CCEE

*Typically offered in Spring only*

*This course is offered alternate even years*

**CE 509 Highway Safety** (3 credit hours)

Methods to reduce collisions and injuries on highways. Identifying promising locations, choosing appropriate countermeasures, and evaluating past projects. Understanding the institutional context and establishing appropriate highway design standards.

Prerequisite: CE 305, Corequisite: ST 370 or equivalent

*Typically offered in Spring only*

*This course is offered alternate even years*

**CE 510 Transportation Policy and Funding** (3 credit hours)

Understanding and debating important current transportation policy issues in the U.S. Raising and allocating funds for building and maintaining the transportation system. Highway, public transit, rail, air, and other modes.

Prerequisite: CE 501 or graduating in Economics or Public Administration

*Typically offered in Fall only*

*This course is offered alternate odd years*

**CE 515 Advanced Strength of Materials** (3 credit hours)

Stresses and strains at a point; rosette analysis; torsion and unsymmetrical bending of open and closed sections; nonlinear and curved beams; stress concentration; beams on elastic foundations; shear deformation of beams; classical plasticity; fracture mechanics.

Prerequisite: CE 225 or MAE 314

*Typically offered in Fall only*

**CE 522 Theory and Design Of Prestressed Concrete** (3 credit hours)

Principles and concepts of design in prestressed concrete including elastic and ultimate strength analyses for flexure, shear, torsion, bond and deflection. Principles of concordancy and linear transformation for indeterminate prestressed structures. Application of pre-stressing to tanks and shells.

Prerequisite: CE 327

*Typically offered in Fall only*

**CE 523 Theory and Behavior Of Steel Structures** (3 credit hours)

Theory and behavior of steel structures leading to the development of design requirements contained in current specifications; flexural, torsional and flexural-torsional buckling of columns; plastic analysis of beams and frames; lateral-torsional buckling of beams; stability and strength of flat plates; beam-columns.

Prerequisite: CE 426

*Typically offered in Fall only*

**CE 524 Analysis and Design Of Masonry Structures** (3 credit hours)

Theory and design of masonry arches, culverts, dams, foundations and masonry walls subjected to lateral loads.

Prerequisite: CE 327

*Typically offered in Spring only*

*This course is offered alternate years*

**CE 525 Advanced Structural Analysis** (3 credit hours)

Analysis of 1D bar and beam, 2D/3D truss, and 2D/3D frame structures using the matrix displacement method. Introduction to the finite element method of analysis by deriving the element stiffness matrices and equivalent nodal loads using the Principle of Virtual Work. Derivation of Timoshenko beam elements for including shear deformation effects. Development of techniques to handle non-standard loading (e.g. support displacements, temperature changes) and accurately model member-releases. Introduction to material/geometric nonlinearity. Implementation of analysis procedures through computer programming and commercial structural analysis software.

Prerequisite: CE 325

*Typically offered in Fall only*

**CE 526 Finite Element Method in Structural Engineering** (3 credit hours)

Development of the finite element method with an emphasis on understanding the fundamental principles governing the analysis technique. Applications to two-dimensional solids with particular attention to applications in structural engineering. Typical modeling considerations are reviewed and applied to the analysis of a realistic structure.

Prerequisite: CE 515

*Typically offered in Spring only*

**CE 527 Structural Dynamics** (3 credit hours)

Analysis of single and multi-degree-of-freedom structures subjected to various types of excitations and initial conditions. Computational aspects of dynamic analysis. Introduction to approximate methods of analysis.

Prerequisite: CE 425 or CE 525

*Typically offered in Spring only*

**CE 528/FB 528 Structural Design in Wood** (3 credit hours)

Behavior, strength and design of wood structural members subjected to moment, shear and axial forces. Design of connections and introduction to design of wood structural systems.

Prerequisite: C- or better in CE 325

*Typically offered in Spring only*

**CE 529 FRP Strengthening and Repair of Concrete Structures** (3 credit hours)

Fundamental behavior of Fiber-Reinforced Polymer (FRP) strengthened/ repaired reinforced concrete structures. Creation of sustainable and resilient civil infrastructure by extending the useful life of existing structures using advances materials. Applications to practical strengthening design of realistic reinforced concrete structures.

Prerequisite: CE 327 and CE 325

*Typically offered in Fall only*

**CE 530 Properties of Concrete and Advanced Cement-Based Composites** (3 credit hours)

This course consists of three parts. First part covers basic properties of cements, mineral/chemical admixtures, and concrete production. Second part covers mechanical properties including compressive and tensile strength, multi-axial loading, composite models, and fracture mechanics. Models of porosity and microstructures are also discussed. Third part covers durability and deterioration mechanisms including corrosion of steel in concrete, mass transport, service life prediction. Advanced laboratory techniques are discussed. This course also covers emerging topics such as geopolymers and aluminates cements.

Prerequisite: CE 332 and CE 225

*Typically offered in Spring only*

**CE 536 Introduction to Numerical Methods for Civil Engineers** (3 credit hours)

Introduction to widely-used numerical methods through application to civil and environmental engineering problems. Emphasis will be on implementation and application rather than the mathematical theory behind the numerical methods.

Prerequisite: MA 302, MA 341, or MA 401

*Typically offered in Spring and Summer*

**CE 537/OR 537 Computer Methods and Applications** (3 credit hours)

Computational approaches to support civil planning, analysis, evaluation and design. Applications to various areas of civil engineering, including construction, structures, transportation and water resources.

Prerequisite: CSC 111 and (MA 341 or MA 305)

*Typically offered in Fall only*

**CE 538 Information Technology and Modeling** (3 credit hours)

Computing research and advanced technologies of interest to civil engineers. Issues in the design and development of engineering software systems and engineering modeling of structures, assemblies, processes and phenomena. Additional topics from the most predominant and recent developments and advances in civil engineering computing.

Prerequisite: CE 390

*Typically offered in Fall and Spring*

**CE 548 Engineering Properties Of Soils I** (3 credit hours)

Significant soil properties in earthwork engineering, including soil elasticity and soil mineralogy, hydraulic conductivity, stress-strain relations and shear strength, compressibility and compaction. Evaluating laboratory work including plasticity, triaxial compression, permeability, consolidation and compaction tests.

Prerequisite: CE 342

*Typically offered in Fall only*

**CE 549 Soil and Site Improvement** (3 credit hours)

Principles and design methodologies for techniques related to densification, including dynamic compaction, vibro-compaction and compaction grouting; drainage, including wick drains, horizontal drains and dewatering; physical and chemical modification, including admixtures, chemical and cement grouting, soil mixing, jet grouting and soil freezing; and use of inclusions, including stone columns, soil nailing, and meta and geosynthetic reinforcement.

Prerequisite: CE 342

*Typically offered in Spring only*

**CE 550 Professional Engineering Communication** (3 credit hours)

Communicating effectively is central to the success of any engineering project and to advance in your engineering career. In this course you will learn principles of writing clearly and effectively for the wide range of communication activities professional engineers must do for a variety of audiences. Topics covered include writing reports, writing proposals, delivering presentations, planning and revising writing, providing feedback, and more. Students will get hands-on experience working on a wide range of documents for their career.

P: Graduate Standing

*Typically offered in Fall, Spring, and Summer*

**CE 557 Engineering Measurement and Data Analysis** (3 credit hours)

The course will introduce students to fundamentals of experimental design, measurement systems and applied data analysis techniques and includes 'hands-on' laboratory exercises with sensors and computer-based data acquisition. Emphasis is on general concepts and their practical application towards engineering problems. The goal of the class is to build needed background, skills and vocabulary to develop students' experimental practice rather than focusing on the underlying fundamentals of distinct areas. Students will develop more topic/media-specific knowledge through a team experimental project. Prerequisites include a course in statistics (e.g. ST 370, ST 515 or equivalent) and some coursework or experience involving scientific programming (e.g. CE 536 or 537; Matlab, Python, R, Igor Pro, IDL). Appropriate background can be determined via discussion with instructor.

*Typically offered in Fall only*

**CE 561 Construction Project Management** (3 credit hours)

Construction project management and control using network based tools, time-money analysis and other quantitative and qualitative techniques. Planning and scheduling, critical path, lead-lag, resource allocation, uncertainty, cash flow and payment scheduling, change orders, project acceleration, coordination and communication, record keeping. Emphasis on computer-based techniques.

Prerequisite: CE 463

*Typically offered in Spring only*

*This course is offered every third semester*

**CE 562 Lean Construction Concepts and Methods** (3 credit hours)

Student teams apply concepts and methods in field studies of real project management processes and construction operations by using principles and methods in Lean Production, Construction, Design, Assembly, Supply, Production Control, and Work Process Design.

Prerequisite: CE 463

*Typically offered in Fall only*

**CE 564/CE 464 Legal Aspects of Contracting** (3 credit hours)

Legal aspects of contract documents, drawings and specifications; owner-engineer-constructor relationships and responsibilities; bids and contract performance, Labor laws; governmental administrative and regulatory agencies; torts; business organizations; ethics and professionalism.

Prerequisite: CE 463; Corequisite: CE 365

*Typically offered in Spring only*

**CE 565 Construction Safety Management** (3 credit hours)

Fundamentals of safety management principles. Detailed review of OSHA regulations and standards critical to construction engineers and managers who expect to design and administer safety related systems in a construction project. Analysis and design of example minimum safety requirements for application in construction field operations. Review of OSHA Standards for the Construction Industry, a review of selected sections of OSHA Standards for General Industry, a review of general principles of construction safety management.

Prerequisite: CE 465 or CE 466

*Typically offered in Spring only*

*This course is offered alternate odd years*

**CE 566 Global Construction Engineering and Management Practices** (3 credit hours)

Construction is a global business. It is common to find design simultaneously performed in different countries (24/7 design); material procured from sources around the globe; and construction performed by a workforce that is multicultural, multilingual, and multinational. Because of these characteristics those involved with this profession need to embrace this reality and become more aware of the various design and construction practices found throughout the world. This course provides students with such a global awareness by revealing construction practices and innovations found in both developed and emerging countries. To introduce this global awareness, unique construction perspectives will be offered by a consortium of universities located in China, Thailand, Africa, and the U.S. Special topic lecturers will present practices found in other parts of the world including the Middle East, Europe and Central and South America.

Restriction: Graduate standing in the Department of Civil, Construction, and Environmental Engineering unless otherwise agreed upon by instructor

*Typically offered in Fall and Spring*

**CE 567 Risk and Financial Management in Construction** (3 credit hours)

Fundamental concepts in financial and risk analysis in construction; accounting and financial metrics in construction; risk assessment and risk management in construction including the cost of risk, decision making strategies, the role of sureties, effects of risk in project delivery methods and contract types; risk effects in project financing including a review of financing sources, considerations for financing local and international projects; and the impact of financial and risk management in strategic planning in construction.

Prerequisite: ACC 220, CE 463

*Typically offered in Spring only*

*This course is offered alternate even years*

**CE 568 Building Information Modeling in Construction** (3 credit hours)

This course will introduce concepts and applications of Building Information Modeling (BIM) both as a product and as a process. BIM is not only a design tool but is also an approach to building project delivery in which a digital representation of the building process is used to facilitate the exchange and interoperability of information. This course will focus on how BIM is used in construction projects for: 3D modeling; 4D modeling that integrates construction schedule; 5D modeling that integrates schedule and cost; and short-term planning.

R: Major in Civil Engineering or approval from the instructor

*Typically offered in Fall only*

**CE 571 Physical Principles of Environmental Engineering** (3 credit hours)

Mass balances, equation of motion for small particles, small particle interactions, particle collision/fast coagulation, partitioning, adsorption isotherms, fluid mechanics, diffusion, interphase mass transport and resistance models, elementary/non-elementary reactions, residence time distributions.

Prerequisite: CE 282, Graduate standing

*Typically offered in Spring only*

**CE 573 Biological Principles of Environmental Engineering** (3 credit hours)

Concepts in environmental microbiology including cell structure and function, phylogeny, survey of environmentally relevant microbial groups, metabolism under different redox conditions, catabolism of macromolecules, methods in microbial ecology. Relationships to engineering processes and systems will be emphasized.

Prerequisite: Graduate standing in CE, BAE, CHE, or SSC

*Typically offered in Fall only*

**CE 574 Chemical Principles of Environmental Engineering** (3 credit hours)

Inorganic and organic environmental chemistry including acid-base equilibria, precipitation, complexation, redox reactions, and natural organic matter. The role of these factors in controlling the fate of contaminants in engineered treatment systems and natural environments.

Prerequisite: Graduate standing in CE, CHE, BAE, NE, MEA, SSC

*Typically offered in Fall only*

**CE 575/CE 475 Renewable Energy and the Grid** (3 credit hours)

Renewable energy technologies such as wind and solar power make up a growing share of the generation mix. Students develop skills in renewable resource assessment, technical design of renewable energy systems, economic assessment of these technologies, and evaluation of relevant policies. We explore fundamentals and practical aspects of commonly used renewable energy models and extensive energy and resource data sets.

Prerequisite: Senior standing and CE 250 or ISE 311 (or equivalent)

*Typically offered in Spring only*

**CE 576 Engineering Principles Of Air Pollution Control** (3 credit hours)

Introduction to air pollution control fundamentals and design. Fundamentals including physics, chemistry and thermodynamics of pollutant formation, prevention and control. Design including gas treatment and process and feedstock modification. Addressed pollutants including sulfur dioxide, nitrogen oxides, particulate matter, volatile organic compounds, hydrocarbons and air toxins. Investigation of current research. Credit for both CE 476 and CE 576 is not allowed.

Prerequisite: CE 375, CE 470, CHE 315 or MAE 301, Corequisite: ST 511 or 515

*Typically offered in Fall only*

**CE 577 Engineering Principles Of Solid Waste Management** (3 credit hours)

Solid waste management including generation, storage, transportation, processing, land disposal and regulation. Processing alternatives including incineration and composting. Integration of policy alternatives with evaluation of engineering decisions. Investigation of current research. Credit is only allowed for one of CE 477 and CE 577.

Prerequisite: CE 373

*Typically offered in Spring only*

**CE 578/CE 478 Energy and Climate** (3 credit hours)

Interdisciplinary analysis of energy technology, natural resources, and the impact on anthropogenic climate change. Topics include basic climate science, energetics of natural and human systems, energy in fossil-fueled civilization, the impact of greenhouse gas emissions on climate, and technology and public policy options for addressing the climate challenge. The course is quantitative with a strong emphasis on engineering and science.

Prerequisite: Senior standing

*Typically offered in Fall only*

**CE 579 Principles of Air Quality Engineering** (3 credit hours)

Introduction to: risk assessment, health effects, and regulation of air pollutants; air pollution statistics; estimation of emissions; air quality meteorology; dispersion modeling for non-reactive pollutants; chemistry and models for tropospheric ozone formation; aqueous-phase chemistry, including the "acid rain" problem; integrated assessment of air quality problems; and the fundamentals and practical aspects of commonly used air quality models. Credit is allowed only for one of CE/MEA 479 or CE/MEA 579.

Prerequisite: CE 373, CE 382 or CHE 311(CHE Majors), or

MEA 421(MEA Majors), Corequisite: ST 370, ST 380(MEA Majors)

*Typically offered in Spring only*

**CE 580 Coastal Modeling** (3 credit hours)

CE 580 Coastal Modeling prepares students to develop and apply computational models for nearshore ocean waves and circulation, for aid in engineering design.

Prerequisite: Introductory course in fluid mechanics (e.g. CE 282) or permission of instructor

*Typically offered in Spring only*

*This course is offered alternate odd years*

**CE 581/MEA 581 Fluid Mechanics in Natural Environments** (3 credit hours)

Free surface flows of water and air occurring in natural fluid systems and influencing environmental transport and mixing. Review of fundamental principles of fluids, covering the scales relevant to both engineering and geo-physical applications. Topics and examples include waves, instability, stratification, turbulent boundary layers, jets and plumes, and open channel flows. Cannot receive credit for both CE 581 and MEA 581.

Prerequisite: CE 282 or MEA 463 or permission of instructor

*Typically offered in Fall only*

**CE 582 Coastal Hydrodynamics** (3 credit hours)

This course gives an introduction to water wave mechanics for engineers and scientists. Topics include wave generation, propagation, kinematics, transformation, breaking, forces, and dissipation.

Prerequisite: CE 282 or permission of instructor.

*Typically offered in Spring only*

**CE 583 Engineering Aspects Of Coastal Processes** (3 credit hours)

Coastal environment, engineering aspects of mechanics of sediment movement, littoral drift, beach profiles, beach stability, meteorological effects, tidal inlets, inlet stability, shoaling, deltas, beach nourishment, mixing processes, pollution of coastal waters, interaction between shore processes and man-made structures, case studies.

C- or better in CE 282.

*Typically offered in Spring only*



**CE 584 Hydraulics Of Ground Water** (3 credit hours)

Introduction to ground water hydraulics and hydrology. Hydrologic cycle, basic ground water hydraulics, numerical solution of governing equations, ground water hydrology of North Carolina, well design and construction, flow net development, and ground water contamination sources.

Prerequisite: CE 282

*Typically offered in Fall only*

**CE 585 Principles of Surface Water Quality Modeling** (3 credit hours)

This course addresses how human inputs affect natural and engineered aquatic systems, through mathematical modeling of system dynamics. Course topics integrate physical, chemical, and biologic processes related to pollutants and lower food-web dynamics. Lectures and assignments cover both theory and application. Applications are relevant to informing management, protection, and restoration of inland and coastal waters.

Prerequisite courses include environmental processes (e.g., CE 373) and quantitative calculus-based hydrology (e.g., CE 383), or permission of instructor.

*Typically offered in Spring only*

**CE 586 Engineering Hydrology** (3 credit hours)

Hydrologic principles underlying procedures for surface water modeling; applications of common hydrologic models to actual watersheds.

Prerequisite: CE 383

*Typically offered in Fall only*

**CE 588/CE 488 Water Resources Engineering** (3 credit hours)

Extension of the concepts of fluid mechanics and hydraulics to applications in water supply, water transmission, water distribution networks and open channels to include water-supply reservoirs, pump and pipe selection, determinate and indeterminate pipe networks, and analysis of open channels with appurtenances.

Prerequisite: CE 339 and CE 383

*Typically offered in Fall only*

**CE 590 Special Topics In Civil Engineering** (1-6 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 591 Special Topics in Civil Engineering Computing** (1-6 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 592 Special Topics in Construction Engineering** (1-6 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 593 Special Topics in Geotechnical Engineering** (1-3 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 594 Special Topics in Structures and Mechanics** (1-6 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 595 Special Topics in Transportation Engineering** (1-6 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 596 Special Topics in Water Resource and Environmental Engineering** (1-6 credit hours)

New or special course on recent developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 603 Construction Engineering Seminar** (1 credit hours)

Discussions and reports of subjects in civil engineering and allied fields.

*Typically offered in Fall and Spring*

**CE 605 Structures and Mechanics Seminar** (1 credit hours)

Discussions and reports of subjects in civil engineering and allied fields.

*Typically offered in Fall and Spring*

**CE 607 Water Resource and Environmental Engineering Seminar** (1 credit hours)

Discussions and reports of subjects in civil engineering and allied fields.

*Typically offered in Fall and Spring*

**CE 610 Special Topics CE** (1-6 credit hours)

**CE 635 Advanced Reading In Civil Engineering** (1-3 credit hours)  
Directed reading of advanced topics in some phase of civil engineering.

Prerequisite: Graduate standing

*Typically offered in Summer only*

**CE 675 Civil Engineering Projects** (1-6 credit hours)

Research- or design-oriented independent study and investigation of a specific civil engineering topic, culminating in final written report.

*Typically offered in Fall, Spring, and Summer*

**CE 685 Master's Supervised Teaching** (1-3 credit hours)

Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Master's student

*Typically offered in Fall, Spring, and Summer*

**CE 688 Non-Thesis Masters Continuous Registration - Half Time Registration** (1 credit hours)

For students in non-thesis master's programs who have completed all credit hour requirements for their degree but need to maintain half-time continuous registration to complete incomplete grades, projects, final master's exam, etc.

Prerequisite: Master's student  
*Typically offered in Summer only*

**CE 689 Non-Thesis Master Continuous Registration - Full Time Registration** (3 credit hours)

For students in non-thesis master's programs who have completed all credit hour requirements for their degree but need to maintain full-time continuous registration to complete incomplete grades, projects, final master's exam, etc. Students may register for this course a maximum of one semester.

Prerequisite: Master's student  
*Typically offered in Summer only*

**CE 693 Master's Supervised Research** (1-9 credit hours)

Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Master's student  
*Typically offered in Summer only*

**CE 695 Master's Thesis Research** (1-9 credit hours)

Thesis research.

Prerequisite: Master's student  
*Typically offered in Fall, Spring, and Summer*

**CE 696 Summer Thesis Research** (1 credit hours)

For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Master's student  
*Typically offered in Summer only*

**CE 699 Master's Thesis Preparation** (1-9 credit hours)

For students who have completed all credit hour requirements and full-time enrollment for the master's degree and are writing and defending their thesis.

Prerequisite: Master's student  
*Typically offered in Summer only*

**CE 701 Urban Transportation Planning** (3 credit hours)

Planning and design of urban transportation systems as related to comprehensive urban planning; principles of land use planning, urban thoroughfare planning and regional planning

Prerequisite: CE 501  
*Typically offered in Spring only*  
*This course is offered alternate odd years*

**CE 702 Traffic Flow Theory** (3 credit hours)

Stream flow, shock wave, queuing, and other macroscopic theories; car following, gap acceptance, and other microscopic theories; distributions of traffic stream parameters; building traffic simulation models.

Prerequisite: CE 502, Corequisite: ST 370  
*Typically offered in Fall only*  
*This course is offered alternate odd years*

**CE 703 Economic Analysis of Transportation Systems** (3 credit hours)

Transportation economics in terms of its supply and demand, costs, pricing, and regulation, especially the way in which the theory of economics in the marketplace and for public and private firms applies to the transportation market given its unique characteristics.

*Typically offered in Fall only*

**CE 706 Advanced Traffic Control** (3 credit hours)

Advanced signalized traffic control methods at intersections, arterials and networks. Applications of mathematical optimization techniques to signal timing and coordination. Use of traffic simulation and optimization models for signal evaluation and design. Roundabout analysis and design.

Prerequisite: CE 502  
*Typically offered in Spring only*  
*This course is offered alternate even years*

**CE 707 Transportation Policy and Funding** (3 credit hours)

Understanding and debating important current transportation policy issues in the U.S. Raising and allocating funds for building and maintaining the transportation system. Highway, public transit, rail, air, and other modes.

Prerequisite: CE 501 or graduating in Economics or Public Administration  
*Typically offered in Spring only*  
*This course is offered alternate even years*

**CE 714 Stress Waves** (3 credit hours)

Theory of stress waves in solids. Origins and nature of longitudinal transverse and surface waves originating at an impact site or from other transient disturbances. Determination of stresses, particle velocities, wave velocities. Wave interaction with other waves and with boundaries and dissimilar materials. Modern instrumentation and seismic refraction exploration.

Prerequisite: MA 341; CE 225 or PY 411 or MA 401  
*Typically offered in Fall only*  
*This course is offered alternate years*

**CE 718 Constitutive Modeling of Engineering Materials** (3 credit hours)

Stresses and strains (vectors, tensors and indicial notations), general theorems for elastic-plastic solids, constitutive modeling of metals and concrete, numerical implementations of plasticity models.

Prerequisite: CE 515 (old CE 715)  
*Typically offered in Spring only*  
*This course is offered alternate years*

**CE 721 Matrix and Finite Element Structural Analysis** (3 credit hours)

Advanced topics in matrix structural analysis and finite element method. Introductory review of the method, isoparametric quadrilateral element and three-dimensional elements. Energy methods and convergence criteria. Higher order elements. Isoparametric beam and plate elements, shear locking. Isoparametric curved beam and shell elements. Axisymmetric elements, Fourier series load and displacement representation. Analysis of systems with geometric and material nonlinearities.

Prerequisite: CE 526  
*Typically offered in Spring only*

**CE 723 Advanced Structural Dynamics** (3 credit hours)

Finite element formulation of equations of motion; advanced analysis techniques for discrete parameter systems; investigation of damping; analysis of continuous systems; applications to civil engineering structures.

Prerequisite: CE 527

*Typically offered in Fall only*

*This course is offered alternate years*

**CE 724 Probabilistic Methods Of Structural Engineering** (3 credit hours)

Application of probability theory and stochastic processes to study safety of structures. Fundamentals of probability theory and stochastic processes; probabilistic modelings of structural loadings, material properties and risk. Reliability analysis of structures; reliability-based design criteria. Random vibration of simple structures; safety analysis of structures under dynamic loads.

Prerequisite: MA 421

*Typically offered in Fall only*

*This course is offered alternate years*

**CE 725 Earthquake Structural Engineering** (3 credit hours)

Effects of earthquakes on structures and of design of structures to resist earthquake motions; earthquake mechanisms and ground motions; response of structures to earthquake motions; behavior of materials, structural elements and assemblages subjected to earthquakes; principles of earthquake-resistant design practice; soil-structure interaction; and special topics.

Prerequisite: CE 527

*Typically offered in Fall only*

**CE 726 Advanced Theory Of Concrete Structures** (3 credit hours)

Inelastic theory of structural concrete members under flexure, axial load, combined flexure and axial compression, shear and torsion. Yield line theory of slabs. Limit analysis of beams and frames of reinforced and prestressed concrete.

Prerequisite: CE 522

*Typically offered in Spring only*

**CE 727 Seismic Analysis, Assessment, and Design of Concrete Buildings** (3 credit hours)

This course covers the seismic analysis, assessment and design of concrete building structures. The progression through the course follows four areas, namely: Concrete non-linear material behavior; Frame analysis and design; Wall analysis and design; assessment and retrofit. The emphasis during the course will be on the relationships between engineer's choices, analysis and design.

P: CE 725 or equivalent

*Typically offered in Spring only*

**CE 728 Performance Based Seismic Design of Bridges** (3 credit hours)

This course covers the seismic analysis and design of bridge structures. The progression through the course follows six thematic areas, namely: Conceptual design; Analysis approaches; Capacity Design; Response Verification; Assessment and Retrofit of Bridges; and New (or underutilized) frontiers in bridge engineering. The emphasis during the course will be on the relationships between engineer's choices, analysis, and design.

Prerequisite: CE 725

*Typically offered in Spring only*

**CE 730 Mechanics and Failure of Quasi-Brittle Materials** (3 credit hours)

This course is in three parts. Part one covers fundamentals of composites including estimating the mechanical and thermomechanical properties, failure of composites, laminate, and shear-lag model. Advanced topics including homogenization theories, Eigenstrain and Eigenstress, dilute, self-consistent and Mori-Tanaka methods are also covered. Part two covers fundamental of fracture mechanics including Griffith theory, stress field at crack tip, energy release rate, crack tip plasticity, and mixed mode fracture. Part three covers interface cracks, cracks approaching an interface, and fracture of composites.

Prerequisite: CE 515 and Corequisite: CE526

*Typically offered in Fall only*

**CE 737 Computer-Aided Engineering Systems** (3 credit hours)

Design and implementation issues for building real-world computer-aided engineering systems. Engineering data modeling; data definition, query and manipulation methodologies; application program interfaces; problem-oriented languages and software supervisors; and knowledge-based systems to support engineering design and decision making.

Prerequisite: CE 537 or 538

*Typically offered in Spring only*

**CE 741 Geomechanics of Stress Deformation** (3 credit hours)

Concepts of volume change and effective stress, stress-strain behavior of clays and sands, stress path and failure conditions; mechanistic interaction between solids and water, problems in elasticity and plasticity pertaining to stress distribution, elastic, consolidation and secondary settlements, and tolerance limits to deformation levels.

Prerequisite: CE 440, or CE 443 or CE 548

**CE 742 Deformation and Instability of Soils** (3 credit hours)

Deformation and failure of soils. Limit equilibrium analyses for: slope stability, lateral earth pressure, bearing capacity of shallow foundations. Constitutive models for soils. Linear elasticity and theory of plasticity. Critical state model for soil behavior. Limit analysis.

Prerequisite: CE 440, or CE 443 or CE 548

**CE 744 Foundation Engineering** (3 credit hours)

Subsoil investigations; excavations; design of sheeting and bracing systems; control of water; footing, grillage and pile foundations; caisson and cofferdam methods of construction.

Prerequisite: CE 342

*Typically offered in Spring only*

**CE 746 Soil Dynamics and Earthquake Engineering** (3 credit hours)

Dynamics of discrete and continuous systems with application to soil dynamics: dynamic soil properties, analysis of foundation vibration, construction-induced vibration, dynamic soil-structure interaction. Geotechnical earthquake engineering: ground motion characteristics, dynamic response of soil sites, effect of local site conditions on design ground motion, liquefaction of soils.

Prerequisite: CE 440, or CE 443 or CE 548

**CE 747 Geosynthetics in Geotechnical Engineering** (3 credit hours)

Introduction to use, manufacturing techniques, design and construction of geosynthetics in geotechnical engineering applications; design and analysis of geotextiles, geonets, geogrids and geomembranes in pavements base and subbase reinforcement, reinforced walls, slopes, moisture barriers, dams and hazardous impoundment, landfill liners and covers.

Prerequisite: CE 548

*Typically offered in Spring only*

**CE 755 Highway Pavement Design** (3 credit hours)

Theoretical analysis and design of highway pavements with critical evaluation of current design practices. Pavement materials characterization; stresses and strains in pavements; traffic consideration; pavement performance models; and actual thickness design of pavements using different methodologies.

Prerequisite: CE 342

*Typically offered in Fall only*

**CE 757 Pavement Management Systems** (3 credit hours)

Fundamental concepts in process of pavement management at both network level and project level. Distress identification and evaluation; concepts and methods for rehabilitation and maintenance techniques; nondestructive testing of pavements; performance prediction models; and principles of prioritization/optimization.

Prerequisite: CE 755

*Typically offered in Spring only*

*This course is offered alternate years*

**CE 758 Multiscale Characterization of Asphalt Materials** (3 credit hours)

Multiscale characterization of asphalt concrete. Chemical, rheological, and damage characterization of asphalt binder; asphalt binder oxidative aging; asphalt modification; asphalt emulsions; asphalt mastics; fine aggregate matrix; coarse aggregate structure. Graduate course on Asphalt and Bituminous Materials or consent by the instructor.

*Typically offered in Spring only*

**CE 759 Inelastic Behavior Of Construction Materials** (3 credit hours)

Application of principles of linear and nonlinear viscoelasticity, fracture mechanics and damage mechanics to modeling inelastic behavior of construction materials. Mechanical analog of time-dependent response; linear and nonlinear elastic-viscoelastic correspondence principles; time-temperature superposition; stress intensity factor; energy release rate; J-integral; and continuum damage mechanics.

Prerequisite: CE 515

*Typically offered in Spring only*

*This course is offered alternate years*

**CE 761 Design Of Temporary Structures in Construction** (3 credit hours)

Computer-based analysis of temporary structures in construction and their design, safety and control. Emphasis on concrete formwork, falsework, earth support, cofferdams, underpinning, lifting and rigging.

Prerequisite: CE 522 or CE 744 or CE 766

*Typically offered in Fall only*

*This course is offered alternate years*

**CE 762 Construction Productivity** (3 credit hours)

Methods of collecting, assembling and analyzing construction productivity data in order to increase construction productivity. Applications of methods improvement techniques such as time-lapse photography, flow charts, process charts and time standards to improvement of construction productivity. Safety and human factors in construction and their relation to construction productivity.

Prerequisite: CE 463

*Typically offered in Spring only*

**CE 763 Materials Management In Construction** (3 credit hours)

Fundamental concepts and methods; construction specific models for integrated materials management; computer usage; vendor analysis and "best-buy;" materials requirement planning and control; management of material waste; automated materials tracking; materials handling; study of current issues; development of practical solution to a real-world problem.

Prerequisite: CE 463, CE 465

*Typically offered in Spring only*

*This course is offered every third semester*

**CE 765 Construction Equipment Systems** (3 credit hours)

Analysis of heavy construction processes as systems in order to optimize the selection and employment of construction equipment. Considerations in system design, cost and productivity estimation, operational procedures, safety and maintenance. Computer applications utilizing analytical and simulation techniques.

Prerequisite: CE 761 or 762

*Typically offered in Spring only*

*This course is offered alternate years*

**CE 766 Building Construction Systems** (3 credit hours)

Construction engineering of conventional and industrialized building systems. Emphasis in areas of structural systems utilizing cast-in-place concrete, precast concrete, prestressed concrete, structural steel, cold-formed steel, masonry, timber, composite and mixed materials. Mechanisms for resisting and transmitting loads, detailing, fabrication, transportation, erection, stability, shoring, quality control and integration of service systems.

Prerequisite: CE 466 or CE 327 or Graduate standing in ARC

*Typically offered in Fall and Spring*

**CE 771 Physical-Chemical Water Treatment Processes** (3 credit hours)

Physical-chemical treatment processes for the treatment of water, including sedimentation, flotation, filtration, coagulation, oxidation, disinfection, precipitation, adsorption, and membrane treatment processes. Current issues in drinking water quality and treatment are discussed.

Prerequisite: CE 574, Corequisite: CE 571

*Typically offered in Spring only*

**CE 772/NE 772 Environmental Exposure and Risk Analysis** (3 credit hours)

Course covers the identification, transport, and fate of hazardous substances in the environment; quantification of human exposures to such substances; dose-response analysis; and uncertainty and variability analysis. The general risk assessment framework, study design aspects for exposure assessment, and quantitative methods for estimating the consequences and probability of adverse health outcomes are emphasized.

Prerequisite: ST 511 or 515

*Typically offered in Spring only*

*This course is offered alternate odd years*

**CE 774 Environmental Bioprocess Technology** (3 credit hours)

Principles of microbiological, biochemical, and biophysical processes used in environmental waste treatment and remediation processes, with particular emphasis on water quality control processes.

Prerequisite: CE 573, CE 574

*Typically offered in Fall only*

**CE 775 Modeling and Analysis Of Environmental Systems** (3 credit hours)

Movement and fate of pollutant discharges. Development and application of analytical solutions and numerical models. Role of these models in planning and management. Mathematical programming models. Alternative management strategies: direct regulation, charges and transferable discharge permits. Multiple objectives: cost, equity and certainty of outcome.

Prerequisite: CE 339 and CE 282

*Typically offered in Fall only*

**CE 776 Advanced Water Management Systems** (3 credit hours)

Application of systems analysis methods to design, analysis and management of water resources and environmental engineering.

Prerequisite: CE 339, CE 775

*Typically offered in Spring only*

*This course is offered alternate years*

**CE 777 Stochastic Methods in Water Resources and Environmental Engineering** (3 credit hours)

Stochastic modeling, water resources and environmental data analysis, Dimension reduction, estimation and detection of periodicities in water resources and environmental data, parametric and non-parametric methods in water and environmental modeling.

Prerequisite: CE 586 or ST 515

*Typically offered in Spring only*

*This course is offered alternate odd years*

**CE 779 Advanced Air Quality** (3 credit hours)

Local, regional and global scale chemical interactions, transport and behavior of trace gases (sulfur carbon, nitrogen, hydrocarbon, and photo-chemical oxidants) in the atmosphere. covers three primary elements of air quality: anthropogenic and natural emissions of trace gases; interactions of the pollutants in the atmosphere; and monitoring and sampling of gaseous and particulate pollutants.

Prerequisite: (CH 201 or CH 203) and MEA(CE) 479

*Typically offered in Spring only*

**CE 784 Ground Water Contaminant Transport** (3 credit hours)

Introduction to movement and attenuation of contaminants in the subsurface. Common contaminant sources; advection and dispersion; numerical modeling of contaminant transport; chemical and biological processes in the subsurface; and ground water restoration technology.

Prerequisite: CE 584 and 574

*Typically offered in Spring only*

**CE 786 Hydroclimatology** (3 credit hours)

Hydroclimatology, El-Nino southern oscillation, climate and streamflow forecasting, forecast verification measures, downscaling, Budyko's Framework, long-term water balance, data assimilation, ensemble Kalman Filter.

Prerequisite: CE 586

*Typically offered in Spring only*

*This course is offered alternate even years*

**CE 790 Advanced Topics In Civil Engineering** (1-3 credit hours)

New or special course on advanced developments in some phase of civil engineering. Specific topics and prerequisites identified for each section and varied from term to term.

*Typically offered in Fall and Spring*

**CE 791 Advanced Topics in Civil Engineering Computing** (1-3 credit hours)

*Typically offered in Fall and Spring*

**CE 792 Advanced Topics in Construction Engineering** (1-3 credit hours)

*Typically offered in Fall and Spring*

**CE 793 Advanced Topics in Geotechnical Engineering** (1-3 credit hours)

*Typically offered in Fall and Spring*

**CE 794 Advanced Topics in Structures and Mechanics** (1-3 credit hours)

*Typically offered in Fall and Spring*

**CE 795 Advanced Topics in Transportation Engineering** (1-3 credit hours)

*Typically offered in Fall and Spring*

**CE 796 Advanced Topics in Water Resource and Environmental Engineering** (1-3 credit hours)

*Typically offered in Fall and Spring*

**CE 803 Advanced Construction Engineering Seminar** (1 credit hours)

*Typically offered in Fall and Spring*

**CE 805 Advanced Structures and Mechanics Seminar** (1 credit hours)

*Typically offered in Fall and Spring*

**CE 807 Advanced Water Resource and Environmental Engineering Seminar** (1 credit hours)

*Typically offered in Fall and Spring*

**CE 839 Advanced Reading In Civil Engineering** (1-3 credit hours)

Directed reading of advanced topics in some phase of civil engineering.

Prerequisite: Graduate standing

*Typically offered in Fall, Spring, and Summer*

**CE 885 Doctoral Supervised Teaching** (1-3 credit hours)

Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Doctoral student  
*Typically offered in Summer only*

**CE 890 Doctoral Preliminary Examination** (1-9 credit hours)

For students who are preparing for and taking written and/or oral preliminary exams.

Prerequisite: Doctoral student  
*Typically offered in Summer only*

**CE 893 Doctoral Supervised Research** (1-9 credit hours)

Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Doctoral student  
*Typically offered in Spring and Summer*

**CE 895 Doctoral Dissertation Research** (1-9 credit hours)

Dissertation research.

Prerequisite: Doctoral student  
*Typically offered in Fall, Spring, and Summer*

**CE 896 Summer Dissertation Research** (1 credit hours)

For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Doctoral student  
*Typically offered in Summer only*

**CE 899 Doctoral Thesis Preparation** (1-9 credit hours)

For students who have completed all credit hour, full-time enrollment, preliminary examination, and residency requirements for the doctoral degree, and are writing and defending their dissertations.

Prerequisite: Doctoral student  
*Typically offered in Fall and Summer*