DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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The Department of Civil and Environmental Engineering offers programs of study in environmental, geotechnical, and structural engineering, construction engineering and management, engineering mechanics, and pre-architecture.

Civil engineers plan, design, and construct facilities for meeting the needs of modern society. Civil engineers also help reduce the environmental impact of these designs to help make modern society more sustainable. Examples of such facilities are transportation systems, schools and office buildings, bridges, dams, land reclamation projects, water treatment and distribution systems, commercial buildings, and industrial plants. Civil engineers can choose from a broad spectrum of opportunities in industry and consulting practice; as well as in research and development in firms in which civil engineers are often owners or partners. Employment can be found among a wide variety of industrial, governmental, construction, and private consulting organizations. There is a large demand for civil engineers nationally. The program at Case Western Reserve University is built around small classes, good faculty-student relationships and advising, and a program flexible enough to meet students' personal career goals.

The Department of Civil and Environmental Engineering of the Case School of Engineering offers a Bachelor of Science in Engineering degree program with a major in Civil Engineering with courses in almost all the traditional Civil Engineering subjects. The graduate program offers the Master of Science and Doctor of Philosophy degrees in areas of structural, geotechnical, environmental engineering, and engineering mechanics. A cooperative education program involving participating engineering firms is also available for both undergraduate and graduate students.

The Department's active research programs provide opportunities for students to participate in projects related to design, analysis, and testing. Projects are in areas such as computational mechanics, probabilistic design, climatic adaptation, risk assessment, bridges, dynamics and wind engineering, response of concrete and steel structures, fracture mechanics, blast engineering, structural health monitoring, foundation engineering, static and dynamic behavior of soils, earthquake engineering, pavement engineering, water and wastewater treatment, water reuse, subsurface and *ex-situ* remediation, urban hydraulics, contaminated sediments, infrastructure materials, and infrastructure systems optimization.

Mission

The Department of Civil and Environmental Engineering has developed its own mission statement and educational objectives that are consistent with those of the Case School of Engineering. This process involved the entire department faculty along with the department's Advisory Committee and alumni. Assessing the Department's mission and educational objectives is an ongoing process.

Our mission is to prepare students for leadership roles in Civil and Environmental Engineering. The Department provides facilities and research expertise to advance the state of the Civil and Environmental Engineering profession within the mission of the Case School of Engineering. Students address problems, building on solid technical foundations while taking advantage of advanced technologies. Our graduates adhere to high technical and ethical standards, in service to the public. Graduates are prepared for the pursuit of advanced learning in civil and environmental engineering and related fields, as well as for the practice of Civil and Environmental Engineering at the highest professional levels.

Research

Research underway in Civil and Environmental Engineering includes work in analytical, design and experimental areas and is sponsored by industry, state, and federal government sources. Major areas of research interest are:

- **Structural Engineering**
  - Behavior of reinforced and prestressed concrete
  - Behavior and design of steel structures
  - Fiber-reinforced concrete
  - Fiber-reinforced composites
  - Wind engineering
  - Earthquake analysis and design of structures
  - Passive vibration control of structures
  - Finite element methods
  - Nondestructive Testing of Structures
  - Structural health monitoring
  - Blast loading of structures
  - Multiscale simulation of nonlinear dynamic structural behavior
  - Modeling of structural materials and structural systems
  - Extreme dynamic load resistant design
  - Multi-hazard and structural risk assessment
  - High and low-cycle fatigue
  - Fracture mechanics and size effect
- **Geotechnical and Infrastructure**
  - Geotechnical/Pavement Materials
  - Non-destructive testing evaluation of soils and pavement materials
  - Static behavior of anisotropic clays and sands
  - Soil liquefaction
  - Centrifuge modeling of static and dynamic soil behavior
  - Dynamic soil-structure interaction
  - Measurement of dynamic soil properties
  - Design of Structures for High-Speed Vehicles
  - Stability of tailings dams
  - Environmentally conscious manufacturing
  - Geoenvironmental engineering
  - Infrastructure engineering
  - Sensor technology
  - Smart materials
  - Intelligent infrastructure and transportation system

    - Transportation safety
    - Driver safety
    - Energy structures and geotechnology
    - Building materials
    - Climatic adaptation
- **Environmental Engineering**
    - Environmental chemistry
    - Water and wastewater treatment
    - Environmental data science
    - Environmental remediation
    - Fate and transport of environmental contaminants
    - Environmental modeling and software development
    - Sediment remediation
    - Bioremediation
    - Biofuel development
    - Urban hydraulics
    - Soil contamination standards
    - Brownfields/structural remediation
    - Environmental materials
    - Environmental hazard and risk engineering

Faculty

Christian Carloni, PhD
(University of Bologna)
Associate Professor
Composite materials for strengthening of reinforced concrete and masonry structures; fracture mechanics, damage mechanics, and fatigue of quasibrittle materials; small and large scale experimental testing of concrete, masonry, geopolymers and other quasibrittle materials and structural systems; mechanics of materials.

YeongAe Heo, PhD
(University of California, Davis)
Assistant Professor
Multi-scale numerical modeling and simulation for nonlinear dynamic behavior of structural materials and systems; Multi-hazard and risk engineering; risk-based extreme dynamic load resistant design for onshore and offshore structures and infrastructures; big data analysis application to structural engineering

Yue Li, PhD
(Georgia Institute of Technology)
Professor
Probabilistic analysis, structural and systems reliability, multi-hazard assessment and mitigation, risk-informed decision making, resilient and sustainability civil infrastructure systems, earthquake engineering, wind engineering, impact of climate change and adaptation strategies.

Michael Pollino, PhD, SE, PE
(University at Buffalo)
Associate Professor
Structural engineering; seismic analysis and design, rehabilitation of structures and civil infrastructure, large scale experimental testing of structural systems and sub-assemblages, structural dynamics, steel structures

Kurt. R. Rhoads, PhD, PE
(Stanford University)
Associate Professor
Environmental Engineering; Fate of organic pollutants, bio-remediation, algal biofuel development

Adel S. Saada, PhD, PE
(Princeton University)
Professor
Mechanics of materials; static and dynamic mechanical behavior of soils; foundation engineering

Katie P. Wheaton, MS, PE, SE
(Lehigh University)
Senior Instructor
Structural engineering; steel, concrete, and wood structures; geomatics; CAD modeling.

Xiong (Bill) Yu, PhD, PE
(Purdue University)
Professor
Geotechnical engineering; infrastructure; construction material testing; information technology; intelligent infrastructure; energy geotechnology; sustainable design; sensors: structural health monitoring

Huichun (Judy) Zhang, PhD
(Georgia Institute of Technology)
Professor
Environmental engineering, environmental chemistry, fate and transformation of emerging contaminants, redox transformation at mineral-water interface, absorption, advanced inorganic and polymer materials for contaminant removal, water and wastewater treatment, and groundwater and soil remediation

Adjunct Faculty

Vincent Beach, PE
Adjunct Lecturer
Construction Management and Estimation

Gina Beim, PE
Adjunct Lecturer
Civil Engineering Infrastructure

Carmen Franks, Ph.D., PE
Adjunct Lecturer
Environmental Engineering

Ruth Klee, PE
Adjunct Lecturer
Civil Engineering Senior Project

Mark Loria, PhD
Adjunct Lecturer
Environmental Engineering, Hydraulics and Hydrology

Phil Nagle
Adjunct Lecturer
Building Information Modeling

Martin Schmidt, PhD
Adjunct Lecturer
Solid and Hazardous Waste Management

Dan Ghiocel, Ph.D.
Adjunct Professor
Structural Engineering

Erwin Zaretsky, Ph.D.
Adjunct Professor
Structural Engineering

Xiangwu (David) Zeng, Ph.D.
Adjunct Professor
Geotechnical Engineering

Emeritus Faculty

J. Ludwig Figueroa, PhD
(University of Illinois)
Professor Emeritus

Dario A. Gasparini, PhD
(Massachusetts Institute of Technology)
Professor Emeritus

Arthur A. Huckelbridge, DEng, PE
(University of California Berkeley)
Professor Emeritus

Aaron Jennings, PhD, PE
(University of Massachusetts Amherst)
Professor Emeritus

Secondary Appointment

Chris Yinchun Yuan, Ph.D.
Professor, Mechanical and Aerospace Engineering
Sustainable Manufacturing

Undergraduate Programs

The faculty of the Civil and Environmental Engineering Department believes very strongly that undergraduate education should prepare students to be productive professional engineers. For this reason, particular emphasis in undergraduate teaching is placed on the application of engineering principles to the solution of problems. After completing a set of core courses in general engineering and civil engineering, undergraduate students choose a sequence in one of the areas of civil engineering of particular interest: Structural (S), Geotechnical (G), or Environmental (E) engineering; Construction Engineering and Management (C), or Pre-architecture (P).

In order to provide undergraduates with experience in the practice of civil engineering, the department attempts to arrange summer employment for students during the three summers between their semesters at Case Western Reserve University. By working for organizations in areas of design and construction, students gain invaluable knowledge about how the profession functions. This experience helps students gain more from their education and helps them be more competitive when seeking future employment.

A cooperative education program is also available. This allows the student to spend time an extended period of time working full-time in an engineering capacity with a contractor, consulting engineer, architect, or materials supplier during the course of his or her education. This learning experience is designed to integrate classroom theory with practical experience and professional development.

The civil engineering curriculum has been designed so that students take a set of core civil engineering courses, a set of required courses in their chosen sequence, and a minimum of six (6) approved elective courses. The sequence gives students the opportunity to pursue a particular area of practice in more depth. In addition, all civil engineering students participate in a team senior capstone design course which provides them experience with solving multidisciplinary problems.

Students enrolled in other majors may pursue a minor in civil engineering. A minimum of 15 credit hours of courses with minor advisor approval is required.

Most classes in the Civil and Environmental Engineering Department have an enrollment of fewer than 25 students to encourage the development of close professional relationships with the faculty. Students also have opportunities to gain practical experience as well as earn a supplemental income by assisting faculty members in consulting work or a funded research project.

Computer use is an integral part of the curriculum. From required courses in computer programming and numerical analysis to the application of civil and environmental engineering programs as a planning, analysis, design, and managerial tool.

All sequences are constructed to provide a balance of marketable skills and theoretical bases for further growth. With departmental approval, other sequences can be developed to meet students' needs.

The Bachelor of Science in Engineering degree program with a major in Civil Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org/.

Program Educational Objectives

1. Graduates of the program will enter the profession of Civil Engineering and advance to positions of greater responsibility and leadership, in line with ASCE Professional Grade Descriptions.
2. Graduates of the program will enter and successfully progress in, or complete, advanced degree programs within their fields of choice.
3. Graduates of the program will progress toward or complete professional registration and licensure.

Student Outcomes

As preparation for achieving the above educational objectives, the Bachelor of Science in Engineering degree program with a major in Civil Engineering is designed so that students attain:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Bachelor of Science in Engineering

Required Courses: Major in Civil Engineering

In addition to engineering general education requirements (http://bulletin.case.edu/undergraduatestudies/csedegree/) and university general education requirements (http://bulletin.case.edu/undergraduatestudies/degreeprograms/), the major requires the following courses:

Required Courses (all sequences)		**22**
ECIV 160	Surveying and Computer Graphics	
ECIV 310	Strength of Materials	
ECIV 320	Structural Analysis I	
ECIV 330	Soil Mechanics	
ECIV 340	Construction Management	
ECIV 360	Civil Engineering Systems	
ECIV 398	Civil Engineering Senior Project	
Structural (S) and Geotechnical (G) Required Courses		**12**
ECIV 311	Civil Engineering Materials	
ECIV 370	Structural Design I	
or ECIV 371	Structural Design II	
ECIV 430	Foundation Engineering	
or ECIV 437	Pavement Analysis and Design	
EMAE 181	Dynamics	
Construction Management (C) and Pre-Architecture (P) Required Courses		**9**
ECIV 311	Civil Engineering Materials	
ECIV 370	Structural Design I	
or ECIV 371	Structural Design II	
ECIV 430	Foundation Engineering	
or ECIV 437	Pavement Analysis and Design	
Environmental (E) Required Courses		**6**
ECIV 351	Engineering Hydraulics and Hydrology	
ECIV 368	Environmental Engineering	
Basic Science/Math Electives (Environmental Sequence Only, 9 total cr. hrs. required)		**9**
BIOL 114	Principles of Biology	
BIOL 214	Genes, Evolution and Ecology	
BIOL 215	Cells and Proteins	
BIOL 300	Dynamics of Biological Systems: A Quantitative Introduction to Biology	
BIOL 343	Microbiology	
CHEM 223	Introductory Organic Chemistry I	
CHEM 224	Introductory Organic Chemistry II	
CHEM 301	Introductory Physical Chemistry I	
CHEM 302	Introductory Physical Chemistry II	
CHEM 323	Organic Chemistry I	
CHEM 324	Organic Chemistry II	
CHEM 335	Physical Chemistry I	
CHEM 336	Physical Chemistry II	
EEPS 110	Physical Geology	
EEPS 117	Weather and Climate	
EEPS 202	Global Environmental Problems	
EEPS 220	Environmental Geology	
EEPS 260	Introduction to Climate Change: Physics, Forecasts, and Strategies	
EEPS 352	Biogeochemistry	
CSDS 132	Introduction to Programming in Java	
CSDS 133	Introduction to Data Science and Engineering for Majors	
CSDS 233	Introduction to Data Structures	
CSDS 313	Introduction to Data Analysis	
CSDS 391	Introduction to Artificial Intelligence	
CSDS 440	Machine Learning	
DSCI 351	Exploratory Data Science	
DSCI 353	Data Science: Statistical Learning, Modeling and Prediction	
DSCI 354	Data Visualization and Analytics	
PQHS 426	An Introduction to GIS for Health and Social Sciences	
PQHS 431	Statistical Methods I	
MATH 380	Introduction to Probability	
STAT 312	Basic Statistics for Engineering and Science	
Technical Electives		**18**
A minimum of six (6) courses and eighteen (18) total cr. hrs. from one of the following technical elective sequences (or alternatives approved by the student's academic advisor), three courses must be from Civil and Environmental Engineering Dept. and two courses must be designated as design courses (indicated with an *)		
Structural (S) Technical Electives		**18**
ECIV 300	Undergraduate Research	
ECIV 321	Matrix Analysis of Structures	
ECIV 342	BIM and Computer Graphics	
ECIV 343	BIM Data Management & Remote Sensing	
ECIV 351	Engineering Hydraulics and Hydrology (*)	
ECIV 370	Structural Design I (*, both courses)	
or ECIV 371	Structural Design II	
ECIV 368	Environmental Engineering (*)	
ECIV 372	Timber and Masonry Design (*)	
ECIV 411	Elasticity, Theory and Applications (*)	
ECIV 415	Fracture Mechanics and Size Effect	
ECIV 420	Finite Element Analysis	
ECIV 421	Advanced Topics in Reinforced Concrete Structures (*)	

ECIV 422	Advanced Structural Steel Design (*)	
ECIV 424	Structural Dynamics	
ECIV 425	Structural Design for Dynamic Loads (*)	
ECIV 426	Probabilistic Analysis	
ECIV 430	Foundation Engineering (*, both courses)	
or ECIV 437	Pavement Analysis and Design	
ECIV 456	Intelligent Infrastructure Systems	
EMAE 250	Computers in Mechanical Engineering	
EMAE 401	Mechanics of Continuous Media	
EMSE 276	Materials Properties and Design	
EMSE 372	Structural Materials by Design	
ECSE 342	Introduction to Global Issues	
ECSE 350	Operations and Systems Design	
ECSE 352	Engineering Economics and Decision Analysis	
ARTS 302	Architecture and City Design I	
ENGR 225	Thermodynamics, Fluid Dynamics, Heat and Mass Transfer	
Geotechnical (G) Technical Electives		**18**
ECIV 300	Undergraduate Research	
ECIV 321	Matrix Analysis of Structures	
ECIV 342	BIM and Computer Graphics	
ECIV 343	BIM Data Management & Remote Sensing	
ECIV 351	Engineering Hydraulics and Hydrology (*)	
ECIV 368	Environmental Engineering (*)	
ECIV 370	Structural Design I (*, both courses)	
or ECIV 371	Structural Design II	
ECIV 372	Timber and Masonry Design (*)	
ECIV 411	Elasticity, Theory and Applications (*)	
ECIV 415	Fracture Mechanics and Size Effect	
ECIV 420	Finite Element Analysis	
ECIV 430	Foundation Engineering (*, both courses)	
or ECIV 437	Pavement Analysis and Design	
ECIV 432	Mechanical Behavior of Soils	
ECIV 433	Soil Dynamics	
ECIV 434	Field Instrumentation and Insitu Testing	
ECIV 456	Intelligent Infrastructure Systems	
ENGR 225	Thermodynamics, Fluid Dynamics, Heat and Mass Transfer	
EMAE 250	Computers in Mechanical Engineering	
EEPS 110	Physical Geology	
EEPS 119	Geology Laboratory	
EEPS 220	Environmental Geology	
EEPS 305	Geomorphology and Remote Sensing	
EEPS 315	Structural Geology and Geodynamics	
EEPS 321	Hydrogeology	
EEPS 336	Aquatic Chemistry	
DSCI 432	Spatial Statistics for Near Surface, Surface, and Subsurface Modeling	
Environmental (E) Technical Electives		**18**
ECIV 300	Undergraduate Research	
ECIV 311	Civil Engineering Materials	
ECIV 361	Water Resources Engineering (*)	
ECIV 362	Solid and Hazardous Waste Management (*)	
ECIV 370	Structural Design I (*)	
ECIV 371	Structural Design II (*)	
ECIV 427	Environmental Organic Chemistry	
ECIV 450	Environmental Engineering Chemistry	
ECIV 461	Environmental Engineering Biotechnology (*)	
ENGR 210	Introduction to Circuits and Instrumentation	
EMAE 181	Dynamics	
EMAE 250	Computers in Mechanical Engineering	
ECHE 260	Introduction to Chemical Systems (*)	
ECHE 360	Transport Phenomena for Chemical Systems (*)	
ECHE 361	Separation Processes (*)	
ECHE 362	Chemical Engineering Laboratory (*)	
ECHE 364	Chemical Reaction Processes (*)	
ECHE 367	Process Control (*)	
ECHE 398	Process Analysis, Design and Safety (*)	
Construction Management (C) Technical Electives		**18**
ECIV 300	Undergraduate Research	
ECIV 341	Construction Scheduling and Estimating	
ECIV 342	BIM and Computer Graphics	
ECIV 343	BIM Data Management & Remote Sensing	
ECIV 370	Structural Design I (*, both courses)	
or ECIV 371	Structural Design II	
ECIV 411	Elasticity, Theory and Applications (*)	
ECIV 430	Foundation Engineering (*, both courses)	
or ECIV 437	Pavement Analysis and Design	
ECIV 434	Field Instrumentation and Insitu Testing	
ECIV 456	Intelligent Infrastructure Systems	
ENGR 225	Thermodynamics, Fluid Dynamics, Heat and Mass Transfer	

EMAE 181	Dynamics	
EMAE 250	Computers in Mechanical Engineering	
ACCT 100	Foundations of Accounting I	
BAFI 355	Corporate Finance	
ECON 312	Entrepreneurial Finance	
ECON 329	Game Theory: The Economics of Thinking Strategically	
ECON 333	The Economics of Organizations and Employment Relationships	
ECON 342	Public Finance	
ECON 368	Environmental Economics	
ECON 369	Economics of Technological Innovation and Entrepreneurship	
ORBH 250	Leading People (LEAD I)	
ORBH 251	Leading Organizations (LEAD II)	
ORBH 303	Leading Teams through Interpersonal Relationships	
ORBH 330	Quantum Leadership: Creating Value for You, Business, and the World	
ORBH 380	Managing Negotiations	
ORBH 391	Leadership in Diversity and Inclusion: Towards a Globally Inclusive Workplace	
Pre-Architecture (P) Technical Electives		**18**
ECIV 300	Undergraduate Research	
ECIV 321	Matrix Analysis of Structures	
ECIV 342	BIM and Computer Graphics	
ECIV 343	BIM Data Management & Remote Sensing	
ECIV 351	Engineering Hydraulics and Hydrology (*)	
ECIV 368	Environmental Engineering (*)	
ECIV 370	Structural Design I (*, both courses)	
or ECIV 371	Structural Design II	
ECIV 372	Timber and Masonry Design (*)	
ECIV 420	Finite Element Analysis	
ECIV 426	Probabilistic Analysis	
ECIV 430	Foundation Engineering (*, both courses)	
or ECIV 437	Pavement Analysis and Design	
ARTS 106	Creative Drawing I	
ARTS 206	Creative Drawing II	
ARTS 302	Architecture and City Design I	
ARTS 303	Architecture and City Design II	
ARTS 304	Architecture and City Design III	
ENGR 225	Thermodynamics, Fluid Dynamics, Heat and Mass Transfer	
EMAE 181	Dynamics	
EMAE 250	Computers in Mechanical Engineering	

Suggested Program of Study: Major in Civil Engineering

The following is a suggested program of study. Current students should always consult their advisers and their individual graduation requirement plans as tracked in SIS (http://sis.case.edu/).

First Year	Units	
	Fall	Spring
Open elective	3	
Principles of Chemistry for Engineers (CHEM 111)**	4	
Elementary Computer Programming (ENGR 131)**	3	
FSXX SAGES First Seminar*	4	
Calculus for Science and Engineering I (MATH 121)**	4	
PHED (two half semester classes)*		
SAGES University Seminar I*		3
Chemistry of Materials (ENGR 145)**		4
Calculus for Science and Engineering II (MATH 122)**		4
General Physics I - Mechanics (PHYS 121)**		4
PHED (two half semester classes)*		
Year Total:	18	15

Second Year	Units	
	Fall	Spring
SAGES University Seminar II*	3	
Surveying and Computer Graphics (ECIV 160)	3	
Statics and Strength of Materials (ENGR 200)**	3	
Calculus for Science and Engineering III (MATH 223)**	3	
General Physics II - Electricity and Magnetism (PHYS 122)**	4	
Breadth elective**		3
Strength of Materials (ECIV 310)		3
Professional Communication for Engineers (ENGR 398)**,1		1
Professional Communication for Engineers (ENGL 398)**,1		2
Approved Natural Science Elective[2]		3
Elementary Differential Equations (MATH 224)**		3
Open Elective		3
Year Total:	16	18

Third Year	Units	
	Fall	Spring
Structural Analysis I (ECIV 320)	3	
Civil Engineering Materials (ECIV 311)[S,G,C,P]	3	
Basic Science/Math Elective[3,E]		
Introduction to Circuits and Instrumentation (ENGR 210)**,S,G,C,P	4	
Thermodynamics, Fluid Dynamics, Heat and Mass Transfer (ENGR 225)**,E		
Dynamics (EMAE 181)[S,G]	3	
Basic Science/Math Elective[3,E]		
Open Elective[C,P]		
Construction Management (ECIV 340)	3	
Soil Mechanics (ECIV 330)		4

Structural Design I (ECIV 370)[4,S,G,C,P] or Structural Design II (ECIV 371)		3
Appr Technical Elective[5,E]		
Engineering Hydraulics and Hydrology (ECIV 351)[E]		3
Appr Technical Elective[5,S,G,C,P]		
Environmental Engineering (ECIV 368)[E]		3
Appr Technical Elective[5,S,G,C,P]		
Open Elective[S,G,C,P]		3
Basic Science/Math Elective[3,E]		
Year Total:	16	16

Fourth Year	**Units**	
	Fall	**Spring**
Civil Engineering Senior Project (ECIV 398)	3	
Foundation Engineering (ECIV 430)[6,S,G,C,P] or Pavement Analysis and Design (ECIV 437)	3	
Appr Technical Elective[5,E]		
Appr Technical Elective[5]	3	
Appr Technical Elective[5]	3	
Breadth Elective**	3	
Breadth Elective**		3
Civil Engineering Systems (ECIV 360)		3
Appr Technical Elective[5]		3
Appr Technical Elective[5]		3
Breadth Elective**		3
Year Total:	15	15

Total Units in Sequence:	**129**

* University general education requirement

** Engineering general education requirement

S,G,E,C,P ECIV Sequences: S = Structural, G = Geotechnical, E = Environmental, C = Construction Management, P = Pre-architecture

1 ENGR 398 and ENGL 398 must be taken concurrently.

2 Must be an approved course in a basic science other than chemistry or physics such as biology, astronomy, or geology

3 See list of pre-approved Basic Science/Math Electives for Environmental (E) sequence

4 ECIV 371, a Fall course, may be taken in lieu of ECIV 370

5 See list of pre-approved Technical Electives for each sequence. Two of these courses must be a designated "design" course (indicated in list of pre-approved Technical Electives with an asterisk*). Three of these courses must be from ECIV department. Other courses may be approved by the student's academic advisor.

6 ECIV 437 may be taken in lieu of ECIV 430

7 ECIV 398 may be taken in Fall or Spring

Co-op and Internship Programs

Opportunities are available for students to alternate studies with work in industry or government as a co-op student, which involves paid full-time employment over seven months (one semester and one summer). Civil Engineering students typically go on a Co-op following the 3rd academic year at CWRU but should discuss their plans for Co-op with their academic advisor as soon as possible. Co-ops provide students the opportunity to gain valuable hands-on experience in their field by completing a significant engineering project while receiving professional mentoring. During a co-op placement, students do not pay tuition but maintain their full-time student status while earning a salary. Learn more at http://engineering.case.edu/coop/. Alternatively or additionally, students may obtain employment as summer interns.

BS/MS Program

The Department also encourages CWRU undergraduate students to make use of the university's BS/MS program to pursue advanced studies in Civil Engineering. Undergraduates should apply for the BS/MS program in their junior year so they are able to select senior electives that will also satisfy MS degree requirements. Up to 9 hours of senior electives may be counted in both the BS and MS programs thus allowing the student to complete the MS degree in the fifth year of study. Fifth-year tuition scholarships may also be available. For more information students should discuss the BS/MS program with their Academic Advisor and/or the department BS/MS program coordinator. Review the Office of Undergraduate Studies BS/MS program requirements here (http://bulletin.case.edu/undergraduatestudies/gradprofessional/#accerleriontowardgraduatedegreestext).

Minor in Civil Engineering

Students enrolled in other majors may elect to pursue a minor in Civil Engineering requiring 15 credit hours. Course selections require the approval of a minor advisor. Recommended courses from the Department's technical sequences are as follows:

Structural Engineering	
ECIV 160	Surveying and Computer Graphics
ECIV 310	Strength of Materials
ECIV 311	Civil Engineering Materials
ECIV 320	Structural Analysis I
ECIV 321	Matrix Analysis of Structures
ECIV 370	Structural Design I
ECIV 371	Structural Design II
ECIV 372	Timber and Masonry Design
Geotechnical Engineering	
ECIV 160	Surveying and Computer Graphics
ECIV 310	Strength of Materials
ECIV 311	Civil Engineering Materials
ECIV 330	Soil Mechanics
ECIV 360	Civil Engineering Systems
ECIV 430	Foundation Engineering
ECIV 434	Field Instrumentation and Insitu Testing
ECIV 437	Pavement Analysis and Design
Construction Engineering and Management	
ECIV 160	Surveying and Computer Graphics
ECIV 310	Strength of Materials
ECIV 311	Civil Engineering Materials
ECIV 340	Construction Management
ECIV 341	Construction Scheduling and Estimating
ECIV 360	Civil Engineering Systems

Environmental Engineering	
ECIV 160	Surveying and Computer Graphics
ECIV 351	Engineering Hydraulics and Hydrology
ECIV 361	Water Resources Engineering
ECIV 362	Solid and Hazardous Waste Management
ECIV 368	Environmental Engineering
ECIV 427	Environmental Organic Chemistry
ECIV 450	Environmental Engineering Chemistry
ECIV 461	Environmental Engineering Biotechnology

Minor in Environmental Engineering

Students enrolled in all majors, except for Civil Engineering with an Environmental Engineering sequence, may elect to pursue a minor in Environmental Engineering requiring 15 credit hours and a minimum of five (5) courses. Three (3) of the courses must be from the list below. The additional two (2) courses can be chosen from the list of courses below or courses in the areas of Environmental Science, Environmental Health, and Environmental Law and approved by the minor advisor.

ECIV 351	Engineering Hydraulics and Hydrology
ECIV 361	Water Resources Engineering
ECIV 362	Solid and Hazardous Waste Management
ECIV 368	Environmental Engineering
ECIV 427	Environmental Organic Chemistry
ECIV 450	Environmental Engineering Chemistry
ECIV 461	Environmental Engineering Biotechnology

Graduate Programs

The Department of Civil and Environmental Engineering offers the following degree programs: Civil Engineering MS and Civil Engineering PhD. These degree programs offer coursework in structural engineering, geotechnical engineering, engineering mechanics, and environmental engineering to prepare students for careers in industry, professional practice, research, and teaching. Experience has shown that job opportunities are excellent for students who receive advanced degrees in Civil Engineering from Case Western Reserve University. Recent advanced degree recipients have found positions in universities, consulting firms, state and federal agencies, aerospace firms, and the energy industry.

Each student's program of course work and research is tailored to their interests in close consultation with a faculty advisor. For students working toward the Civil Engineering MS degree, study plans may include a thesis-focused, project-focused, or course-focused approach followed by a culminating experience. For students working toward the Doctor of Philosophy degree, a research dissertation is required.

All students pursuing graduate studies in the Department of Civil and Environmental Engineering must abide by the academic regulations of the School of Graduate Studies (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/) and the Case School of Engineering (https://bulletin.case.edu/schoolofengineering/#degreeprogramstext) contained in the most recent issue of the Bulletin of Case Western Reserve University and approved by the student's faculty advisor in the Department of Civil and Environmental Engineering.

Civil Engineering MS

Graduate students shall be admitted to one of three MS degree tracks (thesis-focused, project-focused, course-focused) upon recommendation of the faculty of the Department.

Thesis-Focused Track

See academic requirements of the School of Graduate Studies (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/) and Case School of Engineering (https://bulletin.case.edu/schoolofengineering/#degreeprogramstext).

Project-Focused Track

See academic requirements of the School of Graduate Studies (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/) and Case School of Engineering (https://bulletin.case.edu/schoolofengineering/#degreeprogramstext).

Course-Focused Track

See academic requirements of the School of Graduate Studies (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/) and Case School of Engineering (https://bulletin.case.edu/schoolofengineering/#degreeprogramstext).

Civil Engineering PhD

See academic requirements of the School of Graduate Studies (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/) and Case School of Engineering (https://bulletin.case.edu/schoolofengineering/#degreeprogramstext).

Facilities

Vanderhoof-Schuette Structural Laboratory

The Vanderhoof-Schuette Structural Laboratory and Educational facility feature a 2400 ft^2 cellular strong floor and a 28 ft. high, L-shaped cellular strong wall. The strong wall includes a vertical cell for testing tall specimens with loads up to 1000kips. A 15-ton crane, a scissors lift, and a forklift truck are available for positioning specimens. A 95 gpm hydraulic pump powers servo-hydraulic actuators for applying static or dynamic forces. The laboratory has a variety of instrumentation and data acquisition equipment. Four 6 ft x 6 ft uni-axial shaking tables are available for seismic testing of small physical models.

Bingham Concrete Laboratory

A well-equipped concrete testing laboratory supports the educational and research mission of the department. The laboratory includes 1) a room for concrete batching; 2) a humidity- and temperature-controlled room to support small-scale specimen preparation and storage of advanced cementitious materials and composites, and perform various characterization tests on fresh and hardened concrete and mortars, and 3) a curing room with humidity and temperature control. The laboratory space also houses machining and fabrication equipment that includes welding machines, drill presses, grinders, and saws.

The laboratory includes a 55-kip MTS servo-hydraulic universal testing machine with pressure-controlled hydraulic grips, a 220-kip MTS servo-hydraulic universal testing machine, and a 1,000-kip frame compression machine (ControlsGroup USA).

Environmental Engineering Laboratory

This laboratory is one in a suite of laboratories that support Environmental Engineering teaching and research. The facilities include a teaching laboratory, an advanced instrumentation laboratory, a remediation research laboratory and an electronic classroom/software laboratory. The Environmental Engineering Laboratory is equipped for conventional Standard Methods analysis of water, wastewater, soil, solid waste, and air samples (pH meters, furnaces, glove box, ovens, incubators, hoods, etc.), advanced analytical instruments including high performance liquid chromatography (HPLC), Ion chromatography (IC), UV-visible spectrometer, and ATR-FTIR spectroscopy, and for aerobic and anaerobic microbiology work. The lab also offers generous bench top space for student teams to explore laboratory procedures and provides direct access to research, instrumentation, and computational facilities.

Environmental Biotechnology Laboratory

This laboratory is equipped for culturing, processing, and analyzing microorganisms for remediation and biofuel research. Algae are cultivated in a Conviron A1000 growth chamber with programmable temperature and light controls. A Labcomp laminar-flow biocabinet and a Uamato autoclave are used for microbial culturing. Two refrigerated centrifuges, including a microcentrifuge, are available for culture separation. The laboratory is also equipped for molecular analyses with a thermal cycler and regulated temperature baths, with a New Brunswick incubated orbital shaker, a New Brunswick ultra-low temperature freezer and a Panasonic microwave oven.

Geotechnical Engineering Laboratories

The new state of the art Geotechnical Engineering Laboratories and Educational Facilities offer an ideal environment for teaching and research:

The Frank Gerace Undergraduate Laboratory has a complete array of modern units for characterizing and testing soils. Such units lend themselves to automated data acquisition and processing.

The Richard A. Saada Intelligent Geosystems Laboratory houses innovative interdisciplinary research including sensor and non-destructive technologies such as Time Domain Reflectometry (TDR), ultrasonics, fiber optic sensors, smart and functional materials, multiphysics processes in porous materials, etc.

The Saada Family Geotechnical Laboratory has a full array of strength and deformation testing units; notable are automated triaxial units for generalized extension and compression tests, units permitting simultaneous application of hydrostatic, axial and torsional static and dynamic loads, units by means of which one dimensional consolidation in the triaxial cell can be achieved, and various pore pressure, force and deformation measuring devices. Also available is a longitudinal and torsional resonant column device and a large size oedometer equipped with bender elements.

A 20g-tons fully automated centrifuge with a servo-hydraulic earthquake shaker is in operation.

The Warren C. Gibson library has a large array of reference materials, conference proceedings and internet connection to the University library and other sources of technical information.

Haptic Research Laboratory

The haptic interface laboratory hosts two state-of-the-art driving simulators. It provides holistic driving simulations for advanced research, education and training in the area of transportation safety, human perception and human-machine interface.

Concepts in Surveying Laboratory

The Concepts in Surveying Laboratory was established to put surveying equipment into the hands of students. Civil Engineering infrastructure work begins with high-quality, accurate survey data. The experience of surveying in the field using advanced equipment, such as levels and total stations, supports a student's use of teamwork and creative problem-solving. From outdoor data collection to computer modeling, students then post-process data using CAD software. The dynamic and exciting science of Geomatics and modern map-making is then studied with software-based lab work that explores LiDAR, Photogrammetry, and Geographic Information Systems (GIS).

Neff Civil Engineering Undergraduate Computer Laboratory

This laboratory provides Civil Engineering students with access to all the computer resources needed for both course work and research. The laboratory is supplemented by other facilities provided by the university. All of the computers in the Neff lab can act as independent workstations or provide access via a fiber optic link to other campus computers.

Civil Engineering Study Lounge

This study area is designed to supplement the computer laboratories with a quiet workplace for individual or group study.

ASCE Lounge

Provides a student controlled venue for hosting American Society of Civil Engineers (ASCE) student chapter activities.

Miller Library

The Miller Library named in honor of Craig J. Miller, a former Civil Engineering faculty member, acts as both a library and as the Department's premier meeting space.

Vose Room

The department also shares use of the Vose Room equipment for meetings and video conferencing.

Courses

ECIV 160. Surveying and Computer Graphics. 3 Units.
Principles and practice of surveying; error analysis, topographic mapping, introduction to photogrammetry and GIS; principles of graphics; computer-aided-drafting. Laboratory.

ECIV 300. Undergraduate Research. 3 Units.
Research conducted under the supervision of a sponsoring Civil Engineering faculty member. Research can be done on an independent topic or as part of an established on-going research activity. The student will prepare a written report on the results of the research. Course may fulfill one technical elective requirement.

ECIV 310. Strength of Materials. 3 Units.
Mechanical properties of materials, deformations, stresses, strains and their transformation. Torsion of structural and machine elements, pressure vessels and beams under combined loading. Deflection and statically indeterminate beams. Energy methods and column stability. Prereq: ENGR 200.

ECIV 311. Civil Engineering Materials. 3 Units.
Steel, concrete, wood, masonry, and fiber-reinforced plastic. Experiments, advanced reading, and field trips. Strength, stiffness, ductility, and other properties of materials. Experiments on the flexural, compressive, and shear behavior of structural elements. Prereq: ECIV 310.

ECIV 320. Structural Analysis I. 3 Units.
Static, linear, structural analysis of trusses and frames for member forces and displacements. Analysis of cables and arches. Behavior of statically determinate and indeterminate systems using stiffness and flexibility formulations. Introduction to structural analysis software. Structural load calculations and load path. Recommended preparation: ECIV 310. Prereq: ENGR 200.

ECIV 321. Matrix Analysis of Structures. 3 Units.
Matrix formulation and computer analysis (MATLAB recommended) for statically indeterminate linear structural systems; Stiffness method (direct/displacement method); Potential Energy Method; Development of element equations for 1D axial and flexural members and 2D triangle element; Transformation between local to global coordinates; Development of displacement fields (linear function for axial members and cubic function for flexural members); Shape function concept in approximation; Introduction to elasticity, finite element analysis and nonlinear structural analysis. Additional term project on programming for six degrees of freedom beam structure analysis will be assigned to students enrolled in ECIV428. Recommended for all students: Linear Algebra, Structural Analysis, and MATLAB Programing. Offered as ECIV 321 and ECIV 428. Prereq: ECIV 320 and EMAE 250.

ECIV 330. Soil Mechanics. 4 Units.
The physical, chemical, and mechanical properties of soils. Soil classification, capillarity, permeability, and flow nets. One dimensional consolidation, stress and settlement analysis. Shear strength, stability of cuts, and design of embankments, retaining walls and footings. Standard laboratory tests performed for the determination of the physical and mechanical properties of soils. Laboratory. Recommended preparation: ECIV 310.

ECIV 340. Construction Management. 3 Units.
Selected topics in construction management including specifications writing, contract documents, estimating, materials and labor, bidding procedures and scheduling techniques. The course is augmented by guest lecturers from local industries.

ECIV 341. Construction Scheduling and Estimating. 3 Units.
The focus is on scheduling, and estimating and bidding for public and private projects. This includes highways as well as industrial and building construction. The use of computers with the latest software in estimating materials, labor, equipment, overhead and profit is emphasized. Recommended preparation: ECIV 340 and consent of instructor.

ECIV 342. BIM and Computer Graphics. 3 Units.
This course is intended to apply Building Information Modeling tools in a meaningful manner within the AEC field. The course will progress through the core concepts of widely used VDC tools: AutoCAD, Sketchup, Revit, Navisworks. The key areas of focus will be conceptualizing projects, quantity takeoff, scheduling, and constructability review. Class time will involve hands-on training and exercises that will simulate real-world situations and deadlines. Complexity levels in the models will be minimized to ensure focus on concepts. Students will have multiple opportunities to hone their presentation skills with their projects through the course progression. Prereq: ECIV 160 and ECIV 340.

ECIV 343. BIM Data Management & Remote Sensing. 3 Units.
The course is intended to create awareness and advocacy for advanced design and planning technologies in the AEC industry, and integration into standard BIM platforms. The course will enhance competency in utilization of core BIM platforms for students with basic experience in Sketchup, Revit and Navisworks. Class time will involve hands-on exercises to simulate professional applications of technologies that improve accuracy and communication on projects. Technical equipment processes will be demonstrated in person, and situational challenges will be presented and assigned for course projects. Technology focus will include drones, LIDAR, and virtual reality simulations. Recommended Preparation: ECIV 341. Prereq: ECIV 342.

ECIV 351. Engineering Hydraulics and Hydrology. 3 Units.
Application of fluid statics and dynamics to Civil Engineering Design. Hydraulic machinery, pipe network analysis, thrust, hammer, open channel flow, sewer system design, culverts, flow gauging, retention/detention basin design. Applied hydrology, hydrograph analysis and hydraulic routing will also be introduced. Recommended preparation: Concurrent enrollment in ENGR 225.

ECIV 360. Civil Engineering Systems. 3 Units.
Introduction to probability and statistics. Discrete and continuous random variables, probability distributions, bivariate data, probabilistic analysis of systems, and reliability analysis. Introduction to engineering economics. Interest rates and equivalence, present worth, rate of return analysis, depreciation, and inflation.

ECIV 361. Water Resources Engineering. 3 Units.
Water doctrine, probabilistic analysis of hydrologic data, common and rare event analysis, flood forecasting and control, reservoir design, hydrologic routing, synthetic streamflow generation, hydroelectric power, water resource quality, water resources planning. Recommended preparation: ECIV 351.

ECIV 362. Solid and Hazardous Waste Management. 3 Units.
Origin and characterization of solid and hazardous waste. Solid and hazardous waste regulations. Methods of solid and hazardous waste disposal. Waste management planning. Landfill siting and design considerations. Site Conceptual Models for remediation of contaminated sites. Technologies used for soil and groundwater remediation at solid and hazardous waste sites. Offered as ECIV 362 and ECIV 462.

ECIV 368. Environmental Engineering. 3 Units.
Principle and practice of environmental engineering. Water and waste water engineering unit operations and processes including related topics from industrial waste disposal, air pollution and environmental health.

ECIV 370. Structural Design I. 3 Units.
Professional role of a structural engineer. Professional and legal responsibilities. Design of structures, beams, columns, beam-columns, and connections. Structures of steel and reinforced concrete. Recommended preparation: ECIV 320. Prereq: ECIV 310.

ECIV 371. Structural Design II. 3 Units.
Continuation of ECIV 370. Torsion design of concrete members, design of continuous beams and slabs, reinforcement development, concrete serviceability deflection criteria, design of two-way slabs, stability design of steel members, lateral-torsional buckling and local buckling of steel members, steel connection design, software aided design of a steel building structure. Recommended preparation: ECIV 310 and ECIV 315. Offered as ECIV 371 and ECIV 471. Prereq: ECIV 370.

ECIV 372. Timber and Masonry Design. 3 Units.
Introduction to wood material. Design for timber beams and columns to resist vertical and lateral loads. Design of nailed and bolted connections. Introduction to masonry materials and design of wall. Offered as ECIV 372 and ECIV 472. Prereq: ECIV 322.

ECIV 396. Civil Engineering Special Topics I. 1 - 3 Units.
Special topics in civil engineering in which a regular course is not available. Conferences and report.

ECIV 397. Civil Engineering Topics II. 3 Units.
Special topics in civil engineering in which a regular course is not available. Conferences and report.

ECIV 398. Civil Engineering Senior Project. 3 Units.
Capstone course for civil engineering students. Material from previous and concurrent courses used to complete a multidisciplinary engineering design project. Professional engineering topics such as project management, engineering design, communications, and professional ethics. Requirements include periodic reporting of progress, plus a final oral presentation and written report. Counts as SAGES Senior Capstone. Counts as SAGES Senior Capstone.

ECIV 400T. Graduate Teaching I. 0 Unit.
This series of three courses will provide Ph.D. students with practical experience in teaching at the University level and will expose them to effective teaching methods. Each course assignment will be organized in coordination with the student's dissertation advisor and the department chairperson. Assignments will successively require more contact with students, with duties approaching the teaching requirements of a faculty member in the Ph.D. student's area of study. Prereq: Ph.D. students in Civil Engineering.

ECIV 411. Elasticity, Theory and Applications. 3 Units.
General analysis of deformation, strain, and stress. Elastic stress-strain relations and formulation of elasticity problems. Solution of elasticity problems by potentials. Simple beams. The torsion problem. Thick cylinders, disks, and spheres. Energy principle and introduction to variational methods. Elastic stability. Matrix and tensor notations gradually introduced, then used throughout the course. Recommended preparation: ECIV 310 or equivalent.

ECIV 415. Fracture Mechanics and Size Effect. 3 Units.
Linear Elastic Fracture Mechanics: crack tip fields, stress intensity factors, energy release rate, J-integral, fracture criteria. Nonlinear Theories: R-curve, plastic fracture mechanics. Quasibrittle Materials: cohesive crack models, fracture process zone. Fatigue cracks. Size Effect: linear elastic fracture mechanics prediction, size effect in quasibrittle materials. Experimental determination of fracture properties. Recommended preparation: ECIV 411. Prereq: ECIV 310.

ECIV 420. Finite Element Analysis. 3 Units.
Theory and application of the finite element method. Approximation theory as the basis for finite element methods. The formulations for a variety of finite elements in one, two, and three dimensions. The modeling and analysis of structural components and systems using planar, solid, and plate elements. Implementations of element formulations using Matlab. An advanced finite element analysis program will be used for analysis of structural problems. Recommended preparation: ECIV 321 is a prerequisite for structural engineering students. Background in advanced mechanics and numerical analysis of structures is required for this course. If you have not completed these courses, please discuss with the instructor. Prereq: Graduate Standing or ECIV 321.

ECIV 421. Advanced Topics in Reinforced Concrete Structures. 3 Units.
Group project-based course to evaluate nonlinear dynamic behavior of multistory reinforced concrete structures designed to the US building design codes (ACI318, ASCE7, ASCE41); Main Topics including Review of RC Design Principles, Procedure Requirements and Assumptions; Inelastic Behavior of Plain Concrete, Reinforced Concrete, and Reinforcing Steel; Code-Based Design vs. Performance-Based Design; Strength vs. Displacement Demand Parameters at the Member, Story, and Structure Levels; Pushover Analysis Using an Open Source Code (OpenSees). Prereq: Graduate Standing or ECIV 321, ECIV 322 and ECIV 323.

ECIV 422. Advanced Structural Steel Design. 3 Units.
Advanced topics for the design of steel structures including member and frame stability, design of members for torsion, plate girders, base plate and anchorage connections, and basics of composite systems. Plastic analysis and design concepts for structural engineering limit state load applications. Seismic design of steel lateral force resisting systems. Recommended Preparation: ECIV 321. Prereq: ECIV 323 or instructor consent.

ECIV 424. Structural Dynamics. 3 Units.
Modeling of structures as single and multidegree of freedom dynamic systems. The eigenvalue problem, damping, and the behavior of dynamic systems. Deterministic models of dynamic loads such as wind and earthquakes. Analytical methods, including modal, response spectrum, time history, and frequency domain analyses. Recommended preparation: ECIV 321 and consent of instructor.

ECIV 425. Structural Design for Dynamic Loads. 3 Units.
Structural design problems in which dynamic excitations are of importance. Earthquake, wind, blast, traffic, and machinery excitations. Human sensitivity to vibration, mechanical behavior of structural elements under dynamic excitation, earthquake response and earthquake-resistant design, wind loading, damping in structures, hysteretic energy dissipation, and ductility requirements. Recommended preparation: ECIV 424.

ECIV 426. Probabilistic Analysis. 3 Units.
Introduction to probability and statistics. Uncertainty and decision analysis. Probability models for structural loads and strength. Probabilistic analysis of engineering systems. Estimation of the reliability of structures and infrastructure systems. Monte Carlo simulation. Recommended preparation: ECIV 360, introduction of probability and statistics, or equivalent.

ECIV 427. Environmental Organic Chemistry. 3 Units.
This is an advanced course focusing on examination of processes that effect the behavior and fate of anthropogenic organic contaminants in aquatic environments. The lectures will focus on intermolecular interactions and thermodynamic principles governing the kinetics of some of the important chemical and physicochemical transformation reactions of organic contaminants. Recommended Preparation: One semester of Organic chemistry or prior approval of the instructor.

ECIV 428. Matrix Analysis of Structures. 3 Units.
Matrix formulation and computer analysis (MATLAB recommended) for statically indeterminate linear structural systems; Stiffness method (direct/displacement method); Potential Energy Method; Development of element equations for 1D axial and flexural members and 2D triangle element; Transformation between local to global coordinates; Development of displacement fields (linear function for axial members and cubic function for flexural members); Shape function concept in approximation; Introduction to elasticity, finite element analysis and nonlinear structural analysis. Additional term project on programming for six degrees of freedom beam structure analysis will be assigned to students enrolled in ECIV428. Recommended for all students: Linear Algebra, Structural Analysis, and MATLAB Programing. Offered as ECIV 321 and ECIV 428. Prereq: Graduate Student standing.

ECIV 430. Foundation Engineering. 3 Units.
Subsoil exploration. Various types of foundations for structures, their design and settlement performance, including spread and combined footings, mats, piers, and piles. Design of sand-drain installations and earth-retaining structures including retaining walls, sheet piles, and cofferdams. Case studies. Recommended preparation: ECIV 330.

ECIV 432. Mechanical Behavior of Soils. 3 Units.
Soil statics and stresses in a half space-tridimensional consolidation and sand drain theory; stress-strain relations and representations with rheological models. Critical state and various failure theories and their experimental justification for cohesive and noncohesive soils. Laboratory measurement of rheological properties, pore water pressures, and strength under combined stresses. Laboratory. Recommended preparation: ECIV 330.

ECIV 433. Soil Dynamics. 3 Units.
I-DOF and M-DOF dynamics; wave propagation theory; dynamic soil properties. Foundation vibrations, design of machine foundations. Seismology; elastic and elastoplastic response spectra, philosophy of earthquake-resistant design. One and two-dimensional soil amplification, liquefaction, dynamic settlement. Soil-structure interaction during earthquakes. Recommended preparation: ECIV 330 and consent of instructor.

ECIV 434. Field Instrumentation and Insitu Testing. 3 Units.
In situ test methods. Standard Penetration Test (SPT), Cone Penetration Test (CPT), pressuremeter, vane shear test, dilatometer, seismic methods, electromagnetic methods, and electrical methods. Geotechnical field instrumentation. Measurement of load, stress, pore pressure, and deformation in the field. Stress wave theory, pile driving analysis, pavement condition survey. Recommended preparation: ECIV 330.

ECIV 437. Pavement Analysis and Design. 3 Units.
Analysis and design of rigid and flexible airfield and highway pavements. Pavement evaluation and rehabilitations, overlay design. Recommended preparation: ECIV 330.

ECIV 450. Environmental Engineering Chemistry. 3 Units.
Fundamentals of inorganic, organic, and physical chemistry with emphasis on the types of problems encountered in the environmental engineering field. Equilibria among liquid, gaseous, and solid phases; kinetics to the extent that time permits. A strong mathematical approach is taken in solving the equilibrium and kinetic problems presented. Equilibrium speciation software for solution of more complex problems. Topics that will be covered in the course include chemical equilibrium, acid/base reactions, mathematical problem solving approach, graphical approaches, titration curves, solubility of gases and solids, buffering systems, numerical solution of equilibrium problems, thermodynamics, oxidation-reduction reactions, principles of quantitative chemistry and analytical techniques, introduction to the use of analytical instrumentation, and chemical kinetics. Prereq: ECIV 368 or requisites not met permission.

ECIV 456. Intelligent Infrastructure Systems. 3 Units.
Topics on smart infrastructure systems; smart materials fabrication, embedded sensing technology for infrastructure condition monitoring, the system models for infrastructural condition diagnosing and adaptive controlling, and spatial-temporal integrated infrastructure management system.

ECIV 461. Environmental Engineering Biotechnology. 3 Units.
Process design fundamentals for biological reactors applied to environmental engineering processes, including wastewater treatment, bioremediation, and bioenergy production. Topics include mass balances, methane fermentation, fixed-growth reactors, molecular biology tools, and reactor models. Recommended preparation: ECIV 368 Environmental Engineering.

ECIV 462. Solid and Hazardous Waste Management. 3 Units.
Origin and characterization of solid and hazardous waste. Solid and hazardous waste regulations. Methods of solid and hazardous waste disposal. Waste management planning. Landfill siting and design considerations. Site Conceptual Models for remediation of contaminated sites. Technologies used for soil and groundwater remediation at solid and hazardous waste sites. Offered as ECIV 362 and ECIV 462.

ECIV 471. Structural Design II. 3 Units.
Continuation of ECIV 370. Torsion design of concrete members, design of continuous beams and slabs, reinforcement development, concrete serviceability deflection criteria, design of two-way slabs, stability design of steel members, lateral-torsional buckling and local buckling of steel members, steel connection design, software aided design of a steel building structure. Recommended preparation: ECIV 310 and ECIV 315. Offered as ECIV 371 and ECIV 471.

ECIV 472. Timber and Masonry Design. 3 Units.
Introduction to wood material. Design for timber beams and columns to resist vertical and lateral loads. Design of nailed and bolted connections. Introduction to masonry materials and design of wall. Offered as ECIV 372 and ECIV 472.

ECIV 500T. Graduate Teaching II. 0 Unit.
This series of three courses will provide Ph.D. students with practical experience in teaching at the University level and will expose them to effective teaching methods. Each course assignment will be organized in coordination with the student’s dissertation advisor and the department chairperson. Assignments will successively require more contact with students, with duties approaching the teaching requirements of a faculty member in the Ph.D. student’s area of study. Prereq: Ph.D. student in Civil Engineering.

ECIV 600T. Graduate Teaching III. 0 Unit.
This series of three courses will provide Ph.D. students with practical experience in teaching at the University level and will expose them to effective teaching methods. Each course assignment will be organized in coordination with student's dissertation advisor and the department chairperson. Assignments will successively require more contact with students, with duties approaching the teaching requirements of a faculty member in the Ph.D. student's area of study. Prereq: Ph.D. students in Civil Engineering.

ECIV 601. Independent Study. 1 - 18 Units.
Plan B.

ECIV 651. Thesis M.S.. 1 - 18 Units.
Plan A.

ECIV 660. Special Topics. 1 - 18 Units.
Topics of special interest to students and faculty. Topics can be those covered in a regular course when the student cannot wait for the course to be offered.

ECIV 695. Project M.S.. 1 - 9 Units.
Research course taken by Plan B M.S. students. Prereq: Enrolled in the ECIV Plan B MS Program.

ECIV 701. Dissertation Ph.D.. 1 - 9 Units.
(Credit as arranged.) Prereq: Predoctoral research consent or advanced to Ph.D. candidacy milestone.