DEPARTMENT OF CIVIL ENGINEERING

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Phone: 216.368.2950; Fax: 216.368.5229
ecivchair@case.edu

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

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 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 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 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 Civil Engineering faculty and the Department’s Civil Engineering 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 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 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 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:

- Behavior of reinforced and prestressed concrete
- Wind engineering
- Earthquake analysis and design of structures
- Finite element methods
- Nondestructive Testing of Structures
- Passive control of the vibration of structures
- Transient response of nonlinear structures
- Blast loading of structures
- Fracture mechanics
- Multiscale simulation of nonlinear dynamic structural behavior
- Modeling of structural materials and structural systems
- High and low-cycle fatigue
- Geotechnical/Pavement Materials
- Static behavior of anisotropic clays and sands
- Soil liquefaction
- Centrifuge modeling of static and dynamic soil behavior
- Dynamic soil-structure interaction
- Non-destructive testing evaluation of soils and pavement materials
- Measurement of dynamic soil properties
- Design of Structures for High-Speed Vehicles
- Stability of tailings dams
- Environmentally conscious manufacturing
- Brownfields/structural remediation
- Environmental modeling and software development
- Geoenvironmental engineering
- Sediment remediation
- Environmental chemistry
- Bioremediation
- Structural health monitoring
- Transportation safety
- Infrastructure engineering
- Non-destructive Testing
- Sensor technology
- Smart materials
- Energy structures and geotechnology
- Biofuel development
- Urban hydraulics
- Soil contamination standards
- Intelligent infrastructure and transportation system
- Driver safety
- Building materials
- Environmental hazard and risk engineering
• Extreme dynamic load resistant design
• Multi-hazard and structural risk assessment
• Water and wastewater treatment
• Environmental remediation
• Fate and transport of environmental contaminants
• Environmental materials
• Climatic adaptation

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-assemblies, structural dynamics, steel structures

Kurt. R. Rhoads, PhD, PE
(Stanford University)
Assistant 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)
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)
Associate 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

Terrance Cybulski, Adjunct
Martin Schmidt, Adjunct
Philip DeSantis, Adjunct
Dan Ghiocel, Adjunct
Mark D. Rokoff, Adjunct
Erwin V. Zaretsky, Adjunct

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

Undergraduate Programs

The faculty of the Civil 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 broad Civil Engineering core program, undergraduate students choose an elective sequence in one of the areas of civil engineering of particular interest, such as structural, geotechnical, or environmental engineering; construction engineering and management, or engineering mechanics.

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 curriculum has been designed so that students choose a sequence of four (4) or more approved elective courses. The sequence gives students the opportunity to pursue in more depth a particular area of practice in Civil Engineering. Samples of courses from which elective sequences may be chosen follow the Civil Engineering curriculum in this bulletin. In addition, all Civil Engineering students participate in a team senior capstone design course which provides them experience with solving multidisciplinary Civil Engineering problems.

Students enrolled in other majors may pursue a minor in civil engineering. A minimum of 15 credit hours of Civil Engineering courses and prior Department minor advisor approval are required.

Most classes in the Civil 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.

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:

- an ability to apply knowledge of mathematics (including differential equations) and science (including calculus-based physics and general chemistry) and one additional area of science;
- an ability to design and conduct experiments, as well as to analyze and interpret data in more than one area of civil engineering;
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
- an ability to function on multi-disciplinary teams;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility and the role of civil engineers in providing for the safety and well-being of the general public;
- an ability to communicate effectively in written and oral form;
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- a recognition of the need for, and an ability to engage in life-long learning;
- a knowledge of contemporary issues;
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice and the design of functional civil engineering facilities;
- proficiency in probability and statistics, as applied to civil engineering design and planning issues;
- an understanding of professional practice issues, including the role of civil engineering design and management professionals in the construction process; and
- an understanding of the importance of professional licensure and the ethical use of a professional license.

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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECV 160</td>
<td>Surveying and Computer Graphics</td>
<td>3</td>
</tr>
<tr>
<td>ECV 311</td>
<td>Civil Engineering Materials</td>
<td>3</td>
</tr>
<tr>
<td>ECV 310</td>
<td>Strength of Materials</td>
<td>3</td>
</tr>
<tr>
<td>ECV 320</td>
<td>Structural Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>ECV 322</td>
<td>Structural Design I</td>
<td>3</td>
</tr>
<tr>
<td>ECV 330</td>
<td>Soil Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>ECV 340</td>
<td>Construction Management</td>
<td>3</td>
</tr>
<tr>
<td>ECV 351</td>
<td>Engineering Hydraulics and Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>ECV 360</td>
<td>Civil Engineering Systems</td>
<td>3</td>
</tr>
<tr>
<td>ECV 368</td>
<td>Environmental Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ECV 398</td>
<td>Civil Engineering Senior Project</td>
<td>3</td>
</tr>
<tr>
<td>Related Required Courses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMAE 181</td>
<td>Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>EMAE 250</td>
<td>Computers in Mechanical Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

A minimum of four courses from one of the following technical elective sequences (or alternatives approved by the student’s academic advisor), two of which must be from Civil Engineering and two of which must be designated as design courses (indicated with an *)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECV 321</td>
<td>Matrix Analysis of Structures</td>
</tr>
<tr>
<td>ECV 323</td>
<td>Structural Design II (*)</td>
</tr>
<tr>
<td>ECV 324</td>
<td>Timber and Masonry Design (*)</td>
</tr>
</tbody>
</table>

Department of Civil Engineering
Computer use is an integral part of the Civil Engineering curriculum. From required courses in computer programming and numerical analysis to subsequent use and development of Civil Engineering programs, students experience the use of computers as a planning, analysis, design, and managerial tools.

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.

### Bachelor of Science in 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).

<table>
<thead>
<tr>
<th>First Year</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open elective</td>
<td>3</td>
</tr>
<tr>
<td>Principles of Chemistry for Engineers (CHEM 111)**</td>
<td>4</td>
</tr>
<tr>
<td>Elementary Computer Programming (ENGR 131)**</td>
<td>3</td>
</tr>
<tr>
<td>FSXX SAGES First Seminar*</td>
<td>4</td>
</tr>
<tr>
<td>Calculus for Science and Engineering I (MATH 121)**</td>
<td>4</td>
</tr>
<tr>
<td>PHED (two half semester classes)**</td>
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</tr>
<tr>
<td>SAGES University Seminar I*</td>
<td>3</td>
</tr>
<tr>
<td>Chemistry of Materials (ENGR 145)**</td>
<td>4</td>
</tr>
<tr>
<td>Calculus for Science and Engineering II (MATH 122)**</td>
<td>4</td>
</tr>
<tr>
<td>General Physics I - Mechanics (PHYS 121)**</td>
<td>4</td>
</tr>
<tr>
<td>PHED (two half semester classes)**</td>
<td></td>
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<tr>
<td>Year Total:</td>
<td>18 15</td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAGES University Seminar II*</td>
<td>3</td>
</tr>
<tr>
<td>Surveying and Computer Graphics (ECIV 160)</td>
<td>3</td>
</tr>
<tr>
<td>Computers in Mechanical Engineering (EMAE 250)</td>
<td>3</td>
</tr>
<tr>
<td>Statics and Strength of Materials (ENGR 200)**</td>
<td>3</td>
</tr>
<tr>
<td>Calculus for Science and Engineering III (MATH 223)**</td>
<td>3</td>
</tr>
<tr>
<td>General Physics II - Electricity and Magnetism (PHYS 122)**</td>
<td>4</td>
</tr>
<tr>
<td>Breadth elective**</td>
<td>3</td>
</tr>
<tr>
<td>Strength of Materials (ECIV 310)</td>
<td>3</td>
</tr>
<tr>
<td>Dynamics (EMAE 181)</td>
<td>3</td>
</tr>
<tr>
<td>Introduction to Circuits and Instrumentation (ENGR 210)**</td>
<td>4</td>
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<tr>
<td>Elementary Differential Equations (MATH 224)**</td>
<td>3</td>
</tr>
<tr>
<td>Year Total:</td>
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</table>
**Third Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Breadth elective**</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Civil Engineering Materials (ECIV 311)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Structural Analysis I (ECIV 320)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Thermodynamics, Fluid Dynamics, Heat and Mass Transfer (ENGR 225)**</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Professional Communication for Engineers (ENGR 398)**,a</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Professional Communication for Engineers (ENGL 398)**,a</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Structural Design I (ECIV 322)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Soil Mechanics (ECIV 330)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Engineering Hydraulics and Hydrology (ECIV 351)</td>
<td>3</td>
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<tr>
<td>Environmental Engineering (ECIV 368)</td>
<td>3</td>
<td></td>
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<tr>
<td>Approved electiveb</td>
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<tr>
<td>Year Total:</td>
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**Fourth Year**

<table>
<thead>
<tr>
<th>Units</th>
<th>Fall</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Breadth elective**</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Construction Management (ECIV 340)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Civil Engineering Senior Project (ECIV 398)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Approved electiveb</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Approved electiveb</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Breadth elective**</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Civil Engineering Systems (ECIV 360)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Approved Natural Science Electivec</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Approved electiveb</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Open elective</td>
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<td></td>
</tr>
<tr>
<td>Year Total:</td>
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<td>15</td>
</tr>
</tbody>
</table>

Total Units in Sequence: 130

* University general education requirement  
** Engineering general education requirement  
a ENGR 398 Professional Communication for Engineers and ENGL 398 Professional Communication for Engineers must be taken concurrently.  
b Must be part of an approved sequence  
c Must be an approved course in a traditional science other than chemistry or physics such as biology, astronomy, or geology.

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**Co-op and Internship Programs (http://engineering.case.edu/coop)**

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 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 program 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/#accelerationtowardgraduatedegreetext).

**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 Civil Engineering minor advisor. Recommended courses from the Department’s areas of concentration are as follows:

**Engineering Mechanics**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECIV 160</td>
<td>Surveying and Computer Graphics</td>
</tr>
<tr>
<td>ECIV 310</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>ECIV 311</td>
<td>Civil Engineering Materials</td>
</tr>
<tr>
<td>ECIV 360</td>
<td>Civil Engineering Systems</td>
</tr>
<tr>
<td>ECIV 411</td>
<td>Elasticity, Theory and Applications</td>
</tr>
<tr>
<td>ECIV 420</td>
<td>Finite Element Analysis</td>
</tr>
</tbody>
</table>

**Structural Engineering**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECIV 160</td>
<td>Surveying and Computer Graphics</td>
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<tr>
<td>ECIV 310</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>ECIV 311</td>
<td>Civil Engineering Materials</td>
</tr>
<tr>
<td>ECIV 360</td>
<td>Civil Engineering Systems</td>
</tr>
<tr>
<td>ECIV 320</td>
<td>Structural Analysis I</td>
</tr>
<tr>
<td>ECIV 321</td>
<td>Matrix Analysis of Structures</td>
</tr>
<tr>
<td>ECIV 322</td>
<td>Structural Design I</td>
</tr>
<tr>
<td>ECIV 323</td>
<td>Structural Design II</td>
</tr>
</tbody>
</table>

**Geotechnical Engineering**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECIV 160</td>
<td>Surveying and Computer Graphics</td>
</tr>
<tr>
<td>ECIV 310</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>ECIV 311</td>
<td>Civil Engineering Materials</td>
</tr>
<tr>
<td>ECIV 330</td>
<td>Soil Mechanics</td>
</tr>
<tr>
<td>ECIV 360</td>
<td>Civil Engineering Systems</td>
</tr>
<tr>
<td>ECIV 430</td>
<td>Foundation Engineering</td>
</tr>
<tr>
<td>ECIV 433</td>
<td>Soil Dynamics</td>
</tr>
<tr>
<td>ECIV 437</td>
<td>Pavement Analysis and Design</td>
</tr>
</tbody>
</table>

**Construction Engineering and Management**

<table>
<thead>
<tr>
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<th>Title</th>
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</thead>
<tbody>
<tr>
<td>ECIV 160</td>
<td>Surveying and Computer Graphics</td>
</tr>
<tr>
<td>ECIV 311</td>
<td>Civil Engineering Materials</td>
</tr>
<tr>
<td>ECIV 340</td>
<td>Construction Management</td>
</tr>
<tr>
<td>ECIV 341</td>
<td>Construction Scheduling and Estimating</td>
</tr>
</tbody>
</table>
Graduate Programs
The MS and PhD programs in structural engineering, geotechnical engineering, engineering mechanics and environmental engineering 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 his or her interests in close consultation with a faculty advisor. For students working toward the Master of Science 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.

Civil Engineering graduate students are also encouraged to review the CWRU School of Graduate Studies web page for additional details about University requirements for advanced degree programs.

Review the School of Graduate Studies MS and PhD degree requirements here (http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements).

Facilities
Vanderhoof-Schuette Structural Laboratory
The Vanderhoof-Schuette Structural Laboratory and Educational facility features a 2400 ft² 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 scissor lift, and a forklift truck are available for positioning specimens. A 95 gpm hydraulic pump powers servo-hydraulics 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.

Environmental Biotechnology 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:

Civil Engineering Systems
Environmental Engineering
Surveying and Computer Graphics
Civil Engineering Materials
Engineering Hydraulics and Hydrology
Water Resources Engineering
Solid and Hazardous Waste Management
Environmental Engineering
Environmental Organic Chemistry
Environmental Engineering Chemistry
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 Graig 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.**

**ECIV 311. Civil Engineering Materials. 3 Units.**

**ECIV 320. Structural Analysis I. 3 Units.**

**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. Recommended Preparation: Linear Algebra. Prereq: ECIV 320 and EMAE 250.

**ECIV 322. Structural Design I. 3 Units.**

**ECIV 323. Structural Design II. 3 Units.**

**ECIV 324. Timber and Masonry Design. 3 Units.**

**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 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.

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 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.

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 design and evaluate multistory reinforced concrete structures according to the US building design codes (ACI318, ASCE7, ASCE41), including inelastic behavior of plain concrete, reinforced concrete, and reinforcing steel; inelastic rebar buckling and slip behavior; reinforcement design under various loads; design evaluation criteria at member level and system level; nonlinear static structural analysis method (Pushover analysis) for RC frames under dynamic lateral forces 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.
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 430. Foundation Engineering. 3 Units.

ECIV 431. Special Topics in Geotechnical Engineering. 3 Units.

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.

ECIV 434. Field Instrumentation and Insitu Testing. 3 Units.

ECIV 437. Pavement Analysis and Design. 3 Units.

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, buffer 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 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 560. Environmental Engineering Modeling. 3 Units.

ECIV 561. Groundwater Analysis. 3 Units.
Principles of mass transport through porous media, formulation of saturated and unsaturated flow equations in alternative coordinate systems, analytical and numerical solutions of flow equations, application of existing groundwater software, analysis of solute transport problems.

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.