Department of Civil, Architectural, and Environmental Engineering

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Chair:
Gongkang Fu

The Department of Civil, Architectural, and Environmental Engineering offers graduate instruction in structural engineering, transportation engineering, geotechnical engineering, geoenvironmental engineering, environmental engineering, public works, construction engineering and management, and architectural engineering. The department maintains relationships with business, industry, and government. An active research program provides highly relevant perspectives on current engineering challenges and issues in the field.

Degrees Offered

Master of Engineering in Architectural Engineering
Master of Engineering in Construction Engineering and Management
Master of Engineering in Environmental Engineering
Master of Engineering in Geoenvironmental Engineering
Master of Engineering in Geotechnical Engineering
Master of Engineering in Public Works
Master of Engineering in Structural Engineering
Master of Engineering in Transportation Engineering

Master of Science in Architectural Engineering
Master of Science in Civil Engineering with specialization in:

- Architectural Engineering
- Construction Engineering and Management
- Geotechnical Engineering
- Geoenvironmental Engineering
- Structural Engineering
- Transportation Engineering

Master of Science in Environmental Engineering
Doctor of Philosophy in Civil Engineering
Doctor of Philosophy in Environmental Engineering

Joint-Degree Program

Bachelor of Architecture/Master of Science in Civil Engineering

Bachelor of Architecture/Master of Engineering in Construction Engineering and Management
Bachelor of Architecture/Master of Engineering in Structural Engineering

Certificate Programs

Air Resources
Construction Management
Earthquake and Wind Engineering Design
Geoenvironmental Engineering
Hazardous Waste Engineering
Indoor Air Quality
Infrastructure Engineering and Management
Transportation Systems Planning
Waste and Wastewater Treatment

Research Facilities

Research facilities include laboratories devoted to concrete structures, structural models, metal structures, materials, architectural engineering, geotechnical engineering, transportation engineering, construction engineering and management, and environmental engineering.

In addition, faculty and graduate students have access to regional facilities such as the Argonne National Laboratory. The department has a computer-aided engineering and design lab equipped with state-of-the-art hardware and software.

Research Areas

The main research areas in the department are architectural engineering, construction engineering and management, environmental engineering, geotechnical and geoenvironmental engineering, public works, structural engineering, and transportation engineering.

In architectural engineering, faculty conduct research in acoustics, airflow and thermal modeling, energy conservation, indoor air quality, and thermal comfort.

Construction engineering and management research involves construction productivity, scheduling and progress control, dispute resolution, construction company organization, sectorial studies, and project management.

Environmental engineering research areas include air pollution, energy and sustainability, hazardous waste engineering, indoor air quality, and wastewater engineering.

Geotechnical and geonenvironmental research emphasizes soil mechanics, rock mechanics, engineering geology, earthquake engineering, soil structure, and soil-water interactions.

Research in the public works specialty area includes public policy evaluation, management of engineering operations, maintenance, and rehabilitation and construction of civil infrastructures such as roads, bridges, and traffic safety hardware.

Structural engineering research concentrates on structural dynamics and earthquake resistant design, inelsatic behavior and non-linear analysis of steel structures, and bridge engineering.

Transportation engineering research areas include multimodal transportation infrastructure and dynamic traffic network mobility, safety, security and emergency evacuation, as well as energy consumption and vehicle emission performance modeling; transportation asset management, addressing system integration, risk and uncertainty, and sustainability; and network economics.

Faculty

Anderson, Paul, Associate Professor of Environmental Engineering. B.S., Purdue University; M.S., University of California-San Diego; Ph.D., University of Washington. Physical-chemical processes in water and wastewater treatment, water resources management, industrial ecology.

Arditi, David, Professor of Civil and Architectural Engineering. B.S., M.S., Middle East Technical University (Turkey); Ph.D., Loughborough University of Technology (United Kingdom). Construction engineering and management.

Budiman, Jeffry S., Associate Professor of Civil and Architectural Engineering. B.S., Bandung Institute of Technology (Indonesia); M.S., Illinois Institute of Technology; Ph.D., University of Colorado-Boulder. Geotechnical and geoenvironmental engineering.

Du, Lili, Assistant Professor of Transportation Engineering. B.S., Xi'an Jiaotong University (China); M.S., Tsinghua University (China); M.S., Ph.D., Rensselaer Polytechnic Institute. Transportation system analysis, operations research and statistics, network modeling and algorithm design, data fusion.

Fu, Gongkang, Professor of Civil and Architectural Engineering and Chair of the Department. B.S., M.S., Tongji University (China); Ph.D., Case Western Reserve University. Bridge engineering, probabilistic mechanics, infrastructure system engineering.

Guralnick, Sidney A., Perlstein Distinguished Professor of Engineering, Emeritus. B.S., Drexel Institute of Technology; M.S., Ph.D., Cornell University. Structural engineering and materials of construction.

Khisty, C. Jotin, Professor Emeritus of Civil and Architectural Engineering. B.S., Nagpur University (India), M.S., M.C.P., University of Cincinnati; Ph.D., The Ohio State University. Transportation systems, traffic engineering and infrastructure systems.

Li, Zongzhi, Associate Professor of Civil and Architectural Engineering. B.E. Changan University, (China); MSCE, MSIE, Ph.D., Purdue University. Multimodal transportation systems analysis, evaluation, and asset management, and network economics.

Modares, Mehdi, Assistant Professor of Civil and Architectural Enginering. B.S, Tehran Azad Unversity (Iran); MS., Cleveland State University; Ph.D., Case Western Reserve University. Computational mechanics, solid mechanics.

Mohammadi, Jamshid, Professor of Civil and Architectural Engineering and Associate Dean of the Graduate College for Academic Affairs. B.S., M.S., University of Teheran (Iran); M.S., Ph.D., University of Illinois, Urbana-Champaign. Structural reliability and bridge engineering.

Moschandreas, Demetrios J., Professor of Environmental Engineering. B.S., Stetson University; M.S., University of Kentucky; M.S., Ph.D., University of Cincinnati. Air quality transport, exposure analysis, risk assessment, indoor air quality, Environmental Index theory and application, sustainable environmental development.

Noll, Kenneth E., Professor of Environmental Engineering. B.S., Michigan Technological University; M.S., Ph.D., University of Washington. Design of air pollution control devices, study of atmospheric aerosols, VOC emissions from wastewater treatment plants, and physical and chemical changes and fates of toxic air.

Pagilla, Krishna, Professor of Environmental Engineering. B.E., Osmania University (India); M.S., University of Oklahoma; Ph.D., University of California-Berkeley. Water and wastewater engineering, environmental microbiology, biological nutrient control, soil remediation, and sludge treatment.

Pan, Tongyan, Assistant Professor of Civil Engineering. B.S., M.S., Tongji University (China); M.S., Louisiana State University; Ph.D., University of Illinois, Urbana-Champaign. Engineering materials and pavement engineering, pavement management, multiscale computational mechanics, finite element analysis, concrete structures, geotechnical engineering.

Snyder, Mark E., Senior Lecturer of Civil and Architectural Engineering. B.S., M.S., Creighton; M.S., Illinois Institute of Technology; Ph.D., Texas Tech University. Building energy and lighting systems, measurement techniques, fire engineering.

Stephens, Brent, Assistant Professor of Civil and Architectural Engineering. B.S., Tennessee Technological University; M.S., Ph.D., University of Texas-Austin. Architectural engineering, indoor air quality, HVAC systems.

Admission Requirements

Cumulative undergraduate GPA minimum: 3.0/4.0
GRE minimum score:
M.S./M.E.: 900 (quantitative + verbal),
2.5 (analytical writing)
Ph.D.:1000 (quantitative + verbal),
3.0 (analytical writing)
TOEFL minimum: 550/213/80*

Note: The GRE requirement is waived for Master of Engineering degree applicants who hold a Bachelor of Science in a related field, from an ABET-accredited university in the U.S., with a minimum GPA of 3.0/4.0.

Meeting the minimum GPA and test score requirements does not guarantee admission. Test scores and GPA are just two of many factors considered.

Admission to graduate degree programs in civil engineering normally requires a Bachelor of Science degree in civil engineering from an institution accredited by Accreditation Board of Engineering and Technology (ABET). The master's programs in construction engineering and management, and in architectural engineering may also accept a bachelor's degree in architecture or engineering. Students who have completed an accredited program in a related field or in a foreign school may be admitted on a provisional status until any deficiencies in preparation are removed.

Admission to graduate degree programs in environmental engineering requires a bachelor's degree in an appropriate undergraduate field from an accredited institution. Prerequisites for the program are somewhat flexible, but all applicants should have had one year of chemistry, and math through differential equations. Qualified applicants with degrees in the life sciences, engineering, and physical sciences will normally be admitted to the program without extensive prerequisites.

Each full-time graduate student is assigned a faculty advisor at the time of initial registration. Part-time or non-degree students who have not been assigned an advisor and who intend to pursue a program toward a degree should contact the department for counseling before registering for courses. Departmental seminars and colloquia are conducted on a regular basis each semester. All full-time civil and architectural engineering graduate students are expected to register for CAE 593 and attend these seminar meetings regularly for two semesters.

* Paper-based test score/computer-based test score/interet-based test score.

Master of Engineering in Architectural Engineering
Master of Engineering in Construction Engineering and Management
Master of Engineering in Environmental Engineering
Master of Engineering in Geoenvironmental Engineering
Master of Engineering in Geotechnical Engineering
Master of Engineering in Public Works
Master of Engineering in Structural Engineering
Master of Engineering in Transportation Engineering

32 credit hours (minimum)

These Master of Engineering programs are course-only, professionally oriented degree programs that permit a concentration in preparation for engineering practice. Admission requirements to these programs are the same as those for the M.S. program. Candidates in these programs must complete a minimum of 32 credit hours, up to three of which may be a special project course, CAE 597 or ENVE 597. Up to 12 credit hours of 400-level undergraduate coursework (except CAE 431 and CAE 432) may be included in the Master of Engineering program with prior advisor approval. No thesis or comprehensive examination is required for completion of the degree.

Master of Engineering in Architectural Engineering

This program is oriented toward students who need to develop more knowledge about buildings. Students are expected to have educational backgrounds in disciplines such as architecture, structural engineering, mechanical engineering, and/or electrical engineering. The program covers the three basic aspects of architectural engineering: building systems, structures, and construction management.

This program involves four core courses, four or five elective courses from one field of concentration, and two courses from any relevant field of concentration, general background courses, or graduate courses offered by the College of Architecture.

Core Courses

CAE 471 Construction Planning and Scheduling
CAE 513 Building Science
AND
CAE 502 Acoustics & Lighting
OR
CAE 521 Building Illumination Design
CAE 574 Economic Decision Analysis in Civil Engineering

Master of Engineering in Construction Engineering and Management

The Master of Engineering program in Construction Engineering and Management provides students with the knowledge and background that is essential to making decisions at site, company, industrial, and sector levels. Students learn how to plan and schedule projects, estimate and control costs, make economic decisions, administer contracts, organize construction sites, manage construction equipment, analyze productivity, optimize construction activities, plan and manage real estate developments, and address legal problems.

Core Courses

CAE 570 Legal Issues in Civil Engineering
CAE 571 Lean Construction and Control
CAE 574 Economic Decision Analysis in Civil Engineering
CAE 577 Construction Equipment Management

Master of Engineering in Environmental Engineering

All environmental engineering students must take five core courses. The remaining credit hours in the program of study should be selected, in consultation with the student's advisor, to meet the student's professional goals. Up to nine credit hours in courses numbered 400-499 may be selected in some cases to overcome deficiencies or broaden the student's background.

Core Courses

CAE 523 Statistical Analysis of Engineering Data
ENVE 501 Environmental Chemistry
ENVE 506 Chemodynamics
ENVE 542 Physiochemical Processes in Environmental Engineering
ENVE 580 Hazardous Wastes Engineering

Master of Engineering in Geoenvironmental Engineering and Master of Engineering in Geotechnical Engineering

The geoenvironmental and geotechnical engineering programs provide background knowledge and training to prepare students to analyze, design, and construct structures, and to provide solutions to problems in geotechnical engineering and environmental geotechnics. The subjects include engineering behavior of soil and rock, geomechanics, foundations, earth support structures, dams, tunnels, slope stability, geotechnical earthquake engineering and soil dynamics, site improvement, geosynthetics, groundwater, pollutant transport, chemical behavior of soil, and waste disposal facilities. Laboratory experiments and computer analyses/modeling are incorporated.

Geoenvironmental Engineering Core Courses

CAE 562 Engineering Behavior of Soil
CAE 567 Physicochemical Behavior of Soils
CAE 589 Groundwater Hydrology and Sampling
CAE 590 Geotechnical Landfill Design and Maintenance

Geotechnical Engineering Core Courses

CAE 562 Engineering Behavior of Soil
CAE 564 Design of Foundations, Embankments and Earth Structures
CAE 565 Rock Mechanics and Tunneling
CAE 566 Earthquake Engineering and Soil Dynamics

Master of Engineering in Public Works (Infrastructure Engineering and Management)

The Master of Engineering in Public Works (M.P.W.) degree is the most widely recognized educational credential for professionals engaged in public works and infrastructure engineering and management. The M.P.W. program consists of four core courses, four engineering electives (in construction engineering and management, geotechnical engineering, structural engineering, or transportation engineering), two public administration electives (in administration process or policy planning), and one CAE 597 special problems course. The elective courses should be selected in consultation with the student's advisor. This program is offered in cooperation with IIT's Master of Public Administration program.

Core Courses

CAE 574 Economic Decision Analysis in Civil Engineering
CAE 575 Systems Analysis in Civil Engineering
PA 501 Essentials for Public Management in a Complex Society: Processes, Structures and Values
PA 551 Public Infrastructure Management

Master of Engineering in Structural Engineering

IIT's Master of Engineering program in structural engineering provides students with the knowledge needed to design the built environment. Students learn how buildings and bridges may be designed to resist the forces imposed upon them by external loads, gravity, wind, and earthquakes. Up-to-date computer-aided design techniques and the latest national building codes dealing with steel, reinforced concrete, pre-stressed concrete, and masonry structures are treated.

Core courses

MMAE 501 Engineering Analysis 1
OR
CAE 514 Mathematical Methods for Structural Engineering
CAE 503 Advanced Structural Analysis
CAE 518 Advanced Reinforced Concrete
CAE 525 Advanced Steel and Composite Structures

Master of Engineering in Transportation Engineering

With a Master of Engineering in Transportation Engineering degree, a student will be a qualified transportation planner, traffic engineer, and traffic safety engineer. Additionally, the student will be trained to understand and evaluate the socioeconomic impacts of transportation and infrastructure engineering projects.

Core Courses (choose four, with advisor consent)

CAE 523 Statistical Analysis of Engineering Data
CAE 543 Demand Models for Urban Transportation
CAE 544 Urban Transportation Planning
CAE 546 Public Transportation Systems
CAE 548 Transportation Systems Management
CAE 555 Transportation Systems Evaluation
CAE 575 Systems Analysis in Civil Engineering

Master of Science in Architectural Engineering

32 credit hours
Thesis and oral defense

The M.S. in Architectural Engineering couples the architectural engineering coursework curriculum for the advanced study of buildings, building systems, and their construction, with a research and thesis-based curriculum in the same fields. Students are expected to develop advanced knowledge and conduct research at a rigorous level. The program will also serve as a foundation for research for students who intend to pursue a doctoral degree.

Degree candidates in the Master of Science program must complete a minimum of 32 credit hours, six to eight of which must be research and thesis credits. Up to 12 credit hours of 400-level undergraduate coursework may be included in the M.S. program with prior advisor approval. An oral defense of the thesis constitutes the comprehensive examination, and no additional written comprehensive examination is required.

Required Courses

CAE 513 Building Science
CAE 574 Economic Decision Analysis in Civil Engineering

AND minimum of two of the following:

CAE 502 Acoustics & Lighting
CAE 521 Building Illumination Design
CAE 524 Building Enclosure Design
CAE 553 Measurement & Instrumentation in Architectural Engineering
ENVE 576 Indoor Air Pollution

AND research (6-8 credit hours):

CAE 591 Research and Thesis for M.S. Degree

AND 9-15 credit hours of electives

Master of Science in Civil Engineering

32 credit hours
Thesis and oral defense

Six technical areas (architectural, construction, geoenvironmental, geotechnical, structural, and transportation engineering) are included in the M.S. program. Degree candidates in the Master of Science program must complete a minimum of 32 credit hours, six to eight of which are for research and thesis. Up to 12 credit hours of 400-level undergraduate coursework [except CAE 431 (Steel Design) and CAE 432 (Concrete and Foundation Design)] may be included in the M.S. program with prior advisor approval. An oral defense of the thesis constitutes the comprehensive examination, and no additional written comprehensive examination is required.

Master of Science in Environmental Engineering

32 credit hours
Thesis

This program makes it possible for the student to build a strong foundation in environmental engineering and, through their research, to specialize in one area. Candidates are required to take at least 32 credit hours, 15 credits of which must be from the environmental engineerinng core courses listed below.

Core courses

CAE 523 Statistical Analysis of Engineering Data
ENVE 501 Environmental Chemistry
ENVE 506 Chemodynamics
ENVE 542 Physicochemical Processes in Environmental Engineering
ENVE 580 Hazardous Waste Engineering

The student must have a minimum grade point average of 3.0/4.0 in the core areas. Aside from the core courses, coursework may be selected (with advisor approval) to satisfy the needs of the individual student.

Up to nine credit hours in courses numbered 400-499 may be selected in some cases to overcome deficiencies or broaden the student's background. In addition, master's degree students take six to eight credit hours of research (ENVE 591). The final step in this program is an oral defense of the thesis; no additional written comprehensive exam is required.

Bachelor of Architecture/Master of Science in Civil Engineering
Bachelor of Architecture/Master of Engineering in Construction Engineering and Management
Bachelor of Architecture/Master of Engineering in Structural Engineering

Qualified students regularly enrolled at IIT may earn both the Bachelor of Architecture and either the Master of Science or Master of Engineering degree. They must complete preparatory courses for any of these master's programs prior to entry into the combined program.

Students who anticipate entry into the combined B.Arch. and M.S. in Civil Engineering program and who intend to specialize in structural engineering must successfully complete the following courses as part of their undergraduate program in architecture: MATH 151, MATH 152, MATH 251, MATH 252, PHYS 123, PHYS 221, PHYS 224, MMAE 200/CAE 200, MMAE 202/CAE 202, CAE 303, CAE 304, CAE 307, CAE 310, CAE 431 and CAE 432 (in place of MATH 119, MATH 122, and all structural engineering courses for the Architecture major).

Students who anticipate entry into the M.E. in Construction Engineering and Management are not required to complete any additional courses as part of the technical electives in their undergraduate program in architecture.

Students who anticipate entry into the M.E. in Structural Engineering program must successfully complete the following courses as part of their undergraduate program in Architecture: MATH 151, MATH 152, MATH 251, MATH 252, PHYS 123, PHYS 221, PHYS 224, MMAE 200/CAE 200, MMAE 202/CAE 202, CAE 303, CAE 304, CAE 307, CAE 310, CAE 431 and CAE 432 (in place of MATH 119, MATH 122, and all structural engineering courses for the Architecture major).

For undergraduate course descriptions, students should refer to the undergraduate bulletin.

Doctor of Philosophy in Civil Engineering

84 credit hours, which includes a master's degree
Qualifying exam
Comprehensive exam
Dissertation (24 credit hours)
Oral defense

The full-time doctoral program generally consists of at least two complete years of academic preparation, followed by at least one year of full-time research in residence at IIT. To be admitted to candidacy, students must successfully complete a qualifying examination. The department may waive this requirement for students who hold an M.S. degree from IIT in the same field. This examination should be completed within three semesters of entry into the program. The student selects a research advisor after he or she is admitted to candidacy. The research project must be in harmony with the interests of the faculty and with the facilities of the department. Off-campus research for the dissertation is possible. In those cases, the student must register for CAE 691 during each semester in which the thesis is being prepared.

The candidate should complete the comprehensive examination at least one year prior to the date of graduation. The comprehensive examination is an oral examination that is administered by a reearch committee approved by the chairperson. The candidate presents the research proposal and answers questions of a general professional nature.

The preliminary thesis draft must meet the approval of all members of the examination committee. An oral examination in defense of the thesis is given as an open university seminar. The thesis defense must meet with the approval of the examination committee; if it does not, the committee has the authority to determine whether or not to grant a re-examination.

Doctor of Philosophy in Environmental Engineering

84 credit hours
Qualifying exam
Comprehensive exam
Thesis proposal
Dissertation and oral defense

The doctorate degree in environmental engineering is awarded in recognition of mastery in environmental engineering and upon demonstration of an ability to make substantial creative contributions to knowledge in environmental engineering. The recipients of these derees will be capable of a continuing effort toward advancement of knowledge and achievement in research while pursuing an academic or industrial research career. Typically, the program of study includes 30-40 percent enviromental engineering coursework, 40-50 percent research, and 10-30 percent in other fields of study. The coursework must include 15 credits of core environmental engineering courses listed in the section describing the Master of Science in Environmental Engineering.

Students should consult the Transfer Credits section for rules on how many credit hours may be transferred from another institution. Students must pass a written qualifying examination within three semesters after they have been admitted to the Ph.D. program. The exam is diagnostic in nature, and the results of the exam will determine the student's potential for success in the Ph.D. program and recommendations for a future program of study. The examination will cover core areas, including environmental chemistry, chemodynamics, environmental systems and analysis, and physiochemical processes.

The comprehensive examination is oral and may include a written exam based on the student's performance on the qualifying exam. Exam questions will be formulated by the members of the Ph.D. examining committee. The examination will also include an oral presentation and discussion of one or more research articles selected a priori by the examining committee. The exam must be conducted within a year following completion of the qualifying exam. The Ph.D. examining committee, which may be the same as the Ph.D. thesis committee, should be suggested by the advisor and approved and appointed by the chairperson at least three weeks prior to the examination.

The thesis proposal approval examination should be conducted after the comprehensive exam and at least one year before the final thesis defense. This oral exam is administered by the Ph.D. thesis committee.

Although doctoral research can begin after admission to the Ph.D. program, the major portion of the research should take place after the comprehensive examintaion is passed and the thesis proposal is approved by the committee. Research will be conducted under the supervision of a full-time department faculty member and students should work to involve all the members of their research committee. The preliminary thesis draft must meet the approval of all members of the examination committee. An oral examination in defense of the thesis is given as an open university seminar. The thesis defense must meet with the approval of the examination committee; if it does not, the committee has the authority to determine whether or not to grant a re-examination.

Certificate Programs in Civil Engineering

Construction Management

Required Courses (choose four)

CAE 470 Construction Methods and Cost Estimating
CAE 471 Construction Planning and Scheduling
CAE 472 Construction Site Operation
CAE 473 Construction Contract Administration
CAE 570 Legal Issues in Civil Engineering
CAE 571 Lean Construction and Control
CAE 572 Construction Cost Accounting and Control
CAE 573 Construction Management with BIM
CAE 574 Economic Decision Analysis in Civil Engineering
CAE 575 Systems Analysis in Civil Engineering
CAE 576 Legal Aspects of Real Estate and Development
CAE 577 Construction Equipment Management
CAE 578 Construction Claims Management
CAE 579 Real Estate Fundamentals for Engineers and Architects

Earthquake and Wind Engineering Design

Required Courses (choose four)

CAE 410 Introduction to Wind and Earthquake Engineering
CAE 518 Advanced Reinforced Concrete
CAE 525 Advanced Steel and Composite Structures
CAE 582 Structural Wind and Earthquake Engineering
CAE 583 Performance-Based Structural and Seismic Design of Buildings and Bridges
CAE 586 Seismic Design of Building and Bridge Structures

Geoenvironmental Engineering

Required Courses

CAE 567 Physicochemical Behavior of Soils
CAE 589 Ground Water Hydrology and Sampling
CAE 590 Geotechnical Landfill Design and Maintenance

AND one of the following:

CAE 589 Groundwater Hydrology & Sampling
ENVE 580 Hazardous Waste Engineering

Infrastructure Engineering and Management

Required Courses

PA 501 Processes, Structures, and Values
PA 551 Public Infrastructure Management

Elective Courses (choose two)

CAE 408 Bridge and Structural Design
CAE 416 Facility Design of Transportation Systems
CAE 417 Railroad Engineering and Design
CAE 419 Introduction to Transportation Engineering and Design
CAE 471 Construction Planning and Scheduling
CAE 486 Soil and Site Improvement
CAE 508 Advanced Bridge Engineering
CAE 523 Statistical Analysis of Engineering Data
CAE 539 Introduction to Geographic Information Systems
CAE 541 Pavement Evaluation and Management
CAE 544 Urban Transportation Planning
CAE 546 Public Transportation Systems
CAE 548 Transportation Systems Management
CAE 549 Transportaion Economics, Development, and Policy
CAE 555 Transportation Systems Evaluation
CAE 568 Transportation Asset Management
CAE 574 Economic Decision Analysis in Civil Engineering
CAE 575 Systems Analysis in Civil Engineering
CAE 581 Algorithms in Transportation
CAE 590 Geotechnical Landfill Design and Maintenance
ENVE 404 Water and Wastewater Engineering
ENVE 551 Industrial Waste Treatment

Transportation Systems Planning

Required Courses (choose two)

CAE 523 Statistical Analysis of Engineering Data
CAE 544 Urban Transportation Planning
CAE 546 Public Transportation Systems
CAE 548 Transportation Systems Management
CAE 555 Transportation Systems Evaluation
CAE 575 Systems Analysis in Civil Engineering

Elective Courses (choose two)

CAE 416 Facility Design of Transportation Systems
CAE 417 Railroad Engineering and Design
CAE 419 Introduction to Transportation Engineering & Design
CAE 539 Introduction to Geographic Information Systems
CAE 549 Transportaion Economics, Development, and Policy
CAE 568 Transportation Asset Management
CAE 574 Economic Decision Analysis in Civil Engineering
CAE 581 Algorithms in Transportation

Certificate Program in Architectural Engineering

Architectural Engineering

Required Course

CAE 513 Building Science

Elective Courses (choose two)

CAE 461 Plumbing and Fire Protection Design
CAE 464 HVAC Systems Design
CAE 507 Control of Sound and Vibrations in Buildings
CAE 509 Analysis and Design of Acoustic Spaces
CAE 521 Building Illumination Design
CAE 524 Building Enclosure Design
CAE 526 Energy Conservation Design in Buildings
CAE 528 Building Electrical Systems Design
CAE 597 Special Problems

Certificate Programs in Environmental Engineering

Air Resources

This program explores outdoor air quality, causes of outdoor air pollution, and investigative and diagnostic techniques used in outdoor air quality control.

Required Course

ENVE 570 Air Pollution Meteorology

Elective Courses

ENVE 576 Indoor Air Pollution
ENVE 577 Design of Air Pollution Control Devices
ENVE 578 Physical and Chemical Processes for Industrial Gas Cleaning

Hazardous Waste Engineering

This program is an introduction to the characterization of hazardous waste sites, common and innovative remediation techniques, and current issues in hazardous waste engineering.

Required Course

ENVE 580 Hazardous Waste Engineering

Elective Courses (choose two)

CAE 589 Groundwater Hydrology and Sampling
ENVE 506 Chemodynamics
ENVE 542 Physicochemical Processes in Environmental Engineering
ENVE 577 Design of Air Pollution Control Devices

Indoor Air Quality

This program covers sick building syndrome, the causes of indoor air pollution, and investigative and diagnostic techniques used in controlling indoor air quality.

Required Course

ENVE 576 Indoor Air Pollution

Elective Courses (choose one)

CAE 523 Statistical Analysis of Engineering Data
MMAE 452 Aerospace Propulsion
BIOL 514 Toxicology

Water and Wastewater Treatment

This program is an introduction to the biological and physical/chemical processes used in water and wastewater treatment, and the design of water and wastewater treatment processes.

Required Courses

ENVE 513 Biotechnological Processes in Environmental Engineering
ENVE 542 Physicochemical Processes in Environmental Engineering
ENVE 551 Industrial Waste Treatment
ENVE 561 Design of Environmental Engineering Processes

Course Descriptions

Civil and Architectural Engineering

CAE 502
Acoustics & Lighting
General introduction to the aural and visual environment. Subjective and objective scales of measurement. Laws of psychophysics. Introduction to vibration. The hearing mechanism. Transfer of sound. Passive control of noise in buildings, transmission loss. Absorption and reverberation time. Active control of the aural environment. Visual perception. Photometry, brightness, luminance and illumination. Natural lighting of buildings. Artificial lighting.
(3-0-3)

CAE 503
Advanced Structural Analysis
Introduction to the mechanics of solids. Energy methods and the calculus of variations. Ritz/Galerkin approximation methods. Introductory discussions on elastic stability and plate analyses.
Prerequisite(s): [(CAE 411) OR (CAE 514*) OR (MMAE 501*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

CAE 504
Seismic Retrofit & Earthquake Hazard Reduction
Selection of site-dependent earthquake for retrofit. Strength and ductility of aging structures. Cyclic behavior and modeling of structures under seismic loading. Performance-based retrofit criteria. Evaluating earthquake vulnerability of existing buildings and bridges. Upgrading lateral load-carrying systems. Conceptual basis for seismic isolation and energy-absorbing techniques and their applications in earthquake hazard reduction in existing bridges and buildings. Selection of retrofit methods. Case studies of seismic retrofit of typical buildings, bridges, and industrial facilities using strength upgrading, energy dissipation devices, and base isolation.
Prerequisite(s): [(CAE 410 with min. grade of D) OR (CAE 420 with min. grade of D) OR (CAE 582) OR (CAE 583)]
(4-0-4)

CAE 506
Building Envelope Rehabilitation
Repair and rehabilitation of existing building exterior envelopes. The course will include problem identification, investigative techniques, repair methods, preparation of remedial design documents and general management of rehabilitation projects. Types of constructions include buildings, exterior walls, facades, cladding, roofing, plazas and others.
(3-0-3)

CAE 507
Control of Sound & Vibration in Buildings
Basic sound physics and sound propagation in enclosed spaces. Sound and vibration sources in and out of buildings. Theories of sound transmission through building elements. Effects of noise and vibration on man and buildings, criteria and standards. Design of noise control systems. Calculation of airborne and impact sound insulation. Noise and vibration control implementations in various indoor spaces, such as residential units, offices, schools and mechanical rooms.
(3-0-3)

CAE 508
Advanced Bridge Engineering
Specifications for bridge design and evaluation. Advanced bridge design and evaluation topics such as design load envelope, seismic load design, bridge condition rating, bridge load rating, and steel bridge fatigue evaluation. Bridge management systems. Life cycle analyses. Use of high performance materials in bridge engineering.
Prerequisite(s): [(CAE 408)]
(3-0-3)

CAE 509
Analysis & Design of Acoustic Spaces
This course will discuss the design of acoustic spaces such as conference rooms, classrooms, lecture halls, music halls, theater, churches, recording studio, and home theater. Course covers the selection and determination of appropriate steady state, spatial, and temporal acoustic measures such as background noise levels, reverberation time, speech transmission index, and interaural cross correlation, as well as the selection of building materials and layout of rooms to meet those requirements.
Prerequisite(s): [(CAE 502) OR (CAE 542)]
(3-0-3)

CAE 510
Dynamics of Fire
Introduction to fire, physics and chemistry, and mass and heat transfer principles, fire fluid mechanic fundamentals, fundamentals and requirements of the burning of materials (gases, liquids, & solids), fire phenomena in enclosures such as pre-flashover and post-flashover.
(3-0-3)

CAE 511
Fire Protection of Buildings
Fundamentals of building design for fire and life safety. Emphasis on a systematic design approach. Basic considerations of building codes, fire loading, fire resistance, exit design, protective systems & other fire protection systems. For architects, and engineers not majoring in fire protection and safety engineering.
(3-0-3)

CAE 512
Computer Modeling of Fire
Introduction to fire heat transfer processes and fire testing materials; application of a set of quantitative engineering tools (fire models) to construct a description of conditions that occur or might occur during the course of a fire; life and structural impacts from hostile fires in buildings.
(3-0-3)

CAE 513
Building Science
Study of the physical interaction of climate (humidity, temperature, wind, sun, rain, snow, etc.) and buildings. Topics include psychrometrics, indoor air quality, indoor thermal comfort, heat transfer, air infiltration, solar insolation, and heating and cooling load calculation.
(3-0-3)

CAE 514
Mathematical Methods for Structural Engineering
Matrices, linear spaces and transformations, eigenvalue problems, and their application to civil engineering. First-order differential equations for structural dynamics. Calculus of variations and variational principles for dynamics and statics. Rayleigh-Ritz method, finite element approximations, Newmark-Beta method, Green's Function, and Duhamel Integral and their application to civil engineering.
(3-0-3)

CAE 515
Building Energy Modeling
Building energy modeling (BEM) is the core of building information modeling (BIM) and sustainable design which are changing the way of architectural design and engineering. This course builds essential knowledge of building performance simulation and provides necessary background to use a building energy simulation software tool. Proven methods for using BEM to deal with such essential building performance and sustainability issues will be presented by using real world examples placing particular emphasis on using BEM-enabled quantitative analysis to evaluate design alternatives for the whole life cycle of a building. Complete with coverage of integrated design and lean construction requirements, this is a valuable course for architects, engineers, and construction professionals involved in energy performance modeling for buildings.
Prerequisite(s): [(CAE 513)]
(3-0-3)

CAE 516
Lighting Systems Design & Analysis
Intensive study of the calculation techniques and quantitative aspects of good luminous design. Topics covered include photometric quantities and color theory, visual perception, IESNA standards, daylight and artificial illumination, radiative transfer, luminaire characteristics, control systems, and energy conservation techniques. Design and analysis problems, field measurements, and use of industry computer simulations for design and luminaire systems.
(3-0-3)

CAE 518
Advanced Reinforced Concrete
Mechanical properties of hardened concrete, including creep phenomena. Ultimate strength of columns, beams and beam-columns. Introduction to limit analysis of frames and yield-line analysis of plates.
Prerequisite(s): [(CAE 432*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

CAE 520
Buckling of Structures
Review of simple column buckling for various conditions. Basic considerations of stable and unstable equilibrium. Determination of buckling loads of columns with variable cross-section. Analysis of elastic stability of framed structures. Approximate solutions of more complicated problems by various numerical and energy methods. Analysis of lateral and torsional stability of beams and beam-columns. Stability in the inelastic range of columns. Buckling of plates and cylindrical shells.
Prerequisite(s): [(CAE 411 and CAE 431)]
(4-0-4)

CAE 521
Building Illumination Design
An intensive study of the calculation techniques and qualitative aspects of good luminous design. Topics covered include photometric quantities and color theory, visual perception, standards, daylight and artificial illumination systems, radiative transfer, fixture and lamp characteristics, control devices and energy conservation techniques. Design problems, field measurements, computer and other models will be used to explore the major topics. Requires senior standing.
Prerequisite(s): [(CAE 467 with min. grade of D) OR (CAE 502) OR (CAE 515)]
(3-0-3)

CAE 522
Structural Model Analysis
Theory of measurements, statistics, similitude, and model laws and the usefulness of structural models. Displacement and strain measurement techniques. Theory and practice of indirect model analysis. Theory and practice of direct model techniques including photo elasticity and Moire methods.
Prerequisite(s): [(CAE 503)]
(2-2-4)

CAE 523
Statistical Analysis of Engineering Data
Descriptive statistics and graphs, probability distribution, random sampling, independence, significance tests, design of experiments, regression, time series analysis, statistical process control, and introduction to multivariate analysis.
(3-0-3)

CAE 524
Building Enclosure Design
Design of building exteriors, including the control of heat flow, air and moisture penetration, building movements, and deterioration. Study of the principle of rain screen walls and of energy conserving designs. Analytical techniques and building codes are discussed through case studies and design projects.
Prerequisite(s): [(CAE 513)]
(3-0-3)

CAE 525
Advanced Steel & Composite Structures
Torsion and web openings. Behavior and design of rigid and semi rigid beam-to-column connections and base plates. Inelastic behavior of steel and composite members and systems under severe cyclic loading. Design of steel-concrete composite and hybrid systems. P-delta effect and design considerations for system stability. Design of special and ordinary moment-resisting frames. Design of concentrically and eccentrically braced frames. Design of bracing for stability. Plate girders. Fatigue and fracture.
Prerequisite(s): [(CAE 431*)] An asterisk (*) designates a course which may be taken concurrently.
(4-0-4)

CAE 526
Energy Conservation Design in Buildings
Identification of the optimal energy performance achievable with various types of buildings and service systems. Reduction of infiltration. Control systems and strategies to achieve optimal energy performance. Effective utilization of daylight, heat pumps, passive and active solar heaters, heat storage and heat pipes in new and old buildings.
Prerequisite(s): [(CAE 331) OR (CAE 513)]
(3-0-3)

CAE 527
Control of Building Environmental Systems
Introduction to automatic control systems. Control issues related to energy conservation, indoor air quality and thermal comfort in buildings. Classification of HVAC control systems. Control systems hardware: selection & sizing of sensors, actuators & controllers. Practical HVAC control systems; elementary local loop and complete control systems. Case studies. Computer applications.
Prerequisite(s): [(CAE 513) OR (CAE 531)]
(3-0-3)

CAE 528
Building Electrical Systems Design
Study of the analysis and design of electrical systems in buildings utilizing the National Electric Code. Topics include AC, DC, single phase and three-phase circuits, transients, branch circuits, panel boards, system sizing, fault calculations and overcurrent protection design. Also studies the design and specification of emergency power backup and alternative power systems.
(3-0-3)

CAE 529
Dynamics of Structures
Fundamentals of free, forced, and transient undamped and viscously damped vibration of single and multi-degree of freedom structures. Time, frequency, and approximate methods of analysis. Application of numerical methods in time and frequency domain. Response spectra, modes, coupling and modal space. Response history and response spectrum analyses and an introduction to earthquake engineering.
Prerequisite(s): [(CAE 411)]
(3-0-3)

CAE 530
Finite Element Method of Analysis
Advanced and special topics in finite element analysis such as finite element-boundary element method, plates, and shell analysis using finite elements and stochastic finite elements.
Prerequisite(s): [(CAE 442)]
(3-0-3)

CAE 532
Analysis of Plates & Shells
Exact and approximate stress analysis of elastic, isotropic plates of various shapes acted upon by forces in their plane, as well as transverse forces. Stability of plates with various edge conditions, orthotropic plates, elastically supported plates and simple cylinders. Approximate methods such as finite differences, finite elements and the methods of Ritz and Galerkin.
Prerequisite(s): [(CAE 442*) OR (CAE 514*) OR (MMAE 501*)] An asterisk (*) designates a course which may be taken concurrently.
(4-0-4)

CAE 533
Theory & Analysis of Thin Shells
Differential geometry of surfaces. Elastic theory of general shells with nonorthogonal curvilinear coordinates. Specialization to cylindrical shells, shells of revolution and translational shells. Exact and approximate solutions applied to the bending membrane theories of thin shells. Approximate methods including finite differences, finite elements and methods associated with Ritz, Galerkin, Puchler and Gaeckler.
Prerequisite(s): [(CAE 442*) OR (CAE 514*) OR (MMAE 501*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

CAE 534
Computational Techniques in Finite Element Analysis
Survey of numerical methods as applied to FEM software. Database management, equation solvers, eigen value routines and schemes for direct integration (both implicit/explicit), all as employed in the development of a finite element program. Topics covered also include band and front minimizers, static and dynamic substructuring via super elements and sensitivity studies. Same as MAE 538.
Prerequisite(s): [(CAE 442*) OR (CAE 514*) OR (MMAE 501*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

CAE 535
Nonlinear Finite Element Analysis
FEM as applied to nonlinear problems. Contact problems, the mechanics of large deformation, full and updated Lagrange formulations, review of plasticity, solution algorithms, Eulerian approaches, application to FEM to limit analysis. Same as MAE 539.
Prerequisite(s): [(CAE 442) OR (CAE 514) OR (MMAE 501)]
(3-0-3)

CAE 537
Homeland Security Concerns in Building Designs
Review of blast effects produced by solid phase weapons and their effects on structures and people. Estimation of the risk of a terrorist attack and the corresponding threat. Review of simplified methods for the analysis and design of structures to meet homeland security concerns and procedures to minimize casualties. Analysis of post event fires and how to prevent them. Review of security measures to minimize the effects of blast on buildings and people.
(3-0-3)

CAE 539
Introduction to Geographic Information Systems
Geographic information system (GIS) technology allows users to combine tabular information with maps, creating powerful spatial databases which display and query information in new ways. This course will teach general GIS and GPS skills and concepts, useful to students and practitioners in a variety of disciplines. Students will complete a final GIS project relevant to their field of study. This hands-on class will use ESRI's ArcView and Spatial Analyst products, as well as Trimble GeoExplorer GPS units.
(3-0-3)

CAE 540
Asphalt & Concrete Mix Design
Types of asphalt and physical properties of asphalt. Types of mixes: dense graded, open graded, base courses, and maintenance mixes. Types of pavement structures and hot mix asphalt placement. Aggregate physical properties, tests, and blending. Maintenance and rehabilitation materials. Mixture design procedures, including Marshall and Hveem procedures, and weight-volume relationships. Evaluation of mixture properties, engineering property's importance to performance, resilient modulus, fatigue, and creep testing, and thermal cracking properties. Laboratory included.
(2-3-3)

CAE 541
Pavement Evaluation & Management
Pavement management systems (PMS) concepts, network definition, condition survey, pavement condition index (PCI), non-destructive deflection testing (NDT), measurement of roughness and skid resistance, micropaver PMS, PMS implementation, project and network-level management, maintenance alternatives, development of annual and long-range work plans.
(3-0-3)

CAE 543
Demand Models for Urban Transportation
Fundamental theory of supply and demand, transportation economics, network equilibrium, land use and transportation equilibrium. Demand models: trip generation, geographical distribution, mode split, route assignment, the direct-demand model and disaggregate-behavioral-demand models. Special properties of models. Relationships among models.
(3-0-3)

CAE 544
Urban Transportation Planning
Exploration of the goals of urban transportation. Program planning in relating transportation technology to social, economic and environmental systems. Systems analysis in forecasting travel demand and evaluating alternatives in transportation planning.
(4-0-4)

CAE 545
Traffic Operations & Flow Theory
Studies of space and time distribution of speed and other traffic characteristics in the transportation network. Macro- and micro traffic flow theories. Simulation in traffic systems. Application of flow theories to traffic control and operations.
(3-0-3)

CAE 546
Public Transportation Systems
Operational and economic characteristics of urban systems. Transit planning process: demand for transit, transit routing, transit scheduling, network design. Improvements of existing systems and exploration of new technologies.
(3-0-3)

CAE 547
Advanced Traffic Engineering
Data collection, statistical analysis and interpretation of traffic information. Advanced traffic engineering topics, such as signaling, street-and-highway capacity analysis; accident and safety research.
(3-0-3)

CAE 548
Transportation Systems Management
Transportation as a system. Problems of traffic congestion, land use/transportation intersection; intersection control; freeway and arterial incident management; safety considerations; evaluation of strategies; case studies.
(3-0-3)

CAE 549
Transportation Economics, Development & Policy
Application of managerial, micro- and macroeconomic concepts to transportation systems. Investment and impact analysis. Transport policy as it relates to social, economic and environmental issues. Legislative actions affecting transport issues.
(3-0-3)

CAE 551
Prestressed Concrete
Theory and design of prestressed concrete members and structure. Applications to both simple and continuous girder and frames subjected to stationary or moving loads. Prestressed cylindrical shells.
Prerequisite(s): [(CAE 432*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

CAE 553
Measurement & Instrumentation in Architectural Engineering
Hands-on experience with energy and indoor air quality measurements in buildings including experimental design, data analysis, and experimental statistics. Measurements and techniques covered include: thermal performance (e.g., thermal conductivity and resistance, heat flux, and temperature); fluid flows and HVAC characteristics (e.g., velocity, pressure, and airflow); energy performance (e.g., current, voltage, and power draw); whole building diagnostics (e.g., blower door and duct blaster); and indoor air quality (e.g., tracer gas techniques for air exchange, particle measurements, and gas measurements). Course combines lectures and field measurements in buildings on campus.
Prerequisite(s): [(CAE 513)]
(3-0-3)

CAE 555
Transportation Systems Evaluation
Concepts and principles of transportation economic analysis, transportation costs and benefits, user and nonuser consequences, needs studies, finance and taxation, methods of evaluation of plans and projects, cost-effectiveness, environmental impact assessment.
(3-0-3)

CAE 560
Plastic Methods
Fundamental concepts of plasticity in the design of steel structures. Principle of plastic hinges. Upper and lower-bound theorems. Alternating plasticity and incremental collapse. Analysis and design of single story and multi-story framed structures.
Prerequisite(s): [(CAE 431* and CAE 503*)] An asterisk (*) designates a course which may be taken concurrently.
(4-0-4)

CAE 561
Structural Reliability & Probabilistic Bases of Design
Fundamentals of probability theory and stochastic processes; statistical analysis of engineering data; probabilistic modeling of structural loads and material properties. Reliability analysis and design of structure, reliability-based design criteria. Evaluation of existing design codes. Safety analysis of structures under fatigue loads. Fault and event tree analysis.
Prerequisite(s): [(CAE 307)]
(3-0-3)

CAE 562
Engineering Behavior of Soil
Soil mineralogy and soil fabric, soil-water electrolyte system, dispersive clay, stress and strain analyses, elastic equilibrium in soil masses, plastic equilibrium in soil masses, in situ and laboratory stress paths, shear strength of sands and clays, thermal properties of soils, critical state soil mechanics principles, nonlinear pseudo elastic and elastoplastic constitutive models.
Prerequisite(s): [(CAE 323 with min. grade of D)]
(4-0-4)

CAE 563
Advanced Soil Mechanics Laboratory
Advanced aspects of soil property measurement with application to design and analysis, system characteristics on soil sediment, pinhole test for identifying dispersive clays, consolidation, triaxial compression and triaxial extension with porewater measurement, cyclic triaxial test, permeability with back pressure, determination of critical void ratio.
Prerequisite(s): [(CAE 323 with min. grade of D)] AND [(CAE 562*)] An asterisk (*) designates a course which may be taken concurrently.
(1-3-1)

CAE 564
Design of Foundations, Embankments & Earth Structures
Consolidation phenomena, derivation of bearing capacity equations, beams and slabs on soils, piles and pile groups, compaction, earth pressure theories and pressure in embankment, slope stability analyses, retaining structures, embankment design, soil structure interaction during excavation, design of anchors for landslide stabilization and retaining structures and instrumentation.
Prerequisite(s): [(CAE 323 with min. grade of D)] AND [(CAE 457)]
(4-0-4)

CAE 565
Rock Mechanics & Tunneling
Rock classification for engineering purposes, mechanical behavior of rocks, in situ stresses in rock, stresses around underground openings, rock slope engineering, design of underground structures, design of deep support excavation and tunnels, primary and secondary linings of tunnels, mined shafts, instrumentation.
Prerequisite(s): [(CAE 457)]
(4-0-4)

CAE 566
Earthquake Engineering & Soil Dynamics
Earthquakes and their intensity, influence of group motion, review of I-DOF and M-DOF systems, wave propagation theories, vibration due to blast and shock waves, design earthquake motion, dynamic properties of soils, soil liquefaction, bearing capacity during earthquakes and design of machine foundations, isolation of foundations, pile foundation, and dynamic analysis, earth pressure during earthquakes on retaining structures and embankment.
Prerequisite(s): [(CAE 323 with min. grade of D)] AND [(CAE 420)]
(4-0-4)

CAE 567
Physiochemical Behavior of Soils
The nature of soils. Weathering and soil formulation processes. Soil mineralogy. Surface and colloidal chemistry. Structures of water near clay mineral surfaces. Electrolyte solutions. Theories of cation and anion exchange. Adsorption of inorganic chemicals in soils. Organic matter in soils. Adsorption of organic chemicals in soils. Methods to determine petroleum products in soils. Effect of contaminants on permeability of clays. Leachate-clay liner compatibility.
Prerequisite(s): [(CAE 323 and ENVE 501)]
(3-0-3)

CAE 568
Transportation Asset Management
Processes and techniques for managing the preservation and expansion of highway transportation facilities such as pavements, bridges, and so forth, as well as system usage. Five component management systems are first examined: pavements, bridges, roadway maintenance, safety, and congestion. Finally, the methodology for overall transportation asset management is discussed. The primary emphasis is on data collection, life-cycle cost analysis, priority setting and optimization, program development strategies, risk and uncertainty modeling, and institutional issues.
(3-0-3)

CAE 570
Legal Issues in Civil Engineering
This course introduces students to the legal aspects of engineering and construction, contract documents, and contract clauses. Upon completion of this course, students will be able to do the following: (1) identify the elements of contract formation; (2) interpret contract clauses; (3) explain the rights and duties of the parties involved in design and construction; and (4) evaluate changes and their root causes. Students will also be able to objectively identify and analyze legal liabilities and the expected professional standard of architects, engineers, and contractors.
(3-0-3)

CAE 571
Lean Construction & Control
This course introduces students to lean principles and the lean project delivery system (LPDS) applied to the construction industry. Lean construction and lean project delivery embrace concepts and techniques originally conceived in the automobile manufacturing industry and adopted by the construction industry. In the manufacturing sector, lean production has revolutionized product manufacturing, resulting in significant gains in plant productivity, reliability, and reductions in defects. Specific concepts that will be covered in this course include Plan-Do-Check-Act continuous improvement, A3 reporting, value stream mapping, pull systems and pull planning, kanban, 5S, standardization, and the Choosing by Advantages Decisionmaking System.
(3-0-3)

CAE 572
Construction Cost Accounting & Control
Review of basic accounting principles and techniques–purchasing, accounts payable, invoicing, accounts receivable, general ledger, payrolls and indirect costs. Job costing and budgeting. Recording and reporting procedures in construction projects–invoices, subcontractor applications for payment, labor time cards, unit completion reports, change orders. Cost coding systems for construction activities. Variance reporting procedures. Project closeout. Class exercise using computer program.
(3-0-3)

CAE 573
Construction Management with Building Information Modeling
Fundamentals and practical use of information technologies in the construction industry; basic concepts of building information modeling (BIM); review of software and technology available for BIM; practical use of BIM including design and clash detection; impact of BIM on construction management functions; construction scheduling and sequencing using BIM; cost estimating using BIM; facility management with BIM; integrated approach to navigate BIM as a multi-disciplinary design, analysis, construction, and facility management technology; class exercise to create a BIM model and to use it in scheduling, sequencing, cost estimating, management, and simulation of a construction project.
(3-0-3)

CAE 574
Economic Decision Analysis in Civil Engineering
Basic economic concepts including interest calculations, economic comparison of alternatives, replacement decisions, depreciation and depletion, tax considerations, and sensitivity analysis. Evaluation of public projects, the effect of inflation, decision making under risk and/or uncertainty, economic decision models. Case studies from the construction industry.
(3-0-3)

CAE 575
Systems Analysis in Civil Engineering
Management and system concepts, linear programming, graphical methods, Simplex, two-phase Simplex, the transportation problem, the assignment problem, integer programming, and sensitivity analysis. System modeling by activity networks; maximal-low flow, longest-path and shortest-path analyses, flow graphs, decision-tree analysis, stochastic-network modeling, queuing systems, and analysis of inventory systems. Case studies from the construction industry.
(3-0-3)

CAE 576
Legal Aspects of Real Estate & Development
The objective of this course is to introduce civil engineering students to the legal aspects of real estate and the real estate development process. Students will learn the fundamentals of land, air, and water rights; legal interests of parties; purchase agreements, contractual relationships, and real estate contracts; closing real estate transactions; legal aspects of financing; government regulations that impact property transactions; and recent developments in green development law. This course will help civil engineering students learn legal skills that can be applied to real estate purchasing and development processes. This course is the second course in a two-course series on real estate and development. The first course is CAE 579: Real Estate Fundamentals, which is taught each fall semester.
Prerequisite(s): [(CAE 572)]
(3-0-3)

CAE 577
Construction Equipment Management
Factors affecting the selection of construction equipment. Descriptions, operating methods, production rates, unit costs related to excavating equipment. Power shovels, draglines, clam shells, and trenching machines. Engineering fundamentals. Moving construction equipment, including trucks, wagons, scrapers, dozers, soil-stabilization and compaction equipment. Belt conveyors, compaction and drilling equipment, pile driving equipment, pumps and crushers.
(3-0-3)

CAE 578
Construction Claims Management
This course provides a basic explanation of construction contract claims by types such as delays, acceleration, and scope issues, the underlying legal theories of the contract construction and claims, elements required for each claims type defenses to the claim, prophylactic claims measures. The claims process within the contract and extra-contractual basis's for claims are examined. Resolution of claims by ADR techniques and the formal litigation process are explained. AIA, AGC, and federal claims provisions are described. In addition to construction contract claims other types of claims associated with construction projects are covered such as Surety bond claims and various insurance claims (CGL, Builder's Risk, workers comp, etc)
Prerequisite(s): [(CAE 473)]
(3-0-3)

CAE 579
Real Estate Fundamentals for Engineers & Architects
The objective of this course is to introduce civil engineering students to the real estate process. Students will learn techniques and methodologies for evaluating real estate investment opportunities using engineering economic analysis principles. Students will use Time Value of Money analysis for evaluating real estate transactions, including how to carry out calculations using formulas, financial calculators, and spreadsheets. This course will help civil engineering students learn financial skills that can be applied to professional and personal investment decisions.
(3-0-3)

CAE 580
Intelligent Transportation Systems
A seminar course on Intelligent Transportation Systems (ITS). The concept of ITS involves the use of rapidly emerging information and communication technologies in mitigating congestion and attendant problems. A substantial amount of research and development activities have taken place over the last few years. This course will provide an introduction to the various aspects of ITS and will focus on ITS planning, technology, and evaluation. In addition, such topics as deployment, financing and management are also discussed. The course will include guest lectures and possible field visits.
(3-0-3)

CAE 581
Algorithms in Transportation
Modeling and analysis of transportation network problems through the design, analysis, and implementation of algorithms. Emphasis on the use of quantitative techniques of operations research to model system performance. Covers fundamental data structures, complexity analysis, memory management, recursive programs, application of graph theory and network analysis to transportation problems, analytical formulations and solution algorithms for traffic assignment problems, and dynamic traffic assignment.
(3-0-3)

CAE 582
Structural Wind & Earthquake Engineering
Introduction to nature of wind, aerodynamic wind-loading and design. Strong ground motion phenomenon. Investigation of the response of structures to dynamic and pseudo dynamic wind, earthquake, shock waves and other deterministic and probabilistic loadings. Design criteria for buildings and nuclear power stations, special topics in lifeline earthquake engineering.
Prerequisite(s): [(CAE 420) OR (MMAE 406)]
(4-0-4)

CAE 583
Performance-Based Structural & Seismic Design of Buildings & Bridges
This course covers performance-based structural and seismic design (PBSSD) for buildings and bridges. The course will begin with brief reviewing and critical discussion on conventional code-based seismic design followed by the development of the concept and applicability of this new alternative and advanced PBSSD. Computer methods in linear dynamic, nonlinear static, and dynamic analyses will be surveyed and discussed as primary tools in PBSSD. Ample case studies from real-world projects are carried out throughout the course. These case studies include the PBSSD of special structures, tall buildings, and those that building code-based design is not applicable.
Prerequisite(s): [(CAE 410 with min. grade of D) OR (CAE 420 with min. grade of D) OR (CAE 582)]
(3-0-3)

CAE 584
Stormwater Management
Basic principles of storm water management; hydrology and hydraulics of excess water; excess water management and design; sewer system design and management, storm water detention systems; flood plain system design; risk based design of drainage systems; practical and case study problems.
Prerequisite(s): [(CAE 301)]
(3-0-3)

CAE 586
Seismic Design of Building & Bridge Structures
The course covers six topics, as listed in the course outline, on seismic design of steel and R/C building structures and bridges. In addition to offer fundamentals and experiences in seismic design through design examples, it is also assumed that structural engineers who are preparing for their Structural Engineer License Exam might find extremely helpful.
Prerequisite(s): [(CAE 431 and CAE 432)]
(3-0-3)

CAE 589
Groundwater Hydrology & Sampling
Groundwater geology and flow, aquifer and aquitar response of ideal aquifer to pumping. Chemical properties and principles, including source of contamination and estimation of saturated hydraulic conductivity. Principles of exploration and sampling, methods of subsurface explorations, groundwater observation techniques.
Prerequisite(s): [(CAE 323 with min. grade of D) OR (ENVE 401 with min. grade of D)]
(3-0-3)

CAE 590
Geotechnical Landfill Design & Maintenance
Regulatory and legal issues, site selection and assessment, geotechnical-subsurface investigation, clay mineralogy and clay-water-electrolyte system, linear and leachate-control-systems design, stability of landfill slopes, cover design, construction and operation, final use and remediation design.
Prerequisite(s): [(CAE 323)]
(3-0-3)

CAE 591
Research & Thesis for M.S. Degree
Research and Thesis for M.S. Degree.
(Credit: Variable)

CAE 593
Civil Engineering Seminar
Reports on current research. Graduate students are expected to register and attend.
(1-0-0)

CAE 594
Research Problems
Research.
(Credit: Variable)

CAE 597
Special Problems
Graduate course work in the problem subject matter. Subject matter will vary with the interests and background of students and instructor. Design or research problems may be assigned from the areas of architectural, construction, geotechnical, geoenvironmental, structural, or transportation engineering.
(Credit: Variable)

CAE 598
Special Topics
A special topic in civil or architectural engineering at the graduate level.
(Credit: Variable)

CAE 599
Graduate Workshop
Graduate workshop.
(0-0-0)

CAE 691
Research & Thesis for Ph.D. Degree
Research and Thesis for Ph.D. degree.
(Credit: Variable)

CAE 724
Introduction to Acoustics
This short course provides a brief introduction to the fundamentals of acoustics and the application to product noise prediction and reduction. The first part focuses on fundamentals of acoustics and noise generation. The second part of the course focuses on applied noise control.
(2-0-2)

Environmental Engineering

ENVE 501
Environmental Chemistry
Chemical processes in environmental systems, with an emphasis on equilibrium conditions in aquatic systems. The types of processes examined include acid-base, dissolution-precipitation, air-water exchange and oxidation-reduction reactions. Methods presented for describing chemical speciation include analytical and graphical techniques, as well as computer models.
(3-0-3)

ENVE 506
Chemodynamics
Processes that determine the fate and transport of contaminants in the environment. Upon successful completion of this course, students should be able to formulate creative, comprehensive solutions to transport problems, critically evaluate proposed solutions to transport problems, and acquire and integrate new information to build on these fundamentals.
(3-0-3)

ENVE 513
Biotechnological Processes in Environmental Engineering
Fundamentals and applications of biological mixed culture processes for air, water, wastewater, and hazardous waste treatment. Topics include biochemical reactions, stoichometry, enzyme and microbial kinetics, detoxification of toxic chemicals, and suspended growth and attached growth treatment processes. The processes discussed include activated sludge process and its modifications, biofilm processes including trickling filters and biofilters, nitrogen and phosphorous removal processes, sludge treatment processes including mesophilic and thermophilic systems, and natural systems including wetlands and lagoons.
(3-0-3)

ENVE 528
Modeling of Environmental Systems
To introduce students to mathematical modeling as a basic tool for problem solving in engineering and research. Environmental problems will be used as examples to illustrate the procedures of model development, solution techniques and computer programming. These models will then be used to demonstrate the application of the models, including simulation, parameter estimation and experimental design. The goal is to show that mathematical modeling is not only a useful tool but also an integral part of process engineering.
(3-0-3)

ENVE 542
Physiochemical Processes in Environmental Engineering
Fundamentals and applications of physicochemical processes used in air, water, wastewater and hazardous waste treatment systems. Topics include reaction kinetics and reactors, particle characterization, coagulation and flocculation, sedimentation, filtration, membrane separation, adsorption and absorption.
Prerequisite(s): [(ENVE 501*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

ENVE 551
Industrial Waste Treatment
Industrial waste sources and characteristics, significance of industrial waste as environmental pollutants; applications of standard and special treatment processes, including physical, chemical and biological systems.
Prerequisite(s): [(ENVE 513*) OR (ENVE 542*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

ENVE 561
Design of Environmental Engineering Processes
Design of water and wastewater treatment systems. System economics and optimal design principles.
Prerequisite(s): [(ENVE 513*) OR (ENVE 542*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

ENVE 570
Air Pollution Meteorology
Physical processes associated with the dispersion of windborne materials from industrial and other sources. Atmospheric motion including turbulence and diffusion, mathematical models and environmental impact assessment.
(3-0-3)

ENVE 576
Indoor Air Pollution
Indoor air pollution sources, indoor pollutant levels, monitoring instruments and designs; indoor pollution control strategies: source control, control equipment and ventilation; energy conservation and indoor air pollution; exposure studies and population time budgets; effects of indoor air population; risk analysis; models for predicting source emission rates and their impact on indoor air environments.
(3-0-3)

ENVE 577
Design of Air Pollution Control Devices
Principles and modern practices employed in the design of engineering systems for the removal of pollutants. Design of control devices based on physical and chemical characteristics of polluted gas streams.
(3-0-3)

ENVE 578
Physical & Chemical Processes for Industrial Gas Cleaning
Application of physical and chemical processes in the design of air treatment systems; fundamentals of standard and special treatment processes.
(3-0-3)

ENVE 580
Hazardous Waste Engineering
Sources and characteristics of hazardous wastes, legal aspects of hazardous waste management, significance of hazardous wastes as air, water and soil pollutants. Principles and applications of conventional and specialized hazardous waste control technologies.
Prerequisite(s): [(ENVE 506*)] An asterisk (*) designates a course which may be taken concurrently.
(3-0-3)

ENVE 590
Environmental Engineering Seminar
Current topics in environmental engineering featuring presentations by practitioners from a range of institutions such as academia, industry, consulting, research laboratories, or government.
(1-0-0)

ENVE 591
Research & Thesis M.S.
Graduate research.
(Credit: Variable)

ENVE 597
Special Problems
Independent study and project. (Variable credit)
(Credit: Variable)

ENVE 691
Research & Thesis Ph.D.
Graduate research.
(Credit: Variable)