Department of Civil and Architectural Engineering

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Chair:
Jamshid Mohammadi

The Department of Civil and Architectural Engineering offers graduate instruction in structural engineering, transportation engineering, geotechnical engineering, geoenvironmental 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 Architectural Engineering
Master of Construction Engineering and Management
Master of Geoenvironmental Engineering
Master of Geotechnical Engineering
Master of Public Works
Master of Structural Engineering
Master of Transportation Engineering
Master of Science in Civil Engineering
with specialization in:
- Architectural Engineering
- Construction Engineering and Management
- Geotechnical Engineering
- Geoenvironmental Engineering
- Structural Engineering
- Transportation Engineering

Doctor of Philosophy

Joint-Degree Program

Bachelor of Architecture/Master of Civil Engineering

Certificate Programs

Construction Management
Earthquake and Wind Engineering Design
Geoenvironmental Engineering
Infrastructure Engineering and Management
Transportation Systems Planning

Research Facilities

Research facilities include laboratories devoted to concrete structures, structural models, metal structures, materials, architectural engineering, geotechnical engineering, transportation engineering, and construction engineering and management. In addition, researchers have access to the extensive on-campus facilities of the IIT Research Institute and the Argonne National Laboratory nearby. 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 structural, architectural, geotechnical and geoenvironmental engineering, construction engineering and management, transportation engineering and public works. The faculty conducts research in structural mechanics, analysis methods and design in concrete and steel; bridge engineering; acoustics; airflow and thermal modeling, energy conservation, indoor air quality and thermal comfort; soil mechanics, rock mechanics, engineering geology, earthquake engineering, soil structure and soil-water interactions; construction techniques, site productivity, contracts and specifications, planning, scheduling and control of construction activities, quantity takeoff and estimating, economic decision analysis, construction equipment, systems analysis, contract administration and computer applications in scheduling, estimating, resource planning and cost control; traffic engineering, urban transportation planning, traffic flow theory, public transport, railroad engineering and transportation systems management.

Research in the public works specialty area includes public policy evaluation, management of engineering operations, maintenance, repair and rehabilitation of bridges, and rehabilitation and renovation of existing infrastructures. The department also conducts research in the areas of architectural engineering and building envelopes, acoustics, fire protection and safety engineering, fire prevention and protection during construction, fire load environment and performance-based design.

Department of Civil and Architectural Engineering

Faculty

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

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

Eduardo De Santiago, Assistant Professor. B.S., Illinois Institute of Technology; M.S., Ph.D., Stanford University. Structural engineering and computational methods.

Sidney A. Guralnick, Perlstein Distinguished Professor of Engineering, Emeritus, and Director of the Advanced Building Materials and Systems Center. B.S., Drexel Institute of Technology; M.S., Ph.D., Cornell University. Structural engineering and materials of construction.

C. Jotin Khisty, Professor Emeritus. 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.

Zongzhi Li, Assistant Professor of Civil and Architectural Engineering. B.E. Chang'an University, (China); M.S., Ph.D., Purdue University.

A. C. Megri, Assistant Professor. Ph.D., INSA, Lyon (France). Passive cooling, alternative methods for plastic waste recycling, thermal modeling of heat exchangers, airflow modeling, design of cooling systems.

Jamshid Mohammadi, Professor and Chairman. B.S., M.S., University of Teheran (Iran); M.S., Ph.D., University of Illinois, Urbana-Champaign. Structural reliability and bridge engineering.

Ralph T. Muehleisen, Assistant Professor, B.S. University of Wisconsin, Madison, Ph.D., The Pennsylvania State University. Architectural acoustics, building simulations development including lighting and acoustics.

James Novak, Senior Lecturer and Director, Engineering Graphics Division. M.S., Illinois Institute of Technology.

John R. O'Leary, Associate Professor and Associate Chairman. B.S., M.S., Illinois Institute of Technology; Ph.D., University of Texas, Austin. Solid mechanics and computational methods.

Jay H. Shen, Associate Professor. B.S., Hefei University; M.S., Chinese Academy of Sciences; Ph.D., University of California, Berkeley. Structural engineering and seismic design.

Jonathan J. Shi, Associate Professor. B.Sc., M.Sc., Wuhan University; Ph.D., University of Alberta (Canada). Innovation and new development of modeling and simulation methods for construction.

Mark E. Snyder, Research Professor. B.S., M.S., Creighton University, M.S., Illinois Institute of Technology, Ph.D., Texas Tech University. Building energy and lighting systems, measurement techniques, fire engineering.

Admission Requirements

Cumulative undergraduate GPA minimum: 3.0/4.0
GRE minimum score:
For tests taken prior to Oct.1, 2002, M.S./MAS/Ph.D.:
1200 (combined)
For tests taken on or after Oct.1, 2002, M.S./MAS:
900 (quantitative + verbal) 2.5 (analytical writing)
For tests taken on or after Oct.1, 2002, Ph.D.:
1000 (quantitative + verbal) 3.0 (analytical writing)
TOEFL minimum: 550/213*

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 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 also accept a bachelor's degree in architecture. 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.

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

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

Department of Civil and Architectural Engineering

Master of Architectural Engineering

Master of Construction Engineering and Management

Master of Geoenvironmental Engineering

Master of Geotechnical Engineering

Master of Structural Engineering

Master of Transportation Engineering

32 credit hours (minimum)

These master's programs are course-only, professionally oriented degree programs that permit a concentration in preparation for engineering practice. Admission requirements to the programs in construction, architectural, geoenvironmental, geotechnical, structural and transportation engineering are the same as those for the M.S. program, with one possible exception. The GRE requirement is waived for applicants who hold a Bachelor of Science in a related field from an ABET-accredited university in the United States with a minimum GPA of 3.0/4.0.

Candidates in these programs must complete a minimum of 32 credit hours, three of which may be a special project course, CAE 597. Up to 12 credit hours of 400-level undergraduate coursework (except CAE 431 and CAE 432) may be included in the professional master's program with prior adviser approval. No thesis or comprehensive examination is required for successful completion of this degree.

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: mechanical and electrical 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 531	Physical Performance of Buildings
CAE 542	Acoustics and Lighting
CAE 574	Economic Decision Analysis in Civil Engineering

Construction Engineering and Management

The professional master's 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, and address legal problems.

Core courses

CAE 570	Legal Issues in Civil Engineering
CAE 574	Economic Decision Analysis in Civil Engineering
CAE 575	Systems Analysis in Civil Engineering
CAE 577	Construction Equipment Management

Geoenvironmental Engineering and Geotechnical Engineering

The geotechnical and geoenvironmental 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, waste disposal facilities. Laboratory experiments and computer analyses/modeling are incorporated.

Geotechnical engineering core courses

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

Geoenvironmental engineering core courses

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

Structural Engineering

IIT's professional 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 504	Engineering Analysis 1A
CAE 503	Advanced Structural Theory and Design
CAE 518	Advanced Reinforced Concrete
CAE 525	Advanced Steel and Composite Structures

Transportation Engineering

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

Core courses

CAE 543	Demand Models for Urban Transportation
CAE 546	Public Transportation Systems
CAE 548	Transportation Systems Management
CAE 575	Systems Analysis in Civil Engineering

Master of Public Works (Infrastructure Engineering and Management)

32 credit hours

The Master of Public Works (M.P.W.) degree is the most widely recognized educational credential for professionals engaged in public works and infrastructure engineering and management. IIT's M.P.W. program consists of four mandatory and six to seven elective courses, totaling a minimum of 32 credit hours, drawn from the programs in civil and environmental engineering and public administration. This program is offered in cooperation with IIT's Master of Public Administration program. Admission to the M.P.W. program as a regular graduate student requires a bachelor's degree in engineering or science with a GPA of 3.0/4.0 or better.

Master of Science in Civil Engineering

32 credit hours
Thesis and oral defense

Five technical areas (construction, architectural, 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 and Timber Design) and CAE 432 (Concrete and Foundation Design)] may be included in the M.S. program with prior adviser approval. An oral defense of the thesis constitutes the comprehensive examination, and no additional written comprehensive examination is required.

Doctor of Philosophy

96 credit hours, including master's degree
(A maximum of 48 credit hours may be transferred from another institution. Students should consult the rules for transfer credit on page 33.)
Qualifying exam
Comprehensive exam
Dissertation
Oral defense

The full-time doctoral program generally consists of two complete years of academic preparation, followed by 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 a year of entry into the program. After a student is admitted to candidacy, the department appoints a permanent committee consisting of at least two faculty members of the department and representatives of faculty in the minor fields. The advisory committee may permit the student to initiate research at any time after admission to candidacy when, in the committee's opinion, he or she has achieved adequate preparation. Academic preparation normally includes the equivalent of one year of coursework, with civil engineering as the major field, as well as preparation in such minor fields as applied mathematics or solid mechanics.

The student should discuss the choice of a research adviser with the advisory committee before making his or her selection. The research adviser, if not already a member of the committee, will be added at this time. 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 if and only if approved by the entire faculty advisory committee. In those cases, the student must register for CAE 691 during each semester in which the thesis is being prepared. The comprehensive examination must be completed at least one year prior to the date of graduation.

Bachelor of Architecture/Master of Civil Engineering

Qualified students regularly enrolled at IIT may earn both the Bachelor of Architecture and the professional master's degree. They must complete preparatory courses for the professional master's program prior to entry into the combined program. Students who anticipate entry into the combined 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, CAE 303, CAE 304, CAE 307, CAE 310, CAE 315, CAE 431 and CAE 432 (in place of MATH 119), MATH 122, CAE 287, CAE 351, and CAE 352. Students who anticipate entry into the combined program and who intend to specialize in construction engineering and management must successfully complete the following courses as part of the technical electives in their undergraduate program in architecture: CAE 323, CAE 431, CAE 432 and CAE 457. (For undergraduate course descriptions, students should refer to the undergraduate bulletin or the online course-description database at www.enrollment.iit.edu.)

Certificate Programs

Construction Management

Required courses (Select four)

CAE 470	Construction Methods and Cost Estimating
CAE 471	Construction Planning and Scheduling
CAE 472	Construction Site Operation
CAE 473	Construction Project Administration
CAE 570	Legal Issues in Civil Engineering
CAE 571	Advanced Construction Scheduling and Control
CAE 572	Construction Cost Accounting and Control
CAE 573	Computer Applications in Construction
CAE 574	Economic Decision Analysis in Civil Engineering
CAE 575	Systems Analysis in Civil Engineering
CAE 577	Construction Equipment Management
CAE 578	Construction Claims Management

Earthquake and Wind Engineering Design

Required courses (Select four)

CAE 410	Introduction to Wind and Earthquake Engineering
CAE 420	Introduction to Dynamics of Structures
CAE 431	Steel and Timber Design
CAE 432	Concrete and Foundation Design
CAE 504	Seismic Retrofit and Earthquake Hazard Reduction
CAE 518	Advanced Reinforced Concrete
CAE 525	Advanced Steel and Composite Structures
CAE 582	Structural Wind and Earthquake Engineering

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:

ENVE 480	Solid Waste Engineering
ENVE 580	Hazardous Waste Engineering
ENVE 585	Groundwater Contamination and Pollutant Transport

Infrastructure Engineering and Management

Required courses

PA 501	Introduction to Public Administration
PA 551	Public Works Management

AND two of the following:

CAE 408	Bridge and Structural Design
CAE 508	Bridge Inspection, Rehabilitation, Repair and Management
CAE 419	Transportation Engineering and Design
CAE 541	Pavement Evaluation and Management
CAE 486	Soil and Site Improvement
CAE 590	Geotechnical Landfill Design and Maintenance
CAE 471	Construction Planning and Scheduling
CAE 574	Economic Decision Analysis in Civil Engineering
ENVE 405	Environmental Impact Assessment
ENVE 551	Design of Sanitary Engineering Process

Transportation Systems Planning

Required courses (Select four)

CAE 419	Highway and Engineering Design
CAE 430	Probability Concepts in Civil Engineering Design
CAE 543	Demand Models for Urban Transportation
CAE 544	Urban Transportation Planning
CAE 549	Transportation Economics, Development and Policy
CAE 575	Systems Analysis in Civil Engineering

Course Descriptions

Numbers in parentheses indicate class, lab and credit hours, respectively.

CAE 503
Advanced Structural Theory and Design
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: CAE 310. Corequisite: MMAE 504. (4-0-4)

CAE 504
Seismic Retrofit and 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: CAE 420, CAE 582 or instructor's consent. (4-0-4)

CAE 505
Infrastructure Rehabilitation Engineering
Repair and rehabilitation of existing deteriorated infrastructure building structures and facilities. Course will include identification of problems, investigative techniques, non-destructive testing methods, discussion of repair materials, and strengthening and preparation of rehabilitation documents. (2-0-2)

CAE 506
Building Envelope Rehabilitation Engineering
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. (2-0-2)

CAE 507
Control of Sound and 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. Prerequisite: CAE 542 or instructor's Consent. (3-0-3).

CAE 508
Bridge Inspection, Rehabilitation, Repair and Management
Elements of bridge management, rating and inspection process. Life-cycle, project-level and network-level analyses, condition assessment, case studies, and repair, retrofit and replacement alternatives, and their relation to infrastructure management. (3-0-3)

CAE 509
Analysis and 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: CAE 542 or instructor Consent. (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, and solids), fire phenomena in enclosures such as pre-flashover and post-flashover. Prerequisites: MMAE 310 or MMAE 313 or CAE 302, MMAE 322 or CAE 309 or instructor's consent. (Students who have taken the undergraduate course equivalent, CAE 424, may not take this course for credit.) (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, and other fire protection systems. For architects and engineers not majoring in fire protection and safety engineering. (Students who have taken the undergraduate course equivalent, CAE 425, may not take this course for credit). (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. Prerequisites: CAE 424 or instructor's consent. (Students who have taken the undergraduate course equivalent, CAE 426, may not take this course for credit.) (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: CAE 432. (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. Prerequisites: CAE 310, CAE 431. Corequisite: MMAE 504. (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. Prerequisite: instructor's consent. (Students who have taken the undergraduate course equivalent, CAE 467, may not take this course for credit.) (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 photoelasticity and moire methods. Prerequisite: CAE 503. (4-0-4)

CAE 523
Statistical Analysis of Engineering Data
Review of probability, random variables, distribution models, estimation of statistical parameters and testing validity of distribution models. Analysis of variance (ANOVA), hypothesis testing, correlation analysis, multiple range tests, pairwise comparisons, data compilation using unconventional sources, such as using simulations, expert opinion and cycle-counting methods. Prerequisite: MATH 252 or equivalent. (3-0-3)

CAE 525
Advanced Steel and Composite Structures
Torsion and web openings. Behavior and design of rigid and semirigid 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 consideration 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. Prerequisites: CAE 431 or equivalent. (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: instructor's consent. (Students who have taken the undergraduate course equivalent, CAE 465, may not take this course for credit.) (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 system hardware: selection and sizing of sensors, actuators and controllers. Practical HVAC control systems; elementary local loop and complete control systems. Designing and tuning of controllers. Building automation systems. Case studies. Computer Applications. Prerequisite: instructor's consent or CAE 528 or CAE 466 or concurrent registration. (Students who have taken an equivalent undergraduate course may not take this course for credit.) (3-0-3)

CAE 528
Communication and Electrical Systems in Buildings
Study of the analysis and design of electrical systems in buildings utilizing the National Electrical Code. The topics include basic circuits, ac and dc, single phase and three-phase power, transients, capacitance and inductance, branch circuits, panel boards, motors, system sizing, and electrical distribution in buildings. Study of the design and specification of communication systems in buildings, including fire alarm, security, sound, and telephone. Prerequisite: instructor's consent. (Students who have taken the undergraduate course equivalent, CAE 466, may not take this course for credit.) (3-0-3)

CAE 529
Information Technology in Buildings
Understanding the potential, the advantages, and the difficulties associated with using information technology to gain a strategic advantage in the building industry. Knowing the various components of any information system. Selection of suitable hardware and software for a certain design of construction task. Development and implementation of buildings-oriented databases. Use of the Internet to develop Web pages for project information. (3-0-3)

CAE 530
Finite Element Method of Analysis
Continuation of CAE 442. Covers 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: CAE 442. (3-0-3)

CAE 531
Physical Performance of Buildings
Study of the environmental exterior and interior influences (rain, snow, humidity, temperature, wind, sun, etc.) on the physical performance of buildings and the implications of these influences on building design. Study of indoor thermal environment and thermal comfort of building occupant is offered as well. (Students who have completed the undergraduate equivalent may not take this course for credit.) (3-0-3)

CAE 532
Analysis of Plates and 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. Corequisite: MMAE 504. (4-0-4)

CAE 533
Theory and 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. Corequisite: MMAE 504. (3-0-3)

CAE 534
Computational Techniques in Finite Element Analysis
Survey of numerical methods as applied to FEM software. Database management, equation solvers, eigenvalue routines and schemes for direct integration (both implicit and 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 superelements and sensitivity studies. Same as MMAE 538. Prerequisite: CAE 442 or MMAE 451. (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 MMAE 539. Prerequisite: CAE 442 or MMAE 507. Corequisite: MMAE 504. (3-0-3)

CAE 537
Homeland Security Concerns in Building Design
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 concers and procedures to minimize casualties. Analysis of post event fires and how to prevent them. Review of security measure 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 databases that 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 and 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. Prerequisite: instructor's consent. (3-0-3)

CAE 542
Acoustics and 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. Prerequisite: PHYS 221. (Students who have taken the undergraduate course equivalent, CAE 334, may not take this course for credit.) (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. Prerequisite: CAE 416 or instructor's consent. (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 and Flow Theory
Studies of space and time distribution of speed and other traffic characteristics in the transportation network. Macro- and microtraffic 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. Prerequisite: CAE 419 or instructor's consent. (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. Prerequisite: CAE 419 or instructor's consent. (3-0-3)

CAE 549
Transportation Economics, Development and 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. Prerequisite: CAE 419 or instructor's consent. (3-0-3)

CAE 551
Prestressed Concrete
Theory and design of prestressed concrete members and structure. Applications to both simple and continuous girders and frames subjected to stationary or moving loads. Prestressed cylindrical shells. Prerequisite: CAE 432. (3-0-3)

CAE 552
Heating and Refrigeration
Heating load analysis, including building shapes, construction type, infiltration, occupancy effects, and daily load variations. Computer applications for thermal load analysis. Water Heating Systems, Steam Heating Systems, Electrical Heating, Central Heating, Heating of Low and High-rise Buildings, Selection of Heaters, Boilers, Pumps, Piping Design. Computer Applications. Reciprocating Refrigeration. Refrigerant, Refrigeration Cycle, Evaporator, Compressor, Condenser, Thermostatic expansion valves, refrigeration system control equipment, motor and motor control equipment, refrigeration accessories, calculation of refrigeration piping and absorption systems. Computer Applications. Prerequisite: Thermodynamics, Heat Transfer, Fluid Mechanics or instructor's consent. (4-0-4)

CAE 553
Measurement and Instrumentation in Architectural Engineering
Experimental Statistics and Data Analysis. Dynamic measurement. Measurement of Thermal Characteristics (Conductivity, diffusivity, etc). Fluid-Property Measurement (Pressure, Temperature, etc). Fluid Flow measurement (Flow, Viscosity, etc). Blower door and Tracer Gas Techniques. Duct leakage Measurement. Prerequisite: Thermodynamics, Fluid Mechanics and Heat Transfer or instructor's consent. (3-0-3)

CAE 554
Capstone Architectural Engineering Design Project
The student has to perform major design project or an independent research project under the guidance of a CAE faculty member in one or more from the following areas: HVAC systems, Energy Conservation Technology, Lighting and Illumination, Acoustics, Safety and Fire Protection, Plumbing, Structure, Construction Management or integrated building Design. Requires the approval of the advisor (Credit: Variable; three hours maximum).

CAE555
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. Prerequisites: CAE 419 or instructor's consent. (3-0-3)

CAE 556
Architectural Engineering Systems
Introduction to systematic solutions of building engineering problems. Techniques to be treated include linear programming, network analysis, nonlinear programming. Introduction to decision analysis and simulation. Application of optimization methods for solution of design problems in building science, building environment, building structures and construction management. Computer Applications. (3-0-3)

CAE 557
Computer-Aided Building Design
This course introduces students to the process of integrated building design. It emphasizes both computer assistance (CA) and building design (BD). Building design is viewed in a holistic manner integrating related fields such as spatial layouts, structures, enclosures, energy consumption, and construction cost estimation. Building engineering design process: methodology, identification of objectives, building codes, formulation of design problems. Development and evaluation of design alternatives. Conceptual building design: spatial requirements, design of space layout. Preliminary building design: synthesis and design of structures, enclosure systems, and services (HVAC, lighting, electrical distribution) using computer-aided design tools. Performance evaluation using modeling, sensitivity analysis and cost estimation. A major design project is an integral part of this course. Prerequisite: instructor's consent. (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 multistory framed structures. Prerequisites: CAE 503, CAE 431. (4-0-4)

CAE 561
Structural Reliability and 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: CAE 307 or instructor's consent. (3-0-3)

CAE 562
Engineering Behavior of Soils
Soil mineralogy and soil fabric, soil-water electrolyte system, dispersive clay, stress and strain analyses, elastic equilibrium in soil masses, plastic equilibrium in soil of masses, in situ and laboratory stress paths, shear strength of sands and clays, thermal properties of soils, critical state soil mechanics principles, nonlinear pseudoelastic and elastoplastic constitutive models. Corequisite: CAE 563. Prerequisite: CAE 323. (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. Corequisite: CAE 562. Prerequisite: CAE 323. (1-3-1)

CAE 564
Design of Foundations, Embankments and 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. Prerequisites: CAE 323, CAE 457. (4-0-4)

CAE 565
Rock Mechanics and 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: CAE 457. (4-0-4)

CAE 566
Earthquake Engineering and Soil Dynamics
Earthquakes and their intensity, influence of ground motion, review of 1-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. Prerequisites: CAE 323, CAE 420. (4-0-4)

CAE 567
Physicochemical Behavior of Soils
The nature of soils. Weathering and soil formation 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. Prerequisites: CAE 323, ENVE 501. (3-0-3)

CAE 568
Transportation Asset Management
Process and techniques for managing preservation and expansion of highway transportation facilities such as pavements, bridges, as well as system usage. Five component management systems are examined: pavements, bridges, roadway maintenance, safety and congestions. 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 an uncertainty modeling and institutional issues. Prerequisite: CAE 419 or instructor's consent. (3-0-3)

CAE 569
Advanced Heating, Ventilating, and Air-Conditioning
Engineering design and performance analysis procedures for complex commercial building systems, including energy conservation techniques, and a design project. This course will include specific subjects such as spray chambers, cooling towers, Extended Surface Heat Exchangers and also hybrid ventilation. A design of a real commercial Heating, Ventilating, and Air-Conditioning Systems is a major part of this course. Prerequisite: CAE 464 or equivalent, CAE 309 or equivalent, CAE 302 or equivalent (3-0-3)

CAE 570/CAE 770
Legal Issues in Civil Engineering
Basics of the legal system, including contracts, torts, land zoning and property ownership. Working knowledge of the law to avoid and mitigate potential legal problems that frequently occur in construction. Contractor liability. Mechanics liens, litigation and arbitration. International construction law, hazardous waste issues and labor law. Prerequisite: CAE 473. (3-0-3)

CAE 571
Advanced Construction Scheduling and Control
Review of project management principles and network methodologies. Interfacing computerized cost estimating with network scheduling. Claims management with networks. Evaluation and selection criteria for commercially available project-management software. Linear scheduling systems for projects with repetitive characteristics. Acyclic network models. Introduction to expert systems in construction scheduling and control. Prerequisite: CAE 471. (3-0-3)

CAE 572
Construction Cost Accounting and 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. Prerequisites: CAE 470, CAE 570. (3-0-3)

CAE 573
Computer Applications in Construction
Knowledge engineering, human and automated knowledge acquisition and knowledge representation. Inferencing mechanisms. Decision-making under uncertainty. Introduction to very high-level programming languages (LISP and Prolog). Review of commercially available expert system shells and development tools for artificial neural network and case-based reasoning applications. Class exercise to construct a system prototype for a civil engineering problem. Prerequisite: CAE 430. (3-0-3)

CAE 574
Economic Decision Analysis in Civil Engineering
Basic economic concepts, including interest calculations, computation of alternatives, replacements, depreciation and depletion, and tax considerations. Evaluation of public projects, the effect of inflation, decision making under risk and/or uncertainty, economic decision models. Case studies from the civil engineering industry. Prerequisite: CAE 430 or MATH 475. (3-0-3)

CAE 575
Systems Analysis in Civil Engineering
Management and system concepts, linear and dynamic programming, system modeling by activity networks. Maximal-flow and shortest-path analysis, flow graphs, decision-tree analysis, stochastic-network modeling, queuing analysis, and analysis of inventory systems. Case studies from the civil engineering industry. Prerequisites: CAE 430, CAE 471. (3-0-3)

CAE 576
Advanced Construction Accounting and Finance
Review of sole proprietorships, partnerships, corporations, limited liability companies, federal regular income tax and alternative minimum tax, state income tax, inventories, cash-flow statements, analysis of financial statements. Percentage of completion with look-back and completed contract methods of long-term contract accounting, cost-allocation and equipment-cost-recovery deductions, under federal regular income tax, alternative minimum tax and state income tax rules. International construction issues, including foreign taxes, currencies, tax treaties, income exclusion. Construction claims and effects on accounting. Government construction. Introduction to financing, privatization, nonlump-sum contracts, joint ventures and audits, in accounting and the construction process. Prerequisite: 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. Prerequisite: CAE 472. (3-0-3)

CAE 578
Construction Claims Management
Types of contract claims, delays, acceleration, and scope issues. Underlying legal theories of construction contracts and claims, defenses to claims, prophylactic claims measures. The claims process within the contract, extra-contractual basis for claims. Resolution of cliams by ADR techniques, the formal litigation process. AIA, AGC, and federal claims provisions. Other types of

claims associated with construction projects such as a surety bond claims and various insurance claims (CGL, Builder's Risk, workers comp, etc). Prerequisite: CAE 473. (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. This course provides an introduction to varous aspects of ITS and focuses on ITS planning, technology, and evaluation. In addition, such topics as deployment, financing and management are also discussed. Prerequisites: CAE 419, CAE 545 or instructor's consent. (3-0-3)

CAE 581
Algorithms in Transportation
Modeling and analysis of transportation network problems through design, analysis and implementation of agorithms. Emphasis is on the use of quantitative techniques of operations reserach to model system performance. The course covers fundamental datea 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. Prerequisites: CAE 312, CAE 575 or instructor's consent. (3-0-3)

CAE 582
Structural Wind and 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 pseudodynamic 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: CAE 420, MMAE 406, or instructor's consent. (4-0-4)

CAE 586
Seismic Design of Building and Bridge Structures
Several specific topics on seismic design of steel and reinforced concrete building and bridge structures are covered. In addition, fundamentals and experiences in seismic design are presented through design examples. Specific emphasis is placed on using various design codes relevant to design of buildings and bridges. Prerequisites: CAE 431 and CAE 432 or Instructor's consent. (3-0-3)

CAE 583
Special Topics on Earthquake and Wind Engineering
This course covers special topics on earthquake and wind design for buildings and bridges. The course covers eight topics. These topics are independent of each other and cover a variety of engineering applications in earthquake and wind enineering. Prerequisite: instructor's consent (2-0-2)

CAE 587
Numerical Methods in Geotechnical Engineering
Constitutive laws of granular and cohesive material, introduction to coupling of water and soil phase in solution, application to problems of consolidation procedures with finite element method. Prerequisites: CAE 562, CAE 442. (3-0-3)

CAE 588
Theory of Plasticity
Plastic strain, yield criteria, ideal plasticity, hardening and softening, flow theories, Levy-Mises and Prandtl-Reuss relations, Hencky's theory, Drucker's criterion. Modern theories of noncoaxiality. Applications to structures and soils. Same as MMAE 529. Prerequisite: MMAE 530. (4-0-4)

CAE 589
Groundwater Hydrology and 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. Prerequisites: CAE 323 and CAE 301 or ENVE 401. (3-0-3)

CAE 590
Geotechnical Landfill Design and 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: CAE 323. (3-0-3)

CAE 591
Research and Thesis for M.S. Degree

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

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

CAE 599
Graduate Workshop
(0-0-0)

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