

Civil and Environmental Engineering

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The Department of Civil and Environmental Engineering offers advanced study for the degree of Master of Science and Doctor of Philosophy. The areas of specialty are Structures, Mechanics, Geotechnical, Construction, Transportation, Water Resources, and Environmental Engineering. Degrees offered include: Master of Science in Civil Engineering, Master of Science in Environmental Engineering, Master of Science in Environmental and Urban Systems, and Doctor of Philosophy in Civil Engineering.

Master of Science in Civil Engineering

Albert Gan, *Graduate Program Director, Civil Engineering*

The Master of Science program in Civil Engineering emphasizes course work as well as research. The student is generally encouraged to specialize in a defined area of civil engineering, but may also find it desirable to pursue a more general program of studies combining subject material from different areas of specialization and interdisciplinary related courses.

The graduate degree is offered to prepare qualified students for the professional practice of civil engineering. The degree is available in a thesis or non-thesis program. The thesis program entails a minimum of six credits for the successful completion of the research and thesis. The non-thesis program must be supported by the successful completion of a project and a report of substantial engineering content for a minimum of three credits. A student must satisfactorily complete a minimum of 30

semester credits of acceptable graduate course work, which includes a minimum of 12 credits of graduate courses in the specialty area.

Master of Science in Environmental Engineering

Berrin Tansel, *Graduate Program Director, Environmental Engineering*

A Master of Science in Environmental Engineering is available to students interested in graduate work in Environmental Engineering. The program is designed to expose graduate students to a wide range of knowledge on environmental engineering and on problem solving while encouraging them to pursue individual research interests. Thus, the curriculum has a common core of courses but is flexible enough to permit an interdisciplinary approach, if so desired, and allows the student to pursue his or her career goals. A proposed program of studies will be developed by the advisory committee together with the student.

The applicant should hold a Bachelor's degree in engineering, the natural sciences, or a related field. Students who do not meet the stated criteria may be considered for admission if they complete the required prerequisites and satisfy any deficiencies. A student must satisfactorily complete a minimum of 30 semester credits of acceptable graduate courses, including either a master thesis or an engineering project.

Master of Science in Environmental and Urban Systems

Shonali Laha, *Graduate Program Director, Environmental and Urban Systems*

The Master of Environmental and Urban Systems (MEUS) is an interdisciplinary program designed for planning professionals and graduate students in urban issues. The purpose of the MEUS degree is to provide a multi-disciplinary education to students interested in the practice of urban and environmental planning. Graduates of the program may eventually apply their skills in various government agencies or private enterprises within a variety of subject areas. Particular emphasis may be placed on issues related to tropical and subtropical areas. The degree requires completion of 30 graduate semester credits.

Admission Policies for Master of Science Programs

A student seeking admission into Civil Engineering or Environmental Engineering graduate program must have a bachelor's degree in Civil Engineering, Environmental Engineering, or related engineering or equivalent from an accredited institution or, in the case of foreign students, an institution recognized in its own country as preparing students for further study at the graduate level. In the case of a student seeking admission into Environmental and Urban Systems graduate program, the bachelor's degree must be in environmental or urban systems, environmental studies, engineering, architecture, social sciences, natural sciences, or a related field. The minimum requirements for admission to the Master programs are:

1. At least a "B" average in upper level undergraduate work, and

2. A bachelor's degree in engineering, science, or a related field from an accredited institution, and

3. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required, and

4. Three letters of recommendation or the forms provided by the department, and

5. A statement of objectives in which, in addition to other information, the intended concentration must be clearly stated.

Students who meet all criteria, except for requirements 1 and 2 above, may be evaluated for conditional admission. Meeting the minimum requirements does not guarantee admission to the programs.

Grades earned at an institution with non-traditional grading systems will be given every consideration and applicants will be treated equally with students from institutions with traditional grading systems.

Combined BS/MS Program

Students who have completed a minimum of 90 hours towards their BS degree and have earned at least a 3.3 GPA on both overall and upper division courses may, upon recommendation from three CEE faculty members, apply to the department to enroll in the combined BS/MS program. Students enrolled in the program may count up to 9 hours of CEE graduate courses as credits for both the BS CEE electives and the MS degree. The BS/MS Program has been designed to be a continuous program. Students in combined program will apply for graduation with the BS and MS at the same time. Students will receive a BS degree and a MS degree on the same date, after requirements for both are completed. The student's advisor will insure that appropriate forms are completed, and that students do not apply for BS degree graduation until both BS and MS requirements are finished. Upon the completion of BS degree requirements, students may "walk" for the graduation ceremony and may request for a temporary departmental certificate. Students may also elect to permanently leave the combined program at any time and earn only the BS degree. Once the BS is granted, students will have the same access requirements to regular graduate programs as any other student. However, the combined MS degree would not be available to those who elect to leave the combined program.

Admission into the combined program does not automatically qualify the students for admission into the MS degree program. To enroll in the MS degree program, the students must apply (in their senior year) to the graduate school and meet all graduate admission requirements.

Undergraduate students enrolled in the program are encouraged to seek employment with a department faculty to work as student assistants on sponsored research projects. The students will be eligible for graduate assistantships upon admission into the graduate school.

For each of the graduate courses counted as credits for both BS and MS degrees, a minimum grade of B is required. Only graduate courses with formal lectures can be counted for both degrees. The students are responsible for confirming the eligibility of each course with the undergraduate advisor.

Students interested in the program should consult with the undergraduate advisor on their eligibility for the

program. The students should also set up an appointment with the graduate coordinator to learn about the graduate program and available courses before completing the application form and submitting it to the undergraduate advisor. Applicants will be notified by the department on the decision of their application.

Application Procedures for Master of Science Programs

A student planning to enroll in the graduate program must complete the following:

1. Submit a Graduate Application for Admission to the Graduate Admissions Office.

2. Have a copy of the official transcripts of all previously earned college or university credits sent from the applicant's former institution(s) to the Graduate Admissions Office.

3. Send three letters of recommendation and statement of objectives directly to the graduate program director of the appropriate program.

4. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required.

It should be emphasized that the admission cannot be acted upon until all of the documents and credentials have been received.

Students seeking a waiver to normal admissions standards must contact the departmental main office for filing instructions and deadlines.

Degree Requirements

To be eligible for a Master's degree a student must:

1. Satisfy all University requirements for a Master's degree.

2. Meet all undergraduate deficiencies, and requirements as specified by the students' advisory committee.

3. Complete 30 semester hours of acceptable graduate level courses.

4. Earn a minimum grade point average of 3.0 in all approved courses in the student's program of study.

5. Complete an acceptable thesis or graduate project.

6. Pass an oral examination that includes an oral defense of the thesis or graduate project.

7. Master's degree students in Environmental Engineering must in addition register for one credit of the Graduate Environmental Seminar (ENV 6935) and are encouraged to participate in it each year.

Grades and Credits

No course in which a grade below a 'C' is earned may be counted toward a Master of Science degree.

Transfer Credit

The student may receive permission to transfer up to a maximum of six semester hours of graduate credit earned from another institution or up to 12 semester hours of graduate credit earned at FIU after admitted into one of the graduate programs in the Civil and Environmental Engineering Department. Such credits are transferrable provided that: (1) the course(s) were taken at the graduate level at an accredited college or university; (2) grade(s) of 'B' or higher were earned for the courses; (3) the course(s)

are judged relevant by the student's advisory committee; (4) the credits were not used toward another degree; and (5) the credit(s) were completed within six years immediately preceding the awarding of the degree.

Credit is not transferable until the student has earned 12 semester hours in the Civil Engineering or Environmental Engineering programs.

Time Limit

All work applicable to the Master's degree, including transfer credit, must be completed within six years of first enrollment in the master's program.

Doctor of Philosophy in Civil Engineering

Albert Gan, *Graduate Program Director*

Minimum Admission Requirements

The minimum requirements for admission to the doctoral program in civil engineering are:

1. Applicants having a Master's degree in Civil Engineering or Environmental Engineering from a U.S. institution must satisfy the following requirements for admission to the doctoral program:

- a. GPA of at least 3.3/4.0 in the master's program
- b. GRE verbal plus quantitative of at least 1120 points
- c. Three letters of recommendation or the forms provided by the department

d. A statement of objectives in which, in addition to other information, the intended research area must be clearly stated. (see identification of Research Area)

2. Credentials of all other applicants including those with foreign degrees and those with B.S. degrees in other disciplines will be examined by the Graduate Committee on a case by case basis. Additional credentials that will be considered include, but are not limited to, work experience, awards and recognitions, publications and presentations, and other professional experience. All applicants are encouraged to submit a detailed resume with their application for evaluation.

3. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required.

4. In addition to the departmental requirements, all students must satisfy the University's Admission and Graduate Policies and Procedures.

Degree Requirements

Maximum Length of Study

The maximum length of study is 7 years for students admitted with a B.S. degree and 6 years for students with an M.S. degree. For those students who have not completed their studies within these limits, the length of study may be extended on a yearly basis after petition by the student and approval by the student's supervisory committee. Any extension beyond nine years must be approved by the University Graduate School.

Identification of Research Area

There are currently three main areas of research or specialization: (1) Structural and Geotechnical Engineering; (2) Environmental and Water Resources Engineering; and (3) Transportation Engineering. The

student must contact the Department for a list of all faculty members, visit them, and be accepted by one professor to guide the dissertation research. If no such professor can be found, within 15 months of admission, the student will be dismissed from the Ph.D. program.

Course Requirement

The program will consist of at least 90 semester credit hours beyond the baccalaureate degree, 54 hours of which are course work and 24 hours dissertation, or at least 60 semester credit hours beyond the M.S. degree, 24 hours of which are course work and 24 hours dissertation. The remainder of the required minimum credit hours can be taken as either course work or dissertation or a combination thereof as approved by the student's advisor. Applicants who have a Master's degree in Civil and Environmental Engineering or a closely related field from an accredited institution are given a maximum of 30 transferred semester credit hours. In addition to the above requirements, the selection of courses must meet the following requirements for credits beyond the Master's degree:

1. Minimum 3 credits in Mathematics or Statistics
2. Minimum 18 core credits in the selected major area in Civil and Environmental Engineering
3. Any deviation from requirements 1 and 2 above must be justified in writing and approved by the CCE Graduate Program Director.

Additional engineering courses (3000 and 4000 level) may be required as deficiencies for students coming from non-engineering majors.

All courses and dissertation topics must be approved by the student's supervisory committee.

Supervisory Committee

The student's supervisory committee should be appointed as soon as possible and within the 15-month period after the student has been admitted to the Ph.D. program. The committee must have a minimum four members, at least three from the Department of Civil & Environmental Engineering, and at least one from outside the department, but within FIU. All committee members should have a Ph.D. degree and must be members of the graduate faculty. The supervisory committee should meet as early as possible to review student's background, discuss student's expected research areas, provide guidance on course selection, etc.

Residency Requirements

The Ph.D. student should spend at least one academic year in full residency, after successfully passing his/her Comprehensive Examination (see the following description).

Examinations

A student must successfully complete the following written exam and oral defenses in partial fulfillment of requirements for the Ph.D. degree in Civil Engineering:

1. Qualifying Exam: The Qualifying Exam must be taken as soon as possible and no later than the semester the student completes the minimum course requirements. The exam consists of 8 problems covering materials from core courses as determined by the student's supervisory committee. The exam will be open-book and the student will be given 8 hours to solve all 8 problems. In the event

that a student fails the exam, he or she can retake it only once in the subsequent semester.

2. Proposal Defense: The proposal defense must be completed at least one year prior to the expected graduation date. In addition to the five-page proposal (brief version) required by the University Graduate School, the student must prepare a detailed proposal that contains, at a minimum, background information, problem statement, objectives, literature review, methodology, work plan, and schedule. The proposal must be submitted to each committee member at least two weeks prior to the defense date. The defense will be given in the form of a graduate seminar that is open to all faculty, students, and visitors. A student can take the proposal defense twice.

3. Dissertation Defense: A draft dissertation must be submitted to each committee member at least six weeks prior to the date of the defense. The defense will be given in the form of a graduate seminar that is open to all faculty, students, and visitors. A student can fail this defense only once. In addition to dissertation copies to the University Graduate School, the student must deliver one final approved bound copy to the Department Chairperson, one to the major advisor, and one to each member of the supervisory committee.

Graduate Certificate in Information Technology in Civil Engineering (ITCE)

The *ITCE* program brings information, communication and computing technology to the civil and environmental engineering professionals, who otherwise have little opportunity to be exposed to the rapidly changing technologies and techniques in these areas. The proposed program will provide the opportunity to learn the basics and application techniques of these technologies in an organized, systematic, and formal setting. The program offers a set of carefully selected courses on computing and information technologies tailored to the needs of engineers in the fields of civil and environmental engineering, including structural, transportation, geotechnical, construction, and water resources engineering. The *ITCE* program will also provide specialization opportunities for professionals interested in developing computer and information technology applications in the civil and environmental engineering fields. This program will help professional engineers (PE's) earn continuing education credits required to retain their registration. Interested students will be able to continue to earn a Masters in Civil Engineering degree if the admission requirements for the Masters program are met.

A minimum undergraduate GPA of 2.75 is required for admission. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required. To earn a graduate certificate in ITCE, the students must successfully complete the program's core and elective courses.

The ITCE curriculum consists of 18 credit hours – 6 courses (3 core + 3 elective) of 3 credit hours each as shown.

Core (Required) Courses:

CGN 6424	Advanced Computing in Civil Engineering
CGN 6308	Intelligent Civil Engineering Systems
CCE 5505	Computer Integrated Construction Engineering

Electives:

CGN 5321	GIS Applications for Civil and Environmental Engineering
CES 5565	Computer Applications in Structures
CGN 6325	Advanced GIS for Civil and Environmental Engineering
CGN 5315	Civil Engineering Systems
BCN 5784	Construction Information Systems
EIN 6117	Advanced Industrial Information Systems
ISM 6222	Telecommunications Network
MAN 6830	Organization Information Systems

Additional information about this program can be found at:

URL: www.eng.fiu.edu/cee

Tel: (305) 348-3055

Fax: (305) 348-2802

Academic Standard

The Department of Civil and Environmental Engineering requires that students receive no grade less than a "C" with an overall GPA of 3.0 in order to be awarded the graduate certificate.

Course Descriptions

Definition of Prefixes

CES-Civil Engineering Structures; CEG-Engineering General, Civil; CGN-Civil Engineering; CWR-Civil Water Resources; EES-Environmental Engineering Science; EGM-Engineering, Mechanics; EGN-Engineering, General; ENV-Engineering, Environmental; TTE-Transportation and Traffic Engineering

CCE 5035 Construction Engineering Management (3).

Course will cover construction organization, planning and implementation; impact and feasibility studies; contractual subjects; liability and performance; the responsibility of owner, contractor and engineer. Prerequisite: CCE 4001.

CCE 5036 Advanced Project Planning for Civil Engineers (3).

Advanced techniques and methods for planning activities, operations, finance, budget, workforce, quality, safety. Utilize case studies as learning tools for students aspiring to management positions. Prerequisite: Permission of instructor.

CCE 5405 Advanced Heavy Construction Techniques (3).

Heavy construction methods and procedures involved in large construction projects such as bridges, cofferdams, tunnels, and other structures. Selection of equipment based on productivity and economics. Prerequisite: Permission of instructor.

CCE 5505 Computer Integrated Construction Engineering (3).

Course covers the discussion of available software related to Construction Engineering topics; knowledge based expert systems and their relevance to construction engineering planning and management. Prerequisite: CCE 4001.

CEG 5065C Geotechnical Dynamics (4). Analytical, field, and laboratory techniques related to vibration problems of

foundations, wave propagations, behavior of soils and rocks, earth dams, shallow and deep foundations. Earthquake engineering. Prerequisite: CEG 4011.

CEG 6017 Theoretical Geotechnical Mechanics (3). A continuum mechanics interpretation of geotechnical engineering: soil rheology: theories of yielding: failure and plastic stability. Analytical and numerical modeling of non-linear properties. Prerequisites: CEG 4012C and MAP 2302. Suggested corequisite: MAP 4401.

CEG 6105 Advanced Foundations Engineering (3). Computer applications involving the numerical analysis and design of complex soil-structure interactions: highway and airfield pavements, deep foundation groups and NATM tunnelling techniques. Prerequisite: CEG 4012.

CES 5106 Advanced Structural Analysis (3). Extension of the fundamental topics of structural analysis with emphasis on energy methods and methods best suited for nonprismatic members. Prerequisite: CES 4101.

CES 5325 Design of Highway Bridges (3). Structural analysis and design for highway bridge systems which includes design criteria, standards of practice and AASHTO specifications for designing super-structures and substructure elements of various types of bridges. Prerequisites: CES 4605, CES 4702, CEG 4011.

CES 5565 Computer Applications in Structures (3). Discussion and application of available computer programs, techniques and equipment for the analysis, design and drafting of structures. Graduate students have to do a project. Prerequisites: CES 4605 and CES 4702.

CES 5606 Advanced Structural Steel Design (3). Extension of the analysis and design of structural elements and connections for buildings, bridges, and specialized structures utilizing structural steel. Prerequisites: CES 4101, CES 4605.

CES 5715 Prestressed Concrete Design (3). The behavior of steel and concrete under sustained load. Analysis and design of pre-tensioned and post-tensioned reinforced concrete members, and designing these members into the integral structure. Prerequisite: CES 4702.

CES 5800 Timber Design (3). The analysis and design of modern wood structures. Effect of plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design. Prerequisite: CES 4101.

CES 5XXX Topics in Wind Engineering (3). The course will cover the nature of wind related to wind-structure interaction and design loads for extreme winds, tornadoes and hurricanes. Prerequisites: CES 3100 Structural Analysis and CWR 3201.

CES 6209 Advanced Structural Dynamics in Civil Engineering (3). Response of structures subjected to arbitrary forms of deterministic dynamic loading; formulation of methods to evaluate stresses and deflections due to vibrations. Prerequisite: EGM 5421.

CES 6706 Advanced Reinforced Concrete Design (3). The analysis and design of reinforced concrete and masonry structural systems to formalize the student's knowledge of the behavior of structural components into a final integrated structure. Prerequisites: CES 4101, CES 4702, CEG 4011.

CGN 5315 Civil Engineering Systems (3). Application of systems analysis techniques to large scale civil engineering problems. Prerequisites: ESI 3314 or equivalent.

CGN 5320 GIS Applications in Civil and Environmental Engineering (3). Introduction to the basics of geographic information systems, their software and hardware, and their applications in Civil and Environmental Engineering, landscape architecture, and other related fields. Prerequisites: CGS 3420, SUR 3101C and consent of instructor.

CGN 5930 Special Topics in Civil Engineering (1-3). A course designed to give groups of students an opportunity to pursue special studies not otherwise offered. Prerequisite: Permission of the instructor.

CGN 5935 Professional Engineering (Civil) Review (4). Prepares qualified candidates to take the P.E. written examination in the field of Civil Engineering. Reviews hydraulics, hydrology, water supply and wastewater, geotechnics, structures, concrete and steel design, etc.

CGN 6308 Intelligent Civil Engineering System (3). Application of artificial intelligence and other techniques to build intelligent civil and environmental engineering systems. Develop planning, design, analysis, diagnosis, control, monitoring applications through projects. Prerequisite: Permission of the instructor.

CGN 6325 Advanced GIS for Civil and Environmental Engineering (3). Advanced GIS concepts and techniques for civil and environmental engineering applications including LRS, temporal GIS, 3D modeling, GIS data accuracy and standards, spatial statistical analysis, and others. Prerequisites: CGN 5930 or permission of the instructor.

CGN 6426 Advanced Computing in Civil Engineering (3). Advanced computer modeling and programming techniques for civil and environmental engineering applications including data modeling, engineering database design, object-oriented programming, and user interface design. Prerequisite: Permission of the instructor.

CGN 6905 Directed Independent Study (1-3). Individual conferences, assigned readings, and reports independent investigations selected by the student and professor with approval of advisor.

CGN 6910 Supervised Research (1-6). Graduate level research carried out under the supervision of a faculty member.

CGN 6916 Engineering Project (1-3). Independent research work culminating in a professional practice oriented report for the requirements of the non-thesis option of the M.S. degree. Prerequisites: Fifteen graduate credits and approved project plan.

CGN 6930 Advanced Special Topics in Civil Engineering (1-3). A course designed to give groups of students an opportunity to pursue special studies in an advanced topic of Civil Engineering not otherwise offered. Prerequisite: Permission of the instructor.

CGN 6939 Graduate Seminar (1-3). An examination of recent technical findings in selected areas of concern. Emphasis is placed on presentations (oral and written), research activities, readings, and active discussions

among participants. Prerequisite: Permission of graduate's advisor.

CGN 6971 Thesis (1-6). The student following the thesis option of the Master's degree will pursue research through this course. The research work will culminate with an acceptable thesis. Prerequisite: Permission of graduate's thesis advisor.

CGN 7980 Ph.D. Dissertation (1-12). Doctoral research leading to Ph.D. civil engineering dissertation. Prerequisites: Permission of Major Professor and Doctoral Candidacy.

CWR 5235 Open Channel Hydraulics (3). Theoretical treatment and application of hydraulics. Flow in open channels with special reference to varied flow, critical state hydraulic jump, and wave formation. Prerequisite: CWR 3103.

CWR 5251 Environmental Hydraulics (3). Application of fluid mechanics in the study of physical mixing in surface water bodies, dispersion of materials, and design of hydraulic systems. Prerequisite: Permission of the instructor.

CWR 6117 Statistical Hydrology (3). Quantitative determination of surface water run-off from a statistical approach. Prerequisites: CWR 3201 and CWR 3103.

CWR 6125 Groundwater Hydrology (3). Physical properties, equations of flow/mass transport, saturated/unsaturated zone, wells, pumping tests, quality/contamination control, analytical solutions, introduction to numerical models/computer codes. Prerequisite: Permission of the instructor.

CWR 6126 Advanced Groundwater Hydrology.(3). Finite difference/finite element/boundary integral methods, transport and fate of chemically and biologically reacting solutes, tracer tests, hydrological approaches to remedial action and monitoring. Prerequisites: CWR 6125, or permission of the instructor.

CWR 6236 Engineering Sediment Transport (3). Physical processes of sediment transport and deposition, land erosion, river morphology applied to engineering design, design of stable channels, scour, transport of sediment-attached pollutants.

EES 5135 Water Quality Indicators (3). Ecological studies of micro and macro organisms which are indicators of water quality. Emphasis of bioassays and early warning systems. Prerequisite: Permission of the instructor.

EES 5137 Biological Monitoring of Freshwater Ecosystems (3). The use of aquatic insects and other invertebrates to monitor changes in the aquatic environment. The ecological aspects of aquatic insects in relation to pollution stress are assessed. Prerequisites: EES 5135 or permission of the instructor.

EES 5506 Occupational Health (3). Effects, assessments, and control of physical and chemical factors in man's environment, including chemical agents, electromagnetic radiation, temperature, humidity, pressures, illumination, noise, and vibration. Prerequisite: Admission to graduate program.

EES 5605 Noise Control Engineering (3). Fundamentals of sound and noise. Health hazards and other effects.

Measurement and noise control in transportation, construction, and other environments. Prerequisite: Admission to graduate program.

EES 6506 Environmental and Human Factors (3). Effects, assessment and control of physical and chemical factors in the natural and man-made environments, including noise, electro-magnetic radiation, air and water pollution, public and occupational health, vector control, communicable diseases. Prerequisite: Admission to graduate program.

EES 6508 Occupational Health and Toxicology (3). A continuation of EES 6506. Investigation of toxic substances in air, water, and food in the industrial environment. Prerequisite: EES 6506.

EGM 5111 Experimental Stress Analysis (3). Course covers the necessary theory and techniques of experimental stress analysis and the primary methods employed: brittle coating, strain gauges, photoelasticity and Moire. Prerequisites: EGM 3520, EGM 5653.

EGM 5351 Finite Element Methods in Mechanics (3). Matrix techniques and variational methods in solid mechanics; single element, assemblage and generalized theory; non-linear analysis; applications in structural and soil mechanics, torsion, heat conduction and hydro-elasticity, etc. Prerequisite: EGM 3520.

EGM 5421 Structural Dynamics (3). Fundamentals of free, forced, and transient vibration of singles and multidegree of freedom structures, including damping of lumped and distributed parameters systems. Graduate students have to do a project. Prerequisite: MAP 3302.

EGM 6425 Structural Reliability (3). Fundamentals of probability theory and stochastic processes; probabilistic modeling of structural loads and material properties; reliability analysis and design of structures; reliability-based design criteria. Prerequisite: STA 3033.

EGM 6533 Advanced Mechanics of Materials (3). Extension of the fundamental principles of engineering mechanics to include curved beams, warping, stability, etc. Prerequisites: CES 4101, MAP 3302.

EGM 6653 Theory of Elasticity (3). An advanced course covering the concepts of stress and strain tensors, indicia notation, transformation of stresses, compatibility equations, the stress function and the closed form solution of some important continuum mechanics problems. Prerequisites: EGM 3520, MAP 3302.

EGM 6675 Advanced Plasticity (3). Formulation of the plastic stress-strain relationships; Prandtl-Reuss equations; yield criteria; Plane Plastic Flow and the Plane Slip Line Field Theory; limit analysis and basics of creep. Prerequisite: EGM 3520.

EGM 6736 Theory of Elastic Stability (3). Course will cover the beam-column problem; elastic and inelastic buckling of bars and frames; review of experimental work and design formulas; buckling of rings, curved bars and arches; bending and buckling of thin plates and thin shells. Prerequisite: EGM 3520.

EGM 6796 Theory of Plates and Shells (3). A course covering the concepts of thin plates with small deflections; thin plates with large deflections; thick plates; the

Membrane Theory of Shells; and the General Theory of Cylindrical Shells. Prerequisite: EGM 3520.

EGN 5439 Design of Tall Buildings (3). The course analyzes different modern high-rise structural systems, and includes the dynamics of wind and earthquakes to efficiently design very tall buildings and their ancillary structures. Prerequisite: Permission of instructor.

EGN 5455 Numerical Methods in Engineering (3). Study of procedures that permit rapid approximate solutions, within limits of desired accuracy, to complex structural analysis. Graduate students have to do a project. Prerequisite: CES 4101.

EGN 5990 Fundamentals of Engineering (FE) Review (4). Prepares upper level engineering students to take the Fundamentals of Engineering (FE) State Board examinations. Reviews chemistry, computers, statics, dynamics, electrical circuits, fluid mechanics, mechanic of materials, material science and thermodynamics.

ENV 5002C Fundamentals for Environmental Engineers (3). Laws and principles of the physical, chemical and biological phenomena that define and control the fate of chemical species in natural and engineered systems. Prerequisite: Permission of the instructor.

ENV 5007 Environmental Planning (3). Environmental laws and regulations, ecological principles, planning policies and processes, risk assessment, environmental impact due to growth, and environmental indicators.

ENV 5008 Appropriate Technology for Developing Countries (3). Appropriate environmental technologies and associated factors. Topics include water, air, soil and waste management. Low cost and energy alternatives are emphasized. Prerequisite: Permission of the instructor.

ENV 5027 Bioremediation Processes (3). Biotransformation of subsurface contaminants is gaining recognition as a viable treatment tool. This course provides students with quantitative methods required to design bioremediation systems. Project required. Prerequisite: Permission of the instructor.

ENV 5062 Environmental Health (3). Study of the control and prevention of environmental-related diseases, both communicable and non-communicable, injuries, and other interactions of humans with the environment. Prerequisite: Permission of the instructor.

ENV 5065 Vector and Pest Control (3). Effects and management of public health vectors and communicable diseases. Prerequisites: ENV 5500 or permission of the instructor.

ENV 5104 Indoor Air Quality (3). Assessment of sources of indoor air pollutants and human exposure. Remediation of unhealthy conditions by source control.

ENV 5105 Air Quality Management (3). The air pollution problem, principal types, sources and dispersion of pollutants. Physical, economic, and legal aspects of control of atmospheric pollutants.

ENV 5116 Air Sampling Analysis (3). Practical laboratory work and theoretical aspects involved in a wide range of air sampling and analysis systems. Critical comparison and examination of methods and instrumentation. Source

testing, instrumental sensitivity, applicability and remote sensing systems. Prerequisites: ENV 5105 or ENV 4101.

ENV 5126 Particulate Air Pollution Control (3). Particulate pollution control devices, principles, design, costs. Cyclones, electrostatic precipitators, filters, bag houses, scrubbers, noval control devices

ENV 5127 Gaseous Air Pollution Control (3). Gaseous pollution control devices, principles, design, costs. Gaseous pollutants control using adsorption, absorption, incineration, and other novel control systems.

ENV 5334 Spill Response and Hazardous Materials Transport (3). Consequence analysis of accident scenarios covering the release and dispersion of toxic substances during transport into air, soil, or aquifer and fast response to spills and toxics recovery. Prerequisite: Permission of the instructor.

ENV 5335 Advanced Hazardous Waste Treatment Processes (3). Theory and principles of technologies for treatment and disposal of hazardous waste. Procedures for remedial investigations and feasibility studies. Prerequisites: Hazardous Waste Assessment and Remediation or permission of the instructor.

ENV 5347 Waste Incineration (3). Domestic and industrial waste incineration and pollutant stream control of aqueous and airborne pollutants. Design of incinerations.

ENV 5356 Solid Wastes (3). In-depth study of the solid waste problem. Topics include municipal, industrial, and agricultural generation of wastes; municipal collection systems; methods of disposal, hazardous wastes, and energetic considerations in the recovery and recycle of wastes.

ENV 5406 Water Treatment Systems and Design (3). Course emphasizes water quality, quantities, treatment and distribution systems particularly as relates to municipal water supply. Requires laboratory project. Prerequisite: Permission of the instructor.

ENV 5512 Water and Wastewater Analysis (3). Relevance of the main quality parameters and their measurements by wet chemistry and analytical equipment. Includes BOD, COD, TOC, CO, TSS, VSS, alkalinity, acidity, PH hardness, ammonia, TKN, NO₂, NO₃, PO₄, etc. Prerequisites: ENV 5666, CHM 1046, and CHM 1046L. Corequisite: ENV 5512L.

ENV 5512L Water and Wastewater Analysis Laboratory (1). Experiments are conducted which measure gross organic pollution indicators, suspended solids, conductivity, alkalinity, acidity, pH, nitrate, nitrite, TKN, ammonia, total phosphates, chlorine residual and chlorine breakpoint. Prerequisites: ENV 5666, CHM 1046, and CHM 1046L. Corequisite: ENV 5512.

ENV 5517 Design of Wastewater Treatment Plants (3). Wastewater collection systems. Integration of unit operations into the planning and design of treatment plants, including sludge handling and disposal. Prerequisite: Permission of the instructor.

ENV 5519 Reactions in Environmental Engineering (3). Basis for applying microbial and physicochemical principles to understand reactions occurring in natural and engineered systems including water/wastewater treatment

processes. Includes laboratory project. Prerequisite: Permission of the instructor.

ENV 5559 Reactor Design (3). A theoretical and practical basis for reaction kinetics to understand multi-phase reactions, analysis and design of batch and continuous flow reactors. Projects on analysis of reactor design and operating data.

ENV 5659 Regional Planning Engineering (3). Theories of urban and regional growth; collective utility analysis; input-output models in planning; application of linear programming to regional social accounting; economic base analysis. Prerequisites: Computer Programming or permission of the instructor.

ENV 5666 Water Quality Management (3). Predicting and evaluating the effect of human activities on streams, lakes, estuaries, and ground waters; and the relation of human activities to water quality and protection of water resources. Prerequisite: Permission of the instructor.

ENV 5905 Independent Study (1-3). Individual research studies available to academically qualified students on graduate status.

ENV 5930 Special Topics in Environmental Engineering (1-3). Specific aspects of environmental technology and urban systems not available through formal course study. Open to academically qualified students only.

ENV 6045 Environmental Modeling (3). Evaluation of regional resources, environmental stresses, and considerations in regional systems; systems analysis in environmental management and its relation to decision making; modeling of air and water systems. Prerequisites: Computer programming or permission of the instructor.

ENV 6056 Engineering Assessment of Metal Contaminants & Colloidal Transport (3). Kinetics of metal sorption reactions, colloidal transport, assessment of metal contaminants in soil. Prerequisite: Permission of the instructor.

ENV 6070C Green Engineering (3). Pollution prevention guidelines. Characterization, assessments and audits of processes in the energy and industrial sectors. Minimization approaches. Feasibility, cost analysis and implementation. Prerequisite: Permission of the instructor.

ENV 6337 Hazardous Waste Site Assessment (3). Phase I and Phase II Investigations, Environmental Testing, Assessment, Monitoring Design. Prerequisites: ENV 5335 or permission of the instructor.

ENV 6435 Design of Drinking Water Treatment Plants (3). Drinking water treatment plant design, including unit operations from coagulation, sedimentation, filtration to disinfection, together with advanced treatment technologies.

ENV 6510 Advanced Unit Operations I (3). Theory and design of physical and chemical processes for treatment of contaminated media. Application of fluid mechanics, heat and mass transfer to design and operation of physical/chemical systems. Prerequisite: Permission of the instructor.

ENV 6511C Advanced Unit Operations II (3). Theory and design of biological processes for treatment of

contaminated media. Application of biochemical reaction kinetics theory to design and operation of biological treatment systems. Prerequisite: Permission of the instructor.

ENV 6511L Advanced Unit Operations II Lab (1). Bench scale experiments for scaling-up and designing the following water and wastewater processes: sedimentation, coagulation, filtration, adsorption, oxidation and gas transfer. Prerequisite: ENV 6510. Corequisite: ENV 6511.

ENV 6516 Advanced Treatment Systems (3). Integration of unit operations into advanced treatment systems for contaminated media. Applications may include either conventional or innovative/emerging technologies. Prerequisite: Permission of the instructor.

ENV 6558 Industrial Wastewater Treatment (3). Characteristics and composition of industrial wastewaters. Sampling techniques and analyses. Water conservation and reuse. Joint industrial-commercial collection and treatment of wastewaters. Prerequisite: ENV 6516.

ENV 6614 Environmental Risk Assessment (3). Characteristics of risk analysis, hazard identification, exposure assessment, consequence analysis, dose-response analysis. Prerequisite: Permission of the instructor.

ENV 6615 Environmental Impact Assessment (3). An examination of alternative techniques useful for analysis and environmental impacts of man's activities. Environmental impact assessment methodologies are emphasized.

ENV 6916 Engineering Project (1-3). Individual work culminating in a professional practice-oriented report suitable for the requirements of the M.S. degree-project option. Only three credits are applicable towards degree. Prerequisites: Completion of 20 graduate credits and approved proposal.

ENV 6934 Advanced Special Topics in Environmental Engineering (1-3). Specific aspects of Environmental Engineering requiring advanced engineering and research skills. A maximum of three credits are applicable towards degree. Prerequisite: Permission of the instructor.

ENV 6935 Graduate Environmental Seminar (1-3). The course consists of oral presentations made by students, guests, and faculty members on current topics and research activities in environmental systems.

ENV 6971 Thesis (1-6). Research for Master's thesis.

TTE 5007 Transportation Systems in Developing Nations (3). Transportation systems in the Developing Nations. Role of international organizations, technology transfer/choices, orientation of transport networks, socio-economic and environmental impacts. Prerequisites: Graduate standing or permission of the instructor.

TTE 5015 Applied Statistics in Traffic and Transportation (3). Civil and Environmental Engineering statistics methods as applied to traffic and transportation are covered. Topics include: significance tests, standard distributions, analysis of variance, and regression analysis. Prerequisite: Graduate standing.

TTE 5100 Transportation and Growth Management (3). Theory and principles of transportation and growth

management, including the growth phenomena and regional impact planning. Design projects required. Prerequisite: TTE 4201.

TTE 5107 Highway Safety Analysis (3). Accident reconstruction, intersection analysis, highway safety standards, speed estimations from skidding, momentum/energy relationships, human factors. Prerequisites: STA 3033, TTE 4201.

TTE 5205 Advanced Highway Capacity Analysis (3). Parameters involved in calculating highway capacity and level of service on different highway and transportation facilities. Computer application will be also discussed. Prerequisite: TTE 4201.

TTE 5215 Fundamentals of Traffic Engineering (3). Speed and volume studies, stream characteristics, traffic flow theory, accident characteristics. Prerequisite: TTE 4201.

TTE 5606 Transportation Systems Modeling and Analysis (3). Modeling and analysis techniques in transportation. Linear Programming, queueing theory, decision making techniques. Prerequisite: TTE 4201.

TTE 5607 Transportation Demand Analysis (3). Travel demand analysis and forecasting. Modeling techniques including trip generation and distribution, mode split, and trip assignment. Practical applications. Prerequisite: TTE 4201.

TTE 5805 Advanced Geometric Design of Highways (3). Parameters governing the geometric design of highways; curve super-elevation; widening on highway curves; elements of intersection design; design of interchanges; use of AASHO design guidelines. Design project required. Prerequisites: SUR 3101C and TTE 4201.

TTE 5835 Pavement Design (3). Analysis and design of sub-base, base, and pavement of a roadway. Discussions of flexible pavement and rigid pavement as structural units. Boussinesq's approach. Westergaard's theory. Beams on Elastic Foundations. Prerequisites: CEG 4011 and CES 4702.

TTE 5925C Urban Traffic Workshop (3). Selected laboratory problems related to urban traffic. Prerequisite: TTE 4201.

TTE 5930 Transportation Seminar (1-3). Oral presentations made by students, guests, and faculty members on current topics and research activities in traffic and transportation engineering. Prerequisite: TTE 4201.

TTE 6257 Traffic Control Systems Design (3). Theory and principles of traffic control systems design, including both freeway and urban streets. Design projects required. Prerequisite: TTE 4201.

TTE 6267 Traffic Simulation Models (3). Traffic simulation modeling and analysis. Application of microscopic and macroscopic traffic simulation models to evaluate and optimize traffic control systems. Prerequisites: TTE 6257 or equivalent.

TTE 6506 Mass Transit Planning (3). Theories and principles of mass transit planning, include highway transit, rail transit and new transit modes. Design projects required. Prerequisite: TTE 5930.

TTE 6525 Bearing Capacity of Roads and Airfields (3). Advanced study of bearing capacity principles and theory; stress-strain behavior of pavements; constitutive modeling; and failure histories of pavement. Prerequisite: Permission of the instructor.

TTE 6526 Airport Planning and Design (3). Theory and principles of airport planning and design, include both general aviation and major commercial airports. Design projects required. Prerequisite: Permission of the instructor.

TTE 6528 Airport Terminal Design and Operations (3). Theory and practice of airport terminal design and operations, including passenger terminal complex, cargo terminal complex, and ground transportation. Design projects required. Prerequisite: Permission of the instructor.

TTE 6605 Planning and Design of Intermodal Facilities (3). Theory and practice of intermodal facility planning and design, including facility location, site design and access, and intermodal considerations. Design projects required. Prerequisites: TTE 5930 or permission of the instructor.

TTE 6650 Transportation and Land Development (3). Theory and principles of transportation and land development, including site planning, traffic analysis, and access and site circulation. Design projects required. Prerequisite: TTE 4201.

TTE 6701 Light Rail Planning and Design (3). Theory and practices of light rail transit planning and design, including demand analysis, capacity evaluation, geometric design, and track design. Design projects required. Prerequisite: TTE 4201.

TTE 6755 Port Planning and Development (3). Theory and practice of port planning and development, including demand analysis, capacity evaluation, ground access, and port development strategy. Design projects required. Prerequisites: TTE 5930 or permission of the instructor.

TTE 6833 Superpave Asphalt Mixture Design and Analysis (3). Materials characterization and testing; elastic, visco-elastic and plastic behavior; fracture and fatigue, rutting and design of bituminous mixtures. Prerequisite: Permission of the instructor.

TTE 6834 Pavement Maintenance and Rehabilitation (3). Pavement performance assessment; criteria for pavement evaluation, measurement of pavement distress. Analysis and interpretation of pavement condition data. Formulation and evaluation of maintenance and rehabilitation alternative. Prerequisite: Permission of the instructor.

TTE 6837 Pavement Management Systems (3). Theory and principles of pavement management systems (PMS), including PMS at network and project level, PMS strategies, and PMS software packages used for decision making process. Prerequisites: TTE 5835 or permission of the instructor.

URP 5312 Urban Land Use Planning (3). Elements of the general land use plan, location and space requirements; the use of models in planning; development of the land use plan; policy plan, implementation. Prerequisite: Consent of instructor.

URP 5316 Environmental and Urban Systems (3).

Overview of basic issues and principles of environmental and urban planning/design systems. Emphasis will be placed on multidisciplinary linkages.

URP 5912 Research Methods (3). Methods of information search, data interpretation, and hypotheses formulation used in the field.

URP 6222 Urban Regional Analysis (3). The urban areas as a complex system; modeling the urban growth processes; statistical decision making games; modeling and simulation; cost effectiveness; application of the theory; a system-wide view of the Miami area. Prerequisite: Consent of instructor.

URP 6317 Advanced Environmental and Urban Systems (3). To study the application of physical planning and design concepts and their environmental, infrastructural and social impacts.

URP 6906 Independent Study (1-3). Specialized individual studies in Environmental and Urban Systems. Prerequisite: Consent of instructor.

URP 6935 Special Topics (3). Intensive treatment of specific subjects in the field of environmental and urban systems. Topics will vary depending upon the interest of students and faculty.

URP 6937 Final Project (1-3). Individual work culminating towards professional practice that also meets a degree requirement of the Master of Environmental and Urban Systems program. Prerequisite: Permission of instructor.