

## Civil and Environmental Engineering

**Atorod Azizinamini, Ph.D., P.E.,** *Professor and Chair*

**Omar Abdul-Aziz, Ph.D.,** *Assistant Professor*

**Caesar Abi Shdid, Ph.D., P.E.,** *Senior Instructor and Director of External Programs*

**Hesham Ali, Ph.D., P.E.,** *Professor of Practice*

**Ralf W. Arndt, Ph.D.,** *Assistant Professor*

**Michael Bienvenu, Ph.D., P.E.,** *Professor of Practice*

**Anna Bernardo Bricker, Ph.D.,** *Instructor and Environmental Lab Manager*

**Arindam G. Chowdhury, Ph.D.,** *Associate Professor and Director, Laboratory for Wind Engineering Research*

**Hector R. Fuentes, Ph.D., P.E., D.E.E.,** *Professor and Associate Chair of Graduate Studies*

**Albert Gan, Ph.D.,** *Associate Professor*

**Mohammed Hadi, Ph.D., P.E.,** *Associate Professor*

**Peter A. Irwin, Ph.D., P.Eng.,** *Professor of Practice*

**Xia Jin, Ph.D., P.E.,** *Assistant Professor*

**Sylvan C. Jolibois, Jr., Ph.D.,** *Associate Professor*

**Khokiat Kengskool, Ph.D.,** *Instructor*

**Shonali Laha, Ph.D., P.E.,** *Associate Professor*

**Kingsley Lau, Ph.D.,** *Assistant Professor*

**Cora Martinez, Ph.D.,** *Instructor and Undergraduate Advisor*

**Amir Mirmiran, Ph.D., P.E.,** *Vasant H. Surti Professor of Civil Engineering and Dean*

**Lakshmi Reddi, Ph.D., P.E.** *Professor and Dean, University Graduate School*

**L. David Shen, Ph.D., P.E., T.E.,** *Professor and Graduate Program Director, and Director, LCTR*

**Nakin Suksawang, Ph.D.,** *Assistant Professor and Deputy Director, Structures and Construction Laboratory*

**Lambert Tall, Ph.D., P.E.,** *Professor Emeritus*

**Walter Z. Tang, Ph.D., P.E.,** *Associate Professor*

**Berrin Tansel, Ph.D., P.E.,** *Professor and Undergraduate Program Director*

**LeRoy E. Thompson, Ph.D., P.E.,** *Professor Emeritus*

**Oktay Ural, Ph.D.,** *Professor Emeritus*

**Ton-Lo Wang, Ph.D., P.E.,** *Professor and Associate Chair of Undergraduate Studies*

**Ioannis Zisis, Ph.D.,** *Assistant Professor*

### **Affiliated Faculty**

**Irtishad Ahmad, Ph.D., P.E.,** *Construction Management*

**Yelena Katsenovich, Ph.D.,** *ARC*

**Stephen P. Leatherman, Ph.D.,** *IHRC*

**Assefa M. Melesse, Ph.D., P.E.,** *Earth and Environment*

**Fernando Miralles-Wilhelm, Ph.D., P.E.,** *Earth and Environment*

**Yimin Zhu, Ph.D., C.C.E.,** *Construction Management*

### **Lehman Center for Transportation Research**

**L. David Shen, Ph.D., P.E., T.E.,** *Director*

### **Structures and Construction Laboratory**

**Amir Mirmiran, Ph.D., P.E.,** *Director*

**Nakin Suksawang, Ph.D.,** *Deputy Director*

The Department of Civil and Environmental Engineering offers advanced study for the degree of Master of Science and Doctor of Philosophy. Degrees offered include:

Master of Science in Civil Engineering, Master of Science in Environmental Engineering, and Doctor of Philosophy in Civil Engineering. The areas of specialty are Structures, Mechanics, Geotechnical, Construction, Transportation, Water Resources, and Environmental Engineering.

### **Master of Science in Civil Engineering**

The Master of Science program in Civil Engineering emphasizes course work as well as research. The student is required to specialize in a defined area of civil engineering, but may broaden knowledge through 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 or advanced academic research in 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 research and a 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.

### **Master of Science in 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.

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

### **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. 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 closely 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 6.5 overall on the IELTS is required, and
- Three letters of recommendation or the forms provided by the department, and
  - A statement of objectives in which, in addition to other information, the intended concentration must be clearly stated, and
  - A resume including contact information, education and employment history, practical and research experiences (such as projects and publications), skills and other pertinent information.

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 as are students from institutions with traditional grading systems.

### **Application Procedures for Master of Science Programs**

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

- Submit an online Graduate Application for Admission to the Graduate Admissions Office.
- 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.
- Submit three letters of recommendation, statement of objectives, and resume as part of the online Graduate Application for Graduate Admissions Office.
- 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 6.5 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 for Master of Science Programs**

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

- Satisfy all University requirements for a Master's degree.
- Meet all undergraduate deficiencies, and requirements as specified by the students' advisory committee.
- Complete 30 semester hours of acceptable graduate level courses, including up to 3 credits of an Independent Study course. Supervised Research credits are not counted toward the 30 credit degree requirement.
- Successfully complete the core courses defined for the student's chosen specialty area.

- Earn a minimum grade point average of 3.0 in all approved courses in the student's program of study.
- Optionally, complete an acceptable thesis (minimum six credits) or engineering project (minimum three credits).
- Pass an oral examination that includes an oral defense of the thesis or engineering project for students choosing the thesis or project option. For students who chose the non-thesis and non-project (all-course) option, an oral exam in the form of a presentation of selected projects that demonstrated substantial professional engineering knowledge and experience is required. The oral exam will be conducted in a seminar format. A seminar will be scheduled and will be announced to students and faculty at least one week in advance in the last semester of a student's program. Approval of the presentation by a graduate committee, at a minimum, three members is needed with the signatures of the graduate committee members.
- Complete CGN 6939.

### **Core Courses**

In order to master real-life engineering problems, engineers need to have an education with both breadth, as well as depth. Therefore, in addition to the above degree requirements, students must choose an area of technical specialization upon enrollment and satisfy the core course requirements as defined below. A proposed program of study shall be developed by a student's academic advisor together with the student and approved by the Graduate Program Director. All students are strongly encouraged to take the Research Methods for Civil Engineers course - especially those who are pursuing the thesis option. Students are also required to register for the 0-credit Graduate Seminar (CGN 6939) at least once and are encouraged to take it each Fall and Spring semesters.

### **Areas of Technical Specialization:**

#### **Environmental Engineering**

Environmental engineering students are required to take at least one course in each of the following core areas:

- Water supply/wastewater/water quality,
- Air quality,
- Soil/solid/hazardous waste, and
- Water resources (including groundwater).

Furthermore, it is advisable that students gain some expertise in environmental chemistry and in computational techniques including GIS techniques, while seeking knowledge in new areas of research and development.

Students are also required to register for the zero-credit Graduate Seminar (CGN 6936) and are encouraged to participate in it each semester.

#### **Water Resources Engineering**

This field involves the analysis of qualitative and quantitative water issues and the search for integrated, innovative and sustainable solutions to problems in the surface, groundwater, and atmospheric water environments.

Students pursuing a M.S. in Civil Engineering with concentration in Water Resources Engineering will follow a program of study that includes 15 credit-hours of engineering coursework emphasizing advanced

knowledge and applications in either hydrology, hydraulics or hydrosystems or their combination thereof. The students will also complete a three credit-hour independent study to enrich the area of sought expertise.

Students are also required to comply with the following core requirements:

1. Take one course (3 credit-hours) among the following three background courses:
  - CWR 5305 Surface Hydrology
  - CWR 6125 Groundwater Hydrology
  - CWR 5140C Ecohydrology
2. Take one among the following applied courses:
  - CWR 5235 Open Channel Hydraulics
  - CWR 5535 Advanced Modeling Applications in Water Resources Engineering
  - CWR 6236 Engineering Sediment Transport

Students are required to take the Graduate Seminar (CGN 6939) once and are strongly encouraged to attend it while registering in the program. Students may also include up to six credit hours from other civil engineering areas or related disciplines, as long as the subjects relevantly add to the student's water resources engineering knowledge.

### **Structural Engineering**

Students are required to take at least nine (9) credit hours of core course work as follows:

1. One course (3 credits) in analysis of structures. Choose one from:
  - CES 5106 Advanced Structural Analysis
  - EGM 5421 Structural Dynamics
  - CCE 5035 Construction Engineering Management
  - CCE 5036 Advanced Project Planning for Civil Engineers
2. One course (3 credits) in design of structures. Choose one from:
  - CES 5715 Prestressed Concrete Design
  - CES 6706 Advanced Reinforced Concrete Design
3. One course (3 credits) in analysis of lateral loads on structures. Choose one from:
  - CES 5587 Topics in Wind Engineering
  - CES 6209 Advanced Structural Dynamics
  - EGN 5439 Design of Tall Buildings

Furthermore, the student should also take at least six (6) credit hours of elective courses in Structural Engineering. CES 4605 or equivalent is a prerequisite for Structural Engineering specialization. It is advisable that the students gain some expertise in numerical methods.

### **Construction Engineering**

Students are required to take at least nine (9) credit hours of core course work as follows:

1. CCE 5035 Construction Engineering Management;
2. CCE 5036 Advanced Project Planning for Civil Engineers; and
3. CCE 5405 Advanced Heavy Construction Techniques

Furthermore, it is advisable that students gain some expertise in computer methods in construction engineering.

### **Geotechnical Engineering**

Students are required to take at least ten (10) credit hours of core course work as follows:

1. CEG 5065 Geotechnical Dynamics

2. CEG 6017 Theoretical Geotechnical Mechanics; and
3. CEG 6105 Advanced Foundations Engineering

Furthermore, it is advisable that students gain some expertise in numerical methods.

Students are also required to register for the zero-credit Graduate Seminar (CGN 6936) and are encouraged to participate in it each semester.

### **Transportation Engineering**

Transportation engineering is concerned with the planning, design, operation, and maintenance of the transportation infrastructure and systems. A student who chooses to specialize in transportation engineering must complete a minimum of five courses from the list below:

TTE 5205	Advanced Highway Capacity Analysis
TTE 5215	Fundamentals of Traffic Engineering
TTE 5607	Transportation Demand Analysis
TTE 5805	Advanced Geometric Design of Highways
TTE 6257	Traffic Control Systems Design
TTE 6506	Mass Transit Planning
CGN 5320	GIS Applications in Civil and Environmental Engineering

Students are also required to register for the zero-credit Graduate Seminar (CGN 6936) and are encouraged to participate in it each semester.

### **Independent Study Course**

A student may take up to a total of three credits of independent study, which will be letter graded. If a student needs a course that will not be offered during the student's course of study, special topics courses should be set up to meet the student's needs. There will be no limit on the number of special topics courses provided that the core course requirements are satisfied.

### **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 as a non-degree seeking students at FIU after admitted into one of the graduate programs in the Civil and Environmental Engineering Department. Such credits are transferable 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.

Credits are not transferable until the student has earned 12 semester hours in the graduate programs in the Department of Civil Engineering and Environmental Engineering.

### **Time Limit**

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

## Combined BS/MS in Civil Engineering

Students who pursue a BS degree in Civil Engineering and have completed 75-90 credits and have at least a 3.3 GPA on both overall and upper division courses may apply to enroll in the combined BS/MS program in Civil Engineering upon recommendation from three CEE faculty members. In addition to the admission requirements of the combined BS/MS program, students must meet all the admission requirements of both the department and the University Graduate School. Students need only apply once to the combined degree program, but the application must be submitted to Graduate Admissions before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree program will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships.

Students enrolled in the program may count up to nine credit hours of CEE graduate courses as credits for both the BS and MS degrees. The combined BS/MS program has been designed to be a continuous program. However, upon completion of all the requirements of the undergraduate program, students will receive their BS degrees. Students in this program have up to one year to complete the master's degree after receipt of the bachelor's degree. Students who fail to meet this one year post BS requirement or who elect to leave the combined program at any time and earn only the BS degree will have the same access requirements to regular graduate programs as any other student, but will not be able to use the nine credits in both the bachelor's and master's degrees.

For each of the graduate courses counted as credits for both BS and MS degree, a minimum grade of B is required. All double counted courses must be at 5000 level or higher. Students enrolled in the program may count up to nine credit hours of CEE graduate courses toward the elective engineering BS requirements as well as toward the MS degree. 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 meet the Graduate Program Director 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 and the University Graduate School of the decision on their applications.

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 full admission into the graduate school.

## Combined BS in Civil Engineering/MS in Environmental Engineering

Students who pursue a BS degree in Civil Engineering and are in their senior year and have at least a 3.3 GPA on both overall and upper division courses may apply to

the department to enroll in the combined BS (Civil)/MS program in Environmental Engineering upon recommendation from three CEE faculty members. To be considered for admission to the combined bachelor's/masters degree program in Environmental Engineering, students must have completed at least 75-90 credits in the bachelor's degree program in Civil Engineering at FIU and meet the admissions criteria for the graduate degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree program, but the application must be submitted to the Graduate Admissions before the student starts the last 30 credit of the bachelor's degree program. A student admitted to the combined degree program will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and will be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the credits specified by the program catalog, may be applied toward both degrees. In addition to the admission requirements of the combined BS/MS program, students must meet all the admission requirements of both the department and the University Graduate School.

Students enrolled in the program may count up to nine credit hours of CEE graduate courses as credits for both the BS and MS degrees. The combined BS/MS program has been designed to be a continuous program. However, upon completion of all the requirements of the undergraduate program, students will receive their BS degrees. Students in this program have up to one year to complete the master's degree after receipt of the bachelor's degree. Students who fail to meet this one year post BS requirement or who elect to leave the combined program at any time and earn only the BS degree will have the same access requirements to regular graduate programs as any other student, but will not be able to use the nine credits in both the bachelor's and master's degrees.

For each of the graduate courses counted as credits for both BS and MS degree, a minimum grade of "B" is required. All double counted courses must be at 5000 level or higher. Students enrolled in the program may count up to nine credit hours of CEE graduate courses toward the elective engineering BS requirements as well as toward the MS degree. 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 meet the Graduate Program Director 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 and the University Graduate School of the decision on their applications.

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 full admission into the graduate school.

## Combined BS/MS in Environmental Engineering

Students who pursue a BS degree in Environmental Engineering and are in their senior year and have at least a 3.3 GPA on both overall and upper division courses may apply to the department to enroll in the combined BS/MS program in Environmental Engineering upon recommendation from three CEE faculty members. To be considered for admission to the combined bachelor's/masters degree program in Environmental Engineering, students must have completed at least 75-90 credits in the bachelor's degree program in Environmental Engineering at FIU and meet the admissions criteria for the graduate degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree program, but the application must be submitted to the Graduate Admissions before the student starts the last 30 credit of the bachelor's degree program. A student admitted to the combined degree program will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and will be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the credits specified by the program catalog, may be applied toward both degrees. In addition to the admission requirements of the combined BS/MS program, students must meet all the admission requirements of both the department and the University Graduate School.

Students enrolled in the program may count up to nine credit hours of CEE graduate courses as credits for both the BS and MS degrees. The combined BS/MS program has been designed to be a continuous program. However, upon completion of all the requirements of the undergraduate program, students will receive their BS degrees. Students in this program have up to one year to complete the master's degree after receipt of the bachelor's degree. Students who fail to meet this one year post BS requirement or who elect to leave the combined program at any time and earn only the BS degree will have the same access requirements to regular graduate programs as any other student, but will not be able to use the nine credits in both the bachelor's and master's degrees.

For each of the graduate courses counted as credits for both BS and MS degree, a minimum grade of "B" is required. All double counted courses must be at 5000 level or higher. Students enrolled in the program may count up to nine credit hours of CEE graduate courses toward the elective engineering BS requirements as well as toward the MS degree. 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 meet the Graduate Program Director 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 and the University Graduate School of the decision on their applications.

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 full admission into the graduate school.

## Doctor of Philosophy in Civil Engineering

### 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. Official GRE scores
  - c. Three letters of recommendation or recommendation 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)
  - e. A resume containing contact information, education and employment history, practical and research experiences (including publications), skills and other pertinent information.
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 Program Advisory 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.
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 6.5 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 seven years for students admitted with a B.S. degree and six 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, Geotechnical, and Construction 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 may 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 three 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.
4. Complete CGN 6939.

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. A proposed program of study shall be developed by a student's academic advisor together with the student and approved by the Graduate Program Director.

### Core Courses

All Ph.D. students must satisfy the core course requirements defined for the MS degree programs. In addition, all doctoral students are required to take the Research Methods for Civil Engineers course before or during the first semester of dissertation credits. A student may take additional courses in the specialty as well as other areas as approved by the major advisor and the dissertation committee, provided all the core courses have been completed previously during the MS program or will be completed in the Ph.D. program. Students are also required to register for the 0-credit Graduate Seminar (CGN 6939) at least once and are encouraged to take it each Fall and Spring semesters.

### Independent Study Course

A student may take up to a total of three credits of independent study, which will be letter graded. If a student needs a course that will not be offered during the student's course of study, special topics courses should be set up to meet the student's needs. There will be no limit on the number of special topics courses provided that the core course requirements are satisfied.

### 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 of 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 major professor must hold dissertation advisor status. 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 eight 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 eight hours to solve all eight 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. Students should become familiar with the University Graduate School's regulations and deadlines available on line at <http://gradschool.fiu.edu>.

## 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 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 also provides 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 Master of Science 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 6.5 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 – six courses (three core + three elective) of three 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	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](http://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-Environmental Engineering; TTE-Transportation and Traffic Engineering; URP-Urban and Regional Planning

#### 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. Prerequisites: CES 3100 or equivalent and CEG 4011 or equivalent.

#### 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. Prerequisites: CCE 4031 or equivalent.

#### 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: CCE 4001.

#### 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. Prerequisites: CCE 4031 or equivalent.

#### CEG 5065 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 3100.

#### 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 5715, and 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 5587 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 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. Prerequisite: 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 3100.

**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. Prerequisite: CES 4702.

**CES 6707 Reinforced Concrete Mechanics (3).** Limit analysis of reinforced concrete. Concrete plasticity. Use and advantages of methods derived from basic mechanics. How reinforced concrete members respond to overload and fail. Prerequisite: CES 6706.

**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. Corequisites: TTE 4201 or CWR 3540 or ENV 3001.

**CGN 5870 Corrosion Control in Civil Engineering (3).** The course provides understanding of principles of corrosion phenomena with emphasis on its application to materials in civil engineering including testing methods, corrosion control, and durability. Prerequisite: Permission of the instructor.

**CGN 5874 Building Diagnostics (3).** This course will give an introduction into building diagnostics with a focus on non-destructive testing (NDT) techniques used to investigate Civil Engineering materials and structures.

Prerequisites: Graduate standing, enrolled in engineering curriculum.

**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 6030 Research Methods for Civil Engineers (1).** Survey and critical analysis of research in the disciplines of civil and environmental engineering. Emphasizes theory and methods of conducting advanced research, including the scientific method. Prerequisites: First-year doctoral or master standing.

**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 (0).** 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.

**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 the graduate's thesis advisor.

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

**CWR 5140C Ecohydrology (3).** Hydrology of ecosystems, interaction between the hydrologic cycle and vegetative processes. Prerequisite: Permission of the instructor.

**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 3540.

**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 5305 Surface Hydrology (3).** Principles of Hydrology with a particular focus on surficial processes of interest to engineering design. Emphasizes applications to flood prevention and mitigation and stormwater management issues. Prerequisites: CWR 3201, CWR 3540 (or equivalent).

**CWR 5535C Advanced Modeling Applications in Water Resources Engineering (3).** Complex model applications in hydrology, hydraulics, hydrosystems engineering and environmental interconnections. Prerequisite: Permission of the instructor.

**CWR 6117 Stochastic Hydrology (3).** Application of probability and statistics in hydrologic engineering. Frequency analysis of extreme events. Time series analysis and stochastic modeling. Prerequisites: CWR 3201 and CWR 3540.

**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.

**CWR 6625C Ecological Engineering (3).** Introduction and incorporation of the important concepts and theories of ecology into water resources engineering principles and designs. Prerequisite: Permission of the instructor.

**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, photo-elasticity 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: CES 5106.

**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: CES 3100 and MAP 2302.

**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 5106 and MAP 2302.

**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 2302.

**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 the 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 3100.

**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).** Bio-transformation 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 5104 Indoor Air Quality (3).** Sources and causes of poor indoor air quality (IAQ). Protocols for IAQ investigations; problem evaluation and solution proposals. Approaches to sustainable construction; best IAQ and energy savings.

**ENV 5105 Air Quality Management (3).** Technical and regulatory aspects of air quality management. Emissions inventories, ambient monitoring, and models used to evaluate the impact of pollutants on local, regional and global air quality.

**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).** Hazardous waste site assessment, remedial investigation, design of site monitoring strategies and remediation plans. Prerequisites: CHM 1046 and CHM 1046L.

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

**ENV 5356 Solid and Hazardous Waste (3).** Generation, transport, treatment and disposal of solid and hazardous wastes; risk assessment and treatment of contaminated media. Prerequisites: CHM 1046 and CHM 1046L.

**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, NO<sub>2</sub>, NO<sub>3</sub>, PO<sub>4</sub>, 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 Chemistry for Environmental Engineers (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 multiphase reactions, analysis and design of batch and continuous flow reactors. Projects on analysis of reactor design and operating data.

**ENV 5613 Environmental Entrepreneurship (3).** Application of environmental engineering concepts in the development of innovative ideas, products or services; interactive experiences with environmental businesses. Prerequisites: ENV 3001 or permission of the instructor.

**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 6070 Green Engineering (3).** Study of green engineering principles and methodologies to enhance environmental performance of societal sectors, including regulatory framework, sustainability, P2, LCA and

industrial ecology. 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 6510C 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 (0).** 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 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 5273 Intelligent Transportation Systems (3).** ITS functional areas, planning architecture, standards, and evaluation. Implementation of selected ITS technologies and strategies. Prerequisites: TTE 4201 or equivalent.

**TTE 5315 Highway Safety Analysis (3).** Influencing factors (roadway characteristics, vehicle characteristics, and human factors), safety data, network screening, identification and diagnosis of safety problems, selection of countermeasures, evaluation studies, accident reconstruction. Prerequisites: STA 3033, 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 AASHTO 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 5925 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: Permission of the 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: Permission of the 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: Permission of the 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 the instructor.