

# SELF-STUDY REPORT FOR CIVIL ENGINEERING

## A. BACKGROUND INFORMATION

### 1. Degree Titles

Bachelor of Science in Civil Engineering (BSCE); Bachelor of Science in Civil Engineering (BSCE, Cooperative Plan).

### 2. Program Modes

Two separate program modes are offered: BSCE and BSCE, Cooperative Plan. The academic requirements for the two degrees are identical. Current statistics for each are:

Enrolled, Regular Plan: 300  
Enrolled, Cooperative Plan: 143  
Graduated, Regular Plan, 2000-2001: 92  
Graduated, Cooperative Plan, 2000-2001: 34

### 3. Actions to Correct Previous Shortcomings

The civil engineering program was last reviewed by EAC/ABET in the fall of 1997 and there were no shortcomings cited.

### 4. Major Developments Since the Last EAC/ABET Visit

There have been two major developments since the civil engineering program was accredited in 1997: (1) conversion from the academic quarter system to the semester system in the fall of 1999; and (2) creation of the Georgia Tech Regional Engineering Program (GTREP) in 2000. Changes implemented as part of semester conversion are discussed in detail in Section 3 of the Accreditation Summary in this self-study document, while GTREP is primarily covered in a separate self-study document, Civil Engineering – Regional Engineering Program, except where noted in this document.

### 5. Contact Information

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## B. ACCREDITATION SUMMARY

### 1. Students

- a. *Evaluation, Advisement, and Monitoring of Students:* The School of Civil and Environmental Engineering (CEE) has a multi-tiered approach to academic advising of students. The first tier is the responsibility of the Associate Chair for Undergraduate Programs (Dr. Laurence Jacobs) and

the full time professional staff in the Student Services Office (headed by Mr. Rob Hudgins). The first tier provides advising to entering students (new freshmen, external transfers, and internal change of majors) through the Institute's orientation program FASET (Familiarization and Adaptation to the Surroundings and Environs of Tech) and individual student meetings. These advisement sessions deal with course scheduling, class prerequisites, identification of an academic program and the solution of routine problems. An individual flow chart is developed for each student upon entrance into the program. A generic version of this flow chart is available online on our Web page (<http://www.ce.gatech.edu/academics/>) and in hard copy in the *CEE Undergraduate Handbook*. (A copy of the handbook is provided to every student at FASET and is also available online.) The individual student flow charts are updated every semester, are available in electronic format (Excel), and provide students with a clear description of their current progress. (An example is included in Appendix I, Table I-12.) At the second tier, individual appointments are held with either Mr. Hudgins or Dr. Jacobs to discuss class scheduling, specific technical electives and degree progress at intermediate points within a student's degree program. These meetings are mandatory for freshmen and sophomores, and voluntary for juniors and seniors. Typically 400 students are advised every year under this program. Mr. Hudgins and the staff of the Student Services Office have eight years experience in advising within CEE and can resolve most problems and issues. Further, all CEE students receive information regarding academic and professional advising, as well as individual counseling services available during the introductory freshman course, CEE 1770. This information is presented to the students with contact information and is available for reference on the CEE 1770 course Web pages. In the third and final tier, faculty members advise students directly on career development and job placement, advanced degrees and undergraduate research. This tier is voluntary, tends to be more informal and a student can self-select a faculty member with similar technical interests.

In the spring of 2001, the faculty voted to increase student-faculty interactions and a trial, mandatory faculty advisement program is currently being tested. Starting in the fall of 2001, ten faculty volunteers were each (randomly) teamed with a group of six or seven sophomores as their faculty advisors. Based on feedback from the faculty and students, this program may be expanded to include all undergraduate students. Finally, CEE participated in an experimental freshmen mentor program sponsored by the College of Engineering (COE). Two faculty members (Drs. Jacobs and Mulholland) mentored twenty-four freshmen CEE and undecided engineering (UEC) students in the fall of 2001. The purpose of this program was threefold: 1) connect first year students to the faculty of the College of Engineering; 2) convey to the students a sense of the excitement of the study of engineering; and 3) provide a support system for the students during the transition from high school to the academic rigor of engineering at Georgia Tech. The effectiveness of the program is currently being evaluated through the Assessment Office at Georgia Tech.

The evaluation of students occurs in many contexts, with the most formal being through the evaluation of exams, quizzes, homework assignments, projects, and class participation. These tools are used to determine how well each student meets the outcomes of each course, and they provide the basis of the grade given to each student. The Institute requires a minimum GPA of 2.0/4.0 in order to graduate. The School of Civil and Environmental Engineering requires a grade of C or better in MATH 1501-1502, PHYS 2211, BIOL 1510, CHEM 1310, and CEE 2020. In addition, the School requires that the number of quality points (e.g., an A is four quality points, a B is three quality points, a C is two quality points, and a D is one quality point) earned in civil engineering classes taken towards the BSCE degree must be at least twice the number of credit hours in those classes (e.g., minimum major GPA of 2.0/4.0).

The Institute has recently initiated a program of mid-term grades for all freshmen and sophomores (S for satisfactory and U for unsatisfactory). Any freshman with an unsatisfactory mid-term grade is required to meet with either Dr. Jacobs or Mr. Hudgins. They try to determine if the problem is academic or personal, and recommend a course of action (tutoring or counseling) to address the problem. In addition, any student whose GPA is below 2.0 (warning or probation status) has a

hold placed on registration for the following semester. In order to remove the hold, the student must receive advising from the Student Services Office.

- b. *Policies for Transfer Students and Transfer Credit:* Transfer students are admitted to the Institute through a process that indirectly involves the School of Civil and Environmental Engineering. Transfer credit is awarded by the Registrar based on an approved "Equivalency Table." Courses are added to (or deleted from) the Equivalency Table only at the direction of the School at Georgia Tech that offers the course for which credit is being given. All courses not on the equivalency table are referred to the appropriate School for determination of proper transfer credit (if any). Civil and environmental engineering has only a limited number of courses on the equivalency table (primarily for the Regents' Engineering Transfer Program (RETP) and mainly for CEE 1770, 2020 and to a limited extent 3030); all these decisions were made by Dr. Jacobs on the advice of one or more faculty members teaching the courses in question. Dr. Jacobs evaluates all other transfer credit.
- c. *Procedures to Assure Students Meet Program Requirements:* All students who expect to graduate are required to submit degree petitions. These degree petitions are reviewed by the Associate Chair for Undergraduate Programs, and the staff of the Student Services Office. Any deficiencies are noted on the degree petition before it is sent to the Registrar; the Registrar will not certify a student for a degree until these deficiencies are corrected.

## 2. Program Educational Objectives

The mission of the School of Civil and Environmental Engineering is to create a quality education, research and service program designed to achieve five major program goals.

1. Educate a new generation of civil and environmental engineers to meet the challenges of the future.
2. Promote a sense of scholarship, leadership and service among our graduates.
3. Create, develop and disseminate new knowledge.
4. Play a leadership role in fostering interdisciplinary education and research programs fundamental to solving the problems facing a complex society
5. Provide national leadership to a civil engineering profession that is increasingly being driven by advances in technology.

The CEE curriculum is designed to meet the needs of all students within the context of this mission statement. The Program Educational Objectives associated with this mission are to:

1. provide an educational experience that prepares our students for the challenges of the civil and environmental engineering profession that they will face during their professional careers;
2. promote scholarship and problem-solving skills;
3. provide opportunities for our students to exhibit leadership and team-building skills;
4. promote service to the profession and to society;
5. incorporate interdisciplinary concepts and problem-solving exercises into the educational program; and
6. provide exposure to the civil and environmental technologies of today and those likely of tomorrow.

The School of Civil and Environmental Engineering's educational objectives were first developed by the faculty, as part of a Strategic Plan in 1994 and have been periodically revisited to ensure their timeliness. They have been posted on the Civil Engineering Web site (<<http://www.ce.gatech.edu/academics/>>). The process of establishing the educational objectives included numerous opportunities for constituent input. For example, in 1993, the School formed an External Advisory Board consisting of distinguished alumni. This board has met twice yearly to review, evaluate and advise on School programs and educational initiatives. This advisory board was asked to provide input on the desired skills and traits of our graduates. Advisory board members were

presented with initial and draft final statements of educational objectives for further input. The input from this advisory board was instrumental, for example, in defining our approach toward the new semester-based curriculum. The School's Student Advisory Committee, a committee that consisted of student officers and representatives of the different matriculation levels, received the draft set of educational objectives and provided input. The School's newsletter, sent annually to over 6,000 alumni as well as to key employers, has sought input on what was desired from our graduates. A College of Engineering survey of school alumni is used to identify on a periodic basis further constituent desires with regard to graduate skills and knowledge. Finally, we systematically obtain (every 5 years) the educational objectives and curriculum materials from other civil and environmental engineering departments (University of California Berkeley, Carnegie-Mellon, Cornell, Florida, Illinois, MIT, Michigan, North Carolina State, Penn State, Purdue, Stanford, Texas, Virginia Tech, Wisconsin) as well as collect literature from engineering educators and civil engineering professionals (e.g., in the ASEE journal or ASCE's *Professional Issues*) on critical topics for an educated civil engineer. The School's educational objectives were affirmed by the faculty, and are reviewed and updated (and modified if necessary) on a periodic basis. For example, these educational objectives were primary agenda items at a faculty meeting in April 2002 and an external advisory board meeting in May 2002 and were modified based on input from these constituencies. The curriculum (see Appendix A, Table I-1) has been designed to achieve the educational objectives stated above.

The curriculum stresses problem-solving skills and the team-oriented design of complex systems. Our senior design capstone course (CEE 4090) provides a challenging design exposure to seniors using the different areas of knowledge the student has obtained in his or her educational program. These activities begin even in the freshman year with the introductory CEE 1770 course. In CEE 1770, students are asked to work in teams, given team building assignments, make presentations, and create and present a final project containing design content. Our required Civil Engineering Systems class (CEE 3000) provides an overview of infrastructure from a systems perspective, and provides knowledge in sustainability and engineering economy. Other required courses in the BSCE curriculum focus on providing the necessary skills and knowledge that all civil and environmental engineers should obtain, while many of the elective courses provide a breadth of exposure to the many professional and societal facets of the civil engineering profession. The ethics elective (which normally carries social science or humanities credit) exposes students to ethical issues. Our laboratory courses (e.g., CEE 3020 and CEE 4200) provide comprehensive exposure to the latest technologies, and our focus on computer-aided engineering (e.g. CEE 1770) provides a strong foundation for the professional career that many of our students will have during their lifetime. The curriculum also provides independent study opportunities (CEE 4900) for a student to work closely with a professor on a topic of mutual interest.

Assessment of the educational program occurs on a systematic basis. Firstly, at the most basic level, student evaluation in individual courses provides a basic benchmark on the degree to which courses in the curriculum are successfully conveying the desired knowledge. Secondly, at a more general level, measures such as the percentage of CEE students taking and passing the FE exam (the pass rate during the years 1995–2000 averaged 85%), the level of satisfaction expressed by employers and alumni with our graduates through surveys, and faculty assessment of student abilities in teamwork and communications provide an on-going assessment of the degree to which we are successfully meeting our objectives. Areas of importance to the industry, e.g., computer-aided engineering, sustainable development, new materials, and environmental impact assessment are either incorporated into existing courses, and/or are offered in elective courses. Thus, we have the flexibility in the curriculum to incorporate new ideas and concepts that surface from our on-going assessment process.

### **3. Program Outcomes and Assessment**

- a. *Program Outcomes:* The School of Civil and Environmental Engineering derived a set of Program Outcomes from these program educational objectives and the are listed below. Further, the

relationships between the CE Program Educational Objectives and the EAC/ABET Criterion 3 (a-k) outcomes are also identified.

1. Graduates will obtain a broad education necessary to understand the impact of civil engineering solutions in a global, societal, and environmental context consistent with the principles of sustainable development. (EAC/ABET outcomes a, h and j; CEE program objectives 1 and 2)
  2. Graduates will demonstrate an ability to solve engineering problems in practice by applying fundamental knowledge of mathematics, science and engineering, and by using modern engineering techniques, skills, and tools, particularly recognizing the role that computers play in engineering. (EAC/ABET outcomes a and e; CEE program objectives 1, 2 and 5)
  3. Graduates will demonstrate an ability to identify, formulate and solve civil engineering problems, particularly the planning, design, construction and operation of systems, components, or processes that meet specified performance, cost, time, safety and quality needs and objectives. (EAC/ABET outcomes c and e; CEE program objectives 2 and 5)
  4. Graduates will be able to design and construct experiments, and to analyze and interpret data within the various civil engineering specialty disciplines. (EAC/ABET outcomes b, j and k; CEE program objectives 1 and 2)
  5. Graduates will be able to function and communicate effectively, both individually, and within multidisciplinary teams. (EAC/ABET outcomes d and g; CEE program objectives 3 and 5).
  6. Graduates will obtain a solid understanding of professional and ethical responsibility and a recognition of the need for and ability to engage in life-long learning. (EAC/ABET outcomes f and i; CEE program objectives 4 and 6).
  7. Graduates will experience an academic environment that facilitates and encourages learning and retention. (CEE program objectives 1 and 6)
- b. *Assessment Processes and Metrics:* The strategy followed in assessing program outcomes involves a regular review of information obtained from students, faculty, alumni, recruiters, employers, the school's external advisory board, and universities that recruit our students for graduate school. The nature of this information varies from highly formal questionnaires completed by one or more of the sources to ad hoc communications, often oral, involving various aspects of the civil engineering program. These serve as vehicles for communicating trends in enrollments, developing pedagogies, and student activities at the participating institutions. Further interaction takes place at the department heads forums at the annual meetings of the American Society of Civil Engineers and the Southeast Region Department Chairs/Heads Council.

Figure 1 shows the assessment process with an emphasis on data relationships. A mapping of the processes for achieving the seven program outcomes and assessment methods currently in place with the seven program outcomes are provided in Tables I-6 and I-7 in Appendix I.A. Fundamentally, the School believes that its programs are of high quality and continue to improve. This evaluation predates the implementation of formal assessment processes required by the EAC/ABET. This conclusion has been endorsed by the School's faculty members and external advisory board and is consistent with other external evaluations. (For example, the CE program is ranked 3<sup>rd</sup> in the most recent U.S. News and World Report ranking of undergraduate engineering programs.)

The strategy and tools that are selected for assessment provide both immediate feedback and a longer-term perspective on the civil engineering program. This is the most rational way to ensure that the program meets the needs of current students, while at the same time it anticipates the

needs of future students. Examples of issues that have been addressed, how they were identified, and what was done about them, are given in Table I-8 of Appendix I.A.

Course grades are the most direct measure of whether or not a student demonstrates the outcomes required for the graded courses. Grades are based, in large part, on a student's ability to perform on exams, write lab reports, construct solutions to homework assignments and term projects, and meet other criteria defined for each course. A measure of the quality of teaching and testing in each course is provided by results of an institute-conducted student evaluation of teaching (Course-Instructor Opinion Survey) by the students in each section of each course each semester. The School Chair uses the results in the annual evaluations of each faculty member. While the survey contains information about many facets of the course, emphasis is given to the item stating that the "instructor was an effective teacher." Class portfolios for CEE courses have been assembled to allow the visitor to evaluate the level of work that the civil engineering faculty consider worthy of the various grades of A through F, as well as linkages to our program outcomes.

Our current curriculum requires the completion of a major design project in our capstone design course, CEE 4090. This project is done in teams of four to six members. At the end of the semester, each design group gives an oral presentation. Each group is evaluated on the way in which their design and presentation indicate achievement of relevant program outcomes.

Each graduating senior is required to complete an Exit Survey, in which they give their views on various aspects of their educational experience. The School of Civil and Environmental Engineering was part of the original group of engineering programs (Schools) at Georgia Tech that helped develop (in 2000) a new exit survey under the direction of the Georgia Tech Office of Assessment; an example of the exit survey is shown in Table I-10. The survey asks students to assess their preparation in the various areas of civil engineering, the effectiveness of the faculty members, the students' preparation in non-technical skills such as oral presentation, the quality of the learning environment, and the effectiveness of our advising program.

While the Exit Survey provides useful information on the views of the graduating seniors on their educational experience, some items cannot be addressed easily in a written survey. For this reason, the Associate Chair for Undergraduate Programs meets with members of each graduating class for exit interviews. The entire graduating class is invited to attend an informal group discussion, and pizza is served to increase attendance. While there is a list of "talking points" to generate discussion, the interviews cover any items the students feel are important. The results of the interviews are summarized by the

Associate Chair and reported to the School Chair. In compiling the results, the Associate Chair focuses on common themes expressed by multiple students. The exit interviews are helpful in obtaining additional information on issues which arise on the exit survey. For instance, students expressed a desire to have a copying facility available for their use in the Mason Building, and a low-cost copying machine was installed on the second floor in October 2001.

The perspective of the graduating seniors may change after a few years of practicing their profession; an Alumni Survey is completed every four years of students who have graduated three to five years previously. The longer-term perspective of the respondents provides us a broader view of the quality of our program. Results from the most recent Alumni Survey Instrument (2001) will be available to the EAC/ABET program evaluator prior to the visit. Data from these surveys are compiled and compared with previous surveys. They are then reported to the members of the faculty with recommendations for actions toward improvement in the program.

Assessment tools used to evaluate the level of achievement of the program outcomes are applied systematically and the results analyzed against performance criteria established to determine success by the School's undergraduate curriculum committee and the School Chair. When the data collected by one or more assessment tools indicate a program weakness, the undergraduate

curriculum committee formulates options to remedy the weakness or weaknesses. These options are then presented to the faculty for discussion, refinement, and implementation. The assessment tools and their acceptability criteria are periodically re-evaluated to ensure that they remain valid indicators of the achievement of program outcomes.

In an effort to provide a comprehensive evaluation of the CEE undergraduate degree program, the School will, in the upcoming year, introduce an assessment procedure for the four-year-old technical communications program. While the school receives a significant amount of informal feedback regarding the high quality and effectiveness of the program, the only formal feedback is in the form of a few add-on questions on the standard course evaluations. The new assessment program for the in-house technical communications program at the undergraduate level will have these characteristics. It will (1) be multi-dimensional, meaning information from both students and faculty will be assessed, (2) include factual reporting on what types of information is taught, what types of delivery methods are used, and what types of materials are distributed, and (3) consist of surveys separate from the standard course surveys. Once all of this information is collected, the School will be able to assess how well the technical communications goals for a given course are being met.

Many other assessment feedback mechanisms exist. For example, as part of the recent CEE faculty retreat, a facilitator (Dr. Hal Irvin) met with a representative sample (focus group) of undergraduate students to assess their level of satisfaction with the School's program and their educational experience. Dr. Irvin reported back to the School Chair with detailed notes and a summary of their comments. The students reported a very high level of satisfaction with their experience and that the students were glad that they were in the civil and environmental engineering program (see Table I-11 for a summary).

- c. *Recent Examples of Program Changes Resulting from Outcome Assessment:* An example of a program change that benefited from outcome assessment is the semester conversion of the BSCE curriculum, followed by a major curriculum revision in the Fall of 2000. In 1995, the Board of Regents of the University System of Georgia voted to switch the thirty-four universities and colleges in the System from a quarter-based academic year to a semester basis. As part of this conversion, the Board asked that academic units take advantage of this opportunity to incorporate new courses and course content into their curriculum. While semester conversion did not occur because of our assessment process, we used this conversion as an opportunity to test and refine our assessment process. The process of revision included a number of important constituencies that provided important input into the adopted curriculum. The curriculum provides emphasis on civil engineering systems, technical communications, sustainability, and computer-based analysis and design. Several innovative approaches to curriculum content were incorporated into this academic program reflecting the challenges and opportunities that will face civil engineering professionals in the next several decades. In addition, the curriculum development process itself was structured with the EAC/ABET accreditation criteria in mind.

The new curriculum was developed over a one-year period. The School faculty members also examined other civil engineering programs in the country and reviewed the latest literature on civil and environmental engineering education to identify key concepts that should be reflected in the courses and in the overall program. Six important principles guided the development of the new curriculum.

- i) The curriculum should provide depth and breadth of material – Although the curriculum clearly needs to provide the depth of material for engineering practice, there should be plenty of opportunities for exposure to a breadth of material.
- ii) Science has been and will continue to be an important foundation for the curriculum – The civil engineering faculty adopted a position that a strong science foundation was critical for a technological education of the future. In addition, because of the faculty's strong belief in the

importance of life sciences, students were required to take a biology course (including a laboratory experience).

- iii) The curriculum should adopt a systems perspective on the planning, design, and impact assessment of engineered facilities – In a dramatic departure from the old curriculum, the faculty adopted a systems perspective on civil and environmental engineering. A new systems course (CEE 3000) is required of all students and feeds into subsequent courses that develop the systems concepts in more depth. The systems perspective not only relates to the physical characteristics of facilities and services, but also at a much larger scale to the relationship between engineered works and the social and natural environment.
- iv) Social science requirements in the curriculum should be targeted toward an understanding of the social science context of engineering – The faculty supported the breadth requirement for humanities and social science. However, there was a desire to make the social science exposure as relevant to a technical education as possible. In particular, the faculty felt it was very important for every student to have both macro and micro economics in the academic program. In addition, the faculty wanted students to understand the broader social, political, and economic context of civil engineering from a social science perspective.
- v) An exposure to ethics should be incorporated throughout the curriculum – Students graduating from the program had to have strong exposure to ethics and their application to the profession. Historically, the school had taught a one-credit course on professional ethics, which consisted primarily of outside speakers. As part of the curriculum revision, the faculty felt that more attention should be given to ethics in the new curriculum.
- vi) Computer-based analysis and design should be an important element of the curriculum – Computer-based analysis, design, and communications are inherent skills to any civil and environmental engineering professional. In recognition of the important role that computers play in the engineering profession, Georgia Tech requires every student to have a personal computer meeting certain minimum specifications. The civil and environmental engineering curriculum thus had to teach and continually re-emphasize the use of computers to visualize, analyze, design, and communicate.

Two other characteristics of the undergraduate curriculum merit special attention: enhancing technical communications, and developing a team orientation in coursework.

The School's previous approach to technical communications was to require students to take a communications course from the School of Literature, Communications and Culture. CEE faculty members often expressed dissatisfaction with this approach because many students did not acquire the skills necessary for success in the civil engineering program, and CEE student assessment indicated problems with the relevance of this course. At the recommendation of the external advisory board and through the financial support of an alumnus, the School hired a Technical Communications Specialist, Dr. Lisa Rosenstein, to work with faculty members and students in civil engineering courses. The faculty members believe that the students will better grasp the concepts of written, visual, and oral communication if they are taught these skills within the context of their engineering courses. The communications specialist co-teaches two required courses (CEE 3000, Engineering Systems and CEE 4090, Capstone Design), so students are exposed to technical communications instruction at least twice during their program. However, contact is typically greater than that since the specialist frequently guest lectures in other CEE courses, provides teaching materials for faculty, works one-on-one with students in any CEE course, and periodically runs communications workshops.

One of the important characteristics of the engineering profession is the need to work successfully in teams. The laboratory courses in the curriculum focus on a team approach to assignments and for projects. In addition, the capstone design experience is structured to enhance multi-disciplinary team-building skills by selecting projects that require non-engineering expertise and knowledge for successful design. For example, a recent design project examined different access options to a major redevelopment site that not only required transportation and structural engineering skills, but also city planning, finance, and real estate development expertise. The students were responsible for

finding such “expertise” within the university and incorporating them into the project development process.

The semesters curriculum was implemented in the fall of 1999 and has been in existence for three years. Assessment by students, faculty and the external advisory board during the first three years identified a number of issues and difficulties with the semester curriculum. The CEE undergraduate curriculum committee identified a lack of flexibility as the main problem with the semesters curriculum, and the faculty members approved a series of changes to provide more flexibility in the BSCE curriculum. These changes were approved in the fall of 2000 and include a provision that allows CEE undergraduates to select three out of five CEE “breadth” courses (CEE 3055 (Structural Analysis), 4100 (Construction Engineering and Management), 4300 (Environmental Engineering Systems), 4400 (Geosystems Engineering), 4600 (Transportation Planning Operations and Design), rather than requiring all five. Note that fourth area is required of all graduates, CEE 4200 (Hydraulics). The new curriculum also provided more flexibility in the selection of social science and engineering electives, and makes Geomatics, CEE 3010, an elective rather than a required course.

Table I-8 provides a listing of examples of continuous improvement driven by the assessment process.

Supporting material that will be available to demonstrate achievement of this criterion will include: course materials that illustrate evaluation of student performance; videotape of student presentations from senior design course; alumni survey results; and External Advisory Board interviews.

#### **4. Professional Component**

The BSCE curriculum is designed to ensure that the Program Educational Objectives are achieved by offering basic courses in mathematics and physical sciences followed by introductory and advanced engineering science courses. The BSCE degree requires 128 credit hours. The course syllabi are included in Appendix I.B that summarize CEE courses taught during the 2001-02 academic year and non-CEE courses required by the curriculum but not required by other programs. Table I-2, Course and Section Size Summary, provides data for the 2001-2002 academic year. Table I-9 shows how the course objectives of required and elective CE classes are related to our educational outcomes. The curricular requirements specified in criteria 3, 4 and 8 and in the program criteria are addressed in (1) through (3) below (see Table I-1). The design content of the curriculum and the development of communications skills are addressed in (4) and (5) below, respectively.

- i) Mathematics and Basic Sciences – Three courses (12 credit hours) in calculus; one course in ordinary differential equations (4 credit hours in general, but the 3 credit hour transfer differential equations class is allowed as a substitution); one chemistry course (4 credit hours), including laboratory; two courses (8 credit hours) in calculus-based physics, including two laboratories; one earth sciences class (4 credit hours), including laboratory; and one life sciences class (4 credit hours), including laboratory.
- ii) Engineering Topics – A freshman computer science course (3 credit hours) that includes a laboratory; a freshman visualization class (3 credit hours) that includes a laboratory; a sophomore engineering mechanics class in statics and dynamics (3 credit hours); a junior probability and statistics class (3 credit hours) taught by either CEE, ISyE or Mathematics; two junior engineering science classes, one of which is a class in thermodynamics (3 credit hours) and one that can be selected from the following options (3 or 4 credit hours), electrical circuits plus lab, materials science, or digital signal processing; and thirteen civil engineering classes (39 credit hours) that includes required classes in civil engineering systems, CE materials, strength of materials, fluid mechanics, hydraulics, plus three CEE breadth electives and four CEE technical electives.

- iii) General Education Component – Two English courses (6 credit hours) in composition; 6 credit hours of humanities/modern language electives; 6 credit hours of social science electives; a required 3 credit hour course selected from a menu of five courses in history, public policy, political science, and international affairs; a 2 credit hour course in health and performance science; a 3 credit hour course in economics and a required 3 hour class that has an ethics component (note that the ethics requirement can be fulfilled with a humanities or social science elective, depending on class offerings); and 6 credit hours of approved, but undesignated, electives.
- iv) Design – An integrated, capstone design class (3 credit hours) plus any additional CEE design classes.
- v) Technical Communications – Instruction in technical communications is integrated throughout the curriculum. This effort is facilitated by a technical communications specialist, Lisa Rosenstein, (Ph.D. English) who works two-thirds time in CEE. Dr. Rosenstein co-teaches CEE 3000 (Engineering Systems) and CEE 4090 (Capstone Design), but she also often guest lectures in other CEE courses and provides teaching materials to instructors. In CEE 3000, the communications instruction is integrated into the course content through a series of assignments that teach written, visual, and oral communication skills. These skills are put to use in the final team-written report and oral presentation that the students are required to deliver. In CEE 4090, the students are required to submit a series of documents and reports (SOQs, Proposals, Progress Reports, and Preliminary and Final Design Reports), and deliver a series of oral presentations (Design Proposals, and Preliminary and Final Design Proposals). Written reports in both courses are required to adhere to the highest professional standards in content, style, and format, and all oral presentations are delivered electronically to ensure the students can manage the most current forms of technology. Final reports are photocopied and final presentations are videotaped and archived for use in program assessment.

## 5. Faculty

There were forty-five full-time-equivalent (FTE) faculty members and four academic professionals in the School of CEE engaged in the undergraduate program during the 2001-2002 academic year. The size of the faculty (student/faculty ratio of approximately 11:1) is adequate to cover all of the curricular areas of the educational program, as well as the responsibilities to the students and to the Institute and the profession. In addition, the faculty members have substantial interaction with industry and government, professional societies, through their consulting and research, and are thereby able to better assist the students in their professional development. Faculty data are provided in Tables I-3 and I-4. Appendix I.C provides current summary curriculum vitae for all faculty members. The faculty service a cohort of approximately 500 civil engineering undergraduate students.

The normal course load for faculty in the School of CEE is three courses per academic year, divided approximately equally between undergraduate and graduate courses. This leaves adequate time for research, Institute and professional service. The active involvement of faculty with undergraduates is fostered by the student-faculty ratio. In recent years, numerous faculty have advised students on independent research through the Institute's Undergraduate Research Internship Program, NSF's REU Program, or other mechanisms. The vitality of the ASCE Student Chapter and its high level of participation in recent years in both Concrete Canoe and Steel Bridge Contests stem from the strong support of faculty members and the student chapter advisor.

Faculty members teaching in the undergraduate program are internationally renowned for their scholarship and for leadership in professional activities. Numerous faculty have been recognized as Fellows, editors of archival journals, and authors of textbooks. Furthermore, the School has been successful in attracting and retaining outstanding young faculty, laying the groundwork for sustained superior achievement in the future. Recent notable achievements and recognition of young School faculty (see Appendix I.C) include: NSF CAREER Awards, BP-Amoco Junior Teaching Award,

PECASE Awards, Engineer of the Year Award from Atlanta Engineers Council, Educator of the Year by the Society of Hispanic Professional Engineers. Eminent senior faculty members provide stability to the program and mentoring for young faculty members; several are recent recipients of national prizes and two (Clough and Ellingwood) are members of the National Academy of Engineering. Sixteen faculty members, including a majority of those who participate in instruction in design, are professionally registered.

## 6. Facilities

The School's teaching and research activities take place primarily in the Mason Building (Environmental Fluid Mechanics and Water Resources; Geosystems Engineering; Structural Engineering, Mechanics and Materials), the Sustainable Education Building (Construction Engineering and Management; Transportation Engineering), Daniel Laboratory (Environmental Engineering), and the Structural Engineering Laboratory (Materials and Large-scale Structural Testing). The School supports and maintains several teaching laboratories to support undergraduate instruction, including a materials testing laboratory (CEE 3020), soil mechanics laboratory (CEE 4420), hydraulics/fluid mechanics laboratory (CEE 4200), and environmental engineering laboratory (CEE 4390), which are adequate to meet the demands of the curriculum. Laboratory equipment is well-maintained and in excellent condition. In addition to the above mentioned undergraduate laboratories, there are a number of graduate laboratories with advanced testing and instrumentation capabilities, which are available to undergraduates working on independent research under faculty supervision.

There has been a substantial expansion of space to support the School's academic mission since the last EAC/ABET visit in 1997. Since then, the Sustainable Education Building (SEB) (approximately 21,000 square feet) has been completed with the generous support of alumni, and now houses the construction and transportation faculty, students, and ASCE Student Chapter Office. In addition, SEB contains several computerized classrooms, including the new distance learning classroom (SEB 110) which is integral to the School's involvement in the Institute initiative in distance learning (Georgia Tech Regional Engineering Program, or GTREP). A new state-of-the-art Structural Engineering Laboratory has been completed a short distance from campus. Finally, the Environmental Sciences and Technology (ES&T) Building is scheduled to come on-line in August 2002; the School's faculty in Environmental Engineering will occupy approximately 15,000 square feet in the ES&T complex, and will participate in new interdisciplinary initiatives with faculty members in other Schools and Colleges. Georgia Tech has made substantial investment in recent years to enhance the quality of engineering education, and the available and projected space is adequate to meet the educational needs of the students in CEE. Specific laboratory and instructional facilities are described in more detail below.

**Materials Testing Laboratory** – This laboratory, located in Mason 508B, supports CEE 3020-Civil Engineering Materials, which is required of all undergraduates. Equipment housed in this space and used for the laboratory portion of CEE 3020 includes two 22,000 pound-capacity, screw-driven, universal test frames with computer control, one 120,000 pound-capacity, hydraulic universal frame with computer control, one 400,000 pound-capacity compression testing machine, Charpy impact tester, Rockwell Hardness tester, de-ionized water system, two ovens, and an insulated sieve shaker for sieve analysis. Additional support equipment, including testing fixtures for the frames, extensometers, load cells, computers, and other equipment, are housed in this space.

**Hydraulics Laboratory** – This laboratory (Mason 114-116) supports CEE 4200-Hydraulic Engineering, which is required of all undergraduates. This laboratory facilitates hands-on evaluations of fluid mechanics principles, which are theoretically presented in the lecture portion of CEE 4200. Equipment includes a Venturi meter with total and static pressure taps, a jet-impact apparatus to demonstrate conservation of momentum, pipe friction apparatus for air, water, and oil flows for measuring the head loss and velocity profile for a range Reynolds number, flumes to demonstrate basic open channel flow principles (including hydraulic jumps), a drop sphere facility for coefficient of drag measurements and similitude, a wind tunnel for pressure distribution measurements, and a pump stand with computer control and data acquisition.

Soil Mechanics Laboratory – The undergraduate soil mechanics laboratory (Mason 105) provides facilities for students to perform experiments as part of CEE 4420-Subsurface Characterization. The laboratory includes two rooms: one for sample preparation and the other for measurement of soil strength, stiffness, and flow characteristics. The preparation room includes the equipment required for soil classification, (grain size distribution, hydrometer), as well as compaction and specimen control. The testing room includes a fall cone index, an oedometer, pressure cells, and 5 workstations for triaxial shear, permeameter, and consolidation testing. The workstations include computer automation to control the load frame, data acquisition collection, and evaluation of results. A quicksand tank is also available for demonstration of liquefaction principles.

Computer Facilities and Support for Information Technology – The School maintains a networked computer facility, consisting of over 450 workstations and personal computers, and supported by a Information Systems Group under the leadership of the Associate Chair for Information Technologies. The computer facilities of the School have been substantially upgraded since the 1997 EAC/ABET evaluation. The computing environment changes since the 1997 EAC/ABET evaluation can be summarized in several broad categories: computing classrooms/workspaces; CEE classrooms; networking; and, distance learning facilities. Since the 1997 EAC/ABET review, we have added two classrooms dedicated to teaching courses that require substantial amounts of computer-based simulation and/or instruction. These two rooms are housed on the first floor of the SEB building. One room has computers for each student in the room and the other classroom has computers to be shared by every two students in the room. Further, the three existing facilities CEE students use for part of their educational activities have all been upgraded to include minimally Pentium III computers and in most cases Pentium IV processors.

We are on a three year rotation for replacing computing equipment in our educational facilities. Each CEE classroom now has Internet access and a dedicated ceiling mounted projection system connected to a computer in the classroom. Faculty members use their login access from their offices to access shared disk space for educational materials, so the time needed to provide technology in the classroom is only the time necessary to login. The networking infrastructure within the School has been upgraded to provide 100BaseT switched technology to the desktop with Gigabit backbone throughout. This improvement has greatly enhanced the bandwidth and meets our needs for sharing information.

The School has also added a distance learning classroom, located on the first floor of the SEB facility. This room houses connections via GSAMS (the State of Georgia Distance Education network) and TCP/IP connections to remote facilities. With camera projection for remote classes, live instruction from the GT Atlanta campus class to remote students is provided. The room is operated with a faculty member and technology facilitator who handles the equipment requirements and camera angles/exposures to ensure proper delivery of the classroom material. The room contains computers for every two students, a SmartBoard for both projection and large display of information in addition to the normal computer presentation capabilities found in all of the School's classrooms.

In addition to these resources, we have equipped a conference room to have computer projection and distance conferencing capabilities. The conference room facilities are used often by faculty and students in sharing both educational and research information with others off campus. All undergraduate students receive free accounts on the Georgia Tech computer system, allowing them convenient access to the CEE network, and students are expected to make use of the computer facilities in their coursework. Students at Georgia Tech also are required to purchase their own personal computers. Most department announcements are made electronically, courses are expected to maintain Web pages, and many faculty post problem assignments and solutions electronically. A portion of Engineering Visualization (CEE 1770) and Introduction to computing (CS 1321) is devoted to teaching students productivity tools, including word processing, spreadsheets, CAD and Web page construction. Many assignments in these courses are submitted

over the network on student homepages (See <http://www.ce.gatech.edu/academics/> for example courses for the current term).

Tours of the facilities and interviews with students and faculty at the time of the visit will aid in demonstrating the achievement of this criterion.

## **7. Institutional Support and Financial Resources**

- i) Budget Process – The annual School operating budget is determined by the Office of the Dean of Engineering, and reflects the allocation to higher education in the Budget for the State of Georgia. Appendix II (Institutional Profile) contains specific information on the budgeting process of the College of Engineering and the schools within the College.
- ii) Institutional Support and Financial Resources – The School operating budget in recent years has been approximately \$6.3 million, of which approximately 85% is salaries for faculty and staff, 7% is salaries for teaching and other student assistants, and 8% is travel, supplies and budgeted equipment. Extramurally funded research activities add approximately \$11 million. Additional funding for capital expenditures comes from the Office of the Provost (e.g., Technology Fees) and the Board of Regents, and a modest endowment supports miscellaneous expenses that are not recoverable by other means. Table 5 summarizes expenditures for support functions of the civil engineering program during the period July 1, 1999-June 30, 2003. This level of support, with creative and careful management, has been sufficient to meet the needs of the undergraduate curriculum. The School periodically benchmarks itself with programs at other nationally ranked public universities, most recently during the 1998-1999 academic year, to ensure that its administrative support is consistent with its competitors. Startup packages for new faculty are shared between the Provost, Dean and School, and are competitive with those at other comparable institutions.
- iii) Faculty Professional Development – Georgia Tech encourages professional development. Faculty are expected to take their teaching and advising obligations seriously, but they are otherwise free to take on extramural professional activities as time and resources permit. For many years, the School has underwritten the costs of participation of its younger faculty members at national conferences, to present technical papers, participate in technical committee activities, or otherwise make contacts that will enhance their career development. Senior faculty members with established research programs are expected to support their own participation, leaving the limited travel funds for untenured faculty. The vast majority of faculty members in the School are actively involved in extramural technical, professional and leadership activities, with ASCE and similar technical and professional organizations. A perusal of their curriculum vitae in Appendix I.C reveals the level of faculty service to the civil engineering profession as committee chairs, organizers of major conferences, society officers, and membership on editorial boards.
- iv) Laboratory Development – During the period from 1998-1999 to 2001-2002, the average yearly institutional expenditures from the School budget for laboratory equipment and services was approximately \$105,000 per year. In addition, yearly supplemental Capital Funds provided by the Office of the Provost during this period averaged \$141,000/per year. In the 2001-2002 academic year, these Capital Funds totaled \$176,946, and were used to purchase a Web server for the School, completely renovate the computer labs used for the freshman course, CEE 1770 – Engineering Visualization, purchase a fluid visualizer for the undergraduate fluid mechanics lab, and purchase additional instructional software for the undergraduate PC lab. In addition to these resources, funding from extramural grants and contracts occasionally allows purchase of equipment that also can be used in the instructional program. Each year, the School submits proposals to the Institute for allocation of student technology fee funds. These funds must be utilized to improve the education of Georgia Tech students
- v) Support personnel – The School Administrative Office has the services of three administrators and one Building Facilities Manager for the Mason/SEB complex (Daniel Lab has a separate

facility manager) with responsibility for space management and maintenance, and one development officer. Five individuals staff the School Business Office, with responsibility for tracking state budget expenditures and extramurally funded research. These staff report directly to the chair of the School (Dr. Ellingwood). The School's Office of Student Services, supervised by the Associate Chair for Undergraduate Programs (Dr. Jacobs), has four FTE staff, which play an essential administrative role in academic advising, reviewing transcripts of transfer students, and other academic administrative matters. Three laboratory technicians (two in Mason and one in Daniel) to support experimental work. The increase in computer resources during the past several years has necessitated the formation of an Information System Group, staffed by three individuals and supervised by the Associate Chair for Information Technologies (Dr. Baker), which has responsibility for maintaining the School's computer/networking system. In addition, each of the six affinity groups in the school is supported by at least one administrative support person. All these support personnel are supported fully by the School's general funds budget. In addition, the school hires work-study students to help with occasional peak demands (e.g., bulk mailings, graduate applications) during the year. This level of support is adequate for the academic programs of the school.

## 8. Program Criteria

Submitted by the American Society of Civil Engineers; these program criteria apply to engineering programs including "civil" and other modifiers in their titles.

1. *Curriculum – Graduates of the program must have demonstrated: Proficiency in mathematics through differential equations; probability and statistics; calculus-based physics, and general chemistry.*

All students must complete three courses (12 credit hours) in calculus, one course in ordinary differential equations (3 or 4 credit hours); one chemistry course (4 credit hours), including laboratory; two courses (8 credit hours) in calculus-based physics, including two laboratories; one earth sciences class (4 credit hours), including laboratory; and one life sciences class (4 credit hours), including laboratory. In addition, all students must complete a junior probability and statistics class (3 credit hours) taught by CEE, ISyE or Mathematics.

*Proficiency in a minimum of four (4) recognized major civil engineering areas.*

The curriculum requires all students to take a first course in hydraulic engineering (which includes a laboratory), and then select three CEE breadth electives from the following five areas: construction engineering, environmental engineering, geotechnical engineering, structural engineering, and transportation engineering (see Table I-1). Thus, all undergraduates will demonstrate proficiency in at least four recognized civil engineering areas.

*Ability to conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering areas.*

Required courses in physics and chemistry include laboratory experiments and data reduction and analysis. The required class in graphics and visualization (CEE 1770) introduces interpretation of drawings and specifications for product realization. The required civil engineering materials (CEE 3020) course introduces students to concepts of data acquisition, visualization and measurement technology, and provides further experience in design of experiments. Students perform experiments in teams and are expected to generate individual reports based upon the data acquired as a group. For some of the labs, data is shared between groups to allow for analysis of a broader set of experimental parameters. Emphasis is placed on the development of good technical writing skills. Students are expected to describe the experiment, present data, and discuss results in an

organized and informative manner using appropriate technical language and grammar. Students learn to prepare abstracts as part of this course. Geomatics (CEE 3010), which is not required, includes field work in surveying, global positioning, and analysis of spatial data. The required hydraulics class (CEE 4200) includes a laboratory that permits students to verify theoretical principles presented in fluid mechanics lectures, including measurement of pressure losses due to pipe friction, hydraulic flow and jumps, orifice stream velocity as a function of pressure head, fluid drag, viscosity and open-channel flow. Laboratory safety is stressed in all engineering laboratory courses, where students perform experiments under faculty or staff supervision.

*Ability to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum.*

The engineering design experience is integrated in required coursework throughout the curriculum, beginning with Engineering Graphics (CEE/ME 1770) in the spring semester of the freshman year, continuing with four required engineering science courses with design content and three specific design courses devoted to specialty areas, and culminating in the capstone design course (CEE 4090), which is normally taken during the student's last semester. This capstone course requires students to develop and complete an engineering project, from project definition and functional design through the phases of schematic design, design development, to presentation of the project proposal to the client. Solutions must address technical challenges, project safety and reliability, project economics, environmental, political and legal issues, operation and maintenance issues, and professional ethics and responsibility. Students work in teams of 4 - 6 students (depending on class enrollment) throughout the project. Some recent projects have included: Spring 2001, Dr. Rodgers, a variety of design projects coming from the Georgia Regional Transportation Authority (GRTA); Summer 2001, Dr. Emkin, design a free standing overhead lifting crane structure; Fall 2001, Dr. Amirtharajah, hydraulic design projects; Fall 2001, Dr. Rodgers, variety of design projects originating with the GRTA, City of Atlanta/Georgia Tech Parking, Georgia Department of Natural Resources and the Washington County Development Authority; Spring 2002, Dr. Leon, development and design of a medical office complex; and Summer 2002, Dr. Emkin, design a free standing pedestrian bridge structure supported by reinforced concrete tower structures.

In addition to the capstone design experience, members of the ASCE student chapter in the School have participated in regional student involving steel bridge and concrete canoe construction sponsored by ASCE and AISC. These competitions provide an opportunity for team-building, which is an invaluable part of their education as engineers.

*Understanding of professional practice issues such as procurement of work; bidding versus quality based selection processes; how the design professionals and the construction professions interact to construct a project; the importance of professional licensure and continuing education; and/or other professional practice issues.*

The seminars organized by the six affinity groups within the School bring speakers to campus from professional practice. Their talks address a variety of socioeconomic issues involved in project planning and execution, and convey the complexity of engineering in a modern social context and the importance of licensure and continuing education. Outside speakers invited to campus by the ASCE student Chapter usually are practitioners. The School has organized a lecture series as part of its celebration of ASCE's sesquicentennial, which has brought eminent engineers to the campus. These lectures are widely publicized, and undergraduates are strongly encouraged to attend them.

The Systems course focuses on key relationships and linkages among system components and between system and environment with an emphasis on the distributive impacts of engineering systems over their entire life cycles. The course also focuses on the project development and design process including construction issues and how they are represented in project management approaches and systems monitoring beyond project implementation. Case studies on sustainable

initiatives in private companies are used to highlight examples of leadership in society and in the profession. In addition, the course integrates technical communication education in the core syllabus through lectures on written, oral and visual communication. Students are required to use the principles of communication in teams to develop a professionally written report and oral presentation with visual aids for a term project that focuses on assessing infrastructure from a systems perspective. The communications component of the course is taught by a communications specialist hired by the School.

Professional practice and ethical responsibility are integrated into the capstone design sequence, with guest lecturers and field trips, in addition to the required ethics elective. Students are given a broad picture of the interactions that occur among participants of the design and construction team.

All upperclassmen are reminded in the fall of the senior year of the importance of professional registration and taking the Fundamentals of Engineering Examination in the spring semester. Announcements also are made through the ASCE Student Chapter and Tau Beta Pi, which also organizes a FE review course. Application forms for the examination are made available the Student Chapter office.

Faculty instill an appreciation of the civil engineering profession through example. Most faculty are actively involved with national and local professional engineering activities, as can be seen from Appendix I.C.

2. *Faculty – The program must demonstrate that faculty teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, or by education and design experience. The program must demonstrate it is not critically dependent on one individual.*

Courses that are primarily design in content are: CEE 4090 Capstone Design (Meyer, Amirtharajah, Rodgers, Leon, Lindsey); CEE 4310 Water quality engineering (Saunders); CEE 4320 Hazardous substance engineering (Pennell); CEE 4330 Air pollution engineering (Bergin); CEE 4410 Geosystems engineering design (Mayne, Frost); CEE 4510 Structural steel design (Zureick, Leon); CEE 4520 Reinforced concrete design (Leon, DesRoches); CEE 4530 Timber and masonry design (Kahn); and CEE 4610 Multimodal transportation planning, design (Dixon, Williams)

Of these faculty, Amirtharajah, Dixon, Frost, Kahn, Leon, Lindsey, Mayne, Saunders and Williams are licensed professional engineers. Moreover, Amirtharajah, Frost, Leon and Mayne are internationally recognized scholars in their fields, and Lindsey is a former principal in one of the leading structural engineering firms in the United States. The success of the program clearly is not dependent on one individual.

Supporting material that will be available to demonstrate achievement of this criterion will include: course descriptions, outlines, texts; samples of student work; capstone design presentations; and interviews with students.