

# **SELF-STUDY REPORT**

## **Bachelor of Civil Engineering**

*Submitted by*  
**Department of Civil and Environmental  
Engineering  
College of Engineering  
University of Delaware**

*Submitted to*  
**Engineering Accreditation Commission  
Accreditation Board for Engineering and  
Technology**

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## **A. BACKGROUND INFORMATION**

### **A.1 Degree Titles**

Bachelor of Civil Engineering (BCE)

### **A.2 Program Modes**

Courses are generally offered on-campus during the day between 8:00 am and 6:00 pm. A select number of upper level elective courses, as well as the Senior Design course, are offered in the evenings, generally between 6:00 and 9:00 pm. There are no off-campus or distance courses. There is no formal co-op program during the academic year, although an informal summer internship program is coordinated by the department.

### **A.3 Actions to Correct Previous Shortcomings**

The last ABET review of the Civil Engineering degree program took place during the 1999-2000 academic year. The program received a six-year accreditation. There were no concerns or shortcomings of the program identified in that review.

### **A.4 Contact Information**

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The Department of Civil and Environmental Engineering maintains an extensive web site with details and information about our ABET assessment process, including Outcomes, Objectives, and other documentation. The web site can be found at [www.ce.udel.edu/ABET/ABET.html](http://www.ce.udel.edu/ABET/ABET.html).

## B. ACCREDITATION SUMMARY

The University of Delaware (UD) Department of Civil and Environmental Engineering (CEE) offers undergraduate students a stimulating atmosphere for learning and growth. The Department boasts award-winning teachers, world-class research, and state-of-the-art facilities. Unlike many large universities, where the emphasis is on research and graduate education, the University of Delaware places a high priority on undergraduate education. With a model undergraduate research program, problem-based classroom instruction, real-world internship experiences, and a nationally recognized Study Abroad program, we offer our students a well-rounded education that prepares them for engineering practice. Additional information on UD's undergraduate research and study abroad programs can be found in Appendix II, sections A.6.b and A.6.c.

Our civil engineering (CE) curriculum offers concentrations in structural, transportation, environmental and water resources, and geotechnical engineering, while world-class research centers in these areas provide a focal point for research programs that support instruction in the classroom and laboratory, improvements to the curriculum, and the development of new knowledge. Graduates of our program are highly sought after by both industry and government as well as graduate programs.

This document addresses all of the points required by ABET for its review process; in doing so, it highlights many of our departmental accomplishments and underscores the many benefits afforded the students who complete our civil engineering bachelor's degree program. Our faculty consider students to be their number one priority, and they take the time to provide our students with

thoughtful advising and meaningful interactions. We have been receptive to the inputs of our many constituents and have responded with relevant modifications to our curriculum. The following summarizes some of the many changes and improvements that the department and program have undergone since the 1999–2000 ABET review, as well as some notable accomplishments:

- The Civil Engineering curriculum underwent a major revision. The changes were completed and approved by the faculty in spring of 2001. The new curriculum was implemented in the fall of 2002; the class of 2006 will be the first to graduate under the new curriculum. The major curriculum changes included the following:
  - COMM312, "Oral Communication in Business," was added to the curriculum.
  - MATH302, "Differential Equations," was replaced by MATH351, "Differential Equations with Linear Algebra."
  - CIEG321, "Geotechnical Engineering," was added to the curriculum as a required course for all CE students.
  - A two-credit CAD course was replaced by a three-credit "Introduction to CAD and Surveying" course.
  - An optional requirement of either steel or concrete design was replaced by a single four-credit combined steel and concrete design course.
  - The second semesters of physics and chemistry were replaced by a single four-credit science elective.
- Two subsequent curriculum changes that have been completed are the addition of a required Transportation Engineering Lab class (CIEG 451), and the incorporation of a required Construction Methods and Management class (CIEG 486).

- Enrollment in the department has increased, with no accompanying sacrifice in student quality. Average SAT scores have remained steady, as has the percentage of honors students in CE.
- DuPont Hall, home to the Department of Civil and Environmental Engineering, underwent a major expansion and renovation. A new 60,000-square-foot laboratory building was added to the front of the original DuPont Hall. The department's main offices were moved to the third floor of the new building. CEE was also allocated a large conference room, a lab, and a student study room in the new building. The third floor of the original DuPont Hall, where many CEE faculty offices are located, also underwent renovation.
- The Structural Testing Laboratory, located in 180 DuPont, received new lighting, a new industrial door on the north end of the lab, a concrete pad storage area outside the building, and fenced storage areas.
- The Intelligent Transportation Laboratory, located in 341 DuPont, was completed in 2001. The state-of-the-art facility receives real-time images of the traffic conditions at various locations in the state and is used for research and teaching in the areas of traffic engineering and planning.
- Two new research centers have been established in the department, the Center for Innovative Bridge Engineering and the Center for the Study of Metals in the Environment.
- Two female faculty members have been hired since the last ABET visit and will join the department in September 2005.
- The ASCE student chapter has been active in the steel bridge and concrete canoe competitions. In the 2004 events, our students placed first in construction speed and economy, and they took second place overall in the steel bridge competition. In the concrete canoe challenge, our team took second place in the women's distance and sprint races.
- The quality of the CEE faculty is also evidenced by awards and other recognition, including awards from professional societies. For example, Prof. Dennis Mertz recently received the Richard R. Torrens Award from ASCE, and Dr. Nobu Kobayashi was the recipient of the Coasts, Oceans, Ports, and Rivers Institute's Moffatt-Nichol Award. Also during the past year, Prof. Dominic Di Toro was named a "Highly Cited Researcher" by the Institute of Scientific Information, and he was elected to the National Academy of Engineering.
- The department has outstanding teachers. During the past six years, ten of our faculty have been nominated for college or university teaching awards, and four have won such awards.
- Awards by students are another indicator of quality. As examples, Matthew J. Buckley won a number of awards, including being named a Tau Beta Pi Scholar. Football player Ben Cross was named an Academic All American, and Andrew P. Joslyn was the recipient of a 2003 Morris K. Udall Undergraduate Scholarship.

## **B.1 Students**

In this section, students are discussed from the perspectives of admission, advisement, performance evaluation, progress monitoring, transfer, and compliance with degree requirements.

### **B.1.1 Admission Into the Program**

When applying to the University of Delaware, prospective engineering majors are required to choose an engineering major on their application, or select "engineering undecided." Undecided students have until the beginning of their freshman year to choose an engineering major. In this way all freshmen engineering majors are admitted into a specific major by the start of their freshman year.

### **B.1.2 Advising**

Student advising occurs in the following ways:

- Student-faculty contact in a course
- Departmental faculty advisor
- Departmental administrative contacts:
  - Michael J. Chajes, Chair
  - Ardeshir Faghri, Associate Chair
  - Barbara Carcanague, Staff Assistant
- College administrative contacts:
  - Dan Boulet, Assistant Dean for Undergraduate Affairs
  - Michael Vaughan, Assistant Dean for Student Affairs and Director of the RISE Program
- Student Chapter Organization Advisors
- Honors student advising with the Chair

Students who have been admitted into the Civil Engineering major have their initial advising, for classes to take during the Fall semester of their Freshman year, as well as the acceptance of any transfer or AP (Advanced Placement) credits, with the College of Engineering Assistant Dean for Undergraduate Affairs. This occurs

during new student orientation in the summer prior to the start of their freshman year. Thereafter, they are assigned a departmental faculty advisor. The initial assignment of advisors to advisees is done alphabetically by student last name such that each faculty member has approximately the same number of advisees. Most students retain the same faculty advisor throughout their association with the department, but they are allowed to switch if there is mutual agreement between the new advisor and the advisee. Students who change advisors often do so later in their studies to achieve a better match with their selected area of specialization in the department.

Students who are admitted to the honors program meet with the Chair during new student orientation to select their first-semester courses. The Chair serves as the academic advisor to all civil engineering honors students throughout their entire time at the University.

All full-time tenured/tenure track faculty members in the department participate in student advising. This yields a low student-to-advisor ratio and ensures that every student will get personal attention during the scheduled advising period and throughout the academic year as they so desire. It also allows faculty to stay abreast of curriculum matters. A two week advising "window" is scheduled about ten weeks into the fall and spring semesters during which students will meet with their advisor to discuss the selection of courses for the next semester. Outside of the scheduled advising window, students are free to make an appointment to meet with their advisor as needed.

The civil engineering curriculum, degree requirements, and program Objectives are given in detail in the University Catalog, on the department web site ([www.ce.udel.edu](http://www.ce.udel.edu)), and in other departmental publications. The curriculum requirements are also outlined

on a curriculum "check sheet" that is maintained by the department. The check sheet, which shows the curriculum organized by semester and year, also provides information on the degree general education requirements, such as humanities, social sciences, and multicultural requirements. A check sheet is maintained in each student's academic folder and is updated during advising meetings to reflect the courses the student has completed and those that remain to be completed. A copy of the check sheet is included in Appendix I.D.1.

The check sheet is a departmental procedure; the University maintains the student's official transcript and academic progress report online. Faculty advisors have access to the official records through a web-based advising system called "UD Notes." Through UD Notes, faculty have access to their advisees' transcripts and Academic Progress Reports. The Academic Progress Report is like the department check sheet, in that it shows exactly what the student has completed and what requirements remain to be completed. The advisor can also submit "notes" to the student's computer "file" that document the advising meeting. The curriculum check sheet is maintained as an independent record of the student's progress. UD Notes was brought online two years ago and is gradually being adopted by faculty in the department.

Students are expected to meet with their advisors at least once a semester to check their progress and to select courses for the following semester. The two-week advising "window" is scheduled by the department during the University pre-registration period: CE students are notified by email of the advising period and asked to make appointments to meet with their advisors. Students select appointment times from calendars posted by faculty.

Prior to their meeting, the department staff places an updated copy of the student's transcript in the student's folder

(also available on UD Notes), which is then given to the advisor before the meeting. A typical student-faculty advising conference includes discussions of the following:

- A review of academic progress, as shown on the curriculum check sheet
- Courses to be taken during the next semester
- Appropriate choices for humanities, social sciences program electives, and civil and environmental engineering technical electives
- Any particular needs or difficulties the student has, e.g., progress toward the degree, balancing school and work responsibilities, etc.
- Post-baccalaureate activities, e.g., professional practice or graduate school
- Any other appropriate topic raised by either party, depending on individual circumstances

In the past, a worksheet was completed during advising that showed the courses for which the student was to register. The worksheet was signed by the faculty advisor; a copy was given to the student, and another was placed in the student's folder. Currently, advisors complete the worksheet and/or document the advising session in UD Notes.

Any change in student status, such as carrying an excessively high number of credit hours or carrying less than a full-time load, requires the approval of both the advisor and the college Assistant Dean for Undergraduate Affairs. Substitutions for required courses and other exceptions, such as taking courses in other institutions, which may have an impact on fulfillment of graduation requirements, must have the approval of the advisor, the department Chair, and the College Assistant Dean.

In addition to the regular advising period, faculty also advise students who are

members of honor societies as well as student chapters of professional societies (ASCE, ITE, ASWE, Chi Epsilon). All minority students receive additional advising through the RISE (Resources to Insure Successful Engineers) Program within the College of Engineering. RISE is managed by the Assistant Dean for Student Affairs in the College. The RISE office provides advising, mentoring, and class assistance for minority students; the RISE Program is described in detail in Appendix II (Institutional Profile).

Students experiencing extenuating circumstances, conflicts, or serious academic difficulties are referred to the Associate Chair (Ardeshir Faghri) and then to the Chair if the problem is unresolved.

Each student goes through a complete "Senior Check-out," sometime between the spring semester of the junior year and the fall semester of the senior year. This check-out is conducted by the Assistant Dean of the college. During this meeting the Assistant Dean will identify and resolve any issues that remain, such as remaining transfer credits or course substitutions, and will discuss remaining course selections to ensure that the student is on course to graduate the following spring. Additional information on graduation requirements and senior check-out can be found in Appendix II, section A.6.a.

It should be noted that advising is not mandatory. Students are able to register online for courses without first seeing their advisors: this is a University-wide policy, not a College or Department policy. Nevertheless, every effort is made to contact students and encourage them to see their advisors during the scheduled advising period each semester. While official records have not been kept, it is estimated that the vast majority of CE majors see an advisor before registering for courses for the next semester. Feedback from CE majors, as is discussed in later sections of the report, indicates

that our students are very satisfied with the current advising system.

A measure of successful advising is the fact that the vast majority of CE students complete their degrees within four years.

### **B.1.3 Evaluation**

Students in the program are evaluated with respect to their preparation for entry into the general practice of civil engineering and their preparation for graduate education. The evaluation is conducted primarily through performance as described below:

#### **COURSE PERFORMANCE**

- Exams (tests, quizzes, and final exams)
- Problem sets and homework
- Laboratory assignments
- Project reports (oral and written)

Instructors' reviews and comments on homework assignments and tests provide the student with feedback on their performance. Knowledge, skills, and ability to perform in the laboratory are evaluated through review of laboratory reports. Ability to work effectively in teams and to communicate correctly and effectively is evaluated through performance in laboratory work and design teams. Our full-year senior design capstone course provides a unique opportunity to evaluate students' competence during their final year. The University uses an "A" through "F" grading system, with "plus" and "minus" grades available from "A-" through "D-". A minimum average of "C," or a grade point index of 2.0 on a 4.0 scale, on all work taken at the University is required for the baccalaureate degree. Students in civil engineering are also required to earn a "C-" or better in MATH241, MATH242, CHEM103, and PHYS207. The "C-" or better requirement is monitored by the department and faculty advisor: students who do not meet the requirements are

identified and asked to retake the course or courses in question until a satisfactory grade is received.

#### **FUNDAMENTALS OF ENGINEERING (FE) EXAMINATION**

Most UD civil engineering majors take the FE exam during their senior year. This national test is considered a good indicator of students' fundamental knowledge in the field, since the morning portion covers basic mathematics, science, and engineering sciences and the afternoon portion deals with civil engineering topics. Outcomes measured are (1) ability to apply knowledge of mathematics, science and engineering, (2) ability to formulate and solve civil engineering problems, and (3) ability to understand professional and ethical responsibility. As described later in this document, student performance in specific FE subject areas can be evaluated with respect to pre-set performance goals for these subjects, as well as a comparison with national results.

#### **B.1.4 Monitoring**

Monitoring of student progress is primarily the responsibility of the advisor and the Assistant Dean for Undergraduate Affairs. They both have ready access to students' transcripts and Academic Progress Reports, notes from past meetings, and any other pertinent material, in the student files maintained in the department office and through UD Notes. Attention is focused on those students having some form of academic difficulty, since that is a strong indication that proper preparation for civil engineering practice is not occurring. Monitoring occurs in the following ways:

1. Advisor review of academic performance on a periodic basis (twice a year)
2. Assistant Dean review of academic performance on a periodic basis
3. Senior check-out conducted by the Assistant Dean of the College of Engineering

#### **B.1.5 Transfer Students and Transfer Credits**

Students from outside the University of Delaware who wish to transfer into the Civil Engineering program must make a formal application through the University Admissions office. A final decision is made by the admissions staff after the application is reviewed. Once the student has been admitted, the formal transfer of courses from the other institution to the University of Delaware Civil Engineering degree program is completed. Where course equivalents have already been established and are on record, this is done automatically. Where no record of a course equivalent has been established, the student must complete a Transfer-Credit Evaluation form, as described below. Further details of this process are described in Section 9.a.6 of Appendix II.

Students wishing to transfer course credits from another institution must complete a Transfer-Credit Evaluation form, a copy of which is included as Appendix I.D.2. Students transferring from another institution may need to do this for some or all of their courses; the form is also completed by any Delaware student who wishes to take a course at another institution, for example, during the summer to make up a course they missed. The form lists the institution at which the course was taken, when it was taken, the course number, title, and credit hours, and the University of Delaware equivalent course number, title and credit hours. If the course equivalent has not been previously approved by the appropriate department, the student must obtain that department's approval for the individual course in question. That approval is made by the Associate Chair of the department and is based on a review of the course description, and in some cases the course syllabi. Once the individual courses have been approved by the department, the student must obtain the Assistant Dean's approval on the form. The form is then submitted to the

Service Desk at the Student Services Building.

During the senior check-out process, final compliance with the program is verified. Past history has shown that the procedures for transfer students and transfer credits are working effectively. Additional information on admission of transfer students can be found in Appendix II, section B.9.a.

## **B.2. Program Educational Objectives**

The Educational Objectives are the foundation upon which the Outcomes and curriculum for the CE degree are built. Educational Objectives have been developed that are consistent with the mission of the University, the College of Engineering, and the Department of Civil and Environmental Engineering and are intended to satisfy the needs of our constituents.

The following are the Objectives of our Civil Engineering program:

1. Graduates will be prepared with a solid foundation in mathematics, sciences, and technical skills needed to analyze and design civil infrastructure systems.
2. Graduates will possess strong written and oral communication skills.
3. Graduates will be familiar with current and emerging civil engineering and global issues, and have an understanding of ethical and societal responsibilities.
4. Graduates will have the ability to obtain professional licensure, and will recognize the need for engaging in life-long learning.
5. Graduates will have the necessary qualifications for employment in civil engineering and related professions, for entry into advanced studies, and for assuming eventual leadership roles in their profession.

The Objectives are published on the department website at [www.ce.udel.edu/ABET/CEobjectives.html](http://www.ce.udel.edu/ABET/CEobjectives.html) and are also published in the University catalogue.

The Objectives have been reviewed and revised, with input from our constituents. Furthermore, an ongoing process has been implemented to evaluate the Objectives and to ensure that the Objectives are being achieved.

The remainder of this section is organized as follows. The University, College, and Department mission statements are first presented. Next is a discussion of how the Objectives are consistent with the mission of the University and with the ABET accreditation criteria. This is followed by a description of our constituents. Next is a discussion of how the curriculum and processes ensure achievement of the Educational Objectives. Finally, the process used to establish and evaluate the Objectives and the results of that process are described.

### **B.2.1 Mission Statements**

University - The central mission of the University of Delaware is to cultivate both learning and the free exchange of ideas. To this end, the University provides excellent undergraduate and graduate courses of study in a variety of disciplines. Our graduates should know how to reason critically and independently yet collaborate productively. They should understand the cultural and physical world, communicate clearly in writing and speech, and develop into informed citizens and leaders. The University faculty has a strong tradition of distinguished scholarship, research, and teaching, which is grounded in a commitment to increase scientific, humanistic, and social knowledge for the enrichment of the larger society. A state-assisted, privately governed institution, the University of Delaware was founded as a private academy in 1743, received its collegiate charter from the state in 1833, and was designated one of the nation's historic land-grant colleges in 1867. The University works cooperatively with the area's unique cultural and technical institutions; it provides the finest library in the state and offers the region's people a rich array of public lectures, exhibitions, performances, service programs, and athletic competitions. The University strives for an atmosphere in which all people feel welcome to learn, embracing creativity, critical thinking, and free inquiry, and

respecting the views and values of an increasingly diverse population. (The University Mission statement can be found online at <http://udcatalog.udel.edu/general/general/university.html> and in the University catalogue).

*College of Engineering* - The mission of the College of Engineering at the University of Delaware is to cultivate both learning and the advancement of knowledge in the engineering sciences. To this end, we provide all of our students with outstanding undergraduate, graduate, and continuing education programs so that they will know how to reason critically and independently yet cooperate productively. Our graduates should understand our culture, communicate clearly in writing and speech, and develop into informed citizens and leaders. The College encourages a strong tradition of applying its distinguished scholarship, research, and educational resources to serve the local, state, and national communities through collaborative efforts with individuals, industry, and government. The College of Engineering at the University of Delaware recognizes the increasing diversity of its students and faculty and, therefore, strives to create an atmosphere in which all people feel welcome to learn and participate in the free exchange of ideas. (The College Mission statement can be found in the University catalog and online at <http://www.engr.udel.edu/overview/mission.html>).

*Department of Civil and Environmental Engineering* - Our mission is to provide a culturally diverse and intellectually stimulating environment for

- the discovery and application of knowledge in civil and environmental engineering,
- the education of our students to their fullest potential, and

- service to the public through outreach and professional activities.

The Department Mission statement can be found online at [www.ce.udel.edu/prospective/](http://www.ce.udel.edu/prospective/).

### **B.2.2 Relationship Between Educational Objectives and Institutional Mission**

The Department mission is consistent with and subservient to the College mission, just as the College mission is consistent with and subservient to the University mission. The CE Educational Objectives embrace the principles of the University, College, and Department missions. Specifically, Educational Objectives 1, 2, and 3 are consistent with the University mission "to cultivate both learning and the free exchange of ideas"; graduates should "reason critically and independently," "communicate clearly in writing and speech" and "understand the cultural and physical world." Educational Objectives 4 and 5 are consistent with the University mission statement that graduates should "develop into informed citizens and leaders."

### **B.2.3 Relationship Between Educational Objectives and Accreditation Criteria**

Each of the Educational Objectives defined in section B.2.3 is consistent with the eight ABET accreditation criteria, as described in the following sections:

#### **CRITERION 1. STUDENTS**

In order for graduates of the program to be qualified to obtain employment in the civil engineering profession or related fields, or to enter graduate school (Objective 5), they must be evaluated, monitored, and advised throughout the course of their education, to ensure that they successfully complete all of the requirements for the degree. The same can be said if they ultimately wish to sit for the Professional Engineers license

(Objective 4). Students were discussed in Section B.1 of the report.

**CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES**

Not applicable.

**CRITERION 3. PROGRAM OUTCOMES AND ASSESSMENT**

The Program Outcomes and the assessment process are described in detail in Section B.3. There, the link between the Outcomes and Objectives is presented, as is the link between the Outcomes and the curriculum. By virtue of these links, one can see that the Objectives are consistent with this accreditation criterion.

**CRITERION 4. PROFESSIONAL COMPONENT**

This criterion defines general requirements for one year of math and science, one and one-half years of engineering sciences and engineering design, and a general education component. Educational Objectives 1, 2, and 3 are aimed at fulfilling this criterion and are consistent with it. The specific courses that fulfill these requirements are listed in Section B.4 of the report.

**CRITERION 5. FACULTY**

The Educational Objectives are such that graduates of the program can be employed as civil engineers or in related fields, and/or go on to advanced graduate study. This is consistent with the make-up of the faculty in the Department of Civil and Environmental Engineering, which consists almost exclusively of graduates of civil engineering degree programs. Faculty is discussed in more detail in Section B.5 of the report.

**CRITERION 6. FACILITIES**

The Educational Objectives are consistent with this criterion by virtue of the fact that the department and University maintain all of the necessary facilities (classrooms, laboratories, computer facilities) needed to achieve the stated

Objectives. Facilities are discussed in more detail in Section B.6.

**CRITERION 7. INSTITUTIONAL SUPPORT AND RESOURCES**

The Educational Objectives require personnel, facilities, and financial resources to ensure their achievement. We have sufficient institutional support and resources to enable us to meet all of our Objectives. Institutional support and resources are discussed in more detail in Section B.7 of the report.

**CRITERION 8. PROGRAM CRITERIA**

The program criteria, developed through the American Society of Civil Engineers, address curriculum and faculty. The curriculum criteria are addressed via program Outcomes, the faculty criteria are addressed via the make-up of the faculty. Therefore, as described previously for Criteria 3 and 5, the Educational Objectives are also consistent with this criterion. The program criteria are discussed in detail in Section B.8 of the report.

**B.2.4 Constituents**

Constituents of the CE program include students, employers and graduate schools, alumni, and faculty.

**STUDENTS**

The primary and most important constituent group is students currently enrolled in the CE program. Most students enter the program right out of high school and complete the degree in the required four years. Their typical age is 18 to 22. The vast majority of these students are full time, although we occasionally have some students who work and complete the degree on a part-time basis. We typically have between 250 and 350 civil engineering majors in the program at any one time.

**EMPLOYERS**

Employers are the primary “users” of our “product.” They include the public and

private sectors, small and large firms (consulting, construction, management), and federal, state, and local government agencies. While we do have alumni working in many parts of the country, we consider employers in the Mid-Atlantic region the key members of this constituency. The Delaware Department of Transportation, the largest CE employer in the State, hires many UD CE graduates and therefore is a key public sector member of this group.

#### **GRADUATE SCHOOLS**

Between 10 and 20% of our graduates continue into advanced-degree programs. The majority will pursue a Master's degree in their fields of concentration and complete the degree as full-time students. Other graduates who directly enter the engineering profession will pursue graduate degrees on a part-time basis while they work. Some of these students will go on to pursue a Ph.D. On occasion, a student will go on to law school or medical school or enroll in an MBA program. Our graduates have attended some of the best graduate schools in the country, including University of California at Berkeley, University of Illinois at Urbana-Champaign, University of Texas at Austin, Georgia Tech, and Northwestern, to name just a few.

#### **ALUMNI**

This group includes students who have graduated from the University with a degree in Civil Engineering. All alumni are important and can provide useful input to the program; however, the department views recent graduates (1-5 years out) as the most important in terms of providing input to the ABET process. Alumni have been through the program, and we assume that a majority are currently working in the civil engineering profession. They have the experience of the four-year degree program and first-hand knowledge of the profession. The Department relies on alumni for various things including serving on the ABET

Constituent Committee (described later), the department's External Advisory Committee, the internship program, seminars and guest lectures, open house activities, and financial contributions.

#### **FACULTY**

This primarily includes the faculty in the Department of Civil and Environmental Engineering, secondarily the faculty in the College of Engineering, and finally the University faculty as a whole. It also includes civil engineering professionals hired as off-campus faculty to teach in specific professional practice areas on a temporary basis.

#### **B.2.5 How Curriculum and Processes Ensure Achievement of Objectives**

The Civil Engineering curriculum is 126 credits, divided among 43 courses. The courses can be organized into three groups: Engineering (66 credits), math and Science (33 credits), and General Education (27 credits). The engineering courses can be further organized into Basic Engineering (5 credits), Engineering Sciences (21 credits), and Engineering Methodologies (40 credits). The University of Delaware is on a semester system in which typical lecture classes are three credits, and a full year would be 30 credits.

Table B.2.1 shows how each of the courses in the curriculum maps to the Educational Objectives. In the left column all of the courses are listed and grouped by the type of course, and along the top are the abridged Educational Objectives. For each course, a "●" has been placed in the Objective columns that the course supports. Most of the courses support more than one Objective.

Clearly, the foundation of the curriculum is in math, science, and engineering; therefore, Objective 1 is supported by a majority of the courses. While the Educational Objectives are not weighted in any way, as one being more important than any other, clearly Objective 1

describes the core skill set a graduate must possess in order to practice civil engineering. Thirty-two courses, accounting for 96 credits, support Objective 1.

Objective 2 is supported by 12 required courses and up to 9 electives. Objective 3 is supported by 6 required courses and up to 9 electives. Objective 4 is supported by 20 required courses and up to 3 electives. Objective 5 is supported by 23 required courses and up to 3 electives.

The curriculum ensures achievement of the Educational Objectives with a strong foundation in math and science, which leads to training in the relevant engineering sciences, i.e., solid, fluid, and soil mechanics. With this as a background, students pursue studies in the analysis and design of structural, geotechnical, transportation, and environmental and water resources systems. Communications is taught in dedicated courses and reinforced throughout the four years in engineering courses. The students receive an appreciation for global and societal issues through engineering course work, and the general education credits. Obviously, completion of any one course would not ensure achievement of the Educational Objectives; however, taken in their entirety, the successful completion of all of the courses, we believe, will ensure the achievement of the Educational Objectives.

**Table B.2.1 Relationship Between Curriculum and Engineering Objectives**

Area	Course Number (credits)	Course Title	Civil Engineering Objectives					
			1. Foundation in math, science, etc	2. Communication Skills	3. CE & Global Issues; Ethical responsibility	4. Licensure & Life long learning	5. Employment, Grad. School, Leadership	
Engineering	Basic	CIEG125 (2)	Intro. to CE		•	•		
		CIEG126 (3)	Intro. to Surv/CAD	•	•		•	•
	Science	CIEG211 (3)	Statics	•			•	•
		CIEG212 (3)	Solid Mechanics	•			•	•
		CIEG213 (1)	Solid Mech. Lab.	•	•		•	•
		MSEG 302 (3)	Material Science	•			•	•
		CIEG305 (3)	Fluid Mechanics	•			•	•
		CIEG306 (1)	Fluid Mech. Lab	•	•		•	•
		CIEG311 (3)	Dynamics	•	•		•	•
		CIEG320 (3)	Soil Mechanics	•			•	•
		CIEG323 (1)	Soil Mech. Laboratory	•	•		•	•
		Methodology	CIEG301 (4)	Structural Analysis	•			•
	CIEG302 (4)		Structural Design	•		•	•	•
	CIEG315 (3)		Prob. and Statistics	•			•	•
	CIEG321 (3)		Geotechnical Engineering	•			•	•
	CIEG331 (3)		Env. Engineering	•		•	•	•
	CIEG351 (3)		Trans. Engineering	•	•	•	•	•
	CIEG440 (3)		Water Resources Eng.	•		•	•	•
	CIEG451 (1)		Transportation Laboratory	•	•		•	•
	CIEG461 (4)		Senior Design	•	•	•	•	•
CIEG486 (3)	Const. Mthds & Mgement		•			•	•	
CIEGXXX (9)	3 Technical Electives	•	•	•	•	•		
MATH& Science	MATH241 (4)	Calculus A	•					
	MATH242 (4)	Calculus B	•					
	MATH243 (4)	Calculus C	•					
	MATH351 (3)	Eng. Mathematics I	•					
	MATH353 (3)	Eng. Mathematics III	•					
	CHEM103 (4)	Gen. Chem.	•					
	PHYS207 (4)	Physics I	•					
	CISC105 (3)*	Gen. Comp. Sci.	•					
	S-ELEC (4)	Science Elective	•					
General Education	ENGL110 (3)	Critical Read. & Writing		•			•	
	ENGL410 (3)	Tech. Writing		•			•	
	COMM312 (3)	Oral Comm.		•			•	
	GE-ED (18)	6 Gen. Ed. Electives		•	•			

\* - Eng. Science, \*\* Selections in shaded boxes depend on the electives chosen

### **B.2.6 Process Used to Establish, Review, and Revise Objectives**

Before describing the process used to establish our Educational Objectives, it is worth noting that the department's last ABET review took place during the 1999-2000 academic year. That was the last year in which programs were given the choice of being evaluated under the old ABET criteria or the new EC2000 criteria. The College chose to be evaluated under the old ABET criteria.

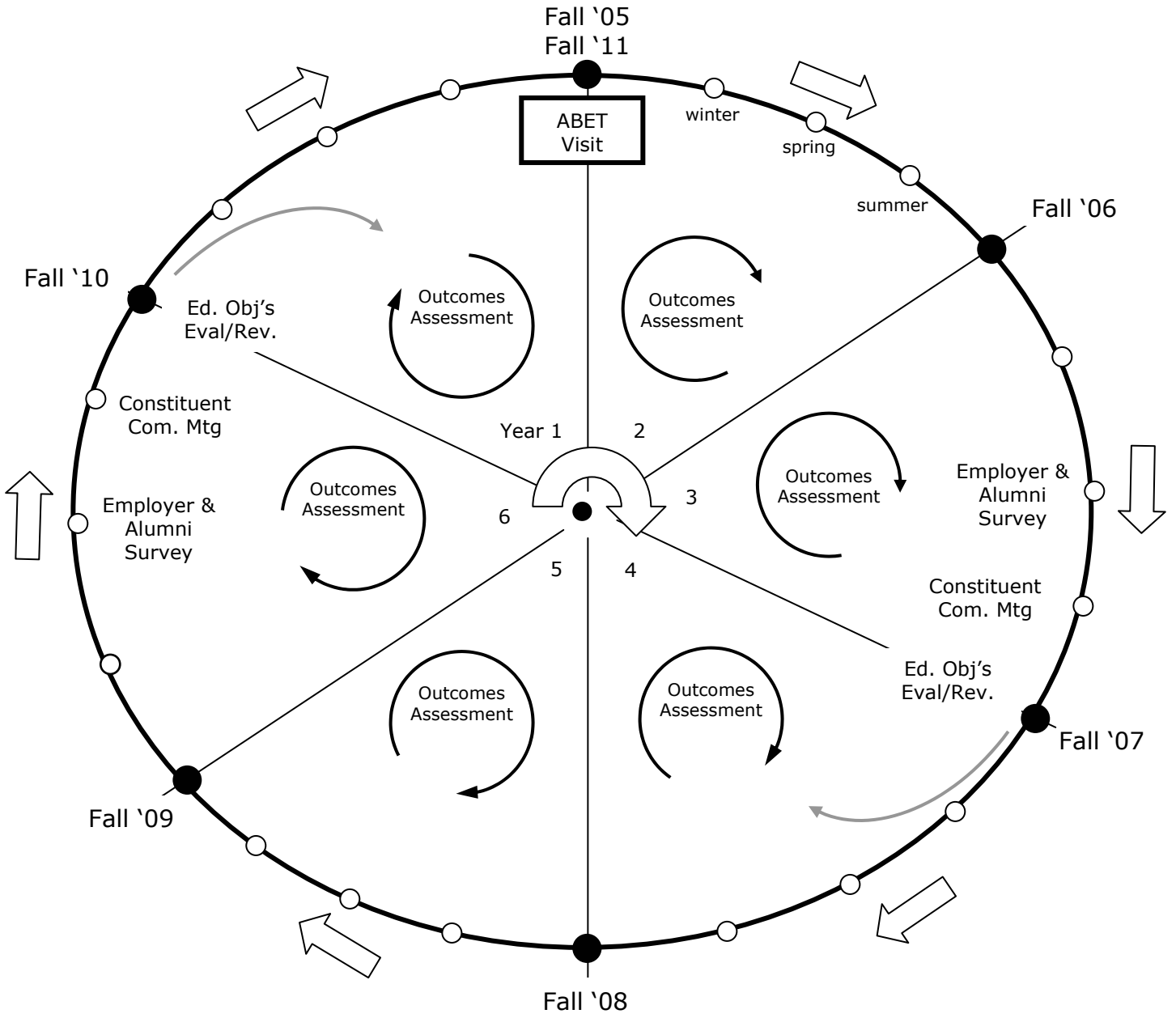
To establish, review, and revise Objectives, two committees have been utilized: (1) the Department ABET Committee, consisting solely of faculty members; and (2) the ABET constituent committee, consisting of practicing engineers and alumni.

#### **ESTABLISHMENT OF OBJECTIVES**

In 2000, the Department ABET Committee included five faculty members: Professors Cheng, Shenton, Cha, Kikuchi, and Bonk (from the English Department). The first task of the committee was to develop draft Educational Objectives. A strawman set of Objectives was drafted when the civil engineering curriculum was revised in the 1999-2000 academic year. The Department ABET committee developed a new set of Objectives, taking into consideration the previous set. The first draft of the Objectives was finished and presented to the entire faculty during a faculty meeting on November 10, 2000. There was considerable discussion about the Objectives at the meeting. Based on comments made during the faculty meeting, and subsequent comments submitted by email by the faculty, the Objectives were revised by the Department ABET Committee. The revised Objectives were submitted to the entire faculty by email on November 22, 2000, with a request for comments and suggested changes. Additional comments were received, changes were made, and the revised Objectives were once again distributed to the faculty for review by

email on December 1, 2000. No additional comments were obtained. The entire faculty voted on and approved the Objectives during a faculty meeting held on December 15, 2000. Documentation of the process can be found in email correspondences and minutes of the faculty meetings.

The original set of Educational Objectives was developed with input from only one constituent group – the faculty. At that time, the department had just completed its last ABET review, under the old ABET criteria. The Department was just beginning to implement the EC2000 criteria. It was working to establish Objectives quickly and at the same time to obtain faculty buy-in to the process. It was felt that this could be best accomplished by involving just the faculty in the development of the first set of Objectives. However, as described in the next section, a process for review and revision of the Objectives has been developed and exercised that relies heavily on our other constituents.



**Figure B.2.1. Educational Objective Evaluation Process**

**REVIEW OF OBJECTIVES**

Figure B.2.1 is a schematic of the process that has been developed and implemented for reviewing, evaluating, and updating the Educational Objectives. The loop represents a six-year cycle and is synchronized to the ABET accreditation cycle; the next six years are used in this illustration. Within the six years, the Educational Objectives go through a thorough evaluation and review every

three years, the last one occurring the year before the next ABET visit. The three-year cycle is short enough that relatively "rapid" changes can be made to the Objectives and curriculum, as needed, to reflect changes in the profession. However, it is not so short that the foundation on which the curriculum is based can change too quickly, relative to the four-year degree time frame.

Input to the Objective review process is obtained from all constituents; however, to date we have relied heavily on employers, alumni, and faculty for this part of the process. A key partner in the Objective review process is the CE ABET Constituent Committee, which consists of twelve practicing engineers. In assembling the committee, the goal was to have primarily representatives from employers in the area that have hired UD CE graduates in the past. As it turns out, many of the members are also alumni of the program; therefore, we have employer and alumni representation on the committee. There is fairly equal representation from the various civil engineering disciplines in which the program claims proficiency: structural, environmental and water resources, transportation, and geotechnical. The committee members are listed in Appendix I.D.3.

a three-year cycle, as outlined on the next page:

The committee's role is to provide input on the constituents' needs, i.e., the skill sets students should have when they graduate from our program. The committee also alerts us to changes occurring in the profession that should be addressed in the Objectives, Outcomes, and curriculum. The committee is also asked to provide feedback on our assessment and evaluation processes. The committee has been referred to as the "Constituent Committee," although a more accurate title would be "Employer/Alumni Constituent Committee." The idea for a Civil Engineering ABET Constituent Committee was formulated in the fall of 2002. The committee met for the first time on June 20, 2003. The second meeting of the committee was held on January 18, 2005. Future in-person meetings will be held at least every three years and perhaps more frequently if the assessment and evaluation processes warrant it. In either case, the department will communicate with and utilize the committee as needed, through email and other distance media.

The review process for Objectives follows

- Spring Year 1: Department ABET committee publishes an annual Outcomes assessment report (see Section B.3 for details of the assessment methods and the report).
- Spring Year 2: Department ABET committee publishes an annual Outcomes assessment report.
- Winter Year 3: Alumni survey is administered.  
Employer survey is administered.
- Spring Year 3: Department ABET committee publishes an annual Outcomes assessment report.  
  
Feedback from the various Educational Objective evaluation methods is collected by the Department ABET Committee and synthesized.
- Summer Year 3: A meeting of the CE ABET Constituent Committee is convened. The assessment and evaluation results are presented to the committee. The Constituent committee provides their feedback on the results, along with input on possible changes to the Objectives and Outcomes.  
  
The Department ABET committee synthesizes the Constituent Committee recommendations. The committee then determines, based on all of the available information, whether changes are needed to the Educational Objectives. If a change is necessary, the Department ABET Committee drafts the changes and presents the new Objectives to the Constituent Committee and the entire faculty.
- Fall Year 3: The faculty discusses the proposed changes in a special or regularly called faculty meeting. If there are no recommended changes, the faculty votes to approve the revised Objectives. If substantive changes are proposed, the Objectives are returned to the Department ABET Committee for further revision. The revised Objectives are then presented to the faculty for their approval.  
  
The revised Objectives are published on the department website and in the University Catalog.

## REVISION OF OBJECTIVES

The first complete review and evaluation cycle of the Educational Objectives was completed in the winter of 2005. The employer survey and alumni survey were administered in the fall of 2004 and winter of 2005. Results of those surveys are discussed in Section B.2.8.

The inaugural meeting of the CE ABET Constituent Committee was held on June 20, 2003. During the meeting, the committee was split into two groups. The groups discussed three topics: body of knowledge (what knowledge and skills should a graduate with a bachelor of civil engineering degree have today to be successful in an entry level position), the CE Educational Objectives, and the CE Outcomes. After the discussion time, the groups were asked to report their results. Each objective was discussed. The detailed results of the meeting can be found in the minutes of the meeting. At that time the department was focusing primarily on the Outcomes assessment process; therefore, no immediate action was taken on the input received from the committee regarding Educational Objectives.

The second meeting of the CE ABET Constituent Committee was held on January 18, 2005. Two key questions were posed: (1) "Are we achieving our Objectives?" and (2) "Do our Objectives need to be revised?" The committee was first presented the results of the employer survey and asked to discuss, among themselves in two small groups, the results and to provide us with their feedback on the survey results. Committee members provided a number of constructive comments about the survey, which will be incorporated into the next employer survey. The committee also had concerns about the relatively small sample size (13 respondents at the time of the meeting). On their suggestion, the committee provided the names and contacts of dozens of other employers in

the region that they believed would have UD CE graduates on their staff. Using this new list of employer contacts, a second set of employer surveys was sent out within a few weeks of the Constituent Committee meeting. Overall, however, the committee felt that the results were very positive and suggested that our graduates are achieving the stated Objectives.

Considerable time was spent reviewing each of the original Objectives and, in light of the employer survey results and the constituents' needs, determining whether and how the Objectives need to be revised. The discussions from this meeting are available in the meeting minutes. Key comments, as they pertain to the Objectives are summarized below:

1. The committee felt that the concept of teamwork should be explicitly stated in the Objectives.
2. The committee felt that graphical or visual communication skills should be included in the Objectives; some also recommended "interpersonal" skills.
3. The committee felt that original Objective 3 was somewhat confusing. They felt there were two competing and somewhat unrelated statements in the Objective. They recommended splitting that objective into two.
4. Some felt there should be an Objective that focuses on the practical aspects of engineering. Objective 1 addresses the technical and analytical skills, but there should be one that brings in the practical issues. This would include things like constructability, life-cycle economics, engineering judgment, etc.

Based on the feedback obtained from the constituent committee and the employer survey results, the Department ABET Committee revised the Educational Objectives. The revised Objectives were presented to the CE faculty on February 4, 2005, and were discussed at length at the general faculty meeting held on

February 11, 2005. The faculty provided feedback. Final revisions to the Objectives were made and the Objectives were presented to the faculty for their approval. The revised Educational Objectives, approved by the faculty in April 2005, are the following:

1. Graduates will be prepared with a solid foundation in mathematics, sciences, and technical skills needed to analyze and design civil infrastructure systems.
2. Graduates will possess strong written, oral, and graphical communication skills, and will be able to function on multi-disciplinary teams.
3. Graduates will be familiar with current and emerging socioeconomic issues and the global context in which civil engineering is practiced.
4. Graduates will have an understanding of professional ethics and their societal responsibilities as a practicing engineer.
5. Graduates will have the ability to obtain professional licensure, will recognize the need for engaging in life-long learning, and will have the ability to assume leadership roles in and outside of the profession.
6. Graduates will have the necessary qualifications for employment in civil engineering and related professions and for entry into advanced studies.

These Objectives will become effective at the start of the 2005-2006 academic year (September 2005). To minimize any confusion, the existing Objectives will be maintained on the department website until September 2005. At that time, the revised Objectives will be posted; the old ones will still be accessible on the web as well. The revised Objectives will be published in the 2005-06 University Catalog, which is currently in print (and will be issued for the 2005-06 academic year).

## **B.2.8 Ongoing Evaluation of Level of Achievement of Objectives**

### **PROCESS**

In concert with the process to review the Educational Objectives, a process for evaluating the level of achievement of the Objectives has also been implemented. The process involves input from employers, alumni, and graduating seniors and follows the same three-year cycle. Three evaluation tools are used to gauge the level of achievement—an employer survey, an alumni survey, and a senior exit survey.

The first, the employer survey (Appendix I.D.4), is a brief questionnaire that we send to employers of UD CE graduates and ask for their evaluation of our graduates' abilities. The survey is concise and derived from the Educational Objectives. It was administered for the first time in December 2004 and was based on the Objectives in place at the time of the survey. The survey was created by expressing each objective as a statement of the graduate's abilities (two of the Objectives were separated in the survey to yield seven Objective related questions). The respondents were then asked to select, from a five-level scale, whether they agreed or disagreed with the statement. The survey was distributed by email to 42 employers in the mid-Atlantic region.

The second, the alumni survey, is presented in Appendix I.D.5. Similar to the employer survey, the questions are derived directly from the original Objectives. The alumni were asked how important a particular skill or ability is to their job or graduate school, and how well their engineering education prepared them in this skill or ability. A seven-level response scale was used, instead of the five-level scale used in the employer survey. A few other questions were asked relating to professional development and lifelong learning. The survey was administered in February of 2005. A

request to complete the survey was sent out to 159 of the 162 UD CE alumni who graduated between 2000 and 2004 (no contact information of any type was available for 3 of the graduates).

The third, the senior exit survey (Appendix I.D.6), was conducted for the first time in 2005, during the last week of the spring semester. The survey was suggested by the ABET Constituent Committee at the January 2005 meeting, as a way to gather information from graduating seniors about their employment opportunities or plans for graduate school, and as a means to gather up to date contact information on the graduates. The survey was conducted online; the request to complete the survey was sent out by email to all graduating seniors.

The employer and alumni surveys are administered in the third year of the Objective review cycle. The senior exit survey will be administered every year. Once the survey results are collected, they are synthesized by the Department ABET Committee. The committee reviews the results and also presents them to the CE ABET Constituent Committee for their review and comment. After that, the Department ABET Committee determines whether any changes to the program are needed as a result of the Objectives evaluation. Course changes are directed to the faculty members who teach the courses. Curricular changes are presented to the entire faculty for their approval, then sent to College Educational Activities Committee, and finally forwarded to the University Senate for their approval.

Another alumni survey is being administered by Education Benchmarking, Inc. (EBI) for the College of Engineering. The results of this survey can be used for evaluation of Objectives and assessment of Outcomes. The College has arranged for this survey to be administered every third year (2001 and 2004). It was developed to be used by any engineering program; therefore, the questions are

based on the ABET criteria but are otherwise generic. The 2004 questionnaire is shown in Appendix I.D.7.

The EBI alumni survey has been used effectively as an Outcomes assessment tool by the department, as reported in Section B.3 of the report. However, after a careful review of the alumni results from 2001 and 2004, the Department ABET Committee felt that the alumni survey left much to be desired as an Objectives evaluation tool. First, the sample sizes were relatively small for both surveys: 42 responses in 2001 and 22 responses in 2004. More importantly, as mentioned previously, the EBI questions are "generic" and do not ask questions specific to program Objectives. For that reason, the decision was made to develop and conduct the previously mentioned CE alumni survey.

## **RESULTS**

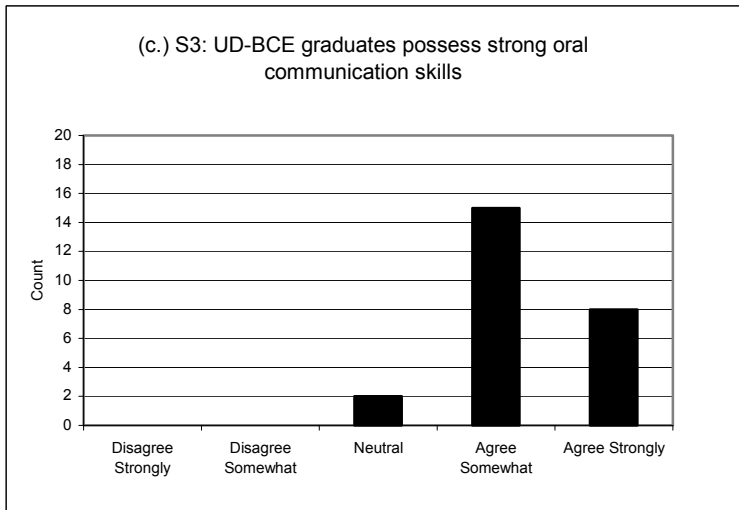
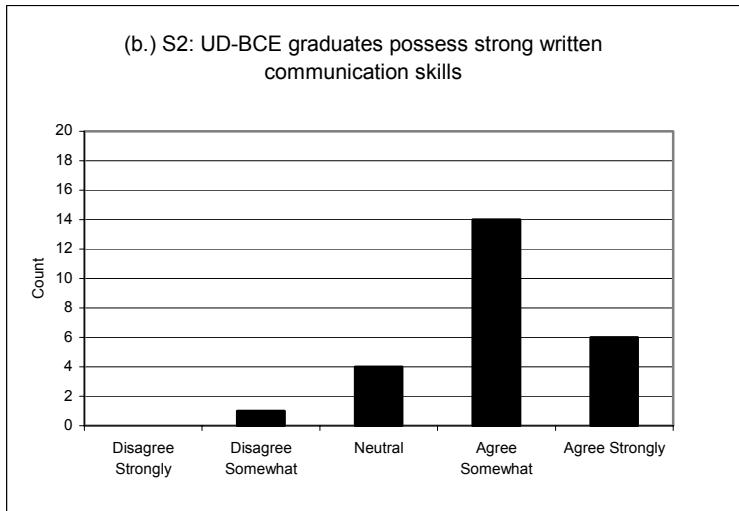
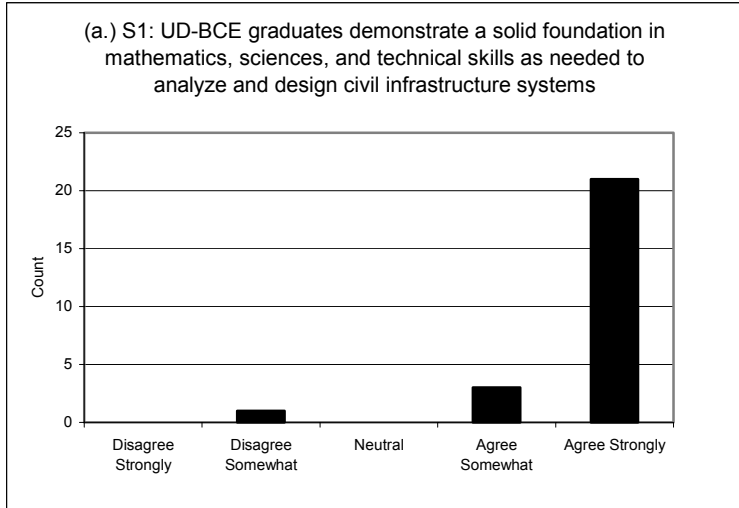
The first complete loop of the Objective evaluation process was completed in the spring of 2005. The results of the employer and alumni surveys are presented below.

Surveys were sent out to 42 employers; 25 completed surveys were returned. The respondents were also asked to list how many graduates they were basing their responses on: the total number for the 25 employers was 188, the average was 7.5.

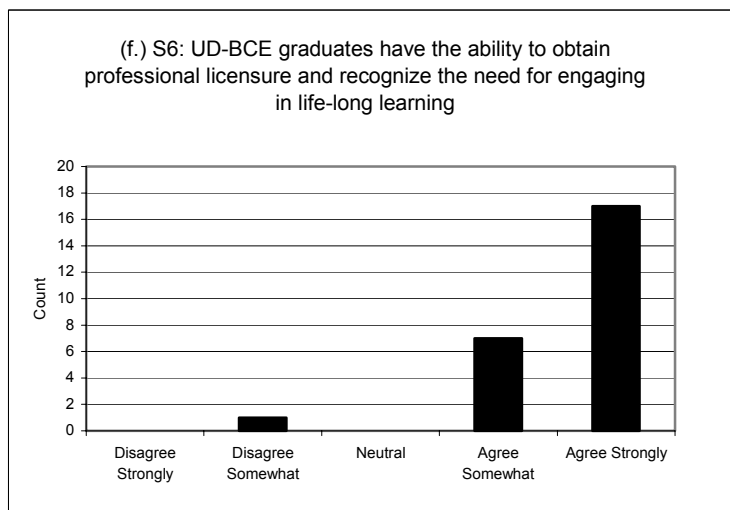
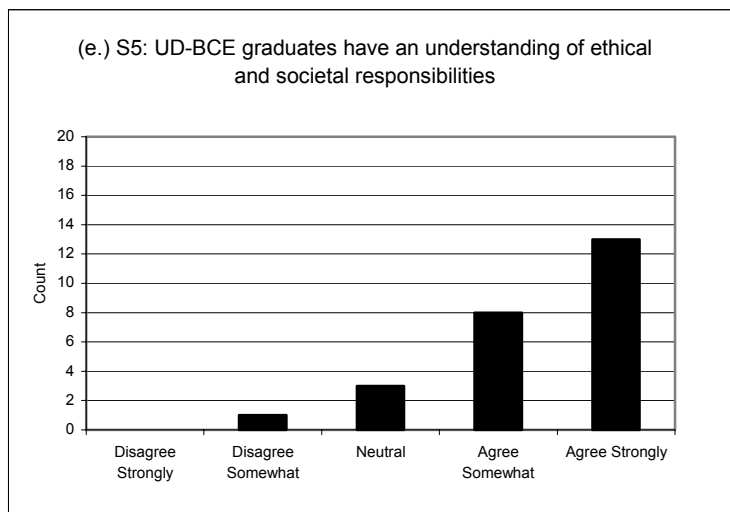
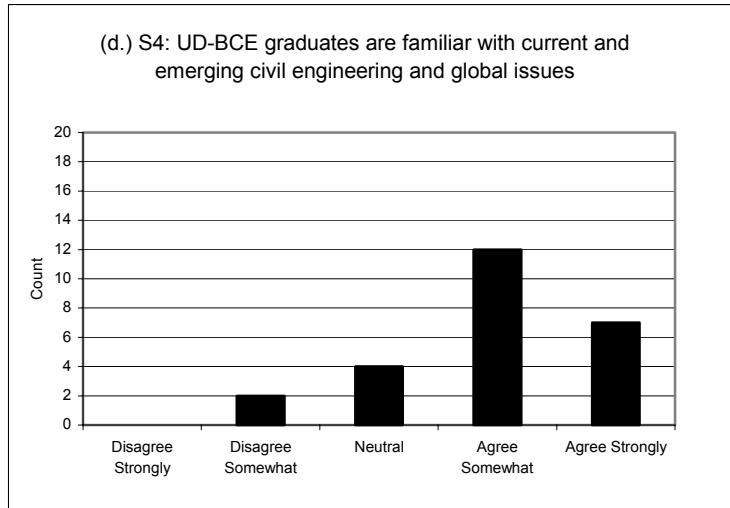
The employer survey results are shown in histograms in Figure B.2.2. Along the X-axis are the response options: from the left – "Disagree strongly," "Disagree somewhat," "Neutral," "Agree somewhat" and "Agree strongly." The Y-axis is count, or the number of responses. The survey statement is shown at the top of the graph. Figure B.2.2.(h) is a column plot of the number of graduates on which each respondent was basing their answers.

Overall, the results were very positive. Employers felt that our graduates were very strong technically, as evidenced by

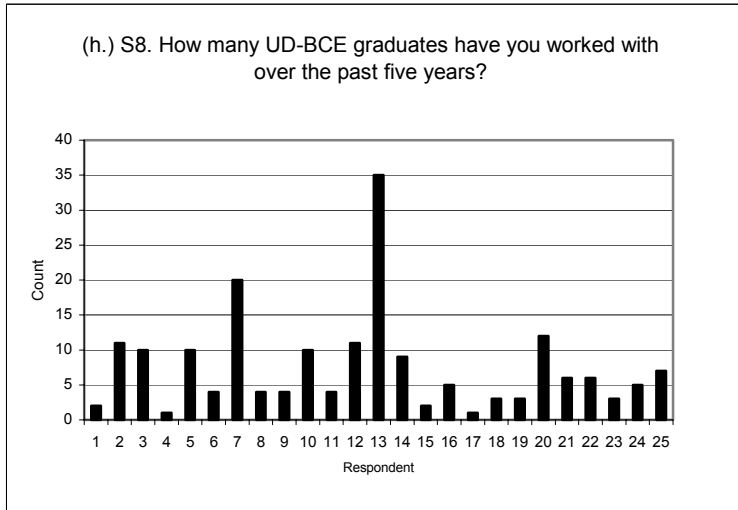
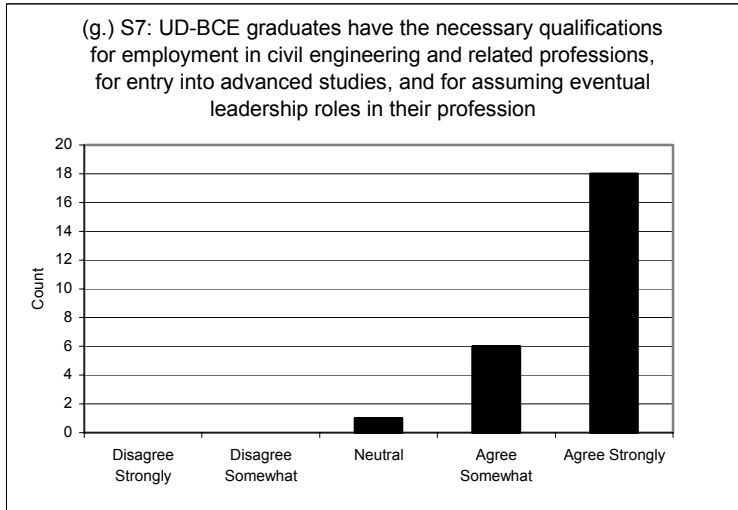
the nearly unanimous response of "Strongly Agree" to statement 1. A majority of respondents also strongly agreed with statements 5, 6 and 7. These pertain to our graduates' understanding of ethical and societal responsibilities, their ability to obtain professional licensure and recognition of the need for engaging in lifelong learning, and their qualifications for employment and advanced studies and their ability to assume leadership roles. While the responses were still positive, a majority of the respondents agreed somewhat with the statement that our graduates possess strong written and oral communication skills and are familiar with current and emerging civil engineering and global issues (statements 2, 3, and 4). In all three of these cases, the great majority of the respondents agreed strongly or agreed somewhat with the statement. Thus, while we believe that the results are very positive and in general show that our graduates have achieved the stated Objectives, they also show that there is room for improvement in some areas.



**Figure B.2.2 Employer Survey Results**



**Figure B.2.2 Employer Survey Results (Cont'd)**



**Figure B.2.2 Employer Survey Results (Cont'd)**

Requests to complete the online alumni survey were sent out to 159 civil engineering students who graduated between 2000 and 2004. About half of the requests were sent via email and half by regular mail. Forty-six responses were obtained, for a return rate of 29%.

The alumni survey results are shown in histograms in Figure B.2.3. Along the X-axis are the response options: for the alumni survey, a seven-level scale was used, with the lowest level (1) being "Not at All," the mid-level (4) being "Moderate," and the highest level (7) being "Extremely." The Y-axis is count, or the number of responses. The survey questions are shown at the top of the graph. The results for the paired questions, i.e., how important was a particular skill and how well did your education prepare you in that skill, are plotted on the same graph.

Overall, the alumni survey results were very positive and in many ways mirrored the employer survey results. The majority score on every preparedness question was 6 out of a possible 7, indicating that in general the alumni believe that their education achieved these Objectives. The responses also show that the alumni place great emphasis and importance on strong written and oral communication skills. While there was still a very positive response for the preparedness in written and oral communication skills, there is room for improvement in this area.

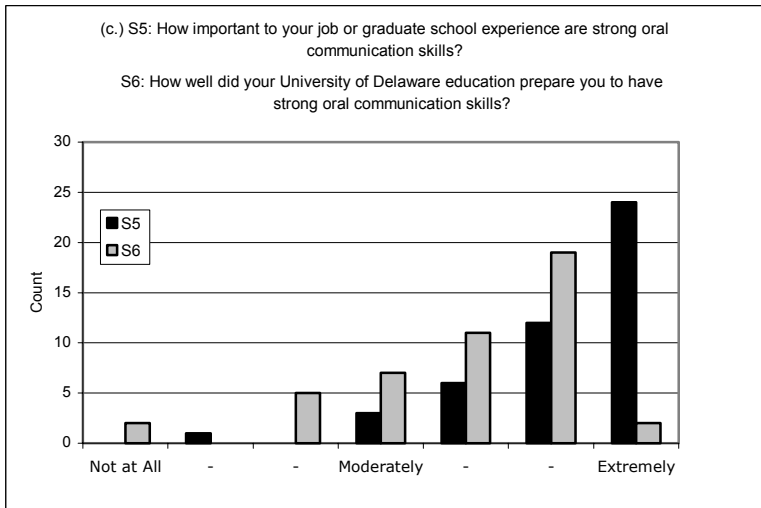
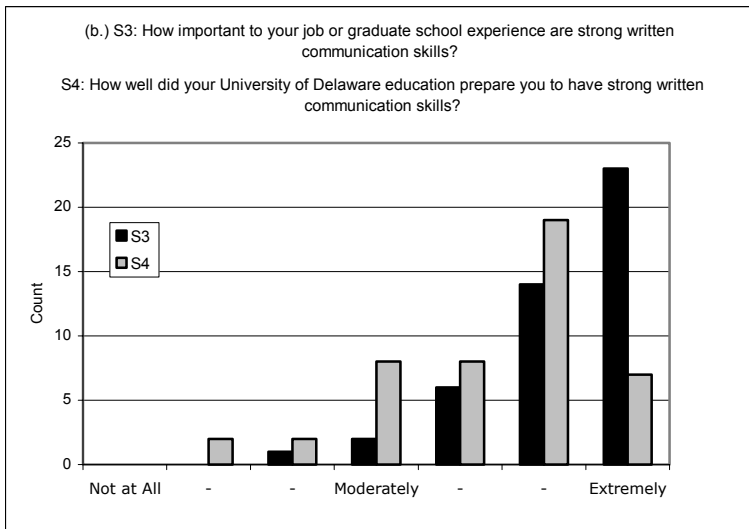
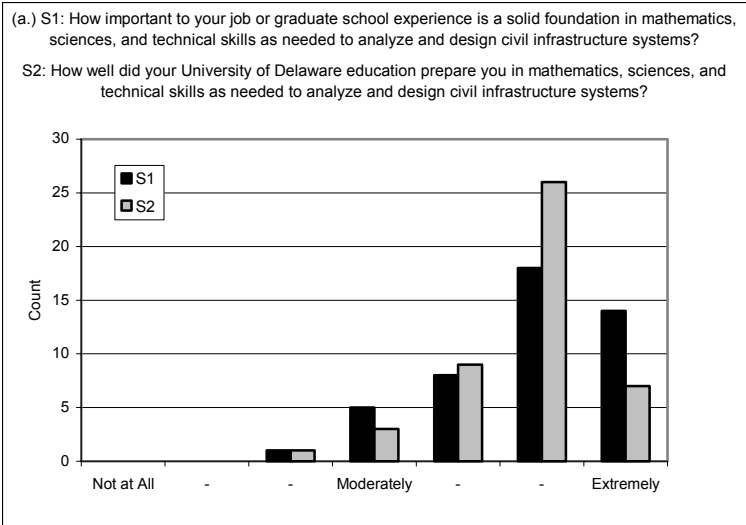
The results shown in Figure B.2.3.(h) pertain to Objective 4. Ninety-three percent of the alumni who responded have taken and passed the Fundamentals of Engineering (FE) Exam. Also, 78% of the respondents have done something to continue their education, e.g., taken a graduate course or short course, attended a conference, or attended a workshop related to their profession. These results strongly support the successful achievement of Objective 4.

It is also important to note that overall,

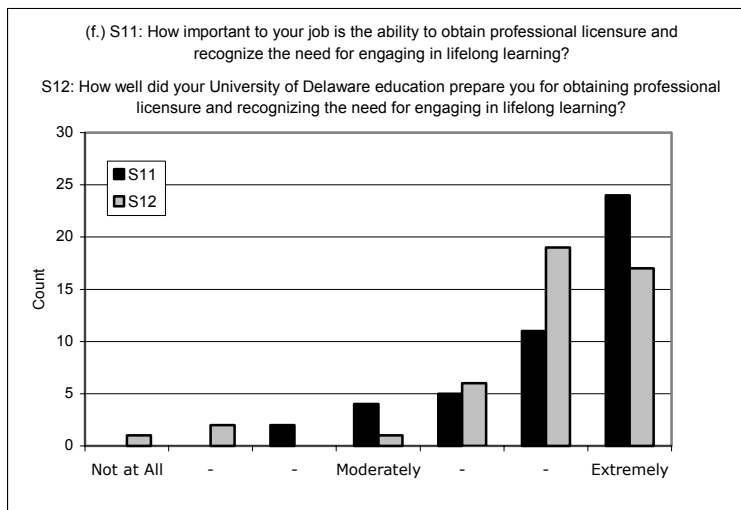
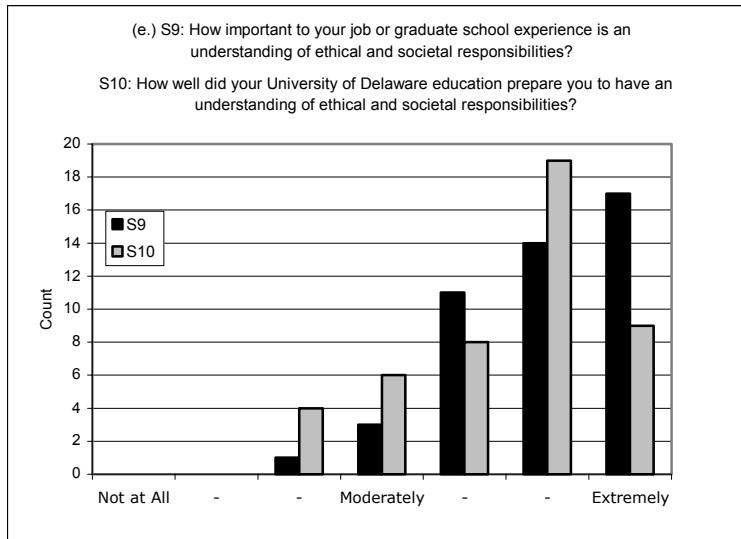
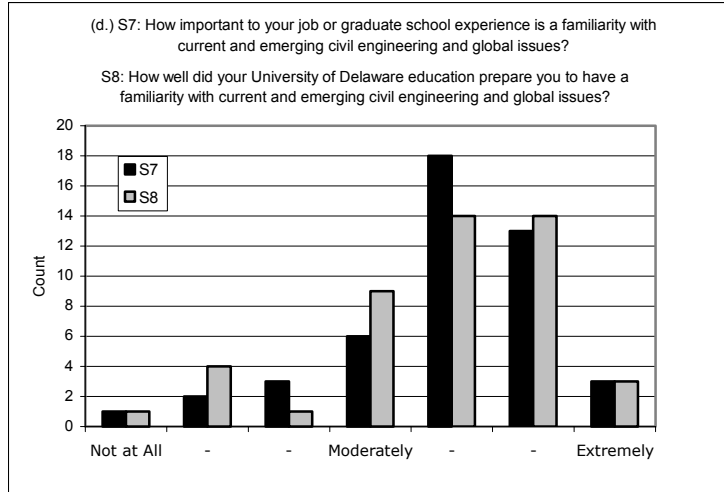
the alumni placed a high level of importance on all of the Objective statements. This provides confidence that our Educational Objectives are well focused and in line with the needs of our constituents.

Figure B.2.3.(i) is a column plot showing the distribution of graduates from each class who responded to the survey and the number of graduates from each class.

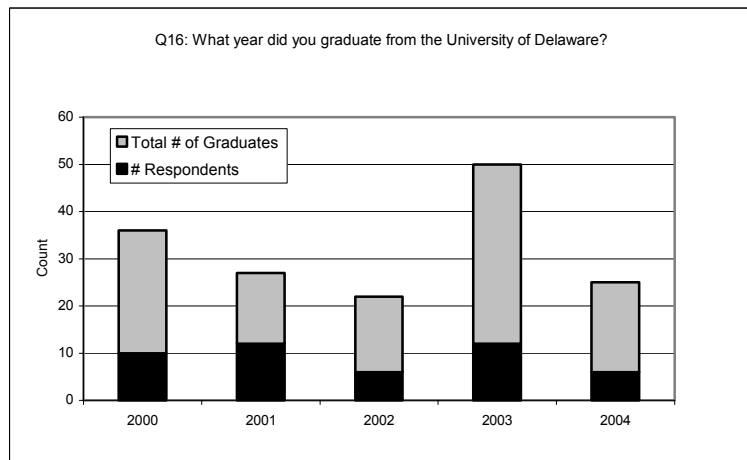
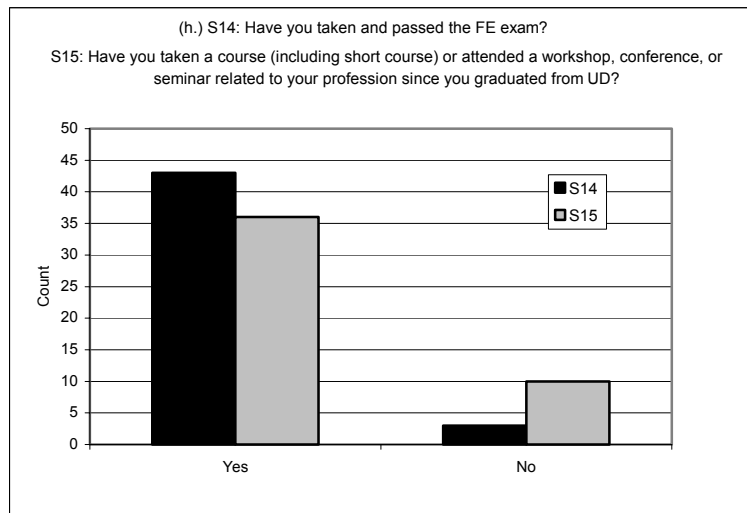
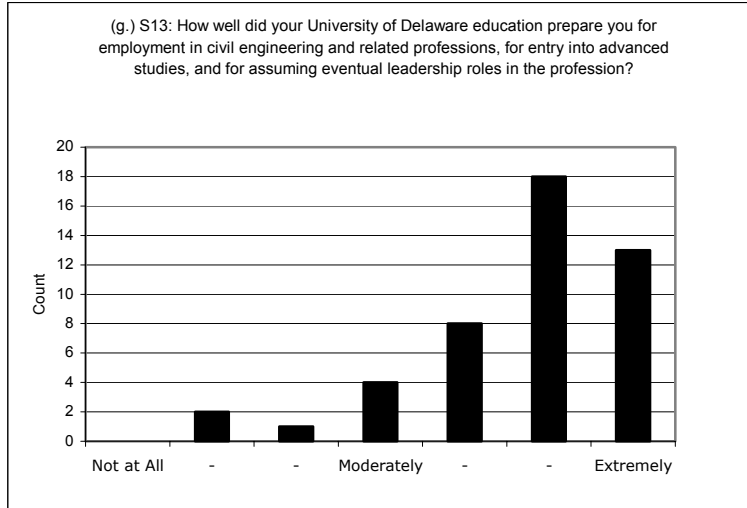
Of the 47 CE students to graduate in 2005, 22 responded to the senior exit survey. Of those who responded, 19 (86%) had interviewed for full-time engineering or engineering related positions, and all 19 had been offered full-time engineering or related positions. At the time of the survey, of those who were offered positions, eight had accepted full-time positions. The average starting salary of those who accepted offers was \$47,000 a year, with the high being \$60,000 a year and the low, \$41,000. Of those who responded, five (23%) applied to graduate school; all five were accepted with funding and intend to enroll. While this is only one year of data, the results are very encouraging. Combined with data from University Career Services Center, these results show that Objective 5 is being met.



**Figure B.2.3. Alumni Survey Results**



**Figure B.2.3. Alumni Survey Results (Cont'd)**



**Figure B.2.3. Alumni Survey Results (Cont'd)**

### **B.2.9 Revisions to Objective Evaluation Process**

Overall, the department is satisfied with the Education Objectives evaluation process. All three surveys provided very valuable feedback. Some specific changes to be implemented in the future include the following:

1. The employer survey will be modified to a seven-level response scale, similar to the UD CE alumni survey and the EBI survey. This will allow for finer gradation of the results. The response options will also be reworded to provide clearer results. In addition, the survey will be structured more like the alumni survey, in which employers are also asked to rate the importance of a particular skill.
2. The Department ABET committee will explore other Objectives evaluation tools. Examples might include Professional Engineer exam results and hiring statistics (which can be obtained from employers and the University Career Services Center).
3. Following a recommendation of the Constituent Committee, the department will make a more concerted effort to keep track of alumni when they graduate, so that in future assessment and evaluation cycles we can continue to obtain the information needed for the process and, we hope, increase the response rate. The first step toward meeting this goal was taken with the initiation of the senior exit survey.

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

This section is organized as follows. The Program Outcomes are first presented, along with a discussion of how the Outcomes relate to the curriculum and the requirements of this criterion. This is followed by a discussion of how the Outcomes were developed. Next, we describe the assessment process, which includes the assessment tools, the schedule, and the metric goals. The process by which the results are applied to further develop and improve the program is then presented. Next, the results of our assessment and changes that have been implemented are presented. Finally, materials available for review during the visit are described.

#### **B.3.1 Program Outcomes**

The following are the twelve Program Outcomes for the Bachelor of Civil Engineering degree:

Graduates of the program must have

1. the ability to apply knowledge of mathematics, science, and engineering;
2. the ability to identify, formulate, and solve engineering problems in the following major civil engineering disciplines: structural, environmental and water resources, transportation, and geotechnical engineering;
3. the ability to design and conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering disciplines;
4. the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;
5. the ability to design a system, component, or processes to meet the desired needs within realistic constraints such as economic, environmental, social, political, health and safety, manufacturability, and

- sustainability;
6. the ability to perform civil engineering design by means of problem-based experiences integrated throughout the curriculum;
7. knowledge of professional practice issues, such as procurement of work, bidding versus quality-based selection processes, and the interactions of design and construction professionals in executing a project;
8. an understanding of professional and ethical responsibility;
9. broad education and knowledge of contemporary issues necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
10. recognition of the importance of professional licensure, and the need for and ability to engage in lifelong learning;
11. the ability to function on multidisciplinary teams; and
12. the ability to communicate effectively.

Table B3.1 shows the relationship between each of the twelve CE Outcomes and the program Educational Objectives (presented previously in Section B.2.3). In all cases, the Educational Objectives are achieved through several Outcomes. Objective 1 is achieved through six Outcomes; Objectives 2 and 3 are achieved through three Outcomes; and Objectives 4 and 5 are achieved through nine and twelve Outcomes, respectively.

Table B3.2 shows the relationship between the ABET Criterion 3 “(a) through (k)” skills and the UD Civil Engineering Outcomes, and the ABET Criterion 8 - Program Criteria (ASCE Civil Engineering Program Criteria) and the UD Civil Engineering Outcomes. All of the Criterion 3 Outcomes [(a) through (k)] as well as the ASCE specific program Outcomes are encompassed within the CE Outcomes. Outcome 6, which describes a student’s ability to perform civil engineering design through problem-based learning design experiences, is unique to the program. The faculty chose to include this Outcome because of a strong belief that problem-based experiences are important and reflect the way that engineering is practiced in the real world. The University of Delaware has been at the forefront in developing and implementing problem-based learning in science, math, and engineering, through

its Institute for Transforming Undergraduate Education (ITUE) (information about the Institute can be found at <http://www.udel.edu/inst/>).

Finally, presented in Table B3.3 is the relationship between the UD CE Outcomes and the curriculum.

Through Tables B2.1, B3.1, and B3.3, the various links among the Objectives, the Outcomes, and the CE curriculum are established.

**Table B3.1 Matrix Showing Relationship Between Program Educational Objectives and Program Outcomes**

Educational Objectives	Civil Engineering Outcomes											
	1. Math & Science	2. Formulate & Solve	3. Experiments	4. Modern Tools	5. Design	6. Prob. Based Exp.	7. Prof. Practice	8. Ethics & Resp	9. Contemp Issues	10. Lic & LLL	11. Teams	12. Communication
1. Foundation in math, science, etc.	●	●	●	●	●	●						
2. Communication skills			●								●	●
3. CE & Global Issues; Ethical responsibility							●	●	●			
4. Licensure & Lifelong learning		●	●	●	●	●	●	●	●	●		
5. Employment, Grad. School, Leadership	●	●	●	●	●	●	●	●	●	●	●	●

**Table B3.2 Relationship Between ABET “(a) through (k)” Criteria and ASCE Program Criteria and UD CE Outcomes**

		UD Civil Engineering Outcomes											
		1. Math & Science	2. Form & Solve	3. Experiments	4. Modern Tools	5. Design	6. Prob. Based Exp.	7. Prof. Prac	8. Ethics & Resp	9. Contemp Issues	10. Lic&LLL	11. Teams	12. Communication
ABET (a)-(k)	a.	●											
	b.			●									
	c.					●							
	d.											●	
	e.		●										
	f.								●				
	g.												●
	h.									●			
	i.										●		
	j.									●			
	k.				●								
ASCE Program Criteria			●	●				●					
Other							●						

**Table B.3.3 Relationship Between Outcomes and Civil Engineering Curriculum**

Area	Course Number	Course Title	Civil Engineering Outcomes												
			1. Math & Science	2. Form & Solve	3. Experiments	4. Tools	5. Design	6. Prob. Based Exp.	7. Prof. Prac	8. Ethics & Resp	9. Contemp Issues	10. Lic&LLL	11. Teams	12. Comm	
Engineering	CIEG125	Intro. to CE	●	●	●	●		●	●	●	●	●	●	●	●
	CIEG126	Intro. to Surv/CAD	●	●		●						●	●		
	CIEG211	Statics	●	●		●									
	CIEG212	Solid Mechanics	●	●		●	●	●							
	CIEG213	Solid Mech. Lab.			●								●	●	
	MSEG 302	Material Science	●	●											
	CIEG301	Structural Analysis	●	●		●	●								
	CIEG 302	Structural Design	●	●			●			●					
	CIEG305	Fluid Mechanics	●	●											
	CIEG306	Fluid Mech. Lab			●								●	●	
	CIEG311	Dynamics	●	●		●							●	●	
	CIEG315	Prob. and Statistics	●	●	●	●	●	●							
	CIEG320	Soil Mechanics	●	●	●	●	●	●							
	CIEG321	Geotechnical Eng.	●	●	●	●	●	●					●		
	CIEG323	Soil Mech. Lab	●		●	●							●	●	
	CIEG331	Env. Engineering	●	●			●	●			●	●	●		
	CIEG351	Trans. Engineering	●	●	●	●	●	●	●	●	●	●			●
	CIEG440	Water Resources Eng.	●	●		●	●	●				●	●		
	CIEG451**	Trans. Laboratory	●	●	●	●								●	●
	CIEG461	Senior Design	●	●		●	●	●	●	●	●	●	●	●	●
CIEG486	Const. Management	●	●		●				●	●	●				
CIEGXXX	3 Technical Electives	●	●	●	●	●	●	●	●	●	●	●	●	●	
MATH& Science	MATH241	Calculus A	●			●									
	MATH242	Calculus B	●			●									
	MATH243	Calculus C	●			●									
	MATH351	Eng. Mathematics I	●			●									
	MATH353	Eng. Mathematics III	●			●									
	CHEM103	Gen. Chem.	●		●									●	
	PHYS207	Physics I	●		●									●	
	CISC106	Gen. Comp. Sci.	●			●									
	S-ELEC	Science Elective	●		●									●	
General Education	ENGL110	Crit. Read. & Writing													●
	ENGL410	Tech. Writing													●
	COMM312	Oral Comm.													●
	GE-ED	6 Gen. Ed. Electives*									●	●	●		●

\* - selections in shaded boxes depend on the elective chosen

\*\* - starts fall 2005

### **B.3.2 Process for Producing Outcomes**

The Department ABET committee, previously described in Section B.2, began the process of drafting Outcomes in the 2000-2001 academic year. This was the second major task for the committee, after developing the Educational Objectives. The committee met regularly throughout the year. The process of drafting the Outcomes began in March 2001. The ABET committee drafted the Outcomes, making sure that they embodied the ABET (a)-(k) and ASCE program outcomes. The draft Outcomes were completed in April of 2001 and presented to the entire faculty for their review and comment. After some discussion and minor changes, the Outcomes were approved by the entire faculty in May of 2001.

### **B.3.3 Assessment Process**

This section outlines the assessment process implemented by the Department of Civil and Environmental Engineering for the Civil Engineering degree. Presented below are the assessment tools, the assessment schedule, and the metrics by which results are assessed.

#### **ASSESSMENT TOOLS**

The Department ABET committee discussed numerous assessment tools and ultimately decided on six: (1) the Educational Benchmarking, Inc (EBI) senior survey, (2) the EBI alumni survey, (3) Student Focus Groups, (4) student sample work, (5) the Fundamentals of Engineering (FE) exam results, and (6) Faculty Course Self Assessment (FCSA) forms. Not all of the tools were implemented at the same time. All of the assessment tools are used annually, except the EBI Alumni Survey, which is conducted every third year. Each of the tools is described in more detail below.

- *EBI senior survey* – is an online survey administered by EBI. The College of Engineering contracts with

EBI to conduct the survey for all departments in the College. The College first used the EBI survey in 2002 and has used it every year since. All graduating seniors, including those graduating mid-year, are asked to complete the survey, which consists of more than 70 questions. There are questions directly relevant to the Outcomes assessment process, i.e., that address ABET Outcomes (a) through (k), and others that are not relevant to the ABET process. All of the questions provide useful feedback to the department on the program; however, only those questions that pertain to ABET are used in the Outcomes assessment process. Students are notified by email and asked to take the survey; several reminder emails are sent to the students if they have not completed the survey. Most survey questions are based on a seven-point scale, 1 being the low score and 7 being the high. Average and standard deviations are reported for each question. For comparison, the mean and standard deviation of each question from all institutions that participated in the survey are provided. Results are also provided for the College's "Select Six" schools. The "Select Six" are six schools, of the College's choosing, that participated in the survey, against which your scores are compared. For the past three years the college has chosen the University of Connecticut, Syracuse University, Northeastern University, Bucknell University, the University of Virginia, and Villanova University as the Select Six. Note that these are all excellent universities located on the east coast that have strong undergraduate engineering programs, place a high standard on undergraduate education and four of the six are major research institutions, comparable to the University of Delaware. The EBI Senior Survey can be found in Appendix I.D.8. Finally, as mentioned earlier in Section B.2., because the EBI survey

is available to any engineering program that wishes to use it, the questions are generic and are not tailored to a specific program and Outcomes. The survey can be supplemented with "Institution" specific questions; however, in the past the College of Engineering has added only a few general questions that are of limited use in the assessment process.

- *EBI alumni survey* – described previously in Section B.2.8, this is also a survey of selected alumni conducted by EBI. The College of Engineering has chosen to contract for the alumni survey once every three years. The target alumni are those that have graduated one to three years prior. The survey consists of 51 questions, and as with the senior survey a number of questions are directly related to ABET criteria (a)-(k), while others are not relevant to ABET. Again the answers are typically on a one-to-seven scale, with averages and standard deviations reported. The survey was conducted in the winter of 2004 for alumni that graduated in 2002 and 2003. The survey was also conducted in 2001 for alumni that had graduated the three previous years. While the data from this earlier survey is available for review, the department has not used it specifically in the Outcomes assessment process, primarily because the Program Outcomes were just being developed when the survey was conducted and also because the number of respondents was low (42).
- *Student focus groups* – three Student Focus Groups are organized each year in late spring. There is a freshman group, a sophomore and junior group, and a senior group. Groups range in size from four to ten. The groups meet for approximately one hour and are asked a variety of questions. A sample of the questions is shown in Appendix I.D.9. Students are encouraged to answer the questions and to discuss

the questions and answers. The sessions are moderated by a graduate student. Sessions are recorded and later transcribed. The first Student Focus Groups were convened in the spring of 2002 (the 2001–2002 academic year).

- *Sample student work* – samples of student work are collected by faculty and are used to assess students' abilities in specific Outcomes. The sample work may include a homework assignment, an exam problem, a project report, a laboratory report, or an oral presentation, to name the more common types. Before the semester starts, faculty are assigned Outcomes for collecting student sample work based on those that it supports, as defined in Table B3.3. For example, one faculty member may be assigned Outcomes 1 and 2 for one class, while another may be assigned Outcomes 4 and 12 for another: faculty are not required to collect samples of student work for every Outcome that their course supports. The assignments are distributed among the various courses so that a few samples of student work for each outcome are collected and assessed each semester. Presented in Table B3.4 is the general schedule and assignment list that shows what samples were assigned to what courses. In the table, "F" denotes collection in the fall semester, and "S" denotes collection in the spring semester.

**Table B.3.4 General Schedule for Collecting Student Sample Work (F-fall semester, S-spring semester)**

Course Number	Course Title	Civil Engineering Outcomes											
		1. MATH& Science	2. Form & Solve	3. Experiments	4. Tools	5. Design	6. Prob. Based Exp.	7. Prof. Prac	8. Ethics & Resp	9. Contemp Issues	10. Lic&LLL	11. Teams	12. Comm
CIEG125	Intro. to CE				F			F	F		F	F	F
CIEG126	Intro. to Surv/CAD	S	S	S	S							S	
CIEG211	Statics	F											
CIEG212	Solid Mechanics	S	S			S							
CIEG213	Solid Mech. Lab.			S									
MSEG 302	Material Science												
CIEG301	Structural Analysis	F	F		F								
CIEG 302	Structural Design	S	S			S			S				
CIEG305	Fluid Mechanics	F	F										
CIEG306	Fluid Mech. Lab			S								S	S
CIEG311	Dynamics	S	S		S					S		S	S
CIEG315	Prob. and Statistics	S	S	S									
CIEG320	Soil Mechanics	F	F				F						
CIEG321	Geotech. Engineering	S	S			S	S						
CIEG323	Soil Mech. Laboratory			F								F	F
CIEG331	Env. Engineering	S	S										
CIEG351	Trans. Engineering					S			S	S			
CIEG440	Water Resources Eng.	F	F			F							
CIEG451*	Trans. Laboratory												
CIEG461	Senior Design				F	F	F	F	F	F	F	F	F
Total		12	11	5	5	6	3	2	4	3	2	6	5

\* - starts fall 2005

For each piece of student sample work, the faculty member is asked to assess the work based on a rubric that was developed for each Outcome. The rubrics define levels of learning on a five-point scale. The rubrics and complete assignment history are available online at [http://ce.udel.edu/ABET/Current%20Documentation/ABET\\_scoring\\_rubrics\\_index.html](http://ce.udel.edu/ABET/Current%20Documentation/ABET_scoring_rubrics_index.html). The average and standard deviation of the set are calculated and reported on a summary sheet. At the end of the semester, faculty submit the summary sheet and a few samples of the student

work for each Outcome they were assigned. The materials are then placed in the appropriate Outcomes binder, which is maintained in the CEE main office. Student sample work was first collected in the 2003-2004 academic year.

- *FE exam results* - in Delaware, the Fundamentals of Engineering (FE) exam is administered by the Delaware Association of Professional Engineers (DAPE). It is offered twice a year and is the first step toward becoming a registered professional engineer. A majority of our seniors take the exam.

All students take the general morning section. In the afternoon, some students take the general section again, and some take the civil engineering specific section. We receive data on how our students do on the exam, broken down by morning and afternoon scores and by subject area. State and national averages are also reported. The overall pass/fail rate for the FE exam can be used as an assessment tool, along with the scores from the subject-specific questions. The FE exam results were first used as an assessment tool at the end of the 2002–2003 academic year.

- *Faculty Course Self Assessment (FCSA) form* - faculty teaching undergraduate courses are required to complete a FCSA form at the end of each semester. Included on the form are entries for the faculty target level of learning for each outcome, the students' assessment of their level of learning (this comes from online course evaluation questionnaires that the students complete at the end of the semester), the faculty assessment of the class's level of learning, general notes about the course, a summary of the assessment results, and suggested changes to be made in the course. FCSA forms were first implemented in the 2002–2003 academic year.

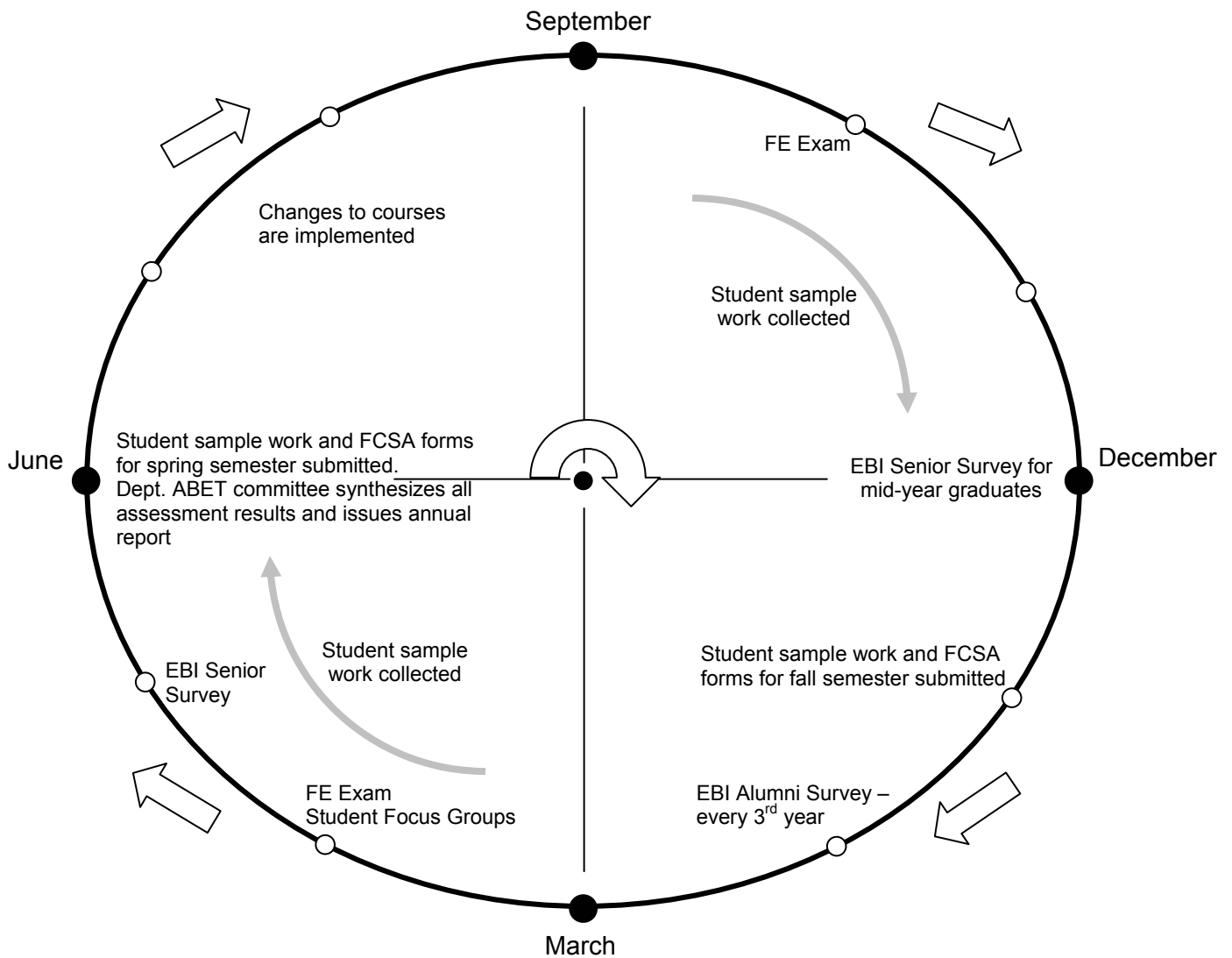
Early on, there was a College-wide move to use student feedback from the online course evaluations that are completed at the end of the semester as an assessment tool. Administered by the University, the course evaluations have two sections, one that deals with the instructor and another that deals with the course itself.

Questions were added to the evaluation that were based on the ABET (a) through (k) skills. Students were asked to choose, on a scale of 1 to 5, how they felt that particular course enhanced their abilities in that skill. After collecting and synthesizing two semesters worth of data, the Department ABET Committee found

that the results were of very limited value and chose not to use it further as an assessment tool.

#### **ASSESSMENT SCHEDULE**

The Department has been assessing student achievement to various degrees for several years. The formal process of gathering all of the assessment data, synthesizing the results, and implementing change began in the 2002–2003 academic year.



**Figure B3.1. Annual Outcomes Assessment Schedule**

The Outcomes assessment process takes place throughout the year. Responsibilities for the assessment process fall on individual faculty and the Department ABET Committee. Individual faculty are responsible for (1) collecting outcome-specific student sample work from their courses, (2) assessing the student sample work based on the outcome rubric, and (3) completing the FCSA form at the end of the semester. The Department ABET committee is responsible for (1) collecting and synthesizing all of the assessment results (EBI Senior survey, EBI alumni survey,

Student Focus Groups, FE exam, student sample work, and faculty course self assessment) for the year; (2) based on the composite assessment results, determining what changes should be made to improve the program; (3) documenting the assessment results and changes in an annual report; (4) defining how the assessment process will be carried out in the subsequent year; and (5) reporting the results and recommended changes to the entire faculty for their review. If the recommendations require changes to the curriculum, these require a formal vote of

**Table B3.5 Annual Outcomes Assessment Process**

<b>Month</b>	<b>Activity</b>
September	Fall semester of the academic year begins. Course, curriculum, and assessment changes established in the previous year are implemented. Faculty begin collecting outcome-specific student sample work for the Outcomes they have been assigned.
October	The FE exam is administered by the DAPE.
December	Fall semester ends. Faculty complete the FCSA form for their fall semester courses. Faculty complete the assessment of the student sample work they have collected. Seniors graduating in December complete the EBI senior survey.
January	FCSA forms and student sample work for the fall semester are collected.
February	Spring semester begins. Faculty begins collecting outcome-specific student sample work for the Outcomes they have been assigned.
April	Student focus groups are convened. The FE exam is administered by the DAPE.
May	Spring semester ends. Seniors complete the EBI senior survey. Alumni complete the EBI alumni survey (every third year). Faculty complete the FCSA form for their spring semester courses. Faculty complete the assessment of the student sample work they have collected.
June	FCSA forms and student sample work for the spring semester are collected. Results from all assessment methods are collected, analyzed, and synthesized by the Department ABET Committee. The committee meets to discuss the assessment results, decides on recommended changes to be made to the curriculum and the assessment process, and results are documented in the annual assessment report. The annual report is distributed to the entire faculty for their review. Faculty then vote to approve the changes to the curriculum.
July-August	Groundwork is laid for implementing changes outlined in the annual report; implementation is complete.

approval of the entire faculty. The annual cycle is shown in Figure B3.1; details of each step are described in Table B.3.5.

**METRIC GOALS FOR ASSESSING OUTCOMES**

Some of the assessment tools are quantitative in nature, while others are more qualitative. For those that are quantitative, a specific target level of achievement has been established. For

those that are more qualitative, a relative scale has been established. The metrics developed and applied to date are the same for all Outcomes. The metric goals are outlined in Table B3.6.

**Table B3.6 Metric Goals for Outcomes Assessment**

<b>Assessment Tool</b>	<b>Metric Goals</b>
EBI Senior Survey	Two criteria are applied to evaluate the EBI senior survey results: (1) the average score and (2) CE's rank among the Select Six, for each question. On a scale of 1 to 7, a score of 5 or above is considered satisfactory. Any question with an average score below 5 is flagged as a potential area of concern. Furthermore, a rank of 6 or 7, in comparison to the Select Six average results, would also indicate a possible area of concern. If <i>both</i> criteria fail to be satisfied for a given question, that question and the Outcome it pertains to are marked as a concern.
EBI Alumni Survey	Similar to the Senior survey, the EBI Alumni survey questions are scored on a scale of 1 to 7, 7 being the best. The questions come in pairs, the "Importance" question first asks "Ability to X: How IMPORTANT is this ability to your job or graduate school performance" (where "X" is some skill) and the "Preparation" question asks "How well does your engineering education prepare you in this area". A score of 5 or above on any question is considered satisfactory. Any "Preparation" question with a score below 5 would be flagged as a possible concern. Of most concern, however, are "Preparation" questions with a score below 5, and a corresponding "Importance" question with a score of 5 or higher (thus, identifying important areas for which alumni feel they were not well prepared).
Student Focus Groups	The focus group results are qualitative in nature; therefore, it is not possible to define a quantitative metric to judge the information. Instead, we look for comments and concerns raised by the students that would indicate a general lack of understanding of a particular subject or a concern about the program in general. We compare the feedback in the same year from the various groups, and the feedback from the same groups, from year to year. We look for issues that come up year after year in the same group, or that come up across the board in all groups, in any given year. Common themes that arise in the various groups are flagged as areas of concern.

**Table B3.6 Metric Goals for Outcomes Assessment (cont'd)**

<b>Assessment Tool</b>	<b>Metric Goals</b>
Student Sample Work	<p>Faculty assess their own student sample work using a 5-scale rubric that has been developed for each Outcome. The rubrics are available online at <a href="http://www.ce.udel.edu/ABET/-Current%20Documentation/ABET_scoring_rubrics_index.html">http://www.ce.udel.edu/ABET/-Current%20Documentation/ABET_scoring_rubrics_index.html</a>. If more than one-quarter of the average scores of all samples of student work for a given Outcome for the year are below 3.0, the Outcome is flagged as a possible concern. For example, suppose ten samples for Outcome 2 are collected in a given year; provided eight out of the ten have average scores greater than 3.0, the Outcome is noted as being achieved. If, instead, three out of the ten have scores less than 3.0, the Outcome is flagged as a possible concern. An average score below 3.0 on any one piece of sample work would suggest a possible problem in that class; the faculty member teaching the class will be asked to investigate in more detail the cause for the low score.</p>
FE Exam Results	<p>An analysis was done of the breakdown of questions on the 2003 FE exam, which showed that 88% of the questions could be related to UD-CE Outcomes 1 (48%), 2 (24%), and 4 (16%). The remaining 12% relate to Outcomes 3, 5, 7, 8, and 9, and there are no questions that relate to Outcomes 6, 10, 11 and 12. Thus, the FE exam result is a general indicator of the student's ability in Outcomes 1, 2 and 4.</p> <p>Pass/fail rates for UD-CE students are provided for each exam sitting. Rates are also provided for the nation. A concern is evident if the combined pass rate for the academic year for UD-CE students is below 70% and below the national average for two or more consecutive years. If neither of these criteria is satisfied, the results are signaling an area of concern for, in particular, Outcomes 1, 2, and 4.</p>
Faculty Course Self Assessment (FCSA)	<p>The FCSA forms are qualitative in nature. Here, we are looking for the individual faculty member's assessment of the student's overall abilities and their ability in the pertinent Outcomes. Indications of poor performance in relation to any one outcome would signal a possible cause for concern. If similar comments are noticed in multiple FCSAs from different faculty, this is a cause for concern. The FCSAs are particularly important in evaluating the students' abilities from prerequisite courses.</p>

### **B.3.4 Application of Results to Program Development and Improvement**

At the end of each academic year, the Outcomes assessment results from the various assessment tools are collected (some of the material—for example, student sample work—is collected at the end of each semester). Each member of the Department ABET Committee is then assigned a set of assessment results to review and summarize. For example, one member is assigned the Student Focus Group results, another the EBI Survey results, and so on. Each member is also assigned two to three Outcome binders of student sample work. The committee member is responsible for synthesizing the results from the assessment tool and writing a brief summary report of their findings.

The ABET committee then meets to discuss all of the results. At this meeting, members are given an opportunity to present their findings. During this process, the committee identifies any problem areas. It should be noted that the results from any one assessment tool may signal a concern that warrants examination; however, the committee looks for indications from more than one assessment method that there exists a particular problem. Those concerns that are identified by different assessment methods are given the highest priority for attention. Assessment reports from the previous years are also reviewed to see whether the identified concerns are new, and if not, whether a plan for improvement was developed and implemented. Once the areas of concern are identified, ways to correct the problem and improve the program are explored.

The committee also discusses the assessment tools and process and examines ways to improve the process itself. Minutes of these meetings are kept, and all of these results are reported in an Annual Report (these minutes and reports

are on file and available for review). The report includes a summary of the assessment tools used that year, the results of the assessment, recommendations for changes to the program, and recommendations for assessment methods for the following year. The Annual Report is distributed to the entire faculty for their review and comment.

Changes outlined in the report are then implemented through appropriate changes to the curriculum or to specific courses. Curriculum changes are first presented to the entire faculty for their approval, then are forwarded to the University Senate for approval. Because curriculum changes must follow the established University Senate procedure/calendar for approval, curriculum changes are initiated immediately but do not become effective for a year. On the other hand, changes to specific courses are instituted before the next offering of that course. This is done by the Chair or members of the Department ABET Committee meeting with the faculty member that teaches the course. Finally, any changes to the assessment process are instituted by the Chair and the Department ABET Committee at the appropriate time throughout the following year.

### **B.3.5 Results of Assessment and Changes Implemented To Improve Program**

Presented in this section are the results of Outcomes assessment for academic years 2002–2003, 2003–2004, and 2004–2005. The results are first discussed by academic year. The findings for the three years are then summarized by individual outcome.

#### **ACADEMIC YEAR 2002-2003**

*Assessment Results:* Four assessment tools were used in the 2002–03 academic year: EBI senior survey, Student Focus Groups, FE exam results, and Faculty Course Self Assessment forms.

EBI Senior Survey. The results for this year were based on 23 responses. Four questions from the survey were identified as possible areas for improvement based on the metrics described earlier. Question 36 asked whether the engineering education enhanced the student's ability to design experiments. The average score on this question was 4.29, and UD ranked last in the Select Six. Question 37 asked whether the engineering education enhanced the student's ability to conduct experiments. The average score on this question was 4.71, and UD ranked 6 out of 7 in the Select Six. Question 43 asked whether the engineering education enhanced the student's ability to understand the impact of engineering solutions in a global/societal context. The average score on this question was 4.78, and UD ranked last in the Select Six. Finally, Question 55 asked whether the engineering education enhanced the student's ability to understand contemporary issues. The average score on this question was 4.74, and UD ranked last in the Select Six. Thus, the EBI results suggest that the program may not be adequately preparing students to design and conduct experiments (Outcome 3) or to understand contemporary issues and the impact of engineering solutions on society (Outcome 9).

Student Focus Groups: A number of interesting issues were raised by the students in the focus groups; however, the one issue that ran through all of the focus groups was the students' concern over a lack of experience in the use of modern tools (Outcome 4). They specifically felt that a course, or at least more time, should be spent in using CAD programs, for example, AutoCAD or Microstation.

FE Exam results: The exam is given twice a year (October and April), and students must choose between the general

afternoon exam and the discipline-specific afternoon exam. We therefore typically have four different pass/fail rates in any given year. The success rate and the national averages for each are shown in Table B3.7 (no data was available for the April 2003 general exam). The combined

**Table B3.7 '03 FE Exam Results**

Exam Date	Test	# UD Students	UD Pass Rate	National Average Pass Rate
October '02	General	2	100%	67%
	Specific	36	83%	81%
April '03	General	0	-	N/D
	Specific	13	54%	87%
For '02-'03 Academic Year			76%	78%

pass rates for the academic year are also listed (the national average pass rate is just the average of the rates listed).

The UD pass rate for the academic year was above 70% and about equal to the national average (76% versus 78%); therefore, the assessment did not signify any concern. Also, this represented just one year of results; recall that the metric is based on two consecutive years of data. Nevertheless, the data suggests that Outcomes 1, 2 and 4 are being achieved.

Faculty Course Self Assessment Forms: No immediate issues or concerns were uncovered through the FCSA forms. They were, however, found to provide somewhat useful faculty feedback on individual courses.

*Changes that were implemented to improve the program:*

Based on the results of the assessment the Department ABET Committee agreed to the following action items.

Designing and conducting experiments. Although students are required to take three laboratory classes (solid, fluid, and soil mechanics), the curricula gave them very little opportunity to actually "design"

an experiment. The laboratories are typically designed and planned out ahead by the instructor and have preconceived Outcomes. Students had few if any opportunities within the curriculum to design an experiment for an open-ended problem, carry it out, and report their findings.

*Action* - Instructors for the laboratory classes were asked to incorporate one or more assignments into their courses in which students would be required to design an experiment on their own. These could be exercises where the student or groups of students simply design the experiment, but do not actually conduct it. Faculty were also encouraged to spend time discussing the process of designing an experiment. In addition, the faculty were asked to collect samples of student work that demonstrate the experiment design components. Experiment design also involves statistics; therefore, the faculty member who teaches CIEG315, Probability and Statistics for Engineers, was asked to incorporate experiment design into the course.

Contemporary issues. The results of the EBI survey indicated that our students do not feel adequately prepared in contemporary issues and the impact that engineering has on society.

*Action* - Faculty in courses that address this outcome were instructed to dedicate some specific time throughout the semester to the discussion of contemporary issues. Faculty were also asked to collect samples of student work that assess their knowledge of contemporary issues.

*Changes that were made to the assessment program:*

The Department ABET committee in general felt that each of the assessment tools had strengths and weaknesses. The

EBI survey and the FE exam results are useful because of the quantitative nature of the results and the ability to compare to a national population. The Student Focus Group results provide feedback on how the students feel they are doing; the FCSA forms provide feedback on how the faculty feel the students are doing. The primary weaknesses of the tools were (1) they were deemed too subjective, and (2) they relied too much on the students' opinions about how well they were learning. The general consensus was to continue with the current methods of assessment; however, beginning the following year a new direct assessment tool would be added: student sample work.

#### **ACADEMIC YEAR 2003-2004**

*Assessment Results:* Six assessment tools were used in this academic year: EBI senior survey, EBI alumni survey, Student Focus Groups, FE exam results, Faculty Course Self Assessment forms, and Student Sample Work

EBI Senior Survey. The results for this year were based on 20 responses. Out of the 18 questions that pertain to ABET on the survey, three had average scores below 5. This included Question 36, which asked whether the engineering education enhanced the student's ability to design experiments (average score of 4.6); Question 37, which asked whether the engineering education enhanced the student's ability to conduct experiments (average score of 4.95); and Question 42, which asked whether the engineering education enhanced the student's ability to use modern tools (average score of 4.95). Of these three, only Question 36 ranked last or next to last among the Select Six (it ranked 6 out of 7). Thus, the EBI results suggest that the program may not be adequately preparing students to design and conduct experiments (Outcome 3), or to use modern tools (Outcome 4); however, based on the metric goals defined, only

designing experiments (Outcome 3) was flagged as a concern.

EBI Alumni Survey (conducted every third year). There were 51 questions on the alumni survey, 34 of which pertain to ABET Outcomes. The questions come in pairs, as described previously. The scores are shown in Table B3.8, as listed under "Importance" and "Preparation." Also listed are the number (N) of respondents, which varies from a low of 13 to a high of 21 (one choice in answering the question is "Not Applicable," which some choose to select and therefore are not counted in the sample, resulting in a variable sample size for each question).

while questions 19 and 21, which pertain to designing and conducting experiments have average "Preparation" scores below 5, the "Importance" scores on the corresponding questions (18 and 20) are below 3.5 and are the two lowest importance scores of all the questions. This was a very significant result. Thus, based on these results, questions 33, 35, 37, and 39 were areas of concern. These questions pertain to ethics, the impact of engineering solutions, modern tools, and oral communication, or, in other words, Outcomes 4, 8, 9 and 12.

Student Focus Groups: Once again, the Student Focus Groups provided valuable

**Table B3.8 '04 EBI Alumni Survey Results**

Question	Outcome	"Importance" Score (out of 7)	"Preparation" Score (out of 7)	N
18,19	Ability to design experiments	3.15	4.18	13
20,21	Ability to conduct experiments	3.36	4.77	14
22,23	Ability to analyze and interpret data	5.71	5.48	21
24,25	Ability to design a system, component, or process to meet desired needs	5.67	5.44	18
26,27	Ability to function on multidisciplinary teams	6.25	5.70	20
28,29	Ability to identify or formulate engineering problems	5.80	5.43	21
30,31	Ability to solve engineering problems	6.20	5.48	21
32,33	Ability to understand ethical responsibilities	5.95	4.86	21
34,35	Ability to understand the impact of engineering solutions in a global/societal context	5.62	4.62	21
36,37	Ability to use modern engineering tools	5.85	4.71	21
38,39	Ability to communicate using oral progress reports	6.20	4.65	20
40,41	Ability to communicate using written progress reports	6.37	5.05	19
44,45	Ability to use reference materials to support project design	5.45	5.25	20
46,47	Ability to recognize the need to engage in lifelong learning	5.95	5.33	21
48,49	Ability to apply knowledge of science	5.10	5.48	21
50,51	Ability to apply knowledge of mathematics	5.55	5.85	20

Based on the metrics described earlier, questions 19, 21, 33, 35, 37 and 39 all have average "Preparation" scores below 5. However, it is important to note that

information and feedback. The students again felt that there was a lack of preparation in the use of CAD programs (Outcome 4). Other useful information

was obtained from the focus groups that has to do with the program in general but not with Outcomes.

FE Exam Results: The success rate and the national averages for the exams given in the 2003–04 academic year are listed in Table B3.9, along with the data for the 2002–03 academic year, presented earlier. The combined pass rates for the academic year are also listed (the national average pass rate is just the average of the rates listed).

**Table B3.9 '03 & '04 FE Exam Results**

Exam Date	Test	# UD Students	UD Pass Rate	National Average Pass Rate
October 02	General	2	100%	67%
	Specific	36	83%	81%
April 03	General	0	-	N/D
	Specific	13	54%	87%
For 02–03 Academic Year			76%	78%
October 03	General	18	67%	76%
	Specific	7	71%	81%
April 04	General	5	40%	71%
	Specific	5	80%	76%
For 03–04 Academic Year			66%	76%

The average pass rate for the 2003–04 academic year was 66%, just below the target of 70%. It was also below the national average. This could highlight a possible concern; however, the single-year results could be anomalous, and that is why the metric is defined for two consecutive years of low scores and scores below the national average. No particular action was directed as a result of this low pass rate; however, the results would be compared the following year to see if there was improvement.

Faculty Course Self Assessment Forms:

No immediate issues or concerns were uncovered through the FCSA forms. We continue to find the faculty feedback on individual courses useful.

Student Sample Work: This was the first year that student sample work was collected and assessed. The first year was

as much about implementing the process, defining how the sample work would be assessed, and figuring out what the results were telling us, as it was actually using the data to make improvements to the program. At the end of the first year, it was generally felt that collecting and assessing student sample work was very worthwhile, but that improvements could be made to the way the process worked. In summary, no glaring deficiencies were uncovered from the student sample work. Overall, the assessment results were more than satisfactory.

*Changes that were implemented to improve the program:*

Based on the results of the assessment, the Department ABET Committee agreed to the following action items.

Designing and conducting experiments (Outcome 3). This was an area

for improvement that was also reported the previous year: the low scores reaffirmed the previous year's results. Although it was recognized as an area of concern in the previous year's assessment, there was no improvement in the assessment results this year. There are two possible reasons for this. First, some, but not all, of the recommendations made in 2002-2003 were implemented in the 2003-2004 academic year. Specifically, designing experiment assignments were implemented in CIEG212 (Solid mechanics laboratory) and CIEG315 (Probability and Statistics for Engineers), but not in the other targeted classes. Second, and more importantly, the concern was identified in the EBI senior and alumni survey results. The seniors taking the survey in 2003–04 would not have benefited from any of the changes implemented, because the changes were

made in a sophomore-level course and a junior-level course. And obviously the alumni who graduated two to three years ago would likewise not have benefited. Thus, it was not surprising that this was again identified as a concern in this assessment cycle.

*Action* – Continuing with the plan to make improvements in this outcome, the instructor for CIEG306 (Fluid Mechanics Laboratory) was asked to incorporate one or more assignments into their course, in which students would be required to design an experiment on their own. This would be in addition to the elements already in CIEG212 and CIEG315. Also, a recommendation was made to introduce the design element into the Geotechnical Engineering (CIEG321) course, rather than the Soil Mechanics Laboratory (CIEG323). In this instance, students would be asked to develop an experimental plan/program for a geotechnical site investigation, which is very important and relevant for civil engineers.

#### Modern engineering tools (Outcome 4).

Once again, the assessment results indicated that we are not preparing our students well enough in the use of modern tools. To make improvements in this area a number of action items were outlined.

#### *Action* -

1. During the next academic year the faculty would be surveyed to find out exactly what modern tools (software, etc.) they require their students to use, how often, and in what capacity.
2. The curriculum would migrate from teaching/using AutoCAD to teaching/using Microstation. There were a number of good reasons for doing this: (a) it seems that Microstation is more popular and widely used in the civil industry than AutoCAD, (b) the founders of

Microstation are UD alum and will provide a free site license for the software and free copies to students, and (c) Microstation headquarters are not far from the University.

3. Several practicing engineers would be invited to meet with us, along with representatives from Microstation, to help us decide the best way to teach Microstation and implement it in our curriculum (e.g., class format, size, content, exercises, etc.).
4. After items 1 through 3 have been completed, we would have the information we needed to better assess the current situation and make specific changes. The changes would most likely be made to CIEG125 (Intro to Civil Engineering) and CIEG126 (Surveying and CAD); however, given the scheduling, the specific changes would be implemented at the earliest during the 2005–06 academic year.
5. In the meantime, faculty were encouraged to incorporate the use of modern tools more often into their courses. In particular, faculty were encouraged to use Autocad or Microstation in their courses.

Contemporary issues (Outcome 9). The results of the EBI alumni survey and the focus groups indicate that our students may not be adequately prepared in contemporary issues and the impact that engineering has on society.

*Action* – Specific courses taught in 2004–05 were targeted for incorporating some discussion of a contemporary issue, developing some type of assignment related to contemporary issues, and collecting student sample work. The courses targeted were CIEG302 Structural Design, CIEG311 Dynamics, CIEG351

Transportation Engineering, and CIEG331 Environmental Engineering. Samples of student work that assess their knowledge of contemporary issues would be collected and evaluated.

*Changes that were made to the assessment program:*

Two changes were proposed and implemented in the assessment process. First, the way in which student sample work is collected and organized and assessment results are reported was standardized and made clearer for the faculty and more meaningful. This was done to make the analysis and comparison of the results at the end of the year easier and more effective. Second, the Faculty Course Self Assessment form was to be revisited. One idea proposed was to do away with the numeric target levels of learning in the courses and to stop recording the students' own estimate of their level of learning from the online course evaluations. There seemed to be a lot of confusion about this, both from the faculty and the students, and the data has not been of sufficient quality to be useful. The most useful aspect of these forms has been found to be the faculty member's input on the strengths and weaknesses of the class, as well as the effectiveness of prerequisite courses.

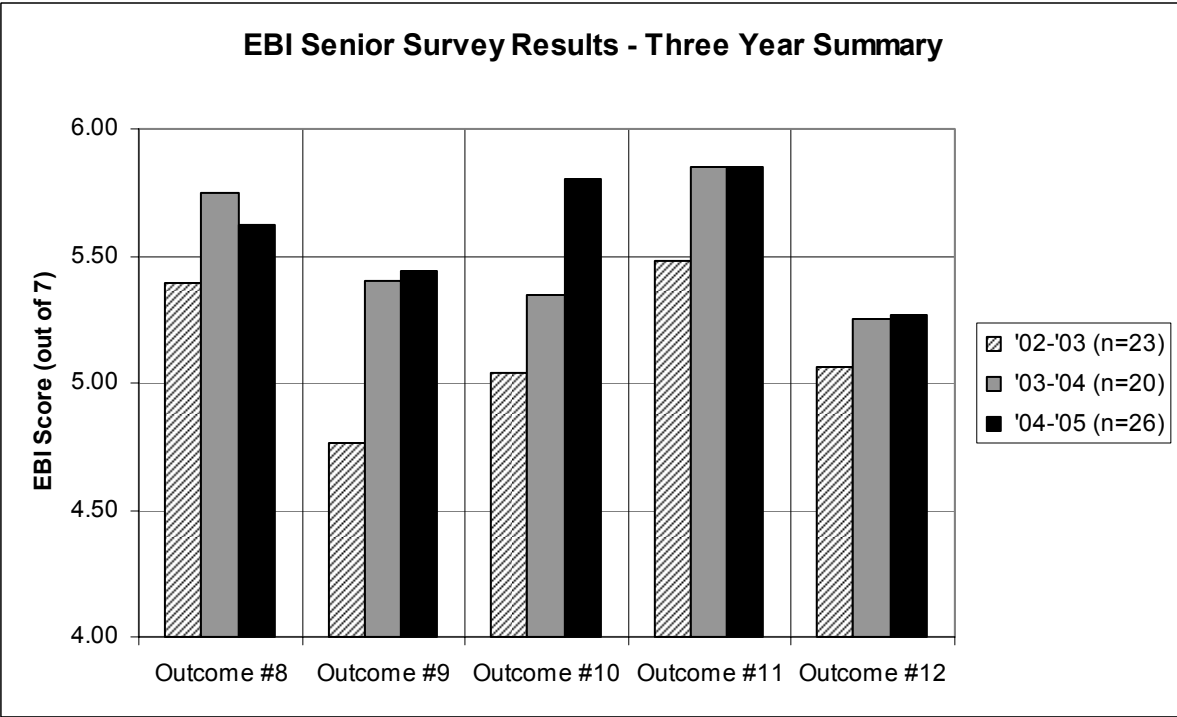
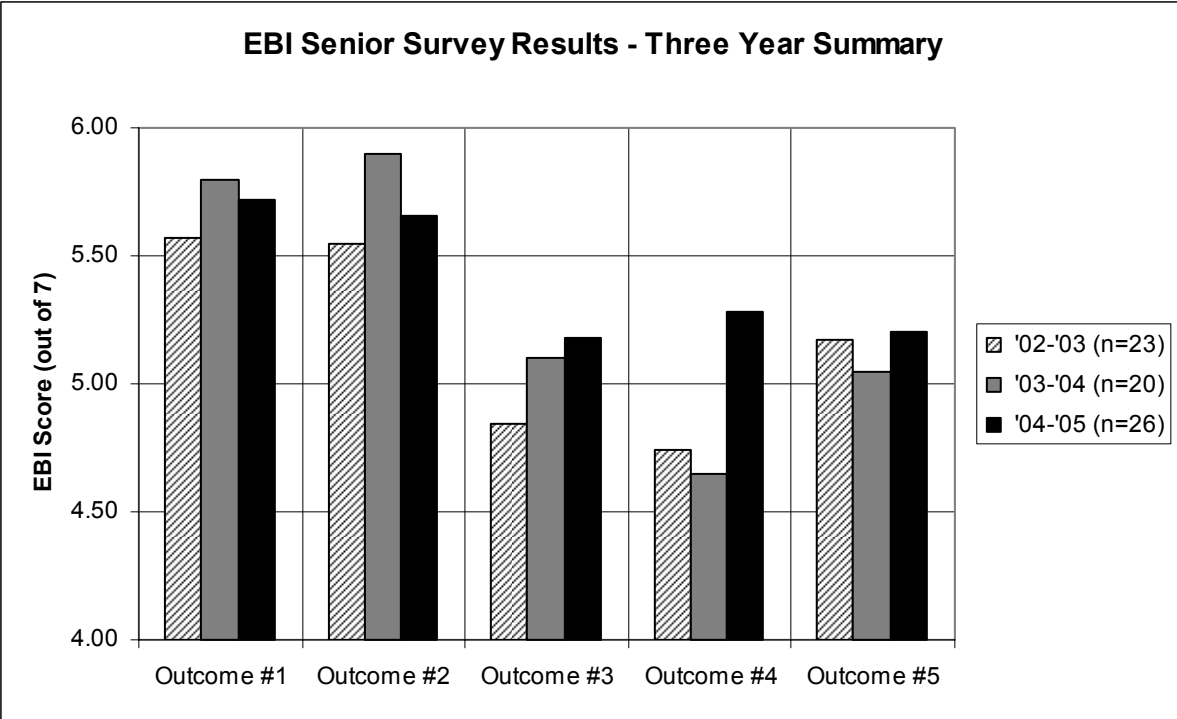
**ACADEMIC YEAR 2004-2005**

*Assessment Results:* Six assessment tools were used in this academic year: EBI senior survey, Student Focus Groups, FE exam results, Faculty Course Self Assessment forms, Student Sample Work and a new tool, the Senior Design Assessment Report.

EBI Senior Survey. The results for this year were based on 26 responses. At the time of writing, the Select Six scores were not available for comparison; therefore, the assessment was made based solely on the mean score. Out of the 18 questions

that pertain to ABET on the survey, two had average scores below 5. This included Question 36, which asked if the engineering education enhanced the student's ability to design experiments (score of 4.96); and Question 37, which asked if the engineering education enhanced the student's ability to conduct experiments (score of 4.96). Questions 36 and 37, which relate to designing and conducting experiments, have been identified in the past as areas for improvement and scored below 5.0.

To date, no hard metric has been established to judge the year-to-year variation of EBI results, but it is worth examining the changes now that three years of data are available. The mean composite score for each outcome from the '02-'03, '03-'04 and '04-'05 surveys are plotted in Figure B.3.2. These are the mean scores from the EBI questions that pertain to the various Outcomes (if an outcome is the focus of more than one survey question, the mean score presented is the average of the survey results).



**Figure B.3.2 EBI Senior Survey Results for Years '02, '03 and '04**

The plots show some significant results, i.e., clear indications of improvement in several Outcomes. (Note that the EBI Senior Survey does not cover our Outcomes 6 and 7 because of the generic

nature of the instrument). In particular, there is a definite trend of increase in score for Outcomes 3, 9, 10, and even 11. Outcome 4 also shows an indication of recent improvement. Outcomes 1, 2, 5, 8

and 12 show level performance, within the statistical variation of the data.

These results are encouraging and clearly indicate improvement being made in several areas. In particular, Outcome 3, which pertains to designing and conducting experiments, has been identified as a possible weakness in the past and steps have been taken to make improvements; results show a clear improvement in this area. Also, Outcome 4, which pertains to the use of modern tools, was identified in years past as an area for improvement, and shows recent improvement. These results are very encouraging and indicate that the changes made to improve the program over the past few years have been effective.

Student Focus Groups: The number of students that participated in the focus groups this year was fairly small, i.e., only two, six and two, for the three respective groups. The low turn out was likely due to a delay organizing the annual groups and scheduling issues with the students. The students felt that the laboratory courses do not promote a true sense of design or creativity (Outcome 3) and that the preparation in AutoCAD was inadequate (Outcome 4). Nevertheless, the responses from the focus groups were generally positive, as in previous years. The students also noted the following:

1. A limited amount of open-ended design other than in the Senior Design class. They say that the design problems are usually "given" to them and they do not experience enough "design and creativity" in homework problems or lab. This relates to Outcome 6 and indicates an area for potential improvement.
2. Greater need for the CE department to monitor non-CE courses, particularly, PHYS207.
3. Need for assistance in computer-based courses, e.g., technology lab assistants.

4. Need for the professors to communicate with one another to understand the students' situation, e.g., scheduling homework and exams conflict.
5. Little connection between course contents and the FE exam topics. For example, the formula notation in the class and the FE book are different.

FE Exam Results: The FE exam results for '04-'05 were not available at the time of this writing and therefore could not be included. Results will be synthesized when they become available and included in an updated annual assessment report.

Faculty Course Self Assessment Forms: No immediate issues or concerns were uncovered through the FCSA forms.

Student Sample Work: Student sample work was collected and assessed, per the metric previously described in Section B.3.6. The results are summarized in Table B3.10.

**Table B3.10 Summary of '05 Student Sample Work Results**

Outcome	Total Number of Samples	Number of Samples with Mean Scores Below 3.0	% of Samples with Scores below 3.0	Satisfied Criteria (Yes or No)	
				Yes	No
1	8	1	12.5%	✓	
2	7	2	29%		✓
3	3	0	0%	✓	
4	5	2	40%		✓
5	2	1	50%		✓
6	1	0	0%	✓	
7	1	1	100%		✓
8	2	1	50%		✓
9	1	0	0%	✓	
10	1	0	0%	✓	
11	2	1	50%		✓
12	2	0	0%	✓	

Results for only 6 out of the 12 Outcomes satisfied the established criteria. However, this being the first year in which the student sample work was to be used seriously as an assessment tool, it is obvious that the results need to be considered in light of the number of samples compiled for any given outcome. Two or fewer samples were collected for eight out of the twelve Outcomes, and three or fewer for nine out of twelve. (The deadline for the ABET Self-Study meant that only a limited number of samples were available for inclusion in the report.) Making any decision based on three or fewer samples would not be appropriate. These results suggest that in the future, a requirement should be established for the minimum number of samples collected, as well as for appropriate distribution among courses, before the assessment results are used to support a finding.

Based on this data, one might say that only the results for Outcomes 1, 2, and 4 could be assessed with any significance this year. These results suggest that Outcomes 2 and 4 are possible areas for improvement. As this data is collected in

future years, the cumulative number of samples will enable the outcome assessment to be more effective.

Senior Design Assessment Report: This new assessment tool was developed and implemented mid-year as a replacement for student sample work in the capstone Senior Design course (CIEG461). (It was not listed as a new assessment tool in the 2003-2004 annual report.) This course is described in more detail in Section B4.2.

Because of the nature of the course (students working in small groups under the umbrella of a larger company) and the many Outcomes the course supports, it is impractical to attempt to collect samples of student work for each of the Outcomes. Instead, the four outside instructors and the faculty coordinator were asked to provide their final, overall assessment of the students in the various Outcomes. The instructors were asked to provide one score for the entire class. The results are presented in Table B3.11. Note that the class does not address Outcome 3 (designing and conducting experiments); therefore, there is no score

listed for that outcome. Also, Outcomes 9 and 12 were each split into two, since they each address more than one major concept.

*Changes that were implemented to improve the program:*

**Table B3.11 '05 Senior Design Assessment Results**

	Outcome	Instructor					Average
		#1	#2	#3	#4	#5	
1	An ability to apply knowledge of mathematics and science to engineering	5	5	3	3	4	4.00
2	An ability to identify, formulate, and solve engineering problems in the following major civil engineering disciplines: structural, environmental, and water resources, transportation, and geotechnical engineering	5	5	5	5	5	5.00
4	An ability to use the techniques, skills, and modern tools of engineering	5	5	5	5	5	5.00
5	An ability to design a system, component, or process	5	5	3	3	4	4.00
6	An ability to perform civil engineering design by means of problem-based experiences integrated throughout the curriculum	3	5	3	3	4	3.60
7	A knowledge of professional practice issues, such as procurement of work, bidding versus quality-based selection processes, and the interactions of design and construction professionals in executing a project	3	5	3	5	4	4.00
8	An understanding of professional and ethical responsibility	5	5	5	5	4	4.80
9a	understanding of the impact of engineering in a global societal context	3	5	3	3	3	3.40
9b	A knowledge of contemporary issues	5	5	5	5	4	4.80
10	An ability to engage in lifelong learning	5	5	5	3	4	4.40
11	The ability to function on (multidisciplinary) teams	5	5	5	5	5	5.00
12a	An ability to communicate effectively (written)	5	5	5	5	5	5.00
12b	An ability to communicate effectively (oral)	5	5	5	5	5	5.00

The raw scores range from 3 to 5, with the average scores ranging from 3.4 to 5.0. The lowest scores were reported in Outcomes 6 and 9a. Perfect scores of 5 were reported for Outcomes 2, 4, 11, 12a and 12b. While at this point we do not have a specific metric for this new assessment method, the scores would suggest that the areas needing improvement have to do with Outcome 6, and understanding the impact of engineering in a global and societal context (Outcome 9).

Based on the results of the assessment, the Department ABET Committee agreed to the following action items.

Designing and conducting experiments(Outcome 3). The results of the EBI senior survey show that clear improvements have been made in this area. However, the scores are still below the target level of 5.0 (albeit, this year just below). The Department needs to continue with the plans developed in previous years and build on this success.

*Action* – Fall 2005 will be the first time that the new CIEG451 (Transportation Laboratory) will be taught. This will be an opportune time to develop new topics in designing and conducting experiments. The faculty member teaching the class will be asked to do just that. Although plans were made last year to have designing a geotechnical site investigation included in CIEG321 (Geotechnical Engineering), that did not happen this year. An effort will be made to have it included in the spring 2006 class.

Modern engineering tools (Outcome 4).

The results of the EBI survey also show recent improvement in this area. Some of the comments brought up by the focus groups indicate that further improvements can be made. The student sample work also indicated this as an area for improvement. A plan of action was outlined in the previous year, but only some of the items were completed. In particular, a faculty survey was developed and administered to find out what modern tools they currently use in their courses, but the results have not been compiled. While not listed in the action items in the 2003-2004 annual report, a major change was made to the way CIEG126, Introduction to Surveying and CAD, is taught. This was brought about by feedback from the faculty member teaching the course, course evaluations, and the projected increase in class size. The CAD portion of the course was taught by an off-campus faculty member with significant experience in AutoCAD. And, because of the larger class size and the limit of 48 seats in the eCALC computer classroom, the class was split into three smaller groups for the laboratory (AutoCAD) portion of the course. Each group received four three-hour sessions of AutoCAD training over a one-month period.

*Action* - continue with the itemized action plan outlined in the 2003-2004 report. This should include synthesizing the faculty survey, migrating to Microstation, and

meeting with representatives from Microstation and consultants to decide how best to teach the CAD class.

Ability to identify, formulate and solve engineering problems (Outcome 2). The assessment of the student sample work for Outcome 2 did not satisfy the established criteria. It should be noted, however, that it was very close to satisfying the criteria, and that while there were seven samples of student work in the collection, three were from the same course, one of which yielded the low score. No other assessment results would suggest a problem or concern with outcome number 2. Thus, the finding that there might be a problem with Outcome 2 is, at this point, not conclusive.

*Action* – no immediate corrective action was planned. The committee decided to monitor this finding carefully in the next year to see whether results that would suggest a problem would present themselves. In addition, when the FE exam results become available, that would be another objective assessment tool that would corroborate the findings.

*Changes that were made to the assessment program:*

Brief summaries of the changes and improvements that were discussed by the committee, and will be implemented next year are presented below. More details can be found in the 2004-2005 annual assessment report.

- The student focus groups are valuable and provide useful feedback; however, after conducting the focus groups for several years, the committee finds it a challenge to get the three separate groups formed. This has resulted in a lower turnout for the meetings than we would like. Consequently, starting in 2006, the focus groups will be replaced by a single standing "Student ABET Committee." There will be representatives from each class. The members will serve two to four year

terms. The committee will meet in the spring to answer questions, provide feedback, and to discuss the pros and cons of the program, just as the focus groups did. This should be easier to administer and more effective.

- Further improvements will be made to the way student sample work is collected and assessed. This includes (1) faculty will be instructed to include an original copy of the problem being assessed along with their solution; (2) the Department ABET Committee will provide feedback to the faculty who submitted the sample, as it relates to the choice of the problem and their assessment of the work; (3) the Department ABET Committee will develop a six-year assignment schedule for collecting student sample work; (4) the Department ABET Committee may explore developing “standard” benchmarking problems for each outcome, which would allow the assessment method to more directly track performance and improvement over time; (5) student sample work assignments will be attached to the class roster and grade sheets, to remind faculty to collect this material; and (6) the Department ABET Committee must decide on minimum sample sizes before the student sample work can be considered a valid sample.
- The Faculty Course Self Assessment form will be simplified.
- The new online senior exit survey (discussed previously in Section B.2) that was administered at the end of the year to gather basic information from the recent graduates about employment and contact information will continue to be administered.

#### **SUMMARY OF RESULTS BY OUTCOME**

The previous sections have outlined the results of the assessment and changes that were made to improve the program by academic year. We feel this has been an effective way to present the results, as

it shows the evolution of the assessment process and the resulting improvements to the program. A summary of results by outcome is available in Appendix I.D.10.

#### **B.3.6 Summary of Changes Resulting from the Assessment Process**

At the outset of the process, before the evaluation and assessment procedures were finalized, several key curriculum changes were made that strengthened our ability to achieve our Objectives and Outcomes. These included the addition of both Oral Communication in Business (COMM312) and Geotechnical Engineering (CIEG323) as required classes. Subsequent changes included the addition of Construction Methods and Management (CIEG486) and a Transportation Engineering Laboratory class (CIEG451), also as required classes.

During the past three years, an Outcomes based assessment process has been introduced. The results have allowed us to refine and improve the process, as well as make meaningful changes to the program to better achieve our Objectives and Outcomes.

In terms of program changes, we identified areas of concern in Outcomes 3, 4, and 9. Through changes in the content of several classes that address these Outcomes, we are making improvements in these areas. The most recent assessment results that we have obtained indicate that the changes have been effective.

In terms of the assessment process, we have added the collection and evaluation of student sample work to more directly assess Outcomes, as well as adding a senior design assessment report. We have developed and implemented useful employee and alumni surveys to help us better evaluate the achievement of our Objectives. We have also modified several of the other tools that we initially selected to make them more effective and efficient.

### **B.3.7 Materials Available for Review During Visit**

The following materials will be available for review during the site visit:

*Outcome Binders:* For each civil engineering Outcome, a binder will be available that includes samples of student work that tests their level of achievement in that Outcome. Also included is the faculty assessment of the work. The materials will be broken down according to semester. For any given semester, there will be samples of student work from a variety of courses throughout the curriculum. (The number of samples varies depending on the outcome.)

*Course Binders:* For each civil engineering course, a binder will be available that includes the course syllabus and samples of student work (from the previous year or the last time the course was offered). The sample work will typically include homework assignments, quizzes, exams, project reports and/or laboratory reports. Samples of good, average, and poor work will typically be provided. The textbook used in the course will also be available with the binder.

*Annual Assessment Reports:* Reports will be available for academic years 2002–03, 2003–04, and 2004–05 summarizing all of the assessment results and findings for the year and provide recommendations for changes to be made to the curriculum and the assessment process. The supporting data from the various assessment methods will also be available.

*Department ABET Committee meetings:* Minutes for all ABET Committee Meetings held over the past two years are available.

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

This section of the report is aimed at describing how our faculty assures that the curriculum devotes adequate attention and time to each curricular component area and how our students are prepared for engineering practice as required by Criterion 4.

### **B.4.1 Student Preparation for Engineering Practice Through Coursework**

The BCE curriculum at the University of Delaware strives to provide proficiency in the following four recognized areas of civil engineering practice: structural engineering, environmental and water resources engineering, geotechnical engineering, and transportation engineering. There are at least two required course in the curriculum in each of these concentrations, as outlined below:

- Structural Engineering: CIEG301, CIEG302
- Environmental and Water Resources Engineering: CIEG331, CIEG440
- Geotechnical Engineering: CIEG320, CIEG321, CIEG323
- Transportation Engineering: CIEG351, CIEG451

In addition to these required courses, all students are required to take CIEG315, Probability and Statistics, which is used to some degree in each of these disciplines. All students are also required to take our capstone Senior Design course (CIEG461), which is described in more detail in the next section. Through this course, all students are exposed to the four proficiency areas, either directly as part of the discipline team, or indirectly by working with the other discipline teams to complete the project. The course also serves to prepare students for engineering practice.

Students in the civil engineering program

must successfully complete three technical elective courses. Technical electives may include upper-level courses in engineering, mathematics, computer science, and the sciences, subject to advisor approval; however, the vast majority of students use upper-level civil engineering courses to fulfill the technical elective requirements. Technical electives are chosen in consultation with a faculty adviser to enable students to meet graduation requirements and to pursue individual interests. Graduate-level courses may also be taken as technical electives subject to advisor approval.

To help meet the requirement that graduates have the ability to communicate effectively, both orally and in writing, the civil engineering curriculum includes the following required courses:

- ENGL110, Critical Reading & Writing
- ENGL410, Technical Writing
- COMM312, Oral Communication

In addition, as noted in Table B.3, eight other civil engineering courses support the development of communication skills. This includes, starting in the freshman year, Introduction to Civil Engineering (CIEG125); in the sophomore year, Dynamics (CIEG311); in the junior year, Transportation Engineering (CIEG351), and in the senior year, the year long senior design capstone course (CIEG461), which involves both written and oral communication assignments, as well as a substantial amount of team work. Furthermore, all of the laboratory courses (CIEG213, 306, 323, and 451) support development of communication skills.

### **B.4.2 Preparation for Engineering Practice Through a Major Design Experience**

Our BCE program culminates in a four-credit, two-semester capstone course, CIEG461, Senior Design. The department is extremely proud of this class and devotes extensive resources to it. The

class has evolved over several years and provides our seniors with a major design experience that completes their preparation for engineering practice. A comprehensive web site for the course, including details on the 2004-2005 project, can be found at <http://www.ce.udel.edu/courses/cieg461/seniordesignhome.html>.

In this class, students are divided into teams, or "companies," that compete for an engineering job from a client ("the owner"). The teams typically have 12-14 students and are responsible for selecting a team president and setting up a management structure. The projects are multidisciplinary in nature, such as the revitalization of a portion of the Wilmington waterfront. Each team is divided into four engineering disciplines: structural, transportation, civil site, and environmental. Once awarded the job, the teams compete against each other to produce the best preliminary design for the engineering project. A paper that describes this unique class was published in the April 2005 issue of the ASCE *Journal of Professional Issues in Engineering Education and Practice* and can be found in Appendix I.D.11.

The course is coordinated by a CE faculty member who is a registered Professional Engineer. Working with that faculty member are four off-campus faculty, all of whom are practicing engineers. In addition, the course draws upon mentors, who are also practicing engineers but who have recently graduated from UD, as well as a host of invited speakers.

The following deliverables are produced by each team during the Senior Design course as listed below:

1. **Proposal**—a document describing the company, its personnel and expertise, and the approach it will take to solve the engineering design problem (fall semester)

2. **Proposal presentation**—a 20-minute oral presentation by each team summarizing the important components of the proposal (fall semester)
3. **Environmental Site Assessment**—a report including an environmental impact study (fall semester)
4. **Progress presentation**—a 15- to 20-minute oral presentation summarizing the company's progress with the project to date (end of fall semester)
5. **Preliminary design**—a comprehensive document that describes in detail the preliminary design (spring semester)
6. **Preliminary design presentation**—a 20-minute oral presentation by each team summarizing the important components of the preliminary design (spring semester)

Grades are based upon class attendance, individual class participation, the quality of project "deliverables," and evaluation by all the student's peers in the group and by the team leader. Bonus points are also awarded for the winning proposal (fall semester) and preliminary design (spring semester).

CIEG461 is the culmination of our students' exposure to the engineering standards and to the eight ABET-stipulated realistic constraints: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political. The course also contributes significantly to the development of both written and oral communication skills and to the ability to participate on a team. Both major presentations are videotaped and made available to the students as feedback to help them improve their presentation skills. Finally, through the involvement of off-campus faculty who are practitioners representing consulting and construction firms and state agencies, our students are exposed to the typical problems

encountered in engineering practice and provided with a practical perspective on the solution of such problems. All of the CIEG461 deliverables for the past two years will be available during the ABET visit.

### **B.4.3 Program Curriculum and Professional Component**

The program curriculum provides significant exposure to all professional components. The curriculum includes more than one year of mathematics and basic sciences, more than one and a half years of engineering topics, and a general education component that is consistent with the program Objectives. Note that on our semester system, one year is equivalent to 30 credits.

Table B.2.1 displays the entire curriculum, including the mathematics/basic science content and the engineering topics portion. The curriculum is also presented in Table I-1, Basic-Level Curriculum, in Appendix I.A. Course syllabi are provided in Appendix I.B for all required mathematics, basic sciences, and required engineering courses. The following sections show how the professional component is addressed.

#### **MATHEMATICS AND BASIC SCIENCE**

Mathematics knowledge and skills are developed through the following six required courses:

- MATH241, Calculus A (4 credits)
- MATH242, Calculus B (4 credits)
- MATH243, Calculus C (4 credits)
- MATH351, Engineering Math I (3 credits)
- MATH353, Engineering Math III (3 credits)

Basic sciences knowledge and skills are developed through the following four classes:

- CHEM103, General Chemistry (4 credits)
- PHYS207, Fundamentals of Physics I (4 credits)
- CISC105, Computer Science (3 credits)
- Science Elective (4 credits); chosen from among
  - CIEG207, Introductory Biology I,
  - CIEG208, Introductory Biology II,
  - GEOL107, General Geology,
  - CHEM104, General Chemistry,
  - PHYS208, Fundamentals of Physics II, or
  - PHYS245, Introduction to Electricity and Electronics

These math and science classes total 33 credits (more than one year of coursework).

#### **ENGINEERING TOPICS**

Civil engineering students are required to take the following *engineering science courses*:

- CIEG211, Statics (3 credits)
- CIEG212, Solid Mechanics (3 credits)
- CIEG213, Solid Mechanics Laboratory (1 credit)
- CIEG305, Fluid Mechanics (3 credits)
- CIEG306, Fluid Mechanics Laboratory (1 credit)
- CIEG311, Dynamics (3 credits)
- CIEG320, Soil Mechanics (3 credits)
- CIEG323, Soil Mechanics Laboratory (1 credit)
- MSEG 302, Materials Science (3 credits)

Civil engineering students are also required to take the following *basic engineering courses*:

- CIEG125 Introduction to Civil Engineering (2 credits)

- CIEG126 Introduction to Surveying and CAD (3 credits)

In addition, civil engineering students are required to take the following *engineering methodology courses*:

- CIEG301 Structural Analysis (4 credits)
- CIEG302 Structural Design (4 credits)
- CIEG315 Probability and Statistics (3 credits)
- CIEG321 Geotechnical Engineering (3 credits)
- CIEG331 Environmental Engineering (3 credits)
- CIEG351 Transportation Engineering (3 credits)
- CIEG440 Water Resources Engineering (3 credits)
- CIEG451 Transportation Laboratory (1 credit)
- CIEG461 Senior Design (4 credits)
- CIEG486 Construction Methods and Management (3 credits)
- CIEGXXX 3 Technical Electives (9 total credits)

These engineering topics classes total 66 credits (more than two years of coursework).

#### **GENERAL EDUCATION**

The general education component of the curriculum consists of 27 credits. All CE majors are required to take the following three courses:

- ENGL110, Critical Reading and Writing (3 credits)
- ENGL410, Technical Writing (3 credits)
- COM 312, Oral Communication in Business (3 credits)

In addition, CE majors are required to take six general education electives (18 credits), as detailed below:

- Two courses in the humanities. Humanities include courses in areas such as Art History, English Literature, Foreign Languages other than the student's native language, History, and Philosophy.
- Two courses in the social sciences. The social sciences include courses in areas such as Economics, Political Science, Psychology, and Sociology.
- Two additional humanities or social science courses.

In selecting the six general education classes, students must also meet the following requirements:

- At least two courses must be above the introductory level. These courses must build upon the content of a previous course, as approved by the faculty advisor. Courses that fulfill this requirement are normally at the 300-level or above.
- At least two courses must be thematically related. Courses that fulfill this requirement are typically in the same department or program.
- One of the courses must also satisfy the University multicultural requirement. Courses that satisfy this requirement are approved by a University committee and are designated as such in the course catalog and course registration booklet.

The general education courses are meant to broaden the education of our engineering students. These classes contribute to the achievement of program Objectives 2 and 3 (see Table B.2.1). The College maintains a list of approved general education courses that CE majors can use to satisfy this requirement. The list is available online at <http://www.engr.udel.edu/adsup/advise/gen-ed-req.html>.

## B.5 Faculty

This section of the report is aimed at demonstrating that our faculty has the competencies to cover all of the curricular areas of the program and that our faculty is of sufficient number and quality to engage in effective student-faculty interaction, advisement and counseling, service activities, professional development, and interaction with practitioners and employers, as required by Criterion 5.

### B.5.1 Faculty Distribution

The Department has 22.5 faculty lines, and there are currently 19.5 active faculty members in the department. (One faculty member, Jack Gillespie, specializes in composite materials and is shared 50-50 with the Department of Materials Science and Engineering.)

Three faculty have retired during the past 18 months, and recent searches to replace them will result in three new tenure-track faculty members joining the department for the 2005-2006 academic year, one in structures, one in coastal engineering, and one in transportation. Two of the three are females. One faculty member is retiring during the 2005-2006 academic year, and a search for his replacement will be conducted.

Table B.5.1 presents the current and future distribution of our faculty across the four sub-disciplines of civil

engineering the department supports.

### B.5.2 Adequacy of Size and Other Descriptors

The following sections provide a brief explanation of our faculty's adequacy to serve our undergraduate student population according to several descriptors.

#### SIZE

The number of full-time faculty directly or indirectly involved in the undergraduate program as of May 2005 is 19.5; this includes the Chair, who teaches classes. National searches have yielded three additional faculty to fill positions created by retirements. Graduate students serve as teaching assistants, laboratory supervisors, and graders but do not serve as primary instructors. With this number of faculty lines, the department has a very good student-to-faculty ratio.

A typical administered workload in the department would include the teaching of three three-credit courses per academic year (a three-credit course has 150 contact minutes per week). These courses would typically be assigned so that in one semester of the academic year a faculty member would have one three-credit contact hour course per week, for a teaching workload of 12.5%. In the other semester, the faculty member would have two such courses, for a teaching workload

**Table B.5.1 Faculty Distribution by Discipline**

Civil Engineering Discipline	Faculty as of 2004-05 Academic Year	New Hires in 2005-2006	Faculty as of 2005-06 Academic Year
Structures	4.5	1	5.5
Geotechnical	2	—	2
Transportation	3	1	3
Environmental and water resources*	10	1	11
<b>Total</b>	<b>19.5</b>	<b>3</b>	<b>21.5**</b>

\* the large number of faculty in environmental and water resources is a function of our bachelor's in environmental engineering degree program, as well as our graduate program in coastal engineering

\*\* reflects one retirement as of 2005-2006

of 25%. Research represents 32.5% of workload effort in the semester with a 12.5% teaching load, and 20% effort in the other semester. Service to the department, university, and profession is expected at a level of 5% effort per semester. All workloads are administered, and variations to teaching occur to accommodate increased or decreased levels of effort in the areas of research or service.

**RANK**

The distribution of rank among the 19.5 current professors (and three new faculty) is as shown in Table B.5.1. Three of the faculty at the full professor level hold named professorships in recognition of their outstanding teaching, research, and service record.

**Table B.5.1 Faculty Distribution by Discipline**

Level	Faculty as of 2004-05 Academic Year	New Hires in 2005-2006	Faculty as of 2005-06 Academic Year
Assistant Professor	2	2	4
Associate Professor	6	0	6
Full Professor	11.5	1	11.5*

\* reflects one retirement as of 2005-2006

**DEGREES**

The large majority of faculty hold BS degrees in civil engineering, and all but one hold earned doctorates (Ph.D.s) in civil engineering. The one non-civil Ph.D. is an environmental engineering professor whose degree is in chemistry. All degrees were earned from reputable research universities.

**AGE**

The average age of the current 19.5 faculty is 50, ranging from 32 to 66. Three faculty have retired during the past 18 months, and one more will retire during the coming year; however, it does

not appear that the department will face another wave of retirements in the near future. Following these retirements, the department’s age distribution suggests stability for the department and the BCE program in the future.

**YEARS AT UD**

The average years of service at UD among the CEE faculty is 15, also suggesting stability.

**NON-ACADEMIC EXPERIENCE**

The average number of years of experience in industry, government, or professional practice outside of academia is 5.2, ranging from 0 to 36.

**PROFESSIONAL REGISTRATION**

Seven of the 19.5 faculty hold PE licenses (36 percent), four in Delaware and one each in Kansas, Michigan, and Pennsylvania. These faculty teach the vast majority of design-related classes, as shown in Section B.8.

**SERVICE**

All of the CEE faculty at the University of Delaware, which is a state-assisted private institution, are involved in service to the department, the College, the University, the State, and the profession. The most common activities include serving on departmental and college committees, reviewing papers for journals, serving on professional societies through committee work, helping to plan conferences, serving as journal editors, reviewing proposals, teaching short courses and workshops, and consulting. Service activities typically comprise about 10% of faculty workload effort.

The following are the CEE departmental committees:

- Graduate Committee
- Undergraduate Committee
- Department ABET committee
- Promotion and Tenure Committee

- Safety Committee
- Ad-Hoc Committee of Group Leaders
- Ad-Hoc Committee of Named Professors
- Ad-Hoc Committee of Center Directors

### **B.5.3 Professional Development Activities**

All faculty are actively engaged in professional development in order to be more effective as teachers, advisors, and scholars. Active participation in professional societies, planning and participation in workshops and conferences, and presentations at professional meetings are among the most prevalent professional development activities of the faculty. The typical faculty member attends four conferences per year and presents six papers. Faculty also participate in professional development for teaching—for example, by attending short courses and workshops sponsored by the University Institute for Transforming Undergraduate Education, and ASCE’s ExCEEEd Workshop. Finally, faculty (primarily those on the ABET Committee) maintain their familiarity with the accreditation process by attending ABET-related workshops and conferences.

### **B.5.4 Undergraduate Advising**

All members of the faculty are involved in undergraduate advisement, as described in Section B.1.2. The rationale for this is that it allows all faculty to stay current on curricular issues and requirements, helps maintain a low faculty-to-student ratio in advising, and fosters new ideas and innovation in the curriculum. Students with special status (e.g., Honors students) are all assigned to a designated faculty member.

### **B.5.5 Faculty-Student Interaction**

Faculty have many opportunities to interact with students, including in the classroom, during scheduled office hours, at student chapter meetings of professional societies, and at

departmental seminars. Faculty offices are located in close proximity to classrooms, the undergraduate study room (DuPont 304), and the eCALC-II Lab (DuPont 140), providing the opportunity for impromptu interaction. Overall, students indicate that the faculty are very accessible and that there are no discernible barriers to open communication between undergraduates and faculty in the department.

### **B.5.6 Interaction with Practitioners and Employers**

Through the course of their efforts in teaching, research, and service, our faculty have significant opportunities to interact with practitioners. This interaction is valuable in understanding the priorities and ideas of practitioners toward enhancing scholarship in the department. The following regular activities engaged in by all of our faculty provide opportunities for significant interaction with practitioners.

- **Conferences**—All of our faculty make presentations at national, international, regional, and state meetings. In most cases, the presentations are to report on research findings to audiences comprising both researchers and practitioners. At these meetings, faculty have numerous opportunities to attend presentations of practitioners and to interact with them at exhibits, meals, and other events associated with these conferences.
- **National Committees**—All of our faculty are members of several national committees, most of which are associated with professional societies and comprise both practitioners and academics. The scope of the national committees includes developing new codes and standards, planning sessions at national meetings, setting technical priorities, and improving education.

- **Professional Societies**—Most of our faculty are involved in professional societies beyond the role of committee member. For example, many have served as session Chairs or organizing committee members for annual meetings or symposia.
- **Consulting**—Many of our faculty members apply their expertise to practical problems at the local, state, regional, and national levels through consulting. Working in this capacity provides interaction with practitioners.
- **Sponsored Research**—A substantial portion of the department’s \$7M+ annual research program is funded by state and federal agencies, as well as industry. A majority of the project managers and program monitors that award and supervise these projects on behalf of agencies are practitioners. Faculty interact significantly with these professionals throughout the course of their research projects.
- **ABET Constituent Committee** – This committee was previously described in Section B.2. It includes employers and alumni. The purpose of the committee is to provide input and feedback to the department as part of the ABET process. The committee is one other mechanism for faculty to interact with practitioners and employers.
- **External Advisory Council**—The roles of the CEE External Advisory Council (EAC) are to provide an outsider’s view for the faculty and the Chair with regard to annual and long-term strategic planning. The EAC focuses on all issues that face the department in areas of education, research, and service. The members represent government agencies, consulting firms, and other academic institutions, providing yet another opportunity for faculty to interact with practitioners and for the department as a whole to benefit from their collective wisdom.
- **Off-campus Faculty**—The department employs a number of off-campus faculty to teach specialized courses, including being heavily involved in the Senior Design class. These individuals are practitioners with consulting firms, government agencies including the Delaware Department of Transportation, and construction companies. They provide both our traditional faculty and our undergraduate students with a practical perspective to augment the theoretical approach typically brought to the classroom. The vast majority of off-campus faculty are registered Professional Engineers.

### **B.5.7 Competence of Faculty to Cover Curricular Areas**

All faculty members hold earned doctorates (Ph.D.s) in civil engineering or a related field from reputable research universities and have strong teaching and research credentials. Two-page CVs of all faculty members, full-time as well as off-campus, are included as Appendix IC.

The quality of the teaching in the department is evidenced by the high performance on Student Evaluations. During the past six years, ten of our faculty have been nominated for college or university teaching awards, and four have won such awards (Professors Chiu, Faghri, Kikuchi, and Shenton).

Most of our faculty are recognized scholars in their field of research specialization. The department averages approximately \$7M in sponsored research expenditures each year—an average of just over \$350K per faculty member—in the form of external contracts and grants. Our faculty have maintained a high degree of quality in their research, averaging about 3.5 archival refereed journal publications per faculty per year.

The quality of the CEE faculty is also evidenced by awards and other recognition, including awards from

professional societies. For example, Professor Dominic Di Toro was recently named a "Highly Cited Researcher" by the Institute of Scientific Information, and he was elected to the National Academy of Engineering this past year, Professor Dennis Mertz recently received the Richard R. Torrens Award from ASCE for his efforts as the founding editor of ASCE's Journal for Bridge Engineering, Professor Nobu Kobayashi was the recipient of the Coasts, Oceans, Ports, and Rivers Institute's Moffatt-Nichol Award, and Professor Ib Svendsen won the International Coastal Engineering Award this past year. In addition, many of our faculty have been sought as experts in their area of expertise: Professor Herbert Allen was invited to testify before the House Resources Committee Subcommittee on Energy and Mineral Resources; Professor Michael Chajes is frequently interviewed on bridge issues; Professor Kirby has been quoted on tsunamis and wave mechanics; and Professors Kirby and Jack Puleo appeared on CBS to describe the dangers of rip currents. Finally, the research accomplishments of several faculty have been received national attention including a piece in *Newsweek* on the work of Professors Shenton and Wool (Chemical Engineering) on bio-based composites and the development and implementation of composite armor for the Army's Humvee by Professor Gillespie and his research team at CCM.

## **B.6 Facilities**

This section addresses the classroom, laboratory, and computer facilities for the Civil Engineering program and draws conclusions on the adequacy of these facilities.

### **B.6.1 Classrooms**

Non-civil engineering courses, e.g., math, science, and general education courses, may be taught in any number of buildings but are typically located in or near the respective "home" department.

A majority of civil engineering (CIEG) courses are taught in DuPont, Gore, and Memorial Halls. DuPont Hall received a 60,000-square-foot addition that was completed in 2002. The building has one lecture-style classroom (Room 350) that seats 35, and a computer teaching laboratory (Room 140) that seats 48. Room 350 was remodeled recently and equipped with permanent audio-video and information technologies. The room is typically used for upper-level required courses and technical electives. DuPont 140 is a state-of-the-art facility that is referred to as "eCALC-II." CIEG126, Introduction to Surveying and CAD, is taught exclusively in eCALC-II. The classroom is also used in other courses on an as-needed basis. For example, the Structural Analysis (CIEG301) has a weekly meeting in eCALC-II, during which the students learn how to use STAAD (a commercial structural analysis software package). A similar computer classroom, called "eCALC-I," is located in Colburn Laboratory. eCALC-I, which seats 52, was built a few years prior to eCALC-II and is also used for certain civil engineering courses. These classrooms are excellent facilities for teaching computer software and applications.

Gore Hall, a 65,000-square-foot general-purpose classroom building located on the "Green" (the central campus mall), was dedicated in April 1998. It was the first new building to be built on the Green in 30 years and features a three-story

central atrium, 17 general classrooms, four seminar rooms, three tiered case-study rooms, and one problem-based learning classroom. The classrooms range in capacity from 10 to 100. All of the classrooms are equipped with the latest in audio-visual and information technologies.

Memorial Hall is also a general-purpose classroom building and the home of the English Department and the University Writing Center. The building has 16 classrooms that range in capacity from 20 to 90. The building underwent a 15-month, \$9.8-million-dollar renovation and was rededicated in 1999. As with Gore Hall, the classrooms are all equipped with the latest audio-visual and information technologies.

Overall, the classroom facilities are in excellent condition.

### **B.6.2 Laboratories**

The Department of Civil and Environmental Engineering maintains four laboratories that are used for civil engineering core courses. All of the laboratories are in very good or excellent condition. The laboratory equipment and instrumentation is in good to excellent condition. Each is described briefly below:

#### **STRUCTURAL TESTING LABORATORY (DUPONT 180)**

The Department maintains a high-bay structures laboratory that is used in teaching CIEG213, Solid Mechanics Laboratory. Students in the class conduct experiments to study the strength and mechanical properties of steel, concrete, and wood. Experiments are also conducted to investigate beam bending. For a detailed list of experiments, see the syllabus for CIEG213. The equipment in the 95 ft. by 40 ft. high-bay lab includes the following:

- 5-ton overhead crane
- Strong Floor
- Several Test Frames

- MTS Flex Test System
- MTS Hydraulic Pump (55 gpm)
- (2) 55-kip MTS Actuators with Load Cells
- (3) 150-kip MTS Actuators with Load Cells
- (2) 20-kip Gilmore Actuators with Load Cells
- 400-kip Tinius Olsen Universal Testing Machine
- 200-kip Tinius Olsen Universal Testing Machine
- 20-kip Tinius Olsen Universal Testing Machine
- 2-kip Instron Testing Machine
- 200-kip Center Hole Jack
- 100-kip Center Hole Jack
- 10,000-psi Hand Pump
- Vishay System 4000 Data Acquisition System
- Vishay System 5000 Data Acquisition System
- Environmental Room for Controlling Temperature of Concrete Specimens
- Concrete Moisture Curing Room
- Freeze Thaw Chambers
- Concrete Compression testing Machines
- 40-Channel Structural Testing System for Field Testing of Bridges
- Vibrating Wire Read-Out Box
- Strain Gage Welder

The laboratory has recently undergone various upgrades and renovations. This included upgrading the 200 and 400 kip Tinius Olsen test machines, installation of new lighting, enlargement of the south laboratory door, installation of a second door on the north end of the lab, and construction of an enclosed loading and storage area.

#### **SOILS LABORATORY (DUPONT 183)**

The Department maintains a soils laboratory that is used in teaching CIEG321, Soil Mechanics Laboratory. Students in the class are divided into small groups and conduct experiments that illustrate the basic properties of soils. For a detailed list of the experiments conducted, see the syllabus for CIEG321. The lab equipment includes the following:

- Sieves system and appropriate scales
- Hydrometers and ovens
- Atterberg device
- Compaction test setting
- Consolidometers
- Direct Shear device
- Triaxial system
- Accessories needed to prepare and test soil samples

#### **FLUID MECHANICS LABORATORY (OCEAN ENGINEERING LABORATORY)**

The Department maintains a two-story, 30 m x 38 m ocean engineering laboratory that is used in teaching CIEG-306, Fluid Mechanics Laboratory. Students in the class conduct seven experiments to examine the limitations and applicability of theories of fluid flows taught in CIEG-305, Fluid Mechanics. They also learn experimental techniques in fluid dynamics and data analyses. For a list of the experiments conducted, see the list of topics on the syllabus for CIEG306.

The undergraduate fluid mechanics laboratory equipment includes

- Hydraulic bench for four experiments.
- Torroid device for hydrostatic pressure experiment.
- Plastic barge for floating body stability experiment.
- Tank with a hole for Bernoulli experiment.
- Apparatus for water jet experiment.

- Flume with a sluice gate for hydraulic jump experiment.
- Pipes with flow meters.
- Apparatus for Reynolds experiment.

Other equipment in the laboratory includes the following:

- Directional wave basin (20 m x 20 m x 1.1 m) to generate three-dimensional wind waves.
- Precision wave flume (33 m x 0.6 m x 0.76 m) to generate two-dimensional waves and currents.
- 8.5-m diameter spiral wave basin to generate obliquely incident waves and longshore sediment transport.
- Silicon Graphics workstations
- Sun workstation network
- Capacitance wave gauges
- Acoustic-Doppler velocimeters
- Fiber-optic Laser-Doppler anemometers

**INTELLIGENT TRANSPORTATION SYSTEMS LABORATORY (DuPONT 341)**

The department maintains a state-of-the-art intelligent transportation laboratory that is used for research and teaching of the Transportation Engineering (CIEG451) course as well as for traffic engineering and planning classes. This laboratory was built in 2001 with financial support from the Delaware Department of Transportation and a gift from alumnus Richard Hangen. This lab receives real-time images of the traffic conditions at various locations (intersections, bridges, freeways) in the state. The images are transmitted through the DelDOT's Transportation Management Center. The lab is expected to receive data on transit vehicle locations, signal timing, and traffic volume count in the near future. The

visual and digital information is used to learn driver behavior, pedestrian behavior, traffic patterns, and traffic signal timing. The information is used to teach students about the real-world probabilistic nature of traffic phenomena and the effects of control. The lab also conducts various basic and applied research related to advanced transportation including simulation (SYNCHRO, VISSIM), modeling of pedestrian movement (WALKSIM), and large-scale travel demand forecasting model (TRANSIMS). In addition, the lab conducts basic research on the application



of Artificial Intelligence techniques for uncertainty analysis and data treatment. The lab has been serving as a recruiting tool for high school students interested in civil engineering.

The department laboratories are more than adequate for the Civil Engineering program.

**B.6.3 Equipment and Tools**

The department maintains a complete machine shop in DuPont Hall. Rooms 147 and 148 provide a combined 800 square feet of shop space for fabrication and assembly of custom parts and equipment. The shop maintains a wide variety of machines for metal and wood fabrication and is staffed by a full-time master

machinist. The department also maintains a complete electronics shop in DuPont 147A. The shop is staffed by a full-time senior electronics specialist. Finally, the Structural Testing Laboratory maintains a collection of equipment and tools for fabrication and assembly of large fixtures and parts. This includes equipment for metal cutting (band saw and plasma cutter) and welding. The structures lab is staffed by a laboratory coordinator and a research technician.

The equipment and tools are used to support the maintenance and operation of the undergraduate laboratories, as well as research activities in the department.

#### **B.6.4 Computer Facilities**

The University prides itself on its IT and networking facilities. Using one of the many on-campus computing sites or personal computers in dorm rooms or off-campus, students can access limitless education resources from on-campus resources and the internet. There are general access computer sites in Smith, McDowell, Pearson, and Willard Halls. These sites maintain Windows, Macintosh, and SUNray platform computers with general application software and hardware. These facilities are generally open from 8:00 am to midnight during the week and 10:00 am to 10:00 pm on the weekend. The College of Engineering maintains engineering computing sites in 010 Spencer Lab and 340 DuPont Hall. These facilities are equipped for special-purpose uses, such as for graphics and engineering. Engineering students can also use the eCALC rooms during non-class times. The rooms are monitored until midnight during the week and from noon to 8:00 pm on weekends. Entrance to the eCALC rooms is by card access only. For those that live on-campus, all dormitories are equipped with direct Ethernet connections. From off-campus, students can access the network using a modem and communications software. The University also offers access to the network via wireless LAN in selected

areas on campus. This includes many of the academic buildings on campus and a majority of the dormitories.

The University computing facilities are more than adequate to meet the demands of the civil engineering program.

Listed below are some of the major software packages available on University computers for student use:

- Microsoft Office (Word, Excel, PowerPoint)
- AutoCAD
- MicroStation (coming during 2005-06)
- STAAD
- Maple
- MatLAB
- MathCAD
- HEC2
- TR-55
- Material Selection for Design

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

This section of the self-study report describes the level and adequacy of institutional support, financial resources, and constructive leadership to achieve program Objectives and assure continuity of the program, as required by Criterion 7.

### **B.7.1 College Budget Process**

The University of Delaware has a decentralized budget. This means that the College of Engineering is basically autonomous in terms of its budget process. The College is allocated a budget to support faculty and staff salaries and funds for teaching assistants, as well as general operating funds. The College retains 70% of all overhead generated through contracts and grants, and the University retains 2%. These funds are first used to pay a pre-defined benchmark set by the University to cover operating costs, as well as graduate student tuition. If the College earns overhead beyond this benchmark, it is used to further support programs in the College.

### **B.7.2 Department Budget Process**

The College of Engineering budget is divided among the five departments in the College. The Civil and Environmental Engineering Department has an allocated budget that covers the salaries of all 22.5 faculty in the department and 8 staff positions. The remaining 9 staff positions are supported on soft funds generated through research contracts and grants. The Department budget also provides temporary teaching funds (for teaching assistants and off-campus faculty), equipment maintenance funds (for undergraduate labs), and computer maintenance funds (for computer upgrades). The Department is also fortunate to have several endowments that support both undergraduate and graduate students, as well as Departmental initiatives. Finally, the

department retains 28% of all overhead generated through contracts and grants, as well as benefits from an active research program that brings new, state-of-the-art equipment into the CE labs. Based on these resources, the department has sufficient funds to operate its programs, as well as perform the needed upgrades.

### **B.7.3 Institutional Support, Funding, and Resources**

The University of Delaware is a state-assisted private institution. Approximately 20% of the University budget comes from state support. Therefore, in addition to funds provided by the State, revenue is generated through tuition and fees, contract and grants, and interest on the University's endowment (which currently exceeds \$1 billion). The allocation of State funds and tuition dollars is made in the form of the operating budgets and faculty and staff salaries already described. The overhead generated from contracts and grants is also allocated as previously described. In addition to these funds, the University provides funding for programmatic and facility upgrades through the allocation of endowment income.

The favorable financial status of the institution over the past decade has allowed the department to hire and retain well-qualified faculty. There are several factors that contribute to our recruitment and retention efforts. First is an outstanding benefits package including faculty salaries that are above the mean for comparable institutions, as reported by the AAUP. Second, the University has recently completed a very successful capital campaign that raised \$425 million. The campaign enabled the creation of 94 new named professorships throughout the University, which are used to attract, reward, and retain highly regarded faculty. Finally, attractive start-up packages for new faculty members enable us to hire talented candidates at all levels. Additional information on faculty benefits

can be found in Appendix II, Section B.6.b.

The department is able to attract outstanding undergraduate students and provides roughly \$250,000 per year for scholarships and awards to some 65 students annually. This is in addition to University-level scholarship support.

Finally, but not least important, the University has actively and aggressively allocated funds to build new facilities and upgrade older buildings. As mentioned previously, a 60,000-square-foot addition has been added to DuPont Hall, the home of the College (CE has space in this building). In addition, the third floor in the original portion of DuPont Hall has been renovated. Campus-wide, many new buildings have been constructed, and several have direct positive impacts on the CE program and students.

#### **B.7.4 Adequacy of Faculty Professional Development**

Faculty professional development is primarily accomplished through workshops, seminars, conferences, professional publications, and committee service in professional societies.

Some of these activities are on campus, including regular departmental seminar series in all of our research concentration areas, named faculty lectures sponsored by the College, and University-wide lectures, seminars, and IT user education classes. There is essentially no cost to faculty for these on-campus events, thus providing a viable source of faculty development without requiring Departmental resources.

Many of these activities are off-campus. Faculty travel funds are the primary cost for off-campus development activities. Sources of travel funds include research contracts, annual Departmental allocation to faculty, and faculty maintained development accounts. Some faculty are invited speakers at conferences with

travel expenses covered by the event or by a professional society such as ASCE.

#### **B.7.5 Resource Plan for Facilities and Equipment**

There is currently a base budget allocation from the College to the department for the timely improvement of computers (\$10,800 annually) and laboratory equipment (\$22,500 annually). These funds are adequate to upgrade and maintain computer and equipment for undergraduate labs. The Department asks the faculty in charge of the undergraduate lab classes to provide annual requests for these funds, and the Chair prioritizes needs and allocates the funds accordingly. During the past years, these funds have been more than adequate for this purpose.

Additional equipment is often purchased as part of research grants, and the University sometimes provides matching funds for some of these equipment purchases. The annual State allocation to the University also designates targeted areas each year for support, which may include facilities and equipment for specific departments, areas, centers, or programs. In addition, the UNIDEL foundation—which provides gifts for purposes that might be difficult or unlikely to be accomplished otherwise—has provided support for CEE programs (this money is a portion of the endowment interest). In the mid 1990s, UNIDEL and the State both provided funding for equipping the department's high-bay structures lab, and in the late 1990s UNIDEL provided funds for equipment to support environmental engineering labs. The foundation gave support for the establishment of the department's bridge laboratory, a virtual-design-firm environment for students. These three most recent UNIDEL allocations totaled nearly \$1 million.

## B.8 Program Criteria

This section covers the program criteria developed by the American Society of Civil Engineers. The criteria address the curriculum and the faculty.

### B.8.1 Curriculum

*Criterion: The program must demonstrate that graduates have proficiency in mathematics through differential equations, probability and statistics, calculus-based physics, and general chemistry.*

All civil engineering students are required to take the following courses:

- MATH241, Calculus A, 4 credits
- MATH242, Calculus B, 4 credits
- MATH243, Calculus C, 4 credits
- MATH351, Engineering MATH I (Differential Equations with Linear Algebra), 3 credits
- MATH353, Engineering MATH III (Numerical Methods), 3 credits
- CIEG315, Probability and Statistics for Engineers, 3 credits
- CHEM103, General Chemistry (with lab), 4 credits
- PHYS207, General Physics I (with lab, MATH241 co-requisite), 4 credits
- Science Elective, as described in Section B.4.3.a (PHYS, CHEM, GEOL, or BIOL), 4 credits

These math and science courses provide the foundation for the core required courses in the civil engineering program.

*Criterion: The program must demonstrate that graduates have proficiency in a minimum of four (4) recognized major civil engineering areas.*

Graduates of our program are proficient in the following four major areas of civil engineering: (1) structural engineering, (2) environmental and water resources

engineering, (3) transportation engineering, and (4) geotechnical engineering. The means by which students obtain proficiency in each of these areas is discussed below.

Structural Engineering – As a foundation for this area, all civil engineering majors are required to take Statics (CIEG211), Solid Mechanics (CIEG212), Civil Engineering Materials Laboratory (CIEG213), Dynamics (CIEG311), and Material Science (MSEG302). Building upon this foundation of solid mechanics and materials science, students are then required to take Structural Analysis (CIEG301) and Structural Design (CIEG302).

Environmental and Water Resources Engineering – As a foundation for this area, all civil engineering majors are required to take Statics (CIEG211), Dynamics (CIEG311), Fluid Mechanics (CIEG305), and Fluid Mechanics Laboratory (CIEG306). Building upon this foundation in mechanics, students are then required to take Environmental Engineering (CIEG331) and Water Resources Engineering (CIEG440).

Transportation Engineering – As a foundation for this area, all civil engineering majors receive extensive preparation in mathematics and numerical methods. Students are also required to take Probability and Statistics for Engineers (CIEG315) and Dynamics (CIEG311). This math background is particularly important for the required Transportation Engineering (CIEG351), and, beginning in the fall of 2005, Transportation Engineering Laboratory (CIEG451) classes.

Geotechnical Engineering – As a foundation for this area, all civil engineering majors are required to take Statics (CIEG211), Solid Mechanics (CIEG212), Civil Engineering Materials Laboratory (CIEG213), Dynamics (CIEG311), Materials Science (MSEG302), Fluid Mechanics (CIEG305), and Fluid

Mechanics Laboratory (CIEG306). Building upon this foundation in solid and fluid mechanics, students are then required to take Soil Mechanics (CIEG320), Soil Mechanics Laboratory (CIEG323), and Geotechnical Engineering (CIEG321).

Finally, our capstone Senior Design (CIEG461) course deals with a multidisciplinary civil engineering problem that incorporates issues from all four of these areas of proficiency. As such, it allows all of our students to further develop their proficiencies in the four areas.

*Criterion: The program must demonstrate that graduates have the ability to conduct laboratory experiments and to critically analyze and interpret data in more than one of the recognized major civil engineering areas.*

All civil engineering students are required to take the following laboratory classes:

- CIEG213, Solid Mechanics Laboratory
- CIEG306, Fluid Mechanics Laboratory
- CIEG323, Soil Mechanics Laboratory
- CIEG451, Transportation Engineering Laboratory (beginning in fall 2005).

All of these courses are laboratory based and require students to conduct experiments, analyze and interpret their results, and present their findings in a laboratory report. In addition, students are required to take Probability and Statistics for Engineers (CIEG315), in which they learn the theory of data analysis.

*Criterion: The program must demonstrate that graduates have the ability to perform civil engineering design by means of design experiences integrated throughout the professional component of the curriculum.*

Civil engineering students gain design experience through a number of courses

that make up the professional component of the curriculum. The students are introduced to design in their Introduction to Civil Engineering class (CIEG125). The sophomore year primarily focuses on engineering sciences classes that form the foundation for design. The treatment of design in the various disciplines begins in the junior year, with four design courses: Structural Design (CIEG302); Geotechnical Engineering (CIEG321); Environmental Engineering (CIEG331); and Transportation Engineering (CIEG351). As its name implies, CIEG302 is a design course in which students learn the fundamentals of steel and concrete design. The other three courses combine analysis and design in the respective disciplines. The design experience continues throughout the senior year, with the capstone Senior Design (CIEG461) course. As previously described in Section B.4.2, students work together in large "companies" to complete the preliminary design of a major civil engineering project. The projects are modeled after actual projects in the region, and each project includes an element of structural, environmental and water resources, transportation, and geotechnical engineering. Students are required to submit a preliminary proposal and a final report and to make an oral presentation to the "owners." To round out their design experience, students take Construction Methods and Management (CIEG486) and three technical elective courses, one of which must be design oriented.

*Criterion: The program must demonstrate that graduates have an 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.*

All students begin to learn about professional practice issues in their Introduction to Civil Engineering class (CIEG125). In this class, guest lecturers such as Terry Neimeyer, President and CEO of KCI Technologies, are invited to speak to the freshman about the CE profession. During the junior year, a representative from the Delaware Association of Professional Engineers gives a presentation in a required class on the importance of professional licensure. The treatment of professional practice issues culminates in the two-semester capstone Senior Design class (CIEG461) and the Construction Methods and Management class (CIEG486).

### **B.8.2 Faculty**

*Criterion: 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 that it is not critically dependent on one individual.*

The Department has 22.5 faculty lines. During the 2004-2005 academic year, the department had 19.5 full-time faculty members including the Chair. During the 2005-2006 academic year, the department will have 21.5 faculty members. As noted in Table I-4 in Appendix I.A, seven of the current 19.5 are registered professional engineers. All but one faculty member holds a Ph.D. in civil and environmental engineering (Professor Allen holds a Ph.D. in Chemistry). Many of the faculty also have professional experience outside the University, are actively involved in consulting, participate regularly on technical committees of ASCE and other professional societies, and interact with practicing engineers from the region. The program is not critically dependent upon any one individual. Further details on the faculty can be found in Section B.5 and Appendix I.C.

As indicated on the check sheet that is provided to each student (see Appendix I.D.1), every student must take and pass courses providing at least 17 design points. Required courses provide 14 design points. At least three (3) additional design points must be completed via the student's three technical electives.

Virtually all of the required design classes are taught by full-time faculty who are professional engineers (PE's). A few of the senior level technical electives that have design components are also taught by off-campus faculty who are professional engineers and are actively engaged in the practice of engineering. The capstone Senior Design class (CIEG461) is taught by a team that for the past several years has comprised a faculty member who is a PE and four off-campus faculty, all of whom are PE's. Below is a list of the primary design classes and the faculty that have taught them during the past three years. Those that are PE's are indicated accordingly. Of the required classes, 19 different faculty have been involved in teaching these classes, and 17 are PE's.

Required classes with design content:

- CIEG302, Structural Design (M. Chajes, PE; D. Mertz, PE)
- CIEG321, Geotechnical Engineering (D. Leshchinsky, J. Yamamuro, PE; D. Charles, PE; S. Zeigler, PE; T. Thomson, PE)
- CIEG331, Environmental Engineering (C.P. Huang, PE; D. Cha)
- CIEG351, Transportation Engineering (S. Kikuchi, PE)
- CIEG440, Water Resources Engineering (G. Kauffman, PE)
- CIEG461, Senior Design (P. Imhoff, PE; M. Chajes, PE; C.P. Huang, PE; J. Bross, PE; M. Paul, PE; E. Kuipers, PE; J. Sentman, PE; M. Thomson, PE)

- CIEG486, Construction Methods & Management (B. Muir, PE, T. O'Brien, PE)