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1 THE SYSTEM OF UNDERGRADUATE ENGINEERING EDUCATION IN THE USA

1.1 Admissions

The admission requirements vary by institution in the US; however, there are five components common to all college applications:
- Application form
- Standardized test scores (SAT or ACT)
- Essay(s)
- Letters of recommendation
- High school transcripts

Recently, many universities and colleges in the US have started using a common application form that can be found online at http://www.commonapp.org. Each university sets its own admission criteria and decides how much importance to place on each of these components when selecting applicants.

1.2 Private and public universities

Colleges and universities in the US may be either public or private. Public institutions are state-run, receive subsidies from the state, and offer reduced tuition rates for in-state students. Private institutions are privately-run non-profit organizations. Often, public universities are larger than private universities. For example, in Pennsylvania, the main campus of The Pennsylvania State University (commonly known as Penn State) is located in State College, PA. It has 36,815 undergraduates at its main campus. Pennsylvania residents pay $14,068 a year for tuition, while non-residents pay $25,166 a year for tuition. The University of Pennsylvania is located in Philadelphia, PA. It has 10,163 undergraduates that pay $35,916 a year for tuition. While it is possible for a student to complete the first two years of schooling at a community (i.e. 2 year) college, typically students directly enroll at a 4 year college or university.

1.3 Bachelor’s degrees in engineering

American Society for Engineering Education (ASEE) publishes statistics on engineering programs in the US (http://www.asee.org). In 2006 (the most recent year for which data was available), 74,186 bachelor’s degrees in engineering were awarded in the US. Of those:
- 9,226 were in civil engineering
- 437 were in environmental engineering
- 339 were in petroleum engineering
- 120 were in mining engineering.

There is no real geographic pattern associated with these degree patterns. Because most of the students taking geo-engineering courses in the US are civil engineering majors, the rest of this paper will focus on civil engineering.

1.4 Accreditation

Engineering programs in the US are accredited by the Engineering Commission of ABET, Inc. Accreditation is important for several reasons. First, students are assured of a certain level of quality, and second, graduation from an accredited program is the first step towards professional licensure. A list of ac-
credited programs and the criteria used to evaluate engineering programs may be found online at http://www.abet.org. (ABET also has a commission that accredits engineering technology programs, but these programs will not be discussed in this paper). ABET has a set of criteria that all engineering programs must fulfill. These criteria underwent a major revision in 2000. In the past, the criteria were much more prescriptive; the new criteria outline a set of educational outcomes that students must achieve by graduation. One effect of this new ABET criteria is that engineering programs in the US are increasingly diverse.

In addition, each program (such as Civil, Mechanical, Chemical, etc.) has a set of program-specific criteria that is developed by the associated professional group. For example, the American Society of Civil Engineers (ASCE) is responsible for developing the program-specific criteria for all programs that grant bachelor’s degrees in civil engineering.

Programs seeking accreditation must write a self-study report documenting their achievement of the various criteria describing their educational outcomes and objectives, admission and advising procedures, curriculum, institutional support, faculty strength, and adequacy of their facilities. Evaluators visit the school after reading the self study and comment on their observations, which informs the ABET Engineering Commission’s decision on whether to accredit the program.

2 PROFESSIONAL LICENSURE

2.1 Typical path

The path to professional licensure has several key steps, although there is some variation amongst the states. First, the candidate must graduate from an accredited program and pass the Fundamentals of Engineering (FE) examination to become an Engineer-in-Training (EIT). The FE is an 8-hour examination. The first half of the exam covers general engineering topics while the second half of the exam is discipline specific (e.g. Civil, Mechanical, Electrical and others). After obtaining at least four years (in most states) of progressive engineering experience under the guidance of a Professional Engineer (PE) as an EIT, the candidate must pass the PE exam. The PE exam is also 8 hours long. This exam is discipline specific (e.g. Civil) for the first half, and specialty specific (e.g. Geotechnical) for the second half. Many states require PEs to complete some continuing education units to maintain an active license. Information on licensure in the US is available online at http://www.ncees.org.

2.2 Changes on the horizon

Several years ago, ASCE passed Policy Statement 465, which will increase the educational requirements of licensure for civil engineers. In essence, this statement requires PE candidates to have an accredited bachelor’s degree plus 30 coordinated credits of graduate-level work in addition to progressive engineering experience under the guidance of a PE. ASCE anticipates that it will take between 5 and 15 years to implement this new policy. This change in policy has spurred the development of several other ASCE documents relating to education: Civil Engineering Body of Knowledge for the 21st Century and The Vision for Civil Engineering in 2025. All of these documents are available online at http://www.asce.org/professional/educ/.

3 GEO-ENGINEERING SUBJECTS AT THE UNDERGRADUATE LEVEL

As mentioned previously, engineering programs have more flexibility to define their own educational outcomes under the new ABET criteria. In addition, many programs are being encouraged to reduce the credits required to graduate with a bachelor’s degree. These two factors have lead to fewer required geo-engineering (usually referred to as geotechnical engineering in the US) subjects. The courses typically found at the undergraduate (bachelor’s degree) level are summarized in Table 1. Note that the total credits required to fulfill the requirements of a bachelor’s degree (BSCE) varies by institution, but usually falls between 120 and 140 credits.

<table>
<thead>
<tr>
<th>Course name</th>
<th>Required or elective</th>
<th>Year</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Mechanics or Geotechnical Engineering (with laboratory)</td>
<td>Required</td>
<td>3rd</td>
<td>4</td>
</tr>
<tr>
<td>Foundation Design Capstone Design</td>
<td>Elective</td>
<td>4th</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1. Geo-engineering courses often found at the undergraduate level in the US

There are approximately 220 universities in the US that offer a bachelor’s degree in civil engineering. At the time of writing, about half of those (116) were members of the United States University Council on Geotechnical Educational and Research (USUCGER). The mission of USUCGER is “to provide advocacy for the continued development and expansion of high quality geomechanical, geotechnical and geo-environmental engineering research and education which will enhance the welfare of humankind and meet the needs of the nation.” More information on USUCGER, including its history and
member organizations, can be found online at http://www.usucger.org/. The geo-engineering course offerings at four member institutions will be evaluated to illustrate the variety of courses available at US universities (Table 2). The only course required by all four universities is a junior-level soil mechanics course. All courses are worth 3 credits with the exception of the junior-level soil mechanics course, which is usually worth 4 credits with the laboratory component.

<table>
<thead>
<tr>
<th>University</th>
<th>Geo-engineering course</th>
<th>Required or elective</th>
<th>Year typically taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Missouri – Columbia</td>
<td>Fundamentals of Geotechnical Engineering (with lab)</td>
<td>Required</td>
<td>3rd</td>
</tr>
<tr>
<td></td>
<td>Geotechnical Earthquake Engineering, Earthwork Engineering and Design, Foundation Design, Geotechnics of Landfill Design, Capstone Design</td>
<td>Elective – graduate level courses open to undergraduates Required, but choose topic area</td>
<td>3rd or 4th</td>
</tr>
<tr>
<td>The University of Texas at Austin</td>
<td>Physical Geology, Introduction to Geology, Geology of Engineering</td>
<td>Elective</td>
<td>3rd or 4th</td>
</tr>
<tr>
<td></td>
<td>Sedimentary Rocks Geotechnical Engineering (with lab)</td>
<td>Required</td>
<td>3rd</td>
</tr>
<tr>
<td></td>
<td>Earth Slopes and Retaining Structures Foundation Engineering</td>
<td>Elective</td>
<td>4th</td>
</tr>
<tr>
<td>Bringham Young University</td>
<td>Geology Geoenvironmental Engineering, Foundation Engineering, Earth and Rockfill Structures, Geotechnical Analysis of Earthquake Phenomena</td>
<td>Elective – graduate level courses open to undergraduates</td>
<td>4th</td>
</tr>
<tr>
<td></td>
<td>Elementary Soil Mechanics (with lab)</td>
<td>Required</td>
<td>2nd</td>
</tr>
<tr>
<td></td>
<td>Geotechnical Analysis of Earthquake Phenomena Capstone Design</td>
<td>Required, but choose topic area</td>
<td>4th</td>
</tr>
<tr>
<td>Villanova University</td>
<td>Geology for Engineers Soil Mechanics (with lab) Foundation Design Capstone Design</td>
<td>Required</td>
<td>3rd</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Required, but choose topic area</td>
<td>4th</td>
</tr>
</tbody>
</table>

4 SPECIALIZATIONS IN GEO-ENGINEERING COURSES AND RESEARCH

There is not much specialization at the undergraduate level in geotechnical engineering. Rather, this specialization occurs at the master’s and doctorate level. At some universities, selected graduate-level classes may be open to exceptional undergraduates and/or those pursuing a 5-year BS/MS program. The courses available at the graduate level are often determined by the expertise and interest of the faculty teaching them. Describing the major sub-specializations within geotechnical engineering is always a difficult task, however, broadly speaking they are:

- Experimental methods
- Flow through porous media
- Foundation engineering
- Geo-environmental engineering
- Geo-statistics
- Geosynthetics
- Numerical modeling
- Risk and reliability of geo-structures
- Rock mechanics
- Site characterization including geophysical methods
- Slope stability
- Soil dynamics/earthquake engineering
- Soil improvement/stabilization
- Soil-structure interaction
- Unsaturated soil behavior

Several funding resources, including the National Science Foundation (NSF), provide support for “Research Experience for Undergraduates (REU)” projects that encourage the involvement of undergraduate students in the research studies. These early efforts of exposing undergraduate students encourage them to pursue higher education including master’s and doctorate studies.

5 GRADUATE PROGRAMS IN GEO-ENGINEERING

5.1 Advanced study

Students that wish to continue studying geotechnical engineering at a more advanced level will pursue a master’s or a doctorate degree. As mentioned previously, the course offerings and research are closely tied to the faculty at the institution; consequently, the variability in the courses at the graduate degree level is even greater than at the undergraduate level.

5.2 Master’s degree

Most (111 out of 116) of the USUCGER member institutions offer a master’s degree (MS or MEng). Typically, 30 credits are required to earn a master’s
degree and the student may or may not perform research that culminates in a thesis. If a thesis is written, about 6 credits of the 30 are for the research performed, while the remaining 24 credits are comprised of course work (MS). The research can be funded by the federal governmental (e.g. National Science Foundation), state government (e.g. state departments of environmental protection), or private industry. If a thesis is not written, all 30 credits are comprised of course work. In addition, a master’s student may go to school full-time or part-time. Usually, a full-time student will complete all of their requirements in two years. Part-time students typically do not pursue the thesis option and take their courses at night or on-line. Usually, a part-time student will need four years to complete their requirements. Part-time graduate programs are more abundant in or near major metropolitan areas.

The availability of 5-year or integrated BS/MS programs has increased in the past five years. Often, students participating in these programs do not pursue a thesis; however, a student with advanced placement credit may be able to do so. The courses available to these students are usually the same graduate level classes available to traditional two-year master’s students.

5.3 Doctoral degree

Ninety-four of the USUCGER member institutions offer a doctorate (PhD) in geotechnical engineering (usually civil engineering). Although a student considering a doctorate has many choices, the large public universities dominate in this arena. Students pursuing a doctorate degree typically complete an additional 24 to 30 credit hours beyond the master’s degree; between 9 and 12 of those credits are for research. Requirements vary by university, but typically after a semester or two at the university, a PhD student will have to pass a qualifying examination (written, oral, or both). This is a comprehensive examination to ensure that the student has sufficient knowledge of the specialty area to succeed in their research and can aid in the selection of additional coursework. Once the student has started their research, they often have to prepare a defense of their proposed work to their doctoral committee (4 to 6 members); this is usually an oral presentation. Finally, after completing their coursework and research, the student writes a dissertation and will orally defend their work to their doctoral committee.

6 CONTINUING EDUCATION

More and more states are requiring licensed PEs to obtain a certain number of continuing education credits each year. Typically, these events are hosted by a professional organization, such as ASCE. Depending on the state regulations the following activities can count towards their continuing education requirements:
- Conferences
- Short courses
- Attendance at a professional meeting/presentation.

7 SUMMARY

The state of geo-engineering education in the US is always in a state of flux – responding to the pressures, needs, desires, and interests of the students, parents, university administrations, federal agencies, industry, professional groups, and state legislatures. As we look forward to the second decade of the third millennium, the most pressing issues facing geo-engineering education will be:
- how to attract and retain the best students;
- continuing pressure by university administration and state legislatures to reduce the number of credits required to earn a BS;
- how to effectively teach an ever-expanding body of knowledge;
- how to effectively teach in light of ever-increasing research requirements; and
- the effect of increased educational requirements (ASCE policy statement 465) for licensure on graduate education.

REFERENCES

All of the information for this report was obtained from online sources so that others may also easily access the information. The websites are provided throughout the text, but are also summarized below:
- Common Application for undergraduate study: http://www.commonapp.org
- American Society for Engineering Education (ASEE) with links to reports on engineering education statistics, conference proceedings, information about upcoming conferences, and fellowships: http://www.asee.org
- Degree accreditation by ABET, Inc., including the criteria used to evaluate programs, a list of accredited programs, and upcoming workshops and conferences: http://www.abet.org/
- American Society of Civil Engineers (ASCE) documents and reports on education, including Policy Statement 465: http://www.asce.org/professional/educ/
- Professional licensing, including requirements, links to state boards, and how to use the FE for educational assessment: http://www.ncees.org/
- United States Council on Geotechnical Educational and Research (USUCGER): http://www.usucger.org