Construction Engineering: an Integrative Branch of Engineering

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Abstract

Construction engineering is a separate and distinct branch of engineering recognized by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC-ABET). The specific case of the developing construction engineering program at the University of Nebraska provides examples supporting the general conclusions of this discussion.

Construction engineering is an integrative branch of engineering that draws upon the basic branches, such as civil, mechanical, and electrical. The relationship construction engineering has to civil engineering is similar to that of industrial engineering to mechanical engineering. In construction engineering, the structural and geotechnical portions of civil engineering integrate with portions of mechanical and electrical engineering that relate to the built environment. Additionally, construction engineering integrates into its curriculum the skills of estimating and scheduling from industrial engineering along with accounting, organizational behavior, psychology, business methods, and business law from disciplines external to engineering. Thus it is shown that construction engineering is one of the 14 integrated programs accredited by EAC-ABET and not one of the 10 specialty programs, such as forestry engineering, recognized by EAC-ABET.

This discussion presents the activities of the University of Nebraska's work in joining the world's eight construction engineering programs accredited by EAC-ABET. The Nebraska construction engineering program is designed to offer undergraduate and graduate degrees including the doctorate. Evidence of employer and society needs is balanced against student demand for construction engineering to show that existing programs are producing graduates capable of obtaining a P.E. license in any U.S. or international jurisdiction. These types of graduates are sought by constructors, designers, regulators, and owners involved with the increasingly complex built environment where construction encompasses about 11 percent of the global GDP.

Overview and Background of Construction Engineering

The earliest EAC-ABET accredited bachelors degree program in construction engineering (ConE) was North Carolina State, which received its accreditation in 1958. Since that time, seven other ConE programs have appeared [1]. The eight exiting programs are listed as follows, with approximate enrollments and graduates in 2003-2004 [2]:

- Iowa State University, 325 students, 65 graduates

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- University of New Mexico, 4 students, 1 graduate
- North Carolina University, 140 students, 39 graduates
- North Dakota State University, 70 students, 17 graduates
- Purdue University, 124 students, 39 graduates
- Western Michigan University, 110 students, 20 graduates
- University of Wisconsin – Madison, 70 students, 35 graduates
- American University in Cairo, no data available at time of writing

The U.S. production of ConE graduates has been insufficient to meet the demand of a construction industry which accounts for about 11 percent of the GDP and affects a much larger portion of the GDP [3]. Construction projects are increasing in complexity as is evidenced by the "Big Dig" in Boston and the Bay Bridge renovation in San Francisco. These projects are very engineering intensive, requiring the engineering discipline for their successful execution. Clearly more than 200 graduates per year are needed to service the U.S. ConE demand alone. Thus the University of Nebraska's new School of Architectural Engineering and Construction (SAEC) has developed a ConE program from its existing base of 500 students enrolled in Construction Engineering Technology and Construction Management Programs.

Distinct Features of Construction Engineering

ConE introduces engineering disciplines into the construction industry by integrating engineering disciplines with other non-engineering disciplines particular to construction. The component disciplines of ConE break down roughly as follows:

- Construction: methods, equipment, business practices
- Civil engineering: structures, geotechnical
- Mechanical engineering: HVAC, piping
- Electrical engineering: power, lighting, control, communication
- Industrial engineering: estimating, scheduling
- Business: accounting, law, management
- Other: psychology, organizational behavior

The University of Nebraska SAEC thus sees ConE as having a partial overlap with civil engineering similar to the overlap industrial engineering has with mechanical engineering. ConE and industrial engineering integrate the pure engineering content of their basic counterparts, civil and mechanical engineering, respectively, with their own and other engineering and non-engineering topics to form a unique learning experience for their students.

The engineering expertise possessed by ConE graduates enables them to make rigorous, quantitative analysis of construction situations from the point of view of a constructor and not of an engineer unfamiliar with construction or a manager unfamiliar with engineering. In this way, complex construction problems can be addressed to avert what are often more serious problems with a constructed facility than problems it will encounter when it is placed into service.

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Integrative Features of Construction Engineering

The preceding portion of this discussion enumerates the disciplines integrated into ConE that make it a unique discipline unto itself, much in the vein of other integrative disciplines of engineering such as aeronautical, agricultural, architectural, industrial, and nuclear engineering. A good taxonomy for engineering disciplines by which ABET's overwhelmingly large array of accredited disciplines can be sorted is suggested by the following groupings:

- basic: chemical, civil, electrical, mechanical
- integrative: ConE and those mentioned previously
- specialty: highly focused, often in a specific economic sector

ABET currently accredits 28 distinct disciplines, two others in "general" and "other" categories, and surveying engineering [1]. Regarding the four basic categories just enumerated, the remaining 24 distinct discipline categories subdivide into 14 integrative and 10 specialty categories such as forestry, marine, plastics, and welding engineering. In terms of P.E. examinations given by NCEES the ratio of basic:integrative:specialty examinations is 4:11:3 which shows that the basic and integrative categories receive more examination scrutiny than the specialty categories [4].

Introducing a New Construction Engineering Program

In response to the conditions presented in the preceding discussion, the SAEC has spent over a year working within the University of Nebraska College of Engineering and Technology (CET) to tailor its ConE program to the needs of the construction industry and the demands of its large construction student base. The CET maintains that the ConE program should be EAC-ABET accredited at the earliest possible date. Accreditation is a moving target as shown by the pair of EAC-ABET publications, the 2004-05 and 2005-06 policy and procedure manuals [5, 6]. However, generally speaking, the ABET "Criteria 2000" policies have stabilized sufficiently to allow the developers of a ConE program to plan accurately a successful mix of courses. Accreditation will be sought at the bachelors level which is consistent with all but one of the CET's 12 currently accredited programs.

The following course types have been included in the 131 semester credit hour (SCH) bachelors program:

- ConE courses	28 – 31 SCH
- civil engineering courses	18 – 21 SCH
- other engineering courses	19 SCH
- arts and sciences courses	63 SCH

The other engineering courses include engineering mechanics, engineering economics, electrical engineering, and graphical processes, The arts and sciences courses include humanities and social sciences and the necessary science requirements of one semester of

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chemistry, two semesters of physics, and five semesters of mathematics including calculus (3 semesters), differential equations, and probability/statistics (1 semester each).

The ConE program will be offered on the CET's Omaha and Lincoln campuses as is civil engineering. Construction management will also be offered at these same locations. The CET has recognized that civil engineering faculty will have representation in the ConE curriculum planning activities which are planned for the Fall 2005 Semester. The Civil Engineering Department is not in the SAEC because of its role as a basic engineering program within the CET. However, its role in the integrative ConE program is recognized and appreciated. Within the SAEC the construction management faculty has played an important part in supporting the non-engineering construction courses in the Construction Management Program and ConE.

Conclusion and Future Plans for Construction Engineering

The ConE bachelors program described in this paper marks a major step forward for the University of Nebraska CET and the SAEC. Their students will be able to take advantage of an engineering curriculum in construction for the first time in the CET's history. The construction industry will be a major benefactor as it receives an infusion of well trained engineers able to secure a P.E. license through the soon-to-be acquired EAC-ABET accreditation.

A major – and perhaps the most significant – benefit of the ConE program described here is the enhancement of serious construction research. The SAEC will offer masters and doctoral programs in construction starting about a year after the bachelors program begins. The possibility of this research has attracted new faculty members to the SAEC at both newly awarded and seasoned Ph.D. levels. The SAEC has just hired a new faculty member for this purpose and expects to hire two to four more in the next several years. These new faculty members will strengthen an already strong faculty of construction practitioners.

Bibliography

1. ABET web site, www.abet.org/accredited_programs.html, accessed since June 23, 2003.

2. *Engineering News-Record*, October 21, 2002, as updated by subsequent communications with program administrators.

3. U. S. Bureau of Economic Analysis web site, www.bea.gov, accessed January 3, 2005, Table 1.1.10. Percentage of U.S. GDP Fixed Investments.

4. NCEES web site, www.ncees.org, accessed since June 23, 2003.

5. EAC-ABET, *2004-05 Accreditation Policy and Procedure Manual*, available at www.ncees.org.

6. EAC-ABET, *2005-06 Accreditation Policy and Procedure Manual*, available at www.ncees.org.

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Biographies

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Dr. Foster is a Professor and on the Graduate Faculty. His Ph.D. is from University of California at Berkeley, and his undergraduate education includes a S.B. and S.M. from MIT. In addition to his academic background, he has held key positions in the engineering, information technology, logistics, and construction industries. He was CEO of MultiTec, a design-construction holding company.

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