Integrating a Construction Engineering Management Focus in the Civil Engineering Curriculum

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Abstract

A large number of civil engineering graduates have to work with contractors on almost a daily basis or are employed by construction companies. To produce students who are better prepared to fulfill this role, the Civil and Environmental Engineering Department at University of Alabama at Birmingham (UAB) is introducing construction engineering management courses at the undergraduate and graduate levels. The objective is to graduate engineers who are familiar with the construction industry and have a better understanding of the role of the civil engineer in the construction process. Courses offered include project management, project planning, contracts, bidding, estimation, and other topics that are of importance to construction.

As a means to provide an incentive to the student, a certificate in Construction Engineering Management is awarded upon the completion of a required number of credit hours. The certificate prepares the undergraduate civil engineering student for a career in the construction industry. For those students who are not interested in a career in construction, the certificate provides them with sufficient background to act as owner's representatives or to supervise the work of contractors. Courses taken towards the certificate can also apply to the master's degree in civil engineering. Graduate students who are interested in pursuing a career in construction or who would like to learn more about the construction industry can also enroll for the certificate.

This describes the construction focus in the civil engineering curriculum that was developed at UAB to produce graduates who are better prepared to tackle the challenges of the future. Highlights of a newly developed construction engineering management (CEM) certificate including the coursework and logistics of the program are presented.

The Importance of the Civil Engineer in Construction

Civil Engineering is a remarkably broad field whose primary goal is to improve the standard of living for all mankind. Some years ago, ASCE coined the slogan that civil engineering is a "people-serving profession." Civil engineers are the central figures in the design and construction of public works that make modern life possible, such as dams, bridges, buildings, housing, highways, railroads, and water and wastewater systems. The civil engineer is an "applied scientist" who by virtue of his training uses scientific knowledge to design and

construct various elements of our infrastructure. While most civil engineering programs across the U.S. place major emphasis on design, little attention is given to the construction management aspect of the project. In order to validate the reliability of the design, the construction process should be properly addressed. It is ironic that while the civil engineer is viewed as the master builder who is responsible for transforming the blueprints into reality, civil engineering programs provide very little training in this area. Every civil engineering project involves three phases: Conception, Design, and Construction. Construction is the actual building; it makes a reality of the idea of conception and the plan of design. As such, some formal construction training is needed to provide our graduates with the necessary tools for successful practice.

However, adding coursework on construction to the undergraduate curriculum is not a simple task. Civil engineering undergraduate programs are constantly encouraged to reduce credit hours and to increase emphasis on liberal arts and social sciences. At the same time, technology is advancing at an exponential rate, which is requiring the civil engineer to be knowledgeable of new techniques and tools such as GIS, GPS, computational mechanics, modeling, etc. While five-year programs or a master's degree have been suggested by ASCE and others, it is felt that some basic training in construction at the undergraduate level is essential to ensure an adequate level of preparation for our graduates.

The Need for a Construction Focus in the Traditional CE Curriculum

Civil engineers practicing in construction manage and direct construction operations. The construction process is complex in nature; it is composed of resources – such as equipment, materials, money, and people – that convert the design drawings and specifications into a constructed facility. Construction management involves people with diverse interests, skills and backgrounds. The owner, designer, contractor, subcontractors, material suppliers, banks, insurance and bonding companies, legal firms, and public agency officials are, among others, very important components of the project team whose interconnected roles must be coordinated to assure a successful project completion. In addition to the complexities of such coordination, management of the construction process requires an understanding of the construction operation, planning and control, quantity take-off, equipment selection and utilization, scheduling, and material flow. Civil engineers with basic knowledge on these topics are needed to prevent problems in safety, productivity, cost overruns, and delays during the execution of the project.

Tener[1] states that the practice of construction engineering and management in the United States increasingly demands professional engineers who are capable of solving technical, management, social, political, and leadership problems as tough as those faced in any other engineering discipline. This complex nature of the of the construction industry, coupled with the challenges of global competitiveness and changing regulatory requirements, created the need for providing higher levels of education and experience of construction professionals.[2]

An increasing number of civil engineering students have recently been choosing careers in construction as the job market in this area seems to be more secure and salaries are competitive. With this increased interest in construction, coupled with the evolution of the construction industry, it is becoming apparent to academia and industry that a new generation of civil

engineering graduates is needed. These graduates will be able to successfully integrate traditional engineering knowledge with fundamental knowledge of information technology, management, and financial principles. The effective integration of such diverse knowledge will allow the future civil engineer to successfully tackle the professional challenges of the construction industry and become an effective and productive professional.[3]

The majority of the present undergraduate civil engineering curricula in the United States are in many aspects traditional in nature and rigid in academic content. Most of the courses included are governed by academic standards stipulated by the Accreditation Board for Engineering and Technology (ABET). The limited electives offered to students are usually extensions of the required courses. As a result, undergraduates tend to get a focused civil engineering education without being introduced to material on construction. Furthermore, most existing curricula do not introduce students to nontraditional topics that are important to construction – such as multidisciplinary collaborative team assignments, technical communications, leadership, and professional ethics – and seem to lack continuity in the material taught thus offering education in fragmented, seemingly unrelated topics.[4, 5]

In response to these challenges and in an effort to produce a future civil engineer that is well prepared for practicing in an age of rapidly advancing technology, the Civil Engineering program at the University of Alabama at Birmingham (UAB) has recently incorporated a focus in Construction Engineering Management (CEM) at the undergraduate and graduate levels.

The Driving Force for a Construction Focus at UAB

Today, national and local construction companies are seeking civil engineers with management and leadership skills that complement their technical abilities. Engineers who have management skills are more apt to advance up the corporate ladder. In a recent article, "Reach Beyond the Technical," published by *Engineering News Record,* it was pointed out that education covering non-technical issues such as project management, leadership, and policymaking is necessary for future generations of engineers to design innovative new solutions for global needs.[5]

In response to this demand, the UAB Civil and Environmental Engineering Department has elected to establish a construction engineering management (CEM) focus in three distinct ways: undergraduate CEM focus, CEM certificate, and a master's in Civil Engineering with a CEM concentration. The new construction engineering management focus provides civil engineering graduates with a solid understanding of the role of the civil engineer in the construction process. In addition to a required course (CE 497 – Engineered Construction), undergraduate students can take one or two electives in the area of construction engineering management that will count towards their undergraduate degree, and graduate students can take several CEM courses as part of their degree. Students who are interested in a more solid background in construction can pursue the new Construction Engineering Management certificate or the master's degree in Civil Engineering with a concentration in Construction Engineering Management.

The Advisory Board Role

The idea of a CEM focus was initiated by the Advisory Board of the Civil and Environmental Engineering Department at UAB. The Advisory Board is comprised of members from a broad distribution of the civil engineering profession. Construction professionals, consulting engineers, contractors, government officials, academia, and research organizations are represented on the Board. The Board meets semi-annually to review the Department's progress and make recommendations for improvement. The Board supports the Department in various ways including raising funds for the program, establishing links with industry, assessing the curriculum, and providing students with cooperative education and internship experiences.

In several of the Board meetings, the need for coursework related to construction was identified and discussed. Topics such as earthmoving operations, foundations and excavations, concrete formwork design, planning and scheduling, quality assurance and quality control, specifications, and construction materials, and workmanship were identified as important topics that undergraduate civil engineering students should be acquainted with. Additional topics such as contracts, construction safety, cost estimating, value engineering, and dispute resolution were also identified; however, it was felt that such courses should be taught by construction professionals with special expertise in these areas.

As a result of the Department's Advisory Board deliberations, a required undergraduate course (CE 497 – Engineered Construction) was implemented and added to the undergraduate civil engineering curriculum at UAB. The course is team taught by faculty with expertise in construction and experienced construction professionals. In addition to the coverage of various topics, the course includes presentations by experts in the field of design and construction as well as field trips to major construction projects in Alabama. The course is considered a pre- or co-requisite to the capstone senior design project (CE 499) since the topics covered in the course are essential to the understanding of the overall process of project planning, design, and construction.

The introduction of a construction focus in the undergraduate curriculum was well received. Students, Advisory Board members, and construction firms expressed significant interest in the availability of more in-depth courses in construction engineering management. Therefore, it became evident that an additional focus in construction engineering management is a step in the right direction for the Civil Engineering program at UAB. As a result, the CEM certificate and a master's in Civil Engineering with a CEM concentration were introduced in the program.

The Construction Engineering Management Focus at UAB

As indicated in the previous section, in addition to the required course in construction (CE 497 – Engineered Construction), undergraduate students may select any of the courses listed in Table 1 to fulfill elective requirements for a B.S. in Civil Engineering. Theses courses are also available for students enrolled in the CEM Certificate program or pursuing a master's in Civil Engineering

with a CEM concentration. The main topics covered in every course are provided in Table 1. The courses are delivered in class, online, or hybrid. In-class courses are delivered entirely in the classroom (students have to attend classes on campus regularly). Online courses are delivered through WebCT. Students taking the online courses are required to take an in-class final exam. Hybrid courses utilize WebCT for a portion of the course. Students enrolled in a hybrid course meet once every other week in the fall and spring terms and once a week in the summer term.

Table 1: Construction Engineering Management Courses

Course	Main Topics Covered	Delivery
Construction Accounting and Finance	• Fundamentals of accounting • Introduction to the stock market (Bonds, REITs, Options, etc.) as it relates to the construction industry • Sources and uses of funds in construction	Hybrid
Techniques of Project Planning and Scheduling	• Work breakdown structure • CPM, AON, AOA, Float • Resource allocation and control • Effective communication of schedule information • SureTrak or Microsoft Project	Online
Contracting, Bidding, and Estimating	• Fundamental concepts of contracts (AIA, AGC, FEDIC) • The bidding process • Insurance and bonding • Alternate Dispute Resolution • Estimating using RSMEANS, Timberline	Hybrid
Construction Management	• Organizational Structure • Construction Delivery Systems • Risk Management • Value Engineering • Introduction to International Construction	Hybrid
Engineering Liability	• Liability for engineering design • Liabilities between various parties involved in construction projects	In Class
Engineering Management	• Organizational Structure • Leadership • Managing the Construction Corporation • Six Sigma in Design and Construction	In Class
Engineered Construction	• Overview of the construction process • Field trips to sites of construction in progress	In Class

Environmental Law	• Law as it applies to the practicing engineer and construction professional • New Environmental Regulations for construction	In Class
Construction Internship	• The students work for an approved construction company for an entire semester	

The Internship Course

It should be pointed out that the Construction Internship course is highly recommended for students pursuing the construction focus. In the 3-semester hour course, the student is required to work with a construction firm for an entire semester on a topic of mutual interest. The objective is to address a problem that will benefit the industry. The student, who is supervised by a faculty advisor and a construction firm professional, works in an effort to come up with innovative solutions or new ways of solving a specific construction problem or improving on current practice. The objective is to conduct research that will solve real problems or improve productivity. In addition to the practical experience gained from the internship course, it has been found that retention rates have drastically improved for engineers who have interned with a construction company.[6]

The CEM Certificate

A newly developed certificate in Construction Engineering Management (CEM) was established for students who are interested in a more in-depth study in construction. The certificate is very unique in the sense that the focus is not limited to managing the construction site. Most construction programs around the nation prepare students for managing the construction site by offering traditional courses on planning and scheduling, estimating, construction management, etc. The new CEM certificate at UAB focuses on managing the construction corporation as well as the construction site. In an age where General Motors is making more money from its finance department than from selling cars, construction managers must have a wide vision that goes beyond managing a job site. Students must be able to identify local and international opportunities in construction. For example, in our Construction Accounting and Finance course, the students are asked questions like: "Where are the global opportunities for construction companies?" "Would you rather open a branch in China, Poland, Japan, or India?" The message is that construction management goes far beyond managing a job site.

The CEM certificate requires a minimum of 12-15 semester credit hours. The students can select any of the courses listed in Table 1. A maximum of three undergraduate credit hours may count towards the Certificate (reducing the number of required credits to 12). Courses taken towards the Certificate may be applied to a master's degree in Civil Engineering with a CEM concentration.

The Certificate prepares the undergraduate civil engineering student for a career in the construction industry. For those students who are not interested in a career in construction, the Certificate provides them with sufficient background to act as owners' representatives or to supervise the work of contractors. The Certificate also provides a way for the large number of construction managers in Alabama to acquire additional experience in construction management through UAB courses. A summary of the certificate requirements is provided below:

- Students must be admitted to the department as either undergraduate or graduate students (BSCE or MSCE program).

- Students with a non-engineering undergraduate degree will be admitted to the certificate program as graduate students provided that they have sufficient construction experience.

- Certificates require a minimum of 15 semester hours. A maximum of three undergraduate credit hours may count towards the certificate.

- Courses taken towards the Certificate may be applied to the MSCE degree, Option II—Technology/Management Emphasis.

Research in Construction Engineering Management

Sponsored faculty research projects materialized as a result of the enthusiasm and dedicated interest in construction engineering management. The research activities are beneficial in supporting graduate students with high interest in construction and permit bringing new practical knowledge into the classroom. Due to the practical nature of the research projects, faculty and students must work closely with the sponsor, which further enhances the educational process and provides invaluable practical experience for the students. As an example, the Alabama Department of Transportation (ALDOT) funded a project entitled "Alternative Project Delivery Systems for Highway Projects." The main objective of this study is to investigate the possibility of using Alternative Project Delivery Systems (APDS) to deliver ALDOT projects. The focus of this research will be on Design-Build (DB), Construction Management at Risk (CM@R), and Job Order Contracting (JOC). The research team will identify certain types of ALDOT projects where APDS might reduce cost, construction time, and improve public safety while delivering projects of better or similar quality when compared to those delivered using the traditional design-bid-build method. The research project will also promote the awareness of the APDS process through technology transfer activities such as workshops, publications, and seminars.

Partnership with AGC

The Alabama Chapter of the Associated General Contractors of America, Inc. (AGC) has partnered with UAB in order to bring closer together the dynamics of the design community, academics and the construction industry. The Alabama Chapter of AGC has been providing valuable services for the construction industry since 1920. As one of the leading chapters of The Associated General Contractors of America, Inc., Alabama's AGC Chapter is connected to

tremendous nationwide educational resources in every area of construction. The Alabama Chapter of AGC is heavily involved in loss control, state and local politics, licensing, ethics, codes, legal issues, management, benefits, and supervisory training. Quality practical education is one of the core values of AGC, and as such AGC was quickly receptive to the idea of partnering with UAB in an effort to bring the program to 990 Alabama member firms as well as to everyone connected to the industry. Due to the involvement of the AGC, we were able to widely promote the CEM certificate across the state by holding regular joint meetings to introduce the CEM program to construction professionals and obtain feedback on needs of the industry and ways to update or improve the curriculum. The AGC has also been an excellent resource for providing faculty for course instruction, speakers for seminar classes, organizing student internships, and arranging class field trips. And through the partnership, the first AGC Student Chapter was established in 2003 to further promote construction education at the early undergraduate levels.

Summary

Current undergraduate civil engineering curricula in the United States provide a solid technical foundation, but they do not address project management, professional and legal issues, leadership skills, and other topics that are fundamental for a successful career in construction. This paper presented an outline of a construction engineering management focus that is integrated in UAB's Civil Engineering program at both the undergraduate and graduate levels. It is envisioned that the civil engineer with adequate education in construction will better serve the civil engineering profession and help in advancing the industry.

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Biographical Information

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Dr. Rizk joined the University of Alabama at Birmingham as an Assistant Professor of Civil and Environmental Engineering in August 2003. He has extensive practical experience including estimating, bid proposals, contract negotiations, purchasing, and supervision of field personnel. Dr. Rizk received several research grants and is the author of several publications in the area of Construction Management.

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