

**Basic Elements of the 21<sup>st</sup> Century Body of Knowledge for a Construction Professional: Challenges for Construction Educators**

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Abstract

The American Society of Civil Engineers has recently released a report, "Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century: Preparing the Civil Engineer for the Future." It calls for sweeping changes in the way we will teach and train our future civil engineers. Since civil engineering and construction are closely related, and go hand in hand, it is important to review our current body of knowledge imparted in a four-year graduate of a construction degree program. It is equally important to devise a curriculum suited for a future construction professional that parallels the educational preparation of a future civil engineering graduate. This paper presents the basic elements of a current four-year educational program for a construction professional, and compares with an educational program that would be more suited for a future construction professional. This paper presents a proactive approach to developing broad-based knowledge, requisite skills, attitudes, and integrity in a future construction graduate. It stresses understanding of issues such as 21<sup>st</sup> century global business economy, and multi-cultural teams; it also lays the foundation for strong understanding of world cultures, languages, and local practices in the context of international collaborations on small to mega construction projects. The future construction professional will be required to be grounded in ethical decision-making, and more versatile in life long learning aspirations. The future role of educators will continue to include characteristics such as scholarly faculty, effective teaching, and practice-oriented teaching and research.

Introduction

Today's world is a lot different than the world of the yester years, and so are the civil engineering projects. As a result of greater public awareness of the environmental concerns and sustainable development, complexity in design and construction has arisen in virtually all major infrastructure projects. The recently released report of the American Society of Civil Engineers (ASCE), *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century: Preparing the Civil Engineer for the Future* (1) states, "Today's world is fundamentally challenging the way civil engineering is practiced. Complexity arises in every aspect of projects, from pre-project planning with varied stakeholders to building with minimum environmental and community disturbance." Aware of these problems of increased complexity of modern-day civil engineering practice, and inadequate academic preparation of BS-degreed civil engineering graduates due to reductions in credit hours required for graduation at colleges and universities, it was determined that the graduates of the current four-year baccalaureate degree programs were ill-prepared for the practice

of civil engineering in the 21<sup>st</sup> century. Hence the American Society of Civil Engineers acted in 2001 to enact the Policy Statement 465, which states that ASCE “.....supports the concept of the master’s degree or equivalent as a prerequisite for licensure and the practice of civil engineering at the professional level.”

For years, the American Society of Civil Engineers (ASCE) has worked on Policy Statement 465 which states that , “admission to the practice of civil engineering at the professional level should occur at licensure and that this admission should require the acquisition of a body of specialized knowledge comprising a bachelor’s degree , a master’s degree or its equivalent, and appropriate experience.” (2) The body of knowledge points to the knowledge, skills, and attitudes necessary to become licensed as a professional engineer. It is expected that existing undergraduate and graduate programs will be revised to reflect this body of knowledge and that new programs will be created. The ASCE board established the Task Committee on Academic Prerequisites for Professional Practice in the fall of 2001 and charged it with developing a plan for implementing Policy Statement 465. That committee pursued three parallel long-term (20 years and beyond) initiatives for implementing the Policy 465: one on the body of knowledge (BOK) and appropriate curricula, a second on licensure, and a third on accreditation. The body of knowledge initiative has been addressed by a subcommittee of the overall Task Force, and is extremely intense.

Body of Knowledge (BOK) for a civil engineering graduate.....A Benchmark for Construction Professional BOK

BOK is the foundation of the implementation master plan of the ASCE’s Policy Statement 465. The BOK committee has recommended the following:

- A. What should be taught to and learned by future civil engineering students
- B. How should it be taught and learned
- C. Who should teach and learn it

The BOK committee’s primary focus was on What Should Be Taught, though BOK committee was also charged with the responsibility of addressing roles of faculty, practitioners, and students.

How does the ASCE’s BOK Committee Work Apply to Construction Engineering?

In the construction engineering discipline, unlike the civil engineering discipline in which a professional engineering (PE) license is mandatory to the practice of civil engineering, construction professionals in contrast are not required to obtain professional constructor’s (CPC) certification. A CPC certification is less well known, and is not mandatory for the practice of construction engineering. However, the requirements for the knowledge base of construction professionals are just as rigorous as that of civil engineers. Therefore, logically speaking, the construction engineering education programs must also address the BOK initiatives for construction with the same zeal and enthusiasm. However, these BOK initiatives for construction are lacking.(3)

“ASCE recognizes that expanding the civil engineering BOK through additional education and enhanced experience, as a prerequisite for licensure, probably cannot be fully implemented without somewhat similar modifications affecting other engineering disciplines. Engineering licensure in the U.S. is typically generic, rather than discipline-specific, and education and experience requirements are generally the same for all engineering disciplines. The ASCE encourages societies representing other engineering disciplines to also consider the necessity for and ramifications of “raising the bar” in the long-term interest of maintaining public safety, health and welfare.”(4)

BOK for civil engineering has begun to take shape. The department heads of civil engineering programs are communicating round the clock to make BOK initiatives a success. No one knows the final outcome but one outcome is guaranteed that civil engineering educators are truly developing the most appropriate curricula for our future civil engineers. There are some schools of engineering such as MIT that recognized the deficiencies of the engineering curriculums in the 1990s and proceeded to take corrective measures. During their review of the civil engineering curriculum, faculty at MIT found the following shortcomings: (5)

- Students were having difficulty conceptualizing and formulating problems.
- There was little exposure to ill-defined (open-ended) problems.
- Teamwork was uncommon and ineffective.
- Coherence was lacking; that is sequels to courses did not rigorously rely on prerequisites. This was particularly true of the engineering fundamentals.
- There was not much hands-on experience, and where it did exist there was only a limited tie-in to the associated theory.
- Courses for the most part ignored the societal context of engineering problems.
- The emphasis on abstraction and analysis gave short shrift to synthesis and creativity.
- Insufficient attention was given to communication. The writing requirements that existed were often poorly linked to the technical courses, and there was very limited use of other types of communication.

Subsequently, MIT’s entire civil engineering program was overhauled. But as expected, no revision is 100% panacea to all the problems; therefore MIT’s new program has not been entirely satisfactory.

The construction engineering discipline needs to follow in the footsteps of civil engineering. Not long ago and up until the 1970s and 1980s, the Resident Engineers at construction sites used to be PEs (Professional Engineers) but not any more. Yet, the responsibilities of construction professionals on construction jobs have increased over time. To keep up with the influx of knowledge in various specialty areas and for reasons that are purely financial, ASCE has developed models of various institutes and construction engineering, as an academic discipline, has established its own institute as well with in the structure of the institutes. The ASCE Board has a vision for the various institutes to be self-supporting. All the institutes, namely, The Construction Institute (CI),

The Structural Engineering Institute (SEI), The Geotechnical Institute (GI), etc. have education as an important element in their mission. The relevancy of practice of the profession to theory, and education of students are inter-twined. In other words, the curricula of the educational programs have to be most appropriate, and content of courses relevant to the practice of the profession.

This paper addresses the issue of BOK for the construction engineering discipline. It compares the present-day BOK with the BOK of the future for construction engineering students. It puts the construction engineering students at a level comparable to the level of a civil engineering student. It defines the need for an integrated construction curriculum, and an integrated BOK for the future construction engineering students.

#### Present-Day Body of Knowledge Taught in a BS-Level Construction Engineering/Technology Degree

Construction professionals are builders. In recent years, the term constructor has been used to define individuals who are builders, yet their expertise goes beyond that of home or commercial builders. Constructors are essentially contractors who know how to build unlike engineers who know ‘Why’ that goes with problem-solving. For a construction project to be successful, both engineers and contractors have their own very significant roles, and the duties and responsibilities of each are well-defined in documents such as AIA 201 document (General Conditions of the Contract). Presently, all four-year construction programs try to educate their students in the following basic essential areas though the degree of content and rigor may vary:

- Construction Materials/Engineering Materials
- Computer-Aided Drafting/Engineering Graphics
- Surveying
- Engineering Mechanics (Statics/Dynamics)
- Strength of Materials (Mechanics of Materials)
- Soil Mechanics and Foundations
- Structural Analysis
- Fluids and Hydraulics
- Design in Reinforced Concrete, Structural Steel, Masonry, and Wood (To a degree)
- Mechanical and Electrical Systems of Buildings
- Construction Estimating
- Construction Contracts
- Construction Safety
- Construction Planning & Scheduling
- Engineering Economic Analysis
- Construction Methods and Equipment
- Calculus
- Physics, Chemistry, Geology
- Technical Report Writing
- General Studies in English, Communications, Humanities, American National Govt., and American History, Foreign Languages, etc.

## Miscellaneous Electives

Computer Applications in Excel, Subject-Specific Computer Software, Power Point, etc.

All this has to be accomplished within a 4-year span of course work. Each program tries to deliver what it can to meet the needs of their students. Ethics, and team work are included, so are oral and written skills in the breadth of the program. It may seem from the surface that essentially every aspect of the curriculum is covered. But it is not. Some topics are mentioned but not covered. Some topics are covered in breadth but not in depth. Each program has its own strengths and weaknesses.

## Basic Elements of the 21<sup>st</sup> Century Body of Knowledge for a Construction Professional

The body of knowledge for the 21<sup>st</sup> century construction professional should parallel the body of knowledge required of the 21<sup>st</sup> century civil engineering professional. Therefore information from the *Civil Engineering Body of Knowledge for the 21<sup>st</sup> Century* is being reproduced to establish it as a benchmark to devise the body of knowledge for the 21<sup>st</sup> century construction professional.

The BOK committee of ASCE selected an outcomes approach (in keeping with the ABET Accreditation Criteria EC 2000 and TC2K) as the principal means of defining the *what* dimension of the civil engineering BOK for the 21<sup>st</sup> century. Relative to today's basic programs, the outcomes collectively prescribe a substantially greater depth and breadth of knowledge, skills, and attitudes required of an individual aspiring to the practice of civil engineering at the professional level (licensure) in the 21<sup>st</sup> century. The 15 outcomes include and begin with the 11 outcomes of the Accreditation Board for Engineering and Technology (ABET) and prescribe more technical depth and additional breadth. (6) All of the 15 outcomes are just as applicable to the academic discipline of construction engineering as they are applicable to civil engineering but the emphasis and focus are different because constructors build, not design. However, the following outcomes must be incorporated in the BOK for the construction professional of the 21<sup>st</sup> century:

- An ability to function on multi-disciplinary teams
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global and social context
- A recognition of the need for, and an ability to engage in, life-long learning
- A knowledge of contemporary issues
- An understanding of the elements of project management, construction, and asset management
- An understanding of business and public policy and administration fundamentals
- An understanding of the role of the leader and leadership principles and attitudes

For a construction professional to be successful in multi-disciplinary, multi-cultural, and multi-national projects, while knowledge and skills are requisite essentials, they must

also be supplemented by constructional professional's right attitude, that is, the manner in which he approaches his task at hand.

### Proposed Specifics of BOK for a Construction Professional of the 21<sup>st</sup> Century

In recent times, big business has been ripe with scandals. The failures of Enron and WorldCom have brought ethical issues to the forefront in academia and higher education. For example, corporate compliance is not new for highway contractors but may be new for other professionals. Imagine you owned a construction company and asked yourself a question, "Do you have a corporate compliance program designed to avoid purposeful and inadvertent violations of law by your employees?" and if you answered 'No', what steps would you take to establish one? Students of construction have to be educated in ethics now like never before, and that is why ABET criteria on accreditation is significantly specific on integration of ethics in engineering and technology curriculums. In May 2002, Halliburton improperly booked \$100 million in annual construction cost overruns before customers agreed to pay for them. Instances such as this need to be brought to the attention of students in a classroom setting so that repetitions of such unethical conduct can be avoided in the future.

In addition to the building blocks of the construction curriculum discussed in the Present-Day Body of Knowledge taught in a BS-Level Construction program, additional topics mentioned below need to be included in the curriculum, and reinforced at a fundamental level.

- Service Learning
- Project-Based Learning
- Sustainable Development
- Environmental Regulations
- Working in Teams
- Learning via Distance Education
- Readiness for Life-Long Learning
- Current Issues in Construction
- Study Abroad Programs

Ultimately the responsibility of developing and implementing the curriculum lies with the faculty and the department chair in an academic department. Faculty are at the heart of development of current, relevant, and futuristic curriculums, and department chairs are responsible for direction, and implementation. The faculty have the special expertise in their area of specialization, and the department chair must play the role of a facilitator and a coordinator to bring balance in the curriculum.

### Role of Faculty in the 21<sup>st</sup> Century Education of Construction Professionals

The BOK committee of the ASCE identified the following four characteristics of the model full or part-time civil engineering faculty; the characteristics of construction faculty should be no different.

- Faculty as Scholars: They should be technically current, and life-long learners.
- Faculty as Effective Teachers: Faculty should engage students in the learning process.
- Faculty with Practical Experience: Faculty should have practical experience in the subjects they teach.
- Faculty as Positive Role Models: Students view faculty as their role models.

Students are primarily responsible for their own education; in the process of learning, it is the responsibility of students to challenge faculty and engage them in intellectual pursuits, in as much as faculty need to engage students to keep them motivated in the learning process.

## Conclusion

Preparing the Construction Professional of the 21<sup>st</sup> century is a daunting task. While the fundamental building blocks of construction engineering are essential for developing the technical skills, the soft skills of communications and developing understanding of opposing and different viewpoints are just as important. The challenges for construction educators lie not only in imparting technical skills in students but developing them as professionals who would be ethical in practice, and sound in human relations. In the execution of multi-national projects where multi-cultural teams are involved, understanding of issues such as global economy, global barriers in communication, different languages, cultures, and customs will play a key role in the overall success of the engineering projects. Working in teams over the internet will be a routine matter in the 21<sup>st</sup> century as it is already being practiced in some areas of engineering, such as design taking place in one country, shop drawings being prepared in another, and construction taking place in a totally different country. The future construction professional will be required to be grounded in ethical decision-making, and more versatile in life-long learning aspirations. The future role of faculty in the education of construction professionals of the 21<sup>st</sup> century will continue to be what it is today but will be seen in more positive light as scholars, effective teachers, and positive role models for students.

## Bibliography

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