AC 2011-668: THE CIVIL ENGINEERING BODY OF KNOWLEDGE AND ACCREDITATION CRITERIA: A PLAN FOR LONG-TERM MANAGEMENT OF CHANGE

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The Civil Engineering Body of Knowledge and Accreditation Criteria: A Plan for Long-Term Management of Change

Purpose and Scope

The American Society of Civil Engineers (ASCE) Civil Engineering Body of Knowledge (BOK) is a dynamic entity that must be continually updated to ensure its relevance. The ABET accreditation criteria provide an effective mechanism for ensuring that the BOK is adequately reflected in civil engineering curricula nationwide. Thus, periodic changes to both the BOK and the accreditation criteria are essential; however, such changes can be disruptive if they occur too frequently or without adequate coordination.

This paper proposes a plan for long-term management of updates to the Civil Engineering BOK and the associated ABET accreditation criteria.

In developing this proposal, the authors first summarize the chronological development of the Civil Engineering BOK and its associated accreditation criteria. We describe how and why the Civil Engineering BOK has evolved since its inception, and we demonstrate that continuous change is a defining characteristic of any professional BOK. We note that the inherent time lag in the implementation of accreditation criteria has created some challenges in managing change; and we address these challenges with a proposed long-term schedule of future BOK and criteria updates that will ensure the relevance of the BOK while enhancing predictability.

Development of the Civil Engineering BOK

In response to a growing consensus that the bachelor's degree is becoming increasingly inadequate as formal academic preparation for the professional practice of civil engineering, the ASCE Board of Direction adopted Policy Statement 465 in October 1998. This initial version of the policy stated that the Society "supports the concept of the master's degree as the First Professional Degree for the practice of civil engineering at the professional level."[1] Charged with implementing Policy Statement 465, the ASCE Committee on Academic Prerequisites for Professional Practice (CAP^3) determined that any consideration of academic degree requirements should derive from a more fundamental analysis of the profession's BOK.

The concept of a formalized professional BOK is well established in the sociology of professions. According to Eliot Freidson, one of the principal defining characteristics of a profession is an officially recognized BOK that is based on abstract concepts and requires the exercise of discretionary judgment.[2] In Andrew Abbott's *system of professions*, the BOK is the principal means by which a profession establishes jurisdictional claims with respect to other professions and paraprofessional groups.[3] Abbott also demonstrates that jurisdictional claims are generally strengthened when a profession defines its BOK more clearly.

Consistent with these principles, CAP^3 initiated a broad-based effort to formally define the Civil Engineering BOK. In January 2004 this endeavor achieved a major milestone with ASCE's publication of *Civil Engineering Body of Knowledge for the 21st Century*—a report describing

the knowledge, skills, and attitudes necessary for entry into the practice of civil engineering at the professional level.[4] This report introduced a conceptual framework that has proved to be enormously valuable in guiding the subsequent implementation of Policy Statement 465. The conceptual framework includes three key characteristics:

- The Civil Engineering BOK is defined in terms of *outcomes*.
- The outcomes have clearly defined *levels of achievement*.
- Expected levels of achievement are separately specified for baccalaureate-level education, master's-level education, and pre-licensure experience.

This first edition of the Civil Engineering BOK (abbreviated BOK1) defined 15 outcomes, the first eleven of which nominally correspond to ABET Criterion 3(a)-(k).[5] The definition of four BOK outcomes *beyond* the eleven Criterion 3 outcomes demonstrated that the BOK cannot be adequately addressed in a traditional four-year baccalaureate degree program—a conclusion subsequently affirmed by a comprehensive curriculum analysis.[6]

The BOK1 report defined three levels of achievement, using the terms *recognition, understanding,* and *ability* to reflect a progression of learning. These specific terms would eventually be superseded by a more broadly accepted taxonomy (described below); however, the *concept* of levels of achievement has persisted as an integral element of the conceptual framework used to define the Civil Engineering BOK.

In October 2004, the ASCE Board reinforced the importance of the BOK by modifying the wording of Policy Statement 465 as follows:

> The American Society of Civil Engineers supports the attainment of a Body of Knowledge for entry into the practice of civil engineering at the professional level. This would be accomplished through the adoption of appropriate engineering education and experience requirements as a prerequisite for licensure.[7]

Influence of the BOK on Accreditation Criteria

With the Civil Engineering BOK formally defined and endorsed in ASCE policy, a broad-based effort to develop and implement new BOK1-compliant ABET accreditation criteria began. The CAP[3] Accreditation Committee was charged with leading this effort.

Implicit in the committee's work was an underlying assumption that the ABET accreditation process is an appropriate mechanism for fostering a transition toward BOK1-compliant curricula in ABET-accredited civil engineering programs. This assumption is well founded. "Engineering Change," a study conducted by the Penn State Center for the Study of Higher Education, clearly demonstrates that accreditation criteria can provide a powerful stimulus for curricular reform.[8] And once curricular reform is underway, the accreditation process provides an effective quality control mechanism to ensure that changes are being implemented in accordance with desired ends.

Although the ABET criteria constitute a viable instrument for effecting BOK implementation, it is *not* true that the criteria are entirely adaptable to this purpose. The ABET criteria consist of

three different components, each with its own unique limitations as an instrument for BOK implementation:

- The ***General Criteria for Baccalaureate Level Programs (GCBLP)*** are applicable to *all* ABET-accredited programs in *all* engineering disciplines. Changing these criteria would require the support of ABET and its 29 member societies. The ABET Engineering Accreditation Commission (EAC) is currently considering the establishment of a process for reviewing and updating the GCBLP;[9] however, that process is unlikely to be implemented in the short term, and ASCE's influence over it will necessarily be limited.

- The ***General Criteria for Masters Level Programs (GCMLP)*** are also applicable to all engineering disciplines; however, because very few programs are currently accredited at the master's level, it is feasible for ASCE to influence changes to these criteria. Nonetheless, such changes must still be applicable and acceptable to all engineering disciplines. Discipline-specific additions to the GCMLP would not be permissible.

- The ***Program Criteria*** are applicable only to specific engineering disciplines and are established and maintained by the associated ABET member societies. The ***Civil Engineering Program Criteria (CEPC)*** are applicable to "civil and similarly named engineering programs." As Lead Society for the civil engineering curricular area, ASCE has responsibility for developing and maintaining the CEPC. Because ASCE has considerable authority to change these criteria, the CEPC must necessarily be the principal accreditation-related mechanism for BOK implementation. Nonetheless, ASCE is not able to exercise complete control over these criteria. All engineering program criteria are subject to approval by the EAC and the ABET Board of Directors; and in order to gain approval, proposed criteria must be appropriately outcomes-based and must not be overly prescriptive. In an era when new engineering disciplines are constantly emerging and existing disciplinary boundaries are blurring, program criteria are viewed as anachronistic in some ABET circles. In this environment, ASCE's ability to use the CEPC as its principal instrument for implementing curricular reform is significantly constrained.

Another major challenge in the use of ABET criteria as a mechanism for BOK implementation lies in a fundamental difference between the nature of the BOK and the nature of accreditation criteria. Although it was not intended as such, the BOK has many characteristics of a strategic vision. It represents, by its very nature, an ambitious, comprehensive, future-oriented goal—one to which all civil engineering programs should aspire, but one that few programs will ever achieve in all of its aspects. Conversely, accreditation criteria represent only a *minimum standard* of educational attainment. They are grounded firmly in the present; they tend to be narrower in scope; and they must be *reasonably attainable by all programs*.

The CAP^3 Accreditation Committee addressed this challenge by adopting the following approach to the formulation of BOK-compliant criteria:

- The criteria should not conflict with the BOK outcomes.

- At least one readily identifiable criterion (or portion of a criterion) should be associated with each BOK outcome.
- Each of these criteria should communicate an appropriate *direction* toward attainment of the associated BOK outcome. Taken as a whole, however, the criteria should stop short of prescribing full BOK attainment, because doing so would be overly prescriptive.

This approach, which evolved during a collaborative two-year process of study, deliberation, and critical review, culminated in the submission of proposed new BOK1-compliant accreditation criteria (both GCMLP and CEPC) to the ABET EAC in June 2006. These criteria, provided in Appendix A, achieved final approval by the ABET Board of Directors in October 2007 and were implemented for accreditation visits starting in the fall of 2008. Given the six-year ABET accreditation cycle, all U.S. civil engineering programs will have been evaluated under these BOK1-compliant criteria by Academic Year 2013-14.

This approach to formulating BOK1-compliant accreditation criteria is illustrated by the tabular comparison provided in Appendix B. The table lists the 15 BOK1 outcomes, the specific requirements articulated for each outcome in *Civil Engineering Body of Knowledge for the 21st Century*, and the associated provisions of the ABET GCBLP and CEPC. An outcome-by-outcome comparison clearly demonstrates that the BOK outcomes represent a significantly more ambitious and comprehensive standard than do the ABET criteria. For example, consider BOK Outcome 1, which includes requirements for "biology, chemistry, ecology, geology/geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology." The corresponding provision of the CEPC requires only "one additional area of basic science, consistent with the program educational objectives."

The sharp difference between the BOK outcomes and the criteria is entirely appropriate, as it reflects the distinctly different natures of these two documents. If the criteria were written at the same level of detail as the BOK, they would be overly prescriptive and perhaps unattainable. If the BOK were formulated as a minimum standard, it would fail to serve as an aspirational goal. The difference suggests, however, that the translation of BOK outcomes to accreditation criteria will always be an inherently challenging process.

The Evolving BOK

Even as formulation of new BOK1-compliant accreditation criteria was just getting underway, it became apparent that significant updates to BOK1 itself would be required. These revisions were driven by:

- aspects of the 1st Edition that did not lend themselves to effective measurement and assessment;
- publication of several strategic vision documents that called for future engineers to develop certain knowledge, skills, and attitudes that had *not* been included in BOK1;[10,11,12] and
- continuing changes in the global civil engineering professional environment (e.g., a dramatic increase in the importance of sustainability and green technologies).

As a result, a second edition of the Civil Engineering BOK was initiated in October 2005 and published in February 2008. The *Civil Engineering Body of Knowledge for the 21st Century, Second Edition,* (abbreviated BOK2) incorporates two particularly substantive changes from the first edition: [13]

- The number of outcomes was increased from 15 to 24. To some extent, this increase reflects the BOK2 authors' attempt to enhance clarity and specificity, rather than to increase the scope of the BOK. Nonetheless, the BOK2 Outcomes do place increased emphasis on such topics as the natural sciences, the humanities, sustainability, globalization, risk and uncertainty, and public policy.

- The BOK2 uses Bloom's Taxonomy as the basis for defining levels of achievement.[14] The fundamental premise of Bloom's Taxonomy is that an educational objective can be referenced to a specific level of cognitive development through the verb used in the objective statement. Table 1 shows Bloom's six levels of cognitive development, accompanied by illustrative examples of verbs associated with each level. The use of measurable, action-oriented verbs linked to levels of achievement is beneficial, in that the resulting outcome statements can be assessed more effectively and consistently.

Level		Illustrative Verbs
1	Knowledge	define, identify, label, list,
2	Comprehension	classify, describe, explain, generalize, paraphrase
3	Application	apply, calculate, compute, demonstrate, solve
4	Analysis	analyze, differentiate, formulate, organize, prioritize
5	Synthesis	create, design, develop, devise, integrate, plan
6	Evaluation	critique, evaluate, judge, justify

Table 1. Six levels of cognitive development and illustrative verbs, as defined in Bloom's Taxonomy

A complete list of the 24 BOK2 Outcomes is provided in Appendix C, along with the expected level of achievement for each one. Note that the outcomes are organized into three broad categories—foundational, technical, and professional. Note also that separate levels of achievement are defined for the bachelor's degree, for the master's degree (or equivalent), and for pre-licensure experience. Following the framework established by the BOK1, this structure emphasizes that both education and experience are essential for full attainment of the Civil Engineering BOK.

A formal comparison of these outcomes with the BOK1-compliant accreditation criteria strongly suggests that the criteria will need to be further modified to foster BOK2 implementation.[15]

Although CAP^3 has not yet initiated the development of BOK2-compliant accreditation criteria, it has formed two committees to study and formulate guidelines for the fulfillment of the Civil Engineering BOK:

- The BOK Educational Fulfillment Committee was formed in 2007. Composed of representatives of ten widely varying institutions, this committee investigated the

incorporation of the 24 BOK2 outcomes into civil engineering curricula.

- The BOK Experiential Fulfillment Committee was formed in early 2009 to address those BOK2 outcomes requiring pre-licensure experience. The committee was charged with developing early-career experience guidelines for engineer interns, supervisors, and mentors.

In the course of their work, both of these committees identified a need for further refinement of BOK2. For example, the Experiential Fulfillment Committee suggested additional emphasis on quality management and public safety.[16]

Taken as a whole, ASCE's experience with the development and refinement of the Civil Engineering BOK has been one of near-constant change. Immediately upon publication of the BOK1 report, it was evident that a second edition would be required. The process of implementing the BOK2 identified the need for further modifications.

Many of the short-term changes in the BOK can be attributed to the specific circumstances associated with the implementation of ASCE Policy Statement 465. No professional society had previously attempted to articulate its BOK; thus, some trial and error was perhaps inevitable. Design is inherently iterative; and, in this case, the iterations have been performed by a succession of committees, each with somewhat different perspectives.

Nonetheless, there is good reason to expect that the BOK will continue to evolve over the long term. Sociological theory supports the notion that continuous change is an inherent characteristic of any professional BOK. In Abbott's *system of professions*, the BOK is the principal means by which a profession establishes jurisdictional claims with respect to other occupational groups. Because the professional environment and the relationships between professions are dynamic, jurisdictional claims and the associated professional bodies of knowledge are constantly in flux. As Abbott demonstrates, a strong profession must be able to adapt its BOK in response to emerging needs, opportunities, and threats.

Thus we can expect that the Civil Engineering BOK will continue to evolve over time, as a result of such influences as:

- new engineering challenges (e.g., climate change, emphasis on sustainability, energy shortages, terrorism, increase in the frequency and severity of natural disasters);
- new technologies (e.g., building information management, high-performance materials, smart buildings and sensing technologies);
- changes in the international business environment (e.g., limited financial capital, low-cost engineering services delivered via the internet, increased market consolidation);
- changes in law and the regulatory environment (e.g., licensure laws, environmental regulation);
- changes in relationships between and within engineering disciplines (e.g., evolving role of paraprofessionals); and
- engineering failures (e.g., Hurricane Katrina, the Gulf oil spill, the Minneapolis I-35 bridge collapse).

Having decided to formally articulate the Civil Engineering BOK, ASCE must now be prepared to review and update it on a regular basis.

Development of BOK2-Compliant Accreditation Criteria

Table 2 summarizes the sequence of events described above. Events associated with BOK1 and BOK2 are listed in separate columns.

DATE	EVENT	
	BOK, 1st Edition	**BOK, 2nd Edition**
June 2002	BOK1 Committee of CAP^3 organized	
November 2003	BOK1 finalized	
January 2004	Accreditation Committee of CAP^3 organized	
February 2004	BOK1 published	
October 2005		BOK2 Committee of CAP^3 organized
February 2006	Draft BOK1-compliant CE Program Criteria published	
July 2006	BOK1-compliant CE Program Criteria approved by ABET EAC (1st reading)	
October 2006	BOK1-compliant CE Program Criteria approved by ABET Board of Directors (1st reading)	
November 2006	Public review of CE Program Criteria initiated	
July 2007	BOK1-compliant CE Program Criteria approved by ABET EAC (2nd reading)	
October 2007	BOK1-compliant CE Program Criteria approved by ABET Board of Directors (2nd reading)	
November 2007		BOK2 finalized
February 2008		BOK2 published
September 2008	First accreditation visits under BOK1-compliant CE Program Criteria	
December 2013	Completion of six accreditation cycles under BOK1-compliant CE Program Criteria	

Table 2. Sequence of Events in the development of the Civil Engineering BOK and associated accreditation criteria

Note that the initiation of BOK1-compliant criteria development coincided with the publication of the BOK1 report. However, in the three years since the publication of the BOK2 report, CAP3 has chosen *not* to initiate the development of new BOK2-compliant accreditation criteria. Why not?

As the timeline suggests, the publication of the BOK2 did not fully account for the inevitable time lag associated with accreditation criteria implementation. The BOK2's publication seven months *ahead of* the first accreditation visits under BOK1-compliant criteria caused both confusion and concern among civil engineering department heads. Some programs moved aggressively to implement the BOK2 outcomes in their curricula but worried that they would still be evaluated under BOK1-compliant criteria. For others, the prospect that BOK2-compliant criteria changes might be initiated before the BOK1-compliant criteria had been implemented caused considerable (if unfounded) angst. In either case, it can be argued that BOK2 was published too soon, at least from the perspective of accreditation criteria implementation.

A Plan for Long-Term Management of BOK and Criteria Changes

At this point, the need for careful synchronization of the published BOK and its associated accreditation criteria has become quite clear. As such, the authors propose a strategic plan for long-term management the Civil Engineering BOK and the associated ABET accreditation criteria. The principal objectives of this proposal are:

- to institutionalize the systematic review and updating of the Civil Engineering BOK;
- to keep the ABET Civil Engineering Program Criteria appropriately synchronized with the BOK; and
- to enhance BOK implementation by providing more *predictability* in the change process.

To achieve these objectives, we propose that all future updates of the Civil Engineering BOK and accreditation criteria be implemented on a ***fixed eight-year cycle***.

Our recommendation for an eight-year change cycle is based on the following considerations, gleaned from the analysis above:

1) As Table 2 suggests, the period of time required to formulate and publish a new edition of the Civil Engineering BOK is between two and three years.
2) The period of time required to formulate, publish, gain approval of, and implement new ABET program criteria is approximately four years.
3) The period of time required for all U.S. engineering programs to be evaluated under a new set of accreditation criteria is six years.

Based on (1) and (2), the total required time for development of a BOK update and its associated criteria changes is between six and seven years. As such, a six-year change cycle would be feasible, though it would likely require a slight overlap between the implementation of one set of criteria and the initiation of the next BOK update. More importantly, a six-year change cycle would correspond exactly to the six-year ABET accreditation cycle, as noted in (3) above. As a consequence, *the same set of civil engineering programs* would always be first to experience accreditation criteria changes. A six-year cycle would place an undue burden on these programs.

A seven-year cycle would be entirely feasible; however, we propose an eight-year cycle to provide an additional margin for error in the development process (e.g., to accommodate publication delays or lack of support from a constituency).

We further propose that the eight-year cycle be implemented according to the schedule outlined in Table 3. This schedule was developed by adding eight years to the implementation of BOK1-compliant accreditation criteria (September 2008), to obtain the target date for implementation of BOK2-compliant criteria (September 2016). All remaining milestones were derived from this date, using the experience-based time intervals and due dates listed in Table 2.

This proposed schedule yields two important short-term implications:

- The Accreditation Committee of CAP[3] should be organized in October 2012 and charged with initiating the formulation of new BOK2-compliant accreditation criteria.

- Should CAP[3] deem it necessary to develop an addendum to BOK2 to incorporate refinements recommended by the BOK Educational Fulfillment and Experiential Fulfillment Committees, that addendum must be finalized by September 2012.

Event	BOK 2nd Edition	BOK 3rd Edition	BOK 4th Edition
BOK Committee of CAP[3] organized	Already accomplished	October 2016	October 2024
BOK finalized		September 2018	September 2026
BOK published		March 2019	March 2027
Accreditation Committee of CAP[3] organized	October 2012	October 2020	October 2028
Draft CE Program Criteria published	March 2014	March 2022	March 2030
CE Program Criteria approved by ABET EAC (1st reading)	July 2014	July 2022	July 2030
CE Program Criteria approved by ABET Board of Directors (1st reading)	October 2014	October 2022	October 2030
Public Review of CE Program Criteria initiated	November 2014	November 2022	November 2030
CE Program Criteria approved by ABET EAC (2nd reading)	July 2015	July 2023	July 2031
CE Program Criteria approved by ABET Board of Directors (2nd reading)	October 2015	October 2023	October 2031
First Reviews Under New CE Program Criteria	September 2016	September 2024	September 2032

Table 3. Proposed long-term schedule for BOK and accreditation criteria development

The principal beneficiaries of this proposed 8-year cycle would be civil engineering programs. With the implementation of criteria changes restricted to specified years (e.g., 2016, 2024, 2032), programs would be able to schedule routine reviews and updates of their Program Educational Objectives and Student Outcomes during these same years. Curriculum modifications and subsequent assessment of the revised objectives and outcomes could then be accomplished with

a reasonable assurance of "closing the loop" before any new criteria changes occur. Thus, predictability would enhance the management of change.

Conclusion

In this paper, we recommend a long-term schedule for managing changes to the Civil Engineering BOK and the associated accreditation criteria according to a fixed eight-year cycle. We suggest that this approach represents a reasonable mechanism for managing change—one that acknowledges the dynamic nature of a professional BOK and the need for a close linkage between the BOK and accreditation criteria, while also enhancing change management through a high degree of predictability.

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Appendix A. BOK1-Compliant Civil Engineering Program Criteria and General Criteria for Master's Level Programs, as submitted to the EAC of ABET

PROGRAM CRITERIA FOR
CIVIL
AND SIMILARLY NAMED ENGINEERING PROGRAMS
Lead Society: American Society of Civil Engineers

These program criteria apply to engineering programs including "civil" and similar modifiers in their titles.

1. Curriculum

The program must demonstrate that graduates can: apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering; conduct civil engineering experiments and analyze and interpret the resulting data; design a system, component, or process in more than one civil engineering context; explain basic concepts in management, business, public policy, and leadership; and explain the importance of professional licensure.

2. Faculty

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.

II. GENERAL CRITERIA FOR MASTERS LEVEL PROGRAMS

Masters level programs must develop, publish, and periodically review, educational objectives and program outcomes. The criteria for masters level programs are fulfillment of the baccalaureate level general criteria, fulfillment of program criteria appropriate to the masters level specialization area, and one academic year of study beyond the baccalaureate level. The program must demonstrate that graduates have an ability to apply masters level knowledge in a specialized area of engineering related to the program area.

Appendix B

Comparison of BOK1 Requirements and ABET Criteria

Civil Engineering Body of Knowledge		ABET Engineering Criteria	
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**CE Program Criteria**
1. An ability to apply knowledge of mathematics, science, and engineering	Breadth of coverage in mathematics, science and civil engineering topics	3(a) An ability to apply knowledge of mathematics, science, and engineering	Apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives; apply knowledge of four technical areas appropriate to civil engineering.
	Mathematics through differential equations, probability and statistics, calculus-based physics, biology, chemistry, ecology, geology, geomorphology, engineering economics, mechanics, material properties, systems, geo-spatial representation, and information technology		
	Understand fundamentals of several recognized major civil engineering areas		
2. An ability to design and conduct experiments, as well as to analyze and interpret data	Design and conduct field and laboratory studies, gather data, create numerical and other models, and then analyze and interpret the results—in at least one of the evolving or current major civil engineering areas	3(b) An ability to design and conduct experiments, as well as to analyze and interpret data	Conduct civil engineering experiments and analyze and interpret the resulting data
3. An ability to design a system, component, or process to meet desired needs	Problem definition, scope, analysis, risk assessment, environmental impact statements, creativity, synthesizing alternatives, iteration, regulations, codes, safety, security, constructability, sustainability, and multiple objectives and various perspectives	3(c) An ability to design a system, component, or process to meet desired needs	Design a system, component, or process in more than one civil engineering context
	Bidding versus qualifications-based selection; estimating engineering costs; interaction between planning, design and construction; design review; owner-engineer relationships; and life-cycle assessment		
	Understanding large-scale systems, including the need to integrate information, organizations, people, processes, and technology		
	Design experiences integrated throughout the professional component of the curriculum		
4. An ability to function on multi-disciplinary teams	Lead a design team or other team	3(d) An ability to function on multi-disciplinary teams	
	Participate as a member of a team		
	Team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, time management, and being able to foster		

Civil Engineering Body of Knowledge		ABET Engineering Criteria	
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**CE Program Criteria**
	and integrate diversity of perspectives, knowledge, and experiences		
5. An ability to identify, formulate and solve engineering problems	Assessing situations in order to identify engineering problems, formulate alternatives, and recommend feasible solutions	3(e) An ability to identify, formulate and solve engineering problems	
6. An understanding of professional and ethical responsibility	Hold paramount public safety, health, and welfare	3(f) An understanding of professional and ethical responsibility	Explain the importance of professional licensure
	Thoughtful and careful weighing of alternatives when values conflict		
	understanding of and commitment to practice according to the seven Fundamental Canons of Ethics and the associated Guidelines to Practice Under the Fundamental Canons of Ethics		
7. An ability to communicate effectively	Listening, observing, reading, speaking, and writing	3(g) An ability to communicate effectively	
	Fundamentals of interacting effectively with technical and non-technical or lay individuals and audiences in a variety of settings		
	Versatility with mathematics, graphics, the worldwide web and other communication tools		
8. The broad education necessary to understand the impact of engineering solutions in a global and societal context	Appreciate, from historical and contemporary perspectives, culture, human and organizational behavior, aesthetics and ecology and their impacts on society	3(h) the broad education necessary to understand the impact of engineering solutions in a global, and societal context	
	History and heritage of the civil engineering profession		
9. A recognition of the need for, and an ability to engage in, life-long learning	Life-long learning mechanisms—additional formal education, continuing education, professional practice experience, active involvement in professional societies, community service, coaching, mentoring, and other learning and growth activities	3(i) A recognition of the need for, and an ability to engage in, life-long learning	

Civil Engineering Body of Knowledge		ABET Engineering Criteria	
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**CE Program Criteria**
	Personal and professional development—developing understanding of and competence in goal setting, personal time management, communication, delegation, personality types, networking, leadership, the socio-political process, effecting change, career management, increasing discipline knowledge, understanding business fundamentals, contributing to the profession, self-employment, additional graduate studies, and achieving licensure and specialty certification		
10. A knowledge of contemporary issues	relationship of engineering to critical contemporary issues such as multicultural globalization of engineering practice; raising the quality of life around the globe; the growing diversity of society; and the technical, environmental, societal, political, legal, aesthetic, economic, and financial implications of engineering projects	3(j) A knowledge of contemporary issues	
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	Role and use of appropriate information technology, contemporary analysis and design methods, and applicable design codes and standards as practical problem-solving tools to complement knowledge of fundamental concepts Ability to select the appropriate tools for solving different types and levels of problems	3(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	
12. An ability to apply knowledge in a specialized area related to civil engineering	Specialized technical coursework (or equivalent) in such areas as environmental engineering, structural engineering, construction engineering and management, public works management, transportation engineering and water resources management	One academic year of study beyond the basic level Ability to apply advanced level knowledge in a specialized area of engineering	
13. An understanding of the elements of project management, construction, and asset management	Project management—project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiation, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes.		Explain basic concepts in management

Civil Engineering Body of Knowledge		ABET Engineering Criteria	
Outcome Statement	**Specific Provisions or Requirements**	**General Criteria for Baccalaureate Level Programs**	**CE Program Criteria**
	Construction—owner-engineer-contractor relationships; project delivery systems (e.g., design-bid-build, design-build); estimating construction costs; bidding by contractors; labor and labor management issues; and construction processes, methods, systems, equipment, planning, scheduling, safety, cost analysis and cost control.		
	Asset management—effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition.		
14. An understanding of business and public policy and administration fundamentals	Business—legal forms of ownership, organizational structure and design, income statements, balance sheets, decision (engineering) economics, finance, marketing and sales, billable time, overhead, and profit		Explain basic concepts in business and public policy
	Public policy and administration—political process, public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and public service responsibility of professionals		
15. An understanding of the role of the leader and leadership principles and attitudes.	Leading—broad motivation, direction, and communication knowledge and skills		Explain basic concepts in leadership
	Attitudes—commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity		
	Behaviors—earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information		

Appendix C. BOK2 Outcomes and Levels of Achievement[13]

Outcome number and title	Level of achievement					
	1 Know-ledge	2 Compre-hension	3 Appli-cation	4 Analy-sis	5 Synthe-sis	6 Evalu-ation
Foundational						
1. Mathematics	B	B	B			
2. Natural sciences	B	B	B			
3. Humanities	B	B	B			
4. Social sciences	B	B	B			
Technical						
5. Materials science	B	B	B			
6. Mechanics	B	B	B	B		
7. Experiments	B	B	B	B	M/30	
8. Problem recognition and solving	B	B	B	M/30		
9. Design	B	B	B	B	B	E
10. Sustainability	B	B	B	E		
11. Contemp. Issues & hist. perspectives	B	B	B	E		
12. Risk and uncertainty	B	B	B	E		
13. Project management	B	B	B	E		
14. Breadth in civil engineering areas	B	B	B	B		
15. Technical specialization	B	M/30	M/30	M/30	M/30	E
Professional						
16. Communication	B	B	B	B	E	
17. Public policy	B	B	E			
18. Business and public administration	B	B	E			
19. Globalization	B	B	B	E		
20. Leadership	B	B	B	E		
21. Teamwork	B	B	B	E		
22. Attitudes	B	B	E			
23. Life-long learning	B	B	B	E	E	
24. Professional and ethical responsibility	B	B	B	B	E	E

Key:		
	B	Portion of the BOK fulfilled through the bachelor's degree
	M/30	Portion of the BOK fulfilled through the master's degree or equivalent (approximately 30 semester credits of acceptable graduate-level or upper- level undergraduate courses)
	E	Portion of the BOK fulfilled through the pre-licensure experience