2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32606

# The Merits of a Civil Engineering Certification to Validate Fulfillment of the CE-BOK

**Mr. Bradley F. Aldrich, American Society of Civil Engineers**

Bradley F. Aldrich, P.E., F.NSPE, F.ASCE is President of Aldrich + Elliott, PC an environmental engineering firm and also serves as vice-chair of the Board of Professional Regulation for Engineers in Vermont. He earned his bachelor's degree in civil engineering from the University of Vermont. Over his thirty-five year career, Mr. Aldrich has held project management and leadership positions with a national general contractor and several engineering firms before forming Aldrich + Elliott twenty years ago. He has served with distinction in the National Society of Professional Engineers (NSPE) where he held the position of national President in 2008-2009. He is a registered professional engineer in Vermont, New Hampshire, Maine and Massachusetts and is a fellow member of both NSPE and ASCE.

**Ms. Jennifer Hofmann, American Society of Civil Engineers**

Jennifer Hofmann, M.A.Ed, Aff.M.ASCE is the Manager of Professional & Technical Advancement at ASCE. In this role, she serves as primary staff contact for the Committee on Preparing the Future Civil Engineer (CPFCE) and aid in advancing the Engineer Tomorrow initiative. Jen has a B.A. in Psychology from The College of William and Mary and an M.A. in Education and Human Development with a concentration in Educational Technology Leadership from The George Washington University.

**Dr. Norma J. Mattei P.E., University of New Orleans**

Norma Jean Mattei, PhD, PE, currently is Professor in the Department of Civil and Environmental Engineering, after recently serving as Dept Chair and Interim Dean of Engineering at the University of New Orleans. She now serves as one of two civilian civil engineer Commissioners on the Mississippi River Commission (MRC), nominated by President Obama. She just completed her year as 2017 President of the American Society of Civil Engineers (ASCE). Locally she is still active on the Executive Committee of the ASCE New Orleans' Chapter of the Structural Engineering Institute. Norma Jean also has served in the past on several National Council of Examiners for Engineering and Surveying (NCEES) committees and task forces, serving as chair of the Board-level NCEES Education Committee and is an Emeritus Member of NCEES. She was named by the Governor of Louisiana to Louisiana's licensing board for professional engineers, LAPELS, serving as Chairman of the LAPELS Board in 2011-12. Mattei received her BSCE in 1982 from Tulane University and practiced as a consulting engineer in the New Orleans area for a decade before returning to Tulane (PhD, 1994). Her research areas of interest include engineering ethics, public policy and leadership, diversity in engineering and engineering education, management of large watersheds, mitigation of repetitively flooded structures in southeast Louisiana, experimental testing of large parts, residual stress measurement using laser interferometry, and materials testing (fatigue, shear, etc.). She, her husband, two engineer daughters and engineer son-in-law all reside in New Orleans.

**Mr. Michael B. O'Connor, New York University**

See profile

**The Merits of a Civil Engineering Certification Program to Validate Fulfillment of the CEBOK**

The American Society of Civil Engineers (ASCE), as the recognized leader of the civil engineering profession, has led many efforts to promote the licensure of civil engineers, to protect the jurisdiction of civil engineers, and to make civil engineering more relevant in our changing world. Through three editions of the Civil Engineering Body of Knowledge (CEBOK), ASCE has identified an increasing gap between the knowledge, skills, and attitudes (KSAs) that civil engineers need to serve in *responsible charge*, and what is measured through civil engineering licensure – the minimum legal authority to practice civil engineering. Addressing this critical gap is why ASCE is exploring the creation of a certification program to recognize attainment of the CEBOK for *responsible charge* in the civil engineering specialties.

Starting in 1998, ASCE attempted to influence licensing laws to increase the minimum educational requirements for licensure to a master's degree (or equivalent). These efforts were unsuccessful as state licensing boards resisted the need to adapt to changes in engineering degree programs and the rapid expansion of the body of knowledge that civil engineers must attain to practice competently today and into the future. As a result, in 2018 ASCE decided to curtail further efforts to change licensure laws, sunsetting their *Raise the Bar Initiative*. Ironically, this lack of success might benefit the civil engineering profession. A master's degree as a new formal educational requirement for licensure might have been appropriate two decades ago, however it alone no longer closes the gap in knowledge that civil engineers must attain and maintain, through education, mentored experience, and self-development for *responsible charge* – as documented in the current edition of the CEBOK.

In 2019, ASCE completed work on the third edition of the CEBOK [1]. This CEBOK demonstrates that the gap continues to expand at the pace of change – and civil engineers need to pursue post-graduate education along with structured mentorship, self-development, and life-long learning to first attain and then maintain the competencies required for *responsible charge*. Hence the need for a certification program and credential to attest to a civil engineer's fulfillment of the CEBOK. Like certification programs in other professions, a civil engineering certification would complement licensure – or one day replace licensure if further threats diminish or eliminate professional licensure as we know it today.

To this end, ASCE created the *Engineer Tomorrow Initiative* in 2019 to promote fulfillment of the CEBOK – to prepare civil engineers to meet their duty to protect public health, safety, and welfare, today and into the future. This includes exploring civil engineering certification.

The purpose of this paper is to answer the following research questions:

- Why do civil engineers need to fulfill the CEBOK?
- Why is professional licensure insufficient for responsible charge?
- What can be learned from certification programs of other licensed professions?
- Is there merit in a certification program to validate fulfillment of the CEBOK?

Based on the answers to these questions, the authors conclude with recommendations.

**The need to fulfill the CEBOK**

The conclusions in ASCE's latest edition of the CEBOK are the foundation for this paper's recommendations. The CEBOK will not be described in detail as there are numerous scholarly works that describe how it was developed and how it has evolved [2][3]. This paper also relies on the conclusions and recommendations from an earlier paper that introduced the *Engineer Tomorrow Initiative*, with a detailed justification of the need to fulfill the CEBOK for *responsible charge* [4]. Therefore, we will only summarize the justification of the need to fulfill the CEBOK and will focus primarily on the merits of certification. Finally, when the term *responsible charge* is used, it means attainment of the KSAs as defined by the CEBOK in a civil engineering specialty to take direct supervision, control, and responsibility for engineering services and deliverables.

First, what is a Body of Knowledge (BOK) and why does it need to be periodically updated? Ressler [5] defines a profession as having a professional domain (or jurisdiction exclusive to the profession) defined by a BOK that describes the complete set of concepts, terms, and activities that make up a professional domain. This BOK is typically defined by the relevant learned society or professional association. However, a profession's BOK is not static. Sociological theory concludes that continuous change is an inherent characteristic in any professional BOK. Therefore, a strong profession must be able to adapt its body of knowledge in response to emerging needs, opportunities, and threats [6].

For this reason, the CEBOK is periodically updated, to address the pace of change in civil engineering. In the first two editions, the CEBOK defined the attributes necessary for *entry into the practice of civil engineering at the professional level* – where *entry into the practice of civil engineering at the professional level* was defined as becoming licensed as a professional engineer (PE). The current CEBOK still recognizes licensure as an important professional career objective, and the minimum legal standard to practice, but defines more rigorous requirements than what is required for licensure – as the minimum standard for *responsible charge*.

To explain this distinction, ASCE adopted the following policy statement in 2019 [7]:

> *The American Society of Civil Engineers (ASCE) supports the attainment of the Civil Engineering Body of Knowledge (CEBOK) as a requirement for exercising responsible charge in the practice of civil engineering. The CEBOK is defined as the knowledge, skills, and attitudes necessary to exercise responsible charge in the practice of civil engineering and is attained through undergraduate and post-graduate engineering education, mentored experience, and self-development.* ***Licensure constitutes a legal authority to practice engineering, however, the requirements for licensure do not ensure attainment of the CEBOK.***
>
> *ASCE encourages institutions of higher education, governments, employers, engineers, and others appropriate organizations to endorse, support, promote, and implement attainment of the CEBOK by individual civil engineers, as a means to protect the health, safety, and welfare of the public. To promote attainment of the CEBOK, ASCE supports: (1) establishing accreditation criteria for the formal education process (2) promoting*

> *structured mentored experience guidelines for the workplace, (3) influencing regulatory bodies to adopt supportive education and experience standards in their laws and rules, (4)* ***implementing board certification to validate attainment of the CEBOK, including technical depth in a civil engineering specialty****, and (5) recognizing educational institutions, employers, and others that have programs supporting individuals' attainment of the CEBOK.* [Emphasis added]

The policy highlights a change from the term *practice at the professional level*, which did not have a universally accepted definition, to *responsible charge* of engineering services. This is not simply nuance, as the terms *responsible charge* and *practice at the professional level* are often mistakenly used interchangeably. All civil engineers – whether licensed or not and whether they act in *responsible charge* or not – have a duty to practice professionally at the level of their competency and qualifications. An Engineer Intern (EI) has a professional duty – among them to ensure that their work is overseen by a PE in *responsible charge*. PEs have a legal and professional duty not to practice outside their area of competence, whether they are acting in *responsible charge* or not. Those in *responsible charge* have a professional duty to directly oversee and take responsibility for the engineering deliverables that they seal. This is the generally accepted definition of *responsible charge* in most licensure laws.

In practice, most civil engineering firms follow this policy. While civil engineering firms encourage all their engineers to pursue licensure (and most engineers do), many PEs seldom (if ever) stamp engineering deliverables, as they are rarely (if ever) assigned *responsible charge*. Their employer recognizes that they have yet to obtain the necessary KSAs required to be in *responsible charge*, and only assign *responsible charge* to those PEs prepared to meet this higher responsibility.

**Why is professional licensure insufficient for responsible charge?**

The PE license establishes an essential malpractice standard under which the PE must operate. The licensee is obligated to perform their duties to a *normal standard of care* – the level at which an ordinary, prudent professional with similar training and experience in good standing in a same or similar community would practice under the same or similar circumstances. Further, PEs must perform in conformance with a professional code of ethics. Common to most engineering codes of ethics, the preamble of ASCE's Code of Ethics [8] states "Members of the American Society of Civil Engineers conduct themselves with integrity and professionalism and above all else protect and advance the health, safety, and welfare of the public". PEs can be held individually liable for their actions (as well as their employer) if they fail to meet this and other universally accepted ethical standards.

Engineering licensure sets a minimum legal standard for practice. However, these standards have remained relatively unchanged for over 100 years. Which is puzzling as each of the other *learned professions* (medicine, law, architecture, and accounting) have increased minimum formal education requirements for licensure to a master's degree or other advanced professional degree over time.

Concerns over the adequacy of a bachelor's degree as the formal educational requirement for licensure are not new. They can be traced as far back as the Mann Report in 1918 [9]. Since that time, numerous other scholarly works have addressed this concern, and will not be detailed here.

Until 2018, most recently through their *Raise the Bar Initiative*, ASCE and others advocated for increasing the minimum educational requirements for licensure from a baccalaureate degree to a master's degree (or equivalent), to no avail. Scholarly works offer reasons why this initiative was unsuccessful so we will not outline them here [4]. Further the current CEBOK makes clear that post-baccalaureate education alone will not close the gap. Structured and comprehensive mentored experience and life-long learning are also essential to prepare civil engineers for *responsible charge* today and into the future.

Is engineering licensure in peril if we do not act? Richard and Daniel Susskind [10], surmise that increasingly capable machines, operating on their own or with non-specific users, will take on many of the tasks that have been the historic preserve of the professions. These fundamental changes will lead eventually to the dismantling of the traditional professions. To maintain relevance as technology and societal expectations evolve, professions must evaluate the following:

- Is there an entirely new way to organize work?
- Must all current licensed work continue to be done only by licensed professionals?
- Can licensed professionals be trusted to admit if services could be delivered by non-licensees?
- Is the traditional arrangement still fit for the purpose and serving society well?

Does this apply to civil engineering? A 2020 report by the Engineering Change Lab (ECL-USA) [11] concludes that the disruptive technologies of the Fourth Industrial Revolution are blurring the boundaries of the traditional practice of engineering and challenging the traditional models of licensure for engineers. The challenges of the Fourth Industrial Revolution are revealing the need for licensure to encompass a broader definition of engineering practice and engineering ethics.

The stark conclusion is that civil engineering licensure has not kept up with the pace of change in civil engineering practice and is in danger of failing its fundamental tenet to protect and advance public health, safety, and welfare. Civil engineering cannot survive as a *learned profession* if we fail to act. The PE will be relegated to a trade license and civil engineering will simply be a trade occupation – no longer a profession.

**The purpose of professional certifications**

A professional certification is a formal recognition that an individual has demonstrated a proficiency within, and comprehension of, a specified body of knowledge (BOK). A BOK establishes the scope of a professional certification that assesses a candidate's knowledge of the concepts, terms, and activities that make up a professional domain. Professional certifications add value because they demonstrate an individual's expertise, document proof of knowledge to a specified BOK and provide a mark of technical excellence. Certifications also demonstrate a commitment to a profession and – because many certified professionals commonly become so of their own volition – demonstrate a person's initiative [12].

Professional certifications remain of value if their BOK stays relevant, are based on independent and authenticated information, and are tightly and impartially controlled. Bodies of knowledge are dynamic, constantly evolving and keeping relevant as technology advances and methodologies improve. For a professional certification to remain relevant, those administering certifications must periodically review and update the BOK – and subsequently the certification standards [12].

A professional organization might establish a certification to apply professional standards, increase the level of practice, and protect the public. This is intended to be portable to all places a certified professional might work. To be portable, the process to develop and administer the program must establish a legally defensible assessment, that can be used in hiring and other employment decisions, and by clients assessing the qualifications of individuals to perform services.

In the United States, certification is different from licensure. Licenses are typically issued by state agencies, whereas certifications are typically awarded by professional/technical societies or educational institutes. Obtaining a certificate is voluntary in some fields, but in others, certification from a government-accredited agency may be legally required to perform certain jobs or tasks.

As an example, in medicine certification in a specialty is granted after the individual has obtained their MD (license to practice) and augments their license with a demonstration of further expertise in a medical specialty. While board certification in a medical specialty is not a legal requirement to practice in that specialty, in many cases board certification is required to attain the hospital privileges that are necessary to practice [13].

**What can we learn from the medical specialty certification program?**

There are numerous examples of professional certification programs including in civil engineering (described later in this paper), with varied utilization and acceptance. However, none validate the fulfillment of the CEBOK. The professional certification program most comparable to what is needed for civil engineering is in medicine where doctors first become licensed to practice (obtain their MD) and then pursue board certification in any number of medical specialties. According to Ressler and Lenox [13] medical specialty certification is a comprehensive, highly structured system of licensure and specialty certification to validate the attainment of expertise within well-defined medical specialties, according to standards controlled by the profession itself.

Medical specialty certification is voluntary however, the effectiveness of this system is greatly enhanced by the medical profession's approaches for motivating individual practitioners to seek board certification. Most hospitals require board certification to practice in a medical specialty area and insurance fee reimbursement rates are typically tied to board certification. Furthermore, many hospitals have independently made the decision to require board certification for staff privileges. Thus, from a physician's perspective, certification serves as both a "carrot and stick". Despite the substantial additional demands associated with board certification, approximately

80% of all licensed physicians in the U.S. are board-certified medical specialists. Moreover, many of the remaining 20% are in the process of obtaining board certification [14].

Medical specialty areas are authoritatively defined by the American Board of Medical Specialties (ABMS) – a non-profit organization currently comprised of 24 certifying boards that develop and implement professional standards for the certification of physicians in their declared medical specialties. These boards certify physicians in 39 different medical specialties and 86 medical subspecialties [15].

To become a *licensed physician* (MD), a candidate must [16]:

1. complete bachelor's level education in a premedical field at a college or university (typically four years),
2. earn a medical degree from an accredited medical school (typically four years),
3. complete one year of medical residency experience, and
4. pass the three-part U.S. Medical Licensing Examination.

To become a *board-certified medical specialist*, a candidate must [16]:

1. become a licensed physician, as described above,
2. complete an outcome based medical education program that uses an organizing framework of competencies. Complete professional development milestones as a roadmap for growth and development [17],
3. pass an exam created and administered by the certification board associated with the candidate's specialty.

Medical *board certification* utilizes a competency-based standard to educate residents and fellows. It is an outcomes-based approach to the design, implementation, assessment, and evaluation of medical education programs, using an organizing framework of competencies to help learners achieve basic abilities in key areas to care for patients in practice. Notably, this is a different model from one where education and training are purely based on how many years you have completed [18].

This comprehensive, highly structured system of licensure and specialty certification quite effectively fulfills its purpose – to validate the attainment of expertise within well-defined medical specialties, according to standards controlled by the profession itself.

Like the medical model, a successful civil engineering certification program must include a PE license, as this is the minimum legal standard to practice. Further, a successful program must be based on a well-defined set of metrics and outcomes – in this case certifying that the individual in *responsible charge* has first attained and then maintains the necessary KSAs (as defined in the CEBOK) in a civil engineering specialty.

A civil engineering certification should:

- Demonstrate competency and specialty expertise in a field of civil engineering (e.g., water resources, structural, transportation, geotechnical).

- Help employers better identify qualified engineers and differentiate between engineers with varied skill sets to select the most qualified engineer to address a specific need.
- Help clients identify qualified engineers to retain for services.
- Support reciprocity throughout the U.S. and globally.
- Enhance the PE license or replace it if, in the future, it is diminished or eliminated.

The "lessons learned" for the civil engineering profession from the implementation of board certification in the medical profession have been carefully studied [19]. It is readily evident how civil engineering could follow a similar model where licensure is a precursor to *specialty board certification*. The CEBOK provides the foundation for civil engineering certification, however competency-based standards specific to each of the civil engineering specialties will need to be developed for examination and assessment.

**What Can We Learn from Existing Engineering Credentials?**

The most widely recognized credentials associated with engineering are associated with engineering licensure – Engineer Intern (EI) and Professional Engineer (PE). These certifications are administered by the 55 licensing jurisdictions (states and territories) in the U.S. – each with its own unique engineering licensing statute, enacted by the legislature of that jurisdiction [20]. Because of this decentralization, licensure systems and qualifications vary somewhat from jurisdiction to jurisdiction; nonetheless, these variations are relatively minor, due to the influence of the NCEES Model Law and Model Rules, which have been promulgated to provide greater uniformity of qualifications to practice [21]. Licensure of medical doctors follows a similar model with similar issues, which is likely one reason why they pursued specialty certification to create unified national standards in the various medical specialties.

There are examples of specialty licensing in civil engineering, but they are not universally adopted and recognized. ASCE offers specialty certification in limited disciplines through *Civil Engineering Certification, Inc.* (CEC), a corporation created by ASCE in 2004 and accredited by the Council of Engineering and Scientific Specialty Boards (CESB). CEC has created three academies which provide board certification in six specialty areas:

- The *American Academy of Water Resource Engineers* (AAWRE) offering certification in Water Resources engineering
- The *Academy of Geo-Professionals* (AGP) offering certification in Geotechnical engineering.
- The *Academy of Coastal, Ocean, Ports, and Navigation Engineers* (ACOPNE) offering certifications in Coastal, Ocean, Port, and Navigation engineering

The minimum requirement for these certifications are a PE license (or international equivalent), a master's degree and eight years of progressive post-licensure engineering experience. An oral exam is sometimes required but may be waived based upon an applicant's depth of experience. Individuals certified in these specialty areas are awarded the title *Diplomate* [22]. The *Diplomate* programs do not attempt to assess fulfillment of the CEBOK.

Other examples of civil engineering credentials include:

- The *Structural Engineering Certification Board* (SECB) – a partnership of the *ASCE Structural Engineering Institute* (SEI), the *National Council of Structural Engineering Associations* (NCSEA), and the *Structural Engineering Licensure Coalition* (SELC) offers *board certification* in structural engineering.
- The *American Academy of Environmental Engineers and Scientists* (AAEES) offers certifications in environmental engineering.
- The *Institute of Traffic Engineers* (ITE) offers certifications in transportation planning and design.
- A handful of states offer a structural engineer (SE) license – some states require a PE license first, but some states do not.
- California also offers a geotechnical engineer (GE) license to those who are licensed civil engineers, have specific geotechnical experience, and pass a geotechnical engineering exam.

In each example the qualifications differ and do not validate fulfillment of the CEBOK. Further, the credentials are not broadly pursued by civil engineers in those specialties and are not widely known and required by most clients who retain engineering services. *Specialty board certification* must achieve what has been achieved in medicine – broad acceptance by the civil engineering community and those who retain engineering services to succeed.

Another issue is the definition of the jurisdiction of the civil engineering specialties. Like medicine, civil engineering spans a diverse body of specialty areas – broadly considered to be construction, environmental, geotechnical, structural, transportation, and water resources – each with distinct differences in the KSAs required to achieve *depth in a civil engineering area*. Further, more civil engineering specialization will continue to occur as the pace of change demands more specialized knowledge in subsets of these broader categories of civil engineering. This may create new categories of civil engineering or subspecialties within one of the existing categories.

Socialist Andrew Abbott [23] calls this *discretionary specialization* – the application of discretionary judgement to accomplish complex tasks, which occurs within professions when the knowledge and skills required for a given task area expand beyond the ability of any individual practitioner to acquire. Thus, after specialization has occurred, the individual practitioner will be able to achieve a higher level of expertise in a narrower domain of knowledge. Across the profession, the aggregate effect is a higher level of expert knowledge and, therefore, enhanced capacity to diagnose and solve problems in the professional jurisdiction. The ultimate result is a stronger profession. A civil engineering certification program must be prepared to evolve as civil engineering specialization evolves.

Further, the civil engineering specialties have never been authoritatively defined, and sometimes get combined as each specialty has overlap with other specialties [24]. As example, many consider environmental and water resources as a single specialty. However, these are two distinct disciplines, where environmental engineering generally encompasses solid and hazardous waste and water resources engineering generally encompasses water, wastewater and stormwater distribution and treatment – two distinctly different specialty skill sets.

Overall – in sharp contrast to the medical profession – the civil engineering profession does not have a single, well-managed certification system, but rather a collection of systems that are incomplete, inconsistent, and poorly integrated. Collectively these existing systems are – as currently organized and managed – unsuitable for the task of validating fulfillment of the CEBOK [13].

**Is there merit in creating a civil engineering certification?**

In 2018, ASCE directed the Committee on Preparing the Future Civil Engineer (CPFCE) to convene a Task Committee on Credentialling (TCC) to study whether a certification program for civil engineers could be an effective way to recognize that engineers have fulfilled the CEBOK.

The TCC developed the broad framework of what a certification program could entail, before conducting a more detailed investigation into the viability of such a program. In furtherance of these efforts, in November 2019, Global Skills X-Change (GSX), a consultant with extensive experience in the creation of certification programs, was retained by ASCE to conduct market research (Phase I) – and if the findings indicate support for certification – provide recommendations on how to develop the program, including the framework of the certification, the development process, market size, and business plan (estimated revenues and expenses) (Phase II).

GSX conducted market research using various certification forms, accreditation options, psychometric best-practices, and feedback from key ASCE stakeholders. This included an on-line survey with over 3,000 responses, four focus groups (with 20 total participants), and 60 individual interviews. The target audience for this research were practicing engineers, engineering students, engineering faculty, engineering owners/principals, insurance professionals, facility owners, and other purchasers of engineering services.

Some key findings of this research include:

- Most civil engineers agree that there is a skills gap between the knowledge required to exercise in *responsible charge* of civil engineering, and the requirements for licensure.
- 90% of respondents agreed that ASCE has a responsibility to establish and advance educational and professional standards, to address the profession's changing landscape and prepare future civil engineers.
- The respondents favor creating a certification program by a margin of two-to-one, with students, early-career civil engineers, and retirees largely supportive, and mid-to-late career engineers supportive to a lesser extent.

The fact that mid-to-late career civil engineers are less supportive is not a surprise, as ASCE witnessed similar attitudes from this cohort toward increasing educational requirements for licensure. It is surmised that these individuals feel they have already established their career expertise and would not be personally served by seeking an additional certification (or previously a post-BS degree for licensure if they do not already have one).

With this information in hand, it was concluded that there was ample support to move to Phase II – determine the viability of a certification program for civil engineers. The Phase II assessment was shaped by the following premises and assumptions:

- The program must be developed in a standardized way that is legally defensible for *high stakes* usage – defensible for pay-affecting purposes such as hiring, employment and promotion, and as a requirement to be retained for a project.
- The program will initially pursue *Council of Engineering and Scientific Specialty Boards* (CESB) accreditation to validate the policies, procedures, and standards developed to create the certification. The program will ultimately pursue a more widely held international standard with accreditation from the *American National Standards Institute* (ANSI) and *Institute for Credentialling Excellence* (ICE). ANSI/ICE accreditation will help the certification better reach an international market that is more familiar with ANSI/ICE accreditation.
- The certification program will be centralized under one governing body and administered by one program management office. Initially ASCE would control the governing body and program management office (though other stakeholders would be included) as ASCE would launch the program and incur the development, marketing, and administration costs to create it. However, once ASCE was able to recoup expenses, the program should move to a stand-alone and independent body that includes ASCE among other stakeholders that represent civil engineers.

Of interest, the market research indicated a strong desire among early-career engineers, and engineering students for a structured program to fulfill the mentored experience outcomes common to all civil engineering specialties – the *cross-specialty* outcomes in the CEBOK, with a corresponding certification to document achievement. These include some of the Technical Outcomes (project management; engineering economics; risk and uncertainty) and all Professional Outcomes (communication; teamwork and leadership; professional attitudes; professional responsibilities; and ethical responsibilities). This led to discussion of the merits of a two-tier certification where a candidate first fulfills the *cross-specialty* outcomes, while concurrently fulfilling depth and breadth outcomes in a civil engineering specialty for *responsible charge*. It is anticipated that the *cross-specialty* outcomes can be fulfilled in 3-5 years post-BS degree, however the technical specialization outcomes will likely take 6-8 years or more to fulfill.

The TCC and GSX agreed on many of the recommendations presented to the ASCE Board of Direction in October 2020 but diverged on the issue of single vs. two-tier certification. The TCC recommended a single-tier certification with the typical pathway for achievement of *specialty board certification* to include:

- A bachelor's degree (or higher) in civil engineering from an ABET-accredited program – a master's degree may be required in some specialties at the discretion of the specialty area working group.
- A PE license or a license in a specialty area of civil engineering (e.g., SE, GE).
- A minimum of eight years of mentored experience (post-bachelor's) with sufficient relevant years in the specialty area they are seeking certification in.

GSX recommended a two-tier certification – *cross-specialty* certification first and then *specialty board* certification. The requirements to achieve cross-*specialty* certification would include:

- A bachelor's degree (or higher) in civil engineering from an ABET-accredited program. Based on the market research, they conclude that a master's degree should not be a rigid requirement for certification in any of the specialty areas – without at least another well-defined pathway to achieve certification.
- Fulfillment of the *cross-specialty* outcomes in the CEBOK. It is anticipated that many individuals would likely already have a PE license, however a PE would not be a prerequisite for the *cross-specialty* certification.

The requirements to achieve *specialty board* certification according to the GSX report would include:

- Fulfillment of the *cross-specialty* certification.
- A PE license or a license in a specialty area of civil engineering (e.g., SE, GE).
- An adequate amount of mentored experience (post-BS degree) with sufficient relevant years in their specialty area. GSX does not recommend dictating a specific number of years of experience.

Both the TCC and GSX concur that *specialty board* certification must include documented and rigorous post-certification professional development, specific to the specialty to maintain certification.

GSX provided a conservative business model for each of the contemplated specialties – structural, environmental/water resources, geotechnical, transportation, and construction. They conclude that single-tier *specialty board* certification is financially viable for most of the specialties with an eight to twelve-year payback – if the certification program is marketed properly and well-received by the civil engineering community. However, it is difficult to quantify just how widely accepted a single-tier certification program would be, making the decision to proceed tenuous, if the program must be financially viable within a reasonable period. Consequently, GSX recommended that ASCE develop and launch a *cross-specialty* certification first for the following reasons:

- The market research documented a strong desire for a *cross-specialty* certification among early-career engineers and engineering students demonstrating strong financial viability.
- The *cross-specialty* certification program can be marketed to all civil engineers in all disciplines, providing a much larger audience of civil engineers to promote certification and launch a program. A single-tier program would have the same overall audience, but programs would need to be developed and marketed to each of the civil engineering specialties – with higher requirements and a longer time horizon for achievement – which may discourage some individuals to pursue certification.
- The *cross-specialty* certification program would be quicker and easier to develop as the outcomes are already clearly defined and apply broadly to all civil engineers. *Specialty board certification* will require more time and effort to define the specific KSA's appropriate for each civil engineering specialty.
- A successful *cross-specialty* certification program can mature, gain broad acceptance in the civil engineering community, and become financially self-supporting more rapidly

than *specialty board* certification. This not only provides needed revenue to develop and launch the *specialty board* certifications, but also provides an identifiable cohort of *cross-specialty* certified civil engineers who should be eager to pursue *specialty board* certification.

Either certification strategy will document the fulfillment of the CEBOK and advance the profession – key initiatives in ASCE's strategic plan. In addition, the certification program establishes a milestone for engineers entering practice, inspiring them to strive for growth. It would also provide employers with a tool to aid in identifying qualified applicants during the hiring process and would focus employee training and mentoring. Further, the certification would provide clients a means to identify (select) highly qualified and specialized engineers, to better mitigate risk during the development of their project.

**How should specialty board certification be promoted?**

Regardless of whether *specialty board* certification is single or two-tier, to be viable it must be widely accepted and pursued by the civil engineering community – including those who retain civil engineers. So how could such a certification program be promoted? To start, the civil engineering community must understand why it is importance for civil engineers who want to serve in *responsible charge* first fulfill the CEBOK.

The CEBOK should be introduced to every freshman civil engineering student and integrated throughout their four-year curriculum, so students can track their path and immerse themselves in their personal CEBOK program. There is no better document to show students the road map of their professional career path. This would also assist educators launching students into their career, showing graduates that their learning has only begun and how they will need additional formal education, structured mentored experience, and self-development to gain and maintain the depth and breadth of engineering knowledge required for *responsible charge* in their area of practice. ASCE is currently working on this initiative.

ASCE, through its *Engineer Tomorrow*, *Future World Vision,* and other initiatives, is explaining to civil engineers how the pace of change is impacting the current and future practice of civil engineering. The opportunities are constantly evolving, but so are the responsibilities for those who practice in *responsible charge*. Consequently, ASCE must promote the essential need for those in *responsible charge* to attain and maintain the necessary KSAs to meet their professional duty to society – KSAs that go far beyond what is validated by the PE license. Indeed, with the pace of change that we are witnessing, civil engineers who graduate in 2021 will practice using technologies and methodologies ten years from now that they did not learn through their undergraduate education. Not because they were not taught these technologies and methodologies, but because these technologies and methodologies do not yet exist!

Civil engineers must embrace the need for certification to demonstrate competency, and clients of engineering services need to require certification to ensure that only those qualified are retained to deliver the services sought. To achieve this, ASCE must promote universal acceptance of fulfillment of the CEBOK for *responsible charge* and the importance of certification to document this achievement.

The profession must also accept that not all civil engineers will pursue certification. Certification is a bar that some civil engineers will decide is unobtainable or undesirable for any number of reasons – and this is OK! Certification is only necessary for those civil engineers who decide to advance to *responsible charge*. Other civil engineers – both licensed and not – will still have an important role on the engineering team and will enjoy a fruitful and rewarding career.

**Recommendations**

The CEBOK documents a well-defined skills gap between the legal minimum standard for licensure to practice and the KSA's required for *responsible charge* – and based on recent market research, the civil engineering community acknowledges this. Other organizations and scholars have documented similar concerns, going back decades. As advances in technology, environmental degradation from global warming and population growth, societal expectations, and concerns over sustainability and resiliency continue to rapidly change how civil engineers' practice, this gap will only widen.

Regardless, attempts to address this skills gap through licensure reform have been unsuccessful – with no evidence that these efforts will succeed in the future. The PE license is no longer adequate evidence that a civil engineer is prepared for *responsible charge*. This puts public health, safety, and welfare at serious risk – and civil engineering licensure and the civil engineering profession on a perilous path. With no action, the civil engineering profession will devolve from a *learned profession* to a trade occupation. Others who understand how to utilize advances in technology and science, the future ramifications of climate change, advances in technology, and evolutions in society and their expectations, will attempt to fill this gap. Society will demand more, and someone will step up to fill it. It should be the civil engineering profession that does.

Like the medical model of specialty certification, a civil engineering certification that measures attainment of the KSA's defined in the CEBOK, including a requirement for life-long learning to maintain competency can and should be created to address this imminent demand.

A successful and effective civil engineering certification program should:

- Accredit the attainment of a body of knowledge founded on academic rigor and a justifiable benchmark – the attainment of the CEBOK for *responsible charge*.
- Be widely accepted within the civil engineering community – both practitioners and clients.
- Provide a roadmap for development of the core competencies in the CEBOK with milestones that describe a stepwise progression towards achieving the KSAs for *responsible charge*. The milestones provide a common framework for the civil engineering community to communicate with individual engineers, leadership, and multiple stakeholders.
- Support individual engineers using these milestones to establish where they are in their development, identify areas to grow, and progression from common or basic abilities to mastering complex problems and design elements.

- Be *high stakes* – legally defensible in hiring and evaluating employees and retaining engineering services.
- Be created and administered by one body with uniform standards across all civil engineering specialties.
- Be certified by a nationally recognized certification board (CESB and/or ANSI/ICE)
- Include all the major civil engineering specialties – construction, environmental, geotechnical, structural, transportation, water resources, and general civil engineering – with a clear definition of each.
- Demonstrate attainment of depth in a specialty area of civil engineering through competency-based examination.
- Include a process supported by standards and methods to document life-long learning that engineers must complete to maintain their competency and their certification to stay current with the pace of change.
- Update requirements as the CEBOK is updated to address the pace of change over time within civil engineering.

To achieve this objective, the authors recommend the following:

- ASCE must continue to highlight the promise the future holds for civil engineers through their *Engineer Tomorrow* and *Future World Vision* initiatives.
- ASCE must provide a common framework to communicate with individual engineers, leadership, and multiple stakeholders, the critical need to fulfill the CEBOK for *responsible charge*.
- ASCE must advocate for *specialty board* certification for *responsible charge*.
- ASCE must develop *specialty board* certification to affirm a civil engineer's attainment of the CEBOK. It is recommended that ASCE develop and launch *cross-specialty* certification first, and then develop *specialty board* certification.
- The certification program should define a stepwise progression towards attainment of the outcomes of the CEBOK, including a competency-based assessment framework to document achievement.
- ASCE must develop the necessary marketing plan to convince both civil engineers and clients of the critical need and the specific benefits of *specialty board* certification.
- ASCE must authoritatively define the civil engineering specialties and gain universal agreement.
- ASCE must start at the undergraduate level to explain to future civil engineers' their duty to pursue post-graduate formal education, mentored experience, and self-development to fulfill the CEBOK – should they choose to serve in *responsible charge*.
- ASCE must develop structured guidance on how to obtain the mentored experience outcomes described in the CEBOK.
- ASCE must continue to assess and update the CEBOK on a periodic basis to ensure that the competencies it defines keep pace with all the societal evolutions that have a direct effect on the practice of civil engineering.
- ASCE must periodically review and update certification standards in each of the specialties to ensure that they cover all outcomes of the updated CEBOK.

- ASCE must create a new governing body (or re-organize CEC), and one program management office to create and administer certification.
- ASCE must identify and entice key stakeholders outside ASCE to serve on the governing body and provide valuable input to the program development, marketing, and management.
- ASCE must commit the substantial financial resources needed to create, launch, and maintain the certification program until it is self-sustaining.

ASCE is at a crossroads. They have acknowledged that licensure is no longer adequate certification that a civil engineer is prepared for *responsible charge*, and that future attempts to change licensure laws to address the gap are futile. Certification is a means to close this gap to protect and advance public health, safety, and welfare, and the profession – but a successful program requires the support and "buy-in" of both the civil engineering profession and those who retain civil engineering services. If ASCE is unsuccessful in marketing this effort, certification will struggle to be widely accepted and financially sustainable.

Ultimately, ASCE needs to choose whether certification is so important to the future of civil engineering that they move forward or not. The observations, and recommendations contained in this paper demonstrate that certification is essential to the future of civil engineering. ASCE is currently investigating other aspects of civil engineering certification, before determining how best to proceed.

**Disclaimer:** While the authors have various affiliations within ASCE and each was involved in ASCE's initial efforts to explore a civil engineering credential (described later in this paper), the observations, conclusions, and recommendations are those of the authors and not necessarily of ASCE.

**References**


1. American Society of Civil Engineers, "Civil Engineering Body of Knowledge – Preparing the Future Civil Engineer, third edition," Reston, VA.
2. Hains, D.B. "Lessons Learned in Developing the Civil Engineering Body of Knowledge" *Proceedings of the 2020 Annual Conference of ASEE*, June 2020, Paper ID#-29462.
3. Fridley, K.J., Hains, D.B., Barry, B.E., Sanford Bernhardt, K.L., Nolen, L., "The Third Edition of the Civil Engineering Body of Knowledge: An Update and Overview," *Proceedings of the 2018 Annual Conference of ASEE*, June 2018, Paper ID #21527.
4. Aldrich, B.F., Rosenfield, K.H., Walton, M.A., Hofmann, J., "Countering Threats to Licensure with ASCE's Engineer Tomorrow Initiative," *Proceedings of the 2020 Annual Conference of ASEE*, June 2020, Paper ID#28967.
5. Ressler, S.J., "Sociology of Professions: Applications for the Civil Engineering 'Raise the Bar' Initiative,". J. Prof. Issues Eng. Educ. Pract. 137(3): 152-153. http://doi.org/10.1061/(ASCE)EI.1943-5541.0000043.
6. Ressler, S.J., Lynch, D.R., "The Civil Engineering Body of Knowledge and Accreditation Criteria: A Plan for Long-Term Management of Change," *Proceedings of the 2011 Annual Conference of ASEE*, June 2011.
7. American Society of Civil Engineers, "Policy Statement 465 – The Civil Engineering Body of Knowledge and the Practice of Civil Engineering," [Accessed at

https://assce.org/issues-and-advocacy/public-policy/policy-statement-465---the-civil-engineering-body-of-knowledge-and-the-practice-of-civil-engineering/].
8. American Society of Civil Engineers, "Code of Ethics," [Accessed at https://www.asce.org/code-of-ethics/].
9. Mann, C.R., "A Study of Engineering Education, Prepared for the Joint Committee on Engineering Education of the National Engineering Societies," 1918, Bull No. 11, The Carnegie Foundation for the Advancement of Teaching. New York.
10. Susskind, R., Susskind, D., "The Future of Professions: How Technology Will Transform the Work of Human Experts," 2016 Oxford University Press.
11. Engineering Change Lab USA, "Licensure Models for the Fourth Industrial Revolution," [Accessed at https://ecl-usa.org/summits/summit-information/].
12. Spichiger, J., "Certification Integrity," October 2020 [Accessed at https://www.qualitymag.com/articles/96234-certification-integrity].
13. Ressler, S.J., Lenox, T.A., "The ASCE Raise the Bar Initiative: A New Paradigm Based on Credentialing in the Medical Profession," *Proceedings of the 2019 Annual Conference of ASEE*, June 2019.
14. Young, A., Arnhart, K., "A Census of Actively Licensed Physicians in the United States, 2016," *Journal of Medical Regulation*, 2017, vol. 103, no.2, 2017, pp7-21.
15. American Board of Medical Specialties, "Fact Sheet: American Board of Specialties (ABMS) and the ABMS Maintenance of Certification Program," [Accessed at https://www.abms.org/media/1209/abms_fact_sheet.pdf].
16. American Board of Medical Specialties, "ABMS Guide to Medical Specialties," 2019, [Accessed at https://www.abms.org/media/194925/abms-guide-to-medical-specialties-2019.pdf].
17. Accreditation Council for Graduate Medical Education, "Milestones Guidebook for Residents and Fellows," 2020 [Accessed at https://www.acgme.org/Portals/0/PDFs/Milestones/MilestonesGuidebookforResidentsFellows.pdf].
18. American Board of Medical Specialties, "A Trusted Credential," [Accessed at https:///www.abms.org/board-certification/a-trusted-credential/].
19. D. Hains, S. Ressler, & T. Lenox, "Lessons Learned from the Implementation of Board Certification in the Medical Profession," *Proceedings of the 2020 Annual Conference of ASEE*, June 2020.
20. Musselman, C., Nelson, J., Phillips, M., "Engineering Licensing Laws and Rules, Today and Tomorrow," *Proceedings of the 2011 Annual Conference of ASEE,* June 2011.
21. National Council of Examiners for Engineering and Surveying, "Model Law" [Accessed at https://ncees.org/wp-content/uploads/Model_Law_2018.pdf].
22. American Society of Civil Engineers, "Academies," [Accessed at https://www.asce.org/academies/].
23. Abbott, A., "The System of Professions: An Essay on the Division of Expert Labor," 1988, www.press.uchicago.edu.
24. Ressler, S.J., Lenox, T.A., "Specialization Within the Civil Engineering Profession: Issues, Analysis, and Recommendations," *Proceedings of the 2018 Annual Conference of ASEE*, June 2018.