A Vision for the Future of Structural Engineering Licensure

A Structural Engineering Licensure Coalition

Task Committee Paper

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Structural Engineering Licensure Coalition

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Executive Summary

There are challenges regarding Structural Engineering (SE) licensure that threaten the status quo and hamper the ability to expand SE licensure. In order to fairly evaluate and manage a path for SE licensure, it is important to consider the history, the method of evaluating competency, the current threats to the profession and licensure, and trends affecting structural engineering. The goal of structural engineering licensure is to protect the safety of the public. This is best achieved by restricting the practice of structural engineering to those who demonstrate that they are best qualified by passing an objective and rigorous examination, in addition to having the appropriate education and experience.

The first SE licensure law was in the state of Illinois in 1915. Since then, there have been at least thirteen other jurisdictions with some form of restriction on the practice or title of structural engineers. A title restriction limits the use of the title, "Structural Engineer," but not the practice of structural engineering. A practice restriction limits the practice of structural engineering to some degree.

Structural engineering licensure currently faces challenges, both inside and outside of the profession. Improving positive messaging regarding structural engineering and overcoming the ambivalence regarding licensing is necessary to gain support to defeat legislative initiatives that would harm licensure.

New trends in the industry will also affect structural engineering and licensure. Rapid advances in technology will require structural engineers to integrate engineering with robotics, Artificial Intelligence (AI), and many other similar technological advances. Technology has made it possible and easier to work in other countries and with engineers around the world. Increased complexity of building codes requires more time for understanding, resulting in a focused study of structural engineering and the profession. At the same time, many engineering colleges are shifting focus from purely "book" knowledge to include classes that are collaborative, experiential, and creative.

In engineering and other professions, recognition of professional competence can take more than one form. In addition to licensure, certification and/or charter are used in various occupations and jurisdictions. A certification is a verification by a professional organization of an individual's level of knowledge or proficiency, and is very common in fields such as aviation, construction, technology, environmental science, healthcare, business, real estate, and finance.

Based on the history, the method of evaluating competency, the current threats to the profession and licensure, and trends affecting structural engineering, the future of structural engineering licensure should include the following:

- Recognition of SE licensure in all 55 US jurisdictions as a post-PE credential.
- Recognition of the SE examination as the testing vehicle to demonstrate minimum competence for the design of Significant Structures. (Appendix D)
- Establishment of uniform requirements for education, examination, and experience across all jurisdictions globally.
- Requirements for enhanced continuing education beyond that for PE licensure in all jurisdictions.
- Portability of the SE license between all jurisdictions.
- Recognition of SE licensure as the minimum standard for the practice of structural engineering.
- Consideration that certification may have a valid place in the credentialing process to enhance licensure, but it does not replace licensure.

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VISION FOR THE FUTURE OF STRUCTURAL ENGINEERING LICENSURE

I. INTRODUCTION

The Council of American Structural Engineers (CASE) of the American Council of Engineering Companies (ACEC), the National Council of Structural Engineers Associations (NCSEA), and the Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE) endorsed a mutual Vision for the Future of Structural Engineering. The final Vision was signed at a joint meeting of leaders from the three organizations in 2019. Structural engineering (SE) licensure is one of the key initiatives of this Vision. Accordingly, the Structural Engineering Licensure Coalition (SELC) believes that SE licensure is vital to the profession. SELC endorses SE licensure as a subsequent step to obtaining a professional engineering (PE) license.

The first SE license was given in 1915 in Illinois. Since that time, thirteen more jurisdictions have added either a title or practice requirement for a structural engineer. Illinois and Hawaii have adopted a “full practice restriction” which requires all structures to be designed by a licensed SE. Ten jurisdictions have a “partial practice restriction,” which requires only significant structures to be designed by a licensed SE, or a “title restriction,” which limits the title “structural engineer” to only those who meet certain requirements.

CASE, NCSEA, SEI, and the Structural Engineering Certification Board (SECB) formed the Structural Engineering Licensure Coalition (SELC) in 2012. The goal of SELC is to provide a united voice for the structural engineering profession for the promotion of structural engineering licensure working toward implementation in all jurisdictions.

SELC:

- Recognizes that certain significant structures can present extraordinary hazards to the safety, health, and welfare of the public if they are not properly designed and detailed.
- Acknowledges that the public needs a means of recognizing and differentiating those professional engineers who possess sufficient education and experience to design these significant structures properly.
- Advocates the creation of a common post-PE structural engineering license.
- Supports a transition clause for PEs who are qualified and currently practicing structural engineering.

Since the formation of SELC, there have been threats to both professional and structural engineering licensure. Examples include the recent threat in Indiana to eliminate the PE and opposition from the National Society of Professional Engineers (NSPE) to licensing engineers with anything other than the PE. There are also other options being considered by certain entities within the structural engineering community such as creating a certification, charter, or other credential as an interim step to SE licensure. These threats need to be investigated to evaluate the influence on the existing and future status of SE licensure.

This paper:

- Discusses the history of PE and SE licensure.
- Provides a detailed description of the current process involved in obtaining the PE and SE licenses.
- Investigates credentialing in other professions within the United States.
- Evaluates the credentialing of engineers in other countries.
- Evaluates the alternatives to SE licensure.
- Investigates the significant trends in licensure.
- Discusses the threats and controversy around SE licensure.
- Offers conclusions regarding the future of structural engineering licensure, including suggested action items.

II. HISTORY OF STRUCTURAL ENGINEERING LICENSURE

Engineering is a profession that incorporates the practical application of mathematical, scientific, and other principles for the creation of items to be used by society. Civil engineering applies such principles to the built environment. History is replete with examples of individuals who employed their skills for invention or construction, especially in the last several hundred years. These visionaries were able to address real-life scenarios, which led to the Industrial Revolution and significant improvements in the built environment, including bridges, canals, and buildings.

A. Historical Background of Professional Engineering Licensure

In the United States, the legislative branch of state governments holds regulatory power for engineering licensure (Acorn Corley 2004). Many governments outside of the US allow the engineering profession to control its credentialing requirements and rights to practice. The following discussion provides a background leading to the first state-required professional engineering license.

In the US, only physicians and lawyers were required to be licensed to practice in the late 18th and early 19th centuries. There was a decrease in licensing requirements in the mid to late 19th century with the Jeffersonian expansion and Jacksonian reformers, whose goal was to secure the rights of the common man. This was followed by a subsequent increase in licensing requirements in the 1870s (Wallace 1972). Additionally, in the mid-19th century, adoption of laissez-faire policy toward industry, a shortage of professionals, and a preference for decentralized government all resulted in relaxation of regulatory standards. Engineering became more important in response to the development of locomotives, steam ships, engines, and public works. Many industrial and military applications were developed. The number of engineers grew from approximately 30 in 1816 to 2,000 in 1850.

As unfortunate deaths resulted from industrial accidents, engineering leaders agreed that societies should be formed to police the profession. Civil engineers formed a local organization in Boston in 1848, followed by New York, St. Louis, and Chicago. The New York society, founded in 1852, eventually became the American Society of Civil Engineers (ASCE). Entrance requirements consisted of ten years of practice, five years of responsible charge, and the ability to perform design work. These different organizations and societies differentiated on their focus of the status of engineering. ASCE attempted to move engineering into a professional status independent from business interests. The goal of the American Institute of Mining Engineers (AIME) was to serve the industry's interests with engineering having a close subservient dependency. As a result, engineers taking jobs in industry assumed the position of minion to the corporate management (Spinden 2015).

One significant case that went before the U. S. Supreme Court in 1889 was Dent v. West Virginia. West Virginia indicted Mr. Dent for practicing medicine without a license. West Virginia had just enacted a law that required education, experience, and an examination in order to practice medicine. The court acknowledged that choosing an occupation is a "distinguishing feature of our republican institutions," but this was offset by the state's right to restrict practice to those who had the appropriate education and experience. The court explained that the practice of medicine was not just an ordinary occupation, but one that required careful preparation, including mastery of the subtle influences on which health and life depend, thus securing medicine's professional standing. The Supreme Court affirmed a state's power to endorse a particular profession from among competing factions, and that government licensing is the best way to transform an occupation into a recognized profession (Spinden 2015).

By 1920, the number of engineers had grown to about 136,000. Initially, ASCE supported self-regulation, rather than government licensure, because it believed that only engineers were qualified to pass judgment on the work of other engineers (Spinden 2015). Accordingly, ASCE worked to defeat professional licensing. However, opposition waned, and support grew for professional licensing in the 1930s.

B. Developments in Engineering Licensure

In 1903 Clarence Johnson became the state engineer of Wyoming. He found the office in disarray because untrained individuals were working as engineers and surveyors. The state law required an application with a map be filed if an individual wanted to use state water to irrigate land. People from many professions were submitting the applications and claiming to be engineers or surveyors, which led to very confusing and inaccurate records. Johnson initiated a bill in 1907 establishing requirements for professional engineers. The quality of water applications resulting from those meeting the licensing requirements improved significantly within a few months (Acorn Corley 2004).

Soon after Wyoming passed its law requiring licensure in 1907, other states began to see the benefits of such a law. Louisiana followed in 1908. Illinois established the structural engineering license in 1915. The Florida PE was established in 1917. Six other states began licensing in 1919. By 1950, all US states, as well as the territories of Alaska, Hawaii, Puerto Rico, and the District of Columbia, had enacted engineering licensure laws (NSPE 2019).

At that time, each state created its own education and experience requirements, but they were inconsistent from state to state. A national body was needed to establish uniformity and reciprocity between states. In 1920, the Council of Boards of Engineering Examiners was established, which was a predecessor of the National Council of Examiners for Engineers and Surveyors (NCEES). This body focused on the uniformity and quality of the education, experience, and examination requirements to practice engineering.

- Education: Eventually, the Accreditation Board for Engineering and Technology (ABET) developed uniform criteria for education.
- Experience: Demonstrating experience was required, but the minimum amount varied from four to twelve years. It was also determined that this experience should be progressive, require the application of engineering knowledge, facilitate self-improvement, and teach the candidate to design, supervise, operate, and superintend (Acorn Corley 2004).
- Examination: In addition to education and experience, it was recognized that an examination played an important part in determining the competence of an individual for the practice of engineering.

Additional information on the history of licensure is provided in Appendix A.

C. Structural Engineering Licensure

The Chicago Fire of 1873 was an impetus for structural engineering licensure. Rapid construction after the fire resulted in numerous structures of questionable quality and safety, because buildings were being designed by people without education or training in engineering. The Illinois Architectural Act was passed in 1897. Efforts to regulate structural engineering began in 1908 when the Western Society of Engineers initiated discussions with the Illinois branch of the American Institute of Architects regarding a state building code. In 1915 the Illinois Structural Engineers' Act was passed. Subsequently, other states began to enact similar legislation. In California, after the 1906 earthquake in San Francisco, the 1925 earthquake in Santa Barbara and, particularly, the St. Francis dam collapse in 1927, civil engineers were instrumental in the passage of a Civil Engineering Registration Law in 1929. Structural engineers were unable to gain a separate practice act at the time. After failing to gain the support of local architects, the structural engineers settled for an amendment in 1931 to regulate the *title* of "Structural Engineer" and the use of the term "SE." Although this did not restrict the class of structures to be designed by either PEs or SEs, it laid the groundwork for two more acts in 1933. After an earthquake in Long Beach that caused widespread damage to many masonry school buildings, the Riley Act and Field Act were passed. These required that all seismic design and school building design, respectively, be performed by licensed SEs. Eventually, hospitals were added to the structures regulated by these requirements (Brandow 2015).

III. LICENSURE EXAMINATIONS

Since the origin of engineering licensure, requirements to practice engineering have included a passing score on a rigorous examination, evidence of sufficient education, and verification of relevant experience. The examination differentiates licensure in the US from engineering credentialing in most other countries, and from certification based on education or experience alone. This section highlights the history of the examination, specific requirements for the PE examination, and specific requirements for the SE examination. Additionally, a discussion of the advantages and disadvantages of the examination as a measure of minimum competence is included.

A. Professional Engineering Examinations

The PE examination has evolved over many years. When licensure was in its infancy, many states had written examinations, some had oral examinations, some had both written and oral examinations, and some had no examinations at all. The content and quality of the examinations varied greatly. Some states required three days of examinations and some only two or one. Eventually it was determined that two days of examination would be required, except for structural engineering which required three days. The first day of examination to test understanding of fundamentals of engineering was to be taken near completion of the college curriculum . After several years of experience, the second examination, or practice examination, would be taken, to test the knowledge gained through practical experience and to verify that the candidate could provide safe designs for the public. The oral examination was eventually eliminated because it was difficult to determine the quality of a candidate using that format. The practice examination was discipline-specific, while the fundamentals examination was much broader and eventually developed into the Engineering-in-Training (EIT) or Fundamentals of Engineering (FE) examination, which is typically administered during the senior year of college. In 1940, the committee on examinations suggested providing questions that required the candidate to demonstrate mastery of patterns of thought and problem-solving strategies, rather than questions that required them to memorize details (Acorn Corley 2004).

In 1965, the National Council of State Boards of Engineering Examiners (NCSBEE), another predecessor to NCEES, administered the first Fundamentals of Engineering (FE) examination. In 1966, the first Principles and Practice of Engineering (PE) examination completed the two-day examination requirements (Acorn Corley 2004). It was given in the fields of chemical, civil, electrical, and mechanical engineering. The PE examination was considered psychometrically sound in 1983, with a fair and just method utilized to determine the cut-off score between passing and failing. (Psychometrics is the field of study primarily concerned with the differences between individuals and focuses on the science for validity, precision, reliability, and fairness of examinations intended to measure competence.) This established what eventually became today's three-fold national requirements for professional licensure in engineering: a sufficient combination of education, experience, and examination.

The process of examination includes establishing a specification, developing the questions, and grading the answers. Examination specifications are developed from surveys of practicing engineers to represent the engineering topics that are considered crucial for public safety. Professional Activities and Knowledge Surveys (PAKS) are conducted every ten years to update the specifications as needed. Examination Development Committees, consisting of professional engineers experienced with the subject matter, develop the questions and grade the answers.

Before 1997, the PE Examination consisted of eight one-hour constructed response questions. The candidate would choose four problems from twelve available in the morning and again in the afternoon. For structural engineers, three of the twelve problems were required to be structural. Constructed-response questions included a problem to be worked out in detail, showing the calculations required. The solution was then graded in accordance with criteria established by the grading committee.

Between 1997 and 2001, the first four hours of the PE examination consisted of four constructed response problems that the candidate chose from twelve available problems in the morning, but for the afternoon the candidate would choose four sets of ten multiple choice problems from twelve sets available. Three of the problems in the morning and three sets of problems in the afternoon were required to be in structural engineering. The sets of ten questions pertained to different aspects of the same situation. In 2002, the PE examination became entirely multiple-choice, with forty breadth questions in the morning and forty depth questions in the afternoon.

Machine scoring was investigated using multiple-choice questions in 2000, because it was believed that these could be more objectively graded. Though the machine-scored multiple-choice questions would provide reliability and consistency in grading, the determination of the passing grade required additional evaluation. A large committee of practicing professional engineers from across the country worked out the first examination based on the specification developed from the PAKS. A scientific psychometric procedure facilitated determination of the passing score for that examination. This was then the anchor examination for the next several years, by which the difficulty of subsequent examinations was measured. The cut score was adjusted up or down for a specific examination, depending on how chosen anchor problems were tested. Additional information on the history of the examination is provided in Appendix A.

Currently, the Civil PE examination includes the morning breadth questions common to five civil engineering subdisciplines: structural, transportation, water resources, geotechnical, and construction. Approximately eight of these breadth problems are structural. The depth problems are all from one chosen subdiscipline; however, several questions in the depth section are from adjacent subdisciplines, such as construction and geotechnical for the structural depth. The breadth portion may warrant further study to determine whether it is truly relevant to the majority of practicing civil engineers.

B. Structural Engineering Examinations

The format of the earliest examinations in Illinois is not certain, but in 1960 it included four problems of four hours each. See Appendix B for additional information on the history of the Illinois-specific examinations.

In 1986, the Illinois SE examination became the NCEE SE examination, consisting of sixteen hours with the Structural I (SE-I) and Structural II (SE-II) portions each being eight hours. It was intended that these two examinations be used together to evaluate the minimum competence of a person desiring to be licensed as a structural engineer. Some states began accepting the SE-I as the equivalent of a PE exam.

The SE-I in 1986 consisted of four one-hour constructed response problems in the morning and four in the afternoon, each chosen from a set of six. Between 1997 and 1999, there were exactly four constructed response problems in the morning and 40 multiple-choice questions in the afternoon. From 2000 to 2010, the examination consisted of forty multiple-choice questions in both the morning and the afternoon.

The SE-II in 1985 and 1986 consisted of four one-hour structural constructed response problems chosen from six available in the morning and in the afternoon. Between 1990 and 1997, the SE-II consisted of one four-hour constructed problem chosen from three in the morning and another four-hour problem in the afternoon. Between 1997 and 2003, it was changed to one four-hour problem chosen from two in the morning and the same in the afternoon. Between 2004 and 2010, there were two two-hour problems in the morning and two two-hour problems in the afternoon, all constructed response.

C. Current Status of the Structural Engineering Examination

The current SE examination development follows, in general, the same process as the PE examination. It is essentially the same as the sixteen-hour examination first offered by NCEES in 2011. The examination consists of two eight-hour components that may be taken back-to-back or during separate sessions. The first component tests proficiency in structural design for vertical forces, such as dead and live loads due to gravity, and the second component tests proficiency in structural design for lateral forces, such as wind and earthquake. The morning session of both days consists of forty multiple-choice questions. The afternoon consists of three or four constructed response questions with each question one or two hours in duration. Calculation work is shown by the candidate and evaluation is based on this shown work. The morning sessions are machine-graded and the afternoon questions are graded by committee. The candidate may choose either bridge or building problems for the afternoon constructed response portions. The morning multiple choice problems are a mixture of general structural engineering, building, and bridge problems. Currently, the multiple-choice morning questions include mostly building questions, with less than ten bridge questions out of forty total questions.

1. Development

Similar to the PE examination, a PAKS is conducted to determine the required topics to be tested. The specifications are used to develop the stringent criteria for the examination. The constructed response problems must include prescribed portions on analysis, design, code review, and detailing. The problems are written, checked twice, pre-tested twice, and evaluated. All engineers who develop the problems and grade the problems are licensed and are subject-matter experts from across the US.

2. Examination Grading

Examination grading for the multiple-choice problems is by machine. A rigorous checking procedure is utilized for the evaluation of each constructed response problem. During the development of the problem, certain key criteria are extracted, which represent the most crucial aspects of the worked solution. Partial credit is provided depending on the number of criteria items correctly solved. Each problem is graded at least twice, and in the case of disparity in grading between the two graders, a third grader is required.

NCEES has set a target date of 2024 for migrating the entire SE examination to Computer-based Testing (CBT). For CBT, candidates will take the examination on a computer at a testing site.

Even the constructed response questions will be worked out on the computer, similar to the way the architectural examination is taken. References will be provided on the computer for the examinees.

D. Comparison of the Current Civil: Structural PE Exam to the Structural 1 Exam

A comparison of the Civil/Structural PE Specification to the SE-I specification in effect in 2010 indicates that most of the structural topics of the Civil PE breadth and depth specifications were covered in the SE-I specification. However, there were numerous topics in the SE-I specification not specifically covered by the Civil/Structural PE specification. A comparison of the current sixteen-hour SE specification yields similar results.

The Civil PE breadth areas not included in the SE-I specification were:

- Highway geometrics
- Hydraulics and hydrology
- Site development
- Project planning (quantity take-offs, cost estimating, project schedules)

The two topics in the Civil/Structural PE depth specification not included in the SE-I specification were:

- OSHA regulations
- Safety management

The areas in the SE-I specification not in the Civil/Structural PE specification included:

- Loads from shrinkage and creep
- Settlement and ponding
- Lateral hydrostatic forces
- Statically indeterminant structures
- Lateral-force-resisting systems with vertical or horizontal/plan irregularities
- Relative rigidity force distribution
- Computer-generated structural analysis techniques
- Moment distribution
- Influence lines
- Fatigue
- Camber
- Vibration

The Civil/Structural PE specification had categories of concrete, steel, timber, and masonry with no subcategories. The SE-I specification had between eight and twelve subcategories for concrete, steel, wood, and masonry, as well as another category for foundations.

In summary, the Civil/Structural PE specification included structural topics that were both broad and shallow, with approximately 40 questions on those topics, whereas the SE-I specification covered structural engineering in much greater depth with 80 questions. The Civil/Structural PE specification included the breadth categories of other civil engineering disciplines, whereas the SE-I examination focused on structural engineering with some related requirements in geotechnical and construction. The morning sessions of the sixteen-hour SE exam are similar to the SE-I examination.

E. Reliability of the Examinations

Discussion has arisen regarding the reliability of the PE and SE examinations as measures of minimum competence, which is the established level required by a candidate to be permitted the responsibility of legally designing structures for the public. The NCEES examinations have proven to be reliable measures of competence because they have specific requirements developed by structural engineers; they have problems that are developed by subject matter experts who are structural engineers; and they are psychometrically sound, meaning that they are scientifically reliable and fair. However, there are arguments suggesting that the SE examination may not be a good test after all.

The examination covers construction materials and design procedures that may not align with a candidate's education or experience. For example, not all engineering schools—even those accredited by the Accreditation Board for Engineering and Technology (ABET)—have masonry and timber engineering classes, yet masonry and timber design problems are often included in the examination. Likewise, an engineer who practices in bridge design will be disadvantaged because the morning sessions include many building problems with only a few bridge problems, even though a number of the problems are supposed to be code neutral. The question also arises whether the exam is a good measure of competence if a candidate passes it because they have had intense and thorough preparation only and not actual design experience.

There are some who argue that the examination focuses too much on knowledge of the building and bridge code requirements and not enough about actual principals and concepts of engineering. For example, the United Kingdom's SE examination consists entirely of conceptual problems, rather than code-related problems. In the US, though, knowledge of the code requirements is a significant part of the test problems. The implementation of the codes is required by many jurisdictions because the codes provide the minimum standards for design as established by science and technology. It is the law. An engineer cannot produce designs that adequately provide for the safety of the public without knowledge of the codes. Though the SE examination includes information on codes, it is not exclusively about codes. Such foundational material as analysis using the equations of equilibrium, material stress-strain, lateral-torsional buckling, and load path analysis are all topics that may be covered.

Another consideration is whether nervousness may affect a candidate's inability to recall information learned over years of experience and study, and thus fail to demonstrate his or her ability accurately on the examination. Despite minor issues in the SE examination, an individual with focused experience in the practice of structural design should find that the problems are more easily solved, and the examination more confidently passed. The combination of experience and education make it possible to achieve a passing score that is representative of competence. Those who only practice structural engineering periodically will not likely perform well on the SE examination.

Without varied, mentored, in-depth experience in structural design practices, a candidate will find the examination difficult to pass. Education and experience are crucial, but those alone cannot assure the public that an engineer is competent. Reliance upon affidavits from colleagues or employers regarding the candidate's experience is helpful, but not definitive regarding the progression of experience. Better evidence would be provided if there was a thorough evaluation of an engineer's work product, but this would be cumbersome, and reliability and fairness many be difficult to ascertain. Examination of a candidate's body of work, while providing more information, would also be less objective, with possibly inconsistent results.

F. Summary

The examination process has always been considered an essential part of engineering licensure. In the early 1900s, each state had its own requirements for education and examination. The number of requirements varied widely by state. By 1965, agreement was reached in NCBEE that there would be two eight-hour written examinations for the PE. The current NCEES examinations for both the PE and SE are psychometrically sound. They are prepared and graded by a scientific process that provides for reliable and fair evaluation of a candidate's competence to solve the problems in the test. While it is believed that some individuals have difficulty with an examination process, it is thought that anyone with good familiarity of the subject matter will be able to achieve a passing score on the examinations.

IV. STRUCTURAL ENGINEERING AND LICENSURE OF OTHER PROFESSIONALS

Most state requirements to practice in any profession include education, experience, and examination. Other state requirements to practice professionally can vary significantly depending on the profession. Some of these requirements include minimum age, ethical standards, background checks, and continuing education requirements after licensing. State requirements for many professions are tied to a national organization that oversees professional practice. The focus of this section will be on three specific areas of similarity: educational qualifications, work experience qualifications, and professional examinations.

Of the fifty-five jurisdictions in NCEES, this study has chosen four that represent approximately 35% of the US population: California, Florida, New York, and Texas. These states permit varied paths to become a licensed/registered professional, which allows individuals some flexibility of career growth. For example, in New York an individual with a high school diploma may work for twelve years in the capacity of an engineer-in-training, submit work experience, and apply for examinations to become a licensed engineer. However, in Texas the minimum education requirement is a four-year accredited degree. This effort to compare will ignore alternative paths to licensure, registration, or professional certification, and focus on the most common path to attaining professional status as an individual making responsible decisions in one's specific field of expertise.

Structural engineers rely on training and experience to ensure that their designs will resist any anticipated loads for the life of the structure. Structural failures can result in loss of life, economic loss, loss of property, disability, and suffering. There are many professions that require a license or registration. However, for the purposes of this report, professions with similar consequences of failure were chosen to compare to structural engineering requirements: architects, doctors, lawyers, and pilots. Table 1 summarizes the requirements for each of these professions and compares them to general engineering and structural engineering.

A. Architects

The profession of architecture has many similarities to structural engineering. Architects are designers in the construction industry who create safe and healthy environments in which people live and work. For buildings that are designed incorrectly the risk can be significant, and in the event of a failure, catastrophic. A building may house hundreds of people on a daily basis, and an incorrect exit or material specification may lead to significant loss of life.

Licensing requirements in the four case study states are all tied to the National Council of Architectural Registration Boards (NCARB). To become licensed or registered to practice one must complete five years of college education or have a master's degree in architecture from a program approved by the National Architecture Accreditation Board (NAAB). Through an NCARB program, architectural interns must submit work experience for about two years (3,750 hours) which has been approved by a registered professional. Applicants must also pass 25.5 hours of examinations.

California: https://www.cab.ca.gov/

Florida: http://www.myfloridalicense.com/DBPR/

New York: http://www.op.nysed.gov/prof/arch/

Texas: https://www.tbae.texas.gov/TBAE/TBAE

National: https://www.ncarb.org/

B. Doctors

Medicine is also directly linked to the management of public safety. For the sake of this analysis, the following data will refer primarily to general practitioner qualifications for doctors and focus on general surgery. To become a doctor, one must first complete four years of undergraduate study, pass an eight-hour examination (MCAT), and obtain a graduate degree from a medical school in a program certified by the Association of American Medical Colleges. Once the degree program is completed, the graduate sits for the United States Medical Licensing Examination, which is a three-step process with 37 hours of examinations.

The subsequent professional path can vary depending on the focus. Generally, one must enter a residency program that can last from three to seven years. These programs typically have certain requirements and milestones that must be achieved before the resident can move to the next level of training. For general surgery, the doctor in training must have completed a certain number of operations, certain types of operations, and have shown that such experience was not limited to specific operations but includes a variety of procedures.

For nearly 80% of medical doctors, the path does not end here. Most medical doctors pursue additional board certifications offered by the American Board of Medical Specialties (ABMS) to demonstrate that they are qualified in specific areas of specialized expertise. Board certification generally is required to work in a US hospital. As an example of the additional requirements for this critical credential in the medical profession, certification in general surgery requires certain work experience in the residency period and an additional 17 hours of examinations.

https://www.aamc.org/

https://www.usmle.org/

https://www.abms.org/

http://www.absurgery.org/default.jsp?examoffered

C. Lawyers

Lawyers are agents acting on behalf of the public to ensure that its health and welfare are represented. To become a lawyer, one must complete four years of undergraduate education. Prior to applying for law school, applicants take the LSAT exam. Law school can take up to three years, but no work experience is needed, although it is recommended. Passing six hours of examinations (depending on the state) is required to become a licensed attorney.

D. Pilots

Pilots who fly for airlines have an airline transport pilot certificate, which is a license regulated by the Federal Aviation Administration. A person must hold a bachelor's degree with an aviation major, complete 60 credit hours of aviation or aviation-related coursework that has been recognized by the administrator as designed to improve and enhance the knowledge and skills of a person seeking a career as a professional pilot, complete a minimum of 1,000 flight hours as a pilot, and successfully complete a seven-hour written examination.

https://www.ecfr.gov/cgi-bin/text-dx?c=ecfr&sid=40760189a03dfea0b501608f33820a45&rgn=div5&view=text&node=14:2.0.1.1.2&idno=14

E. State Licensing Boards

When a state government requires a professional license, the public may have questions :

- Is this license necessary for the services provided?
- What are the requirements needed to obtain this license?
- Is the standard needed to obtain this license high enough to qualify this individual to protect the safety, health, and welfare of the public?

There are state-mandated licenses and voluntary certifications. The medical field uses both, including certifications found under the ABMS. Most at-risk procedures in the medical field are performed by doctors under the authority of hospital boards and department boards who determine the standards for competence of the doctors. These local boards usually have higher requirements than the medical license issued by the state, in order to lower the risk to the board and hospital.

This approach is similar to a jury determining the outcome of a criminal court case. Instead of just one person making a decision based on the evidence, a group of people makes this decision to come up with the verdict. The same comparison can be made between state legislatures, licensing boards, and the licensed engineer. Once the state legislature has established policies to protect the safety, health, and welfare of the public, the licensing board creates the rules necessary to ensure that the engineering profession abides by them.

Many states currently allow individual licensed engineers to decide whether they are competent to practice in various disciplines. Since the engineering licensing boards operate within the powers granted by the state legislature, most state licensing boards cannot create additional rules to implement practice restrictions.

Since many state boards do not regulate structural engineering beyond the PE license, there is no evaluation mechanism to monitor that an engineer practices within their expertise. Neither do they monitor the competence of licensed engineers performing the structural design of significant structures. Without such oversight, it becomes easier for any engineer to make the decision to design significant structures based only on their own perceived abilities. The states that have raised the standard in the structural engineering discipline avoid the problem by requiring structural designs only by engineers that have demonstrated competence by passing the structural engineering licensure examination.

As in the medical field, the final authority for choosing a qualified engineer in structural engineering rests in the hands of a local city council, school board, board of a non-profit organization, or state legislature if the structure involves public safety and/or uses public money. Some may argue that if a structural failure occurs the courts are in place to punish engineers for practicing outside their areas of expertise. This is a reactive approach after the failure has occurred instead of a proactive approach to prevent the unqualified engineer from attempting to practice structural engineering in the first place. If government boards were to be held liable for construction projects, similar to private boards at hospitals, then these government boards would likely demand a higher standard for engineers practicing structural engineering.

Principles of oversight and policy over the structural engineering profession should be considered that will be in the best interests of the public, without negative impact to the free market due to license restrictions. A structural engineering license should be first considered as a tool required by entities to ensure that those performing structural design of significant structures will protect the public safety., The license should also ensure that they will have an economical product that meets sound engineering principles and design code requirements. When considering whether to adopt structural engineering licensure, states must weigh carefully the values of free market competition, good stewardship of public money, and the safety of the public.

Table 1 – Requirements for Selected Professions in Selected States

	College (Years)				Experience (Years)				Examinations (Hours)			
Profession\State	NY	CA	TX	FL	NY	CA	TX	FL	NY	CA	TX	FL
Engineering - other	4	4	4	4	4	2	4	4	16	16	16	16
Structural Engineering	4	4	4	4	4	3	4	4	16	16	16	16
Architecture	5								25.5	25.5	25.5	25.5
Airline pilot	4 yrs college + 0.5 yrs work or 0 yrs college + 0.75 yrs work								7 hrs written + flight			
Trial Lawyer	7				None				6			
Doctor – General Surg.	8	8	8	8	3 - 7	3-7	3-7	3-7	43	43	43	43

V. DETERMINATION OF COMPETENCE IN OTHER COUNTRIES

A web-based search revealed how countries other than the US determine the competence of practicing structural engineers. The countries investigated were the United Kingdom, Europe, Canada, Mexico, Australia, New Zealand, the Philippines, Japan, India, and South Africa. The majority of these have education, work experience, and professional review requirements before licensed status or its equivalent is achieved by an individual. Several also have continuing education requirements.

Additionally, a web-based investigation also provided information about various international agreements for recognition of engineers practicing in other countries. Mobility is of growing interest to many individuals and companies, as they wish to practice outside their own jurisdictions and around the world.

The information below and in Table 2 provides a comparison of the different general requirements in each country. The specific details for each country can be found in Appendix C.

A. License Mobility through International Agreements on Education Standards and International Professional Engineering Recognition

1. Education Standards – Washington Accord

The Washington Accord is an international agreement between bodies responsible for accrediting engineering degree programs. Originally signed in 1989, it is a multi-lateral agreement between bodies responsible for accreditation or recognition of tertiary-level engineering qualifications within their jurisdictions who have chosen to work collectively to assist the mobility of professional engineers.

As with the other accords, the signatories are committed to the development and recognition of good practice in engineering education. The activities of the Accord signatories—for example, in developing exemplars of the graduates' profiles from certain types of qualification—are intended to assist growing globalization through mutual recognition of engineering qualifications. The Washington Accord is specifically focused on academic programs that deal with the practice of engineering at the professional level.

The Accord acknowledges that accreditation of engineering academic programs is a key foundation for the practice of engineering at the professional level in each of the countries or territories covered by it. It outlines the mutual recognition between the participating bodies of accredited engineering degree programs. It also establishes and benchmarks the standard for professional engineering education across those bodies.

Currently there are twenty signatories that make up the Washington Accord. There are also eight organizations that hold provisional signatory status. Signatories have full rights of participation, such that qualifications accredited or recognized by other signatories are recognized by each signatory as being substantially equivalent to accredited or recognized qualifications within its own jurisdiction.

- Australia - Represented by Engineers Australia (EA) (1989)
- Canada - Represented by Engineers Canada (EC) (1989)
- China - Represented by China Association for Science and Technology (CAST) (2016)

- Chinese Taipei - Represented by Institute of Engineering Education Taiwan (IEET) (2007)
- Hong Kong China - Represented by Hong Kong Institution of Engineers (HKIE) (1995)
- India - Represented by National Board of Accreditation (NBA) (2014)
- Ireland - Represented by Engineers Ireland (EI) (1989)
- Japan - Represented by JABEE (2005)
- Korea - Represented by Accreditation Board for Engineering Education of Korea (ABEEK) (2007)
- Malaysia - Represented by Board of Engineers Malaysia (BEM) (2009)
- New Zealand - Represented by Engineering New Zealand (EngNZ) (1989)
- Russia - Represented by Association for Engineering Education of Russia (AEER) (2012)
- Singapore - Represented by Institution of Engineers Singapore (IES) (2006)
- South Africa - Represented by Engineering Council South Africa (ECSA) (1999)
- Sri Lanka - Represented by Institution of Engineers Sri Lanka (IESL) (2014)
- Turkey - Represented by Association for Evaluation and Accreditation of Engineering Programs (MÜDEK) (2011)
- United States - Represented by Accreditation Board for Engineering and Technology (ABET) (1989)
- United Kingdom - Represented by Engineering Council United Kingdom (ECUK) (1989)
- Pakistan - Represented by Pakistan Engineering Council (PEC) (2017)
- Peru - Represented by Instituto de Calidad y Acreditacion de Programas de Computacion, Ingenieria y Tecnologia (ICACIT) (2018)

  Provisional Signatories are recognized as having appropriate systems and processes in place to develop towards becoming a full signatory:

- Bangladesh - Represented by The Institution of Engineers Bangladesh (IEB)Provisional Status Approved in 2016.
- Costa Rica - Represented by Colegio Federado de Ingenieros y de Arquitectos de Costa Rica (CFIA)Provisional Status Approved in 2016.
- Mexico - Represented by Consejo de Acreditación de la Enseñanza de la Ingeniería (CACEI)Provisional Status Approved in 2016.
- Philippines - Represented by Philippine Technological Council (PTC)Provisional Status Approved in 2016.
- Chile - Represented by Agencia Acreditadora Colegio De Ingenieros De Chile S A (ACREDITA CI)Provisional Status Approved in 2018.
- Myanmar - Represented by Myanmar Engineering Council (MEngC)Provisional Status Approved in 2019.
- Thailand - Represented by Thailand Accreditation Board of Engineering Education (TABEE)Provisional Status Approved in 2019.
- Indonesia - Represented by Indonesian Accreditation Board for Engineering Education (IABEE)Provisional Status Approved in 2019.

“Washington Accord”, International Engineering Alliance, http://www.ieagreements.org/accords/washington/ (7/14/2019)

B. International Professional Engineering Recognition

There are some organizations providing international recognition for professional engineers. Also, some countries have reciprocity agreements with other countries, but this is not covered in detail here due to space constraints.

1. The NCEES International Registry for Professional Engineers (IRPE):

The IRPE assists US-based professional engineers who are seeking recognition in countries that are members of the Asia-Pacific Economic Cooperation (APEC) or the International Engineering Alliance (IEA), formerly the Engineers Mobility Forum (EMF). The countries include:

- Australia
- Chinese Taipei
- Hong Kong China
- India
- Indonesia
- Ireland
- Japan
- Korea
- Malaysia
- New Zealand
- Philippines
- Russia
- Singapore
- South Africa
- Sri Lanka
- Thailand
- United Kingdom

"NCEES International Registry for Professional Engineers", NCEES, https://ncees.org/records/international-registry/ (7/14/2019)

2. The International Professional Engineer (IntPE):

The International Professional Engineer (IntPE) register was launched in late 2002 by the Engineers Mobility Forum (EMF). In 2012, the EMF was renamed the International Professional Engineers Agreement (IPEA). Each member of the IPEA holds its own section of the IntPE register. This is denoted by the addition of a jurisdiction identifier to the IntPE designatory letters, e.g. IntPE(UK) if issued by The Engineering Council (UK).

"International Register of Professional Engineers", Engineering Council, https://www.engc.org.uk/international-activity/international-recognition-outside-europe/international-register-of-professional-engineers/ (7/14/2019)

Table 2 - COMPARISON OF STRUCTURAL ENGINEERING COMPETANCY REQUIREMENTS OF OTHER COUNTRIES

Country		United Kingdom		Europe	Canada	Mexico	Australia
Licensing Body		Institution of Civil Engineers (ICE)	Institution of Structural Engineers (IStructE)	European Federation of National Engineering Associations (FEANI)	Engineers Canada		Registered Professional Engineer of Professionals Australia
Academic Qualifications	Years Required	4		3 Min		4	4
	Accreditation required	CEng or MEng		FEANI	By Canadian Engineering Accreditation Board	By Federal Secretary of Education	Australian Institution
Experience Requirements	No. of Years	4	None	2 Min (Need 7 total of exp and educ)	None	None	5
	Type of experience	Knowledge, Experience, Ability	Knowledge, Experience, Ability				
	Participation in Professional Organization required						
Examination Requirements	Type of Test Required	Professional Interview	Professional Interview and Written	None	Written Exam	Written Exam	None
	Exam hours		7		3		
	Discipline specific				No		
	NCEES exams utilized					Yes	
	Ethics exam required				Yes		
	Laws and rules exam required				Yes		
Licensure by Comity	Permitted			Yes within Europe	Yes within Canada	Yes with Texas	
	Type required				Self-Regulated		
Continuing Education Requirements to Become Registered	Required						Yes
	Hours/Year						150 / 3 Years

Table2 - COMPARISON OF STRUCTURAL ENGINEERING COMPETANCY REQUIREMENTS OF OTHER COUNTRIES (cont.)						
Country		New Zealand	Philippine Islands	Japan	India	South Africa
Licensing Body		Engineering New Zealand	Professional Regulations Commission (PRC)		Institute of Engineers (India) (IEI)	Engineering Council of South Africa (ESCA)
Academic Qualifications	Years Required		5			
	Accreditation required	Washington Accord accredited		Japan Accreditation Board for Engineering Education	BE/BTech recognized by Government of India	Washington Accord accredited
Experience Requirements	No. of Years	None	None	4-7 Years	5	3 Years
	Type of experience					Training & Experience
	Participation in Professional Organization required				Yes	
Examination Requirements	Type of Test Required	Application and meeting (reassessed every 6 years)	Written Exam	EIT Written Exam, Professional Written and Oral Exam		Professional Review Interview
	Exam hours		2 days			
	Discipline specific		Yes			
	NCEES exams utilized					
	Ethics exam required	Commit to CPEng Code of Ethical Conduct				
	Laws and rules exam required					
Licensure by Comity	Permitted		No			
	Type required					
Continuing Education Requirements	Required				Yes	
	Hours/Year				At a Satisfactory Level	

VI. STRUCTURAL ENGINEERING LICENSURE THREATS AND CONTROVERSY

A ***"threat"*** frequently describes an effort to *harm* or *injure* with a goal of damage or total destruction. For the purposes of this discussion on the future of structural engineering, a "threat" is any current action or inaction that may potentially weaken the status of structural engineering licensure. Among the threats that are considered, some involve direct and deliberate efforts aimed at the licensure of structural engineers, while others indirectly affect structural licensure, perhaps inadvertently.

The seriousness of any threat depends on the value of the object being threatened. Therefore, the status of structural engineering is important to understand. If structural engineers are afforded few rights and appreciated by only a few people, the risk of a meaningful loss from a threat is low. If, on the other hand, structural engineers are highly esteemed by many and afforded multiple responsibilities that are far-reaching, the risk of a meaningful loss from a threat increases. Reasonable threats that should be heeded only exist against things that are valued. Understanding the ways structural engineering value is assessed and the biases that influence such assessment should be of equal interest.

Fortunately, groups that are *exclusively* devoted to opposing *only* structural engineering licensure do not exist. This means, however, that any threats that do exist and their sources can be difficult to detect and characterize. They can be short- or long-term. They can be found in subtle efforts that coalesce slowly or result unexpectedly after a message is poorly communicated. They can develop by mistake from an unrelated action or manifest due to inaction. And oddly, they can originate from the least suspected sources.

The purpose of this section is briefly to examine the status of structural engineering licensure value and the types of threats that structural engineering licensure faces today.

A. Structural Engineering Licensure Status

Engineering is currently regulated in every state plus the District of Columbia and four US territories of Guam, Puerto Rico, Northern Mariana Islands, and the US Virgin Islands. Professional engineering boards are essentially governmental agencies whose purpose is to implement and enforce engineering licensure statutes enacted by legislatures. The fundamental functions that are regulated are the admission of licensees and the practice of engineering. Licensees are typically required to meet specific qualifications in education, years of work experience, and examination. State board members are typically appointed by the governor.

Although engineering statutes in most states are very similar, no two states are exactly the same, and the regulation of structural engineering can differ drastically across state lines. Specifically, how a structural engineer is identified and when one is required for the design of a project varies widely and is sometimes dictated by local municipalities. Structural engineering licensure currently faces challenging discussions regarding how structural engineers get licensed and what it means to be a structural engineer. For instance, Illinois and Hawaii have adopted full practice restrictions that regulate structural engineering no matter the project. Several other jurisdictions, including Alaska, California, Georgia, Guam, Nevada, Northern Mariana Islands, Oklahoma, Oregon, Utah, and Washington, have adopted partial practice restrictions that require specified structure types to be designed by a licensed structural engineer. Multiple states have adopted a roster designation approach to regulate licensure, which stipulates that practicing engineers identify their area of expertise for the information of the general public. States lack uniformity of laws, exposing a lack of agreement on the value of the structural engineer. The perceived value is strong in some states, but not in others.

Geographic location and historic events appear to influence a state's perceived value of structural engineers. In western states, where seismic events are more common, structural design is more tightly regulated and the perceived value of structural engineering is correspondingly greater. Historic events, such as the 1933 Long Beach Earthquake in California that resulted in the Field Act or the Great Chicago Fire of 1871 that killed approximately 300 people and devastated many structures, have clearly added value to structural engineering through laws that were passed as a direct result of these tragic events.

The composition of a state's licensing board indicates its immediate ability to relate to issues that concern structural engineers. Currently, fewer than half of the state boards have a structural engineer on the board. While this does not preclude the board from seeking the assistance of a structural engineer, the ability of the board to understand issues from a structural perspective is weakened. Since boards generally have considerable leverage with the adopted statutes governing the practice of engineering, their influence is widely seen in municipalities where much of the structural engineering work is submitted. Where representation of structural engineering on state boards does not exist, a potential threat against structural engineering does exist.

B. Type of Threats

Threats are divided into two broad categories: internal and external. Internal threats are those that develop within the engineering profession, with little influence from outside. External threats are those that originate from non-engineering organizations or people.

Internal Threats

The lack of positive messaging poses a threat to structural engineering. Although consistent and positive messaging is being promoted through the efforts of SELC, widespread adoption of this communication should be enhanced. Positive messaging should include fundamentals of constructive communication to express the importance of structural licensure in a manner that is proactive, affirmative, and reassuring. Positive messaging includes a strategic relationship with as many media outlets as possible, including social media. The objective of the messaging should be to increase awareness of structural engineering virtues.

The Internet is a tremendous source of information and is widely used to express views. Promoting structural engineering licensure on the Internet should be maximized with a strategic and consistent message. A compelling narrative should also be incorporated into positive messaging so that the audience feels empowered to create a very supportive position. Currently the Association for Responsible Professional Licensure (ARPL), which is a coalition of several organizations including ASCE, NSPE, and the American Institute of Architects (AIA), is actively promoting positive messaging. Involvement with this initiative should be considered.

The lack of research data also constitutes a self-inflicted threat. Extensive, meaningful data is difficult to research and can be costly to develop. Consideration should be given to understanding how this type of information from a reputable data analytics firm can enhance structural engineering licensure. Isolating data sets that provide meaningful insight can be hard to determine, but strong strategic decisions require a solid knowledge of researched data. Having a poor understanding of data increases the potential for making weak decisions regarding the future of structural engineering licensure.

Ambivalence among engineers is another self-inflicted threat and difficult to overcome. Paul Spinden, in his 2015 publication, "The Enigma of Engineering's Industrial Exemption to Licensure: The Exception that Swallowed a Profession," makes this assertion: "Even with monetary benefits to be reaped from licensing, American engineers have been surprisingly ambivalent toward licensing, if not outright rejecting of it." Spinden continues by stating that nearly 80% of graduate engineers do not even try to become licensed. This is not the case for structural engineering, with only an estimated 20% of graduates electing not to pursue licensure. Indifferent attitudes among engineers toward licensure threaten the overall value of licensure.

Senior engineers who are established in their careers sometimes bristle at the idea of taking the 16-hour SE exam to demonstrate a higher level of competence, since they have already passed the Civil/Structural exam many years earlier. This is understandable when tenure and experience are considered. Younger engineers, if not encouraged by senior engineers, may not feel compelled to take the 16-hour exam. The ambivalence of senior engineers, therefore, can become problematic especially if it turns into cynicism that aims to discourage younger engineers from taking the 16-hour exam.

As Spinden's title alludes, many states have an "industrial exemption," a catch-all description for the ability of an unlicensed engineer to perform engineering work even when it may affect the safety, health, and welfare of the general public. This risks weakening the engineering profession, particularly if engineer ambivalence is widespread. These exemptions take various forms in state statutes and are the direct result of conflicts between industrial/commercial interests and technical interests, a struggle that extends as far back as the years immediately following the industrial revolution. At the core of this debate is the status of professional engineering and what it means to be a professional. Ambivalence toward licensure threatens to strengthen proponents of the industrial exemption.

Lack of portability, the ability to become licensed in another state, is a recurring theme in discussions about obstacles prohibiting engineers from quickly and seamlessly being able to work across state lines. This difficulty is particularly felt among spouses of active military personnel who tend to be transferred frequently and sometimes on short notice. Unless interstate agreements for comity can be arranged, challenges in becoming licensed easily in multiple states will continue to be a talking point for opponents of licensure and threaten to weaken the engineering profession.

Lastly, the lack of consensus with other engineering societies, most notably NSPE, presents a conflict which essentially increases the difficulty of enacting any licensure legislation that differentiates structural engineering from other engineering disciplines. As an example, NSPE recently attempted to stop proposed structural engineering licensure legislation in Oklahoma. There has been productive dialogue between NSPE and SELC during the past few years. Clear communication and willingness by all parties to negotiate will be required to achieve a consensus.

External threats

Threats that originate outside the structural engineering profession are sometimes short-lived but can present equally frustrating challenges. These threats are generally political and often involve big money. Their messaging is usually crafted so that it attracts the broadest audience possible, and this mass appeal frequently makes it difficult to identify actual positions and true intentions.

According to an investigation by *USA TODAY*, *The Arizona Republic*, and the Center for Public Integrity, it is common practice among state legislators to let corporations, industry groups, and think tanks prepare the bills that get considered. The report states, "Disguised as the work of lawmakers, these so-called 'model bills' get copied in one state Capitol after another, quietly advancing the agenda of the people who write them." The collaborative research determined that approximately "10,000 bills almost entirely copied from model legislation were introduced nationwide in the past eight years, and more than 2,100 of those bills were signed into law."

The actual threat from this "copy and paste" strategy is not easy to assess definitively. For instance, how many of the proposed bills directly affect structural engineering (positively or negatively)? Tracking this information in real time across the nation would require a full-time staff of savvy researchers who understand engineering issues, enjoy reading legislative bills, and are familiar with political machinations. NSPE maintains a fairly comprehensive list of "threats to professional licensure" (https://www.nspe.org/resources/issues-and-advocacy/action-issues/threats-professional-licensure), which is a good resource. Using this website and other similar searchable bill-tracking databases to follow these issues is important, because even if the level of the threat is vague, there is a high potential for broad risk to licensure due to the "copy and paste" mentality.

There are many organizations that might qualify as participants politically or otherwise in issues that threaten to weaken structural engineering licensure. Four of these organizations are mentioned below.

1. American Legislative Exchange Council (ALEC)

   ALEC is a coalition of state lawmakers and some private sector individuals whose focus is "limited government, free market and federalism." It began as the Conservative Caucus of State Legislators in 1973. The stated mission of ALEC is to assist state legislators, members of Congress, and the general and business public by sharing research and educational information. ALEC is a 501(c)(3) corporation that claims to be nonpartisan and has voluntary membership. Comprised of nearly one-quarter of the country's state legislators and stakeholders, ALEC alleges to represent more than 60 million Americans and provide jobs to more than 30 million people in the United States.

According to ALEC, government should be involved in certain issues related to public safety, health, and welfare. However, ALEC is responsible for creating and offering the "Occupational Licensing Review Act" (formerly part of the Occupational Board Reform Model Act). The policy of this act is intended to:

1. Guarantee the right of an individual to pursue a lawful occupation.

2. Use the least restrictive regulation to protect consumers from present, significant, and substantiated harms that threaten public health and safety.

3. Review legislation and laws related to occupational regulations

ALEC develops and disseminates model legislation bills to advance the causes that it advocates. Because ALEC's stated position is to reduce restrictive regulation, it is considered a threat to structural engineering (and professional engineering) licensure, which is intended to regulate those who can perform structural design.

2. Americans for Prosperity (AFP)

   Founded in 2004 by Charles and David Koch, AFP is a conservative political advocacy group. According to its website, AFP encourages people to "take an active role in building a culture of mutual benefit, where people succeed by helping one another." It claims to be a grassroots organization whose membership is over 3.2 million. AFP is a very influential conservative organization and is recognized as helping the Tea Party develop into a political force. AFP is a 501(c)(4) entity.

   One of AFP's five major initiatives include a stated effort to address regulations that "reduce occupational licensing burdens that unreasonably prevent Americans from pursuing their dreams." Based on its position of opposing licensing regulation burdens, AFP is considered to be a threat to structural engineering (and professional engineering) licensure.

3. National Council of State Legislatures (NCSL)

   NCSL is a bipartisan organization whose goal is to provide state legislatures with information and data to address current issues. Founded in 1975, it is considered one of the Big Seven groups that serve local legislatures and state governments. All state legislators and legislative staff are automatically members of NCSL. According to its website, NCSL works to "protect state sovereignty and flexibility, fight against unfunded mandates and oppose unwarranted federal pre-emption of state authority."

   The threat, if any, of NCSL is not clear. However, NCSL participated in a three-year study, entitled *Occupational Licensing: Assessing State Policy and Practice*, funded by the Department of Labor to increase portability of occupation licenses. One of the goals of the study was to "identify licensing criteria to ensure that existing and new licensing requirements are not overly broad, burdensome or restrictive, and that they do not create unnecessary barriers to labor market entry." Furthermore, NCSL questions the ability of licensing to improve safety. This type of ideology presents a possible threat to structural engineering licensure.

4. Institute for Justice (IJ)

   Economic liberty is one of the primary missions of IJ. As indicated on its website, "The right to earn a living in the occupation of your choice without unnecessary government interference is at the heart of the American dream." IJ is a 501(c)(3) organization that is a public interest law firm with most of its litigation providing free advocacy for people who feel that their constitutional rights have been denied. IJ was founded in 1991 and has approximately 70 employees.

   Numerous cases represented by IJ indicate that they oppose many kinds of business licensing. One recent case involved a complaint filed against the Oregon State Board of Examiners for Engineering and Land Surveying by a citizen who claimed to be an engineer but was not licensed to practice engineering by the state of Oregon. IJ eventually won the case in federal court in December 2018. As seen in this case, IJ's adversarial stance toward licensure identifies it as a threat to structural engineering licensure.

C. CONTROVERSY

There are several points of controversy that surround SE licensure. These include:

- Certification as an alternative to licensure.
- The potentially confusing two-tiered system of licensure in partial practice states, consisting of those who have the PE and practice in structural engineering for non-significant structures and those who have the SE and can design significant structures.
- Adequacy of the depth portion of the NCEES Civil/Structural examination to demonstrate competence for designing non-significant structures.
- Necessity of the breadth portion of the NCEES Civil/Structural examination for most structural practitioners.
- Qualification of the SE license as an initial PE license.
- Equivalence of the discontinued NCEES SE-I and/or SE-II examinations, sixteen-hour state SE examinations, and current 16-hour SE examination to the Civil/Structural PE examination for PE licensure.

Certification

NSPE has reasoned that additional licensure beyond the PE is not necessary, instead calling for a certification that is administered by the profession itself. NSPE believes that additional licensing beyond the PE dilutes the profession. In 1949, D. B. Steinman, one of the organizers of NSPE, emphasized, in an address to the National Council of Examiners for Engineers and Surveyors (NCEES) board that engineering was one profession and that NCEES had successfully prevented the breakup of the profession into branches and specialties with different qualifications and separate licenses. “We do not want our profession pictured as a heterogenous aggregation of trades and specialties” (Acorn Corley 2004). They believe that as long as structural engineers practice ethically, within the realm of what they are qualified to do, the safety of the public should be preserved.

It can also be reasoned that the professional licensing process, regardless of whether the license is a PE or an SE, does not validate all the knowledge, skills, and attitudes necessary to be in Responsible Charge (e.g., project management, professional attitudes, sustainability) (see the ASCE Body of Knowledge https://www.asce.org/civil_engineering_body_of_knowledge/). Post-licensure certification programs, administered by the profession, can be designed to validate these essential outcomes.

Those who support SE licensure believe that it provides a necessary distinction between those who have demonstrated their proficiency by passing a sixteen-hour exam and those who have not. They believe that the difference between the SE license and Civil/Structural PE license is essentially the exam itself. Chapter III. Licensure Examinations, of this paper includes a comparison of the two examinations. Supporters of SE licensure believe that the SE exam is an excellent barometer of the technical competence of the engineer to design structures that are considered more important. Some structures are classified as more important or critical because a failure of the structure would impact a larger number of people. If the safety of the public is to be held paramount and the exam delineates those who have a stronger, more robust knowledge of structural design, then the public will be better served by those engineers who pass the SE examination. Those endorsing SE licensure also believe that individuals cannot always judge their own competence accurately because they have a natural bias and often do not realize the real limits of their own knowledge and skills. Those endorsing SE licensure believe an objective, unbiased criteria, such as the SE examination, should be utilized to establish competency.

Two Tiers

Partial practice states typically permit those who have the PE to provide structural engineering for non-significant structures and require the SE to provide structural engineering for significant structures. Some in the profession, particularly those on PE boards, believe that the partial practice restriction complicates and confuses licensing. It indicates that certain structures need to be designed by a person that holds an SE license, but all other structures may be designed by a person holding a PE license. This is more complicated than having a full practice restriction or no structural engineer title or license. However, it is not unlike the difference between those who can drive passenger cars and those who can drive motorcycles or commercial vehicles. Different levels are necessary so as not to disenfranchise the typical driver and yet maintain safety for those who drive other types of vehicles.

Civil/Structural PE Examination

There is a significant difference between the eight-hour Civil/Structural PE exam and the sixteen-hour SE examination in the number of questions and depth of the questions. Some proponents of SE licensure argue that the Civil/Structural PE Examination is not adequate even for non-significant structures. Another big difference is the breadth portion of the Civil/Structural PE examination. Those who promote the SE license argue that if the SE examination has accurate coverage of an engineer’s practice, then it should be accepted as a stand-alone PE examination. They indicate that the Civil/Structural PE breadth portion is not necessary if a person’s practice focuses narrowly on structural engineering and does not encompass the other areas of civil engineering included in the breadth portion.

SE License as PE License

NSPE holds paramount the PE as symbolizing the difference between a person who is a professional and a person who is subject to the whims and fancies of the industry. The former is someone who competently makes decisions based on education and experience for the protection of the safety, health, and welfare of the public. The professional engineer designs in an ethical fashion, regardless of any implications for profits or schedules. If something must be sacrificed due to unforeseen circumstances it may need to be quality, schedule, or profits. The professional regards that quality must not be sacrificed which leaves the necessity of schedule or profits being deficient. A professional engineer acts independently from strong influences of business.

Those who promote the view of the SE license as being equivalent to a PE license point out that there is nothing in the PE exam that tests any of the qualifications necessary to be delineated as a "professional" such as integrity, independence of thought, and holding the safety of the public as most important. These are qualifications that are in the Codes of Ethics with which a licensee is required to comply, but there is no objective method to ascertain such compliance. They believe that the SE examination is just as good, if not better, then the PE examination for determining competence and thus should be just as qualifying to determine the "professional" designation as the PE examination.

Discontinued Examinations

Some jurisdictions do not accept the SE-I, SE-II, or other past SE examinations as satisfying the requirements to obtain a PE license. In Chapter III, the SE-I examination is compared to the Civil/Structural PE examination. The difference between the two hinges on the breadth portion. The SE-I and other SE examinations have much more intense, difficult, and robust questions on structural engineering than the Civil/Structural examination, but they do not have the 40 questions on the breadth of civil engineering outside of structural engineering. Those who promote the SE-I and other SE examinations as equivalent to the Civil/Structural examination indicate that the breadth portion need not be tested if a candidate's actual practice does not include that breadth.

VII. TRENDS INFLUENCING STRUCTURAL ENGINEERING LICENSURE

A. Employer Preferences and Requirements

In the business of civil and structural engineering, an important metric is utilization, i.e., the number of working hours that can be charged to a project divided by the total hours paid in salary. These are the hours that will be paid by a client. In general, if the percentage of total hours charged to projects is low, the expenses of running the business will outweigh the profits obtained. If utilization is high, profits are also likely high, and the business will thrive.

It has always been the desire of employers in civil engineering fields to hire graduates who can hit the ground running. It would be ideal if these graduates had adequate education and training to be productive from the start. However, it usually takes an employer multiple years to train a graduate engineer to be fully productive. If this period can be shortened, it helps the business of engineering. To shorten this time, universities can encourage, or even require, internships for every student. The experience gained working an internship will help these students start ahead in the process.

In addition to the experience gained through internships, the basic foundational knowledge of a student is important. For structural engineering, graduates need more credit hours of education, not less. That is one reason why the master's degree, or at least 30 hours of education beyond a bachelor's degree, is important. Many employers of structural engineers only interview graduates with master's degrees for this reason. Because these graduates have additional knowledge in specialty structural areas such as concrete and steel, it is more likely that they will have the skills necessary to pass the SE exam and also be more productive on projects.

Most employers in consulting structural engineering require that their engineers be licensed because clients and state statutes require projects to be designed and documents to be sealed by licensed engineers. Hiring engineers with the SE license is advantageous because it allows the firm to practice in states that require this credential, and is also a selling point to clients—their structural engineers have the higher level of knowledge and skill to pass the SE exam.

B. Insurance Considerations

A 2016 study by a task committee of SELC addressed trends in the professional liability insurance industry regarding structural engineering licensure (Brewe, 2016). It cites a 2005 *CE News* article by Frank Musica, which indicated that the dollar value of structural engineering claims averaged almost 30 percent higher than other engineering disciplines. It also cites an analysis of claims data by Design Professional Insurance Company (DPIC, now XL Catlin), which found that structural engineering firms account for almost twice as many claims relative to their proportion of fees generated, and almost three times the claims dollars.

Risks to insurance carriers are high, as well. In the US, OneBeacon Insurance has left the architecture and engineering market entirely, and other carriers have done likewise. Structural engineering is the discipline with the most risk and highest number of claims. The majority of these claims are based on designs not meeting code.

Although evidence is difficult to obtain because of the lack of openness by insurance companies, it is believed that there would be fewer insurance claims if designs were completed by SEs as opposed to those who have a Civil PE license and only incidentally practice in structural engineering. It is possible that this could lead to lower risk, fewer claims, and lower premiums.

C. Advances in Technology

Forty years ago, computer analysis required punch cards and tremendous amounts of time to arrive at a solution iteratively. Today, the same analysis—or even a more sophisticated one—can be completed interactively on a laptop in a fraction of the time.

Forty years ago, there were no cell phones, the Internet was in its infancy and not available to the mainstream, and drafting was by ink on mylar. Today, the speed of communication has increased tremendously. People are upset if they must wait 30 seconds for an answer to an email message. Computer-aided drafting (CAD) has advanced to building information modeling (BIM). The Internet has opened a wide world of information to everyone.

Today there are a number of advances that will influence civil engineering and structural engineering (Outsource2India, 2019):

a. Virtual reality
b. BIM
c. Sustainable design
d. Drones
e. Advanced building materials
f. Internet of things
g. 3D printing
h. Robotics
i. Artificial intelligence (AI)

All of these tools will change how structural engineering is implemented in the real world to some degree. The increased complexity and newness of these tools will require structural engineers to attain new knowledge to utilize them effectively. Additionally, consideration must be given to whether SEs can maintain control over their designs as they pass through various hands in a collaborative BIM environment.

Jerry Buckwalter, Chief Strategic Officer of ASCE, foresees that future rapid advances in technology will require structural engineers to be skilled in their discipline, but also skilled as systems engineers. They will need to be able to coalesce structural engineering with advances in robotics, AI, and the use of many other technological advances in the design and construction of structures.

D. Working Globally

With the advance of the Internet age, the world has become smaller. It is no longer a great undertaking to communicate with someone on a different continent. Outsourcing engineering tasks to companies in India or elsewhere in Asia became common among larger engineering companies in the early 2000s. Because there were differences in credentialing for engineers from different companies, there arose the need for agreements regarding this issue. The International Professional Engineers' Agreement is between professional engineering organizations from different countries including the US, Canada, China, UK, Japan, New Zealand, India, and seven others. They have established a Benchmark Competency Standard that includes consideration of academic achievement as recognized in licensure or registration, professional engineering competence in accord with the International Engineering Agreement competency profile, seven years of practical experience after graduation, and two years of responsible charge (NCEES, 2018). Another agreed competency standard, the Asia-Pacific Economic Cooperation Engineering Agreement, has almost identical competency standards (NCEES, 2018). It should be noted that an examination is not included in these standards.

ABET, a nonprofit organization that accredits college and university programs in applied science, computing, engineering, and engineering technology has accredited 677 programs and 139 institutions outside the US as of 2018, according to a presentation given at the 2018 NCEES Annual Conference.

Work in the US is still licensed at the state level. However, it must be considered whether the influence of these international mobility agreements in which NCEES participates will weaken the SE license in the US. It must be considered whether it could be possible in the future for someone from outside the US who has not taken the SE exam to be accepted to practice structural engineering in the US.

E. The Narrow Focus of Structural Engineering

Historically, the civil engineer was a generalist, engaged in designs for civil works including bridges, highways, railroads, and dams. James Eads, for instance, designed important waterway improvements for the Mississippi River, as well as the first steel bridge in the United States over it. Besides designing the structures, he was also thoroughly involved in the construction means and methods of these significant works.

Many civil/structural engineers in the early to late 1900s may have focused on one area of civil engineering as a specialty, but also engaged in designs of other subdisciplines. It was not uncommon for a young bridge engineer to design not only bridges, but also participate in the topographic survey and design of approach roadways, ditches, storm sewers, and hydraulics. In later years, there tended to be a concentration of civil engineers specifically focused in one of those areas, such as highways, hydraulics, and water resources, especially in larger firms. For the majority, the structural engineer eventually became entirely focused on the structural engineering aspect of the project and less involved in the other areas of civil engineering. This migration away from generalizing in many civil engineering disciplines to focusing on one of them is the experience of the structural engineering profession. There still are generalist civil engineers, but today those generalists are in the minority.

Most structural engineers focus on structural engineering. However, this does not negate the advantage of having knowledge of other engineering or architectural areas. A completed project is a collaborative effort, and knowledge of related disciplines leads to better coordination among them. For example, the structural engineer needs to know about geotechnical engineering in order to collaborate on the subsurface exploration and testing requirements leading to the recommended parameters necessary for structural design of foundations. Additionally, a building structural engineer needs to have basic knowledge of architecture, as well as mechanical, electrical, site, and geotechnical engineering, because these disciplines coalesce to make a completed project. As examples, the structural engineer must be aware that ductwork may need to go coordinated with floor beams, or that pumps or other mechanical equipment have vibrations that should be accommodated by the structural system.

One of the reasons for a narrow focus on a subdiscipline is the advent of more complicated building codes and more detailed methods of analysis. The increased complexity requires much more time for understanding, analyzing, and applying the code-mandated principles and requirements. This has resulted from research and a more complete understanding of the forces and their application to a structure (Brewe, 2016). A better understanding of risk probability has led to additional checks and more detailed design. The 1955 version of the USA Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures (ANSI A58.1-1955) was 34 pages long, including appendices (Thompson, George N., et al, 1955). The 2016 version of the ASCE/SEI Standard Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16) (ASCE/SEI Minimum Design Loads on Buildings and Other Structures Standards Committee, 2016) is 401 pages long, not including the extensive accompanying commentary.

In another example of code complexity, wind design has gone from applying a horizontal pressure on the windward side of a building to more complicated methods for consideration of internal pressures, external pressures, and windward vs. leeward pressures depending on building size and shape. The 1955 A58.1 wind requirement consisted of four paragraphs, a table and a map. Now there are six chapters and 140 pages for wind design, not including the commentary.

In many cases, structural failures were the impetus for new research and code requirements. The 1955 A58.1 had one page for seismic forces. The ASCE/SEI 7-16 has twelve chapters and approximately 162 pages of information on seismic forces, largely due to research conducted following large and destructive earthquakes.

The conclusion drawn is that structural engineering has become more complex with only incidental engagement with the disciplines outside of the structural focus. Again, although there are still a few civil engineering generalists, the majority are specialists in a particular area.

F. Trends in Education

For years, engineering colleges were intent on increasing the “book” knowledge of the student. There has been a subtle shift to include classes that are collaborative, experiential, and creative (National Academies of Sciences, Engineering, and Medicine. , 2016). Forward-thinking schools are teaching students to be innovative by introducing real-world problems and teaching how to solve them in new ways. According to Robert Miller from Olin College of Engineering, employers have reported that Olin graduates have qualities reflective of a couple of years of work experience because of the emphasis on innovation, creativity, and problem solving in their education. The highest salaries are going to graduates who not only have knowledge, but can do something with that knowledge in a practical way (National Academies of Sciences, Engineering, and Medicine. , 2016).

Some universities promote this type of education by requiring students to have internships to gain practical real-world experience that is difficult to provide in the university setting. In general, though, the curriculum for students desiring to major in structural engineering has been unchanged for decades. There are still several classes required that cover the breadth of civil engineering in many universities, with a few structural-only classes in the junior and senior years. ASCE’s Raise the Bar initiative recommended that a civil engineer would need a master’s degree or 30 hours of additional credit hours of engineering education to acquire the knowledge necessary to be competent in providing safe designs (ASCE Body of Knowledge Committee, 2008).

There are trends indicating that the number of credit hours to graduate has decreased from over 140 in the mid-1900's to somewhere around 128 today. There is a push by some university leaders to get students out the door even faster. This means cutting additional credit hours required for graduation. Although professional advisory boards oppose cutting credit hours in general, they are powerless to do anything but advise the department chairs to oppose this to their boards.

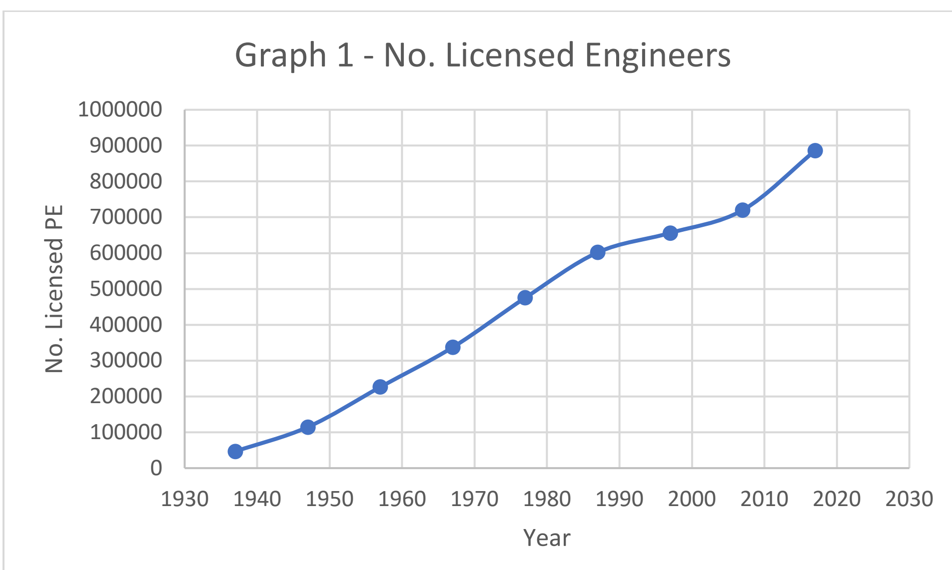
There has also been a movement among faculty to insist that university professors who teach the classes need not have a professional engineering license. It is a huge obstacle for some professors who did not take the fundamentals of engineering examination or did not receive an ABET-accredited education. However, most employers in the structural engineering field believe that if they are going to hire a graduate, it would be better if the professor of that graduate had the experience and education adequate to obtain a PE license. How can that graduate be prepared to gain the practical knowledge necessary, if the professor does not have it and does not know the end goal? There have been two paths for faculty at universities: research and education. Both are necessary. Faculty on both paths would be wise to gain the experience requisite to obtain the PE or SE license. They would then be better enabled to prepare students for real-world experience.

G. Trends in Civil/Structure PE vs. SE Licensure Statistics

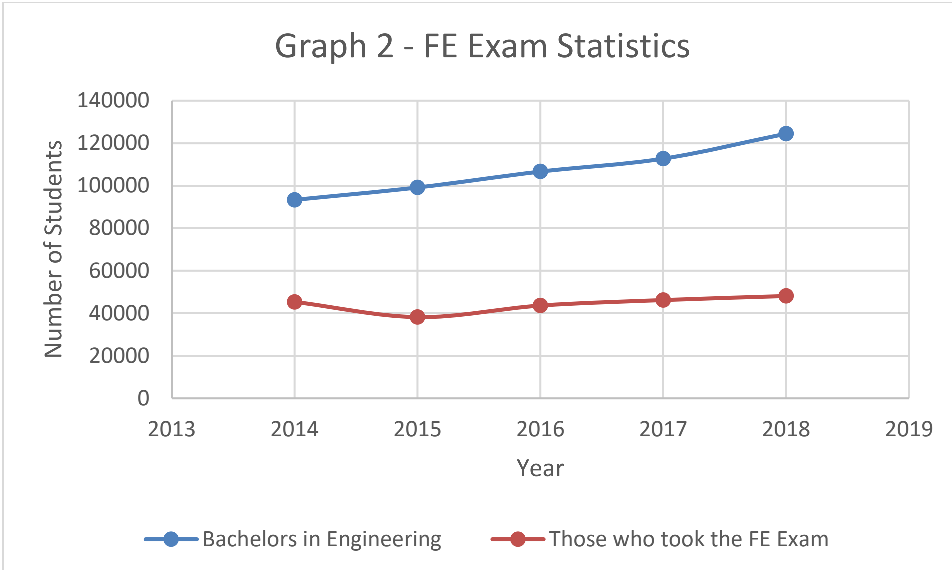
NCEES has kept records of the number of examinees taking the FE, Civil/Structural, and SE exams. It is important to consider any perceived trends in these numbers.

Graphs 1 through 5 were developed from information in the NCEES publication, "NCEES Squared," for the years 2014 through 2018 (National Council of Examiners for Engineering and Surveying, 2018).

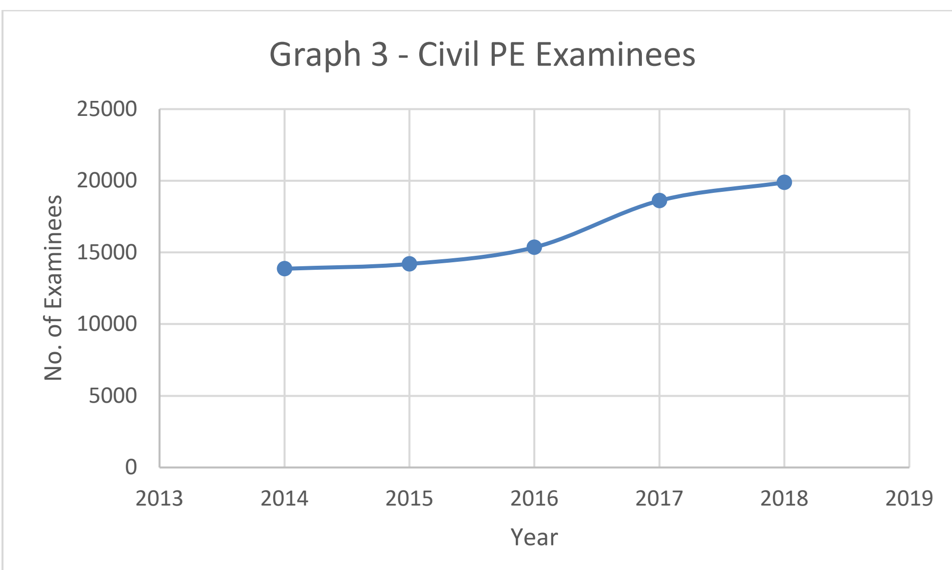
As can be seen in Graph 1, since 1937 the number of engineers in all disciplines becoming licensed has steadily increased. There was somewhat of a plateau in the 1990s through the early 2000s, but otherwise the increase has been at about the same rate.

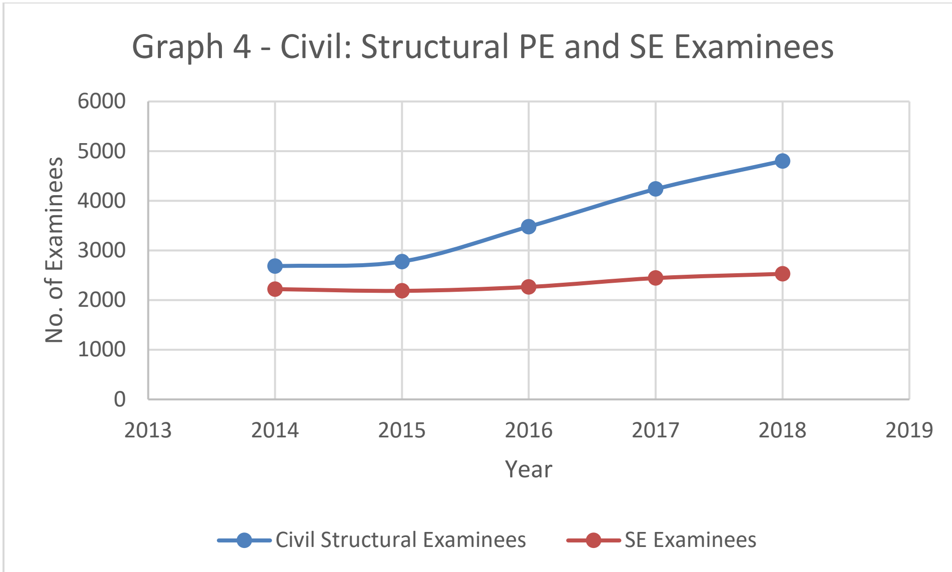


In Graph 2, FE Exam Statistics, it is seen that number of graduates in engineering programs has steadily increased, while those taking the FE exam has remained about the same proportion (about 40 percent) and decreased slightly since 2014.



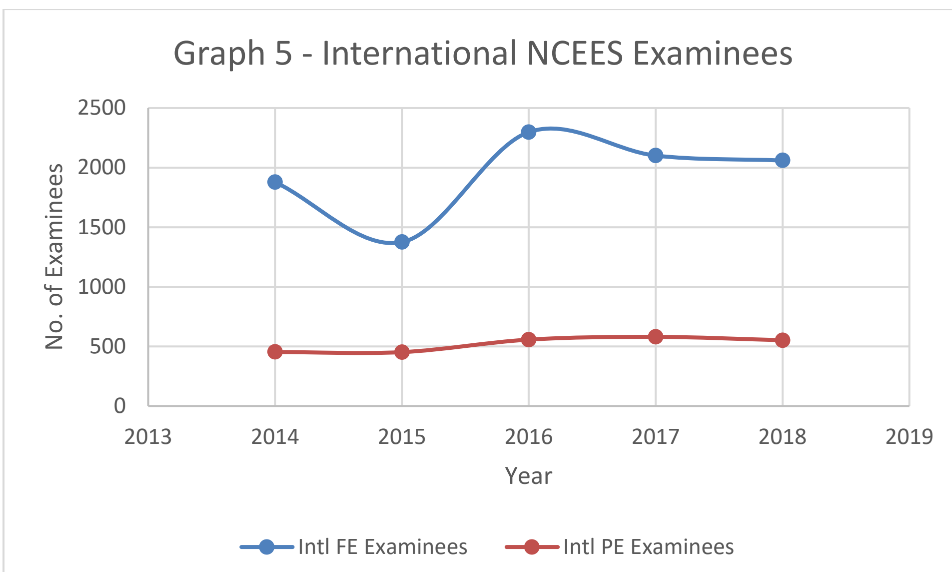
Graph 3 shows the number of Civil Engineering Examinees, while Graph 4 shows the number of Civil/Structural PE examinees and SE examinees. The numbers of total Civil PE examinees have increased steadily over the last few years to almost 20,000 in 2018 from fewer than 14,000 in 2014. The number who have taken the Civil/Structural exam has increased at a similar rate. They are one of the largest of the disciplines of Civil PE examinees, growing from 19% in 2014 to 24% in 2018. The number taking the SE exam has increased slightly from 2,221 in 2014 to 2,528 in 2018. In comparison to those taking the Civil/Structural PE exam, the SE examinees have decreased from 83% in 2014 to 53% in 2018.





It should be noted that the passing rate for the Civil/Structural exam decreased from 76% in 2014 to 64% in 2018. The SE exam contains four modules, and the passing rate for some of them has been as low as 20-30%, whereas for other modules it has been closer to 60%.

Graph 5 reflects the number of examinees taking the FE and PE Examination in other countries. There has been a slight increase in FE examinees since 2014, as well as a slight increase in PE examinees from close to 450 in 2014 to about 550 in 2018.

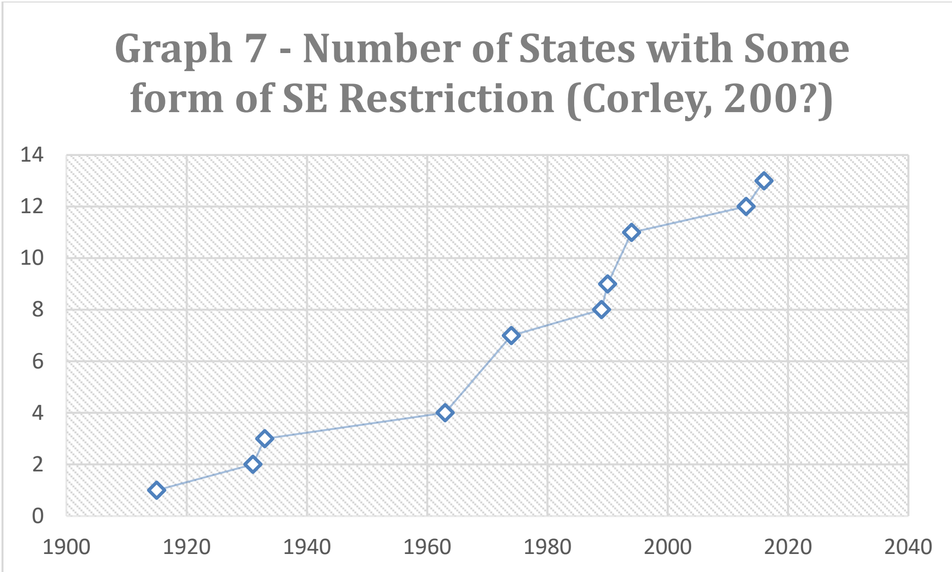


H. Number of States with Some Form of Structural Engineering Licensure

The first SE licensure law was in the state of Illinois in 1915. Since then, there have been at least 15 other jurisdictions with some form of restriction on the practice or title of structural engineers. Table 3 provides a list of the jurisdictions and the restrictions. A title restriction limits the use of the title, "Structural Engineer," but not the practice of structural engineering. A practice restriction limits the practice of structural engineering to some degree. Illinois, Hawaii and Guam are jurisdictions that limit the practice of structural engineering for all structures. The other practice-restricted jurisdictions limit the practice of structural engineering for specifically defined significant structures whose failure would potentially impact a large number of people. Each state has a slightly different list of structures that are considered significant. Graph 7 shows a chart of the progression to 2019 of the jurisdictions that adopted some form of structural engineering licensure, whether by title restriction or practice restriction. Though the chart only depicts up to 2019, in 2021 there are sixteen jurisdictions with some form of restriction. There has been a steady increase over the years.

TABLE 3 - *Jurisdictions with S.E. Protected Title or Practice Restrictions* (Luke, 2016)

State	Title Protected	Practice Restricted	Post-PE (PE License Req'd)	S.E. as First P.E. License
Alaska	✓	✓	Any PE	-
Arizona	✓	-	-	✓
California	✓	✓	CE	-
Georgia	✓	✓	-	✓
Guam	✓	✓	CE	-
Hawaii	✓	✓	-	✓
Idaho	✓	-	Any PE	-
Illinois	✓	✓	-	✓
Louisiana	✓	-	-	✓
Nebraska	✓	-	-	✓
Nevada	✓	✓	-	✓
Oklahoma	✓	✓	-	✓
N. Mariana Islands	✓	✓	-	✓
Oregon	✓	✓	Any PE	-
Utah	✓	✓	-	✓
Washington	✓	✓	Any PE	-


Graph 7 - Number of States with Some form of SE Restriction (Corley, 200?)
14
12
10
8
6
4
2
0
1900
1920
1940
1960
1980
2000
2020
2040

VIII. CERTIFICATION AND CHARTER

A. Overview

Recognition of the professional competence of a structural engineer can take more than one form. Licensure is the form advocated by SELC. In some countries, there is no professional engineering body at all, because the development of mechanisms for recognizing professional competence is in its infancy. Those countries with less formal or rigorous systems are often interested in the US licensure system or the qualifications stipulated by the UK-based Institution of Civil Engineers (ICE) and Institution of Structural Engineers (IStructE). Candidates who take either the US licensing examinations or the ICE or IStructE professional reviews and examinations may work for international firms that require or desire a professional structural engineering credential. For other applicants, obtaining the PE license or the ICE or IStructE qualifications is not required, but is viewed as an honor.

ICE and IStructE (see Chapter V for more details) are both looking to expand their global outreach. They both have Memoranda of Understanding (MOU) with counterpart organizations in other countries.

Some countries have licensing requirements to practice, while others do not. The UK does not require a Chartered Engineer to be on the team, nor are any drawings sealed; the only requirement is that a Chartered Engineer must be able to persuade and satisfy the Building Official that the design meets the building code.

B. Certification

A certification is a verification of an individual's level of knowledge or proficiency in a certain industry or profession. It is granted by an authority in the field, such as a professional society or university, or by a private certificate-granting agency. Most certifications are time-limited; some expire after a period of time, such as the lifetime of a product that required certification for use, while others can be renewed indefinitely as long as certain stipulations are met. For example, ongoing continuing education is usually necessary to ensure that the practitioner remains current on advancements in the field, evidenced by earning the specified number of approved credits/units.

Many certification programs are affiliated with professional associations, trade organizations, or private vendors interested in raising industry standards. They are very common in fields such as aviation, construction, technology, environmental, and other industrial sectors, including healthcare, business, real estate, and finance.

Certification is different from professional licensure. In the United States, licenses are typically issued by state agencies as required by law, whereas certifications are usually awarded by professional societies or educational institutions. 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. In other countries, licenses are typically granted by professional societies or universities and require a more practice-specific certificate after about three to five years. The assessment process for certification may be more comprehensive than that of licensure, though sometimes it is very similar or even the same, despite differing in terms of legal status.

To promote public safety, health, and welfare, and to aid stakeholders in selecting professional engineers qualified to perform structural design, NCSEA sought to find an alternative solution for recognizing structural competence. Delegates from around the US discussed the idea of self-certification at its 1998 Annual Conference in Portland, Maine, and formed an ad hoc committee. After several years of further discussion and research, a vote after the 2003 Annual Conference in Denver, Colorado authorized NCSEA to form the Structural Engineering Certification Board (SECB).

"History and Mission", SECB, http://www.secb.org/about/historyandmission/ (7/14/2019)

C. The Structural Engineering Certification Board (SECB)

SECB's mission is three-fold:

- To promote SE licensure in all jurisdictions by providing a common national certification.
- To determine the level of unique and additional education, examination, and experience necessary to perform the science and art of structural engineering.
- To provide the public and stakeholders with an identification instrument (SECB) that distinguishes an engineer meeting those established levels of education, examination, and experience necessary to perform structural engineering.

SECB recognizes that structural engineering is the science and art of designing and constructing, with efficiency and elegance, buildings, bridges, towers, tanks, frameworks, and similar structures so that they can safely resist the forces to which they may be subjected. By submitting to the certification process, an engineer demonstrates the unique qualities necessary to be certified in the practice of structural engineering. This is not intended to supplant the licensing and regulatory rights of states and other legal jurisdictions of the US. In fact, licensure by a recognized legal jurisdiction is a prerequisite to becoming certified.

Presently, approximately 25 jurisdictions recognize some form of structural engineering practice. In the future, under the certification model, it is envisioned that certification will facilitate licensure in states where the structural engineering discipline is not currently recognized.

D. The benefits of becoming certified by SECB

- Promotes the structural engineering industry as owning its destiny through self-certification.
- Provides another testament to the level of skill that a certified structural engineer possesses, which may exceed the minimum requirements of a state licensing board.
- Facilitates recognition by stakeholders in states that do not license structural engineers.
- Establishes an identity for structural engineering distinct from civil engineering, similar to how medical specialties have established professional certification programs to identify licensed physicians qualified in the various practice fields.
- Assists the broader efforts by CASE, NCSEA, SEI, and NCEES to work with various states to promote the adoption of uniform structural engineering legislation, so that the certification will be portable from state to state in the future.
- Ensures that structural engineering practice is restricted to those who have the appropriate education and experience by giving the profession a direct voice in establishing the appropriate standards of education, experience, examination, and continuing education for licensure.
- Establishes structural engineering as a profession, rather than a technical vocation, thus enhancing the perceived value of services to clients.

"History and Mission", SECB, http://www.secb.org/about/historyandmission/ (7/14/2019)
"Certification", SECB, http://www.secb.org/certification/faqs/ (7/14/2019)

E. Charter Status

The United Kingdom (UK) has a unique system of acknowledging qualified engineers. The title given is "Chartered Engineer," which is achieved by being a member of either ICE or IStructE, but is regulated by The Engineering Council, which holds the national registers of 222,000 Engineering Technicians (EngTech), Incorporated Engineers (IEng), Chartered Engineers (CEng), and Information and Communications Technology Technicians (ICTTech). In the UK, the title most analogous to "Professional Engineer" is "Chartered Engineer".

The Engineering Council sets and maintains the internationally recognized standards of professional competence and ethics that govern the award and retention of these titles. This ensures that employers, government, and wider society—both in the UK and overseas—can have confidence in the knowledge, experience, and commitment of professionally registered engineers and technicians. To achieve registration, each candidate's competence and commitment is independently and thoroughly assessed by peers.

The Engineering Council grants licenses to professional engineering institutions, allowing them to assess candidates for inclusion on the national register. Licensed institutions are deemed to have sufficient experience, procedures, and resources to undertake the following tasks:

- Assessing the competence and commitment of candidates for registration.
- Monitoring the continuing professional development of registrants.
- Monitoring the conduct of registrants.

IX. DISCUSSION

There are challenges regarding SE licensure that threaten the status quo and hamper the ability to expand SE licensure. In order to fairly evaluate and manage a projected path for SE licensure, it is important to consider the history, the method of evaluating competency in other professions and in other countries, the current threats to the profession and licensure in general, and trends affecting structural engineering and the design profession. This should be evaluated in parallel with the state jurisdiction requirements for practicing. The goal of certification is to raise the bar of structural engineering practice in the eyes of the public and to validate additional outcomes necessary to be in responsible charge, especially as continuing education is mandatory, and in view of the fact that not all states have SE licensure. The goal of structural engineering licensure is to protect the safety of the public by restricting the practice of structural engineering to those who demonstrate that they are best qualified to practice by passing an objective and rigorous examination.

A. History and Current SE Licensure

Licensure has been a fundamental element in the structural engineering profession since the first SE license in 1915. Having passed the SE exam has been a badge of proficiency proudly worn by many and looked upon with envy by those desiring to attain recognition of a higher level of proficiency in structural engineering. In the US, SE licensure is well-entrenched with at least twleve states and two territories currently restricting either the practice or the title. The method of attaining licensure has improved over the years. Strict requirements for education, experience, and examination have evolved under the guidance of NCEES.

Education

ABET-accredited education is typically required. According to the ABET website, ABET accredits college programs, not institutions; verifies that the curriculum meets the global standard for technical education in the chosen profession; verifies that graduates from an accredited program have a solid educational foundation and are capable of leading the way in innovation, emerging technologies, and anticipating the welfare and safety needs of the public.

Experience

Verification of experience for licensure is perhaps an area that can be improved further. Affidavits from colleagues or supervisors are usually required by each state to verify experience. The signers of the affidavits are attesting that the candidate's experience is progressive, requires the application of engineering knowledge, shows self-improvement, teaches the candidate to design, and puts the candidate in a position of responsibility for the design product. Other possibilities for verification of experience could include the submission of evidence of work product for review.

Most states require four years of experience, although fewer years may be sufficient for those who have an advanced degree. It should be considered whether four years of experience are adequate to enable a candidate to gain the practical experience level necessary for a licensed structural engineer to be in responsible charge and to seal documents.

Examination

The examination process for SE licensure is the most robust for any discipline of professional engineering in the US. The exams are prepared and developed by practicing structural engineers to meet the specifications that they developed in accordance with input from their colleagues around the country and are psychometrically sound. This means that they could withstand challenges by courts and regulatory agencies regarding their validity in measuring competence.

Civil/Structural PE Exam vs. SE Exam

Many jurisdictions accept the Civil/Structural PE exam to show adequate qualification to practice structural engineering. Even those jurisdictions with a partial practice restriction allow engineers with this PE to practice structural engineering for most structures. For the design of significant structures, a person who has passed the 16-hour SE exam and obtained the SE license must be in responsible charge. It is, therefore, a two-tiered system in these states. A model set of thresholds for significant structures has been prepared by SELC and is presented in Appendix D.

If the Civil/Structural PE exam is to be used to identify structural engineers who are qualified to be in responsible charge for most of the structures in the country, then it also needs to be evaluated as to whether it is a good measure for minimum competence. Recent review of the breadth portion indicates that it is not applicable for most practicing structural engineers. The civil engineering discipline has, for the most part, become divided into specialties of structural, geotechnical, transportation, construction, and water resources. Whereas most civil engineers in the past may have practiced in several of those areas, most civil engineers today practice only within a single area of specialty.

If the focus of the discipline has changed, then the PE exam should also change. If most structural engineers do not practice in the other civil engineering subdisciplines, then the exam should not include those aspects, but focus on structural engineering only. The current Civil/Structural exam may be retained for those who practice civil engineering more broadly. The current 16-hour SE exam includes ample and thorough testing for competence in structural engineering.

Validity of the SE Exam for a PE License

There are some jurisdictions that do not accept the SE exam for a PE license. If their rationale is that the SE exam does not include the breadth portion, then they should evaluate whether the candidate's practice includes such aspects. If the candidate's practice is strictly in structural engineering, then a PE license using the SE exam should be acceptable. To be a *professional* engineer means competently making decisions based on education and experience for the protection of the safety, health, and welfare of the public. The professional engineer designs in an ethical fashion, ensuring quality and safety despite implications to profits or schedules. If something must be sacrificed due to circumstances, quality must not fall below the standard of care.

Professional structural engineers must have adequate proficiency in their discipline and experience to make wise decisions that provide safe designs. A competent structural engineer has strong fundamental knowledge and has built on that education with experience. The competent engineer has the passion to ask questions and research practical applications of structural engineering principles, which may not always be immediately obvious. Education is essential, but practical knowledge of how to deliver plans and specifications for a safe and constructible product is also crucial. These tenets can never be subservient to profit, schedule, or the acquisition of future projects.

Continuing Education

NCEES has recognized that continuing education is important for the engineer to stay abreast of changes in standards, codes and methods of analysis. Some states require that engineers keep track of continuing education and occasionally audit the records of engineers. Continuing education should be credible and of sufficient merit to enhance an engineer's knowledge base. Thorough tracking of continuing education should be maintained SECB has a thorough method of reviewing and accepting meaningful continuing education. Perhaps could SECB be established as the gatekeeper for structural engineering continuing education in all jurisdictions.

B. Competence in Other Professions

The question arises as to whether, instead of a license as a credential for the specialty of structural engineering, a board certification like that for doctors would be more appropriate. Some believe that professional organizations should regulate the licensing process, rather than state governments. Doctors and other professionals such as accountants have a basic license that is required, but then they get board-certified or obtain additional certification in certain specialty areas. For doctors, the exam for board certification must typically be retaken every ten years.

It is possible that the structural engineering profession may be able to learn something from these other professions. There might be a place for board certifications as a step toward SE licensure. Perhaps those who have additional education meeting the guidelines of the ASCE Body of Knowledge could receive a certification that represents their additional education. Other possibilities for certification may be for a specific specialty within structural engineering, such as tall buildings or long bridges.

C. Structural Engineering Competence in other Countries

There are many methods of determining the minimum competence of engineers in other countries. Most use some combination of education and experience as the determining factors. Only the UK adds the requirement of examination. None of these other countries have as robust an examination process as SE licensure in the US. However, some require much more experience.

The following should be considered by the prominent structural engineering organizations as they plan for the future of SE licensure:

- How will SE licensure in the US coexist with these other forms of credentialing as globalization becomes much more prominent in the future?
- Should SE licensure be made more accessible to those across the globe by weakening or eliminating the SE exam?
- Should there be a global standard for structural engineering credentialing?

D. Alternatives to Structural Engineering Licensure

Advantages of Board Certification

- The profession will have control of the credentialing process from start to finish.
- There will be no chance for uninformed legislators to pass laws that negatively influence the credentialing process.
- Certification offers a higher standard of continuing education compared to current requirements in jurisdictional licensure. For example, SECB requires 45 hours every 3 years in structural engineering topics.

Advantages of SE Licensure

- It is not required by law that a hospital must use doctors that are board-certified, rather it is up to each hospital to determine the credentials of those who work in that facility.
- Board certification is not as powerful as licensing. Licensing is enforced by statutes and the government can be brought to bear on those who do not abide by it.
- Licensure better protects the public because it is enforced by the law and not easily influenced by outside entities.
- The SE exam is a much higher standard compared to the PE exam, and has been validated as a means to demonstrate the minimum competence of structural engineers who are in responsible charge.
- The process for obtaining a license is greatly controlled by the engineering community, even though legislators are the ones who pass laws regarding licensure.
    - NCEES develops the licensing exams and model law and is mostly made up of engineers.
    - Experienced engineers develop the specifications and the questions for the exam.
    - State boards administer the laws and rules, and these are made up of professionals who are mostly engineers.
- SE licensure is already in place for 14 jurisdictions. It would be very difficult to pass legislation removing SE licensure in those states.

CASE, NCSEA, and SEI agree that structural engineering licensure is currently the most valid means of demonstrating the minimum competence of structural engineers with the aim of protecting the public. They currently do not envision certification as replacing such licensure. Certification may hold a place in credentialing those who have specialties in the structural engineering field. This possibility should be evaluated by the leadership of the three organizations.

E. Threats

Threats were discussed as being internal and external. Measures should be considered to protect SE licensure. The threats should be examined to see if there are any valid criticisms of SE licensure. Communication regarding the positive and negative aspects of SE licensure could be more robust within the engineering community. Improving it is necessary to rally support to defeat legislative initiatives that would harm licensure.

F. Trends

One prominent trend is the narrowing focus of structural engineering. It would seem important to ascertain if this indeed exists and if it is being correctly perceived. If it is real, then the traditional view of civil engineering as comprising a number of subdisciplines is no longer valid for most engineers, which then reflects on the validity of the Civil/Structural PE exam and license. It should also be reflected in engineering education. If the traditional view is not valid for most structural engineers, then the currently required broad education in all the subdisciplines should be adjusted. It may be that instead, a broad education focused in structural engineering should be included in the bachelor's degree curriculum. The master's degree emphasis could then focus on a specialty within structural engineering.

X. CONCLUSIONS

THE VISION:

Based on the above, SELC believes that the Vision for the Future of Structural Engineering Licensure should include the following:

A. Recognition and endorsement of SE licensure in all 55 US jurisdictions as a post-PE credential.
B. Recognition and endorsement of the SE examination as the testing vehicle to demonstrate minimum competence for the design of Significant Structures. (Appendix D)
C. Promote requirements for education, examination, and experience that are uniform across all jurisdictions globally.
D. Promote continuing education that is enhanced beyond that for PE licensure and is required in all jurisdictions.
E. The portability of SE license between all jurisdictions.
F. Recognition and endorsement of SE licensure as the minimum standard for the practice of structural engineering.
G. Certification has a valid place in the credentialing process. It does not replace licensure but may be used to enhance licensure.

THE IMPLEMENTATION PLAN

The following initiatives would address some of the questions, deficiencies, and trends in the practice of structural engineering and its licensure process.

A. Improve the Licensure Process:
    1. Evaluate alternative methods for evaluating the experience of those applying for SE licensure, such as submitting examples of work product.
    1. Develop a white paper regarding the need for meaningful continuing education and highlight the process already developed by SECB. Follow this up with discussions with NCEES to promote SECB as the record-keeper for structural engineering continuing education.
        i. Develop a standard for the content of continuing education that assures its validity in the eyes of the public.
        ii. Require a regular review of each engineer's continuing education content.
    2. Develop a white paper rationalizing the need to develop common SE licensure requirements across all jurisdictions globally.
B. Improve Communication Regarding the Positive Aspects of SE Licensure
    1. Include topics on licensure as part of the regular communications during the leadership meetings of CASE, NCSEA, and SEI.
    2. Develop a communication program to reach out to the general membership of these organizations with positive messages regarding SE licensure, as well as a very robust public outreach program.
    3. Develop a method to gain grassroots support to oppose negative legislative initiatives.
    4. Develop a program to communicate the importance of SE licensure to students, educators, and employers in engineering.

C. Develop Initiatives to Prepare for the Continuing Globalization of Structural Engineering
D. Develop Initiatives to Prepare for Continuing Advances in Technology
E. Determine the Proper Role of Structural Engineering Certification
    1. Acknowledge that structural engineering licensing is firmly established and is not threatened with being replaced.
    2. Explore whether the profession is better served by regulating itself in accordance with its own standards, in parallel with jurisdictional requirements for practicing.
    3. Pursue the goal of enhancing structural engineering and protecting the public.

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APPENDICES

APPENDIX A SUPPLEMENTAL HISTORY OF LICENSING INFORMATION

APPENDIX B STATE SPECIFIC SE EXAM HISTORY

APPENDIX C SPECIFIC CREDENTIALING FOR COUNTRIES OUTSIDE US

APPENDIC D SIGNIFICANT STRUCTURE DOCUMENT DEVELOPED BY SELC

APPENDIX A - SUPPLEMENTAL HISTORY OF LICENSING INFORMATION

APPENDIX A Historical Requirements for Engineering Licensure as Taken from the History of NCEES

The 1907 Wyoming Engineering Licensure statue included the establishment of a Board of Examining Engineers. The board was entrusted to "satisfy itself by conducting examination or by investigations of the record, training and experience of those who may desire to qualify." Additionally, "The Board of Examining Engineers shall in all cases make inquiry relative to the moral character of every applicant".[1]

The Council of Boards of Engineering Examiners was trying to develop a model law that included requirements for an examination. In 1926, they agreed that the examination should contain both written and oral portions. In 1929 a survey of the member boards, found that three required only oral examinations, six required only written examinations and eight required both. The content also varied greatly. It was recommended that the Council work toward standardizing the examination and certification process. [2]

In 1930, the Council sponsored the National Bureau of Engineering Registration, (NBER), whose research found a professional engineering system in British Columbia that included an Engineer-in-training examination and a professional engineering examination. [3] The NBER provided certificates for engineers registered in one state, so that they could become registered in other states.

In 1932, the Council organized the Engineers' Council on Professional Development consisting of members of the Council and representatives from the professional societies. This council worked on developing criteria for accrediting schools, providing guidance to high school students, developed minimum qualifications for an engineer and provided certification for those engineers that had already been established. They established that until a certain date, an engineer meeting the requirements of the model law would not have to take the examination, but after a certain date they would. There was a movement within this group to establish a certifying agency that would parallel and supplant the Council, but this movement was defeated.[4]

In 1933, a committee from the Council recommended that the examination be 3 days long with only half of the third day being discipline specific. Graduates of accredited engineering schools would only have the last half of the third day exam if they had taken an examination similar to the breadth portion before graduation. In 1934, the examination was dropped to two days. In 1938, the Committee on Qualifying Experience reported that the 4 to 12 years' experience required by different boards was a better measure of the better candidates. [5] Over the years, many delegates to the Council had argued that experience and references was so valuable it should be the primary measure of candidates. The problem was that it was difficult to measure the quality of the experience – not all experience was the same. It was resolved that education and examination must be combined with an evaluation of experience. The experience should be progressive,

[1] Chapter 86, Section 28 of the Session Laws of Wyoming, 1907.

[2] Acorn Corley, Joana (Ed.) The History of the National Council of Examiners for Engineering and Surveying 1920–2004, IBID, Clemson, SC, 2004, pg 13,14

[3] IBID, pg. 15

[4] IBID, pg. 27

[5] IBID, pg. 33

require the application of engineering knowledge, show self-improvement, teach the candidate to design, supervise, operate and superintend.[6]

In 1940, the committee on examinations suggested that the board provide questions that required the candidate to demonstrate mastery of patterns of thought and problem-solving strategies, rather than required them to memorize details.[7] At this time, an interview was required of the candidates to obtain a competent opinion of the applicant's personality, general information and experience. This personal interview caused a hardship on applicant's applying at several states.

In 1944 the topic of continuing education was raised. Registration should include reasonable assurance that the registrant will remain competent throughout their practice. They asked if there was a method by which boards could have reasonable assurance of continued competence.[8]

In 1946, the Council formulated a joint committee with NSPE and the Council. It was thought that NSPE would represent the interests of the other societies. This committee would maintain contact with the other professional societies and report on matters of common interest.[9]

In 1949, D. B. Steinman, one of the organizers of NSPE, emphasized in an address to the board that engineering was one profession and that the Board had successfully prevented the breakup of the profession into branches and specialties with different qualifications and separate licenses. "We do not want our profession pictured as a heterogenous aggregation of trades and specialties."[10]

By 1951, most states had a two-day examination with the first day on fundamentals and the second day experience and practice. In 1954, a Council report discouraged the use of oral examinations as being unreliable. At this time, the EIT examination was recognized as the first day of examination for fundamentals. The first national fundamentals examination was given in 1965. The first national principles and practice examination was held in 1966.

In 1968, a question was raised by Council delegates and the professional societies as to whether the registered engineer should retain the title as "Professional Engineer" or as a specialist such as "Civil Engineer". Discussion included topics such as that many of the questions on the examination had nothing to do with the discipline of the engineer being tested. It was suggested that a solution would be to use a test using multiple choice questions and be machine graded.[11]

In 1968 a report by a committee was formed to study the future of the professional recognition of engineers. They reported that because the licensing laws were formulated when the main design items were buildings and bridges, the laws had difficulty being applied to the more fluid nature of the many engineering specialties that had arisen in the 1950's and 1960's.[12]

In 1980 the Council studied the validity of the examinations as a method of determining competency. The examinations were compared to the knowledge and practices that were actually used in the profession. The question of how to determine cutoff scores – the line between pass

[6] IBID, pg. 40
[7] IBID, pg. 39
[8] IBID, pg. 47
[9] IBID, pg. 52
[10] IBID, pg. 60
[11] IBID, pg. 96
[12] IBID, pg. 97

and fail – had been adrift since the national exam was adopted. The "Modified Angoff" procedure was adopted for establishing the minimum passing standard.[13]

In 1981, there were 15 engineering disciplines covered by examinations.

In 1984, Dr. Edward O. Pfrang, executive director of the ASCE, described his role in the investigation of the 1981 Hyatt Regency Skywalk Collapse in Kansas City, Missouri. Pfrang urged the Council to address the issue saying, "I submit that you are the last hope in regard to professional responsibility. Engineering examiners represent the public; they have been appointed to protect the health and safety of the public…[If a major disaster occurs] we as engineers will lose total control of our destiny, because legislation will be passed so quickly that we will no longer be in control of the practice of engineering…."14

Paul Munger and Sam Wainwright, both presidents of the Council, stated that though improving the exam was the focus of the Council, rules of professional conduct and their enforcement were of equal value to licensure. [15]

The PE Examinations were considered psychometrically sound beginning with the 1983 examinations. This meant that they could withstand challenges by courts and regulatory agencies regarding their validity in measuring competence.[16] Psychometrics is the field of study primarily concerned with the study of differences between individuals and focuses on the science for validity, precision, reliability and fairness of examinations in measuring competence. In the 1980's the method for determining the minimum passing score was changed from a norm-referenced method to a criterion-referenced method where a group of licensed engineers familiar with what practicing engineers say they are required to know establish the minimum passing score on each item.[17] Machine scoring was also being investigated as a means of providing fair and reliable grading. The committee investigating the exam format recommended a format of traditional free-response and objectively scored multiple choice items.[18]

In 1988, the examination included three objectively scored items in the AM and PM sections of the PE exam. The discipline examinations included: Chemical, Civil/Sanitary/Structural, Electrical, Mechanical, Manufacturing, Ceramic, Industrial, Petroleum, Agricultural, Nuclear, Aeronautics/Aerospace, Mining/Mineral, Fire Protection, Supplemental Special Structural I and II, and Metallurgical.[19]

In 1994, the FE exam was changed to allow discipline-specific modules. For the PE exam, the Council began moving toward breadth and depth examinations following a long-standing recommendation by Dr. Wiley Boyles, the Council's psychometrician.[20]

In the 1990's, there were negotiations with other countries where it was discussed whether experience could be substituted for examinations. The US method of licensing was considered

[13] IBID pg. 118
[14] IBID, pg. 127
[15] IBID, pg. 128
[16] IBID. pg. 132
[17] IBID, pg. 132
[18] IBID, pg. 133
[19] IBID, pg. 133
[20] IBID, pg. 134

the most rigorous in the world in setting standards of competency to protect the welfare of the public.[21] The Council allowed competency to be validated by licensed experience rather than examination in Professional Policy 18.[22]

By 1994, there were a total of over 641,000 engineering licenses in the US.[23]

In 1996, all PE Exams except for the Structural Exams were slated to be 100% multiple choice and not essay problems. Multiple choice problems can be scored by machine, eliminating the human input and a more accurate bias-free score. As a result, they are less likely to be challenged because of uneven scoring.[24]

In 1997, the EPE completed examination specification development with a procedure to update the specifications on a continual basis.[25]

The conversion to breadth and depth exams was initiated in 1998 with the Civil Exam and was administered in 2000.

In most states today, the requirements to sit for the professional exam are some combination of four years of progressive engineering education followed by four years of engineering design experience under the direct supervision of a professional engineer. Some states have begun to require more than this minimum benchmark.

Additionally, most states require a constant continuation of education to keep the professional license active.

[21] IBID, pg. 139
[22] IBID, pg. 141
[23] IBID, pg. 143
[24] IBID, pg. 155
[25] IBID, pg. 156

APPENDIX B SUPPLEMENTAL ILLINOIS SE EXAM HISTORY

APPENDIX B

Supplemental Illinois SE Exam History

The SE exam was established to test the competency of those applying for SE licensure, similar to the exam required for the professional license. The following information was obtained from Nancy Gavlin, SE, retired member of the Illinois SE Board.

Following is an excerpt f*rom the Illinois Structural Engineering Act of 1915:*

Each applicant examined shall sustain a satisfactory examination in the design and construction of buildings and structures according to scientific principles and with special reference to strength and safety; the strength and properties of the various building materials; the principles of theoretical and applied mechanics; the ability to apply his knowledge to the ordinary requirements of structural engineering; and in such other matters and subjects as the Board of Examiners may require as suitable to fairly and thoroughly test the competency of the applicant to practice structural engineering in this State.

In 1919 the exam provisions were slightly modified to:

The examination of applicants for certificates of registration as registered structural engineers may consist of written and oral tests and shall embrace the subjects normally taught in schools of structural engineering approved by the Department of Registration and Education.

Between 1919 and 1985, the wording did not change.

Illinois SE Board Rules

The Board Rules of 1960 required four 4-hour problems to be worked out. They consisted of A) General Engineering Knowledge, B) Reinforced Concrete, C) Structural Steel and D) Wood, Masonry and Foundations. An oral examination was an alternative, including an examination of blueprints of three or more major structures prepared by the candidate or under their supervision over a 10-year period. The General Knowledge section served the purpose of the FE exam today.

In 1967 the Rules required four 4-hour divisions with A1-General Knowledge, A2-Fundamentalsof Structures, B1-Structural Design-General, B2-Structural Design Major.

1972 the four 4-hour divisions consisted of A1-Basic Engineering Science and General Knowledge, A2-Structural Theory, B1-Structural Design-General, B2-Structural Design-Specialized. PE's and EIT's may be exempted from A1. Oral exams were granted to structural engineers of eminence.

In 1980, the four divisions consisted of:

Division A1 –Basic Engineering Science and General Engineering Knowledge
This Division consists of multiple-choice questions and may cover any area of general engineering knowledge, physics, theoretical and applied mechanics, mathematics, construction practice, economics, codes and engineering law.
Division A2 – Basic Engineering Mechanics and Structural Theory
This Division consists of problem to be solved in structural mechanics and analysis including dynamics.

Division B1 – Structural Design – General
This Division consists of five problems in structural design, one each in reinforced concrete, structural steel, foundation engineering, wood and masonry. Each problem constitutes 20% of the grade for this Division.
Division B2 – Structural Design – Specialized
In this Division, the examinee chooses one of three problem sets. Of the three problem sets, there will be one each dealing with structural design in reinforced concrete, structural steel and foundation engineering.

Starting in 1987, the Illinois SE exam was changed to the NCEES Examination. The NCEES structural examination consisted of 16 hours of examination with the Structural I (STR1) and Structural II (STR2) each being 8 hours. It was intended that these two examinations be used together to evaluate the minimum competency of a person desiring to be licensed as a structural engineer. Some states began accepting the STR1 as the equivalent of a PE exam.

The STR1 in 1985 consisted of four 1- hour constructed response problems in the morning and in the afternoon, each chosen from a set of six problems. Between 1997 and 1999, there were four constructed response in the morning, but no choice, and 40 multiple choice problems in the afternoon. From 2000 to 2010, the exam consisted of forty multiple choice problems in each of the morning and afternoon.

The STR2 in 1985 and 1986 consisted of four 1-hour structural constructed response problems chosen from six available in the morning and in the afternoon. Between 1990 and 1997, the STR2 consisted of one four-hour constructed problem chosen from three problems in the morning and the same in the afternoon. Between 1997 and 2003 it changed to one four-hour problem chosen from two problems in the morning and the same in the afternoon. Between 2004 and 2010 there were two 2-hour problems in the morning and two 2-hour problems in the afternoon, all constructed response.

In 1991, the Rules indicated that there were three eight-hour parts. The first part was the FE exam. The second part was Part 1 of the SE exam. The third part was Part 2 of the SE exam.
2010 was the last administration of the STR1 and STR2 examinations. In 2011, a new 16-hour structural exam was formulated.

The NCEES SE exam has always had a bridge exam and a building exam. Currently, the multiple-choice morning questions include mostly building questions with less than 10 bridge questions of 40 total. The afternoon constructed response exams are entirely either building or bridge. A candidate would choose which they would take, however, whether they passed the bridge or building portion would not be stated on any SE license certificates.

California SE Exam

The following information was obtained from a presentation by Gregg Brandow. The California SE exam was started in 1931. The Western states SE exam was started in 1985 and was used by California and a number of Western states until 1998, at which time California continued with the exam as its own 16-hour SE exam. The California-specific SE exam (sometimes referred to as the California SE III exam) was started in 2004 and was used in conjunction with the NCEES SE II exam to make up California's required 16-hour examination for structural engineer candidates. The Western states SE exam was 16 hours long and the California-specific SE exam was 8 hours long. Testing of seismic design was a focus with all the California SE exams. In 2011, the California-specific SE exam was dropped in lieu of the 16-hour NCEES SE exam

Washington, Hawaii and Oregon SE Exam

In 1963, the first two-day structural exam was provided in the State of Washington. Before this time the examinations were 8 hours long. In October 1998, the last Western States SE Exam was administered for the last time. After that the NCEES SE I, SE II and the 4-hour SE III-WA Exams were administered. In 2001, the NCEES SE I exam was no longer accepted. In 2002, the Washington State SE III exam was changed from a four-hour exam to an eight-hour exam.

In April 2011, NCEES began administrations of the 16-hour SE (lateral and vertical portions) and discontinued administrations of the SE I & SE II exams. WA offered exam options to SE candidates. They could take the WA SE III and the NCEES SE II or the new NCEES 16-hour SE exam. In October 2011, the Washington SE III was administered for the last time.

Hawaii began giving NCEES Structural I & II exams in October 1994. Before that, the Western States structural exam was administered.

Oregon began giving the NCEES Structural I & II exams in October 1996. Before that, Oregon administered the Western States structural exam.

APPENDIX C DEFINITION OF ENGINEERING COMPETENCY IN OTHER COUNTRIES

APPENDIX C

Definition of Engineering Competency in Other Countries

The United Kingdom (UK)

The Engineering Council is the UK regulatory body for the engineering profession. It holds the national registers of 222,000 Engineering Technicians (EngTech), Incorporated Engineers (IEng), Chartered Engineers (CEng) and Information and Communications Technology Technicians (ICTTech). In the United Kingdom, the title most analogous to "Professional Engineer" is "Chartered Engineer." ("Chartered Engineer," Engineering Council, https://www.engc.org.uk/professional-registration/the-professional-titles/chartered-engineer/ (7/14/2019).

The Engineering Council sets and maintains the internationally recognized standards of professional competence and ethics that govern the award and retention of these titles. This ensures that employers, government and wider society - both in the UK and overseas - can have confidence in the knowledge, experience and commitment of professionally registered engineers and technicians. To achieve registration each individuals' competence and commitment is independently and thoroughly assessed by their peers.

The Engineering Council grants licenses to professional engineering institutions, allowing them to assess candidates for inclusion on the national register of professional engineers and technicians. Licensed institutions are deemed to have sufficient experience, procedures and resources to undertake the following tasks:

- Assess the competence and commitment of candidates for registration
- Monitor the continuing professional development of registrants
- Monitor the conduct of registrants

There are currently 35 licensed institutions, those relevant to structural engineering are listed below and their procedures for admission as a Member are outlined below that:

Institution of Civil Engineers (ICE)
Institution of Structural Engineers (IStructE)

"About Us", The Engineering Council (UK based) that administers CEng (Chartered Engineer) – UK regulatory body for Engineers https://www.engc.org.uk/ (7/14/2019)

The Institution of Civil Engineers (UK based, MICE is a Member)

Chartered engineers (CEng) need to be highly qualified in their fields. The title CEng is protected by law, as is the title Chartered Civil Engineer, and is one of the most recognizable international engineering qualifications. This means that the educational requirements are demanding. For most members, there are three stages to becoming qualified. This is based on:

1. Your academic qualifications
2. Your work experience (also called initial professional development)
3. Passing your Professional Review

Academic/Education qualifications needed for CEng:

An accredited four-year integrated MEng degree, or a bachelor's degree which is accredited as CEng with further learning, plus an accredited master's degree

Work experience (Initial Professional Development (IPD)) needed for CEng:

(IPD is measured against a set of 'attributes', which can be achieved in three stages. Typically this work experience is for approximately 4 years):

1. Knowledge – a basic understanding and knowledge of the attribute and how it is achieved
2. Experience – achieving the attribute in different situations, working under supervision
3. Ability – achieving the attribute in different situations, assisting others and working unsupervised

There are three ways to complete the IPD:

1. ICE Training Scheme – this is a structured training program run by an employer who provides support and guidance throughout your training from a supervising civil engineer (SCE), who your employer assigns to you.
2. Mentor-supported Training – this is similar to the ICE Training Scheme but is not run by your employer. You're responsible for managing your own training with the support of a mentor, who'll need to be approved by ICE.
3. Career Appraisal – you can do this if you've already got enough experience to complete your IPD.

The Professional Review:

A Professional Review is the final stage in becoming professionally qualified. This is where you prove that you've developed all the right skills to become professionally qualified. The Professional Review itself is made up of three steps:

1. Initial application – this gives ICE the information needed to arrange your Professional Review
2. Submission –submit a report of up to 5,000 words showing how you meet all the requirements to become a chartered engineer and also your CPD records
3. Professional Review – you'll be interviewed by experienced civil engineering professionals. Be prepared to discuss your report and show off your knowledge. You will also have to complete a written exercise which is an assessment of your written skills

"How to become a professionally qualified civil engineer", Institution of Civil Engineers, https://www.ice.org.uk/careers-and-training/graduate-civil-engineers/how-to-become-professionally-qualified (7/14/2019)

The Institution of Structural Engineers (UK based, MIStructE is a Member)

The MIStructE grade is arguably the most widely respected mark of competence in the structural engineering profession. The process to become Chartered is described on the website and essentially there are three stages to becoming a Member, MIStructE:

1. Satisfying the academic base
2. Undertaking a period of Initial Professional Development
3. Passing the Professional Review which incorporates an Interview (PRI) and Exam

Academic/Education qualifications needed:

An accredited MEng degree, or a BEng (Hons) degree partially accredited for Chartered Membership or a Washington Accord or FEANI recognized degree:

Initial professional Development (IPD):

Candidates are required to demonstrate the required standard of Appreciation, Knowledge, Experience and Ability (as appropriate) in each of 13 Core Objectives. Candidates must develop a portfolio of work showing how the competence has been gain and they must write reports on each of the Objectives summarising how they developed the required standard. We do not have time limits in terms of how much experience a candidate should have but we do state that it is unlikely that any candidate will demonstrate the ability required with less than 4 years' experience.

Professional Review:

Professional Review Interview (PRI) – candidates sit an Interview based on the 13 Core Objectives and must demonstrate to two trained Reviewers that they have satisfied all 13 Core Objectives. There is no compensation in our system you must pass all 13 Objectives to pass the Interview.

Examination – The exam assesses the validity of your training and experience. Our examiners need to be satisfied that you have:

- An understanding of structural engineering principles
- An ability to initiate and communicate structural design
- An ability to provide effective and viable solutions to a structural design problem

Exam format

The exam is seven hours long. You must choose one question from a choice of five. All questions have two sections and both parts of the question must be satisfactorily answered to achieve a pass:

Section 1 (50% of total mark) requires you to prepare a design appraisal with appropriate sketches indicating two distinct and viable solutions for the proposed structure, including the foundations. You are required to indicate the functional framing, load transfer, serviceability and stability aspects of each scheme. You must then appraise the schemes, identify the preferred solution and give reasons for your choice. Finally, you will write a letter to the client outlining design implications arising from a change in the client's brief.

Section 2 (50% of total mark) requires you to provide sufficient design calculations to establish the form and size of all the principal structural elements, including the foundations. You must prepare general arrangement drawings and finally prepare a detailed method statement for the safe construction of the works and outline a construction program.

IStructE also offers a membership path for engineers holding a Structural Engineer license. IStructE will submit applicants to a tailored examination and interview process to verify that the applicant holds the knowledge and skills not verified directly by the US SE licensing process.

"How to become a Structural Engineer", The Institution of Structural Engineers, https://www.istructe.org/become-a-structural-engineer/how-to-become-a-structural-engineer/ (7/14/2019)

Europe

The European Federation of National Engineering Associations (FEANI) is a federation of professional engineers that unites national engineering associations from 33 European Higher Education Area (EHEA) countries. Thus, FEANI represents the interests of over 3.5 million professional engineers in Europe. FEANI is striving for a single voice for the engineering profession in Europe and wants to affirm and develop the professional identity of engineers. Through its activities and services, especially with the attribution of the European Engineer, EUR ING professional title, FEANI aims to facilitate the mutual recognition of engineering qualifications in Europe and to strengthen the position, role and responsibility of engineers in society.

The EUR ING title delivered by FEANI is designed as a guarantee of competence for professional engineers, in order:

- to facilitate the movement of practicing engineers within and outside the geographical area represented by FEANI's member countries and to establish a framework of mutual recognition of qualifications in order to enable engineers who wish to practice outside their own country to carry with them a guarantee of competence
- to provide information about the various formation systems of individual engineers for the benefit of prospective employers
- to encourage the continuous improvement of the quality of engineers by setting, monitoring and reviewing standards

The EUR INGs are listed in the FEANI Register, a database maintained by the Secretariat General in Brussels. Currently over 32,000 European Engineers are listed in the register (May 2013).

The European Commission, in a statement to the European Parliament, has recognized the FEANI Register and the EUR ING title as valuable tools for the recognition of national diplomas among member states: "The FEANI scheme is an excellent example of self-regulation by a profession at European level and it provides a model for other professional groups in the technical and scientific sector, such as chemists and physicists. The FEANI register recognizes and builds upon the diversity of forms of engineering education which exist in the Community and can adapt to any changes which may be decided upon at national level. The procedures for dealing with applications for registration also provide a good respective expertise. Registration on the FEANI register indicates that, whatever the duration or content of his or her initial training, the engineer has reached a certain level of professional competence, certified by his or her peers both at national and European level. Bearing in mind that Member States are required by the case law of the Court to take post-diploma professional experience into consideration, when reaching their decision on recognition, the Commission considers that an engineer who has obtained the title of Eur ING should not normally be required to undertake an adaptation period or sit an aptitude test, as provided for in Article 4 of Directive 89/48/EEC."

Criteria for the EUR ING Title:

The basic principles are presented hereafter:

Principles and structure of the educational and professional systems in Europe vary considerably. Their value is judged by FEANI according to the potential competence of the engineer who emerges from them.

The qualification of the engineer, which falls into two main categories of different but equally important competencies - more theory oriented and more application oriented - first requires an approved engineering education. But full professional competence is only reached after gaining valid professional experience.

After a secondary education at a high level validated by one or more official certificates, normally awarded at the age of about 18 years, a minimum total period of seven years' formation - education, training and experience -is required by FEANI for the EUR ING title. This formation consists of:

- Minimum three years of engineering education successfully completed by an official degree, in a discipline/program and given by a university (U) or other recognized body at university level, recognized by FEANI (see FEANI Index).
- Minimum two years of valid professional experience (E).
- In case the education and experience together is less than the minimum seven years' formation required, the balance to seven years should be covered by education (U), experience (E), or training (T) monitored by the approved engineering institutions, or by preliminary engineering professional experience.

In addition to these formation requirements, EUR INGs are required to comply with a Code of Conduct respecting the provisions of the FEANI Position Paper on Code of Conduct: Ethics and Conduct of Professional Engineers.

“What is the Eur Ing title”, FEANI, https://www.feani.org/feani/eur-ing-title/what-eur-ing-title (7/14/2019)

Canada

In Canada, the title "P.Eng." designates the status of a professional engineer. This is analogous to the title "PE" in the United States. Approximately 160,000 professional engineers are registered in Canada. There are ten provinces and two territories in Canada, each with its own licensing body, commonly called "the engineering association." Engineering in Canada is self-regulated, which means the Canadian government has delegated the responsibility for administering engineering legislation to the profession.

Engineers Canada is the national organization of the 12 engineering regulators that license the country's 295,000 members of the profession. The members are the provincial and territorial engineering regulatory bodies. These engineering regulators are the constituent associations of Engineers Canada. They regulate the engineering profession and license professional engineers in Canada. Together, they work to advance the profession in the public interest. Only licensed engineers can practice engineering in Canada. Engineers require a license in each province or territory where they intend to practice. There are five criteria that must be satisfied to obtain a license:

- Academics: Hold an engineering degree from an Engineers Canada Accreditation Board-accredited undergraduate program or possess equivalent qualifications.
- Work Experience: Fulfill the engineering work experience requirement in the province or territory where you are applying for a license. (No details could be found about the number of years of experience required).
- Professionalism and Ethics: Pass the Professional Practice Examination (PPE), which tests your knowledge of the laws that affect the engineering profession, the professional standards to which you will be held accountable, and ethical standards and other topics such as patents, trademarks and copyrights.
- Good Character: Applicants must demonstrate good character.
- Language: Applicants must demonstrate an ability to work in either English or French, depending on the province or territory in which they apply for licensure.

Academic/Education qualifications needed:

All Canadian undergraduate engineering (B.Eng., B.E.Sc., and B.A.Sc.) programs are accredited by the Canadian Engineering Accreditation Board (CEAB), a standing committee of the Canadian Council of Professional Engineers (CCPE). The CEAB uses volunteer professional engineers from across Canada, with members from both industry and academia. CEAB performs functions in Canada that are parallel to those performed by the Accreditation Board of Engineering and Technology (ABET) in the United States.

Professionalism and Ethics Exam:

The law and ethics exam typically contains short questions on legal definitions and key precedent- setting cases, professionalism and professional practice, regulation of the profession, and the Engineers Act. The exams are usually two to three hours in length. Within a province or territory, all engineers take the same law and ethics exam, regardless of discipline.

Passing rates are usually high--70% and above. Language is often a cause of failure. Many provinces use a machine-graded, multiple-choice exam--the so-called "National Professional Practice Examination" developed by the Association of Professional Engineers, Geologists, and Geophysicists of Alberta (APEGGA). This examination is closed book and two hours in duration. There are 100 multiple-choice questions. All questions are common to the professions of engineering, geology, geophysics, and geoscience. The examination is graded as pass/fail. A detailed report indicating areas of weakness is available to candidates who fail. There is no penalty for wrong answers (i.e., for guessing). The minimum passing score is 65%, although psychometric adjustments may be made by APEGGA to ensure that, over time and among groups of candidates, pass/fail decisions are made consistently. The grade is final, and there are no appeals. In Ontario, exams also include written essay questions concerning fictitious legal cases. The fictitious legal cases are based on actual case law. Additional questions cover ethical dilemmas (i.e., "what would you do" questions). These exams are three hours in length and require essay responses.

“Engineering Licensure Outside of the United States”, PE Exam Licensure in Canada, https://ppi2pass.com/pe-exam/resources/pe-licensure-outside-the-usa (7/14/2019)

“Engineers Canada”, Promoting and maintaining THE INTEGRITY, HONOUR AND INTERESTS of Canada's engineering profession, https://engineerscanada.ca/ (7/14/2019)

Mexico

Mexico awards the federal professional engineering license after an exit exam or thesis in addition to the successful completion of a four-year engineering program accredited by the Federal Secretary of Education. The exit exam is written and evaluated by the professors at the accredited institution. The Mexican engineer is not required to be registered to practice before becoming employed as an engineer. However, there is a social and professional distinction between a graduado (one who has passed all subjects) and a titulado en ingenieria (one who holds the title of "Ingeniero"). Successful engineers are allowed to use the prefix "Ing" prior to their names.

At least one educational institution, Centro de Ensenanza Technica y Superior (CETYS), accepts the NCEES FE exam in lieu of the general-knowledge exit exam. The Mexican accreditation system requires that students perform community service. An educational institute may also define additional requirements for graduation. These additional requirements might include service within the educational institution, foreign language proficiency, and professional practice in local industry.

As a result of the North Atlantic Free Trade Agreement (NAFTA), Mexico has created an engineering curriculum accreditation board, Consejo de Acreditacion de la Ensenanza de la Ingenieria (CACEI), which performs functions similar to ABET in the United States and CEAB in Canada.

Texas is the only state the offers the Mexican Ingeniero a reciprocal PE license without examination. There is no reciprocity between Mexico and other states.

“PE Exam Licensure in Mexico,” ppi2pass, https://ppi2pass.com/pe-exam/resources/pe-licensure-outside-the-usa/mexico (7/14/2019)

Australia

There are two professional engineering designations in Australia. The two schemes are run by different Engineer Organizations. Engineers Australia runs CPEng, and Professionals Australia runs Registered Professional Engineer of Professionals Australia (RPEng). Both are quality schemes.

Engineers Australia (CPEng) requires:

Current Member of Engineers Australia at the grade of Full Member (MIEAust, TMIEAust or AMIEAust).
Understand the Stage 2 Competencies and our Chartered Evidence Requirements
Completed a Self Assessment and Industry Review at the level of Functional or Above
Have a Continuing Professional Development (CPD) Log ready and up to date
Clear on your Areas of Practice you are seeking for Chartered

"Pathways to Chartered", Engineers Australia
https://www.engineersaustralia.org.au/Chartered/Applying-for-chartered (7/14/2019)

Registered Professional Engineer of Professionals Australia (RPEng) requires:
An acceptable four-year engineering qualification, working as an engineer for a minimum of 5 years and have three other suitable engineers vouch for your work experience, and have undertaken 150 hours of continuing professional development over the last three years. Acceptance of Code of Ethics.

To be considered eligible, your qualification must meet one of the following requirements:
1. Be four-year full-time Bachelor Degree from an Australian institution or a part time equivalent degree;
2. Be a previously recognized historical equivalent qualification; or
3. Be a qualification gained elsewhere that satisfies the requirements of "the Washington Accord" for recognition as a Professional Engineer

New Zealand

Becoming a Chartered Professional Engineer (CPEng)

A Chartered Professional Engineer is an experienced engineer who is registered through Engineering New Zealand, as the Registration Authority (https://www.registrationauthority.org.nz/ (7/14/2019)). Like our Chartered Member class, you need to complete an assessment to show you can deal with complex engineering problems that require specialist knowledge. The difference is CPEng need to demonstrate New Zealand specific technical experience and be reassessed at least every 6 years. The CPEng assessment shows you meet an international standard, so travelling overseas to work is not a problem!

Registration and membership are two separate things. You can be both a Chartered Member of Engineering New Zealand and a Chartered Professional Engineer.

Eligibility

To become a Chartered Professional Engineer, you must:

- Have a Washington Accord-accredited qualification (Bachelor of Engineering, Honors) or be able to demonstrate equivalent knowledge.
- Complete an assessment to demonstrate you meet the competence standard.
- Commit to the CPEng Code of Ethical Conduct.
- Be reassessed at least every 6 years to maintain your CPEng registration.

Philippine Islands

Other than the United States, the Philippines are the only country to license Professional Engineers by examination. Various exams (the "Engineering Boards," "Board Exams," or just "Boards") are administered by the Professional Regulations Commission (PRC) in Manila. These exams may be taken by any graduate of a five-year engineering program. The only requirements are a diploma and transcript of records issued by the university.

The engineering disciplines have different examination and experience requirements for licensing. For example, civil engineering and geodetic graduates take one exam; mechanical engineers take two exams; and, electrical engineers take three exams. Most exam problems are multiple choice and machine-graded. The civil engineering exam is administered over two days. Mathematics and surveying are tested on the first day. On the second day, the morning session covers hydraulics, water supply, hydrology, and wastewater. The afternoon session covers design and construction in concrete, steel, timber, and masonry, as well as seismic design.

Reciprocity with the United States:

The Philippines' professional engineering license is not recognized in the United States. At one time, California permitted Filipino PEs to skip the FE exam. However, this is no longer the case.

“Philippine Islands,” ppi2pass.com, https://ppi2pass.com/pe-exam/resources/pe-licensure-outside-the-usa/philippines (7/14/2019)

Japan

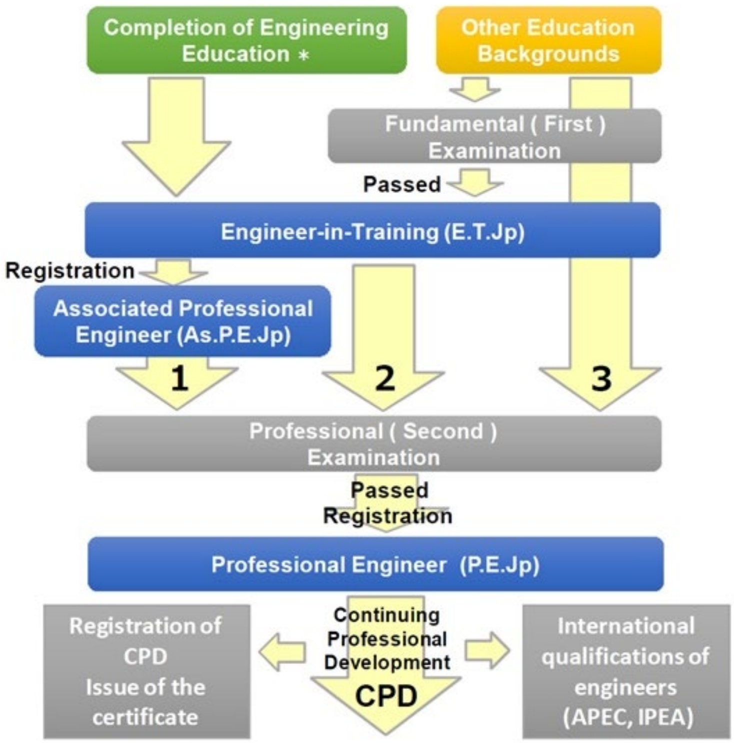
Professional Engineer, Japan (P.E. Jp) is the national qualification stipulated by the Professional Engineer Act.

A Professional Engineer is defined as an engineer engaged in the professional practice (except for cases where such practice is prohibited under other laws) of rendering services for science and technology in planning, research, design, analysis, testing, evaluation, and training in such work, which requires application of extensive scientific and technical expertise.

The Enforcement Regulation of the Professional Engineer Act specifies 21 technical disciplines, in each of which a Professional Engineers is qualified.

Professional Engineer (Japan), P.E. Jp. The Paths to P.E.Jp Certification.

A person has to pass examinations to be certified as P.E.Jp. The Professional Engineer Examinations consist of two step examinations (fundamental examination and professional examination), and these examinations are implemented according to each technical discipline. Those who have passed the professional (second) examination can be registered as P.E.Jp.



Notes:

[1] Minimum 4 years of practical experience under supervision of a Professional Engineer

[2] Minimum 4 years of practical experience under supervision of an experienced engineer. ****

[3] Minimum 7 years of practical experience.

* Accredited Programs:

Programs are accredited by the Japan Accreditation Board for Engineering Education (JABEE).

The MEXT announces those accredited programs through the official gazette.

** The Fundamental (First) Examination:

The multiple-choice examination is held every year in October.

*** The Professional (Second) Examination:

The written examination for Professional Engineers is held every year in July. Applicants who have passed the written examination are qualified to take the oral examination, which is usually held in December of the same year as the written exam.

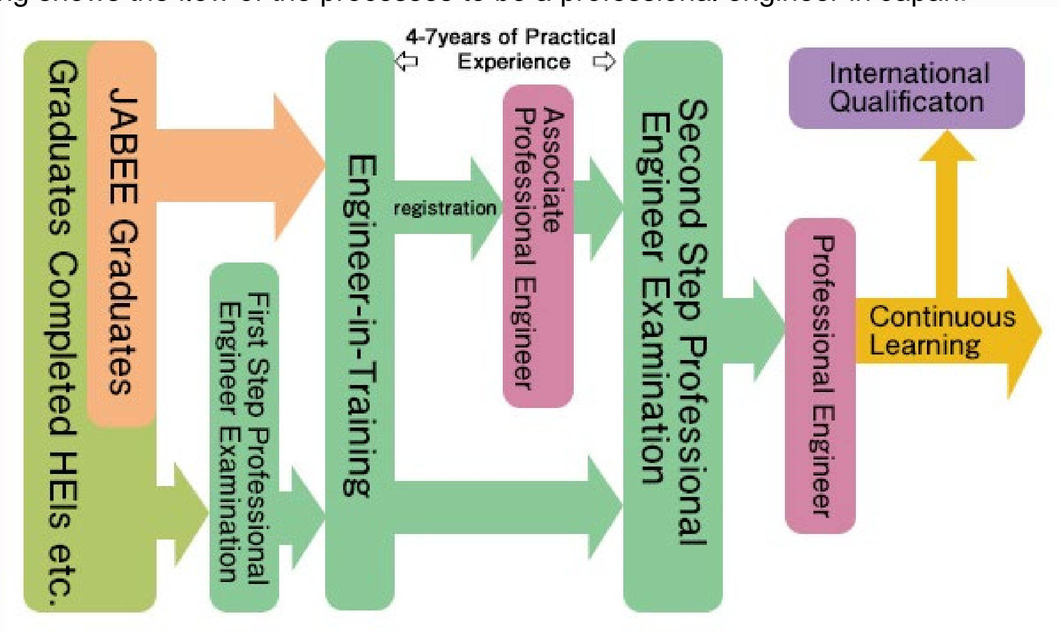
**** Experienced engineer:

An engineer who has engaged for 7 years or longer in practice including planning, research, design, analysis, testing and evaluation on matters requiring professional practical abilities of science and technology. Also, he/she must hold an official supervisory position in advising applicants.

"Paths to P.E.Jp", The Institution of Professional Engineer, Japan, https://www.engineer.or.jp/c_topics/000/000345.html (7/14/2019)

From the worldwide perspective, an individual to be called as a professional engineer is required to complete "accredited" engineering education programs provided by a higher education institution. The completion of such an education program is a prerequisite and the starting point to be an engineer in the future. This is the internationally shared understanding. JABEE joins the Washington Accord, which is an international framework for the accreditation for engineering education. The Institution of Professional Engineers, Japan (IPEJ) joins the International Professional Engineers Agreement (IPEA) and APEC Engineer, which are international and regional frameworks for the mobility of professional engineers. Under the International Engineering Alliance (IEA), the Washington Accord, IPEA and APEC Engineer have been discussing the consistency from the perspective on quality assurance of international engineers.

The following shows the flow of the processes to be a professional engineer in Japan.



Process to be a Qualified Professional Engineer

A JABEE program graduate is called an engineer-in-training. For a non-JABEE graduate, another path is available to be an engineer-in-training. If he or she passes the first step professional engineer examination, he or she is called as an engineer-in-training.
An engineer-in-training if he or she registers, is called as an associate professional engineer, which is the qualification of the Japanese Government. After 4-7 years practical experience, an engineer-in-training is eligible to take the second step professional engineer examination. If he or she passes the second step examination, he or she is registered by the Japanese Government as a professional engineer.

"To be a Professional Engineer," JABEE, https://jabee.org/en/about_jabee/gijutsushi (7/14/2019)

India

Professional Engineers (PE) Certification by IEI, The Institution of Engineers (India), eligibility requirement:

Engineers whose qualification is BE / BTech or equivalent, recognized by the Statutory Authority or Government of India and who are having 5 years or more experience, having membership of a recognized professional society and having maintained continuous professional development at satisfactory level

What is required to become a PE:

- Having Bachelor's Degree in Engineering or equivalent recognized by Statutory Authority or Government of India
- Minimum 5 years', professional experience
- Membership of recognized professional engineering institution / association
- Maintained Continued Professional Development (CPD) at a satisfactory level

The function of IEI will be to grant appropriate certificate of competence to individuals to practice as "Professional Engineers" and to develop the profession of Engineering and to regulate the profession through a "Code of Ethics." In furtherance of these functions of the profession, it will be aimed that only a Professional Engineer, either working individually or in an organizational set-up will approve designs/drawings/reports/products before these are released for use by the public at large. Such certified professional engineers will be designated as Professional Engineer (PE). Professional Engineer (PE) Certification enables engineering professionals to advance their career aspiration in wide ranging ways.

- Gives confidence to employer/prospective employer about competency of Engineer in a particular domain
- Enhances an engineering professional's stature,
- Makes them suitable for higher levels of responsibility.
- In future, only a professional engineer may prepare, sign, seal and submit engineering plans and drawings to a public authority for approval, or to seal engineering work for public and private clients.
- With the growing economy and massive expansion of technological infrastructure, the market demand of PE certified engineers is expected to be much higher.
- P.Eng. (India) Certification enables an engineer to become an independent engineering consultant, a valuer, a planner, a designer, an educator.

Additional Qualification, Chartered Engineer

As per the Declaration No.16 of the Royal Charter, 1935 and Clause 69(i) of the Bye-Laws & Regulations of the Institution, every Corporate Member (FIE/MIE/AMIE) is entitled to use the style and title of Chartered Engineer (India).

The Chartered Engineer certificate is often useful for the following purpose:

- To be impaneled as Valuer, Loss Assessor in various financial institutions like Bank, Insurance companies etc.
- To be impaneled as Chartered Engineer in the Original Side of High Courts, Central Excise and Customs and other similar govt concerns.
- To win contract of civil works from Municipal Corporation and similar govt bodies.
- To be employed and/or promoted in foreign companies.
- To practice as self-employed consultant in India and abroad.

In general, the Chartered Engineer certificate being issued by the IEI (which is one of world's oldest and largest professional bodies of Engineers), plays the role of recognition and acceptance of one's techno-academic qualification and professional attainment on a global platform.

"Professional Engineers (PE) Certification by IEI," The Institution of Engineers (India), https://www.ieindia.org/webui/IEI_PE_Certification.aspx (7/14/2019)

South Africa

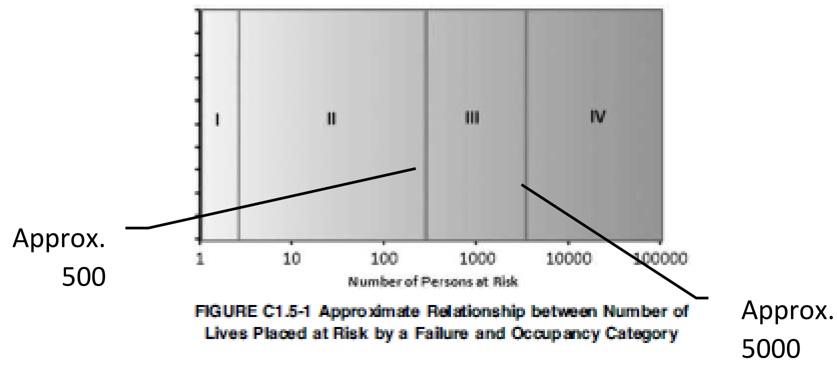
The Engineering Council of South Africa (ECSA) is a statutory body established in terms of the Engineering Profession Act (EPA), 46 of 2000. The ECSA's primary role is the regulation of the engineering profession in terms of this Act. Its core functions are the accreditation of engineering programs, registration of persons as professionals in specified categories, and the regulation of the practice of registered persons. Consequently, the ECSA is the only body in South Africa that is authorized to register engineering professionals and bestow the use of engineering titles, such as Pr Eng, Pr Tech Eng, Pr Techni Eng, Pr Cert Eng, on persons who have met the requisite professional registration criteria.

Professional Engineer (Pr Eng) applications from persons holding accredited qualifications or qualifications recognised by ECSA in terms of the Washington Accord, will not be subjected to a detailed evaluation of their qualifications. It is a prerequisite, however, that they should at least have had three years of post-qualification training and experience before their applications will be considered. Assuming that an applicant's qualification is recognised, the process of evaluating the applicant's training and experience starts. Copies are distributed amongst the members of the relevant Professional Advisory Committees (PAC). ECSA has established nine PACs, one for each discipline of engineering, and their members are drawn from the various professional engineering institutes. Since January 2001 all applicants are required to sit for a compulsory "Professional Review". This entails an interview with the applicant, which is done in collaboration with the Voluntary Associations. The process for Civil Engineering differs from the other disciplines in that all applicants are required to write two essays under examination conditions.

"Professional Engineer," ECSA, https://www.ecsa.co.za/register/SitePages/Professional%20Engineer.aspx?WikiPageMode=Edit&InitialTabId=Ribbon.EditingTools.CPEditTab&VisibilityContext=WSSWikiPage (7/14/2019)

APPENDIX D SIGNFICANT STRUCTURE DOCUMENT DEVELOPED BY SELC

<u>**Significant Structure Model Recommendations**</u>

Significant Structure Model	**Commentary**
Structural engineering for the following structures should be under the responsible charge of a Licensed Structural Engineer:	*This document is intended to be a general description of structures that should be designed under the responsible charge of a Licensed Structural Engineer (SE). An SE is an engineer recognized by the Authority Having Jurisdiction (AHJ) to use the title SE and practice structural engineering. Structural engineering based on more complicated methods of analysis or whose failure could impact over approximately 500 lives should be designed by SE (See Figure 1).*  ***Figure 1 (Reference: American Society of Civil Engineers Standard 7, Minimum Design Loads for Buildings and Other Structures (2016), Figure C1.5-1)*** *A wide range of structure types, all of which have specific code requirements and risk implications, are listed here. Each AHJ can select the structure types that are appropriate for it. The terminology and requirements here are from the International Building Code and the ASCE 7 Standard. Additionally, the requirements of several jurisdictions with partial practice restrictions were reviewed in the preparation of this document: Washington, Utah, Oregon, Georgia, Alaska, Guam, Northern Mariana Islands, California, and Nevada. Committees of the National Council of Structural Engineering Associations (NCSEA) and the Structural Engineering Institute (SEI) prepared the document.*

1. **Buildings and other structures representing a substantial hazard to human life in the event of structural failure or that are designated as essential facilities, or that have been engineered using advanced levels of analysis including but not limited to:**	*Commentary Item 1:* *The requirements in item 1 were developed using the IBC Table 1604.5 and ASCE 7 Table 1.5-1 for Risk Categories III and IV. Since codes and standards may be significantly reorganized in subsequent editions or may not be widely available, blanket references to any design document have been avoided. Instead, descriptions for structures in each category are used. Additionally, to reduce repetition, structure types in different risk categories were combined when possible. Terminology from the source document was maintained and any ambiguities should be clarified by the AHJ.*
a. Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. b. Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250. c. Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500. d. Foster care facilities, detoxification facilities, hospitals, nursing homes, psychiatric hospitals with an occupant load of 50 or more resident care recipients or having surgery or emergency treatment facilities. e. Correctional centers, detention centers, jails, prerelease centers, prisons, reformatories. f. Any other occupancy with an occupant load greater than 5,000. g. Power-generating stations, water treatment facilities for potable water, wastewater treatment facilities and other public utility facilities including those required for emergency response. h. Buildings and other structures containing quantities of toxic or explosive materials that are sufficient to pose a threat to the public if released.	

i. Fire, rescue, ambulance and police stations and emergency vehicle garages. j. Designated earthquake, hurricane, or other emergency shelters. k. Designated emergency preparedness, communication and operations centers and other facilities required for emergency response. l. Aviation control towers, air traffic control centers and emergency aircraft hangars. m. Buildings and other structures having critical national defense functions. n. Water storage facilities and pump structures required to maintain water pressure for fire suppression. o. Buildings and other structures over 45-feet in height with lateral loadings which are: • subjected to ultimate design 3-second wind gust speeds corresponding to approximately a 3% or lower probability of exceedance in 50 years or • located in Seismic Design Category D and above. p. Buildings and other occupied structures over 60 feet in height or unoccupied structures over 100 feet	______________________ *Commentary Item 1.o.: Structures in Item 1-o are based on descriptions of categories included in the NCEES 16-hour SE exam. These categories reflect high wind and seismic loads and do not include one- and two-family residential housing structures. The AHJ has the discretion to include residential housing. This has been modified on November 14, 2019 to address the changes in the wind speed maps indicated in ASCE 7-16.* *Commentary Item 1.p.: This item acknowledges the effect of building height in the development of wind loads in ASCE 7-10. Several AHJ's require building heights of greater than 45 feet to 100 feet to be designed by an SE. The 60-foot value was a height that had a basis in a current code (ASCE 7 Wind Design Method) requirement for a more complicated wind analysis.*
2. **Bridges that require advanced levels of analysis or represent a substantial hazard to human life in the event of failure, including but not limited to:**	*Commentary Item 2: The requirements of other states were reviewed and state department of transportation members were consulted on restrictions that have some rationale for bridges. Bridges require the American Association of State Highway Officials, LRFD Bridge Design Specifications. Railroad bridges are not included at this time.* *Commentary Item 2.a.: AASHTO Section 1.3.3 and 1.3.4 imply that these conditions require a higher factor of safety because the sudden loss of load-*

a. Bridges with "nonductile components and connections" or "nonredundant members".	*carrying capability may result with overloads on non-ductile and nonredundant members. For those bridges with ductile components and redundancies, there is a reserve load-carrying capacity above the design values providing additional safety. Current designs preclude the use of nonductile components, but historic bridges may include these.*
b. Bridges which are classified as "critical or essential" as defined by the Federal Highway Administration or the State Department of Transportation.	*Commentary Item 2.b.: AASHTO Section 1.3.5 describes measures to be taken for bridges based on Operational Importance. Critical or essential bridges require a greater factor of safety. The definition of what is critical or essential is left up to the AHJ. Some states consider all bridges to be critical or essential. Others restrict the classification to bridges with greater traffic or if it is the only bridge for a critical defense route.*
c. Bridges with aero-elastic instability, aero-elastic phenomena, or those which require wind tunnel testing.	
d. Multi-span bridges in seismic zone 3 or 4; those which require the seismic acceleration spectrum to be determined using the Site Specific Procedure; or that require multi-modal or time history seismic analysis.	*Commentary Item 2.d.: The 16-hour SE exam specifically tests for knowledge regarding the special requirements for the highest seismic zones 3 or 4 for bridges. For bridges in these seismic zones and for bridges requiring the analysis methods indicated, an advanced level of knowledge is required. Table 4.7.4.3.1-1, Minimum Analysis Requirements for Seismic Effects stipulates the conditions when the more advanced analysis methods are required.*
e. Bridges designed for blast loading.	
f. Bridges which are cable-stayed or suspension type.	
g. Bridges with an average daily traffic (ADT) of greater than 10000 vehicles per day	*Commentary Item 2.g.: The basis for this requirement is similar to the requirements for IBC and ASCE in buildings regarding risk categories. Those bridges with higher vehicle loads will influence more people and because of this importance should be designed by an SE. The 10000 vehicle value was selected because it is near the bottom of the building Risk Category IV. A value of 5000 was deemed too low.*

h. Single or multi-span bridges with any span with length over 240 feet.	*Commentary Item 2.h.: Washington State is the only state that has a restriction for bridges based on bridge length. Their restriction includes bridges having a total span of more than two hundred feet and piers having a surface area greater than 10,000 square feet, though no basis is provided for these numbers. The 240-foot value is a restriction based on AASHTO Table 4.6.2.2.2b-1 Distribution of Live Loads for Moment in Interior Beam. For the more common scenario of concrete deck on concrete or steel beams, if the span is greater than 240 feet, the tabulated formulas for live load distribution cannot be used and a more rigorous analysis is required to distribute live loads.*
i. Bridges with a high degree of curvature including a central angle greater than 12 degrees within a single span, bridges with variable widths, bridges with non-parallel substructure units or high skewed substructures of greater than 45 degrees.	*Commentary Item 2.i.: These bridge configurations require consideration of torsion effects and non-uniform superstructure stiffnesses that require a three-dimensional analysis.*