**Proposed Change to License Laws**
**related to**
**California Structural Engineers**

**White Paper**

**November 26, 2008**

Current and future buildings and other structures in California, and with them the people of California, are at risk due to the high probability of moderate and major earthquakes occurring in populated areas. Our knowledge of structural engineering has grown exponentially over the past several decades, with even seasoned professionals struggling to stay up with current developments. There has been a trend nationwide over the past few years–and particularly in the seismically-active Western United States–to require by law that "significant structures" be designed by licensed Structural Engineers. While California requires that public schools and hospitals be designed by Structural Engineers (or, in some instances, Architects), many other classes of buildings and structures are also in need of special attention during original design or structural strengthening. Two proposals are offered to help assure that these special classes of buildings and structures, whose damage or destruction would cause serious personal and economic harm to the people of California, receive the attention required from qualified, licensed professional Structural Engineers. Neither proposal will have *any* fiscal impact on the California state budget.

## Risk to the People of California

More than any other state in the country and perhaps more than any other economic center in the world, California is vulnerable to the devastating effects of a major earthquake. While the effects of moderate earthquakes in recent history have been a severe blow to the state and to the nation ($30 Billion in damages, 72 fatalities, 7000 injuries due to the 6.7 magnitude 1994 Northridge Earthquake and $5.9 Billion in damages, 63 fatalities, 3700 injuries due to the 6.9 magnitude Loma Prieta earthquake)[1], recent studies by a coalition of seismic researchers and engineers predict that if an earthquake similar to the 7.8 magnitude 1906 San Francisco earthquake were to strike today, the results would be $150 Billion in damage to buildings and property with as many as 13,000 people requiring hospitalization.[2] Other studies show that this damage could be as high as $200 billion in direct and indirect losses.[3] To add further urgency to these statistics, a recent report created for the California Earthquake Authority predicts that the chances of another earthquake similar to size as Northridge is 97% for Southern California and 93% for Northern California over the next 30 years. The chance of a 7.5 magnitude earthquake–which shakes at 16 times the intensity of that a 6.7 earthquake–is 37% in Southern California and 15% for Northern California over the same period.[4] In 1857 at the time of the 7.9 magnitude Fort Tejon Earthquake, the largest earthquake that has occurred in California, the entire population of the state was only about 350,000. By 1906 at the time of the San Francisco earthquake the population of California was about 1,500,000. By 2015, the population of California is projected to be 42,000,000[5] and by 2020 the population is projected to be over 45,400,000[6].

Given the probability of a serious earthquake occurring in the near future in California, it is imperative certain classes of buildings and structures remain operational to serve the public, including (in addition to hospitals) emergency operations and communications, disaster response, and recovery operations. Furthermore, it is imperative that certain classes of buildings, particularly those that house large numbers of people, people with mobility impairment, and buildings that house hazardous materials provide a lower probability of life endangerment and a low probability of release of stored materials. These classes of buildings and structures generally fall under the Seismic Use Groups (SUG) II and III as defined by the National Earthquake Hazard Reduction Program (NEHRP) Provisions[7] and further defined as Occupancy Categories III and IV in the *2007 California Building Code* [8] and in ASCE/SEI 7-05 *Minimum Design Loads for Buildings and other Structures* which is included by reference as part of the 2006 International Building Code.[9]

**Previous Legislative Studies**

In November 2002 a report was released which was prepared by the Institute for Social Research and commissioned by the Joint Committee on Boards, Commissions, and Consumer Protection of the Senate Committee on Business and Professions. That report entitled the *Engineering Title Act Study: The Practice/Title Act Distinction and Protection of Public Health, Safety and Welfare* acknowledged structural engineering was a discipline that clearly affected the health and welfare of more people on a daily basis than many other engineering disciplines.[10]

**Translating Research into Practice - The Complexity of the Building Codes**

While the level of research for preventing structural damage due to earthquakes has exploded over the past 30 years with the advent of new software tools, research facilities, and a greater understanding of how structures perform, the incorporation of these results have taken great effort, with the structural engineering community struggling to stay on top of the new developments. In recent years and particularly since 1988–well before the Northridge earthquake–there has been a steady reorganization and reworking of the building codes in an attempt to accommodate this new research. Engineers have had to continually learn, adapt, and rethink the way that they design buildings and other structures. The current California Building Code (2007 CBC) incorporates by reference dozens of other publications which form the basis of the code. Even experienced structural engineers must work at staying informed regarding changes and updates in the core publications. An engineer who was not educated or trained in structural engineering–and even many who are–will find it difficult to remain current with the source documents, let alone stay on top of changes to the actual code itself. The current *basic* source documents which cover the most general structural provision of the codes include thousands of pages of material and cost in excess of $1,200.[11] These basic source documents are revised, updated, and published anew on a 3 to 6 year cycle. Engineers who do not practice structural engineering on a regular basis can easily get lost in the morass of documents and standards.

**Minimum Educational Standards for Engineers**

Universities have continually made changes in curriculum to stay on top of new developments and it is becoming recognized that for many engineering disciplines–and particularly for structural engineering–a bachelors degree does not provide enough background and training to prepare a graduate for introduction into the profession. In the past, to earn a Bachelor of Science in Engineering may have required on the order of 140 to 150 semester hours. Nowadays, many universities have requirements as low as 124 semester hours, and there are greater requirements for general education courses– courses which are valuable to produce a well-rounded engineer–but which do reduce the amount of technical classes provided during the course of study for a Bachelors degree.

In 2006 the National Council of Examiners for Engineering and Surveying (NCEES) recommended a change in their Model Law for Structural Engineers such that by 2015, engineers who would be licensed as a Structural Engineer have a Master's Degree or equivalent (i.e. at least 30 credits of graduate-level work) prior to being allowed to sit for their exams.[12] (See Appendix B.) The American Society of Civil Engineers in its 2007 Policy Statement 465 acknowledged that the Bachelors degree does not provide enough education for incoming engineers.

> Clearly there is a recognized need for more education and training of our incoming engineers. The American Society of Civil Engineers (ASCE) supports the attainment of a Body of Knowledge (BOK) for entry into the practice of civil engineering at the professional level...Fulfillment of the Body of Knowledge requires additional education beyond the bachelor's degree for the practice of civil engineering at the professional level.[13]

In California, 45.9% of Structural Engineers have a Master's Degree or PhD, compared with 10.4% of the practicing Civil Engineers who hold a Master's degree or PhD.[14] There is a clear recognition that advanced education and training is required for structural engineers.

**Current Requirements In California for Design of Structures**

Currently in California, schools and hospitals must be designed by a California-licensed Structural Engineer. Any other buildings and structures with the exception of schools and hospitals may be designed by a licensed civil engineer, although there is a further exception that allows some residences and non-habitable structures to be designed without any input from a design professional–so-called "exempt" buildings. Civil engineer candidates in California are required to take a 2½ hour multiple choice California Special Civil Seismic Examination, however, in itself, this rudimentary exam clearly is not adequate to test for the engineer's competency in structural engineering. No structural engineering course work is required of civil engineering applicants other than those basic classes that may be necessary as part of a particular school's curriculum. It is entirely possible for a civil engineer currently to legally practice structural engineering even if his or her area of expertise and training is not in structural engineering. While the California Rules of the Board for Professional Engineers and Land Surveyors state that one can only practice within one's area of competence[15], by far, the most common enforcement actions reported by the Board of Professional Engineers and Land Surveyors involve the negligent or incompetent practice (including practice of structural engineering) by civil engineers.[16] Even the Institute for Social Research cited in their 2002 report:

> Another possible explanation for the apparent over-representation of civil engineers in the complaint and claims populations is that, for whatever reason, incompetence may be more common in this branch of engineering. Both the complaint and pass rate data provide some support for this interpretation.[17]

Unfortunately, it is all too common for an engineer with little training or out-of-date training in structural engineering to supplement his or her practice or income by preparing structural calculations and/or drawings. Because the full design loads on a building are not tested until there is a catastrophic event, many problems with design (and construction) will go unnoticed and unreported until or unless there is a serious earthquake. By then it is too late.

Interestingly, the results of the California Structural Engineering Exam also shed light on the preparedness and abilities of civil engineers, practicing or wishing to practice Structural Engineering. Consistently over the past twenty years the percentage of applicants who pass the SE exam has hovered around 30%. These applicants are licensed Civil Engineers who supposedly have been working in the area of structural engineering for at least three years prior to being able to sit for the exam.

**Recent Trends in Structural Engineering Licensure**

Two states, Illinois and Hawaii, currently require that all structures (with some minor exceptions) be designed by licensed Structural Engineers. Both of these states have had this requirement for many years, with the Illinois law dating back to 1915. Both of these states do not require that engineers first be licensed as a Civil Engineer before becoming a Structural Engineer. All other states including California have a two-step process requiring that a Structural Engineer first obtain a Civil Engineer License.

Since 1985 four Western States have passed legislation requiring that special classes of buildings and structures be designed by licensed Structural Engineers. In 1985 Nevada passed legislation requiring that certain types of structures including buildings in excess of three stories or 45 feet in height be designed by licensed Structural Engineers.[18] While recent studies have shown that Nevada is much more seismically active than previously believed, in general, it is much less active than most of California. In 1999 Oregon passed legislation requiring that significant structures, as defined, be designed by licensed Structural Engineers. These structures include, among others: essential facilities, buildings that are irregular, or over 45 feet in height.[19] In 2007, the State of Washington also passed legislation requiring that significant structures be designed by licensed Structural Engineers.[20] Washington's definition of significant structures includes, among others: essential facilities, buildings housing hazardous material, buildings where large groups of people congregate, buildings and structures above a certain height, and some bridges. This year, in 2008, Utah also passed legislation which goes into effect on January 1, 2009, requiring that significant structures be designed by licensed Structural Engineers.[21] Again the definition of significant structures encompasses the same general classes of buildings and structures, including but not limited to: essential and emergency facilities, buildings with high occupant loads, or buildings in excess of a particular height or square footage.

All of these states including Hawaii and Illinois are in seismically active areas, albeit in areas that are less seismically active than California. Even Illinois, particularly Southern Illinois, is impacted by its proximity to the New Madrid Seismic Zone, which was the center of the largest earthquake recorded in contiguous United States, the 8.0 magnitude New Madrid Earthquake.

**To "Grandfather" or Not to "Grandfather"**

With any change in licensing law comes the question of how do you give permission to engineers who are currently allowed to do certain work to continue to do that work, to continue to practice their profession and make a living. If an engineer is allowed to do a particular type of work that he or she could not do previously, if they are given a new title or designation without the requisite education, examination or experience, the process is often referred to as "grandfathering." With the two proposals that we are presenting, we are *not* suggesting that there be any "grandfathering" related to structural engineering. The proposals that are presented, would allow currently licensed Civil Engineers to continue designing buildings that they are presently allowed to design. Civil Engineers who are licensed after January 1, 2010 would not be able to design buildings or not be able to design "significant structures," that would be limited to Structural Engineers and Civil Engineers who were licensed prior to that date. The exception would be schools and hospitals which are governed by the Field Act and Alquist Act and require and would continue to require the services of a licensed Structural Engineer (or Architect, in some cases). There would be no change in the types of structures that could be designed by currently licensed Civil Engineers, assuming, of course, that they are practicing within their area of competency.

**Fiscal Impact**

Both of the proposals offered will have no fiscal impact on the California state budget.

**Proposal for Revisions to California SE Licensure and Class of Buildings Requiring SE License**

*Proposal No. 1*

- Elimination of the California Special Civil Seismic and Survey Examinations on the Civil (PE) exam

- With the exception of "exempt" structures (e.g. some residences and non-habitable structures), all structures shall be designed by licensed structural engineers. Civil Engineers who were licensed before 1/1/2010 may continue to design structures, with the exception of schools and hospitals as described in and in accordance with the Field Act and Alquist Hospital Seismic Safety Act.

- Structural Engineering Licensure will require that a Civil Engineering license be obtained first. Licensure as a Structural Engineer will be in general accordance with the NCEES Model Law - Structural Engineer. To be allowed to sit for the Structural Engineering Exam, in addition to having a Civil Engineering License, the applicant must have at least 30 credits of acceptable upper division course work in Structural Engineering and three years of experience after obtaining a Civil Engineering license working under the auspices of a California-licensed Structural Engineer.

*Proposal No. 2*

- All "significant structures" shall be designed by licensed structural engineers. Civil Engineers who were licensed before 1/1/2010 may continue to design structures including "significant" structures with the exception of schools and hospitals as described in and in accordance with current laws including the Field Act and Alquist Hospital Seismic Safety Act.

- "Significant structures" shall be defined as:
  - (a) Hazardous facilities, defined as: Structures housing, supporting, or containing sufficient quantities of hazardous materials or explosive substances to be of danger to the safety of the public if released;
  - (b) Essential facilities, defined as:
    - (i) Hospitals and other medical facilities having surgery and emergency treatment areas;
    - (ii) Fire and police stations;
    - (iii) Jails and detention facilities;
    - (iv) Buildings or ancillary structures (including but not limited to communication towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water or fire suppression material or equipment) required for the operation of essential or hazardous facilities or special occupancy structures
    - (v) Water storage facilities and pump structures required to maintain water pressure for fire suppression;

   - (vi) Emergency vehicle shelters and garages;
   - (vii) Buildings and other structures housing or supporting emergency preparedness centers;
   - (viii) Power-generating stations and other public utility facilities required in an emergency;
   - (ix) Buildings and other structures housing or supporting communication centers and other facilities required for emergency response;
   - (x) Aviation control towers, air traffic control centers, and emergency aircraft hangars; and
   - (xi) Buildings and other structures having critical national defense functions;
- (c) All schools and daycare facilities;
- (d) Structures exceeding one hundred feet in height above average ground level;
- (e) Buildings that are customarily occupied by human beings and are thirty feet or more above lowest ground level;
- (f) Bridges having a total span of more than two hundred feet and piers having a surface area greater than ten thousand square feet; and
- (g) Buildings and other structures where more than three hundred people congregate in one area.

- Structural Engineering Licensure will require that a Civil Engineering license be obtained first. Licensure as a Structural Engineer will be in general accordance with the NCEES Model Law - Structural Engineer. To be allowed to sit for the Structural Engineering Exam, in addition to having a Civil Engineering License, the applicant must have at least 30 credits of acceptable upper division course work in Structural Engineering and three years of experience after obtaining a Civil Engineering license working under the auspices of a California-licensed Structural Engineer.

## Appendix A

## Brief Outline History of Structural Engineering Issues in California

1857 Fort Tejon Earthquake (Magnitude 7.9) 40 deaths - Total population of California: 350,000
1906 San Francisco Earthquake (Magnitude 7.8) 3,000-6,000 deaths, about 250,000 homeless
1915 Imperial Valley Earthquake (Magnitude 6.3) Six deaths
1925 Santa Barbara Earthquake (Magnitude 6.3) 13 deaths

*1927 First Uniform Building Code (UBC) published*
*1930 Structural Engineers Association of California (SEAOC) founded*

1933 Long Beach Earthquake (Magnitude 6.3) 115 deaths

*1933 Field Act - Requires that public schools in California be designed by licensed Structural Engineers*
*1933 Riley Act - Requires that local California governments have building departments, inspect new construction, and that a minimum lateral design force of 3% of building weight be applied to the design of structures (excepting some residences and minor buildings)*
*1939 Garrison Act - Covered the continued use or abandonment of the pre-1933 school buildings*

1940 Imperial Valley Earthquake (Magnitude 5.5) Nine deaths
1952 Kern County Earthquakes (Magnitude 7.3 & 5.8) 14 deaths

*1959 <u>SEAOC Recommended Lateral Force Requirements and Commentary</u> (called "The Blue Book")1st Edition is published, later becomes the basis for the seismic design provisions in the Uniform Building Code*

1971 San Fernando (Sylmar) Earthquake (Magnitude 6.4) 65 deaths

*1973 Alquist Hospital Seismic Safety Act passed - required hospitals to be structurally designed by licensed Structural Engineers*
*1973 Significant changes to UBC due to lessons from Sylmar earthquake*
*1973 Applied Technology Council (ATC) is established through efforts of SEAOC to encourage research, develop consensus opinions on structural engineering issues.*
*1975 California Seismic Safety Commission created*
*1977 National Earthquake Hazards Reduction Program (NEHRP) established*

1979 El Centro Earthquake (Magnitude 6.4)
1980 Humboldt County Earthquake (Magnitude 7.2)
1983 Coalinga Earthquake (Magnitude 6.5)

*1985 Nevada passes a law requiring that any building more than three stories in height or more than 45 feet in height, as well as structures requiring special expertise be designed by a licensed structural engineer.*

1987 Whittier Narrows Earthquake (Magnitude 5.9) Nine deaths, 200 injuries, $358 million damage

1987 Superstition Hills Earthquake (Magnitude 6.5) Two deaths

*1988 Based on an eight year effort by the SEAOC Seismology Committee in cooperation with the Applied Technology Council (ATC), the 1988 Blue Book and 1988 UBC are published which marked a new generation of earthquake design codes.*

1989 Loma Prieta Earthquake (Magnitude 6.9) 63 deaths, 3,757 injured, 8,000-12,000 homeless, estimated $6-13 billion damage.
1991 Sierra Madre Earthquake (Magnitude 5.6) Two deaths
1992 Landers Earthquake (Magnitude 7.3) Three deaths, 400 injuries
1992 Big Bear Earthquake (Magnitude 6.4)
1994 Northridge Earthquake (Magnitude 6.7) 72 deaths, 7,000 injuries, 1,200 requiring hospitalization, estimated $30 billion damage

*1999 Oregon passes law requiring that significant structures be designed by licensed Structural Engineers*

2003 San Simeon Earthquake (Magnitude 6.6) Two deaths

*2007 Washington State passes law requiring that significant structures be designed by licensed Structural Engineers.*
*2006 The on-line edition of the SEAOC Blue Book now entitled Seismic Design Recommendations begins.*
*2006 SEAOC Blue Book is awarded "Top Seismic Product of the 20th Century" by the Applied Technology Council.*
*2006 NCEES approves a new Model Law - Structural Engineer.*
*2007 After nine years using the 1997 Uniform Building Code as the basis of the California Building Code, California adopts the 2007 California Building Code based on the 2006 International Building Code.*
*2008 Utah passes law requiring that significant structures be designed by licensed Structural Engineers.*
*2020 Projected population in California: 45,449,000*[22]

## Appendix B

## NCEES Model Law

Model Law Structural Engineer – The term “Model Law Structural Engineer” refers to a licensed engineer who has obtained licensure in at least one jurisdiction as the result of satisfying the following conditions:

a. Is a graduate of an engineering program accredited by the Engineering Accreditation Commission of ABET, Inc. (EAC/ABET)
b. Passes a minimum of 18 semester (27 quarter) hours of structural analysis and design courses. At least 9 of the semester (14 quarter) hours must be structural design courses.
c. Passes the 8-hour NCEES Fundamentals of Engineering (FE) examination
d. Passes 16 hours of structural examinations consisting of one of the following:
   (1) NCEES structural examinations, 8 hours of which are SE II
   (2) 16-hour state-written structural examinations taken prior to 2004
   (3) NCEES SE II plus 8-hour state-written examinations
e. Completes 4 years of acceptable structural engineering experience after confirmation of a bachelor’s degree. A maximum of 1 year of credit may be given for graduate engineering degrees that include at least 6 semester (9 quarter) hours of structural engineering (in addition to the 18 hours noted above).
f. Has a record clear of disciplinary action

Model Law Structural Engineer (effective January 1, 2015) – The term “Model Law Structural Engineer” refers to a person who has obtained licensure in at least one jurisdiction as the result of satisfying the following conditions:

a. Is a graduate of an engineering program accredited by the Engineering Accreditation Commission of ABET, Inc. (EAC/ABET) and has completed an additional 30 credits of acceptable upper-level undergraduate or graduate level course work from approved course providers
b. Passes a minimum of 18 semester (27 quarter) hours of structural analysis and design courses. At least 9 of the semester (14 quarter) hours must be structural design courses.
c. Passes the 8-hour NCEES Fundamentals of Engineering (FE) examination
d. Passes 16 hours of structural examinations consisting of one of the following:
   (1) NCEES structural examinations, 8 hours of which are SE II
   (2) 16-hour state-written structural examinations taken prior to 2004
   (3) NCEES SE II plus 8-hour state written examinations
e. Completes 4 years of acceptable structural engineering experience after confirmation of a bachelor’s of science degree in an engineering program and has completed an additional 30 credits of acceptable course work. A maximum of 1 year of experience may be credited to engineer interns with a master’s degree in engineering that includes at least 6 semester (9 quarter) hours of structural engineering (in addition to the 18 hours noted above). A maximum of 2 years of experience may be credited to engineer interns with a doctorate in engineering focused on structural engineering.
f. Has a record clear of disciplinary action

## Endnotes


1. "Preventing Earthquake Disasters: the Grand Challenge in Earthquake Engineering: A Research Agenda for the Network for Earthquake Engineering Simulation (NEES)," Page 13, National Academies Press

2. "State Called Unready for the Big One," *Los Angeles Times*, April 21, 2006

3. "Preventing Earthquake Disasters...," Ibid. Page 13.

4. "Likelier Here: the Next Big One," *Los Angeles Times*, April 15, 2008

5. "Interim County Population Projections," State of California, Department of Finance, Demographic Research Unit, http://www.dof.ca.gov, June 2001

6. "Projecting the Population of California's Regions by Nativity to 2020 - A California Housing Futures Project Memo," by John Pitkin, Analysis and Forecasting, Inc., http://www.usc.edu/schools/sppd/futures/pdf/Regmemos.pdf

7. The 2003 National Earthquake Hazard Reduction Program Recommended Provisions for New Buildings And Other Structures, Part 1: Provisions (FEMA 450)

8.*2007 California Building Code*, Table 1604.5 Occupancy Category of Buildings and Other Structures.

9. *ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures*, Table 1-1Occupance Category for Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads.

10. *The Engineering Title Act Study: The Practice/Title Act Distinction and Protection of Public Health, Safety and Welfare*, Submitted to: The California Department of Consumer Affairs, California Legislature, Joint Legislative Sunset Review Committee, November 2002, Institute for Social Research, California State University, Sacramento, CA

11. International Code Council, ICC Store, Structural References Combo, Price: $1,200.00:
- ASCE/SEI 7-05: Minimum Design Loads For Buildings and Other Structures
- Code Requirements For Structural Concrete (ACI 318-05) and Commentary (ACI 318R-05)
- 2005 National Design Specification® (NDS®) For Wood Construction Package
- ACI 530-05/ASCE 5-05/TMS 402-05, Building Code Requirements For Masonry Structures
- AISC Steel Construction Manual (ANSI/AISC 360-05), 13th edition
- AISC Seismic Design Manual (ANSI/AISC 341-05)
- ASTM Standards: As Referenced in the 2006 IBC

12. "Model Law Structural Engineer," National Council of Examiners for Engineers and Surveyors (NCEES), Adopted 2006.

13. "Academic Prerequisites for Licensure and Professional Practice," ASCE Policy Statement 465, Adopted by the Board of Direction on April 24, 2007

14. *The Engineering Title Act Study: The Practice/Title Act Distinction and Protection of Public Health, Safety and Welfare*, Ibid.

15. “Rules of the Board for Professional Engineers and Land Surveyors,” California Code of Regulations, Title 16, Division 5, § 415.

16. *The Engineering Title Act Study: The Practice/Title Act Distinction and Protection of Public Health, Safety and Welfare*, Ibid.

17. *The Engineering Title Act Study: The Practice/Title Act Distinction and Protection of Public Health, Safety and Welfare*, Ibid.

18. Nevada Administrative Code: Chapter 625 - Professional Engineers and Surveyors, 625.260 Licensure as structural engineer required for certain activities.

19. State of Oregon, Chapter 672 — Professional Engineers; Land Surveyors; Geologists, 672.129 Additional registration required to perform engineering services on significant structures; rules.

20. State of Washington, Substitute Senate Bill 5984, Chapter 193, Laws of 2007, 60th Legislature 2007 Regular Session, Structural Engineers–Significant Structures

21. State of Utah. Senate Bill 200, Enrolled, Professional Engineers Licensing Amendments, 2008 General Session, Chief Sponsor: Fred J. Fife, House Sponsor: Bradley A. Winn

22. “Projecting the Population of California’s Regions by Nativity to 2020...,” Ibid.