# Testing Core Knowledge

## NCEES Changes Format of Structural II Exam

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### Exam History

*The Structural II Examination is prepared by National Council for the Examiners for Engineering and Surveying (NCEES) and offered, in addition to another eight-hour structural exam, in those states that require sixteen hours of examination for structural licensure. This exam is written, reviewed and graded by a group of volunteers who are all licensed. The exam was originally written by Illinois for its candidates. NCEES began writing the exam and offering it on a national basis in 1985. The Structural II Examination was first offered in its current format in 1987. Hawaii, Idaho, Nevada, Oregon and Washington previously offered the Western States Exam and these states now offer the NCEES Structural II Exam. Arizona previously offered its own exam, but now requires its licensees to pass the NCEES Structural II Exam. In 2004 California will also be offering the Structural II Exam.*

### Current Structural II Content, Grading and Analysis

The specifications for the exam came out of the 2000 Professional Activities and Knowledge Survey (PAKS), conducted in conjunction with the PAKS for the Structural I Exam. Practicing engineers responded to the survey and indicated the knowledge and abilities that a licensed engineer should have. The knowledge required are not very different between the Structural I and Structural II Exams. The differences mainly lie in the process of using and integrating those knowledges in solving the problems. The Structural I Exam is multiple-choice, and measures discrete knowledges. The Structural II Exam uses essay solutions to measure the way that structural competence is demonstrated and integrated. This format allows the examinee to demonstrate engineering knowledge, ability and judgment.

The Structural II Exam, in its current format, consists of morning and afternoon sessions. There is a four-hour building and a four-hour bridge problem in each session. Candidates are allowed to choose between the building and bridge problems. Since 1992 there has been some level of seismic content on the afternoon problems. This change was based on a 1991 request from Illinois Board of Registration for Structural Engineers. All problems typically contain some level of structural analysis, the design of wood and masonry for buildings, and the design of concrete and steel for both buildings and bridges.

> *"Since 1992 there has been some level of seismic content on the afternoon problems."*

In an article in the September 2003 issue of STRUCTURE Magazine, George Nishimura discussed the disadvantages of essay problem scoring on the Structural I Exam. Previously, when essay problems were used on that exam, a single grader, who was assisted by a monitor, graded all solutions for each one-hour essay problem. The monitor and the grader each graded a set of papers at the beginning of the grading process and discussed any differences in scoring to establish consistency and conformance with the grading plan. The disadvantages that Mr. Nishimura mentioned include the difficulty of maintaining scoring consistency over a several week process, variations in a grader's adherence to the scoring plan, and the recognition of alternate solutions.

> *"…the difficulty of maintaining scoring consistency over a several week process …"*

To eliminate the disadvantages discussed by Mr. Nishimura, the grading of problems on the Structural II Examination is conducted in a workshop environment. A problem coordinator is chosen and that coordinator reviews the previously written problem statement, solutions and scoring criteria.

Separate solutions for building problems are created for all three model building codes. Steel problems have alternate ASD and LRFD solutions (even though less than 10% of the candidates attempt to solve a steel problem using LRFD.) Thus, there are typically three to six alternate solutions available for each building problem.

The problem coordinator arrives at the grading site a day before the problem scoring team and reviews the examinees' problem solutions, selecting several that demonstrate the range of candidates' solutions and common variations of these solutions. At the beginning of the scoring session, the coordinator leads the scoring team, all of whom have previously received and reviewed the problem statement, solutions and scoring criteria, in a discussion of these items. The scoring team discussion is intended to ensure that all scorers have equal appreciation of the problem content. After this discussion, each member of the scoring team grades the sample problems that the coordinator has chosen. The problems on the Structural II Examination are graded holistically. A pass or fail mark is applied to each problem by each grader. After each sample problem is graded, the scoring team discusses the grade. Graders describe their thought process and their reasons for marking the paper the way they did. This step in the process is to develop and ensure consistency between the individual graders. The review of sample problems prior to the actual grading session also helps to identify possible alternate solutions. Once the graders have demonstrated that they have achieved consistency, the grading of the individual papers begins. Two different, randomly selected, graders grade each paper. Sometimes a paper is on the border between pass and fail. One grader passes the candidate, while another grader fails the candidate. In this case, the paper is graded a third time to determine its outcome. The third grader has no prior knowledge of how the previous graders marked the candidate's paper.

Many states allow their candidates to

pass this examination in parts. That is, if a candidate passes one four-hour session and fails the other, the state would only require that the candidate retake the four-hour session that was not passed.

Discussions held during the 2000 PAKS study demonstrated two possible shortcomings of the Structural II Exam in its current format. The first was the fact that the exam could be passed in parts. It was pointed out that by allowing candidates to pass the exam in parts; a candidate's breadth of knowledge was not necessarily being demonstrated. For example, a candidate with sufficient knowledge of concrete design but insufficient knowledge of steel, wood and masonry design takes an exam with a concrete problem in the morning and a steel problem in the afternoon. The candidate might pass the morning problem and fail the afternoon problem. This hypothetical candidate could repeatedly retake the afternoon session until that session contained a concrete problem and then pass that problem. This candidate could become licensed, even though knowledge of only one of the four common building materials had been demonstrated.

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The second and related shortcoming was that different exam administrations had different content. One exam would have steel and concrete building problems while the next exam might have steel and wood/masonry problems. For the licensing process to be fair to the candidates, and to ensure that all licensees have demonstrated equivalent knowledge, ability and judgment, each exam administration should have the same content. This is not meant to imply that all examinees will do equally well on any given problem. However, if each exam administration has the same content, all examinees will have a "level playing field" on which to demonstrate their knowledge, ability and judgment.

To address these possible shortcomings, a change in exam format was suggested and the Member Boards that make up NCEES have approved that change.

## Format Change

Beginning in April 2004, the format of the Structural II Exam will change from two four-hour problems to four two-hour problems. This change will allow the major materials and building and bridge types to be tested each time the test is given. This change should improve the consistency and reliability of the exam. In other words, no matter when an examinee takes the exam, it will test the same knowledges in the same way. For building problems, this change also means that, at the most, any single material group will only make up 25% of the weight of the exam, rather than 50%.

*"…ensures that examinees demonstrate knowledge in more than one building material."*

There are four bridge problems and four building problems. The examinee must choose to solve all of the bridge problems or all of the building problems. This change ensures that a candidate cannot pick and choose and only demonstrate knowledge in a single building material. Half of the building problems and half of the bridge problems will continue to have seismic content.

As noted above, some states previously allowed the separate passage of the morning portion or the afternoon portion of the exam. Since the exam is now testing a complete body of knowledge, this will no longer be possible. In order to not disenfranchise candidates who have previously passed only one portion of the exam, this change will be phased in. Currently each state is determining the cutoff date by which these examinees must complete the passage of the previously failed portion of the exam. The Member Boards of NCEES decided this final date is to be no later than 2006.

While some fluctuation in passing rates between different examination administrations may occur, the Structural II Exam Committee anticipates that these format changes will bring more consistency to the passing rates.

## Code Usage

Each year, the exam committee discusses which codes and editions of the codes will be used. Previously, three model building codes were allowed: UBC, NBC, and SBC. However, a significant number of jurisdictions have now adopted the IBC and a few jurisdictions have adopted the NFPA. This means that a significant number of candidates are being tested on codes that they no longer use. Effective with the April 2004 exam, only the IBC 2000 will be used, along with the ASCE7-98. This new use of the IBC will unify solutions, and require only one solution (or two solutions for steel problems) to be prepared by the Structural II Committee. The IBC was chosen over the NFPA because it has been adopted by many more jurisdictions than the NFPA. Since both of these model codes rely on the same reference documents, the use of the IBC over the NFPA should not be unduly burdensome to candidates in jurisdictions that are using the NFPA. Additionally, most of these candidates will be well versed in the use of both codes in their day-to-day practice, since most structural engineers design buildings in multiple jurisdictions.

## Exam Preparation, Pre-testing and Grading

The problems are prepared in a workshop type setting. As with grading, all of the participants are licensed, practicing engineers. They come from all regions of the country and bring a varied perspective to the process. The committee has ethnic, age and gender diversity. Problems are typically authored by one person and are subsequently reviewed and re-worked by two or three other engineers. The final problem is then pre-tested by two independent, licensed, practicing engineers. Their comments, completion time, and suggestions are incorporated into the problem before it is finally given on the exam. Grading of the Structural II Exam, in its new format, will be very similar to the grading process discussed above; however, a numeric score will be assigned to each problem by each grader.

## How Can You Prepare for the Exam?

The exam will test steel design, concrete design and foundation design in buildings, non-building structures, and bridges, as well as masonry and wood design in buildings. All exams test statics, analysis, design, and sketching of details. Some problems may require an approximate analysis method by hand or the interpretation and verification of computer output data.

Successful candidates have reported that they performed more hand calculations and fewer computer generated calculations in the year prior to sitting for the exam to improve their hand calculation skills. Many candidates work example problems and time themselves to simulate exam conditions.

*"…do not overlook the need to refresh your knowledge of static's."*

Study the subject matter areas mentioned above and refresh your memory of these areas. Having to search through reference books for analysis methods or design techniques can only waste time and causes additional unneeded stress. In your study, do not overlook the need to refresh your knowledge of static's. The inability of many candidates to resolve forces, determine moments and shears, balance a set of moments or shears at a joint or present a solution that is in static equilibrium is a constant source of dismay to grading teams.

## Taking the Structural II Exam

Begin by reading the entire problem before starting the solution. The problem may contain some simplifying assumptions to make it fit into the time constraints.

Do not recopy the problem statement into the answer book. Although the problems undergo a timed pretest to ensure that they are of an appropriate length, most candidates report that they needed every minute of the allotted time to complete the exam. Restating parts of the problem statement wastes precious time that could be spent in demonstrating knowledge. The grading team has copies of the problem statements to work from.

Candidates must realize that they need to focus on demonstrating knowledge, rather than getting the "right" answer. To highlight this point, consider a calculation in which one or more terms have a value of 1.0. The calculation could include the reliability-redundancy factor, ρ, the duration of load factor, CD, or the effective column length factor, K. The "right" numeric answer can be obtained without including any of these factors. However, if the candidate omits any of these factors when they should be considered, the candidate has not demonstrated full knowledge of the subject.

*"This exam tests structural engineering, not calculator programming techniques."*

If you do not show all parts of a solution, at least show the intermediate steps, so that the graders will see that you have demonstrated the appropriate knowledge. If you are designing a steel column for axial load it is acceptable to reference the axial load tables in the steel manual. Reference the edition and page number and make sure that you state what your assumptions for effective length are. If you are designing the reinforcement in a concrete beam, you do not have to go back to first principles and derive the reinforcement equations. However, you will not have demonstrated knowledge if you calculate the moment and just write down the required area of steel next to it. The graders will have to assume that you used a calculator program to obtain that answer. This exam tests structural engineering, not calculator programming techniques. State what reference you are using: ACI SP-17, the CRSI manual, etc, and then show the intermediate steps that you go through to determine the required area of reinforcement.

Several years ago, on a one-hour essay problem, an examinee determined that a glued laminated beam needed to be 6¾" x 33". The examinee commented that there was probably an error in the calculation, because the expected depth was 21" to 27". The candidate stated that there was insufficient time to find the error. The correct beam depth was 24". As it turned out, the candidate had incorrectly calculated the load, but demonstrated the knowledge and judgment to know the answer didn't make sense, and in fact knew the range of the correct answer. The candidate received an "exceptionally competent" rating on that problem.

When sitting for the exam, test your answers for reasonableness. Can a 4x8 really carry roof loads with an 8'-0" tributary width and a 25'-0" length? Will a 40'-0' long beam really only deflect 6 x 10-27 inches? Probably not, however these were actual solutions submitted by examinees! Similarly, a candidate whose solution would be a threat to life safety or create a structural failure will not have demonstrated adequate knowledge, ability or judgment. Unfortunately, several candidates' solutions in almost every exam administration, would, if constructed, create a life safety threat or a potential failure scenario.

*"Spend a few moments … conceptualizing the solution."*

Finally, bring all of your years of education and experience to each problem. Think the problem through before you start it. If you were starting a new project, you would begin with a conceptual design. Treat the exam problem the same way. Spend a few moments of your precious time conceptualizing the solution. When you begin your solution, you should have a good idea of what the final solution should look like and know what you have to do to get there. Ask yourself what knowledge and abilities you need to demonstrate to show that your design will not be a threat to life safety, but will result in an economic and even esthetic structural design. Then, make sure that you demonstrate those knowledge and abilities.

## How Can you Participate in the Exam Process?

NCEES is always looking for qualified volunteers for this committee. If you are interested in contributing to this effort, visit the NCEES web site at **www.ncees.org** and submit a Volunteer Interest Form.▪

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