Structural Columns

Report of the First Trial Design Study

Submitted by: Design Practices Committee of the Business and Professional Activities Division of SEI

Background: In August of 1998, the Design Practices Committee of the Structural Engineering Institute's Business and Professional Activities Division met in Seattle for the purpose of developing a set of trial design problems. The problems were created to gauge the practicing engineer's knowledge of selected code provisions and computation techniques.

The first trial design study, the first of what the committee intends to be an on-going effort, was also a test of the committee's process. The goals of the project were not only to test the participants' knowledge of the code, but also their ability to solve common structural engineering problems. The committee set out to determine whether the average practicing engineer understood selected provisions of ASCE 7-95 as well as some of the finer points of the design of a simple multi-story frame building supported on pile foundations. The problems were designed so that the average engineer could solve them in a reasonable amount of time, approximately four hours.

Demographics of Participants: The committee requested that the participants provide information as to their education, experience, and familiarity with the various model building codes. The committee planned to use this information to determine if a correlation existed between the solutions and the demographic information.

The average experience level of the participants in the first study was 11 years; heavily weighted by one participant with 35 and another with 43 years experience. The education level was high with 6 individuals possessing a bachelors degree, 14 a masters degree, and one person a doctorate. Considering experience and education, the exercise was conducted with a very qualified group of participants. This was exactly the type of participation the committee desired. There was a good variety of experience levels and the education level was felt to be equivalent or slightly higher than that of a typical practitioner. The majority of participants were more familiar with the Uniform Building Code than any of the other three model codes.

Problem #1: The participants were asked to compute the wind loads according to ASCE 7-95 for a small building with a stepped roof. The building was patterned after a common structure such as a warehouse with an attached office. Wind loads were to be calculated on the exterior walls and roof surfaces by both the general provisions and the low-rise provisions.

Of the 21 individuals that solved the problem, 15 computed the pressures on high and low sections of the building, considering them separate structures. ASCE 7-95 does not specifically state how to determine the wind loads for different height structures that are attached, leaving the engineer to use his/her judgement. The provision in the ASCE 7 standard that addresses stepped roofs, figure 6-5C, was ignored by 13 out of the 21 participants. Only 11 of the 21 who solved the problem actually computed the wind pressures for all directions as was requested in the problem statement. Only nine actually solved the problem for both the low-rise and the general provisions.

Of particular interest was the lack of understanding of positive and negative pressures on buildings. Eight out of 19 respondents had one or more errors in their problem solutions when applying this provision. The requirement to apply both positive and negative pressure to the inside of the building seemed to give the participants trouble, with eight of the respondents having one or more errors in their problem solutions. For most buildings, the main wind force resisting system is not affected by the application of these pressures because the walls span vertically. However, for buildings where the walls span horizontally, such as the classic pre-engineered metal building, this misapplication could have serious design implications.

Based on the results, the committee concluded that there is a definite lack of understanding of one or more provisions of ASCE 7-95. An obvious reason for this is lack of practice in using the standard. Many engineers have historically used other codes or standards for determining wind loads. The Uniform Building Code contains its own wind analysis methods. In the case of the Standard Building Code, an alternate method for structures less than 60' tall is provided in the code. The SBC alternate is less conservative and therefore commonly used, especially on cost sensitive projects.

Another major factor that contributes to the lack of proper understanding is the relatively sparse reference material available on the application of ASCE 7 wind provisions. ASCE's *Guide to the Use of the ASCE 7-95 Wind Provisions* contains six common examples but should be expanded to provide design examples for buildings not explicitly covered by the standard. With the adoption of ASCE 7-98 as the standard for wind analysis in the International Building Code 2000, there should be a much higher usage of ASCE 7. We hope that this will prompt the development of more sample applications similar to the reference book the Structural Engineers Association of Washington produced on the UBC wind calculation methods.

Problem #2: The second problem required the participants to perform a gravity load analysis of a bay of a simple framed multistory building supported on piles. They were asked to compute the bending moment and reactions for one of the girders, the pile reaction, and design a grade beam that cantilevered over a single pile. All the work was to be performed in accordance with applicable provisions of ACI 318 and ASCE 7-95.

The grade beam supported a column at its extremity as well as a foundation wall perpendicular to it. The floor slab and roof slab weights were given. The building was described as having carpeted floors, 1" thick cementitious fireproofing, suspended acoustical ceilings, and mechanical and electrical components suspended from the structure. Participants were instructed to use minimum live loads with applicable reduction factors. A roof snow load was given. Other loads such as partition loads and allowances for the structure were to be determined by the participants. Solutions were not requested in any particular format nor was of the exercise known to the participant.

The answers to the various parts of the problem had considerable variation in magnitude. The live load reduction was computed from a low of 15% to a high of 50% depending on how the influence area was interpreted. Because the floor filler beams framed to the girder, there were differences in whether the influence area consisted of the sum of the girder length times ½ the bay spacing on either side of the girder, or whether it was the sum of ½ the influence area of the beams framing into the girder. Following the provisions of ASCE 7-95, the correct live load reduction was 32%. Of those respondents that solved this part of the problem, 7 of 19 used 40% as the reduction. The committee concluded that the code provision allowing for live load reduction is ambiguous and too often misinterpreted.

The part of the problem that required computation of the beam bending moment yielded equally varied answers. Bending moments and shears varied from 297ft. -kips to 423 ft.-kips. This was due to several factors: incorrect live load reduction; omission of a partition allowance or treatment of the partition weight as live load; a variation in the computed dead load of 19 psf; and an analysis with uniform loads instead of the actual concentrated loads from the filler beams. Three of the respondents omitted the partition load. The miscalculations carried forward and were the basis for erroneous pile reaction computations as well as the design of the grade beam.

For the foundation design segment a multitude of errors surfaced. The pile reactions varied by 100%. The miscalculations that existed in the analysis of the framing carried forward. In addition, three of the participants ignored the exterior wall of the building that was supported on a grade beam that framed to the cantilevered beam. This led to a large variation in computed moments in the cantilevered grade beam. In addition, the solutions of the grade beam design contained many errors. The computed shear varied by 178%. Omitting the three respondents who did not consider the exterior wall, this variation dropped to 40%. Of the 19 solutions, none checked the ACI 318 provisions for Deep Flexural Members, only six provided longitudinal side bars even though the grade beam was 48" deep, and five of the 19 exceeded Rho max.

Conclusions: Based upon the solutions that were submitted, the committee concluded that there is a definite lack of understanding of ASCE 7-95. As stated above, the standard is not used universally, and this is at least one of the reasons that many of the answers presented were erroneous. In the new IBC 2000, ASCE 7-98 is adopted by reference for the determination of wind loads. This should help both in giving more engineers the opportunity to use it on a daily basis and by making it more attractive for authors to write manuals and textbooks illustrating the solutions to various types of problems.

The committee was surprised with the variation in answers to the second problem. Whether or not ACI 318 is written clearly was never truly tested. Before we can make any statements about the clarity of a code, we must at least do it justice by reading the document. This may be a symptom of too much computer software. Do most of the participants use computer programs to analyze and design buildings to the extent that they are incapable of doing so by hand? If so, maybe we need to rethink our approach to engineering.

The sampling for this study was small, but very generous with their time. To complete both problems took an average of approximately four hours.

The committee sincerely thanks all of those who participated and hopes that the number will be much larger for future trial design exercises.

New Trial Design Problems

Problem statements for the second round of trial designs can be found on the SEI web page at **www.seinstitute.org**. *There are two problems: a pile cap design problem and a seismic problem on the analysis and design of a shear wall. Both problems and answer sheets can be downloaded in pdf format. In lieu of retrieving the problems from the web page, you may contact Larry Troxell at* **ltroxell@asce.org** *and a file will be forwarded directly to you by email. Instructions on how to return the solutions are contained within the problem packets. As a gesture of appreciation, the first 50 participants who return solutions will receive a copy of the Special Edition of ASCE 7-98, which contains the provisions referenced in the IBC 2000. Please be certain to include your name and address with your solution in order to receive the book. SEI will ensure that the solutions forwarded to the Design Practices Committee are anonymous.*

Revisions to ASCE 7

The ASCE/SEI Standards Committee responsible for maintaining ASCE 7 Minimum Design Loads for Buildings and Other Structures is initiating the next revision cycle of the standard. Anyone interested in submitting a proposed revision to the standard may do so by submitting their proposal in writing to Jim Rossberg at SEI Headquarters. Proposals should contain specific modifications to the text of the standard and provide a detailed reason for the proposed change. All proposals received will be forwarded to the appropriate task committee chair for consideration.

Currently, the Chair of the ASCE 7 Committee is studying options for improving the process by which the seismic provisions of the standard are developed. Consideration is being given to expanding the size and composition of the seismic task committee to more greatly involve the practicing community from around the country. In addition, methods for achieving greater input during the public review process are being studied. To assist in this effort, SEI has initiated meetings with representatives from NCSEA and the Building Seismic Safety Council to gain their insights and suggestions.

Summit on Licensing

The Professional Practices Committee of SEI's Business and Professional Activities Division is organizing a national summit meeting to begin the process of developing a national position on the future of licensing of structural engineers. The summit is tentatively scheduled for early June in Reston, VA, and both the Council of American Structural Engineers and NCSEA will be invited to participate.

The summit will be conducted over two days and will consist of three phases. The first phase will consist of a series of presentations presenting a variety of perspectives including certification vs. separate licensure, separate licensure vs. existing system, education-experience-testing requirements, a review of existing separate license systems, and the experiences of other professions. The second will be a series of break-out sessions for the participants to discuss the advantages and disadvantages - pros and cons of each issue. The final phase will bring all the participants back together to begin assembling the results of the break-out sessions and work towards formulating a common position.

Invitations to provide a representative to the summit will be sent to all local structural groups. Registration is limited and although it is expected that most participants will be representing an organization or group, individual registrations will be accepted. Anyone interested in attending the summit should contact Jim Rossberg at **jrossberg@asce.org**. A registration fee will be charged to cover the direct expenses.

For further information and details about SEI's many activities, please visit, www.seinstitute.org or contact us at: **sei@asce.org**, Structural Engineering Institute, 1801 Alexander Bell Drive, Reston, VA 20191-4400, Telephone: (703) 295-6360, Fax: (703) 295-6361