Building Seismic Safety Council
a council of the National Institute of Building Sciences

Issues and Research Recommendations Advisory Committee Report

March 4, 2016

Four issues are recommended by the Issues and Research Recommendations Advisory Committee, appointed by the BSSC Board of Direction, for consideration by the Provisions Update Committee (PUC). (Page and item numbers in parentheses reference ***Issues and Research Needs Identified During the Development of the NEHRP Recommended Seismic Provisions for New Buildings and Other Structures***.)

Wood diaphragms and related issues - Gary Ehrlich

The list of Research Needs for Wood Structures includes several items related either specifically or tangentially to analysis and performance of wood diaphragms. Most prominently is the need for research on the best design assumption for wood diaphragms for use in ASCE 7 – flexible, rigid, or other techniques (p. 32, Item #3). Also important is further research to verify the applicability of the alternative diaphragm design method introduced in ASCE 7-16 (p. 33, Item #11).

Related topics are the performance of open-front wood construction (p. 32, Item #5) and performance of light-frame buildings with soft/weak stories (p. 33, Items #5 and #7) including techniques for retrofit of existing buildings (p. 33, Item #8).

All of these tie into the development of analysis techniques and guidance to insure cost-effective design of multifamily buildings, the sector that is leading the housing recovery. This sector is seeing increasing demand for mid-rise wood buildings, and complex building designs and floor plans that accommodate large, open ground floor spaces.

Site response effects of shallow soil sites and profiles withy sharp velocity contrasts – John Egan

With the exception of Site Class designations E and F that are characterized, respectively, as “soft” and “vulnerable to potential failure or collapse,” the descriptions of Site Classes A through D in ASCE/SEI 7 and ASCE/SEI 41 (Standards) suggest subsurface conditions (e.g., shear wave velocity [V_S], penetration resistance [N], or undrained shear strength [S_u]) that are relatively constant or vary fairly uniformly over a depth of 30 m [100 feet] from the ground surface. The tabulated values of site response factors, F_a and F_v, corresponding to these Site Classes suggest, in turn, a reasonably well-behaved variation of site response effects (i.e., ground motion amplification or de-amplification relative to reference rock) across the matrix of Site Classes and spectral acceleration (S_a) levels.

There are, however, subsurface conditions for which observed or analyzed site response effects do not fit neatly into the reasonably well-behaved characterization implied by the Standards, even though one can calculate a V_{S-30} [V_{S-100}] or average N or S_u over a depth of 30 m [100 ft] that falls within a designated Site Class definition. A key example of such a condition that is present at many locations across the country is a site with a relatively shallow veneer of soil (e.g., ≈10 m [≈30 ft]) overlying rock or a profile that exhibits a sharp shear wave velocity or strength contrast between geologic units within a depth of 30 m [100 ft] or other depth that could affect the spectral response characteristics that may be important to the response of a structure at the site. A recent study of strong motion observations and site response during the 2011 Mineral earthquake by Murphy et al. (2014) and parametric studies of site response by Nikolaou et al. (2014) indicate that soil amplification effects based on the site coefficient F_a from the Standards can significantly underestimate the short-period response of shallow soil sites in the eastern US. Similar comparisons have been found for locations in the western US, as well; in fact, Mohraz (1976) illustrated the significant short-period spectral amplification at sites with shallow (< 10 m [30 ft]) alluvium relative to rock using strong-motion recordings from the 1971 San Fernando earthquake. These studies suggest that use of Standard-based response coefficients for such sites may lead to <u>unconservative</u> design of structures and evaluation of site geohazards.

Because effects of shallow soil sites and profiles with sharp velocity contrasts on spectral response characteristics are very site-specific, we anticipate that developing a generic set of site coefficients F_a and F_v would not be practical or prudent. Many users of the Standards calculate a V_{S-30} [V_{S-100}] (or average N or S_u) and blindly use the corresponding Site Class site coefficients, without recognizing the out-of-the-ordinary spectral amplification characteristics that may be presented by their site. It is recommended, therefore, that consideration be given to developing and incorporating guidance language in the Standards to "warn" users of the unusual amplification effects that such sites may present to help identify when site conditions may fall into that category and steer the user to site-specific response analyses.

Irregularities (P. 2, Item 3) - Jason Collins

The document, Issues and Research Needs Identified During Development of the 2015 NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, dated August 31st, 2015 highlights the need for System Irregularity Provisions in Future Provisions Issue #3 within the Design and Analysis section. Specifically, "System irregularity provisions, both horizontal and vertical, include both penalty factors (in the case of excessive torsional response) and prohibitions (in the case of weak-story mechanisms) that have not necessarily been supported on a technical basis. Research is currently underway to investigate system irregularity provisions. The research results should be reviewed an incorporated into the Provisions as appropriate."

Furthermore, a torsional irregularity (or extreme torsional irregularity) can be triggered by the geometry of the building rather than the performance of the lateral force resistance system. (ie rectangular shaped buildings are penalized by the current equations, even when displacements due to torsional deformations are minimal). Since this irregularity can affect the permissibility of a building in a given Seismic Design Category or limit the height of the building, the current equations should be reviewed as to whether they are providing the desired outcome.

Non-building structures and non-structural components research needs (PP. 35-36, Items 2, 9, 11, 12 and 13) – Philip Caldwell

It is suggested that the 2020 NEHRP Issues teams assigned to review the recommendations of items 2, 9, 11, 12, 13 consider the implications of state of the art research on the topic of "Cumulative Absolute Velocity." A good place to start is the most recently reviewed by Ken Campbell and Yousef in the journal of Nuclear Engineering and Design:

Citation:

Kennth W. Campbell
Yousef Bozorgnia
"Prediction equations for the standardized version of cumulative absolute velocity as adapted for use in the shutdown of U.S. nuclear power plants"
Nuclear Engineering and Design, Elsevier
Vol 241, Issue 7, July 2011, Pages 2558-2569 doi:10.1016/j.nucengdes.2011.04.020

The abstract can be viewed on the ScienceDirect website:

http://www.sciencedirect.com/science/article/pii/S0029549311003268

or the INIS IAEA website:

https://inis.iaea.org/search/search.aspx?orig_q=RN:43048237

The literature on this topic is extensive and include a diverse range of highly visible international reviewers such as the Global Earthquake Model project (GEM).