Notes on
National Institute of Building Sciences

Building Seismic Safety Council
Burlingame, CA
March 8, 2016

BSSC Annual Meeting and Colloquium
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Annual Meeting

Provisions Update Committee (PUC) has 23 members and 8 issue teams
March 10 the PUC will select of first of eight issue teams and identify issues and research
recommendations via the Issues and Research Recommendations Advisory Committee.
  ▪ Two PUC meetings in 2016 and three face to face meetings per year 2017-2019.
  ▪ Last PUC ballot in mid 2019.

Project ‘17 – Science continues to evolve and procedures continue to be update accordingly.
S1 values are going up and down by location. Assessment of existing issues related to the National
Seismic Design Maps. Some issues included timing of maps and how often should they be regenerated.
Precision versus uncertainty (precise map values, but lacks guidance on how to represent ground motion
parameters with significant figures – completely inaccurate but precise levels); acceptable risk (collapse
fragility is inappropriate – claim is is a 1% fifty year risk but can’t afford it so we design for something
else – need to figure out what we are really designing for), multi-point spectra (constant acceleration
response is not representative of performance on softer soils); and deterministic caps (rules of cap no
longer apply to how seismologist predict acceptable risk). Planned effort is for two-years with outcome
being recommendations for both the PUC and US Geological Survey (USGS). Going forward it would be
such that there should be a really good reason to change maps. Probability and statistics allow a
collapse rate that is far more at risk than intent of code. Current precision gives a false sense of
accuracy. There appears to be consensus on what the uncertainty is. How to provide guidance on
uncertainty is still a struggle. Design procedures could benefit from more consideration of duration. Are
ground motions increased accordingly where we can afford it and not where we cannot afford it (Los
Angeles and Seattle versus San Francisco)?

Code Resource Support Committee – integrates PUC (NEHRP provisions) into the building codes.
Prepares proposals and addresses proposals by others. FEMA has other contracts to take care of wind
and flood. Focus will be International Building Code – Structural (IBC-S), International Existing Building
Code – Structural (IEBC-S), and International Residential Code – Structural (IRC-S) and Administrative on
Referenced Codes and Standards.

Six proposed changes (to be posed by ICC today March 8, 2016).
1. Implement new USGS maps in IBC-S – made by USGS
2. Implement new USGS maps in IRC-s – two maps Seismic Design Category (SDC) Maps and Alternate
SDC Maps for use at the prerogative of the building official.
3. Sprinkler pipe and head connections during event
4. Design of precast diaphragms
5. Post earthquake removal of masonry chimneys
6. Second story for masonry veneers in areas like new Madrid in lieu of just a single story (still limited to about 25% of first story area)

Advisory committees within BSSC developed recommendations to PUC. Volunteers were from BSSC membership. A report has been prepared focusing on 4 issues to be added to the agenda of the PUC [All included in the attached report.]
1. Wood diaphragms
2. Shallow soil sites (100 to 130 meters) – site response [East coast shallow sharp velocity increases and in tune with the periods of the buildings resulting in more damage than anticipated.]
3. Irregularities (not just system, but also physical, shape of building, etc.)
4. Non-building structures

Committee may or may not be ready for sunset.

There are four advisory committees [issues and research; project ‘17; outreach; and procedural advisory committee (appointed by the board)]. Project ‘17 is for the development of next-generation seismic design maps regarding the USGS hazard and engineering design value maps. Effort is sponsored by the Federal Emergency Management Agency, the National Institute of Building Sciences Building Seismic Safety Council (BSSC) and the U.S. Geological Survey (USGS).

Executive Order 13717 [http://www.nehrp.gov/pdf/E013717.pdf] launched on February 2, 2016. Followed a 14 month development effort to establish earthquake risk management standards revoking 12899 and 12941 based on Mitigation Framework Leadership Group (MFLG) with recommendations to the Executive Offices. All related to the National Earthquake Hazard Reduction Program (NEHRP). Recognizes that consensus codes and standards focus on life safety and encourages agencies to go beyond minimum code. Federal owned and leased buildings must adhere to IBC. A new one is under development for wildland fire interface exposures. National Institute for Standards and Technology (NIST) is required to issue implement guidelines within eight months. Implementation is the responsibility of each individual agency. Agencies are free to require higher than minimum codes and standards, but not required. Exemptions are permitted for national security or law enforcement purposes [Office of Management and Budget (OMB) Director must be notified]. Compliance and any efforts to exceed minimum code will be difficult because there is no money for this. Federal building environment guidelines are posted on NEHRP website: http://www.nehrp.gov/pdf/NRC2011.pdf

Colloquium

Project ‘17 - Start of development of provisions for ASCE 7-22 with a special project on the basis of seismic design category maps (Project ‘17). Project is essentially a road map for USGS to develop new seismic design category maps. Convert seismic maps based on science with engineering input. Process started with ATC 3-06. Project ‘97 focused on the constant acceleration with short period and long period maps – 10% change of 50 year exceedance. Project ‘07 added the Risk-Targeted Maximum Considered Earthquake Concept (MCEₐ). West coast frequency is once every 20 years where East coast
is once every 100 years. Thus maps are not uniform hazard map but now a uniform risk of collapse. The return period for the maps is adjusted. This effort also had consideration of location with respect to really large active faults. Current scientific modeling results in the values going up and down every three years. Project ‘17 will assess existing issues by identifying emerging technologies improve science and consider needs for design.
1. Timing for map publication (3 or 10 years)
2. Design values conveyance – maps or electronic
3. Precision vs. uncertainty (60% accuracy with precise contours on maps)
4. Acceptable collapse risk (one in 50 year snot representative of real risk – 10% risk of collapse for given MCE, but recent earthquakes do not support a collapse risk this high)
5. Maximum direction versus geomean (legitimized average for vertical and horizontal ground motion)
6. Multi-period spectral values (more and newer data on ground motion measurements)
7. Duration (crustal 25 seconds and subduction (3-4 minutes) record
8. Damping levels
9. Vertical motion (only map horizontal motion) can be very important for non-building structures.
10. Deterministic parameter derivation probabilistic motion for active faults
11. Basin effects (deep soft deposits of soil over rock which forms a bowl of Jello)
12. Use of 3-D numerical simulation in seismic hazard model (need data for East coast)

Four priority tasks are:

- Precision versus uncertainty. The use of contour lines representing zones on maps result in step functions. The problem with deterministic zones is they appear as contours on maps. One side of a contour line represents a more significant magnitude of Maximum Considered Earthquake (MCE) than on the other side of the contour line.
- Acceptable risk. Consideration will be given to staying with 2,500 year event (1% occurrence in 50 years) or going to 1,000 year event (2% occurrence in 50 years). This activity may also result in the elimination deterministic zones.
- Multi-point spectra to reflect new data and more data on ground motion measurements. However, there is little new data for earthquakes not on the West Coast. This is simply because there are fewer earthquakes in the Midwest and East Coast.
- Deterministic (DSHA) versus probabilistic seismic hazard analysis (PSHA). Generally, the deterministic approach addresses the maximum considered earthquake (MCE) with consideration of the frequency of such events. The probabilistic approach considers various types of earthquakes that may occur and addresses design criteria for the different types of ground motions including directionality. For PSHA the probability of each type of event is taken into account.

Issue 1 Balancing Precision and Uncertainty

Maybe go back to zone maps. Should jurisdictional boundaries be considered? Residential seismic maps in the International Residential Codes are all short period maps under the assumption that all residential buildings are short period buildings. The zones result in step functions. Problem remains that there is a lack of East coast data. Should seismic design category be redefined?

Issue 2 Acceptable Risk
Only simulated collapses investigated and not floor on floor collapses in determining the 10% risk of collapse. Still tied to 1906 San Francisco earthquake with ductility at about 10% of building weight. When probabilistic approach was applied for Memphis and Charleston, then values were surprisingly high for San Francisco and other high frequency areas resulting deterministic approaches used for the West coast, but nothing is truly engineered as completely deterministic because of uncertainty in component response. Change for 2% probability of exceedance in 50 years to 1% absolute risk of collapse in 50 years. Thus the MCE period ranged from 1,000 to 3,000 years depending on where in the country. Greater risks in collapse in high seismic areas where based on deterministic approach. Alternatively, low risk areas are designed for lower risk of collapse compared to areas where possibility of large earthquake is high.

Should provisions stay with uniform risk of collapse approach to defining maximum considered ground motions for design or examine the difference between the risks. Typically you don’t see 10% of buildings having collapse in design events. Are projects in Memphis and Seattle over designed or projects in San Francisco under-designed. If there is a shift from uniform risk then what get used, uniform hazard? The work group will evaluate 10% probability of collapse; and determine absolute risk; and evaluate the effects of changing.

Issue 3 Multi-point Spectra
There is considerable more data but still lack big magnitude close to fault earthquakes. Assumption currently used for softer soil sites not appropriate. Problem exists for high motion and soft soil sites. Moment frames being designed for about half the force as they should be. Solution in ASCE 7-16 is to use a little more force if not doing site specific design. The new approach might be a spectrum shape adjustment reformulation for Design Parameters. Might develop and adopt a multi-period spectrum approach. This will require reworking design requirements, develop new ground motion parameters, and develop new site factors. Web-based might be the solution over 100 of maps. Next generation of design might look at spectra for acceleration domain, velocity domain, and displacement domain.

Issue 4 Deterministic Caps on MCE
Determine the probabilistic MCE, determine the deterministic MCE and site specific MCE is the lower of the two. Procedure is:
1. Identify all controlling fault
2. Postulate maximum moment M_max for fault-rupture scenario for each fault (Characteristic Earthquake) – Weighted average, worse case or something else. Select faults, local fault of short period and San Andreas Fault for long period. Also must consider the type of fault (strike slip or normal or reverse) as well as forward or backward directivity and fault normal and fault parallel. Several decisions if using the deterministic path.
3. Use same GMPEs and weights in PSHA
4. Determine 84th percentile S_84(T)
5. Increase S_84(T) for direction of motion.
6. Deterministic caps may be eliminated in this cycle.
A basic DSHA is a simple process that is useful especially where tectonic features are reasonably active and well defined. The focus is generally on determining the maximum credible earthquake (MCE) motion at the site. The steps in the process are as follows:

1. Identify nearby seismic source zones - these can be specific faults or distributed sources

2. Identify distance to site for each source (nearby distributed sources are a problem)

3. Determine magnitude and other characteristics (ie. fault length, recurrence interval) for each source

4. Establish response parameter of interest for each source as a function of magnitude, distance, soil conditions, etc., using either the envelope or the average of several ground motion attenuation relationships

5. Tabulate values from each source and use the largest value

Deterministic Seismic Hazard Analysis (DSHA): Where the DSHA is based on tectonic features, it tends to be conservative since the maximum earthquake the fault is "capable" of generating is assumed to occur at the location on the fault closest to the site. DSHA is frequently used in California due to the knowledge of faults and the region's high seismicity.

When a distributed source is considered in the analysis, a distance must be determined. This presents much more of a problem for nearby distributed sources than those which are distant. Often, engineering judgment is used or a back calculation is employed to give the desired answer.

The DSHA method is simple, but it does not treat uncertainties well. Rudimentary statistics can be incorporated into the procedure by taking one standard deviation above median at each step (magnitude, PGA, etc.), which gives a very big, very conservative estimate. However, the DSHA does not account for the probability of an earthquake occurring on a fault.

Probabilistic Seismic Hazard Analysis (PSHA): PSHA rectifies several problems inherent in its deterministic predecessor - the lack of quantification of uncertainty and probability of earthquake occurrence. To do this, the PSHA follows a similar process to the DSHA, but the uncertainty is quantified by a probability distribution at each step. Distributions are determined for 1) the magnitude of each earthquake on each source, 2) the location of the earthquake in or along each source, and 3) the prediction of the response parameter of interest.

PSHA is used for many important projects, and is the basis of the seismic hazard maps found in NEHRP and the UBC, which were the work of USGS committees. PSHA is not without its shortcomings, however. The calculations and theory are very complex and a varying amount of rigor is used by different individuals. Also, many assumptions are involved due to the limited amount of data available.

PSHA versus DSHA: The basic dilemma is that the actual earthquake can be larger than the PSHA predicts, but will likely be smaller than a DHSA estimate. Thus, it is useful to know the difference between a rare and a very rare event. In some places like the San Francisco Bay Area, there is a small difference and a deterministic analysis (which predicts the very rare event) may suffice. However, in other locations such as the New Madrid area, the difference between rare and very rare events is large. For the latter locations, the question of what to design for becomes difficult.

2020 National Earthquake Hazard Reduction Program (NEHRP) Provisions Issues

and Earthquake Risk Reduction in Buildings and Infrastructure

Design and Analysis
- Simplify ASCE 7 Table 12.2.1 with ordinary, intermediate and special systems have the same R-value irrespective of material
- Minimum detailing levels for moderate and high SDCs
- Need for height limits: D1 System R-Factors: Change from Life safety in the 10% for 50-year earthquake to 2% in collapse prevention in the 50-year earthquake. What is next?
- SDC D covers way too much ground. Reassessment of cut-offs and possible consolidation of SDCs
- Short period building collapse modeling is showing the 10% MCE_r is exceeded, but this is not supported by observations
- Criteria for force-controlled and deformation controlled consideration of unacceptable response
- Alternative diaphragm design force level beyond the limited system currently listed. Testing and analysis procedures across materials
- Analyzing transfer and inertia forces in diaphragms
- Modal response spectrum analysis might consider higher modes are elastic while considering accidental torsion
- Rigid wall flexible diaphragm buildings FEMA P-1026 methodology is only applicable to very simply buildings and must be expanded.
- Should SDC for risk category IV be increased from A to B.?
- Full system modeling with: 3 dimensional analysis, semi-rigid diaphragms, P-Delta effects, orthogonal loading, dynamic effects, accidental torsion, deformations, and inclusion of structural elements that are not part of the lateral force-resisting system.

Geotechnical Considerations
- Multi period response spectra
- Deterministic caps
- Physics based models – A new approach for computing long period seismic acceleration S_a maps. Basin issues require special ground motion mapping due to anticipated much larger response spectrum. Possible approach might be a weighted average of traditional ground motion and modeling with some smoothing.
- Site specific coefficients
- Vertical components
- Induced seismicity (fracking) – probably off the table
- Soil-structure interaction – foundations on piles; footing soil modeling; relaxation of some restrictions

Concrete Structures - PUC issues and research issues
- Concrete shear wall design – behavior of slender versus squat and ductile versus non-ductile shear walls
- Concrete coupled shear walls thought to be superior performance but lack seismic design parameters and R-factors.
Concrete structural slab reinforcement for combined gravity and seismic loads – part of diaphragm cord?
Concrete precast diaphragm connector and joint reinforcement – refinements needed based on practice and need concept qualification of procedures
ATC 115 road map for high strength rebar (Grade 75 and higher)

Masonry Structures
- Shear walls with irregular openings
- Partially grouted walls – in-plane shear capacity and detailing necessary to achieve in-plane capacity
- Standard hooks
- Masonry joint reinforcement for use in shear capacity – may be more effective than bond beams

Wood Structures
- Influence of finish materials in light frame (ATC - 116 still in progress) – does it need to be incorporated and would be a big change?
- Wood (&CFS): rules for increased capacity shear wall systems – what are the rules adjusting shear wall capacity?
- Wood (FEMA P-695) guidance for proprietary performance – quantify propriety attributes and numbers.
- Mid-rise shear wall construction seismic design methodology
- Wood hillside buildings – torsional issues and deflections (ATC 110 might be a resource)
- Wood mid-rise CTL – there might be an outcome for FEMA P-695.
- Heavy timber construction braced frame buildings – not a lot of buildings (mostly historic) and not much guidance.
- Shear wall tie down system criteria may need consideration of deformation behavior for story connections in multistory buildings.

Steel Structures
- Building periods – many estimates but typically only within 30%. – assessment of drift and performance and may need to extend beyond steel
- R=3 systems can be used for SDC B and C only but what about composite concrete and steel systems?
- Low and moderate seismic design – there may be reserve capacity and also silent on composite.
- SMF connection pre-qualifications
- System parameters for metal buildings
- Columns and orthogonal frames – potential for simultaneous yielding leading to higher column demands than 100/30 approach in ASCE 7. This is most important for low-rise buildings. AISC (without guidance) advises that simultaneous yielding needs to be considered.

Nonstructural Components
- Rationalize the $R_f$ factor
- Current criteria is that performance for drift controlled components must be accommodated (some criteria could come out of ATC 120)
▪ Rp is a component response based on ruggedness. Correlated back to the old Uniform Building Code $C_p$ – need a rationale and new approach.

▪ Ductile behavior may not be the appropriate performance for support non-structural elements like chillers.

▪ Knowledge study is nearing completion which will hopefully culminate in a holistic assessment of the current design approach in ASCE 7 – floor spectra and assessment of anchorage demands.

▪ Explicit performance objectives for non-structural components and systems

Non Building Structures

▪ Refineries (Coker drums) – very heavy supported on very thick slabs and currently treated ordinary structures

▪ Floating roofs (storage tanks) – when they sink, followed by fires

▪ Large bore piping systems – large pipes can transfer large forces into structural systems

▪ Flexibility and deflection of large bore piping system connections.

▪ Steel storage racks for falling hazards on palletized racking systems and should also include when pallet lands on adjacent racks.

▪ Large anchors under tension and shear loads – bolts tend to stretch quite nicely

▪ $T_L$ (long period transition period) with regard to sloshing in tanks

▪ Corrugated steel water tanks – no seismic performance history. When used for grain no real life safety threat, but now being used for water – either provisions or restrictions.

▪ Vertical ground motions.

Seismic Maps

ASCE 7-16 will have over 30 maps for seismic design: $S_s$ (spectral response acceleration at 0.2 sec), $S_1$ (spectral response acceleration at 1.0 sec), $T_L$ (long period transition period), and $pga$ (peak ground acceleration). With current direction and new science this will soon be over 100 maps, thus there is a drive toward web-based site specific seismic design criteria.

PUC Issue Teams - Grouping

1 - Seismic Performance Objectives

▪ Acceptable Risk

▪ Collapse, Functional and Economic Risks

▪ Risk Category IV/SDC A Considerations

▪ Implicit Risk Objectives of Chapters 12, 16, 17, and 18

▪ Global versus component failure of collapse

▪ MRS versus LRH – eliminate MRS

2 - Geotechnical, Ground Motion and Mapping Issues

▪ USGS Maps Update

▪ MCE Hazard Level

▪ Uncertainty and Provisions

▪ Deterministic Values

▪ Basin Effects
- Near Fault Directivity
- Induced Seismic
- Shallow Soils Sites and Profiles with Sharp Velocity Contracts
- Ground motion selection and scaling
- Reconcile safety factors in provisions versus geotechnical
- Site response analysis in the frequency domain versus time history

3 - Multi-Period Spectrum and Site Coefficients
4 - Seismic Force-Resisting Systems and Design Coefficients
  - Table 12.2.1 Simplifications
  - SDC Ranges, Height Limits
  - General Systems-Related Issues including steel, concrete, masonry wood, outside material properties

5 - Modal Response Spectrum Analysis Issues
  - List of unfinished issues from the 2015 cycle

6 - Other Analysis and Modeling Issues
  - Full-system Modeling
  - System Irregularities

7 - Diaphragm and Shear Wall Design
  - Diaphragm Force Reduction Factors
  - Rigid Wall Flexible Diaphragm (RWFD) Systems

8 - Nonstructural Components
  - Reconsideration of criteria and values

9 - Non-building Structures

10 - Non-linear Response History updates

11 - Soil Structure Interaction (SSI) Updates

12 - Additional Suggestions
  - Rocking
  - Rammed Earth
  - Multi-period Spectrum Eliminates T1 Maps
  - Large Metal Tanks
  - GMPEs versus physics-based
  - Step Function versus the Continuum
  - Transparency
  - Holistic approach to Project ‘17 – acceptable risk and SDC
  - Approach to USGS Hazard Model for Induced Seismicity
  - Financial Loss
  - Anchorage to Concrete