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From the Editor's Desk

by Tuna Onur

Happy 2018! CAEE wishes you a productive, fulfilling and disaster-free year ahead.

A quick glance at major earthquake activity in Canada during the past year reveals a relatively calm year. The most significant events were two magnitude 6.2 earthquakes near Yukon - Alaska border, both of which happened on the same day, May 1st, 2017. While they were strongly felt in the epicentral area, no major damage was reported.

Elsewhere around the world, Mexico had the misfortune to have two major earthquakes last year, one Mw8.2 on September 8th and one Mw7.1 on September 9th. Combined, these two earthquakes took nearly 500 lives. However, the single deadliest earthquake of 2017 was an Mw7.3 earthquake on the Iran/Iraq border, which caused more than 600 deaths and many more injuries.

We continue to learn from each earthquake, and as CAEE, work towards improving earthquake safety at home and around the world. To this end, we invite you to contribute a short summary of your research activities and findings to be published in the CAEE Newsletter (secretary@caee-acgp.ca).

Inside This Issue

Understanding Risk for Policy Making and Implementation

Contributed by Jessica Shoubridge

Understanding Risk British Columbia (UR+ BC): Implementing Strategies to Reduce Natural Hazard Risk in BC's Built Environment

The Understanding Risk (UR) Community is the pre-eminent platform for collaborating and sharing knowledge in the field of disaster risk assessment. Created in 2009 by the World Bank's Global Facility for Disaster Reduction and Recovery, the UR Community convenes every two years at the global UR Forum to showcase the latest innovations and build new partnerships to foster advances in the field.

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The UR+ BC symposium will be held in Victoria in April 2018, and is a spinoff event that is designed to maintain the spirit of the global UR forum at national, regional and local settings.

UR+ BC builds off the outcomes of UR+ Vancouver in March 2017 (*understandrisk.org/event/ur-vancouver*) to focus on hazard mitigation and increased resilience in our province's built environment.

This year's UR+ symposium assembles an interdisciplinary group to share knowledge and perspective on how to build long-term resilience to future hazard events and the impacts of climate change. Emphasis will be placed on seismic hazard, but there is a recognition of risks associated with wildfire, tsunami, flood and sea level rise and that a variety of these hazards need to be considered in the built environment in various regions throughout the province. Engineers, planners, and emergency managers will collaborate with developers, builders, investors and insurers to find solutions and drive change. Researchers, academics and scientists will support the dialogue to help shrink the gap between science, policy, and real-world action that builds resilience.

Insights and knowledge gained through the symposium will be shared with the BC community of practice— and to the broader global community through the World Bank's Understanding Risk platform.

With a significant portion of our environment built after the introduction of seismic codes, a changing hazard environment as a result of climate change and code requirements focused on life safety rather than business continuity/functionality, there is enormous scope for change. Symposium workshops include topics such as:

- What are the likely impacts and consequences of earthquakes, floods and fires in BC based on risk modelling efforts as well as recent, local, lived experiences?
- How does the built environment play a role in our capacity to withstand and recover from natural hazard events?
- How can we inspire the construction, infrastructure, and development sectors to reduce risk and build resiliently before events -- and build back better after events?
- What are the business opportunities presented by a comprehensive resilience strategy for our built environment that integrates energy, climate adaptation, and seismic mitigation policy and approach?
- How do we unite work on hazard mitigation materials and methods with environmentally-friendly building innovations?
- How can we 'skill up and scale up' in the construction and allied sectors for increased uptake of open risk assessment and performance-based designs?
- How will future jurisdictional credit ratings be impacted by the level of natural hazard risk in the built environment?

Engineers are a big part of the answers to all these questions, and we hope to link risk knowledge to actionable policies and implementable solutions for reducing risk from natural hazards.

Code Corner

By Jag Humar

In the building code cycle between 2010 and 2015, significant changes took place in the seismic design provisions of the National Building Code (NBC) of Canada. The main factor that drives these changes is an improved understanding of the seismic hazard across the country. Changes were also introduced in the site effect factors. The structural design provisions were appropriately adjusted to respond to changes in the estimates of hazard and the new site effect factors. There are also new provisions related to design in regions of low hazard, buildings with flexible diaphragms, buildings with inclined columns, passive energy dissipation systems, base isolation, rocking foundations, glazing systems, racks, and elevators. We will briefly discuss some of these changes in this column.

Seismic Hazard

In NBC 2010, design spectral accelerations were provided for fundamental periods of 0.2, 0.5, 1.0, and 2.0 s for localities throughout Canada. Based on available information on drop-off gradient of the spectral acceleration (S_a) with period, the design spectral acceleration at 4.0 s and longer was conservatively specified as half of that at 2.0 s. The code also provided values of peak ground acceleration (PGA). In **NBC 2015** spectral accelerations are specified for periods of 0.2, 0.5, 1.0, 2.0, 5.0, and 10.0 s. In addition, values are provided for PGA and peak ground velocity (PGV).

In NBC 2010, the specified values of S_a represented the median, implying that there was 50% chance of the spectral acceleration exceeding the specified value. In **NBC 2015**, the mean rather than the median value is used in the specification of seismic hazard; the mean being closer to the expected value. Mean hazard typically lies between the 65th and 75th percentiles of the distribution and is thus larger than the median (50th percentile) hazard.

Changes in hazard are due to changes in the way seismic sources and ground motions are characterized. The NBC 2010 seismic hazard values were based on measured ground motion data collected during earthquakes up to the early 1990s. Since then, considerably more data has been obtained. This information along with improved understanding of the seismotectonics has led to improvements in how the source zones are defined, in the ground motion prediction equations (GMPEs), and in the manner in which contributions from different sources are combined.

In NBC 2010 the design seismic hazard for the eastern regions was determined by first calculating the probabilistic values of S_a obtained for the H, R and F source zones and then adopting the largest of the three values as the design value. For the western region, the largest of four different estimates, probabilistic values for H, R, and F zones, and deterministic value for the Cascadia subduction zone, was taken as the design value. In **NBC 2015**, the contributions from all sources are combined probabilistically, which is a superior method that is used in most modern seismic hazard assessments.

Overall, in eastern Canada, estimates of long-period hazard increased while the estimates of short-period hazard decreased. In the west, the long period hazard increased significantly for regions affected by the Cascadia Subduction Zone.

> *"Between the 2010 and 2015 cycle, significant changes took place in the seismic design provisions of the National Building Code (NBC) of Canada"*

Code Corner *Continued from Page 3*

Site Effect Factors

The classification of soils and the treatment of Site Class C as the reference soil condition remained unchanged in **NBC 2015**.

For sites other than Site Class C, NBC 2010 specified two different factors: factor F_a applicable in the short period range, and factor F_v in the long period range. Values of F_a and F_v were specified for each of the 5 soil categories, A to E, and 5 different earthquake intensities. In the short period, the intensity was measured by the spectral acceleration at a period of 0.2 s, while in the long period range it was measured by the spectral acceleration at a period of 1.0 s. Since the publication of NBC 2010, far more ground motion data have become available. Seismologists have developed new methodologies that use this much larger database to provide GMPEs in which the site characteristic measured by Vs30 serves as a predictor variable to obtain estimates of the site factors. The site factors in **NBC 2015** are specified for 6 different periods: 0.2, 0.5, 1.0, 2.0, 5.0 and 10.0 s. Factors F(T) depend on a reference peak ground acceleration PGA_{ref} , which serves as a measure of the intensity. For locations in the east, and for a given sustained shaking, ground motions have higher amplitudes for PGA than in the west. However these amplitudes sometimes arise from small earthquakes with short duration of shaking and hence have low damage potential, as their ground displacements are very small. In the context of soil amplification and deamplification, the direct use of PGA would give F(T) values with larger non-linear deamplification effects in the east than appropriate for their sustained level of shaking. Accordingly, in the computation of F(T), PGA_{ref} is used instead of PGA, where $PGA_{ref} = 0.8 \times PGA$ when Sa(0.2)/PGA is less than 2.0, and PGA_{ref} = PGA otherwise. A few localities in the west are also affected by this provision. The design spectral acceleration is denoted by S and is given by $S(T) = F(T)\ S_a(T)$.

NBC 2010 included several triggers which directed the designer to select one of two alternative design procedures. The triggers were generally specified in terms of $I_E F_a S_a(0.2)$, for the short period hazard and $I_E F_v S_a(1.0)$, for the medium period hazard. As an example, the code allowed the use of equivalent static load method of design whenever $I_E F_a S_a(0.2)$ was less than 0.35. In **NBC 2015**, for trigger purposes, F_a is defined as being equal to F(0.2) and F_v is defined as being equal to F(1.0).

Short Period Cut-Off

Recognizing that short period structures usually have more reserve strength than accounted for, undergo small displacement, and performed relatively well during past earthquakes, **NBC 2015** allows such structures to be designed for 2/3 the calculated base shear, provided the structure is detailed to have at least a limited amount of ductility. This is achieved by specifying a short period cap at $2 \times S(0.2)/3$ on the UHS. However, in some cases the spectral shape is so flat that the cap extends to periods considerably longer than 0.5 s, the period range for which such cap was not intended. To avoid such a situation, **NBC 2015** defines the cap as $2 \times S(0.2)/3$ or S(0.5), whichever is greater.

We will continue to highlight changes introduced in NBC 2015 in the next issue.

NBC2015 and its structural commentaries are available for purchase at: *https://www.nrc-cnrc.gc.ca/eng/publications/codes_centre/codes_guides.html*

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News

2015 NBC Structural Commentaries Released

The Structural Commentaries (User's Guide – NBC 2015: Part 4 of Division B) document is now available through the NRC's web site:

https://www.nrc-cnrc.gc.ca/eng/publications/codes_centre/2015_user_guide_nbc_part4.html

This supporting document reflects technical changes incorporated into the National Building Code (NBC) of Canada 2015. It is intended to help users understand and apply the design requirements provided in Part 4, Division B of the NBC 2015. It also provides additional information on issues likely to be addressed in the next edition of the NBC.

News and Upcoming Events

We are soliciting news items, announcements, and events to publish in this column. Please let us know if you hear of earthquake engineering related news or events that you would like to bring to the attention of your colleagues.

Upcoming events

UR+ BC: Implementing Strategies to Reduce Natural Hazard Risk in BC's Built Environment
16-17 April 2018
Victoria, British Columbia
www.bccassn.com/meetings-and-events/understanding-risk-bc/

SSA 2018 Annual Meeting
(Note the change in date and location!)
14-17 May 2018
Miami, Florida
www.seismosoc.org/meetings/

Geotechnical Earthquake Engineering and Soil Dynamics Conference V
10-13 June 2018
Austin, Texas
www.geesd2018.org

CSCE 2018 Annual Conference
13-16 June 2018
Fredericton, New Brunswick
csce.ca/event/csce-2018-fredericton-annual-conference

16th European Conference on Earthquake Engineering
18-21 June 2018
Thessaloniki, Greece
www.16ecee.org

11th U.S. National Conference on Earthquake Engineering
25-29 June 2018
Los Angeles, California
11ncee.org