Canadian Association for Earthquake Engineering (CAEE)
L'Association Canadienne du Génie Parasismique (ACGP)

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Inside This Issue

From the Editor's Desk

by Tuna Onur

CAEE Annual General Meeting was held during the past quarter, and a variety of topics were discussed, which we summarize in this issue.

Also in this issue, we highlight research on seismic vulnerability of buildings in Ottawa. Although Central and Eastern Canada are away from major plate boundaries and experience major earthquakes less frequently than Western Canada, damaging earthquakes cannot be ruled out anywhere in the country. In fact, when a major earthquake happens in Central and Eastern Canada, the impact will likely be larger than Western Canada for two main reasons: 1) seismic waves propagate farther and more efficiently in Central and Eastern Canada, generating strong shaking in a larger area than a similar earthquake would in the west; and 2) the building stock is more vulnerable since seismic design loads are generally lower than Western Canada. The study we cover in this issue starts to shed light into this topic by quantifying the fragility of reinforced concrete buildings in Ottawa.

CAEE Newsletter offers to highlight your research and professional activities. Please send your articles to: secretary@caee-acgp.ca

Report from the CAEE Annual General Meeting

by Lydell Wiebe

The 2018 Annual General Meeting of the CAEE was held by WebEx on Thursday, March 1. CAEE President Carlos Ventura highlighted the work of the Board including improvements to the website, a regular newsletter, and scanning all proceedings from previous conferences into digital form.

A reconnaissance team of six CAEE members was sent to Mexico after the September 2017 earthquake, under the leadership of past CAEE President Murat Saatcioglu. A report on the findings of this team is in preparation.

Board of Directors: Trevor Allen stepped down from the Board and is replaced by Stephen Halchuk (Natural Resources Canada) until term elections in 2019, at which time half the board will be elected for a four-year term and half for a two-year term to maintain continuity. The current CAEE Directors are: Carlos Ventura (President), Sharlie Huffman (Vice-President), Ghasan Doudak (Treasurer), Lydell Wiebe (Secretary), Jeff Erochko, Jorge Prieto, Don Kennedy, John Sherstobitoff, Martin Lawrence and Stephen Halchuk.

Finances: The CAEE continues to be in good financial health, spending only about 7% of its assets over the last year.

Web Site: The CAEE web site is being updated and feedback from members is being requested.

CAEE Annual General Meeting… *Continued from Page 1*

Please send all your suggestions related to CAEE to: secretary@caee-acgp.ca

The next CAEE Board of Directors Meeting will be held on Thursday, May 3rd at 10am PT (1pm ET).

Fragility Analysis of Reinforced Concrete Buildings in Ottawa

by Murat Saatcioglu, Abdullah Al-Mamun, and Yasamin Rafie Nazari

Seismic design requirements in the National Building Code (NBC) of Canada have evolved and improved since its inception in 1941. While buildings designed using recent editions of the NBC are expected to perform better during a seismic event, older buildings designed prior to the enactment of modern seismic codes remain vulnerable to earthquakes. Fragility curves, relating seismic hazard to probability of exceeding pre-selected performance levels, were developed for representative reinforced concrete frame and shear wall buildings in Ottawa, representing pre-1975 and post-1975 code era.

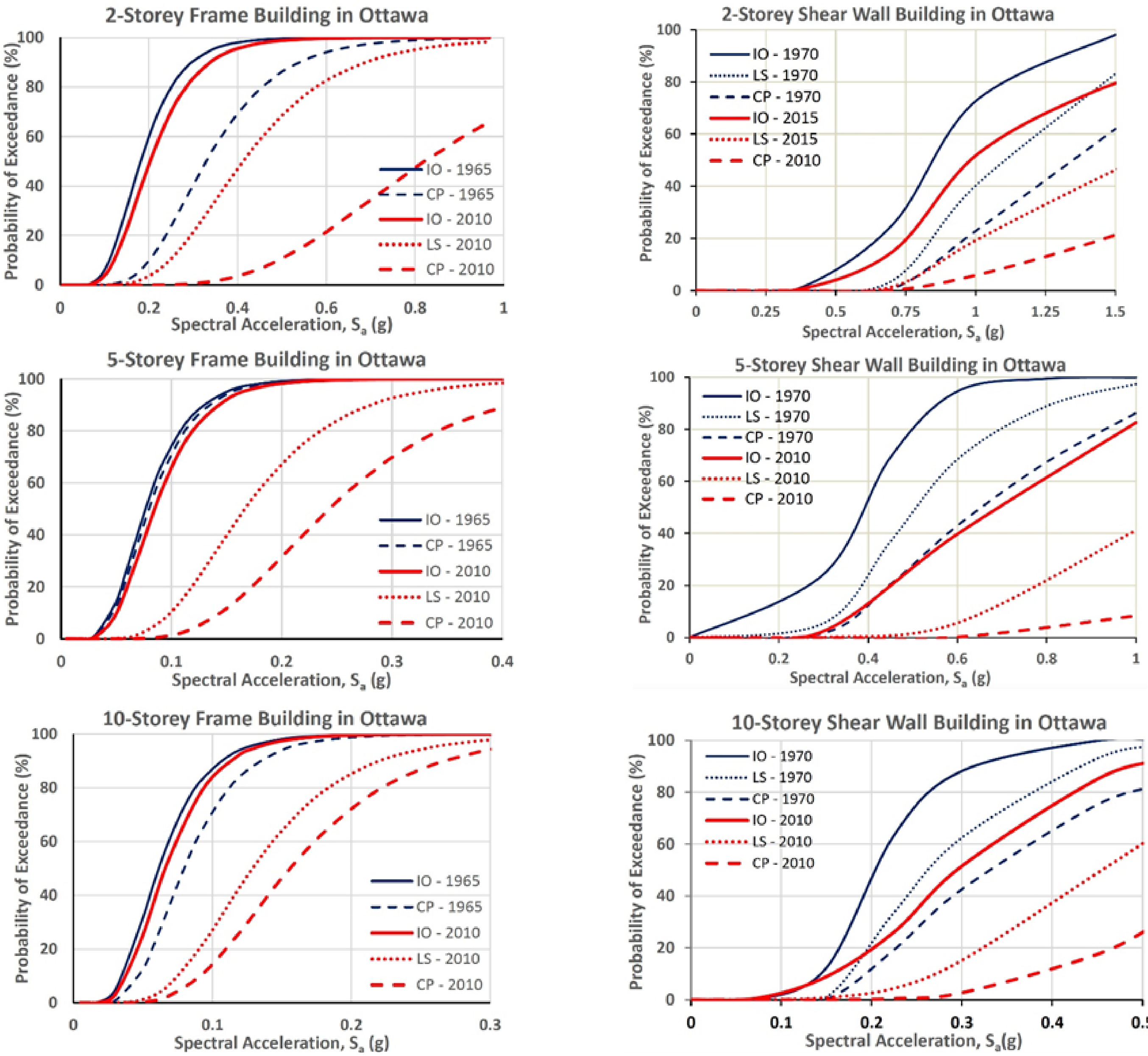
While the former era represents non-ductile design practices without seismic design and detailing, the latter era represents ductile buildings with gradually improving seismic design and detailing requirements as reflected in CSA Standard A23.3. This broad classification of the two different design practices was made after a review of the progression of seismic design requirements in the NBC and CSA A23.3 over the years (*Al Mamun and Saatcioglu 2017, Rafie Nazari and Saatcioglu 2017*). Three different buildings with 2-storey, 5-storey and 10-storey building heights were designed using concrete frames and shear walls as the seismic force resisting systems.

The representative frame buildings were designed following the requirements of the 1965 NBC and the 2010 NBC, while shear wall buildings were designed based on the 1970 NBC and the 2010 NBC requirements. Both buildings consist of regular floor plans having 5 bays in each direction, with a span length of 7m. Incremental dynamic analysis (IDA) was conducted using computer software PERFORM-3D and 20 earthquake records compatible with the 2010 NBC Uniform Hazard Spectra with different scale factors, resulting in over 200 dynamic inelastic analyses for each building model. The intensity measure used in the IDA was the spectral acceleration at the fundamental period of the structure. The inter-storey drift ratio was adopted as the damage indicator.

Three damage states were considered corresponding to three performance levels as commonly accepted performance limits; i) Immediate Occupancy (IO), ii) Life Safety (LS), and iii) Collapse Prevention (CP) (ASCE 41-13). IO describes the damage state where structure is safe to be re-occupied having suffered minor damage to the structural elements with minor spalling and flexural cracking. The inter-storey drift of 1% and 0.5% were considered for this limit state for frame and shear wall buildings, respectively. LS describes the damage state where significant damage has occurred to the structure with extensive cracking and hinge formation in primary structural elements, while maintaining life safety of the occupants. The inter-storey drift of 2% and 1% were adopted for frame and shear wall building for this limit state. CP describes the damage state where structure is at the onset of partial or total collapse with extensive cracking, hinge formation and reinforcement buckling in structural elements. The median value of maximum inter-storey drift demands for all records was considered as CP performance level. The maximum inter-storey drift for CP limit was obtained as the smaller of the drift at which either dynamic instability is attained or the tangential slope of the IDA curve dropped to 20% of the initial slope (FEMA 350).

Al Mamun, A., and Saatcioglu, M. 2017. *Seismic fragility curves for reinforced concrete frame buildings in Canada designed after 1985. Canadian Journal of Civil Engineering.*

Rafie Nazari, Y. and Saatcioglu, M. 2017. *Seismic vulnerability assessment of concrete shear wall buildings through fragility analysis. Journal of Building Engineering.*



Seismic fragility curves for reinforced concrete buildings in Ottawa for non-ductile frame and shear wall structures designed based on the 1965 and 1970 NBC, respectively; and moderately ductile buildings designed based on the 2010 NBC

Earthquake Waves

by Winson Cheng

On January 23, 2018, a large earthquake of Mw7.9 occurred in the Gulf of Alaska. The earthquake had an epicenter located approximately 280 km southeast of Kodiak Island at a depth of 25 km. While the earthquake was strongly felt by people on Kodiak Island, people on the Alaskan mainland and Northwestern British Columbia felt only light shaking due to the distance.

The earthquake prompted tsunami warnings and evacuation advisories for Alaska, British Columbia, the West Coast of the United States, and Hawaii. People in hazard and low-lying areas along the Gulf of Alaska and in British Columbia were evacuated to shelters and higher ground.

Within four hours of the earthquake, due to the apparent lack of tsunami, most alerts of the earthquake were cancelled by the Pacific Tsunami Warning Center.

Code Corner

by Jag Humar

In the previous issue of the CAEE Newsletter, we introduced some of the major changes in the NBC 2015, including seismic hazard, site effect (foundation) factors, and the short-period cut-off. In this issue, we highlight a new section in the code.

Low Hazard Areas

A large portion of Canada's land mass consists of a tectonically stable region with low seismic activity. However, in spite of the low levels of seismic activity, large earthquakes cannot be ruled out in the region. Experiences in stable tectonic regions around the world confirm this statement. For example, the 2012 Christchurch (New Zealand) Earthquake, the 1995 Kobe (Japan) Earthquake, and the Newcastle (Australia) all occurred in areas of moderate to low seismic activity. Although moderate in magnitude, these earthquakes were close to urban centres, causing significant damage.

Considering the low probability of damaging earthquakes in stable regions of Canada, the NBC 2010 exempted such areas, specifically those where $F_aS_a(0.2)$ was less than 0.12, from the requirements of seismic design. In view of the experience in other tectonically stable areas of the world and the fact that parts of eastern Canada has experienced considerable seismic activity, **NBC 2015** requires that seismic design is carried out in all regions of Canada. However, the code provides a much simplified design procedure for areas of low hazard, defined as those where $I_EF_sS_a(0.2)$ is less than 0.16 and $I_EF_sS_a(2.0)$ is less than 0.03.

The $I_EF_sS_a(0.2)$ trigger of 0.16 implies that all buildings in a low hazard zone, such as Winnipeg, with the exception of important or post-disaster buildings located on poor soil, could be designed using the simplified procedure. The trigger also exempts from full design, buildings in some eastern locations where the hazard is low, but still notable.

Buildings in Calgary will need full design since both the 0.16 and 0.03 triggers are exceeded. There are regions in BC where the spectral curve is quite flat and the 0.2 second value is quite low but the 2 second value is higher than 0.03. Detailed design will be required for such regions.

The site effect (foundation) factor F_s, which substitutes for F_a, does not require measurement of shear wave velocity and is given by

F_s = 1.0 for rock or when $N_{60}>50$ or $S_u>100$kPa,
= 1.6 when $15\leq N_{60}\leq 50$ or $50\text{kPa}\leq S_u\leq 100\text{kPa}$,
= 2.8 for all other cases.

The trigger value beyond which detailed design would be required was raised from 0.12 to 0.16, since even the structures below the trigger will be designed for earthquake forces, albeit using a simplified procedure. On the other hand, the trigger in **NBC 2015** includes the importance factor to ensure that important structures perform better.

The minimum design base shear formula is similar to that of detailed design, except that there is no higher mode effect factor and the factors R_d and R_o have been replaced by a single factor R_s.

The design procedure specified for low hazard zones is a much simplified and self-contained version of the detailed procedure. The specification of the simple procedure appears in a new section at the beginning of the seismic requirements, so that if the site meets the definition of a low-hazard zone, the designer would not be required to review the steps involved in the detailed procedure.

"NBC 2015 requires that seismic design is carried out in all regions of Canada, with a much simplified design procedure for areas of low hazard"

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News

CAEE Announces the 12th Canadian Conference on Earthquake Engineering (CCEE) !

The 12th CCEE will be held at the Château Frontenac Fairmont Hotel in Quebec City, on June 17-20, 2019.

The theme of the conference is "Improving Seismic Infrastructure Performance and Community Resilience". The conference includes a variety of topics including seismic hazard, codes and standards, geotechnical issues, structural behaviour and design, seismic rehabilitation and mitigation, societal impacts, seismic risk, dam safety, seismic reliability of structures and structural health monitoring.

Abstract submission is open from now until September 15, 2018 at the conference web site: http://www.ccee2019.org/

News and Upcoming Events

We welcome 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