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

NEWSLETTER

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From the Editor's Desk

by Tuna Onur

This spring feels a lot different than usual, as COVID-19 impacts us all in various ways. You will see in our Upcoming Events column that almost all the in-person conferences and workshops this year have been cancelled. In the spirit of continuing exchange of knowledge and information, we provide links to the keynote presentations and the Proceedings of the most recent European Conference on Earthquake Engineering in the News section. If you are aware of other earthquake engineering conference or webinar material, please bring them to our attention and we can include in the next issue of our Newsletter.

In late March, there was a small magnitude (3.7) earthquake near Montréal that was widely felt in the region, reminding us that the earthquake hazard in Canada is not limited to the West Coast. You can find the details in the Earthquake Waves column.

The CAEE Annual General Meeting is being held in April. See the Message from the President for an update on the activities of CAEE in the past year.

Stay healthy, and as always, we encourage you to share short articles, news or other items. Please send your contributions to secretary@caee-acgp.ca

INSIDE THIS ISSUE

Message from the President

by Sharlie Huffman

The CAEE AGM is being held on April 8th, 2020. The past year has been a busy one for our Board of Directors. The Board has worked on CAEE's strategy, updated its Mission statement, goals and policies.

Our Directors have also been working hard to improve our services to the members, the professions and to the public. Our Newsletter remains a staple of our member services.

We are increasing our educational and knowledge transfer offerings and encouraging research. We are developing a student outreach component within the CAEE and have established a liaison with Codes Canada. We have been updating our website and would welcome comments and suggestions from the membership. We are also planning to establish a set of CAEE Awards.

Our member only site will be going live shortly. As a member you will have immediate access to conference proceedings as well as the library of seismic instructional and research topic webcasts. The library of webcasts will be built up by the Education and Research Committees over the next few years. The CAEE has been operating for several years at zero membership fees. We will discuss the initiation and timing of fees at this AGM.

Message from the President… *Continued from Page 1*

What can you do as a member to help?

- Please send in your comments and suggestions on every topic. Tell us what you would like the CAEE to be for you.
- Encourage your students to become involved in the student chapters and help develop fun and worthwhile contests and activities.
- Send in comments, letters and articles on technical topics to the Newsletter.
- Tell us what topics you would like to see in a seminar or instructional webcast.
- What type of Awards do you think CAEE should bestow?
- If you have an interest in a specific committee and feel you can contribute, please contact the Chair of that committee.

Our team and chairs are all listed on our website as well as on our AGM agenda. We would like to hear from you.

And last, I thank all of you who are able to attend our AGM this year. Stay safe.

Code Corner

by Don Kennedy and Denis Mitchell

The design of most road and pedestrian bridges in Canada will be based on the 2019 Canadian Highway Bridge Design Code (CHBDC). Since the previous edition (2014), seismic design has used performance-based seismic design (PBD), a displacement-based method that targets bridge damage, repair and return to service requirements at multiple levels of seismic hazard. In 2014, the design included three hazard levels; 10%, 5% and 2% probabilities of exceedance in 50 years. In 2019, this has been reduced to two of these same three hazard levels, depending on the bridge importance and complexity.

For the PBD of new bridges there are a number of key steps. Some issues and considerations are discussed below that are unique to PBD compared to force-based (albeit still based on ductility) seismic design. Key steps are:

(1) Develop the bridge concept considering gravity and lateral load-resisting systems. Foundation and sub-structure types, bridge articulation (bearings and joints), span lengths and superstructure types, and abutment arrangements are selected as a starting point. Abutments have such a fundamental impact on the seismic response of the bridge that they warrant separate mention.

(2) *Proportion* the bridge components for seismic demands and damage. This may require iteration. The method to be used is fully the choice of the engineer. Both current and previous editions of the CHBDC also included force-based design (FBD), in which seismic demands were determined using linear elastic models. For ductility-based designs, the column moments would be reduced by a ductility factor (R) between unity (elastic) and five (ductile, redundant piers). In PBD, an approach analogous to the FBD approach can be useful for preliminary proportioning of (say) ductile columns. Other methods available include engineering experience and judgement or rules-of-thumb for column height-to-diameter or dead-load axial load levels in columns.

(3) Model and analyse the bridge with an emphasis on achieving reasonable estimates of displacement demands. The seismic hazard levels, design spectra or ground motion time-histories are obtained as discussed in previous Code Corner columns for the CHBDC or the National Building Code (NBC) of Canada.

Code Corner… *Continued from Page 3*

(4) Assess strains or other deformation-based quantities as surrogate measures for damage, return to service times and repairability. Strains are obtained using the displacement demands on piers (or on isolation bearings or other components) and either non-linear static (pushover) analyses or non-linear time-history analyses. As noted in a previous column, strain checks for discrete, worst-case plastic hinge locations within a pier may give a conservative result. This would be less so for an existing bridge with non-ductile columns in which spalling at the first plastic hinge could lead to a sudden loss of structural integrity of a column.

(5) Ensure that brittle failure modes are prevented through "capacity design" checks, in which upper-bound seismic demands within a plastic mechanism, base-isolated bridge or other reliable fusing mechanism is provided.

In each of the above steps, but especially in the damage and capacity-design steps, the assumed material strengths and section behaviours of the lateral load-resisting mechanisms are particularly important. Their application differs from traditional FBD in other concrete codes. In the CHBDC, both damage and capacity design checks are based on *nominal* (unfactored, i.e. $\phi=1.0$) *expected* material properties, i.e. on strengths greater than the minimum specified design strengths. Clause 4.4.6.3 may need clarification, in that, as currently written, *nominal* may appear to imply that f_y is to be used for low-damage cases rather than $f_{y,e}$. However, the latter should be used in all PBD checks at all damage levels; *nominal* should be interpreted as unfactored resistance.

The *expected* yield strength of reinforcing bars, $f_{y,e}$ is taken as $f_{y,e} = R_y f_y$ where $R_y = 1.1$ for ductile substructure elements with lower anticipated strain or damage levels and hence also for capacity-protected elements, and $R_y = 1.2$ for ductile substructure elements with higher expected damage or for use in performance assessments (Clause 4.7.2). This approach was adopted in 2014, in which the 1.1 factor applied to sections that "qualified for" $R < 3$ or for resistances of capacity-protected elements, and 1.2 for ductile substructure elements that "qualified for" $R = 3$. The 0.1 increase for more ductile cases can be ascribed to the higher strain-hardening effects at higher deformation demand levels. The 1.1 factor on the minimum specified yield strength refers to the basic yield stress that is intrinsic to the material, such as would be expected from a tensile test in a lab.

For capacity-protected members and capacity-protected actions such as shear in ductile substructure elements, Clause 4.7.2 specifies that a *factored* resistance (ϕ_c=0.75 and ϕ_s=0.90 as defined in Clause 8.4.6) along with expected material properties should be used. Clause 4.7.2 refers to "flexural resistances for design", and therefore ensures that the plastic hinge can form where intended, rather than having it shift unintentionally to an adjacent section. The use of expected material properties allows the same properties as used in other steps through the PBD process. For <u>demands</u> on the capacity-protected sections, a *probable* section strength factor of 1.3 is specified in Clause 4.4.10.4.3. This accounts for moment capacities increased by additional strain hardening and concrete confinement effects. In summary, the margins of strength for capacity-protected concrete sections are approximately 1.3 / 0.9 = 1.43 for flexure and 1.3 / 0.83 = 1.58 for shear for a case in which concrete and steel spirals contribute equally to shear strength.

The Section 4 sub-committee of the CHBDC recognizes that further clarifications of Section 4 would be beneficial in a future edition to simplify and clarify both PBD and FBD requirements.

It is important to recognize that the CHBDC content remains the legal or contractual standard in Canada, along with supplements or exceptions as formally adopted by Provincial Ministries or as specified formal contract requirements. Those documents govern over any conflicts arising from the content we present here in Code Corner.

Earthquake Waves

by John Cassidy

In the early morning hours (3:21 a.m.) of Sunday, March 29th, 2020, thousands of people across greater Montréal were rudely awakened by shaking from a magnitude 3.7 earthquake. Although relatively small, this earthquake was located only ~40 km from downtown Montréal.

Shaking was felt over an area of nearly 150,000 km² (Figure 1). More than 4,700 felt reports were received on the EarthquakesCanada website, including some reports from as far away as Ottawa (~170 km to the east), Québec City (200 km to the northeast, northern Vermont (150 km to the south), and Maniwaki (200 km to the northwest). There were no reports of damage, and most people indicated weak shaking (MMI II-III) for 2-10 seconds duration. Many people in the closest communities reported loud noises and very strong and frightening shaking (of 10 seconds or more).

earthquake occurred in the same area (only 23 km from the March 29th event) and woke up more than 1,200 people across the greater Montréal region. The March 29th earthquake, although widely felt, occurred in the mid-lower crust (~18 km deep) and produced maximum ground accelerations of only 1-2% g in the epicentral region.

While this small earthquake is not of engineering significance (although seismic recordings can be used to help assess local site effects), it serves as a clear reminder that Montréal and the rest of the St. Lawrence and Ottawa Valley regions are an area of moderate to high seismic hazard. The largest known earthquake in the greater Montréal region was a magnitude ~5.8 event that struck on September 16th, 1732. That event caused significant damage (chimneys, walls) to more than 300 houses, and triggered a fire that destroyed another 185 buildings.

Intensity	Reports
I	45
II	2666
III	1471
IV	495
V	19
VI	5
VII	1
VIII	0
IX	0
Total	4702

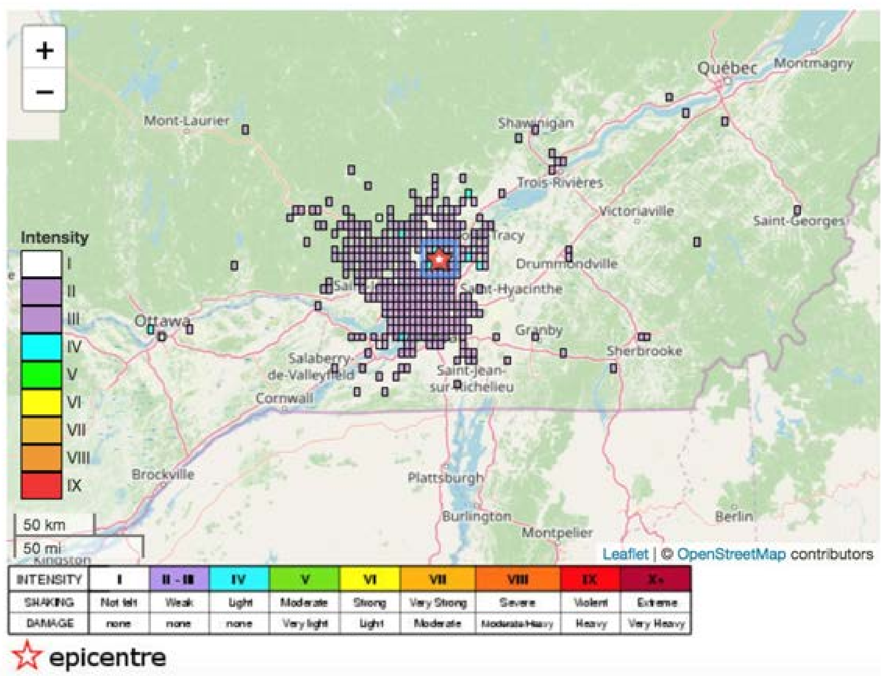

Figure 1. Felt intensity reports for the magnitude 3.7 earthquake on 29 March 2020

Some people were concerned as this was the second felt earthquake in Montréal during the month of March. On March 6th, 2020 (and coincidentally at 3:22 a.m. - nearly the same time as the March 29th earthquake), a magnitude 3.2

This very recent earthquake and the larger historical earthquakes are clear reminders of the importance of earthquake hazard research and earthquake engineering to help reduce the impacts of seismic events that we know will occur in the future.

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News

Proceedings of the 16th European Conference on Earthquake Engineering

The 16th European Conference on Earthquake Engineering was held in June 2018 in Thessaloniki, Greece.

If you missed this conference but interested in what your European colleagues are up to, the organizers kindly posted all keynote speakers' presentations and the Proceedings from this conference online.

You can find the PDF version of the keynote speakers' presentations at this link:

files.16ecee.org/

You can also search the Proceedings at the following link (leave all fields blank and click search to see all papers):

papers.16ecee.org/

News and Upcoming Events

Due to COVID-19 outbreak, many conferences and workshops have been cancelled or postponed globally. We tracked the status of events we announced here previously. Please find this information below for each event, marked in red, as of beginning of April.

Upcoming events

NZSEE (New Zealand Society for Earthquake Engineering) Annual Conference 2020
CANCELLED
22-24 April 2020
Wellington, New Zealand
conferences.co.nz/nzsee2020/

SSA (Seismological Society of America) Annual Meeting
CANCELLED
27-30 April 2020
Albuquerque, NM
www.seismosoc.org/annual-meeting/

Annual Meeting of the CGU (Canadian Geophysical Union)
CANCELLED
3-6 May 2020
Banff, AB
https://meeting2020.cgu-ugc.ca/

37th General Assembly of the European Seismological Commission
CANCELLED
6-11 September 2020
Corfu, Greece
www.escgreece2020.eu/

17th World Conference on Earthquake Engineering
Currently proceeding as planned
13-18 September 2020
Sendai, Japan
www.17wcee.jp/