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

The last time a Canadian city hosted the World Conference on Earthquake Engineering (WCEE) was in 2004 (Vancouver). 20 years later, another Canadian city (Montréal) wants to host it, and CAEE is looking for volunteers to help Montréal's bid for the 18th WCEE in 2024. You can find more information in the following pages about the team preparing the bid and how you can help!

CAEE continues to conduct reconnaissance trips following damaging earthquakes, and recently released a report on the 2017 Puebla-Morelos earthquake (Mw7.1) in Mexico and its implications for seismic design in Canada. You can find a summary of the findings below.

INSIDE THIS ISSUE

The new edition of the Canadian Highway Bridge Design Code, S6-19, is due to be released soon. In the Code Corner column, we cover highlights of the changes to Section 4 (Seismic Design).

Finally, read the Earthquake Waves column to find out which Canadian earthquake had recorded vertical accelerations exceeding 2g!

CAEE Reconnaissance of the 19 September 2017 Mw7.1 Puebla-Morelos Earthquake in Mexico

by CAEE Reconnaissance Team

A magnitude 7.1 earthquake occurred in central Mexico on September 19, 2017 at 1:14 pm local time, causing widespread geotechnical and structural damage in the States of Morelos and Puebla, including parts of Mexico City, resulting in 369 casualties. The epicentre of the earthquake was 120 km southeast of Mexico City, and it was a normal-faulting intraplate event at a depth of approximately 50 km.

The CAEE sent a team of geotechnical and structural engineers to investigate the effects of the earthquake from a Canadian seismic design perspective. The team conducted its investigation between October 15 and 21, 2017, during which period they also met with their colleagues at the National Autonomous University of Mexico (UNAM) and the Centre responsible for the Mexican earthquake early warning system, the Centro de Instrumentación y Registro Sísmico (CIRES) and gathered valuable background information.

The full report with the CAEE reconnaissance team's findings can be found at: *https://www.caee.ca/files/Reports/2017%20Central%20Mexico%20Earthquake%20CAEE%20Reconnaissance%20Report%202019.pdf*

CAEE Reconnaissance of the 2017 Puebla-Morenos Earthquake… *Continued from Page 1*

In this article, we highlight some of the significant conclusions that were drawn from the observations made by the CAEE reconnaissance team as follows:

- The soft lacustrine clays in Mexico City tend to amplify ground motions over a broad period range varying between 1.0 sec and 5.0 sec. Unlike the 1985 Mexico City Earthquake, which caused widespread damage to long period structures, the September 19, 2017 event produced spectral peaks between 1.0 sec and 2.0 sec, mainly affecting mid-rise buildings.

- Reinforced concrete (RC) frame buildings with masonry infill walls, confined masonry buildings and non-engineered traditional masonry and adobe buildings suffered the most damage, especially if built prior to the improvements in seismic design practices following the 1985 Mexico City Earthquake.

- Lack of seismic design and detailing in older RC columns and improper use of tie columns and bond beams in confined masonry, as well as non-code-compliant construction in general, were found to be the primary causes of damage, in addition to the ground motion amplification effects associated with prevailing soft soils conditions.

- Newer buildings built after the improvement of the Mexico City Seismic Code in the post-1985 era performed well. This is especially true for buildings built in more recent years.

- The lack of proper separation of masonry infill walls and their participation in seismic resistance resulted in varying degrees of masonry damage. This was observed to be also true in newer buildings.

- Lack of implementation of the current seismic code requirement for having proper separation between buildings caused pounding effects, resulting in varying degrees of damage, sometimes causing partial or complete collapse.

- Soft-storey buildings performed poorly, especially if the soft storey columns did not have sufficient capacity to resist increased force and deformation demands.

- Retrofitted buildings performed well, if the retrofit strategy involved cross bracing of frames, providing global drift control. However, common form of column retrofit technique used in Mexico City, consisting of externally placed steel cages, made up of welded steel angles and strips, was not able to provide sufficient resistance to poorly designed columns.

- Comparison of seismic hazard values recorded after the earthquake with those used to design buildings in western Canada indicates that the buildings in Canada could be vulnerable to similar earthquakes if located on soft soils and not designed to have inelastic deformability.

- The unusual ground conditions of Mexico City, built on thick soft lake deposits, coupled with widespread use of ground water for city's water needs resulted in extensive soil settlements before and during the earthquake. This resulted in the settlement, tilting and pounding of buildings with undesirable consequences.

- The earthquake early warning system functioned reasonably well. However, because the earthquake coincided with the anniversary of the 1985 Mexico City Earthquake, it was mistaken for a drill, which reduced its effectiveness.

"Comparison of ground motions from this earthquake with design motions in western Canada indicates that our buildings could be vulnerable if located on soft soils and not designed to have inelastic deformability."

Call for Volunteers – Preparation of Montréal's Bid to Host WCEE2024

by Sharlie Huffman and Ghyslaine McClure

It was confirmed at the Annual General Meeting of the CAEE in June that the CAEE is supporting the initiative to prepare a bid to host the 18th World Conference on Earthquake Engineering (WCEE) in July 2024 in Montréal at Palais des Congrès. A Local Organizing Committee (LOC) was put together last year for the bid, which is comprised of seven professors from McGill, Concordia, École de technologie supérieure (ÉTS), Polytechnique Montréal, Université Laval and Université de Sherbrooke, and event organization experts from Palais des Congrès.

The LOC will be working closely with the CAEE Board of Directors, as CAEE is officially presenting the proposal to the national delegates of countries that are voting members of the International Association of Earthquake Engineering (IAEE). An elaborate proposal must be submitted to the IAEE and a short oral presentation made to voting delegates in mid-September 2020 at the 17th WCEE in Sendai, Japan.

We are inviting all interested CAEE members to participate in the preparation of the bid. At this stage, your involvement can take the form of suggestions for the scientific programme, technical exhibition, technical visits, reasons why WCEE2024 should be hosted in Canada or any other logistical aspects of the conference, commitment to volunteer on various committees, or becoming a sponsor. There is solid international competition to host this prestigious conference, so we need your input to prepare the most attractive proposal. You may recall that WCEE was held in Vancouver in 2004. It was very successful on all counts for the attendees and in particular, financially, for CAEE. So the bar is high!

To make suggestions or indicate your willingness to participate, please e-mail: *bidforWCEE2024@caee-acgp.ca* and members of the LOC will get back to you. We look forward to receiving your input.

Sharlie Huffman, President, CAEE

Ghyslaine McClure, McGill University, Chair of the LOC preparing the WCEE2024 bid

Members of the LOC: Rola Assi and Marie-José Nollet of ÉTS, Sanda Koboevic of Polytechnique Montréal, Lucia Tirca of Concordia University, Nathalie Roy of Université de Sherbrooke, and Pampa Dey of Université Laval. The expert advisor from Palais des Congrès is Marc-André Gemme.

Code Corner

by Don Kennedy

The new edition of the Canadian Highway Bridge Design Code, S6-19, will be published in November. Section 4 (Seismic Design), Section 6 (Geotechnical) and Section 11 (Joints and Bearings) will all include updates affecting the seismic design of bridges and transportation structures in Canada. Performance-based design (PBD) remains the default design approach for highway bridges in higher seismic zones of Canada, while force-based design remains applicable in lower seismic zones or for regular bridges.

In previous editions of S6, it was Section 4, Seismic Design, that contained the primary seismic design provisions, within which Section 4.6 contained geotechnical and foundation seismic design provisions. In S6-19, geotechnical aspects of seismic design were fully moved into Section 6, including foundation seismic design requirements.

We will provide context for and highlight changes to Section 6 in a future Code Corner column.

In this issue, we focus on the updates to Section 4 of S6-19 as follows:

Code Corner… *Continued from Page 3*

- Basic seismic hazard remains unchanged; however hazard updates will be published on the NRCan website in 2020. These updates were approved by the Standing Committee of Earthquake Design (SCED) for both the bridge and the building codes in Canada.

- Some updates to F factors are provided.

- Seismic Performance Categories were refined. Irregular bridges in lower seismic hazard areas no longer require performance-based design. These bridges had low demands such that seismic damage was typically low, in which case the advantages of PBD did not apply.

- Design for performance (return to traffic, damage and repair) is now required for only two seismic hazard levels for each bridge classification, reduced from three in S6-14. Table 4-15 defines these hazard levels for each bridge type. The catalyst for this change was that the difference between seismic damage levels within Lifeline bridges was small for the 5%- and 10%-in-50-year exceedence levels. As well, for Other bridges the collapse prevention requirement applies at the 2%-in-50-year hazard level and a low damage objective remains for the 10%-in-50-year hazard level. For Major Route bridges, it was agreed that two levels of performance assessment were sufficient (immediate use at 10%, service disruption at 2% in 50 years), and therefore all three bridge types were revised to reflect a two-level performance set of requirements.

- The application of ‘expected’ material properties was clarified; changes to the approach were not necessary.

- Updates to damage states (strains, residual displacements) were made and several damage descriptions were added.

- A re-organizing and clarification of seismic design forces were made for performance-based, force-based and capacity design.

- It was clarified that below-ground yielding of piles in extended-pile bents and integral abutment bridges is acceptable in appropriate conditions.

- Shear design for seismic-force resisting columns was changed to increase section shear capacity and allow and encourage capacity design approaches.

- Some prescriptive provisions were updated (hold-down details, seat lengths, shear keys).

- The design of joints and bearings for seismic effects was clarified, and references to bearing design changes in Section 11 were added.

- For existing bridges, guidance on recommended minimum levels of seismic hazard and design for seismic performance are provided in S6.1-19, the Commentary to S6-19. As a minimum, and for bridges for which owners have opted to upgrade seismically, a collapse prevention performance objective was included for each bridge type. The minimum hazard level for collapse prevention for Other bridges was set at 5% in 50 years. This was decided in consideration of the fact that existing bridges typically contain brittle details and have little resilience, therefore warranting a higher ‘force’ level than new bridges. Lifeline and Major Route bridges are recommended to be upgraded to 2%- and 5%-year-in-50-year hazard levels, respectively. In addition, the recognition that a risk-based framework is appropriate for existing bridges was included.

- Guidance in the Commentary for existing bridges was added for retrofit and rehabilitation, recognizing that staging of works may be considered by owners. Clarification was added to the effect that PBD damage or strain descriptions for new bridges would likely be unsafe for existing bridges. Some guidance on expected material properties for existing bridges is also added.

Code users and the engineering community are also reminded that the “CSA Communities” web page contains code-related resources, including a mechanism to submit questions to CSA sub-Committees on any code section. Past questions and answers are also posted there and provide additional context, clarifications or interpretations of some code clauses based on user queries.

Earthquake Waves

by John Cassidy

Although largely unknown, one of the most important Canadian earthquake sequences (for both earthquake engineering and seismology), is the 1985 magnitude 6.6-6.9 Nahanni, NWT earthquake sequence.

The two largest earthquakes in this sequence occurred on October 5 (M6.6) and December 23, 1985 (M6.9) at the eastern edge of the Canadian Cordillera. Shaking was felt in the Northwest Territories, Yukon, southeastern Alaska, British Columbia, Alberta and Saskatchewan. These shallow, thrust earthquakes (followed by thousands of aftershocks) surprised both the public and earthquake scientists – as no earthquakes larger than magnitude 5 had ever been recorded in this region. Strong shaking from the second (larger) event was recorded at three near-field sites (within 8-10 km of the earthquake hypocentre). At one site, a high-frequency peak exceeded 2g on the vertical component and was (for many years) the strongest earthquake shaking ever recorded anywhere in the world. The earthquakes caused landslides and rockfalls, including a massive 7 million cubic metre rock avalanche (one of the largest in Canada).

A few key lessons from analysis of these unique strong motion records include:

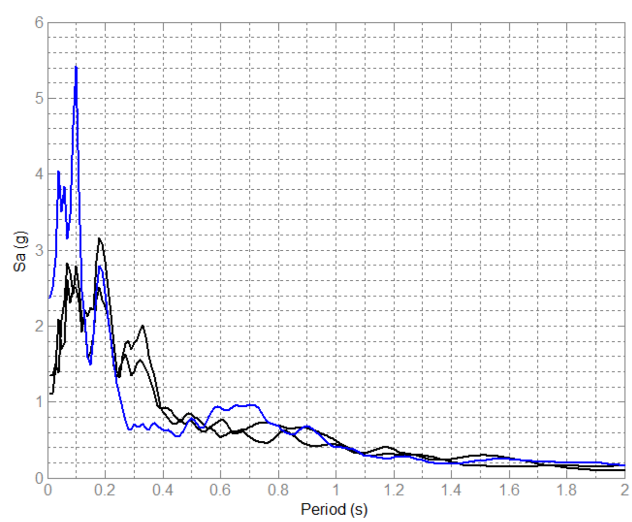
The largest of the landslides caused by the 1985 Nahanni, NWT earthquake sequence.

- the importance of rupture directivity effects in the near-field
- design codes at the time did not adequately capture the observed shaking
- source spectral scaling (estimating shaking from large earthquakes based on recordings of smaller earthquakes) needed revision based on the new data

Detailed studies on this earthquake sequence have contributed to a better understanding of earthquake hazards, improved building codes, and the strong motion records have been used for seismic design of infrastructure – in Canada, in the United States, and around the world.

Strong motion recordings of the largest event in the sequence are available here: ftp://ftp.seismo.nrcan.gc.ca/exports/strongmotion_historical_events/old/Nahanni_1985-86/

Finally, these unusual earthquakes raised the question "Could similar earthquakes occur anywhere along the eastern margin of the Canadian Cordillera?", and reminded us that our job is still far from done – there is still much to learn!



Response spectra of the ground motions recorded at Site 1 during the December 23 event. Black lines correspond to the two horizontal components (PGA > 1g) and blue line corresponds to the vertical component (PGA > 2g).

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News

The Great Shake Out (La Grande Secousse) Earthquake Drills

Every year on October 17, British Columbia, Québec, and Yukon in Canada join the US, Japan, New Zealand and many other countries around the world to hold an earthquake drill.

These drills are an opportunity to practice how to be safer during earthquakes and remember to "Drop, Cover and Hold On." ShakeOut also aims to encourage individuals, communities, schools, and other organizations to update emergency plans and supplies, and to take measures in order to prevent damage and injuries.

You can read more at:

www.shakeoutbc.ca

www.grandesecousse.org/quebec/

www.shakeout.org/yukon/

News and Upcoming Events

We are soliciting earthquake engineering related news and events that you would like to bring to the attention of your colleagues. Please send your contributions by December 15 to secretary@caee-acgp.ca to get them included in the January Newsletter.

Upcoming events

2019 Annual COSMOS (Consortium of Organizations for Strong Motion Observation Systems) Technical Session
22 November 2019
Oakland, CA
www.strongmotion.org/TS/COSMOS2019TS/

2019 AEES (Australian Earthquake Engineering Society) Conference
29 November - 1 December 2019
Newcastle, NSW, Australia
aees.org.au/2019-aees-conference/

2020 US National Earthquake Conference and 72nd EERI Annual Meeting
3-6 March 2020
San Diego, CA
earthquakeconference.org/

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

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

2020 Understanding Risk Forum
18-22 May 2020
Singapore
understandrisk.org/event/ur2020/