Canadian Association for Earthquake Engineering and Seismology (CAEES)
L'Association Canadienne du Génie Parasismique et de la Sismologie (ACGPS)

NEWSLETTER

October 2024
Volume 8, Issue 4

http://caee.ca/

From the Editor's Desk

by Tuna Onur

INSIDE THIS ISSUE

The next World Conference on Earthquake Engineering (2028) will be hosted in Montréal! Congratulations to the CAEES team who successfully prepared for and presented the CAEES's bid in Milan!

Following the release of the CAEES earthquake reconnaissance team's report regarding the February 2023 earthquakes in Turkey, the team will present its findings in a CAEES Webinar this month. You can find the details in the "Upcoming Events" section of the Newsletter and the CAEES website.

In Code Corner, we take a look at CSA S6.1's guidance for abutment-backfill interaction in the earthquake-resisting system of a bridge structure.

And our feature article for this issue covers a project in the Metro Vancouver area that is generating region-specific seismic hazard maps that capture local earthquake site effects, including regional ground motion amplification hazard, and liquefaction and landslide hazard potentials.

Our Newsletter is a great way to share short articles, news or other items related to earthquake engineering with your colleagues. Please send your contributions to secretary@caee-acgp.ca

Code Corner

by Juan-Carlos Carvajal

Abutment-backfill interaction represents a component of the earthquake-resisting system of a bridge structure. Therefore, a proper determination of the force-displacement characteristics is fundamental for determination of the seismic demands in the bridge structure.

The Commentary on CSA S6.1:19 includes two formulations for estimating the lateral stiffness and resistance of abutment systems using lumped soil springs.

The first formulation is from Caltrans (2013) and represents a linear elastic-perfectly plastic force-displacement curve as shown in the Figure below (see next page), where H is abutment height.

This formulation was obtained from a full-scale test carried out at the University of California Los Angeles (UCLA, 2007), which had the following characteristics:

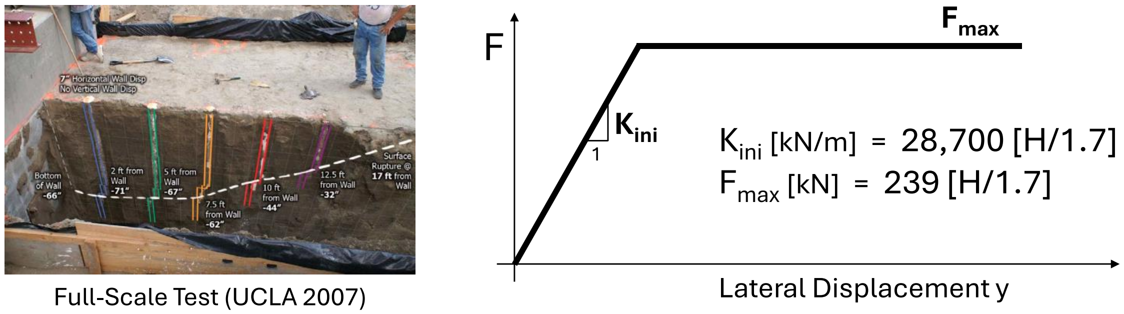
- Abutment height H = 1.7 m. The test was intended to represent the backwall-backfill interaction of stub abutments under the assumption that the backwall will detach from the abutment after pounding with the bridge deck in seismic loading.
- Pure translational static pushover. The displacement of the top and the base of the wall was the same. No lateral acceleration was included in the backfill to simulate seismic loading.

Code Corner… *Continued from Page 1*

- Backfill consists of silty sand with effective cohesion C = 14 to 24 kPa, friction angle, Φ = 40°, and dilation angle, Ψ = 10°.

The limitations of this formulation for seismic analysis of bridges in Canada are:

- Abutment height H ≤ 1.7 m. Single, medium span bridges are supported on abutments that are up to 6 m high, and full-height integral abutment bridges are up to 10 m high. Therefore, the Caltrans formulation cannot be applied to these types of bridge abutments.
- The abutment backfills used in Canadian practice consist of sand and gravel, whose mechanical properties differ from those of the silty sand used in the 2007 UCLA full-scale test.
- The reduction of the stiffness and passive resistance of the backfill in seismic condition is not considered in the Caltrans (2013) formulation. Therefore, the model is fundamentally applicable to static conditions, even though it is used in practice for seismic conditions as well; and
- The linear elastic part of the model underestimates the abutment-backfill resistance for small levels of displacement, which overestimates the displacement demands in the bridge structure for small levels of earthquake shaking.



$$K_{ini}\ [\mathrm{kN/m}] = 28{,}700\ [H/1.7]$$

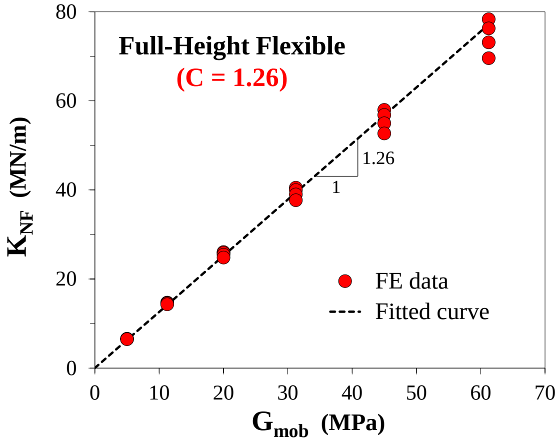
$$F_{max}\ [\mathrm{kN}] = 239\ [H/1.7]$$

Full-Scale Test (UCLA 2007)

Linear elastic-perfectly plastic abutment model (Caltrans 2013)

The second formulation is a linear approximation of the abutment-backfill stiffness K_{NF} based on the mobilized secant shear modulus (G_{mob}) of the approach embankment for the design earthquake and it is valid for small abutment displacements in either pure rotation (full-height integral abutment bridges) or pure translation (stub abutment) for abutments up to 10 m high (Carvajal 2011) as shown in the Figure below.

This formulation considers the degradation of the shear modulus with the mobilized shear strain during seismic loading, but it does not consider the passive resistance of the backfill. Therefore,



$$K_{NF}\ [\mathrm{kN/m}] = C\ G_{mob}\ W$$

Rotation		Translation	
Full-Height Abutment		Stub Abutment	
Flexible	Rigid	h = 2 m	h = 3 m
1.26	0.94	0.96	1.16

(CSA S6-19 Commentary)

Equivalent-Linear abutment model (Carvajal 2011)

Code Corner... *Continued from Page 2*

this model tends to overestimate the abutment stiffness and the acceleration demands in the bridge, and underestimate the relative displacement of the structure for strong shaking levels.

The mobilized shear modulus of the approach embankment is obtained either using 1D site response analysis or response spectrum-based seismic response analysis of bridge embankments (Carvajal 2020).

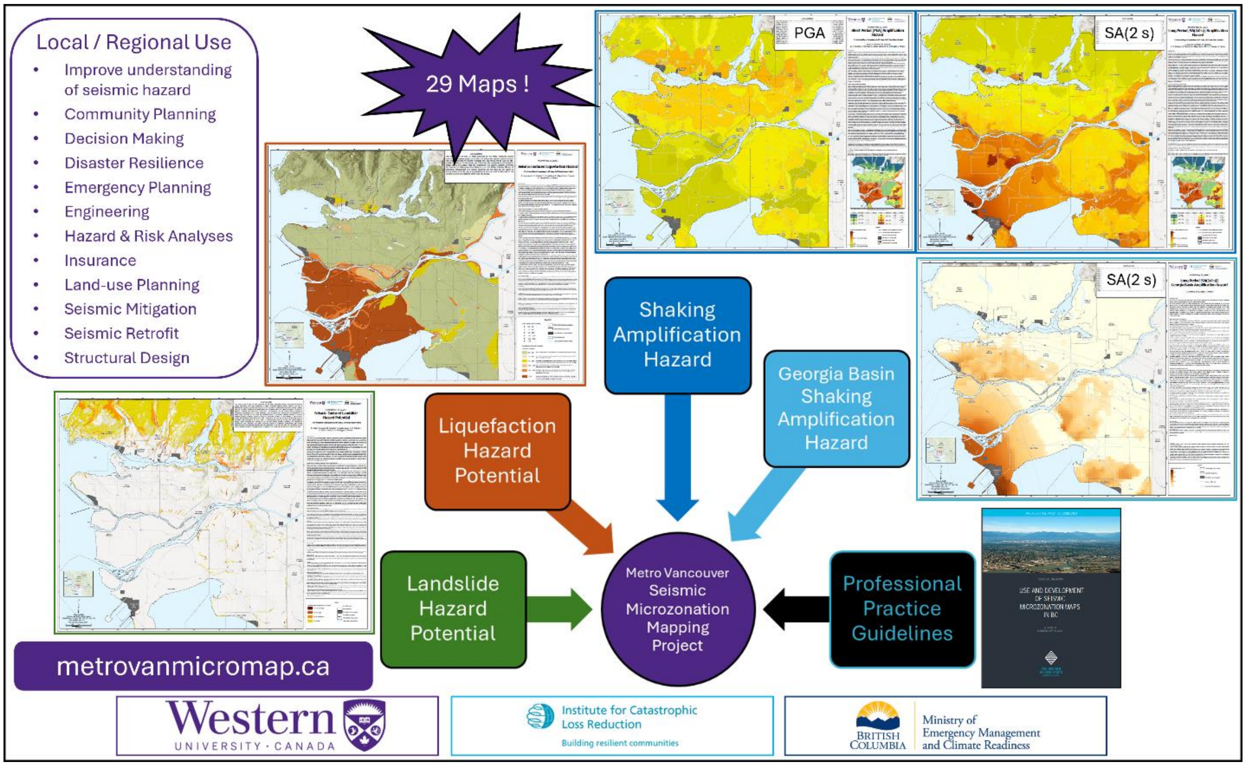
In this regard, the Ministry of Transportation Ontario (MTO) is conducting a research study to develop a hyperbolic abutment-backfill model that overcomes the limitations of the models included in the Commentary on CSA S6.1:19 and that can be easily implemented in bridge design.

The MTO research study includes advanced laboratory testing for determination of strength and stiffness properties of the sand and gravel backfill material, determination of the friction coefficient between the backfill and the abutment, and finite element simulations using an advanced soil model and static and pseudo-static pushover analysis for abutments from 1 m to 10 m high in pure translation and pure rotation. The study will be completed in 2025.

Updates on the Metro Vancouver Seismic Microzonation Mapping Project

by Sheri Molnar

The goal of the Metro Vancouver seismic microzonation mapping project is to generate region-specific seismic hazard maps that capture local earthquake site effects, specifically earthquake shaking inclusive of 1D site and 3D sedimentary basin effects and seismic-induced liquefaction and landslide hazard potential (see Figure below).



The Metro Vancouver seismic microzonation mapping project's first package of 29 seismic susceptibility and hazard maps of western Metro Vancouver are set for release.

Metro Vancouver Seismic Microzonation… *Continued from Page 3*

This near decade (2017–2026) project is led by Associate Professor Sheri Molnar at the University of Western Ontario in collaboration with the Institute of Catastrophic Loss Reduction and supported by the British Columbia Ministry of Emergency Management and Climate Readiness. The prediction of earthquake ground motion inclusive of local site effects and the potential for seismic triggering of liquefaction and landsliding across Metro Vancouver is a multi-faceted technical challenge that was tackled by developing a comprehensive regional geodatabase of subsurface seismic site conditions to achieve probabilistic seismic, liquefaction, and landslide hazard analyses at 2% and 10% probabilities of exceedance in 50 years using the 6th Generation National Seismic Hazard Model that was used in the 2020 Edition of the National Building Code (NBC) of Canada.

The project is **releasing the first suite of 29 seismic microzonation maps** that improves understanding and communication of regional seismic site conditions (e.g., post-glacial and glacial sediment thickness, site period, Vs_{30}), region-specific shaking amplification hazard (at six spectral periods), and liquefaction and landslide hazard potential at the two chosen probabilities of exceedance. The project's website (*https://metrovanmicromap.ca/*) will host an open data portal with access to this first suite of 29 seismic microzonation maps of western Metro Vancouver. Each map is produced as a traditional map sheet with explanatory text that can be downloaded and printed. The project team has also prioritized sharing of the maps in digital form via an online map viewer accessed from the project's open data portal that allows GIS-based interaction with the maps (e.g., zooming, toggling of layers) in combination with simplified explanation. Users will also be able to download the map sheet and it is associated GIS-layer package at the project's open data repository (*https://borealisdata.ca/dataverse/MVSMMP*).

This summer, the project's sixth 30-day field campaign of multi-method non-invasive seismic testing was accomplished by Molnar and field manager Natalia Gómez Jaramillo with four graduate students and one undergraduate student. Single-station microtremor method testing was accomplished at 433 locations across Pitt Meadows, Maple Ridge, and Langley to measure amplification spectra and site resonance frequencies. More detailed active- and passive-source surface wave array testing was accomplished at 42 select locations (an example is shown in the Figure below) to obtain Rayleigh wave dispersion curves for shear-wave velocity (Vs) profiling by depth, and to resolve any major seismic impedance contrast(s) in the upper hundred(s) of metres. These data will supplement the regional geodatabase under development for eastern Metro Vancouver to accomplish earthquake shaking amplification, and liquefaction and landslide hazard potential mapping. The suite of seismic microzonation maps for these eastern Metro Vancouver communities are expected to be released by 2026.

Molnar (left), PhD student Benjamin Fordjour (right) and the project's field manager Natalia Gómez Jaramillo (seated) review seismic shot gathers at an array site in Maple Ridge.

CAEES
Dept. of Civil Engineering
Univ. of British Columbia
2324 Main Mall
Vancouver, BC,
Canada V6T 1Z4
Fax:
604-822-6901
E-mail:
secretary@caee-acgp.ca

We're on the Web!

Visit us at:

http://caee.ca

News

NGA-Subduction Ground Motion Time Histories Available Online

The UCLA is hosting the full NGA-Subduction Database online. The data includes an Excel ground-motion tool as well as various flatfiles containing response spectra for all three components of ground motion, metadata, Arias Intensity, duration, etc. The NGA-Subduction Web Portal provides access to the recorded and processed time histories, comprised of over 70,000 three-component ground motion records from subduction zones around the world.

You can follow the link below to access this dataset:

https://www.risksciences.ucla.edu/nhr3/nga-subduction

News and Upcoming Events

Below, we provide some information on upcoming events related to earthquake engineering and seismology. Please send us any events you would like highlighted here.

Upcoming events

CAEES Webinar: Lessons Learned from the February 6, 2023 Earthquakes in Türkiye
30 October 2024
Online at 12:00pm PT / 3:00pm ET
caee.ca

15th General Assembly of the Asian Seismological Commission
3 – 7 November 2024
Antalya, Türkiye
asc2024.org

2024 COSMOS (Consortium of Organizations for Strong Motion Observation Systems) Technical Session and Annual Meeting
14 – 15 November 2024
Oakland, CA (also available online)
strongmotion.org/technicalsessions/

US National Disaster Resilience Conference
20 – 22 November 2024
Clearwater Beach, FL
nationaldisasterresilienceconference.org/

American Geophysical Union (AGU) Annual Meeting
9 – 13 December 2024
Washington, DC
www.agu.org/annual-meeting

Seismological Society of America 2025 Annual Meeting
14 – 18 April 2025
Baltimore, MD
meetings.seismosoc.org/