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

NEWSLETTER

January 2020
Volume 5, Issue 1

http://caee.ca/

Inside This Issue

From the Editor's Desk

by Tuna Onur

Non-structural components typically comprise three quarters of a building's cost of construction, and pose significant risk of injuries and even loss of life during earthquakes. Therefore, finding safe and practical solutions to seismically secure non-structural components is important. In this issue, we bring this topic to your attention and potential improvements to be considered in the way non-structural components are seismically restrained.

In 1997, an earthquake occurred under Georgia Strait in southwestern BC. While it had a moderate magnitude (ML4.6), this was a significant Canadian earthquake because it helped reveal a previously unknown fault beneath the Strait of Georgia between Vancouver Island and the Lower Mainland. Read the "Earthquake Waves" column to find out more.

The 2015 Edition of the National Building Code (NBC) of Canada introduced the most comprehensive guidance to date on selection and scaling of ground motion time histories. We outline a summary of these guidelines in "Code Corner".

Also, NBC 2020 is reaching the end of its development cycle and is currently open for public review. See our "News" column to see how you can participate in the public review process.

As always, we encourage you to share short articles, news items or event announcements to be published in the CAEE Newsletter. Please send your contributions to secretary@caee-acgp.ca

Seismic Restraints of Non-structural Components

Contributed by Ralph Watts

The current practice for seismic restraints of non-structural components is not working well. It is expensive and often fails to achieve the desired results, particularly if T-bar ceilings are used. There can be a multitude of services above a T-bar ceiling: air ducts, diffusers, plumbing, sprinklers, electrical lines, lights, etc. These, along with the T-bar ceiling and the tops of any partitions, are to be laterally restrained for seismic forces. Each sub-trade hires its own engineer for their restraints.

Some of the problems with current practice are as follows: (1) there is a lack of co-ordination; (2) engineers are often selected on price or availability rather than ability, and (3) each engineer is required to visit the site and file the appropriate paperwork.

While this last requirement may not be too onerous for a new building, it is expensive when renovating a single suite, where three or more engineers can be involved.

Seismic Restraints of Non-structural Components… *Continued from Page 1*

The first two problems manifest themselves in a variety of ways. First, as price is a key factor, generic details showing vertical and lateral restraints going to anchor points in the floor or roof above are often referenced. They do not show (1) all the obstructions in the way and (2) problems with anchorage points. In the case of obstructions, the lines or struts are either omitted, or attached to or bent around other items such as ducts, etc., that are in the way. However, these ducts will not have been designed for the new loads because they were not known at the design stage. The problems with the anchorage points can include poor access, or fireproofing, which might contain toxic substances that will need to be removed, and whether it is properly reinstalled or not afterwards. Should fire resistance be undermined for seismic resistance? Some very light items (e.g. new LED lights) do not require a lot of restraint, but others are quite heavy.

Even when theoretically possible to get all the anchors in, it is often not practical as the upper ends of the anchors may need to be installed before the ducts, plumbing, etc. block access. As well, in many cases anchor points should be done before the fire-proofing. If all the restraint lines manage to be installed, future maintenance, in some cases, becomes practically impossible. There can be so many ties and struts that it is often difficult to find a ceiling panel that can be moved, let alone one to access the needed area. Lines will be cut to gain access and it is doubtful they will be restored properly after the job is complete. The net result is poorly done restraints, difficulty in accessing the equipment, and excessive damage when an earthquake strikes.

"On new buildings, seismic restraints should be taken seriously from the start."

So, what should be done? There are several possibilities:

1. On new buildings, seismic restraint should be taken seriously from the start. It may be necessary to add extra struts or attachment points so connections can be made later, once the services are in place.

2. Have a single engineer design all the seismic restraints in an area, e.g., the T-bar ceiling and above. The goal should be to get the best seismic resistance possible while allowing for future maintenance. Given the numerous field reviews that will be necessary, this should be done by a local engineer where possible.

3. Have engineers only sign off on life-safety restraint of items where appropriate. While full seismic restraint should be possible in many new buildings and definitely done in post-disaster structures, a lower standard of life safety makes more sense in less-significant structures and renovations. Placement of mechanical and electrical services should be based on functional requirements, not seismic restraint; we should not have the tail wagging the dog. Does it make sense to spend $300 to fully restrain a $200 light, or is it better to risk having to replace it? In California, some wine tanks failed the same way in two different earthquakes. The owners figured it was cheaper to accept the damage periodically than restrain the tanks. This trade-off is often more complicated; consideration should be given not just to the cost of replacing the fixture, but also to water damage, lost productivity, etc.

4. Allow for an integrated approach to reducing damage. In some cases, it would make more sense to better restrain the T-bar ceiling or some ducts and then laterally restrain other

Seismic Restraints of Non-structural Components… *Continued from Page 2*

items to these elements. This should be a simple calculation so the designs can be done quickly and efficiently.

5. Allow the Authority having Jurisdiction to ban firms and engineers who have done shoddy work in the past. Some engineers just do not get the basic concepts. For example, lights near objects need to be either free to swing without hitting anything or restrained in all directions. Restraints on one side only (see the Picture to the right) do not work; the light can swing towards the restraint and on the return swing the line comes taut when the light has its maximum kinetic energy. This can snap the line, damage the fixture or pull the anchor. There is no excuse for leaving out the short lines to the truss.

Code Corner

by Tuna Onur

The 2015 Edition of the National Building Code (NBC) of Canada introduced, in its Structural Commentaries, an Appendix detailing guidelines on selection and scaling of ground motion time histories to be used in dynamic analyses. The Appendix constitutes the most detailed guidance thus far by NBC on ground motion time histories.

The target spectrum is the same as the design spectrum specified in NBC 2015 for periods 0.5s and longer. For shorter periods, the target spectrum is defined as:

S(T) = F(PGA) x PGA for T = 0 s,

S(T) = F(0.05) x Sa(0.05) for T = 0.05 s,

S(T) = F(0.1) x Sa(0.1) for T = 0.1 s,

S(T) = F(0.2) x Sa(0.2) for T = 0.2 s, and

S(T) = F(0.3) x Sa(0.3) for T = 0.3 s.

PGA (peak ground acceleration) and Sa(0.2), the spectral acceleration at 0.2s, are available in Table C-3 (Seismic Design Data for Selected Locations in Canada) in Appendix C of NBC 2015. The site coefficients, F(PGA) and F(0.2) can be found in Tables 4.1.8.4.-H and 4.1.8.4.-B, respectively, of NBC 2015. The rest of the F(T) values listed above, F(0.05), F(0.1), and F(0.3) are not specified in NBC. They can be found instead in Table J-4 (Paragraph 181 of the Structural Commentaries). Similarly, Sa(0.05), Sa(0.1), and Sa(0.3) are not specified in NBC. Instead, they can be obtained from the Geological Survey of Canada by using the “Hazard Calculator” at the following link: https://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index-en.php

For the purposes of selecting and scaling ground motions, a period range is defined. The upper-bound period must be greater than or equal to twice the first-mode period, but not less than 1.5s.

Code Corner… *Continued from Page 3*

And the lower-bound period should be established such that the shortest period is included from all modes of vibrations that are necessary to achieve 90% mass participation, but should not be more than 0.15 times the first-mode period.

Appropriate ground motion time histories should be selected based on the tectonic regime, and the magnitudes and distances that significantly contribute to the seismic hazard at the site. Geotechnical conditions should also be considered, including the soil profile. The shapes of the response spectra of the selected motions should be similar to that of the target spectrum in the period range of interest. Recorded ground motions are preferred; however, in places where adequate number of recorded motions is not available, ground motions simulated using a seismological model may be used as alternative. If possible, the ground motions should be selected from at least two different earthquakes. Also, where possible, no more than two ground motion records from the same earthquake should be selected.

There are two broad methodologies described in the guidelines for determining the target spectrum.

Method A specifies a single target spectrum that can be covered by more than one suite of ground motion time histories if different types of earthquakes are dominating the hazard at different period ranges.

Method B allows defining two or more site-specific scenario target spectra. Two different ways to derive site-specific scenario target spectra are described in the guidelines.

According to Method B1, target spectra are created for each dominant earthquake magnitude-distance combination and/or for each tectonic source that contributes to the hazard as indicated by a hazard deaggregation. In Method B1, the envelope of the scenario target spectra should be no less than the design spectrum, S(T) as defined above.

According to Method B2, target spectra are created for periods that correspond to the modes of vibration that significantly contribute to the dynamic response of the building. Lengthening of the elastic periods due to anticipated inelastic response also has to be accounted for when selecting the periods. The scenario target spectra should be representative of spectral shapes for the dominant magnitude-distance combinations indicated by the hazard deaggregation. Conditional mean spectra (CMS) may be used as scenario target spectra. In Method B2, for each period selected, the scenario target spectrum must match or exceed the design spectrum, S(T). Elsewhere the envelope of the scenario target spectra should not fall below 75% of the design spectrum.

Total number of records in all suites of ground motion time histories should not be less than 11. If more than one suite of records is being used to represent different types of earthquakes, minimum number records in each suites should be five when using Method A; however when using Method B1 or B2, using fewer than 11 records per suite is only permitted when the number of records for each suite is not less than five, and the number of records is approved by a peer review panel.

Response spectral amplitudes of the selected ground motion records should be computed at period increments of no more than 0.02s over the period range of interest.

The mean response spectrum of the suite should not be less than 90% of the target spectrum over the period range of interest. Caution should be exercised when excessively low or high scaling factors are required (e.g., less than 0.5 or larger than 4.0) as this may suggest that the ground motion is not compatible with the source mechanisms or seismic hazard level considered.

Frequency-domain and time-domain spectral matching techniques intended to closely match the target spectrum are not recommended but allowed to be used with caution. However in this case, the mean response spectrum of the suite should not be less than 110% of the target spectrum over the period range of interest.

Earthquake Waves

by John Cassidy

In this issue, I bring to your attention another "retro" Canadian earthquake of significance. The 1997 ML 4.6 earthquake beneath the Strait of Georgia, midway between Vancouver and Nanaimo (Vancouver Island), was important for a number of reasons as described below, especially in its numerous applications as a "scenario event" (a much larger but fictitious M7.3 earthquake at this location) for preparedness and planning purposes.

The thing that I remember most about this earthquake? I didn't feel it! Likely because I was in the kitchen with three young children running around. I was alerted to the event by my wife running downstairs to tell me that there had been a big earthquake!

The June 24th, 1997 ML 4.6 Georgia Strait earthquake struck at 7:40 a.m. local time and was felt across most of southwestern British Columbia, from Campbell River, BC in the north to Seattle, WA in the south, and as far east as Abbotsford, BC. It caused some minor damage (broken glass and a broken water pipe) in Vancouver, and some power outages. It was unusual and interesting for several reasons: 1) it was preceded by a felt (M 3.4) foreshock 11 days earlier; 2) it was a rare, very shallow (<6 km) earthquake; 3) it was followed by hundreds of small aftershocks; and 4) it occurred at the same location as a shallow M 4.9 earthquake in 1975, suggesting that there may be an active fault at this site.

There were more than a hundred small aftershocks and, with seismic stations providing excellent azimuthal coverage and new processing techniques (such as waveform cross-correlation), very precise locations (+/- 100's of m's) could be determined for these earthquakes, revealing a small northward dipping fault beneath the Strait of Georgia. The focal mechanism for this earthquake was thrust faulting along a northward-dipping plane, in agreement with the precise aftershock relocations.

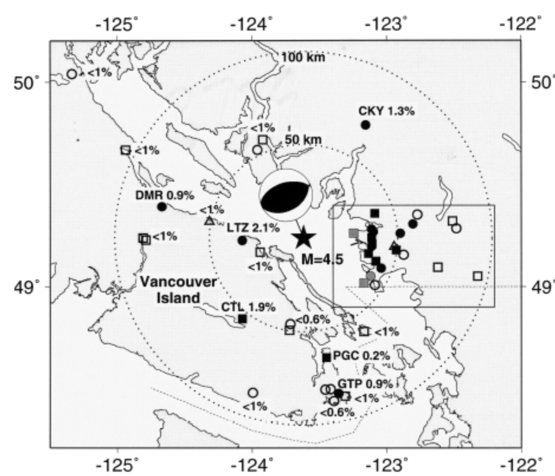
Following this earthquake, high-resolution marine imaging was conducted in the area. No evidence for surface (sea-floor) rupture was found, but seismic reflection data showed interesting distortions within the sedimentary sequences at depth in this region.

Recordings of this earthquake collected across the greater Vancouver area proved useful for estimating local site effects - and revealed that the strongest shaking was along the north arm of the Fraser River (as observed in other moderate earthquakes), perhaps indicating basin edge amplification effects in this area.

This earthquake has been used numerous times as a "scenario earthquake" for planning and preparedness purposes. At M 4.6 it is too small to cause any significant damage, so most of the scenarios considered an earthquake of M 7.3 - the largest known crustal earthquake in southwestern British Columbia (beneath central Vancouver Island in 1946) but at the location of the 1997 event.

Finally, this rare, shallow earthquake sequence raised the question "Where else can shallow, crustal earthquakes occur in southwestern British Columbia?", and has helped to encourage studies of faults (both on land and beneath the seafloor) in this region.

A report on the ground motions recorded from this earthquake (largest PGA was 0.024g) can be found at the following link: *http://ftp.geogratis.gc.ca/pub/nrcan_rncan/publications/ess_sst/209/209892/of_3599.pdf*



CAEE
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 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 March 15 to secretary@caee-acgp.ca to get them included in the April Newsletter.

News

2020 Public Review of National Building Code (NBC) of Canada

Final public review of proposed changes to the 2015 Edition of the NBC is open from January 13 to March 13, 2020.

The public review process provides all stakeholders with the opportunity to see the changes being considered and to offer comments. Each comment will be reviewed by the responsible standing committee. The final changes, after approval, will go into the 2020 Edition of NBC. To participate, follow the link below:

https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-development-process/public-review-proposed-changes-codes-canada-publications-winter-2020

Upcoming events

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/

International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics
13-16 July 2020
Bangalore, India
7icragee.org/

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