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From the Editor's Desk

by Tuna Onur

On September 28, Indonesia was hit, once more, by a devastating earthquake (Mw7.5) and tsunami. While Indonesia was equipped with a tsunami alert system after the 2004 Sumatra earthquake and tsunami, the alert system severely underestimated the tsunami wave heights. More than 70,000 buildings were damaged killing more than 1,000 people, many of them in areas of 2-3m high waves, highlighting how destructive tsunamis can be, even when the wave heights are a few metres.

Canada's coastal communities should take note! All of Canada's coasts are prone to tsunamis, and even modest waves can cause devastation as evidenced by the September tsunami in Indonesia and other recent tsunamis around the world.

Building-related Seismic Risk in Eastern Canada

by S. K. Ploeger, University of Ottawa

Within eastern Canada, there are regions that exhibit moderate-to-high seismic hazard due to large crustal weaknesses (i.e. Iapetan rift structures) that exist along the St Lawrence and Ottawa River Valleys, which have produced several +M6.5 earthquakes in the past. There are an estimated 7.3 million people who reside along these rift structures in the Toronto-Quebec City corridor; herein referred to as the rift-urban-corridor (RUC). Additionally, there are 3,525 census units (e.g. dissemination areas) with an estimated 2.2 million buildings that intersect the RUC.

A combination of general neighbourhood characteristics (e.g. geographic area, population, land use) and sampled building inventories can be used to infer representative building information for geographic areas/units with similar characteristics. With this, building distributions using sampled inventory information were assigned to census units with similar features across the RUC.

This approach can be useful in highlighting building-related seismic risk in eastern Canada. Common building and neighbourhood vulnerabilities are briefly reviewed below.

First, buildings built before 1970 generally have low earthquake protection as pre-1970 building codes adopted in eastern Canada have few seismic provisions. Data from Census Canada's National Household Survey allows for the estimation of the census unit's relative building age as either before or after 1960; 1970 falls within the 1960-1980 range. Of the 3,525 census units within the RUC, almost a third of them (n=1,133) were constructed before 1960; this encompasses roughly ~497,000 buildings.

Second, downtown cores magnify seismic risk for several reasons including (1) the densification of neighbourhoods and (2) the concentration of historical buildings. Using the above selection (pre-1960 census units in the RUC), 50% (n=565)

Building-related Seismic Risk… *Continued from Page 1*

are located in communities with populations greater than 30,000 and ~35% (n=394) with populations greater than 100,000; that is ~271,000 and ~226,000 buildings respectively. In the most dense urban census units (n=241; population density > 1,000 people/km²; i.e downtown cores and commercial strips), there is approximately 105,000 buildings. Of these, an estimated 19% are unreinforced masonry and 56% are older wood-framed buildings - many of the wood buildings may have non-structural masonry elements. Based on the above parameters, there could be as many as 78,750 buildings in the RUC that are in pre-1960 densely populated urban core neighbourhoods with vulnerable masonry elements.

Third, the preponderance of mid- and high-rise concrete buildings in urban neighbourhoods also presents a unique seismic risk with respect to the possibility of a mass casualty building failure; notably in pre-1970 buildings and/or those with vertical irregularities. In the Ottawa inventory, the number of mid- to high-rise concrete buildings with a vertical irregularity is 556, of which 33% (n=185) were constructed before 1970. Of the noted vertical irregularities, the majority are soft storey.

This information can be used to facilitate informed decision making with regard to broad risk assessment activities and the identification of areas with increased building-related seismic risk. This information can ultimately support proactive decision making to reduce future losses and increase both resilience and earthquake protection within the RUC.

OFCs - A Historical Brief of US-Canadian Technical and Legal Framework for Earthquake Resistant Design

by Ghyslaine McClure and Effie Bouras, McGill University

Building codes including design provisions for structural integrity during seismic events have been in place in the US since early 20th century. American seismic codes commenced with the publication of a simple lateral design method, which was included as a voluntary appendix in the 1927 Uniform Building Code (UBC); legal enforcement of which was made compulsory in California after the 1933 Long Beach earthquake. Canada's seismic regulations for buildings, started with the National Building Code (NBC) of Canada in 1941, which mirrored the seismic related contents of the 1937 edition of the UBC; with later editions expanding the seismic scope (*Heidebrecht, 2003*).

Provisions for seismic design of operational and functional components (also termed OFCs, or non-structural components) in both Canada and the US, however, have been slower to adopt. Legislation regarding the safety of OFCs in the US was introduced relatively recently with the enactment of the Alfred E. Alquist Hospital Seismic Safety Act (1972) in California, as a reaction to the poor performance of buildings, including non-structural components, as a result of the 1971 San Fernando Earthquake. The Act required all newly constructed hospital buildings in California to be operational after earthquake events. The provision, outlining full functionality, naturally extended seismic design regulations to non-structural components such as HVAC and ceiling systems. Although established legislation is considered cumbersome at times, it has been noted in various studies that losses due to failure of OFCs after a significant earthquake have

OFCs – A Historical Brief… *Continued from Page 2*

decreased substantially in buildings where the legislation was enforced (*Ferner et al., 2014*).

Prior to the publication, in 1978, of the ATC-3-06 document titled "Tentative Provisions for the Development of Seismic Regulations for Buildings", methods of non-structural design were fundamentally not addressed. Most notably, the ATC-3-06 effort also outlined a system of certification for non-structural components, demanding their vetting through tests, data and analysis (*Phipps et al., 2017*).

> *"The Alfred E. Alquist Hospital Seismic Safety Act (1972) in California required all newly constructed hospital buildings in California to be operational after earthquake events"*

In Canada, provisions for the design of OFCs were introduced in the 1953 edition of the NBC, with further refinements in subsequent editions. In early editions, up until 1965, seismic force requirements were uniform for both structural and non-structural components, with the introduction of stricter force requirements for OFCs, as well as provisions for displacements and probability of occurrence (*Assi and McClure, 2015*). Currently, the CSA Standard S832-14 (2014 edition), "Seismic Risk Reduction of Operational and Functional Components of Buildings", represents a risk assessment methodology that covers OFCs for the NBC and outlines specific technical details and responsibilities for the design team. The CSA standard requires that a registered professional identify performance objectives, including defining a seismic risk index. The seismic risk index is a function of the component's vulnerability, which is determined by several factors including its restraints, potential impact with other building components and geometry, for example, and the consequence of component failure with respect to life safety and functionality.

Similarly, for the US, a registered professional (architect or engineer) is expected to determine seismic category per International Building Code (IBC) or ASCE 7 (ASCE/SEI 7-16), with state and local jurisdictions (authorities having jurisdiction), authorized for adoption of seismic codes. In some jurisdictions that have been at the forefront of OFC design, such as California, stricter policies were implemented that have influenced national codes. For example, periodic special inspections for OFCs, first developed in California, were subsequently incorporated within the 2012 edition of the IBC (*Ferner et al., 2014*).

Past credible failures of OFCs under seismic duress have formed the groundwork for increasing awareness regarding the importance of proper seismic bracing, for clarifying the legal and professional framework, and for outlining responsibilities. Further development will serve to refine responsibilities and streamline perceived procedural bottlenecks.

Assi, R. and McClure, G. 2015. *Evolution of the NBCC seismic provisions for operational and functional components in buildings, Canadian Journal of Civil Engineering.*

CSA S832. 2014. *S832-14: Seismic risk reduction of operational and functional components (OFCs) of buildings. Canadian Standards Association (CSA).*

Ferner, H., Wemyss, M., Baird, A., Beer, A., Hunter, D. 2014. *Seismic performance of non-structural elements within buildings. Proceedings of the New Zealand Society for Earthquake Engineering Conference.*

Heidebrecht, A. C. 2003. *Overview of seismic provisions of the proposed 2005 edition of the National Building Code of Canada. Canadian Journal of Civil Engineering.*

Phipps, M., Gillengerten, J., Lizundia, B., Medina, R., Miranda, E., Pekelnicky, R. 2017. *Improved seismic design of non-structural components and systems (ATC-120). Proceedings of the Structural Engineers Association of California (SEAOC) Convention.*

Code Corner

by Saqib Khan

As highlighted in the previous issue of the CAEE Newsletter, the new Canadian Highway Bridge Design Code (CAN/CSA-S6-14; the Code or S6-14) has incorporated the performance-based design (PBD) methodology for seismic design. The need for PBD has arisen due to inconsistencies in the force-based seismic design of structures. In addition, Owners increasingly expect their structures to be serviceable after small and moderate earthquakes. In other instances, only repairable damage may be allowed, even in case of large earthquakes. However, seismic and post-seismic structural performance cannot be explicitly quantified or demonstrated using the force-based design, which is primarily strength-based. It has been found that in recent earthquakes (for example, Christchurch, New Zealand, 2011), there was a clear disconnect between the Owner's and society's expectations and the seismic design assumptions used by designers. There has since been a push to better understand and demonstrate structural performance explicitly. PBD is the tool that allows us to articulate, understand, demonstrate, and incorporate such requirements into the seismic design of bridges.

In 2016, Engineers and Geoscientist British Columbia contracted several professional engineers who are industry experts to help produce the Professional Practice Guidelines for the Performance-based Seismic Design of Bridges in BC. The Preface to the document states:

"The guidelines will assist engineering professionals in carrying out performance-based seismic design of bridges in a consistent manner while incorporating best practices. This document has been prepared for the information of Engineering Professionals, statutory decision-makers, regulators, the public at large, and a range of other stakeholders who might be involved in, or have an interest in, performance-based seismic design of bridges."

This document is meant to provide a common level of expectation for the various stakeholders for the level of effort, due diligence, and standard of practice to be followed when carrying out PBD of bridges. The document is not meant to be a replacement for the S6-14 or the BC Ministry of Transportation and Infrastructure's Supplement (the Supplement) to S6-14. Rather, it is meant to be read in conjunction with S6-14 and the Supplement, and it provides guidance in applying them in a consistent manner.

Within the framework of PBD of bridges, various entities have different and overlapping responsibilities under different project delivery models. The responsibilities may lie with the Owner, the Engineer of Record, or the Owner's Engineer. A significant advantage of PBD lies in aligning the Owner's and the Engineer of Record's requirements and expectations early in the design process. The Engineer of Record or Owner's Engineer should be familiar with the Code provisions, inform the Owner of the different performance levels, and discuss the need and requirements for emergency response on the route after seismic events. The Owner can then decide which inputs to use.

It should be noted that the document underwent a thorough review by other leading engineers representing both the consultants and the Owners. In addition, the document underwent editorial and legal reviews by Engineers and Geoscientist British Columbia. This is a living document and will be revised as more knowledge is gained and the state of practice requires upgrades.

> *"In recent earthquakes, there has been a clear disconnect between the society's expectations and the seismic design assumptions used by designers"*

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News

Key Dates for the 12th Canadian Conference on Earthquake Engineering (CCEE)

Abstract Submission: Closed.

Abstract Acceptance Notice: 15 Nov 2018.

Registration Starts: 15 Nov 2018.

Full Paper Submission Deadline: 6 Jan 2019.

Full Paper Acceptance Notice: 28 Feb 2019.

Early Bird Registration Ends: 15 Mar 2019.

For more information, please visit the conference web site: http://www.ccee2019.org/

News and Upcoming Events

We welcome news items, announcements, and events to publish. 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

17th U.S.-Japan-New Zealand Workshop on the Improvement of Structural Engineering and Resilience (ATC-15-16)
12-14 November 2018
Queenstown, New Zealand
www.atcouncil.org/atc-15-16

AEES (Australian Earthquake Engineering Society) 2018 Annual Conference
16-18 November 2018
Perth, Australia
www.aees.org.au/aees-2018-conference-perth/

EERI 71st Annual Meeting
5-8 March 2019
Vancouver, British Columbia
2019am.eeri-events.org

SSA 2019 Annual Meeting
23 - 26 April, 2019
Seattle, Washington
https://www.seismosoc.org/annual-meeting/

7 ICEGE 2019 - International Conference on Earthquake Geotechnical Engineering
16-20 June 2019
Rome, Italy
http://www.7icege.com/

12th CCEE - Canadian Conference on Earthquake Engineering
17-20 June 2019
Quebec City, Quebec
http://www.ccee2019.org/