



NEWSLETTER

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From the Editor's Desk

by Tuna Onur

There are significant challenges involved in seismic upgrading of heritage buildings. In this issue of the CAEES Newsletter, we are pleased to highlight a landmark seismic upgrade project for a high-profile building that falls in the highest category of heritage building in Canada: the Centre Block on Parliament Hill, Ottawa.

As summer is upon us, we wish you fire- and smoke-free weeks ahead. Keep cool and enjoy the summer!

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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

Seismic Upgrade of the Canadian Centre Block Building

by David Arnold, Daniel Carson, John Sherstobitoff, Julien Koop & Carl Mohammadi

The Centre Block and Peace Tower are iconic structures located on Parliament Hill, Ottawa, above the banks of the Ottawa river and adjacent Rideau Canal (see figure below). The original Centre Block was constructed in 1866 and was destroyed by fire in 1916. A new Centre Block was constructed on the same site after the fire. The new Centre Block was completed by October 1920, and the Peace Tower by 1925.



Centre Block, Parliament Hill, Ottawa

Centre Block's seismic force resisting system consists of unreinforced load-bearing masonry walls above grade and unreinforced concrete walls below grade. Some infill masonry walls with embedded steel frames are also present. The Level 1 floor diaphragm is a reinforced concrete slab. Above Level 1, the building's floor and flat roof diaphragms are constructed of hollow terracotta tiles infilled between supporting steel beams, with a weak cementitious topping. The building's sloped roofs consist of a thin cementitious topping placed over expanded metals forms supported on structural steel framing.

The Peace Tower's primary structural elements are its four corner piers and the walls/spandrel beams that connect them intermittently over its height. The piers and walls were constructed with unreinforced concrete and an exterior wythe of sandstone masonry. The Peace Tower resists seismic loads via frame action of its corner piers and walls/spandrels.

Seismic Upgrade of the Centre Block... *Continued from Page 1*

The building is rich in heritage fabric, making it the highest category of heritage building in Canada (see figure below).



Centre Block's Confederation Hall

The mandate of the current project is to renew all building systems, including the seismic force resisting system. The project also includes the addition of a large multi-level below-grade Parliament Welcome Centre to provide a secure, enhanced visitor experience and additional functional space. The Parliament Welcome Centre excavation will primarily be in front of Centre Block but will also extend under the existing building.

CURRENT SEISMIC PERFORMANCE LEVEL AND KEY VULNERABILITIES

Ottawa is located in the Western Quebec Seismic Zone, a region of moderate seismicity. The limestone bedrock that Centre Block is founded on has an average shear wave velocity of 1,978 m/s.

Centre Block's fundamental vibration periods were estimated from an analytical model to be approximately 0.25 seconds and 0.30 seconds in the East-West and North-South directions respectively. These were confirmed through ambient vibration testing of the building. The corresponding equivalent static base shears were found to be 25% and 23% of the building weight.

A seismic assessment of Centre Block identified the following vulnerabilities:

- Its unreinforced masonry walls have less than 30% of the capacity required to resist seismic loads prescribed by the 2020 Edition of the National Building Code of Canada (NBC 2020).
- The capacity of its hollow terracotta floor tile assemblies (see figure below) to act as structural diaphragms is limited, with few areas where a complete horizontal load path can be rationalized.



Hollow Terracotta Tile Floor Assembly

- The four towers on the building's north side (see figure below) are particularly weak, with capacities that range between 8%–47% of NBCC seismic loads.



Centre Block's West Water and Ventilation Towers under construction (1918)

Seismic Upgrade of the Centre Block... *Continued from Page 2*

GOAL OF THE SEISMIC UPGRADE

Centre Block's seismic upgrade is to meet 100% of the NBC 2020 seismic performance objectives. Due to the brittle nature of its underlying unreinforced masonry structure and heritage finishes, this will require a near elastic response of the building's superstructure to the design ground motion.

SEISMIC UPGRADE APPROACH

In the rehabilitation schematic design phase, two different seismic upgrade schemes were considered. The first scheme proposed strengthening Centre Block's unreinforced masonry walls with strategic application of reinforced concrete laminations and the complete replacement of its hollow terracotta tile floor slabs. The second scheme explored using a basement level seismic isolation scheme to reduce superstructure seismic demands.

The reduction in superstructure demand afforded by the seismic isolation system resulted in the elimination of much of the strengthening work that would otherwise have been required in the fixed-based condition. Most of Centre Block's unreinforced masonry walls were found to have adequate capacity to resist the reduced seismic loads, and it became feasible to strengthen its hollow terracotta tile floor diaphragms with a thin topping only.

The large reduction in superstructure seismic force is partly due to the shape of Ottawa's seismic hazard acceleration response spectrum. At increasing periods of vibration, Ottawa's spectrum exhibits a rapid decrease in spectral acceleration demand. The relative decrease is greater than what is commonly observed in a high seismic zone spectrum (such as in Western Canada).

Each of the seismic upgrade approaches were developed to a 90% schematic design level to allow each option to be costed by the project's construction manager. It was concluded that the upgrade approach incorporating seismic isolation would be lower in cost and require less time to

complete. Seismic isolation was selected by the client.

Advanced design packages for the isolation system procurement are already released. A summary of the isolation system's key characteristics, and implementation details for the main building and the Peace Tower are provided next.

Key characteristics of isolation system

- Centre Block's seismic isolation system requires 580 bearings.
- The isolation system comprises natural rubber, lead-rubber, and flat sliding bearings.
- The maximum horizontal shear at the isolation plane was assessed through non-linear time history analysis to be approximately 3.4% of the building's superstructure weight.
- The maximum design displacement of the isolation system was specified as 115 mm.

Main building isolation system implementation details

- Centre Block's seismic isolation system requires 580 bearings.
- The isolation system comprises natural rubber, lead-rubber, and flat sliding bearings.
- The isolation plane for the main building will be located near to the underside of Centre Block's level 1 slab.
- The seismic isolation bearing layout was selected to accommodate Centre Block's existing load bearing structure of walls and columns above Level 1. The resulting bearing spacing is approximately 4 m.
- A gravity load transfer structure is required above the seismic isolation bearings to transfer building weight that is currently supported between bearing locations. Transversely post-tensioned concrete 'sandwich' beams will be used to strengthen the existing unreinforced concrete basement structure.

Seismic Upgrade of the Centre Block... *Continued from Page 3*

- The existing unreinforced concrete basement structure below the seismic isolation bearings will be strengthened with reinforced concrete laminations to provide sufficient lateral stiffness and overturning resistance.
- A below grade perimeter seismic 'moat' is required to permit unrestrained movement.

Peace Tower isolation system implementation details

- The Peace Tower will be supported on 34 seismic isolation bearings and connected to the main building's seismic isolation system. A small 'stress-relief' joint at floors above Level 1 will be introduced between the Peace Tower and Centre Block to accommodate their differing dynamic response.
- A 2 m thick suspended transfer slab will be used to transfer the weight of the Peace Tower on to its seismic isolation bearings (see figure below). This slab will envelop the Peace Tower's existing foundations and will be fully connected to the Level 1 slab of the Centre Block.

MAIN BUILDING SUPERSTRUCTURE SEISMIC UPGRADES

Some superstructure strengthening is still required. This includes strengthening of its hollow terracotta tile floors, water and ventilation towers, select load bearing walls and heavy decorative ceilings. The following subsections discuss the unique seismic

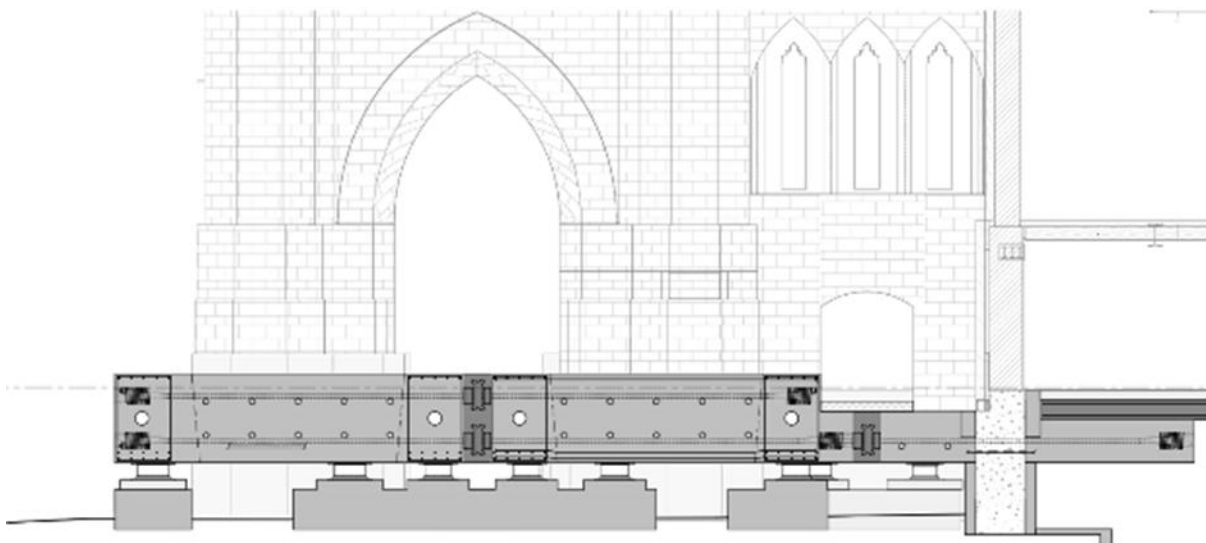
upgrading strategies chosen for these specific elements.

Hollow terracotta tile floor diaphragms

One of Centre Block's critical structural components that requires seismic upgrading is its hollow terracotta tile floor diaphragms. These floors are vulnerable to damage when subjected to in-plane (horizontal) deformations. Additionally, these floors rely on historical steel-to-steel connections, which typically have inadequate capacity to resist seismically induced axial force in combination with a vertical gravity shear force. As a result, an earthquake could jeopardize their ability to support vertical loads.

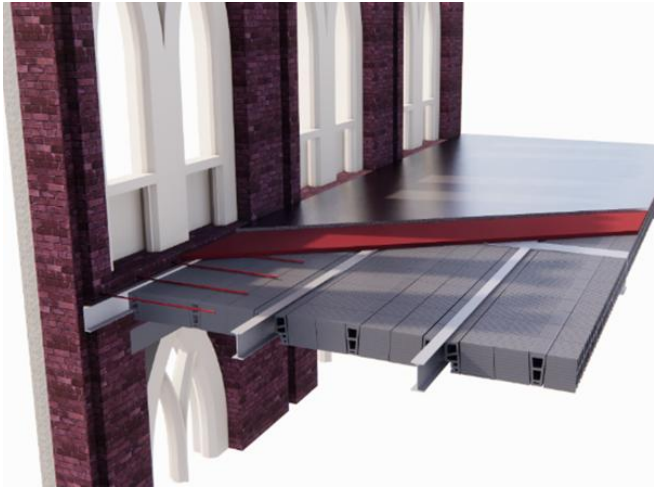
Two strengthening options were tested: 1) strengthening with a thin ultra-high-performance concrete (UHPC) topping and 2) strengthening with in-plane steel cross-bracing installed beneath the floor.

The figure on the next page illustrates the upgrade concept. The UHPC topping, applied directly to the topside of the existing hollow terracotta floor tiles will be 60 mm thick, improving both its in-plane shear capacity and in-plane stiffness. Reinforcing steel bars, drilled and epoxied into the adjacent masonry walls will provide a diaphragm shear connection as well as out-of-plane wall restraint. Banded reinforcing steel within the UHPC topping will address diaphragm chord and collector forces.



Peace Tower Transfer Slab

Seismic Upgrade of the Centre Block... *Continued from Page 4*



UHPC topping diaphragm upgrade

Water and ventilation towers

Centre Block's four water and ventilation towers, located along its north facade, are vulnerable to damage in a seismic event. These towers have previously required emergency repairs due to deep cracks at their corners. The towers also have inadequate connection to the main building's floor diaphragms and insufficient seismic overturning resistance.

To address these vulnerabilities, a 350 mm thick interior reinforced concrete lamination was chosen as the preferred upgrade option for the towers. This upgrade option also permits a relatively simple solution to the deficient diaphragm connections to Centre Block's floors.

Load bearing masonry walls

With implementation of a seismic isolation system, most of Centre Block's unreinforced masonry walls have adequate lateral capacity. However, at a few select locations, some walls require strengthening due to their low axial load and high geometric aspect ratio. This deficiency will be addressed by installing vertically drilled anchors from the tops of the walls into the level 1 beams above the isolation plane. In addition, improved wall-to-floor diaphragm connections will allow force redistribution as necessary, providing additional protection to the most vulnerable walls.

PEACE TOWER SUPERSTRUCTURE SEISMIC UPGRADE

In addition to its seismic isolation, the Peace Tower requires strengthening to withstand NBC 2020 seismic loads. This includes drilling and post-tensioning its existing piers and spandrels to increase their bending capacity. For the piers, this will require core drilling 50 m deep holes (beginning at approximately the clock level) and grouting in post-tensioned rods. Similarly, the spandrels will be drilled horizontally and post-tensioned to increase their bending capacity and connection to the piers.

SUMMARY

The seismic upgrade of Centre Block presents a unique challenge due to the historical materials used in its construction and its sensitive heritage finishes. However, with the application of seismic isolation and an innovative concrete material to strengthen its floor diaphragms, a seismic performance level equivalent to, or better than, the current new building standard is expected to be achieved. This will be a unique application of seismic isolation in a moderate seismic zone requiring a novel isolation system design. Both the maximum isolation system base shear and lateral displacement will be considerably smaller than what is typically seen in high seismic zone applications.

Centre Block's overall rehabilitation design is still in progress; however, there is much advance structural work already under way. This includes the strengthening of Centre Block's Level 1 slab in preparation for the excavation below the building, construction of the Peace Tower's transfer slab and production of the seismic isolation bearings.

The Centre Block's seismic upgrade design is a collaborative effort involving WSP Canada, Ausenco, Seismic Isolation Engineering (SIE), and Forell/Elsesser Engineers. The scaled time histories for the analysis have been provided by Onur Seemann Consulting, Inc. WSP also acknowledges the continued support of our client, Public Services and Procurement Canada and the ongoing participation of our joint venture partner, HOK.

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News

EERI Webinar Series on the 2025 Mw7.7 Myanmar Earthquake

Earthquake Engineering Research Institute (EERI) is hosting a two-part series of webinars to share observations from the 28 March 2025 Mw7.7 Myanmar earthquake.

The first webinar will be held on Thursday, July 31st and the second on Wednesday, August 6th. The webinars are free but require registration. To register for the first webinar, follow this link:

us02web.zoom.us/webinar/register/WN_Rsv38saHTAeQGo11TKolZA#/registration

To register for the second webinar:

my.eeri.org/events/event-details/?id=4bf98faf-e760-f011-95f3-0022484cc592&reload=timezone

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 to see highlighted here.

Upcoming events

19th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures

15 – 19 September 2025

Berkeley, CA

19wcsi.org/

Environmental Seismology: Earth's Surface and Subsurface Hazards, Dynamics and Resources

14 – 18 October 2025

Denver, CO

www.seismosoc.org/environmental-seismology/

CRESCENT (Cascadia Region Earthquake Science Center) Annual Meeting

28 – 29 October 2025

Seattle, WA

cascadiaquakes.org/2025/01/22/october-2025-annual-meeting/

Geo-Extreme 2025

2 – 5 November 2025

Long Beach, CA

www.geo-extreme.org/

Seismological Society of America 2026 Annual Meeting

14 – 18 April 2026

Pasadena, CA

meetings.seismosoc.org/

13th US National Conference on Earthquake Engineering

13 – 17 July 2026

Portland, OR

13ncee.eeri.org/