Canadian Conference - Pacific Conference on Earthquake Engineering 2023
Vancouver, British Columbia
June 25th – June 30th, 2023

Seismic Upgrade of the Canadian Parliament Building: Part 1- Project Overview

David Arnold[1], Daniel Carson[2]

[1]WSP Canada
[2]WSP Canada

ABSTRACT

Centre Block, Canada's heritage designated federal parliament building, was constructed in 1916 after fire destroyed an earlier building of the same name that occupied the site. The building is currently undergoing a major rehabilitation that includes conservation of its heritage fabric, modernization of its mechanical and electrical systems, enclosure of its interior light courts with glass roofs, the addition of a large multi-level below grade Parliament Welcome Centre, and a comprehensive seismic upgrade. This paper provides an overview of the existing building along with a summary of its current seismic performance level, key vulnerabilities, and goals of its seismic upgrade.

Keywords: seismic upgrade, unreinforced masonry, heritage.

INTRODUCTION

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 1). 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.

Figure 1: 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. 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 Level 1 floor diaphragm is a reinforced concrete slab. 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 main 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.

Figure 2: Centre Block's Confederation Hall

The building is rich in heritage fabric, making it the highest category of heritage building in Canada (see Figure 2). The mandate of the current project is to renew all building systems, including the seismic force resisting system, to extend its service life for another 100 years. 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 (refer Figure 3) will primarily be in front of Centre Block but will also extend under the existing building to provide below grade access to the building's interior light courts.

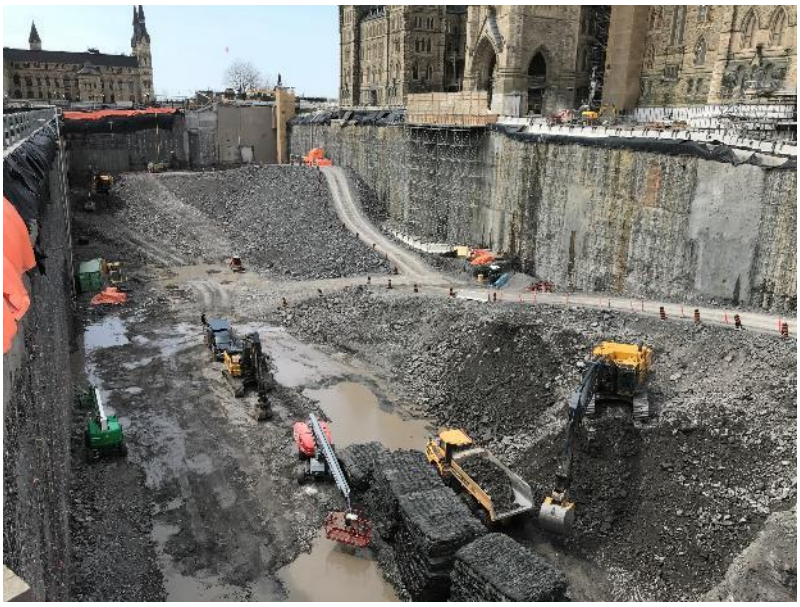

Figure 3: Centre Block's Parliament Welcome Centre excavation, April 2023

CURRENT SEISMIC PERFORMANCE LEVEL

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 peak shear wave velocity of 1978 m/s. The resulting 2015 NBCC seismic hazard spectrum is provided in Table 1.

Table 1: 2015 NBCC Design spectral acceleration values for Ottawa, Site Class A, v_{s30}=1978 m/s

S(0.2)	S(0.5)	S(1.0)	S(2.0)	S(5.0)	S(10.0)
0.276	0.123	0.061	0.030	0.008	0.003

Centre Block's fundamental 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, determined in accordance with the provisions of the 2015 NBCC 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 2015 NBCC seismic loads.
- The capacity of its hollow terracotta floor tile assemblies (see Figure 4) to act as structural diaphragms is limited, with few areas where a complete horizontal load path can be rationalized.
- The four towers on the building's north side (see Figure 5) are particularly weak, with capacities that range between 8%-47% of 2015 NBCC seismic loads.
- The building has many operational and functional components (heavy ceiling structures etc.) that require seismic restraint (see Figure 6).

Figure 4: Hollow terracotta tile floor assembly

Figure 5: Historic photo of North Tower construction

Figure 6: The Hall of Honour's heavy vaulted stone ceiling

GOAL OF SEISMIC UPGRADE AND CURRENT PROJECT STATUS

The goal of Centre Block's seismic upgrade is to meet 100% of the 2020 NBCC seismic performance objectives. During the schematic design phase, two seismic upgrade approaches were developed: 1) a conventional approach, involving the strengthening of Centre Block's unreinforced masonry walls and the full replacement of its hollow terracotta floors and, 2) an approach incorporating seismic isolation and the strengthening of the building's floor diaphragms by application of a thin ultra-high performance concrete topping. The seismic upgrade approach incorporating seismic isolation has been selected by the client as the approach that best balances the structure requirements of the project against the functional program and heritage conservation objectives, as well as providing an improved post-earthquake performance and lower implementation cost.

The project is currently in the design development phase, with some early structural work already under construction, including the 3-storey Parliament Welcome Centre excavation and the strengthening of Centre Block's Level 1 slab in preparation for the excavation below the building and installation of the seismic isolation bearings.

SUMMARY

The seismic upgrade of Centre Block presents a unique challenge due to the historic 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.

ACKNOWLEDGMENTS

Centre Block's seismic upgrade design is a collaborative effort involving WSP Canada, Ausenco, SIE, and Forell Elsesser Engineers.

WSP acknowledges the continued support of our client, Public Services and Procurement Canada and the ongoing participation of our joint venture partner, HOK.