SEISMIC ASSESSMENT AND UPGRADE DESIGN REPORT

NORTHERN JUNK BUILDINGS

1314 - 1318 Wharf Street, Victoria, BC

Prepared for:

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TABLE OF CONTENTS

1.0 INTRODUCTION

Read Jones Christoffersen Ltd (RJC) was engaged to provide structural consulting services for the design of seismic upgrades and additions for the Northern Junk Buildings. This report summarizes the design parameters and proposed seismic upgrading work to maintain the exterior façade of the two existing heritage buildings.

1.1 DOCUMENTS REVIEWED

The following drawings were available for review:

- Architectural plans for a 4-storey addition, prepared by Boniface Oleksiuk Politano Architects and dated September 19, 2022.
- Structural plans for a 4-storey addition, prepared by RJC and dated September 30, 2022 "Issued for Tender"

1.2 DESCRIPTION OF HERITAGE STRUCTURES

The buildings were reportedly constructed circa 1860 and are utilitarian, warehouse-style structures. They are designated heritage buildings with the City of Victoria. Both buildings are two levels, with the upper floor matching street level on the east elevation and the lower level matching ground level on the west, as the site slopes down to the water.

The two buildings are entirely separate structures. The address of the northern building is 1316-1318 Wharf Street and the southern building's address is 1314 Wharf Street. In this report, the buildings are simply referred to as the "north building" and the "south building."

The north building is primarily a stone masonry structure. The south building is constructed from brick masonry at the upper level and stone masonry at the lower level. Floors and roofs are constructed from sawn lumber and heavy timber.

1.3 STRUCTURAL TESTING

To date anchor bolts testing has been performed on the existing brick and stone masonry. In 14 locations distributed across both the north and south buildings ¾" anchors were installed with epoxy adhesive and loaded up to 2,400 lbs. None of the anchors visibly failed at this loading confirming that this method of anchorage to the existing walls is viable and the bond values will be in general conformance with the epoxy supplier's assumptions. This is outlined in a memo from RJC dated January 28, 2022.

No testing on the masonry or mortar material properties have been performed to date which is considered acceptable as the walls are no longer intended to act as shear walls and only need to support their own self weight with the aid of steel supports.

1.4 REGIONAL TECTONIC SETTING AND SEISMICITY

Despite not having experienced a truly damaging earthquake in its history, Victoria has one of the highest seismic hazards in Canada – there is approximately a 25% chance of a damaging earthquake affecting Victoria in the next 50 years and over 40% chance in the next 100 years.

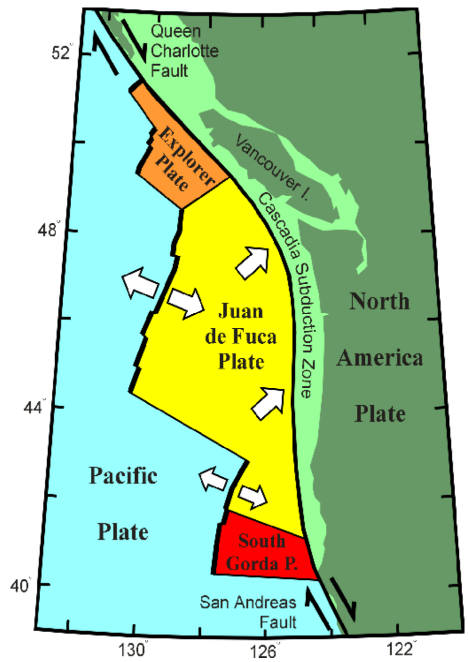

Figure 1 - Tectonic Setting of the Cascadia Subduction Zone

Source: http://commons.bcit.ca/civil/students/earthquakes/unit1_02.htm

Southwestern British Columbia is situated near important plate boundaries, in a complex tectonic setting. The Cascadia subduction zone (CSZ) extends from northern Vancouver Island to northern California; ocean ridges between the Juan de Fuca and Pacific plates push relatively young ocean crust towards the North American plate, where it is forced below the larger, continental plate. As a result, Vancouver Island is compressed and uplifted, moving in a general Northeast direction. Measurements indicate that Victoria is currently moving at a rate of about 5mm/yr due to compressive strains. This process is essentially responsible for the entirety of the Vancouver Island's seismicity. Transform faults are also present to the North and South of the CSZ, in the form of the Queen Charlotte and San Andreas faults, respectively. Figure 1 illustrates the tectonic setting of the region.

Earthquakes can be classified into three general types: crustal (shallow), subcrustal (deep), subduction (interplate); they are discussed below. Due to the aforementioned tectonic setting, Victoria is subject to hazards from all three types. Figure 2 illustrates the seismic history of the region in terms of crustal, subcrustal, and subduction earthquakes.

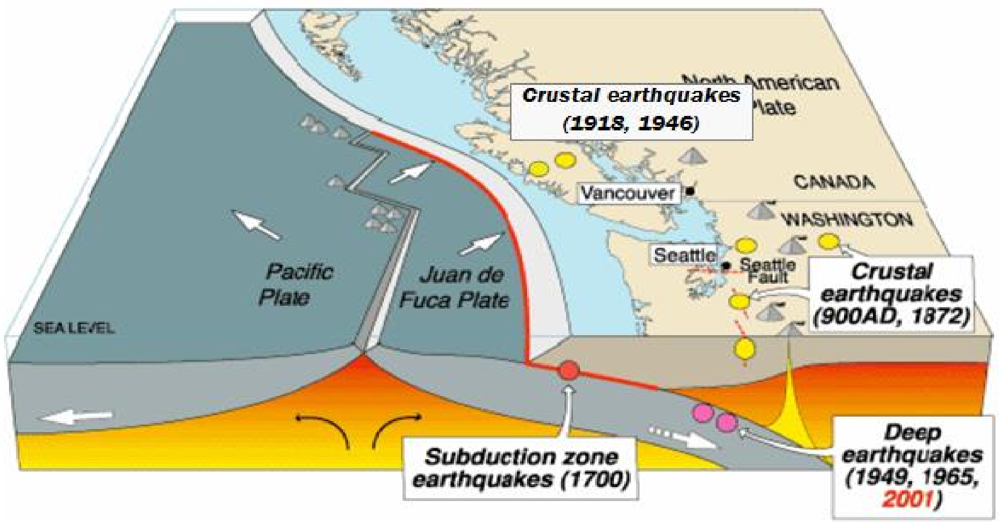

Figure 2 - Recent Seismic History of the Pacific Northwest

Source: http://www.quaketrip.com/wp-content/uploads/2011/01/CascadiaSubductionZone2.jpg

Crustal Earthquakes

Crustal earthquakes are generated as compressive stresses within the crust of the North American plate are relieved on individual faults. They occur at depths up to 10 or 15km in the earth's surface (i.e. the crust). Historical examples of crustal earthquakes in the region include the 1918 and 1946 earthquakes on Vancouver Island (see Figure 2). The 1946 earthquake – which measured M7.3 and occurred near Courtenay, BC – remains the most damaging earthquake to have ever occurred in Western Canada.

Subcrustal Earthquakes

Subcrustal earthquakes are not as well understood, but are thought to be primarily due to bending of the Juan de Fuca plate as it is subducted deep below the North American plate. These earthquakes contribute very significantly to Victoria's seismic hazard, as they occur at a higher rate than do crustal earthquakes and yield larger ground shaking at a given site for the same distance and magnitude. The last large subcrustal earthquake in the Puget Sound was the Nisqually earthquake of 2001, measuring M6.8 and occurring near Olympia, Washington. Other significant events occurred in the Puget Sound in 1949 and 1965 (see Figure 2).

Subduction Earthquakes

Subduction earthquakes are generated at the interface of locked plates, with one being pushed (subducted) under the other. Because they occur at the interface, their depth is shallow and because the locked areas are large, a great amount of energy can be released: it is for this reason that subduction zones are capable of producing the largest of earthquakes. The Cacadia Subduction Zone is thought to be capable of producing ~M9 events; the last such "megaquake" occurred in the year 1700 (see Figure 2). Based on paleoseismic evidence, it appears that their mean recurrence interval is about 400 to 500 years

1.5 SITE SEISMIC HAZARD

The building code currently in effect is the 2018 BC Building Code (BCBC 2018), which is based on the 2015 National Building Code of Canada (NBCC 2015). Seismic forces have increased in recent editions of the BCBC and significant further increase will occur in the next edition of the BCBC (which will be based on NBCC 2020). This is in part due to new observations and data on the recurrence rate of subduction events in the CSZ. Figure 3 shows the design spectra for NBCC 2010, 2015, and 2020 for site class C.

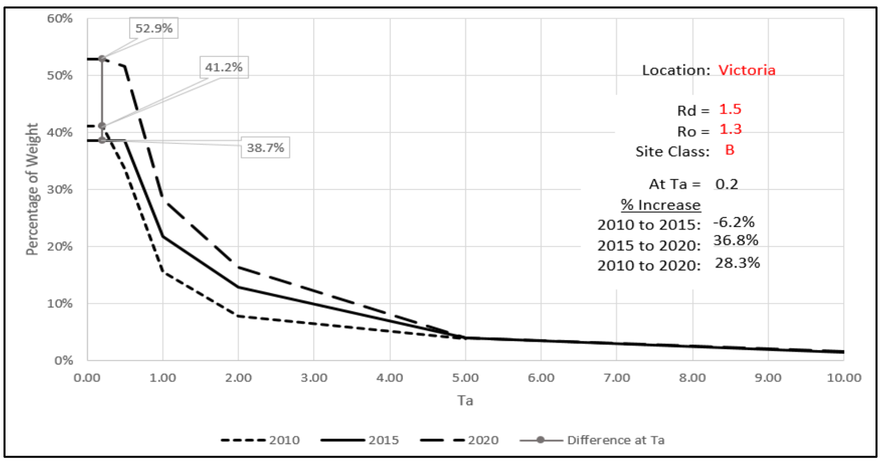

Figure 3 – Design Spectra (NBCC 2010, 2015, & 2020)

Figure 4 shows an example seismic hazard curve for Victoria. We note that this hazard curve is not directly applicable to the subject building, but is provided to illustrate the nonlinear relationship between "%code" and probability of exceedance (i.e. risk).

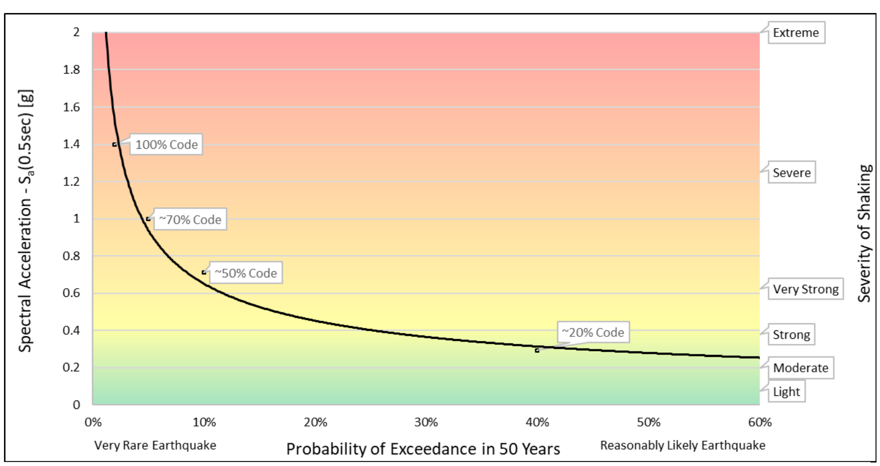

Figure 4 - Example Hazard Curve

1.6 BUILDING PERFORMANCE OBJECTIVES

Defining Performance Levels

When planning and designing seismic retrofits, it is important for all parties to have an understanding of the desired building performance. The most commonly used building performance levels are as noted below and shown in Figure 5.

- **Operational:** Backup utility services main functions. Very little damage.
- **Immediate Occupancy:** The building remains safe to occupy. Some minor repairs needed.
- **Life Safety:** Structure remains stable and has significant reserve capacity. Significant repairs are likely required before the building can be re-occupied. Demolition may be more economical than repair.
- **Collapse Prevention:** The building barely remains standing. Occupants may be endangered. Demolition is virtually certain.

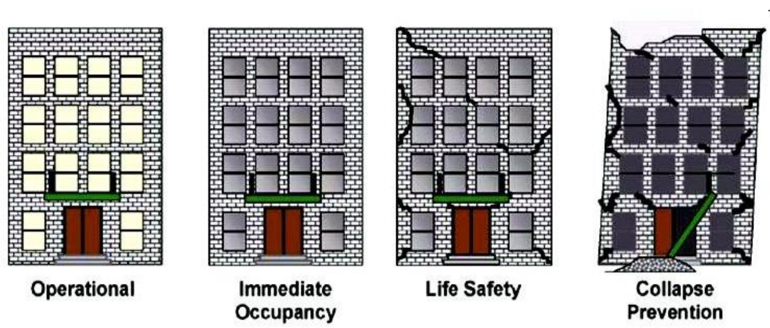

Figure 5 - Building Performance Levels Per ASCE 41

Typical building codes aim to achieve "Life Safety" performance for the vast majority of buildings (except for example, hospitals, fire stations, etc) under a "very rare" earthquake (see point for "100% Code" in Figure 4). Performance under more frequent (less severe) earthquakes is typically not explicitly considered.

Performance Objective and Seismic Hazard Level Used in This Study

In the proposed additions and renovation of these buildings we have used a performance objective of "life safety", as described previously. The upgrade design was to approximately 100% of current code (BCBC 2018).

Analysis Methodology

Analysis and design was per ASCE 41-17 using the Linear Dynamic Procedure and Nonlinear Dynamic Procedure. The structure was modelled using ETABS 2018 and/or SAP2000. Elements were modelled as a combination of shell and frame elements. For the nonlinear procedures, concentrated hinges were defined within the frame elements for the masonry piers, the new frame elements and the diaphragms. The use of the nonlinear analysis allowed for the capacity of the existing masonry piers to be combined with new retrofit elements in the most effective manner possible, minimizing the required upgrading. It should be noted that only 1 or 2 spectrally-matched ground motions were used. More ground motions are required for detailed design. The figures below show a 3-D view of the proposed retrofit to west wall of the North Building and the corresponding analysis model.

Figure 6 – Part of Structural Retrofit of Fraser Building West Wall

Figure 7 – Part of Structural Retrofit of CG Building West Wall

2.0 ASSESSMENT AND PROPOSED UPGRADES

2.1 ASSESSMENT OF EXISTING CAPACITY

Our assessment indicates that the existing structure is capable of resisting approximately 15% of BCBC 2018 design demands, primarily due to lack of adequate connections. It should also be remembered that design forces will increase with the next edition of the BCBC.

2.2 UPGRADE STRATEGY

The design strategy is considered a “traditional” seismic retrofit approach. The method involves increasing the strength and stiffness of the structure primarily by adding new structural elements (see

Figure 8). A key consideration in the design was that the outside appearance of the building should not be impacted.

In the process of adding new floors above the existing historic buildings a new lateral load resisting system of cast in place concrete shear walls will be installed. This new system is designed to restrain the new additional floors as well as the two existing's stories of the historic buildings. The main floor and second floor concrete slabs will be doweled in the masonry walls where they make contact and between those floors wood and steel bracing members, known as strong backs, will be installed to prevent the wall from buckling out-of-plane. The wood strong backs will be from repurposed timber sources from the demolition of the existing main floor and roof. Once complete the entire building, new construction and historic masonry walls, will be 100% BCBC 2018 compliant.

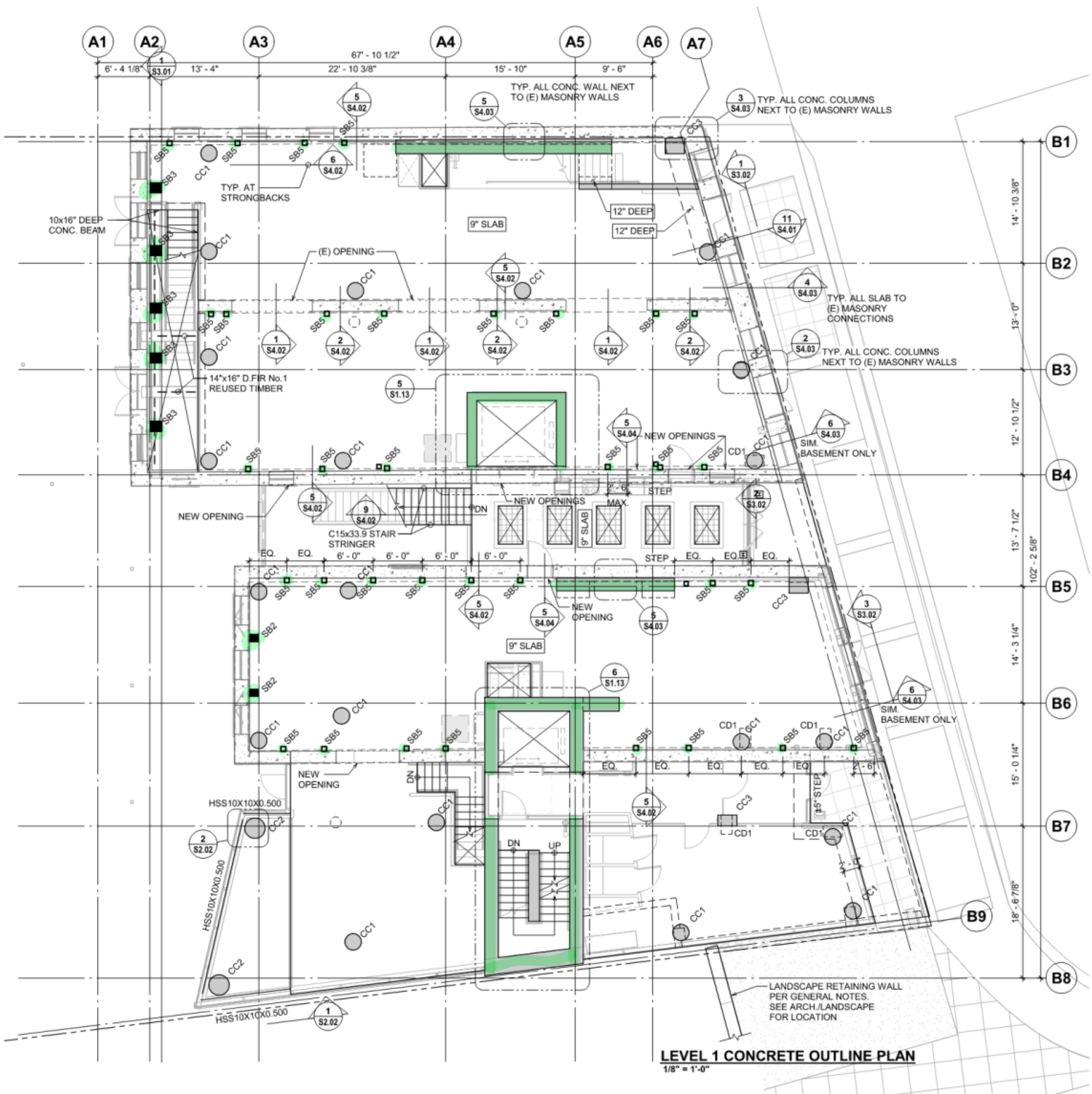

Figure 8 - Traditional Seismic Upgrade Strategy with New Shear Walls and Strongbacks highlighted

3.0 SUMMARY

Greater Victoria is a region at high risk of experiencing damaging earthquakes (approximately 25% chance in next 50 years).

In Canada, new buildings are typically designed to achieve “life safety” performance under very rare earthquakes (2% probability of exceedance in 50 years). “Life safety” performance provides significant protection to the occupants, but does not aim to limit damage to the building or to ensure that it is repairable in a timely fashion.

In this study, we have proposed a retrofit aimed to achieve life-safety performance at 100% of current code (BCBC 2018). We note that design forces will increase under the next version of the BCBC.

We trust this information meets your current requirements. Please do not hesitate to contact the undersigned if you have any questions, comments or concerns.

Yours truly,

Read Jones Christoffersen Ltd.
EGBC PERMIT TO PRACTICE NO. 1002503

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