Preliminary Seismic Risk Screening Tool for Existing Buildings in Canada: An Overview

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ABSTRACT

This paper presents an overview of a recently developed Preliminary Seismic Risk Screening Tool, which aims to quickly identify existing buildings with potential unacceptable seismic risk for further detailed seismic risk assessment. The methodology adopted in this tool is based on a number of key criteria to assist in the decision of exempting existing buildings from further seismic risk assessment. The tool also provides a second list of criteria, which, if satisfied, automatically triggers detailed seismic risk assessment. A screening form was developed for assisting trained screeners in implementing the Preliminary Seismic Risk Screening Tool. The screening does not require site visit as all building information needed to complete the screening form can be collected in office. An example is provided to illustrate the preliminary seismic risk screening of existing buildings, including how to collect the key building information and complete the screening form.

Keywords: preliminary seismic risk screening, seismic risk screening criteria, screening form, existing buildings.

INTRODUCTION

A large number of existing buildings in Canada can potentially suffer severe damage or collapse in the event of strong ground shaking. The assessment and mitigation of seismic risk in large portfolios of existing buildings presents technical and economic challenges to building owners such as Public Services and Procurement Canada (PSPC) which owns and (or) manages thousands of existing buildings. To address these challenges, in the early1990s, the National Research Council Canada (NRC) developed a series of manuals and technical guidelines for seismic screening [1], evaluation [2], and upgrading [3] of existing buildings, based on the 1990 edition of the National Building Code of Canada (NBC). In addition, in 2001, PSPC issued the Real Property Services (RPS) Policy with respect to the seismic resistance of PSPC buildings, which referred to the three aforementioned NRC technical guidelines.

The existing NRC technical guidelines do not capture the current seismic requirements in the NBC as well as recent developments in seismic risk assessment methodologies. The earthquake requirements in the current NBC are significantly more stringent than those in the NBC 1990, on which the NRC technical guidelines and the PSPC RPS Policy were based. Moreover, new seismic risk assessment methodologies have emerged in North America and around the world based on new data and research.

To update the PSPC RPS Policy, the NRC developed a multi-criteria and multi-level seismic risk management framework [4], which consists of three key levels, as follows:

1. Level 1 – PST: Preliminary Seismic Risk Screening Tool (PST);
2. Level 2 – SQST: Semi-Quantitative Seismic Risk Screening Tool (SQST); and
3. Level 3 – SEG: Seismic Evaluation Guidelines (SEG).

The aim of the framework is to minimize seismic risk while ensuring critical resources are efficiently directed towards existing buildings with potential unacceptable seismic risk. It is achieved by first using Level 1 – PST, and then using Level 2 – SQST and/or Level 3 – SEG, if required by the preceding level of screenings. The framework is intended only for all typical existing buildings covered by Part 4 of the NBC. Other existing buildings, such as those under Part 9 of the NBC are out of the scope of the framework.

The objective of this paper is to overview the key seismic risk screening criteria of the Level 1 – PST. In addition, an example of implementing the Level 1 – PST is provided to illustrate how to complete Level 1 – PST screening forms, which facilitates the use of the tool by practicing engineers and other end-users. Details of Level 1 – PST is provided below.

LEVEL 1 – PST

The Level 1 – PST has been developed to quickly identify potentially seismically hazardous existing buildings for further seismic risk assessment [5]. This tool adopts a methodology based on review of available building information and a screening form, as shown in Figure 1, which is completed by trained screeners with minimum knowledge in seismic design of buildings.

The screening form provides space to document the collected data, including: building identification, building occupancy and consequence class, site class, seismic category, geological hazards, and building characteristics. Based on this information, the seismic risk of the building is compared with the seismic risk acceptance criteria as a matrix of seismicity, remaining occupancy time, and the consequence class of the building. If the acceptance criteria are met, the building is exempt from Level 2 – SQST. Buildings identified as potentially hazardous are tagged for Level 2 – SQST, which is a more detailed seismic risk screening procedure. The Level 1 – PST also exempts buildings that were originally designed or fully upgraded to an applicable benchmark code edition. The Level 2 – SQST, however, is still required for non-structural components. Furthermore, the Level 1 –PST identifies the criteria that trigger seismic evaluation using Level 3 – SEG, in presence of any of the following conditions: (1) any of geologic hazards; (2) site class F (such as liquefiable soils and quick and highly sensitive clays); (3) building deterioration and damage; (4) federal heritage designations; and (5) current building consequence class higher than its original consequence class [6].

Site visit is not a requirement of the Level 1 – PST, but the screening procedure requires documenting key building information needed to complete the screening form. In some cases, missing information can be obtained by communicating with the local property manager, consulting the local building authority, and navigating through street views found online. In cases where there is any ambiguity or conflicting information, the buildings should be flagged for Level 2 – SQST or Level 3 – SEG.

SEISMIC RISK SCREENING CRITERIA

Benchmark Code Edition

The NBC has periodical editions (every five years since 2005), which includes revisions regarding the seismic design/detailing requirements for new buildings. When a new edition of the NBC is released, one key question to the building owners is whether those buildings designed and constructed prior to the new NBC edition can still be considered seismically acceptable or not. In Level 1 – PST, the NBC edition in which substantial improvements in seismic code requirements were adopted and enforced is referred to as benchmark code edition. The benchmark code edition varies depending on the type of seismic force-resisting system (SFRS) and the construction material. Table 1 presents the description and benchmark code edition for each model building type that is defined based on the type of SFRS and the construction material. The model building types are largely based on the type of structures in the 1993 NRC screening manual [1], with addition of cold-formed steel buildings (CFS) and manufactured homes (MH). The addition of new building types reflect the advances of seismic design practice in the last two decades.

Any building designed and constructed to an applicable benchmark code edition or after is referred to as post-benchmark building. An existing building that is qualified as a post-benchmark building is deemed to comply with the Commentary L of the current edition of the NBC and thus exempt from further seismic risk assessment. However, Level 2 – SQST is still required to assess the seismic risk of non-structural components in the building given that non-structural components are easily modified and installed without complying with the current earthquake requirements in the NBC.

Consequence Class

The seismic risk of existing buildings is the result of the combined effect of building failure (structural and non-structural) and the associated consequences due to building failure. Therefore, the consequence of building failure was considered as one of key seismic acceptance criteria in the Level 1 – PST. To maintain consistency with the seismic risk management framework [4], the consequence classification system proposed by the NRC [6] was adopted and subdivided to describe different levels of consequences of failure of buildings, i.e., Very Low (VLC), Low (LC), Medium (MC), High (HC), and Very High (VHC). The consequence of failure is dependent on the type of building occupancy, building size, and the number of storeys, which need to be gathered in office.

Building Seismic Category

The Modified Mercalli Intensity (MMI) scale has long been used in seismic design practice to associate the seismicity with anticipated building damage. A coarse relationship between the anticipated building damage level and the MMI scale is presented in Table 2 [8]. MMI V is generally considered as the threshold for no building damage, MMI VI is considered as the threshold for non-structural damage, and MMI VII is considered as the threshold for structural damage [9]. Given this, buildings are expected to experience none to light non-structural damage at MMI V and MMI VI and may be exempt from Level 2 – SQST.

Level 1 – PST Screening Form

PART A: DATA COLLECTION

Bldg. Name:	**Street Address:**	**Postal Code:**	**City/Province:**
Seismic Data: $S_a(0.2)$=	$S_a(0.5)$=	$S_a(1.0)$=	PGA= PGA$_{ref}$=
Design NBC:			
Model Building Type: WLF WPB SMF SBF SLF SCW SIW CMF CSW CIW PCW PCF RML RMC URM CFS MH DNK (Do Not Know)			
Benchmark Code Edition[1]:			**Post-benchmark Building:** Yes/No
No. of Storeys:	**Total Floor Area (m²):**	**Screener:** ☐ P.Eng./ing.	**Date/Time:**

Current Occupancy: Office Public Commercial Industrial Educational Residential Care/Treatment Parking Public Assembly Passenger Stations Other_____ **Federal Heritage Designation:** Yes/No **Original Occupancy:**_____	**Geologic Hazards[2]: Liquefaction:** Yes/No/DNK **Landslide Potential:** Yes/No/DNK **Surface Rupture Fault:** Yes/No/DNK **Building Deterioration[2]:** Yes/No/DNK **Building Damage[2]:** Yes/No/DNK **Full Seismic Upgrade to Benchmark Code Edition or After[3]:** Yes/No/DNK
Current Consequence Class (CC): ☐ Very Low (VLC) ☐ Low-Med. (LC&MC) ☐ High (HC) ☐ Very High (VHC) **Original CC:**_____ **Current CC Higher than Original CC:** Yes/No	**Remaining Occupancy Time (Year)[4]:** ☐ ≤5 ☐ >5 and ≤10 ☐ > 10 ☐ DNK **EXTENT OF REVIEW** **Drawings Reviewed:** ☐ Yes ☐ No (Not Available)
Site Class: ☐ A ☐ B ☐ C ☐ D ☐ E ☐ F ☐ DNK (If DNK, assume E)	**Site Class Source:**_____
Site Coefficients: $F(0.2)$= $F(0.5)$= $F(1.0)$=	**Geologic Hazards Source:**_____
Site Seismic Category: ☐ Very Low (SSC-0) ☐ Low (SSC-1) ☐ Moderate (SSC-2) ☐ Moderately High (SSC-3) ☐ High (SSC-4) ☐ Very High (SSC-5)	

PART B: SEISMIC RISK ACCEPTANCE CRITERIA

Site Seismic Category (SSC)	**Current Consequence Class**			
	Very Low (VLC)	**Low/Medium (LC&MC)**	**High (HC)**	**Very High (VHC)**
Very Low (SSC-0)	☐ Met			
Low (SSC-1)	☐ Met		☐ Met if $n \le 10$ ☐ Not Met if $n > 10$	☐ Not Met
Moderate (SSC-2)	☐ Met if n[5] ≤ 10	☐ Not Met if $n > 10$	☐ Met if $n \le 5$ ☐ Not Met if $n > 5$	☐ Not Met
Moderately High (SSC-3)	☐ Met if $n \le 5$	☐ Not Met if $n > 5$	☐ Not Met	
High (SSC-4)	☐ Not Met			
Very High (SSC-5)	☐ Not Met			

PART C: DECISION MAKING

Level 3 – Seismic Evaluation Required? ☐ Yes, if any of the following conditions applies ☐ Unknown model building type ☐ Federal heritage designation ☐ Current consequence class higher than original consequence class ☐ Site class F ☐ Any of geologic hazards ☐ Building damage or deterioration ☐ No, proceed to below. **Level 2 – SQST Required?** ☐ Yes, if both of the following conditions apply ☐ Not post-benchmark building ☐ Seismic risk acceptance criteria in Part B Not Met ☐ No, seismic risk of the building is acceptable, no further action is required. For post-benchmark buildings, Level 2 – SQST is still required for non-structural components.	**Comments:**

[1]The Benchmark Code Edition is not applicable for unknown model building type. [2]If DNK, assume No. If the building is exempt from Level 2 – SQST or Level 3 – Seismic Evaluation, the exemption is conditional upon the confirmation of no geologic hazards and/or building deterioration/damage. Non-engineered modification to building SFRS is considered as one type of building damage. [3]If DNK, assume No. [4]If DNK, assume >10. [5]n refers to the remaining occupancy time identified in Part A.

Figure 1. Level 1 – PST Screening Form.

Table 1. Benchmark Code Editions of Model Building Types

Model Building Type		Benchmark Code Edition (NBC)
WLF	Wood, light frame	2005 (≤ 4 *storeys*); 2015 (4 < *storeys* ≤ 6)
WPB	Wood, post and beam	1995
SMF	Steel moment-resisting frame	2005
SBF	Steel braced frame	2005
SLF	Steel light frame	2005
SCW	Steel frame with concrete shear walls	2005
SIW	Steel frame with infill masonry shear walls	2005
CMF	Concrete moment-resisting frame	2005
CSW	Concrete shear walls	2005
CIW	Concrete frame with infill masonry shear walls	2005
PCW	Precast concrete wall	2015
PCF	Precast concrete frame	2005
RML	Reinforced masonry bearing walls with wood or metal deck diaphragms	2005
RMC	Reinforced masonry bearing walls with concrete diaphragms	2005
URM	Unreinforced-masonry bearing-wall buildings	2015 (Post-disaster and High Importance) 2005 (All other importance categories)
CFS	Cold-formed steel buildings	2010
MH	Manufactured homes	2005 (< 4.3 m wide and ≤ 1 *storey*) 2010 (≥ 4.3 m wide and ≤ 3 *storeys*)

Table 2. Relationship between Anticipated Building Damage Level and MMI Scale

Anticipated Building Damage Level	MMI Scale
No real damage	V
Light non-structural damage	VI
Hazardous non-structural damage	VII
Hazardous damage to susceptible structures	VIII
Hazardous damage to robust structures	IX+

Table 3 presents six site seismic categories (SSCs) implemented in Level 1 – PST. The thresholds of $S(0.2)$ [corresponding to the maximum of $F(0.2)S_a(0.2)$ and $F(0.5)S_a(0.5)$] and $S(1.0)$ [i.e. $F(1.0)S_a(1.0)$] are determined primarily based on anticipated building damage levels correlated to MMI scales, and then adjusted to suit the Canadian seismic design practice [7]. The SSC based on $S(0.2)$ may be different from the SSC based on $S(1.0)$. In this case, the higher of these two SSCs is selected for preliminary screening. Based on the MMI scale associated with structural and non-structural damage, buildings located in SSC-0 and SSC-1, corresponding to approximate MMI V and VI, respectively, may be exempt from Level 2 – SQST.

Table 3. Site Seismic Categories and Corresponding Spectral Acceleration Thresholds

Site Seismic Category (SSC)	S(0.2)		S(1.0)		Approximate MMI Scale
	>	≤	>	≤	
SSC-0		0.10g		0.05g	V
SSC-1	0.10g	0.20g	0.05g	0.10g	VI
SSC-2	0.20g	0.35g	0.10g	0.15g	VII
SSC-3	0.35g	0.75g	0.15g	0.30g	VIII
SSC-4	0.75g	1.15g	0.30g	0.50g	IX+
SSC-5	1.15g		0.50g		

Remaining Occupancy Time

An existing building with a shorter remaining occupancy life has a smaller chance of experiencing a code-level earthquake event over its remaining life [10]. Furthermore, for many publically-owned buildings, the time required for planning,

conducting and then completing a seismic retrofit, is greater than the remaining planned occupancy time of the building, and hence a detailed evaluation of these structures is not warranted. A building may be exempt from Level 2 – SQST if its remaining occupancy time is short enough to drop the design seismic hazard to an appreciably low level. In the Level 1 – PST, a remaining occupancy time factor, κ, is applied to the thresholds in Table 3 and was calculated as follows:

$$\kappa = 1.133 - 1.05e^{-0.041n} \quad (1)$$

where n denotes the remaining occupancy time (in year). Level 1 – PST considers remaining occupancy time for $n \leq 5$ and $n \leq 10$, resulting in κ values of 0.28 and 0.44, respectively.

By applying the factor of 0.28 to the thresholds in Table 3, the SSC-3 drops to SSC-1; by applying the factor of 0.44 to the thresholds in Table 3, the SSC-2 drops to SSC-1. Therefore, buildings located in SSC-3 and SSC-2 may be exempt from Level 2 – SQST if their remaining occupancy time are not greater than 5 years and 10 years, respectively. The remaining occupancy time is not applied to buildings of very high consequence (VHC) due to extremely high consequences of failure of these buildings.

CRITERIA TRIGGERING LEVEL 3 – SEISMIC EVALUATION GUIDELINES

Federal Heritage Designation

A building holding a federal heritage designation is defined as a building that is included in the Directory of federal heritage designations by Parks Canada and falls into any one of the following two categories: (1) buildings of any age, which are designated as recognized or classified federal heritage at the time of screening; and (2) buildings of age not less than 40 years that have not been evaluated by Federal Heritage buildings Review Office at the time of screening. Given the potential social and political consequences resulting from the failure of federal heritage designations, Level 1 – PST flags federal heritage designations for Level 3 – SEG.

Current Consequence Class Higher than Original Consequence Class

The occupancy of a building may change for different purposes during its service life. Due to the change, the building use and occupancy density may also change. This would result in the change of the loads in the building as well as the consequence class of the building. In this case, Level 3 – SEG is required to evaluate the effect of the change on the building's seismic performance rather than proceeding with Level 1 – PST.

Site Class F

According to the current edition of the NBC, no site coefficients are provided for Site Class F (such as liquefiable soils and quick and highly sensitive clays) and site-specific evaluation is required. Due to the large uncertainty of the effect of Site Class F on building's seismic performance, Level 1 – PST flags building with site class F for Level 3 – SEG.

Geologic Hazards

Geologic hazards, including (1) liquefaction, (2) landslide potential, and (3) surface fault rupture, have the potential to significantly impair building's seismic performance. Level 3 – SEG is triggered to evaluate the effect of geologic hazards near the building if any geologic hazard is present.

Building Deterioration or Damage

Building deterioration and damage can significantly impact the expected performance of an existing building. Any previous report concerning damage or deterioration in a building that has not been repaired at the time of screening triggers Level 3 – SEG.

EXAMPLE OF SEISMIC RISK SCREENING

Building Description

An existing building with a hypothetical address in Ottawa, Ontario, was screened with Level 1 – PST. The building was designed in 1973 and built between 1975 and 1980. The original structural drawings do not specify the edition of the NBC followed for the design of the building. Given the construction period, it was assumed that the design of the building conformed to the NBC 1970 edition. The building consists of three sections that are separated by expansion joints as specified in the structural drawings. Screening of the building focused on the first section of the building.

Data Collection

The building is an office building located in a site with spectral accelerations of $S_a(0.2)$ = 0.439g, $S_a(0.5)$ = 0.237g, $S_a(1.0)$ = 0.118g at 0.2-, 0.5-, and 1.0-second periods, respectively, and peak ground acceleration (PGA) of 0.281g. The seismic data of the building were retrieved from the NRCan earthquake hazard calculator (http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2015-en.php). The PGA_{ref} corresponds to 80% of PGA (i.e. 0.225g) given that the ratio of $S_a(0.2)$ to PGA was smaller than 2.

Original structural drawings, geotechnical report, and seismic assessment report were reviewed in office. Key information were extracted as follows:

- The building section has five storeys above grade. The fifth storey is used for mechanical space.
- An approximate total floor area of 10,500 m2 was calculated by adding the floor area of each storey above grade (excluding the unoccupied mechanical space). The dimensions of each storey were obtained from the structural drawings.
- The seismic force-resisting system (SFRS) consists of concrete columns, flat slabs, dropped panels, and four reinforced concrete shear walls around the elevator and stairwell cores. It was judged that the reinforced concrete walls were not sufficient to resist 100% of seismic loadings. The building also contains masonry walls that may contribute to resist seismic forces. However, it was difficult to determine whether these walls were designed to resist such forces. Given the structural characteristics of the building, concrete moment frame (CMF) and concrete frame with infill masonry walls (CIW) were selected as the model building types.
- The original and current occupancies were identified as office.
- Given the height, area, and current occupancy of the building, the current consequence class of the building was determined as Medium Consequence (MC) [7].
- The building is located on Site Class A.
- Site coefficients are calculated and provided as follows: $F(0.2)$=0.69, $F(0.5)$=0.57, and $F(1.0)$=0.57.
- The Site Seismic Category (SSC) is SSC-2 based on the maximum value of $S(0.2)$, but SSC-1 based on the value of $S(1.0)$. The SSC is selected as the higher of SSC-1 and SSC-2, i.e. SSC-2.
- Geologic hazards were identified from existing structural analysis and geotechnical report. There is no potential liquefaction hazard given the location on Site Class A (hard rock). A surface fault rupture is reported to cross the building site. No landslide potential has been reported (assumed no landslide potential).
- Building deterioration and damage information is unavailable (assumed no deterioration or damage).
- Although a partial upgrade in the 3rd and 4th storeys of the building was performed in 2011, it did not improve the SFRS to satisfy the seismic code requirements in the NBC 2010. Therefore, seismic upgrade was not considered as full seismic upgrade.
- The remaining occupancy time is unknown. It was assumed more than 10 years.

Completion of Level 1 – PST Form

Based on the collected data, the Level 1 – PST screening form was completed as shown in Figure 2. As a result of the screening, the building was flagged for Level 3 – SEG due to the presence of a geologic hazard (i.e. surface fault). Level 2 – SQST was also triggered due to the building not being a post-benchmark building and not meeting the seismic risk criteria in Part B of the screening form.

CONCLUSIONS

A newly developed Preliminary Seismic Risk Screening Tool was overviewed. The tool is intended to be the first level of a multi-criteria and multi-level seismic risk management framework, recently developed by the National Research Council Canada. The tool aims to effectively reduce the number of buildings that require further seismic risk assessment by quickly identifying existing buildings that are expected to experience none or light non-structural damage based on a number of key criteria. In doing so, critical resources can be efficiently directed towards more detailed seismic risk assessment.

The Preliminary Seismic Risk Screening Tool was designed to be completed by trained screeners with minimum knowledge of seismic design of buildings. Although site visit is not required, it requires collecting key building information, including: building identification, building occupancy and consequence class, site class, seismic category, geological hazards, and building characteristics. Based on this information, seismic risk screening criteria, namely (1) seismicity, (2) building age, (3) remaining occupancy time, and (4) consequence class, are checked to determine if the building being screened is exempt from further seismic risk assessment. In addition, a second list of criteria are provided to trigger further detailed seismic risk assessment. An example is provided to illustrate how to collect the key building information and complete the screening form, which facilitates the adoption of the tool by practicing engineers and other end-users.

Level 1 – PST Screening Form

PART A: DATA COLLECTION

Bldg. Name:	**Street Address:** 251 Any Street	**Postal Code:** K1M 3K4	**City/Province:** Ottawa/ON
Seismic Data: $S_a(0.2)$= 0.439 $S_a(0.5)$= 0.237 $S_a(1.0)$= 0.118 PGA= 0.281 PGA_{ref}= 0.225		**Design NBC:** 1970	
Model Building Type: WLF WPB SMF SBF SLF SCW SIW (CMF) CSW (CIW) PCW PCF RML RMC URM CFS MH DNK (Do Not Know)			
Benchmark Code Edition[1]: 2005 (CMF), NA (CIW)		**Post-benchmark Building:** Yes/☒	
No. of Storeys: 5	**Total Floor Area (m²):** 10,500	**Screener:** LC ☐ P.Eng./ing.	**Date/Time:** 20180524/11:20 am

Current Occupancy: (Office) Public Commercial Industrial Educational Residential Care/Treatment Parking Public Assembly Passenger Stations Other_____ **Federal Heritage Designation:** Yes/☒ **Original Occupancy:**_____	**Geologic Hazards[2]: Liquefaction:** Yes/☒/DNK **Landslide Potential:** Yes/No/☒ **Surface Rupture Fault:** ☒/No/DNK
	Building Deterioration[2]: Yes/No/☒ **Building Damage[2]:** Yes/No/☒
	Full Seismic Upgrade to Benchmark Code Edition or After[3]: Yes/☒/DNK
Current Consequence Class (CC): ☐ Very Low (VLC) ☒ Low-Med. (LC&MC) ☐ High (HC) ☐ Very High (VHC)	**Remaining Occupancy Time (Year)[4]:** ☐ ≤5 ☐ >5 and ≤10 ☐ > 10 ☒ DNK
Original CC: Low-Med **Current CC Higher than Original CC:** Yes/☒	**EXTENT OF REVIEW**
Site Class: ☒ A ☐ B ☐ C ☐ D ☐ E ☐ F ☐ DNK (If DNK, assume E)	**Drawings Reviewed:** ☒ Yes ☐ No (Not Available)
Site Coefficients: $F(0.2)$= 0.69 $F(0.5)$= 0.57 $F(1.0)$= 0.57	**Site Class Source:** Golder Associates
Site Seismic Category: ☐ Very Low (SSC-0) ☐ Low (SSC-1) ☒ Moderate (SSC-2) ☐ Moderately High (SSC-3) ☐ High (SSC-4) ☐ Very High (SSC-5)	**Geologic Hazards Source:** Golder Associates

PART B: SEISMIC RISK ACCEPTANCE CRITERIA

Site Seismic Category (SSC)	**Current Consequence Class**			
	Very Low (VLC)	**Low/Medium (LC&MC)**	**High (HC)**	**Very High (VHC)**
Very Low (SSC-0)	☐ Met			
Low (SSC-1)	☐ Met		☐ Met if $n \leq 10$ ☐ Not Met if n >10	☐ Not Met
Moderate (SSC-2)	☐ Met if $n^5 \leq 10$ ☒ Not Met if n >10		☐ Met if $n \leq 5$ ☐ Not Met if n >5	☐ Not Met
Moderately High (SSC-3)	☐ Met if $n \leq 5$ ☐ Not Met if n >5		☐ Not Met	
High (SSC-4)	☐ Not Met			
Very High (SSC-5)	☐ Not Met			

PART C: DECISION MAKING

Level 3 – Seismic Evaluation Required?

☒ Yes, if any of the following conditions applies

- ☐ Unknown model building type
- ☐ Federal heritage designation
- ☐ Current consequence class higher than original consequence class
- ☐ Site class F
- ☒ Any of geologic hazards
- ☐ Building damage or deterioration

☐ No, proceed to below.

Level 2 – SQST Required?

☒ Yes, if both of the following conditions apply

- ☒ Not post-benchmark building
- ☒ Seismic risk acceptance criteria in Part B Not Met

☐ No, seismic risk of the building is acceptable, no further action is required. For post-benchmark buildings, Level 2 – SQST is still required for non-structural components.

Comments:

- Rupture fault crossing building (subsidiary branch of Gloucester fault)
- $F(0.2)Sa(0.2) = 0.69 \times 0.437 = 0.303$ g
  $F(0.5)Sa(0.5) = 0.57 \times 0.237 = 0.135$ g
  $Max[F(0.2)Sa(0.2), F(0.5)Sa(0.5)] = 0.303$ (SSC-2)
  $F(1.0)Sa(1.0) = 0.57 \times 0.118 = 0.067$ g (SSC-1)
- Therefore, the seismic category is SSC-2 (Moderate).

[1]The Benchmark Code Edition is not applicable for unknown model building type. [2]If DNK, assume No. If the building is exempt from Level 2 – SQST or Level 3 – Seismic Evaluation, the exemption is conditional upon the confirmation of no geologic hazards and/or building deterioration/damage. Non-engineered modification to building SFRS is considered as one type of building damage. [3]If DNK, assume No. [4]If DNK, assume >10. [5]*n* refers to the remaining occupancy time identified in Part A.

Figure 2. Completed Level 1 – PST screening form.

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REFERENCES

[1] NRC. (1993a). Manual for screening of buildings for seismic investigation. National Research Council Canada, Ottawa, Ontario, Canada.
[2] NRC. (1993b). Guidelines for seismic evaluation of existing buildings. National Research Council Canada, Ottawa, Ontario, Canada.
[3] NRC. (1995). Guideline for seismic upgrading of building structures. National Research Council Canada, Ottawa, Ontario, Canada.
[4] Lounis, Z., Fathi-Fazl, R., Almansour, H., Cusson, D., and Singh, J. (2016). *Framework for seismic risk management of existing buildings*. Report No. A1-008205, National Research Council Canada, Ottawa, Ontario, Canada.
[5] Fathi-Fazl, R., Jacques, E., Cai, Z., Kadhom, B., Saassouh, B., and Motazedian, D. (2018). "Development of a preliminary seismic risk screening tool for existing buildings in Canada". *Canadian Journal of Civil Engineering*, 45, 717–727.
[6] Fathi-Fazl, R., and Lounis, Z. (2017). *Identification of Consequences of failure criteria for seismic risk management of existing buildings*. Report No. A1-011750, National Research Council Canada, Ottawa, Ontario, Canada.
[7] Fathi-Fazl, R., Jacques, E., Cai, Z., Kadhom, B., Saassouh, B., and Singh, J. (2017). *Volume I: Preliminary Seismic Risk Screening Tool for Existing Buildings*. Report No. A1-010575, National Research Council Canada, Ottawa, Ontario, Canada.
[8] American Society of Civil Engineers/Structural Engineering Institute – ASCE/SEI (2016). *ASCE/SEI 7-16: Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Published by the ASCE, Reston, VA, USA.
[9] Onur, T., Ventura, C., and Liam Finn, W. D. (2005). "Regional seismic risk in British Columbia-damage and loss distribution in Victoria and Vancouver". *Canadian Journal of Civil Engineering*, 32, 361–371.
[10] American Society of Civil Engineers/Structural Engineering Institute – ASCE/SEI (2016). *ASCE/SEI 41-17: Seismic Evaluation and Retrofit of Existing Buildings*. Published by the ASCE, Reston, VA, USA.