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History Of The Seismic Retrofit Guidelines

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ABSTRACT

In 2004, the Ministry of Education (EDUC) engaged Engineers and Geoscientists British Columbia (BC), with support from the University of British Columbia (UBC) Civil Engineering Department, to assist with the implementation of a seismic upgrade program for BC schools which included the development of seismic assessment tools and guidelines for the performance-based seismic retrofit of BC school buildings [1]. Five versions of the Seismic Retrofit Guidelines (SRG) have been released to date:

- interim Bridging Guidelines (2006),
- SRG-1 (May 2011),
- SRG-2 (November 2013),
- SRG-3 (June 2017), and
- SRG2020 (November 2022).

Engineers and Geoscientists BC's Technical Review Board (TRB), funded by EDUC and consisting of structural and geotechnical engineers, provides ongoing technical support, advice, and guidance on EDUC's Seismic Mitigation Program (SMP) [1]. This includes the creation of templated structural reports that are used to confirm seismic/structural risk through a seismic risk assessment, and conceptual design with a Class C cost estimate through a Seismic Project Identification Report (SPIR) on a block-by-block basis. The TRB also provides peer review services for all seismic reports and works with the Peer Review Committee (PRC) on the development of the SRG.

This paper outlines the history of the SRG, both technically and administratively, and includes a summary of the developments made in SRG2020, namely consideration for effects of the 2020 National Building Code (NBC 2020) ground motions and updating Seismic Performance Analyzer I (Analyzer I) with enhanced features and additional prototypes.

Keywords: seismic, retrofit, performance-based, schools, analyzer.

INTRODUCTION

In 2004, the Ministry of Education (EDUC) engaged Engineers and Geoscientists British Columbia (BC), with support from the University of British Columbia (UBC) Civil Engineering Department, to assist with the implementation of a seismic upgrade program for BC schools [1].

The long-term goal of this program is to mitigate, within a reasonable period of time, the risk of seismically deficient buildings in EDUC's inventory [2]. Seismic mitigation is typically accomplished by structurally upgrading the high risk blocks, or replacing the blocks or the whole schools when the business case (i.e., Project Definition Report [PDR]) shows these options are more cost effective.

The SRG were developed to achieve two important goals [2]:

1) A consistent approach for the assessment of the seismic resilience of existing schools in their current condition having different materials and types of construction located in areas having varying levels of seismic hazard for the purpose of establishing a rating for prioritization purposes.

2) Implementing seismic retrofits of BC school buildings that achieve a common life safety objective in a cost-effective manner by adopting a consistent engineering approach using a performance-based methodology for the seismic retrofit of school buildings.

The following sections provide a history and progression of the seismic retrofit guidelines.

HISTORY OF THE SEISMIC RETROFIT GUIDELINES

2004 – 2017

Four versions of the Seismic Retrofit Guidelines (SRG) were released in the first 13 years of the Seismic Mitigation Program (SMP). The guidelines, as listed and detailed below, have evolved over time with enhancements and improvements being made as each edition was developed and published.

The first version of the guidelines was an interim version, the Bridging Guidelines for the Performance-based Seismic Retrofit of BC Schools, were published in 2006 to address the immediate need for guidance in support of the $254 million investment to fund the first capital construction phase by the Ministry of Education (EDUC) [2].

The official first version of the guidelines, the Seismic Retrofit Guidelines, 1st Edition, (SRG-1), were published in 2011 was a comprehensive, state of the art technical manual for the overall bridging program.

In November 2013, The Seismic Retrofit Guidelines, 2nd Edition, (SRG-2), were introduced. SRG-2 applied the same performance-based methodology used in the previous editions, but also included enhanced information on seismicity by community and common school construction types, prioritizing structural elements that are at greatest risk. These guidelines also introduced the Seismic Performance Analyzer (Analyzer I), a complementary web-based tool that allows engineers to instantly generate seismic resistance criteria for specific types of construction [1].

The third edition of the guidelines, The Seismic Retrofit Guidelines, 3rd Edition, (SRG-3), were expanded and published in 2017 to include pre-event and post-event evaluation and retrofit design, consideration for liquefaction potential, updated seismic hazard data per the 2015 National Building Code (NBC 2015), and further refined the accompanying evaluation tools (i.e., Analyzer I) [2]. The manual on liquefaction addressed how the simplified procedure, which is deterministic, can be applied when the seismic hazard is probabilistic and provided guidance on evaluating liquefaction potential and quantifying consequences of liquefaction for use in structural design. Analyzer I was updated to include a database of thousands of non-linear analyses so that engineers could benefit from an innovative, performance-based methodology using a probabilistic approach without needing to conduct a sophisticated non-linear analysis for each building. These guidelines also introduced the "Toolbox Method" whereby engineers can combine and assess the contributions from different structural systems.

2017 – Present

In November 2022, The Seismic Retrofit Guidelines, 2020 Edition, (SRG2020) were approved for use by EDUC. SRG2020 incorporates the seismic hazard data from the 2020 National Building Code (NBC 2020) and introduces new definitions for damage state drift limits – from minor damage to total damage – to further aid the ranking of school blocks within the existing rating system (e.g., H1, H2) [2]. Notably, SRG2020 includes two new geotechnical features [2]:

1) Vs30, the average shear wave velocity for the top 30 metres in the soil column, and
2) Seismic Site Response Analysis (SSRA), to more accurately and reliably determine a site's soil amplification effects.

These values are provided by a geotechnical engineer to a structural engineer to input in SRG2020 Analyzer I (Analyzer I Version 4.0).

In 2020, EDUC extended the SRG contract for another 3 years. The Seismic Retrofit Guidelines, 2023 Edition (SRG2023) are currently under development to refine the guidance on V_{s30} and SSRA, which were first introduced in SRG2020, as well as to update Volume 11 for Post-Earthquake Evaluations and Volume 8 for Retrofit Strategies. The performance of existing and retrofitted wood frame buildings is being analyzed to inform updates to the same.

ADMINISTRATION OF THE SEISMIC RETROFIT GUIDELINES

Engineers and Geoscientists BC's Technical Review Board (TRB), funded by the Ministry of Education (EDUC) and consisting of structural and geotechnical engineers, provides technical reviews of Seismic Project Identification Reports (SPIRs), responds to questions and comments regarding the application of the guidelines, and advises the Peer Review Committee (PRC) on innovative seismic retrofit techniques which should proceed to formal testing [1].

Training and Qualifications

The EDUC has directed that the Seismic Retrofit Guidelines (SRG) be applied to all schools undergoing a seismic retrofit under their school Seismic Mitigation Program (SMP). Training and qualification requirements for the SRG are outlined and maintained on Engineers and Geoscientists BC's *Seismic Retrofit Guidance* webpage [1]. Only firms who have been trained on the current SRG are granted access to the guidelines and permitted to take on seismic assessments and retrofits of BC school buildings under EDUC's SMP. In order to provide such services, these companies need to remain up-to-date. To maintain their status, at least one individual within their office must have attended the latest training seminar, conducted by Engineers and Geoscientists BC on the current version of the SRG. Engineers and Geoscientists BC hosts one full-day in-person training for each published SRG and for those wishing to be trained between SRG editions, a recorded version is available. The most recent, and current, training for SRG was on May 5, 2023, for SRG2020.

There are currently 54 firms that have an in-office engineer trained on the use and application of the SRG. In addition to being permitting to take on the assessment and retrofit of BC schools buildings under EDUC's SMP, once an engineer within a firm is trained on the current SRG, the firm has access to the seismic retrofit prototypes being applied to the seismic retrofit of other schools of similar construction and materials. This level of collaboration and sharing of engineering design approaches amongst firms has facilitated the development of innovative approaches in the seismic retrofit of various types of school construction.

Initiating a Seismic Retrofit Project

As discussed in *Seismic Project Identification Report Guidelines Edition 3.0* (Engineers and Geoscientists BC, 2018) [3], to start a seismic retrofit project, engineers trained on the current SRG must develop a SPIR and be granted approval from EDUC to proceed. SPIRs are due diligence documents that are designed to confirm the seismic risk and present seismic upgrading options in a consistent, safe, and cost-effective manner to assist seismic safety planning by both School Districts and EDUC. The SPIR provides the required information and framework for structural engineers to prepare the Project Definition Report (PDR) through the list of PDR requirements given in Chapter 11 of the SPIR. The PDR requirements are developed by the structural engineer in consultation with the assigned TRB representative and may include, but not be limited to, any of the following:

- Additional Field Testing
- Custom Site Response Analysis
- Ambient Vibration Testing
- Additional Figures
- Additional Photographs
- Class C Cost Estimate

Project and budget approval are granted by the EDUC's SMP and are primarily funded by the SMP, though some minor improvements may be funded directly by the School District.

Program Progress

Since the program was initiated, EDUC has spent over $1.9 billion to complete high risk school seismic upgrade projects. An additional $1.098 billion is allocated for the current 3-year capital plan [4]. As of April 2023, the following progress (since inception) on the SMP was reported [5]:

- Schools Completed: 216
- Schools Under Construction: 13
- Schools Proceeding to Construction: 5
- Schools Under Business Case Development (i.e., PDR stage): 19
- Schools Identified for Future Priority: 244

CONCLUSIONS

The Seismic Retrofit Guidelines (SRG) have been evolving over the past 19 years both technically and administratively. Technically, the latest versions have been expanded, and continue to expand, to include consideration for Vs30 and SSRA, as well as additional prototypes that are suitable for retrofit of all low-rise buildings in BC. Administratively, high risk school seismic upgrade projects continue to be identified, constructed, and completed.

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