

Risk Management Plan for the School Seismic Mitigation Program in the Province of British Columbia, Canada

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Background

In 2004, the British Columbia Ministry of Education initiated a \$1.5 billion seismic mitigation program to make all public elementary and secondary school buildings safe. This seismic safety program is being implemented by the BC Ministry of Education (MED) in collaboration with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). APEGBC has been contracted by MED to develop a set of state-of-the-art performance-based technical guidelines for structural engineers to use in the seismic risk assessment and retrofit design of low-rise school buildings. In undertaking this technical development program, APEGBC contracted the University of British Columbia (UBC) to draft the performance-based technical guidelines based on an extensive applied research program (APEGBC, 2006). Each draft of these technical guidelines has been peer-reviewed by a BC peer review committee of experienced local consulting engineers and by an external peer review committee comprised of prominent California consulting engineers and researchers. Research on innovative retrofit methods is still being conducted and technical guidelines are issued to keep current with research developments.

The three overall objectives of the guidelines are enhanced life safety, cost effective retrofits and user-friendly technical guidelines. The life safety philosophy of these guidelines is enhanced life safety through minimizing the probability of structural collapse by the use of rational performance-based earthquake engineering (PBEE) methods for damage estimation. The performance criterion of life safety is defined by acceptable drift ratios specified for each generic school building type. The performance standard is that the risk to life safety should not be more than 2% in 50 years

The Auditor General of British Columbia reviewed the whole project and commended MED for the high standard of their approach to handling the technical risks associated with the project. However he felt that a risk management plan was essential for the implementation of the project. In response to this advice MED commissioned the authors to develop such a plan.

Introduction

A comprehensive risk management plan for the Seismic Mitigation Program (SMP) of MED is presented here. It clearly defines roles and responsibilities for risk management and addresses the process by which the Program Manager can identify and quantify program and project risks, implement and track risk response activities, and monitor and control risks throughout the duration of the program.

Seismic mitigation is focused on preserving life safety in schools during an earthquake. The major objective of the National Building Code of Canada (NBCC) is life safety but the code has no quantitative measure of life safety. Code design is based on providing resistance to the seismic forces associated with

a ground motion hazard with a probability of exceedance of 2% in 50 years. MED wished to retrofit schools to achieve an acceptable quantitative standard of life safety and to be assured that this standard would be met in each retrofitted school. Therefore MED opted for a performance based design (PBD) approach based on the risk to life safety being also 2% in 50 years. This procedure is described in detail in the document Seismic Retrofit Guidelines, First Edition (APEGBC 2011)

Schools were evaluated by professional engineers acting under the direction of MED, using best practice and the latest research findings. The engineers classified the schools into 5 categories according to the risk to life safety, expressed as the probable risk to life safety over a 50 year period. The risk was evaluated on a building block by block basis for each school.

There are 3 high risk block categories as follows:

CATEGORY	DESCRIPTION
High 1 (H1)	Risk to life safety greater than 10%
High 2 (H2)	Risk to life safety $\geq 10\%$ and $< 7\%$
High 3 (H3)	Risk to life safety $\geq 7\%$ and $< 5\%$
Medium (M)	Risk to life safety $\geq 5\%$ and $< 2\%$
Low (L)	Risk to life safety $\geq 2\%$

The high risk buildings have priority for retrofit according to their estimated risk to life safety and are retrofitted to reduce risk to 2% in 50 years, the Low Risk category. The MED is concerned at the slow pace of the retrofit program. There are many reasons for this. For example, Vancouver has a large number of schools at high risk, nearly half the total but has been able to accommodate at best a few retrofit projects at a time. Vancouver also has a large number of heritage schools which take a long time to deal with for political and technical reasons. Because of its concern for life safety in the schools, MED has been examining options for achieving a faster rate of high risk reduction.

The most effective option appears to be a phased implementation program which would see the risk first reduced on a global basis to Medium for all the high risk schools. The medium risk schools would then be retrofitted during the regular capital projects cycle. This option has been recommended independently to MED by the University of British Columbia Research Group and by Craig Comartin, California seismic consultant, in his program assessment report.

It is clear that the mitigation program is not a static process but a dynamic approach to a very difficult challenge. This risk management plan has been developed with the dynamic aspects of the mitigation in mind and formally recognizes that the program management staff should be alert to opportunities for improving schedules and costs.

Purpose

The aims of the Risk Management Plan are:

- To provide a process to identify, document, mitigate and manage events that could adversely affect the successful completion of the SMP.
- To provide updated evaluations of the probable completion date, cost, and the adequacy of program contingency.
- To comply with the requirements of government policy and the Capital Asset Management Framework (CAMF) of the British Columbia government.

The Program Risk Management Plan:

- Defines terms used in risk management.
- Describes the risk management process.
- Defines the roles and responsibilities of MED and the Risk Management Team (RMT) in performing risk management of the SMP.
- Describes how the program Risk Management Plan is implemented.
- Lists the scheduled activities for review, updating, reporting and monitoring.

Risk Management Process

The Risk Management Process is a structured and systematic procedure for managing risks that includes six processes:

1. **Risk Management Planning**
Deciding how to approach, plan and execute the risk management activities.
2. **Risk Identification**
Determining which risks might affect the program and documenting their characteristics.
3. **Qualitative Risks Analysis**
Prioritizing risks that may affect the program and documenting their characteristics.
4. **Quantitative Risk Analysis**
Prioritizing risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact.
5. **Risk Response Planning**
Developing options and actions to enhance opportunities and reduce threats to project activities.
6. **Risk Monitoring and Control**
Tracing identified risks, monitoring residual risks, identifying new risks, executing risk response plans, and evaluating their effectiveness throughout the program life cycle.

Risk Management Organization

The MED owns all risks associated with the seismic mitigation program and carries the responsibility for providing adequate resources, both financial and technical, to the school districts to equip them to carry out successfully their seismic mitigation projects. Risk Management is an integral component of decision making at each administrative level in the process, especially at the School Districts which own and operate the facilities and develop specific seismic projects. Risk management responsibilities are outlined in Table 1.

Table 1 – Risk Management Responsibilities

Roles	Responsibilities
<p>Program Management – Ministry of Education</p>	<ul style="list-style-type: none"> • Recommends strategies to maintain the schedule, scope and budget for the program to government. • Ensures the proactive response to all risks and opportunities that will impact the successful delivery of the program. • Provides an adequate contingency funding to allow quick response to many of the risks to schedule, scope and costs for specific projects.
<p>Project Management – School Districts</p>	<ul style="list-style-type: none"> • Implements project strategies recommended by MED. • Develops project risk management plans. • Provides updates to the MED through their Planning Officer. • Implements strategies to address risks locally. • Provides justification to support requests for reserve funds.

The School District project manager submits project risk plans as part of the project development and approval stage. The Risk Management Plan is reviewed by the MED staff prior to project approval.

The development of risk response actions requires prioritizing risk for treatment and this requires some quantitative specification of the risk and impact levels. The specification provides a valid basis for action on a particular risk. Quantitative specifications of risk and impacts are presented later.

The members of the School District Project Team should collectively have all of the expertise required to identify, assess and respond to risks of the project. In addition, the School District Project Team must present their seismic project to the Technical Review Board (TRB) established by APEGBC to confirm the application of the Seismic Retrofit Guidelines. The extensive talent pool of APEGBC is available to the School District Project Team and MED for technical assistance throughout the program.

Risk Identification and Categorization

Risk identification determines what may happen that could affect the objectives of the project, and how these things might happen. The first time that risk management is applied to a project is usually when it is in the Project Identification Report (PIR) phase and will be a key element in the follow-up Project Development Report (PDR) phase. The Planning Officer should confirm that a meaningful risk plan has been developed and submitted by the school district after each phase.

In identifying risks, the project management team should consider and document:

- What may happen or not go according to plan?
- What are the impacts to the project objectives such as scope and budget should the risk arise?
- Is there a time window of opportunity for the risk to occur?
- What can trigger the risk?
- What are the assumptions and current status supporting the assessment of the risk?
- What action, if any, has been taken to respond to the risk?
- Are there further options for responding to the risk?

Adjustments to the Program Risk Plan will be made as required.

Risk Probabilities and Impacts

Risk identification and the assignment of probabilities and impacts to the risks were conducted in consultation with MED during the development of this risk management plan. Risks at the program and project levels are detailed in Appendix A: *Registers of Risks to School Seismic Mitigation Program*.

Definitions of impacts and risks are given in Table 2 in order to give some concrete meaning to the terms Low, Medium and High used in the risk registers in Appendix A. Five ranges in impacts and risks are used: very low, low, medium, high and very high. To give these qualitative classifications some clarity, cost impact is expressed as a percentage range of initial costs and schedule slippage as a percentage range of initial time to completion. Similarly, risks categories are defined as a percentage probability of occurrence. These levels for the project serve as a consistent frame of reference for the team in assessing the risks it defines. The suggested quantitative levels are subject to modification by MED as the program develops.

Table 2 – Tentative Definition of Impact and Probability Levels					
Impact	Very Low	Low	Moderate	High	Very High
Cost impact	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-30% cost increase	>30% cost increase
Schedule Impact	Insignificant slippage	<10% project slippage	10-20% project slippage	20-30% project slippage	>30% project slippage
Scope Impact	Change is barely noticeable	Minor areas are affected	Change requires MED approval	Change not acceptable to MED	Termination of project
Probability	1-19%	20-39%	40-59%	60-79%	80-99%

Prioritize the Risks

The project management team assesses each identified risk for:

- The probability of the risk occurring.
- The impact of each risk on cost, time and scope of the project.

The importance of potential impacts of a risk ranks the priority of the risk for risk response planning and action. A risk matrix similar to that shown in Figure 1 may be used to determine the importance of each impact on Scope, Schedule and Costs. The risk matrix for Program Schedule Risks is shown in Figure 1. The numbers shown in the cells identify the individual risks in the risk register for the Program Schedule Risks in Appendix A. Clearly the greatest threats to the program schedule are Risks #2 and #5 which are designated in the risk register for Program Schedule Risks.

Probability	Very High					
	High					
	Medium			3	2, 5	
	Low			4	1	
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High

Figure 1. Risk Matrix for Program Schedule Risks

This stage of the risk management process generates a prioritized list of risks and a detailed understanding of their impacts upon the success of the projects, should they occur. The probability levels, impact levels and impact importance are recorded in the risk register.

The priorities of the risks determine where the greatest effort should be focused in responding to identified risks. Priorities facilitate structured response actions planning and resource allocation.

Risk Review and Updating

Periodically, the project's risk register and risk response allocations (e.g. contingency funds), should be reviewed and updated.

Monitor and Control

Continuous monitoring by the Risk Management Team ensures that new and changing risks are detected and managed and that risk response actions are implemented. Risk monitoring and control continues for the life of the project.

Risk control may involve recommending:

- Alternative risk response strategies.
- Implementing a contingency plan.
- Taking corrective actions.
- Changing the project objectives.

Post-Implementation Audit

An essential control mechanism for projects such as the ones anticipated by this risk management plan is the use of a post-implementation audit or review. This process reviews the original intended cost/benefits from the project in light of actual experiences with outcomes, costs expended and time to completion. The goal of this process is to improve the project management process, to learn from the experiences, prepare better for the next project and above all to ensure that best practices are being used to advance the seismic mitigation program.

Reporting to Stakeholders

Communications and consultation with project stakeholders are crucial factors in undertaking good risk management and achieving project outcomes that are broadly accepted. It helps everyone to understand the risks and trade-offs that must be made in a large complex project. Communication ensures that all parties are fully informed.

To communicate both policy and technical information about this program, a coordinated approach is required. A web site for communication on technical issues related to the school seismic mitigation program is in development for MED by APEGBC. UBC's Earthquake Engineering Research Facility is providing direct support to APEGBC regarding the communication of technical issues. MED has its own website that informs the public about policy information, the evolution of the program, describes progress and outlines updated plans for completion.

These are major steps in keeping all stakeholders adequately informed and MED and APEGBC are coordinating their communication strategies to meet stakeholder's expectations. This type of communication carries risks of its own, unless carefully planned and executed. A communication plan including protocols is being developed with close consultation between APEGBC and MED and all web postings will require MED approval. The use of clear, non-technical terminology will be important for public information.

Final Comments

The plan outlined above has been accepted by MED and will form the basis for the ongoing management of risks associated with the implementation of the Schools Seismic Mitigation Program.

Appendix A

Registers of Risks to School Seismic Mitigation Program

Program Risks

Program Schedule Risks

These are risks that potentially affect the schedule of the overall program and project cash flow. The management of cash flow for capital projects is a priority requirement for government.

#	Schedule Risk	Risk Probability	Risk Impact	Risk Management Strategies	Manage, Price or Transfer
1	Funding level	Low	High	<ul style="list-style-type: none"> Modify scope. Modify schedule. 	Manage risk
2	School District performance in project development and approval – earned independence on seismic projects	Medium	High	<ul style="list-style-type: none"> Approve future funding to SD based on track record with previous projects. Modify scope. Require school districts to provide options analysis. Impose alternative delivery strategies. 	Manage risk
3	Escalation of costs	Medium	Medium	<ul style="list-style-type: none"> Contingency in program estimates. 	Manage risk
4	Selection of procurement model	Low	Medium	<ul style="list-style-type: none"> Complete procurement review to ensure appropriate method is selected. 	Manage risk
5	School Districts capacity to deliver - implementation phase	Medium	High	<ul style="list-style-type: none"> Provides resources and/or oversight structure. Impose project specific conditions. 	Manage risk

Program Schedule Risks: Impacts and Probabilities

Probability	Very High					
	High					
	Medium			3	2, 5	
	Low			4	1	
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High

Program Scope Risks

These risks potentially affect the scope of the overall program. A significant change in scope may cause the projects to be delayed or have some postponed to a future approval period.

#	Scope Risk	Risk Probability	Risk Impact	Risk Management Strategies	Manage, Price or Transfer
1	Change in scope as a result of ministry initiative or other external requirements	Low	Medium	<ul style="list-style-type: none"> Adjust funding, schedule or scope. 	Manage risk
2	Change of scope as a result of requests by School District	High	High	<ul style="list-style-type: none"> Provide clear expectations on approved scope. Complete preliminary structural studies to confirm options. School District provides additional funding. 	Manage risk
3	Change of scope as a result of requests by local government for additional feature (underground parking, etc)	High	Medium	<ul style="list-style-type: none"> Contingency funds built in to program estimates. Comprehensive plan with municipality for heritage. Phased implementation of seismic to reduce impact on heritage or other municipal requirements. 	Manage risk

Program Scope Risks: Impacts and Probabilities

Probability	Very High					
	High			3	2	
	Medium			1		
	Low					
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High

Program Cost Risks

These are risks that potentially affect the cost of the overall program.

A program contingency fund is one of the major methods for coping with these risks. MED requires a detailed rationale for the release of contingency funds for any particular risk.

#	Cost Risk	Risk Probability	Risk Impact	Risk Management Strategy	Manage, Price or Transfer
1	Cost of project delivery exceeds the established budget	Low	Medium	<ul style="list-style-type: none"> Program contingency fund to be applied to address justifiable project cost increases. Ensure proper planning and options analysis. Employ phased upgrade strategy. Employ alternative delivery strategies. 	Manage risk
2	Provision of temporary accommodation	Low	Medium	<ul style="list-style-type: none"> Request options to identify cost-effective temporary accommodation. 	Manage jointly with school districts

Program Cost Risks: Impacts and Probabilities

Probability	Very High					
	High					
	Medium					
	Low			1, 2		
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High

Project Risks

Project Schedule Risks

These are risks that potentially affect the schedule of an individual project. The management of scheduled cash flow for capital projects is a priority requirement for government.

#	Schedule Risk	Risk Probability	Risk Impact	Risk Management Strategy	Manage, Price or Transfer
1	Potential impact of labor, material and/or equipment shortages	Low	High	<ul style="list-style-type: none"> Ensure original schedule is realistic and reflects market conditions. 	Transfer risk to bonded contractor by contract
2	Impact of local jurisdiction permit approval process i.e. Design Panel, Development Permit, Building Permit, Utility Permits etc.	Medium	High	<ul style="list-style-type: none"> Confirm timelines and requirements with local jurisdiction. Develop approval process schedule and integrate with project schedule. Obtaining prior agreement with city on what project is responsible for. 	Manage
3	Delay in availability of temporary accommodation	Low	High	<ul style="list-style-type: none"> Ensure temporary accommodation needs clearly identified and available. 	Manage
4	Delay in Ministry approval to proceed	Low	High	<ul style="list-style-type: none"> Clearly identify fixed milestones in PIR and allowing sufficient flexibility in schedule. 	Manage
5	Labor unrest	Medium	High	<ul style="list-style-type: none"> Adjust schedule. 	Manage
6	Capacity of the school district to deliver the project – earned independence	Medium	Medium	<ul style="list-style-type: none"> Review previous performance. Assign resources and oversight. 	Manage
7	Selection of appropriate procurement model	Medium	High	<ul style="list-style-type: none"> Require school district to provide an independent procurement analysis for evaluation. 	Manage

Project Schedule Risks: Impacts and Probabilities

Probability	Very High					
	High					
	Medium			6	2, 5, 7	
	Low				1, 3,4	
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High

Project Scope Risks

These risks potentially affect the scope of an individual project. A significant change in scope may cause the project to be delayed or have it postponed to a future approval period.

#	Scope Risk	Risk Probability	Risk Impact	Risk Management Strategy	Manage, Price or Transfer
1	Change in scope by SD	Medium	Medium	<ol style="list-style-type: none"> SD provides rationale for the change in scope associated with specified risks. SD is responsible for all costs associated with the work beyond that approved by the ministry. Conduct testing and investigation prior to project approval. Employ TRB to confirm scope of work. 	<ol style="list-style-type: none"> Ministry manage risk SD manage risk

Project Scope Risks: Impacts and Probabilities

Probability	Very High					
	High					
	Medium			1		
	Low					
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High

Project Cost Risks

These are risks that potentially affect the cost of an individual project.

A program contingency fund is one of the major methods for coping with these project risks. MED requires a detailed rationale for the release of contingency funds for any particular risk.

#	Cost Risk	Risk Probability	Risk Impact	Risk Management Strategy	Manage, Price or Transfer
1	Current SD budget inconsistent with ministry estimates	Low	Medium	<ol style="list-style-type: none"> 1. Assemble professional integrated team to develop sound project contingency. 2. Provide adequate funding for investigation. 	Manage risk
2	Inadequate project management practices	Medium	High	<ol style="list-style-type: none"> 1. Establish project management team with appropriate and qualified professionals. 2. Establish written monthly reporting system that supports audit trail. 	Manage risk
3	Inadequate analysis of change orders and costs	Medium	Medium	<ol style="list-style-type: none"> 1. Rigorous control of Change Orders and hold contractor accountable. 2. Establish the reasonable transfer of risk to the contractor. 	Manage risk
4	Overall project contingency	Low	Medium	<ol style="list-style-type: none"> 1. Identify risk of all questionable cost items and provide a detailed rationale for calculation. 2. Ministry provides the funds based on justification provided by schools districts. 	Manage risk
5	Quality of construction documents	High	Medium	<ul style="list-style-type: none"> • Peer review of construction documents. 	Manage risk
6	Selection of appropriate procurement model	Medium	High	<ul style="list-style-type: none"> • Require school district to provide an independent procurement analysis for evaluation. 	Manage risk

Project Cost Risks: Impacts and Probabilities

Probability	Very High					
	High			5		
	Medium			3	2,6	
	Low			1, 4		
	Very Low					
	Impact	Very Low	Low	Medium	High	Very High