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PANEL ON SEISMIC SAFETY OF SCHOOLS

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ABSTRACT

Panelists in the panel session on Seismic School Safety will address or comment on the following questions:

1. What is the expected earthquake damage to public (elementary through high school) schools in the U.S. and British Columbia?

2. What is the worst case earthquake scenario in terms of student fatalities (in the U.S. and British Columbia)?

3. What level of seismic safety of schools is acceptable?

4. What actions are needed to achieve that level of safety?

5. What new state, provincial or national programs (or policies) are needed?

1. What is the expected earthquake damage to public (elementary through high school) schools in the U.S. and British Columbia?

There are 747 public schools within seismic hazard zones in British Columbia. The schools range in age from early 1900 to new with over 30 building types. Since 1990 a variety of seismic upgrade programs have been initiated by the Government of British Columbia and portions of schools have been updated to the design standards of the period.

In 2004 the Government announced a $1.5 billion, 15 year, Seismic Mitigation Program. Since that time 80 schools have been completed, 16 schools are in the construction phase and 23 projects are proceeding to construction. In addition 81 new or replacement schools have been built to modern seismic standards.

The extent of the earthquake damage to BC schools is difficult to quantify for a specific event. Therefore, recent building screening and enhanced risk assessment studies have estimated the vulnerability of BC schools to earthquake damage in terms of risk and the associated retrofit priority as given in Table 1.

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Table 1: 2010 Distribution of Earthquake Damage Vulnerability in BC Schools

Retrofit Priority	Floor Area (sm)	Percent of Total
High (1)	700,000	15%
Medium	1,500,000	31%
Low	2,600,000	54%

Notes: (1) Refer to Table 2 for the retrofit priority definitions.
(2) Above Floor area is for all BC schools in regions of significant seismicity.

The Ministry of Education has provided $5 million annually to school districts for non-structural upgrade projects initiated at the school district level. In addition the Government has initiated a 3 year program to complete a building condition assessment on all schools (1600) in the Province. Non-structural deficiencies of schools within the seismic zones will be identified as part of this assessment using methodology based on the Canadian Standard CSA-S832.

2. What is the worst-case earthquake scenario in terms of student fatalities (in the U.S. and British Columbia)?

There has been no analysis of this nature. Our efforts have been directed towards strategies to address the condition of schools, the risk analysis of building failure and cost effective mitigation strategies to make schools life safe.

3. What level of seismic safety of schools is acceptable?

British Columbia may be affected by three types of earthquakes. The subduction earthquakes in BC are expected to occur every 300 to 500 years, the sub-crustal earthquakes are expected every 100 years and the crustal earthquakes are expected every 50 years. The seismic section of the BC Building Code provides a design-level earthquake for each region in BC based on an earthquake with a probability of occurrence of 2% in 50 years. Soil conditions are taken into account when determining the design level for a given region. The design-level earthquake has been determined taking into account the contribution to the hazard from each to the three earthquake sources in the province.

It is interesting to note that the last subduction event occurred over 300 years ago. Also, the recent subduction earthquake in Chile in February 2010 caused ground motions in Santiago, the capital city of Chile, of intensities comparable to the expected design-level shaking for Vancouver.

For the retrofitted schools in BC a performance level has been established following a probabilistic approach: 2% chance of the building capacity being exceeded by a seismic event in 50 years . The objective is to achieve a life safe standard and not necessarily a building safe

standard unless there are specific post disaster requirements for the school. For new schools, an importance factor of 1.3 is used in the calculation of the building capacity.

4. What actions are needed to achieve that level of safety?

The building risk assessment is based on the probability of exceeding a prescribed drift limit for the structure as shown in Table 2.

The risk assessments identified schools that range from very high risk of failure to low risk of failure. The action required is to address the upgrades in a period of time which maintains the 2% in 50 year performance level, the retrofit period. For example a school with a 10% chance of building capacity being exceeded in 50 years can remain within the 2% standard if it is upgraded within 10 years.

Table 2: Refined Retrofit Priority Categories and Corresponding Retrofit Period

Retrofit Priority Ranking	PDE Range Over 50 Years	Retrofit Period
Very High (VH)	PDE > 20%	0 – 5 years
Very High (VH)	20% ≥ PDE > 10%	5 – 10 years
High – Level 1 (H1)	10% ≥ PDE > 7%	10 – 15 years
High – Level 2 (H2)	7% ≥ PDE > 5%	15 – 20 years
Medium (M)	5% ≥ PDE > 2%	20 – 50 years

Note:
(1) PDE is the Probability of Drift Exceedance for the specified period (e.g., 50 years)

5. What new state, provincial or national programs (or policies) are needed?

The Provincial Government of BC has taken the most important step by initiating the $1.5 billion seismic mitigation program to make schools life safe over a 15 year period.

The initial challenge in the implementation of the seismic mitigation program has been the development of seismic risk assessment and seismic mitigation strategies which are understood and accepted by the design community, the local authorities and the contractors.

Since 2005, the Association of Professional Engineers and Geoscientists of British Columbia and the University of British Columbia, Civil Engineering Department Earthquake Engineering Research Department have been engaged by the Ministry of Education. They have conducted significant research and analysis, worked closely with leading structural engineers within BC and from California, completed extensive laboratory testing and analysis, inspected actual earthquake sites including China and Chile, developed bridging guidelines now being upgraded to technical

guidelines on seismic assessment and mitigation design and conducted training for engineers on the assessment and design for seismic upgrades of schools within BC. There is a requirement to ensure engineers completing seismic upgrade projects are applying the latest design strategies. To accomplish this requirement, APEGBC has established a Technical Review Board composed of experienced structural and geotechnical engineers to review preliminary plans for seismic upgrade projects.

The Bridging Guidelines were developed to provide the Engineer with expedient tools and to insure consistent analysis of the various types of school structures. The Provincial Government accepted the liability for the use of the bridging guidelines as the best practice available to make schools life safe and directed that they be applied in the seismic upgrade projects.

Seismic Project Challenges

A challenge with the seismic mitigation program has been the length of time it has taken to complete projects supported by the Provincial Government. 95 projects were supported by Government in 2005 which were in addition to 11 projects previously approved; by 2008 only 12 had been completed and 17 were under construction.

Schools are owned and operated by School Boards. Capital funding is provided to the School Districts by the Provincial Government. Projects, including new schools, replacement schools, major renovations or seismic upgrades are approved for funding based on requests submitted by School Districts in their annual Five Year Capital Plan submission. The Provincial Government initiated the seismic mitigation program with an established budget each year. The priorities of the School District may not match the seismic program requirements. In addition, School Districts often wish to carry out functional changes and other building systems upgrades in conjunction with seismic projects, creating budget pressures and delays.

In spite of the fact that seismic upgrades are voluntary, municipal authorities may demand other system upgrades in accordance with their bylaws which redirects funds to non-seismic requirements.

Many of the older schools have significant seismic deficiencies and high heritage value. Retention of heritage features has complicated the seismic upgrades and results in higher costs for the upgrades.

A school may have several building types and varying levels of seismic risk. The school district would like to complete all the seismic work at one time. Implementation of high priority seismic projects in other schools may be delayed due to the fixed annual funding being directed to lower risk blocks. The school districts also want to complete the building renewal work at the same time which increases pressure on the fixed level of funding.

Seismic upgrade projects are very disruptive to school operations. Some school districts

have decided to only implement a few projects at a time so they can manage the projects effectively with their available resources.

Some small school districts rarely obtain capital projects therefore they may lack the resources to complete seismic projects even though provincial funding has been committed.

The final approval of many seismic projects has been onerous. The initial school assessments in 2004 were based on best practice at that time. The 2004 assessment of the costs for the upgrades did not consider a number of key factors required for project delivery such as temporary accommodations. Changes to the 2006 Building Code resulted in many schools being considered for full replacement rather than upgrading thereby increasing the project costs well above the original budget. The market conditions changed dramatically and construction costs doubled over the four year period. There has been significant decline in student enrolment so school districts have been updating their long term facilities plans to confirm which schools will be required for the future. School Districts are required to fund non-seismic work from their building renewal funds which were limited. Various reviews were conducted by the School District and Ministry to verify the approved work was related to the seismic requirements. In some cases the consultant team engaged by the school district did not apply the Bridging Guidelines for the Seismic Upgrading of Schools. The various project complications resulted in project delays. As a result, the annual Provincial seismic allocations were not fully utilized.

Required Action:

- Funding for seismic upgrades should be provided to projects which the school district is prepared to implement without delay.
- Funding should be directed to the higher risk structures prior to medium risk structures.
- Adequate funding should be provided early in the process for comprehensive field investigations and analysis to confirm the scope of work and all costs related to the completion of the project.
- A program delivery model should be implemented which ensures the funds are directed to the life safety requirements of the seismic program.
- Project resources should be provided to expedite the delivery of seismic projects within the retrofit period if school districts do not have capacity to meet the required timelines.
- The Technical Guidelines for the Seismic Upgrading of BC Schools should be finalized and made available to Engineers.
- Development, documentation and distribution of refined retrofit strategies need to be supported in an ongoing process.