THE UNIVERSITY OF BRITISH COLUMBIA

REPORT TO THE BOARD OF GOVERNORS
Agenda Item #4.2

SUBJECT	**SEISMIC MITIGATION PLAN – PROGRESS REPORT**
MEETING DATE	**APRIL 13, 2017**

Forwarded to the Board of Governors on the Recommendation of the President

APPROVED FOR SUBMISSION

Santa J. Ono, President and Vice-Chancellor

For Information

Report Date	March 13, 2017
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EXECUTIVE SUMMARY

Major changes since previous presentation to the Board of Governors	Since June 2016, the project team have completed several components that will inform the updated seismic mitigation plan. Some of these elements include a utility assessment to identify vulnerabilities, an initial investigation to calibrate the 1994 plan and 2012 update against current assessment methods and an initial screening of over 340 buildings which identified those which should be further analyzed. The team have also finished a multi-hazard assessment of the campus which identified fire following earthquake as a high risk, so further analysis of this hazard is now under way. A further additional scope item that is under way is an assessment of the student housing population vulnerability.

UBC places the safety of students, faculty and staff as its highest priority. Reducing or mitigating the risk of injury or death as a result of a seismic event is critical. As reported in June 2016, the plan for the seismic mitigation of the Vancouver campus is now being updated to ensure that this risk is reduced as much as possible and as quickly as possible within the University's logistical and financial capacity.

In 1994, UBC undertook a comprehensive seismic assessment of the full building stock on the Vancouver campus. At that time, each building was classified on a scale from low to very high seismic risk. Some of the highest risk buildings identified at this time were seismically upgraded as part of the UBC Renew program undertaken between 2003 and 2011. In 2012, the University commissioned a follow-up study to upgrade the seismic assessment based on evolving earthquake science and building codes. This study changed some of the buildings' classifications to reflect this evolution. This work subsequently formed the basis for UBC's current seismic mitigation plan.

While several buildings have been retrofitted or replaced since 2012, there are still 28 buildings (out of approximately 400) on the Vancouver campus that are classified as being at high or very high seismic risk. Of these 28 buildings, four are in the process of design or construction to be seismically retrofitted.

Another fourteen have identified strategies for their upgrade, retrofit or demolition by 2027. There are still ten buildings for which there is no identified strategy or funding.

The need for an update was identified for three reasons as follows:

- The timeliness of the planned upgrades needs to be re-evaluated – the feasibility of reducing to zero the number of buildings not yet upgraded by 2027 needs to be investigated.
- The science of different seismic fault lines has evolved significantly since the buildings were originally assessed in 1994 and re-evaluated in 2012. New fault lines and new earthquake intensities are now recognized that are more severe than were identified previously. As a result, the newest building codes are significantly more stringent than the ones used in the previous assessments so the new evaluation needs to reflect these changes. While this change may mean that additional buildings are added to the list of buildings of concern, clearly, it is necessary to reflect this updated thinking in the seismic planning.
- Best practice thinking around resilience, risk assessment and the ability of a major public institution like UBC to respond to a natural disaster like an earthquake has evolved. Bringing the plan to a level that reflects this best practice is necessary. This updated practice shows a more nuanced approach to seismic planning, reflecting a risk assessment approach that allows for a spectrum of needs to be addressed. While life safety is paramount, it looks beyond this one aspect to address the ability of an institution to resume operations after a disaster, and addresses broader technical aspects such as utility vulnerabilities and non-structural seismic hazards.

The new seismic plan is still in the works and is anticipated to be complete in May 2017, with the intention to present to the Board in June 2017. This plan will reflect the latest thinking in seismic assessment and planning, recognizing that there are different seismic vulnerabilities for different buildings on campus and different levels of criticality for different kinds of spaces. The steps that have been completed are as follows:

- A seismic risk hazard assessment identifying the specific seismic risk of the Vancouver Campus has been done, and a multi-hazard assessment of all potential natural disasters and re-assessment of all Vancouver campus buildings,
- Measurable resiliency objectives have been set in consultation with key stakeholders,
- An initial utilities assessment is complete, identifying vulnerabilities and potential failure points, and,
- An initial screening of over 340 buildings has been completed. This screening has shown which buildings should undergo more in-depth analysis based on risk.

The items that are remaining to be completed are as follows:

- Completing the more in-depth analysis of the structures and contents of the campus portfolio and the utilities that serve the campus; conducting a risk assessment of fire following earthquake and an assessment of the vulnerability of the student housing population,
- Conducting a gap analysis and evaluating how best to spend resources to respond to the spectrum of anticipated seismic events, and,
- Determining what financial and operational resources are required to meet the vision of being a disaster-resilient university, one that is able to withstand impacts of possible hazard events without harm to people, unacceptable losses to property or interruptions to UBC's mission.

INSTITUTIONAL STRATEGIC PRIORITIES SUPPORTED				
☐ Learning	☐ Research	☐ Innovation	☐ Engagement (Internal / External)	☐ International
or ✔ Operational				

DESCRIPTION & RATIONALE

Infrastructure Development and Risk Management Services are in the process of updating the seismic mitigation plan with a revised plan that reflects updated thinking with respect to earthquake science and the need to reflect not just life safety but also organizational resilience and ability to recover from major incidents.

UBC has had a seismic mitigation plan for over 20 years. This plan has undergone revisions as needed to reflect changes to codes and standards, with the most recent revision coming in 2012.

History

In 1994, UBC undertook a comprehensive seismic assessment of the full building stock on the Vancouver campus. At that time, each building was classified on a scale from low to very high seismic risk. The study was based on the current code which at the time was the 1990 British Columbia Building Code and the assessment methodology used was a 1992 National Research Council of Canada guideline. At that time, 28% of the 273 campus buildings assessed were identified to be either high or very high seismic risk. Some of the highest risk buildings that were identified at this time were seismically upgraded as part of the UBC Renew program undertaken between 2003 and 2011.

In 2012, UBC commissioned a follow-up study to upgrade the seismic assessment based on evolving earthquake science and building codes. This study changed some of the buildings' classifications to reflect this evolution. The study is based on the 2006 British Columbia Building Code but still uses the 1992 National Research Council of Canada assessment methodology as that was still the current industry standard at the time. In the course of this investigation, some buildings were reclassified although the study focused strictly on the high and very high seismic risk buildings to compare them to the building code that was in force at that time. This work subsequently formed the basis for UBC's current seismic mitigation plan.

Retrofits Completed & 2012 Plan

While several buildings have been retrofitted or replaced since 2012, there are currently still 28 buildings (out of approximately 400) on the Vancouver campus that are classified as being at high or very high seismic risk based on the 2012 update to the seismic assessments.

Of these 28 buildings, four are in the process of design or construction to be seismically retrofitted. They are being retrofitted to the current British Columbia Building Code. These buildings have been prioritized based on the potential for greatest impact on students, faculty and staff. Buildings that have the largest ratio of occupants to upgrade cost have generally been upgraded first. Another fourteen buildings have identified strategies for upgrade, retrofit or demolition that are scheduled to be completed by 2027. There are still ten buildings for which there is no identified strategy or funding.

Background – Evolution of Thinking

This current plan is being updated in three areas – timeliness, changed code requirements and recognition of resiliency in seismic thinking. The project team is developing a more comprehensive, up-to-date plan that will be an example of best practice.

Timeliness

The timeliness of the planned upgrades needs to be re-evaluated. Ideally, all buildings will be upgraded sooner to ensure that the life safety of the whole campus community is safeguarded more quickly against the threat of a seismic event. The proposed new plan includes investigating the feasibility of reducing the number of buildings not yet upgraded by 2027.

Code Evolution

The science of different seismic fault lines has evolved significantly since the buildings were originally assessed in 1994 and re-evaluated in 2012. New fault lines and new earthquake intensities are now recognized that are more severe than were identified previously. Figure 1 shows how the code-based design standards have evolved over the past several versions of the building code. The most recent code design is 20% more stringent that the last version upon which the current plan is based. As a result, the newest building codes are significantly more stringent than the ones used in the previous assessments so the new plan needs to reflect these changes. While this code change may mean that additional buildings are added to the list of buildings of concern, clearly, it is necessary to reflect this updated thinking in the seismic planning.

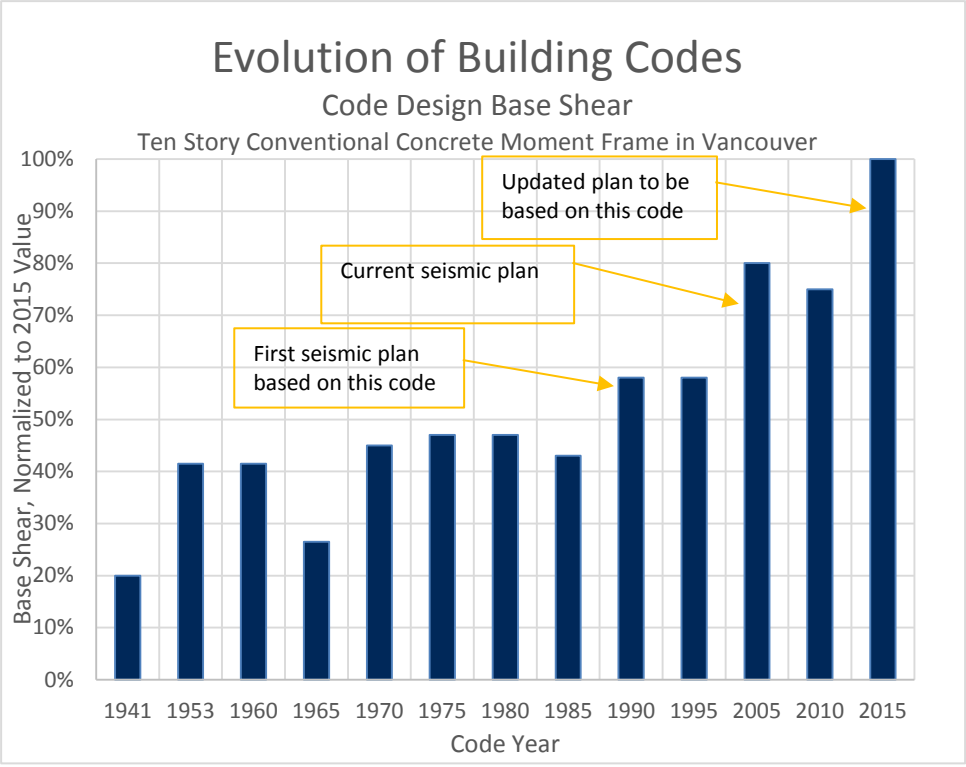


Figure 1 – The evolution of code-based design in the BC Building Code

Best Practice Thinking – Incorporating Resilience and Risk

Best practice thinking around resilience, risk assessment and the ability of a major public institution like UBC to respond to a natural disaster like an earthquake has evolved significantly in recent years. Bringing UBC's seismic plan to a level that reflects this best practice is necessary. This updated practice shows a more nuanced approach to seismic planning, reflecting a risk assessment approach that allows for a spectrum of needs to be addressed. While life safety is paramount, it looks beyond this one aspect to address the ability of an institution to resume operations after a disaster and looks at aspects such as utility vulnerabilities, the ability to resume teaching and research post-event and the criticality of different buildings in carrying out the mission of the University.

Previous plans focussed solely on structural vulnerability – basically, when a building has been upgraded with this focus only, it means that people will be able to get out alive after an earthquake but there is no consideration of overall risk. Broadening the plan to consider overall risk means looking not only at the structural vulnerability but also integrating hazard, exposure and vulnerability. This translates into assessing not only the potential for loss of life but also economic impact and the likely downtime of the university after a seismic event. In addition, the evaluation of non-structural seismic hazards (e.g. falling books, equipment, furniture, etc.), which can prove fatal if not secured, is also part of this broader assessment.

One of the critical items to recognize with this shift in thinking is that there are different strengths of earthquakes with different frequencies of occurrence. While building codes tend to only recognize one (the "Rare" event listed below), best practice considers multiple frequencies and strengths of events to build a more complete picture of the risks that need to be addressed. The tables below show a comparison between a code-based approach and an outline framework of a resiliency-based approach.

Code Performance Objectives			
Earthquake Intensity	**Expected Performance**	**Downtime**	**Probability of Occurrence**
Frequent	Little damage	Short	50% in 50 years
Rare	"Life safety"	Months to years	10% in 50 years
Very Rare	"Collapse prevention"	Years, if recovery is possible	2% in 50 years

Sample Resilience-Based Objective Framework					
Earthquake Intensity	**Life Safety?**	**Continuity of Teaching**	**Continuity of Research**	**Housing Re-Occupancy**	**Preserve Assets?**
Frequent	Yes	< X hours	< X hours	Immediate	All
Rare	Yes	< X days	< X days	< X days	All
Very Rare	Yes	< X months	< X months	< X months	Only critical/ invaluable

This comparison demonstrates that continuing with a code-based set of performance measures means that UBC's ability to recover from and continue with its broader mandate as a teaching and research institution could be compromised.

There are a handful of peer institutions, notably Stanford University and University of California – Berkeley, who have arrived at the same conclusion and have developed resiliency-based plans. These plans outline measurable, numerical objectives that respond to frameworks similar to the example above. These institutions have spent time doing a gap analysis to determine how much of their campus can meet these objectives, what it would take both technically and financially to achieve that objective and then have been closing that gap over a number of years.

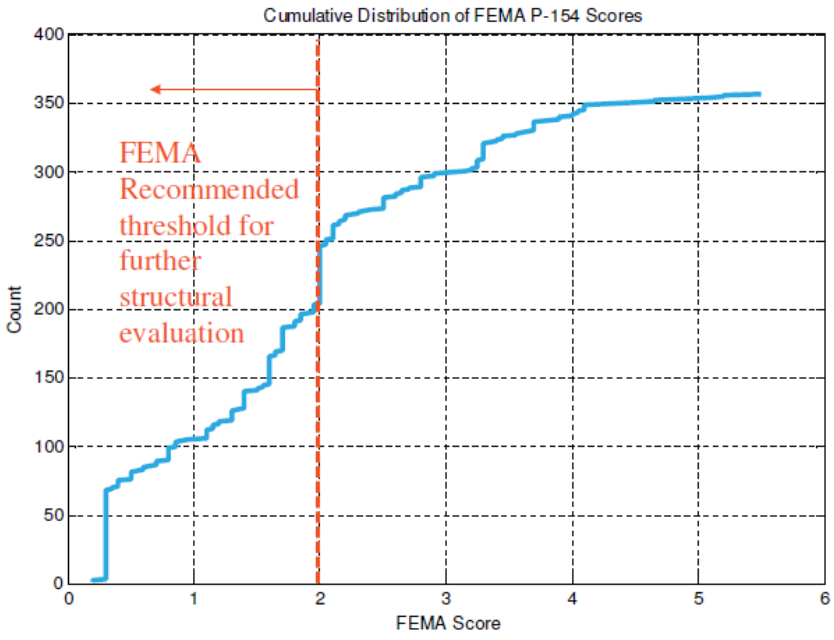
New Direction & Updated Plan

The new seismic plan will reflect this resiliency-based thinking and will include an updated seismic assessment and planning exercise. This new plan will establish and recognize the different seismic vulnerabilities in different parts of campus and different levels of criticality for different kinds of spaces. The project team has undertaken a significant amount of work since this direction was presented in June 2016, as outlined below, but there is still work to be done, completion of which is targeted in time for presentation at the June, 2017 meeting of the Board.

Updated Plan – Work to Date

One of the first steps that was undertaken by the project team was confirming which seismic events are the right ones (specific to the Vancouver campus) for each frequency (*i.e.,* which event is the "Frequent" and which is the "Very Rare" if the code-based event is the "Rare" event?). This work was undertaken in collaboration with UBC Faculty member, Dr. Carlos Ventura, and his team. The results of this investigation showed that there are a number of different kinds of seismic events which could strike the campus, all of which will be used in the more detailed structural modeling of the buildings. These different kinds of events could result in different types of structural impacts or modes of failure so it is important to assess all of them as part of this work.

Next, the re-assessment of all buildings on campus as well as the utility infrastructure has been started with this new context. A preliminary screening analysis has been completed using the FEMA-P154 standard. This standard sets a threshold below which more detailed structural evaluation is recommended. The analysis shows that many (over 200) of the buildings on campus will be part of this more in-depth analysis but it should be noted that this is simply a screening analysis so it does not definitively indicate that these buildings are high seismic risk buildings. The graph below shows the cumulative distribution of the building scores from this screening analysis.



Aside from the buildings, having the water, natural gas and electricity to operate the buildings is a critical piece of the resilience conversation. Consequently, the project team have completed a preliminary utility assessment which has identified the vulnerabilities and potential failure points of these services. The outputs of this analysis include the likely disruption time or the time to restore each of these services after each of three seismic scenarios and identification of critical failure points. The team is now working on a more detailed assessment which also includes the sanitary sewers and district energy piping, and an evaluation of the Campus Energy Centre, the Power House and the Main and South Campus substations. This further evaluation will result in a series of mitigation strategies and their associated estimated probable costs.

In parallel with the work on buildings and utilities and in consultation with key stakeholders including the offices of the Vice President Research and Vice President Academic, the project team have set the measurable resilience objectives are for the campus. These objectives will help the university community measure successful implementation of the plan and are as follows:

Resilience-Based Objectives – UBC Vancouver Campus					
Earthquake Intensity	**Life Safety?**	**Continuity of Teaching**	**Continuity of Research**	**Housing Re-Occupancy**	**Preserve Assets?**
Frequent	Yes	< 24 hours	< 24 hours	Immediate	All
Rare	Yes	< 30 days	< 30 days	< X days	All
Very Rare	Yes	< 1 semester	< 1 semester	< 1 semester	Only critical /invaluable

Another parallel investigation that the team completed is a multi-hazard assessment that was done to look at all potential related hazards that could impact the Vancouver campus. As a result of this work, the threat of a fire following an earthquake was identified as a high risk event in addition to the already-identified hazards of seismic events and interface fires from the Pacific Spirit Park. Investigation of this hazard has been added to the scope of work for the seismic mitigation plan team.

Updated Plan – Remaining Work

As outlined above, the team are working on a more in-depth utility assessment, and a qualitative assessment of the vulnerability of the Vancouver campus to fire following earthquake.

In parallel, the team are refining the current building risk estimates to improve the accuracy of the estimated risks of the buildings on campus. Evaluating the criticality of spaces as well as the vulnerabilities is also a key objective of this stage of work. This evaluation includes assessing the strategic value and importance of the contents and functions of buildings on campus and comparing them to the risk that each building faces in order to optimize the risk reduction benefits for a given investment of capital and resources.

An additional scope item that has been added is a student housing population vulnerability study. Recognizing the concern that after an earthquake, one of the chief concerns of the University will be the safety and security of the student population, both in the immediate aftermath of the event and in the short term after. As a result, the team is studying the vulnerabilities that students face following an earthquake, identifying the drivers that will contribute to students deciding to remain on campus or deciding to relocate, estimating the proportion of students that may be displaced based on availability of space and continuity of services and generating a series of high level strategies to reduce the number of students displaced.

Finally, the team will create a financial and operational roadmap evaluating how best to spend resources to respond to the spectrum of anticipated seismic events,

	and determining what financial and other resources are required to meet the vision of being a disaster-resilient university, one that is able to withstand impacts of possible hazard events without harm to people, unacceptable losses to property or interruptions to UBC's mission.
BENEFITS Learning, Research, Financial, Sustainability & Reputational	Clearly, the most direct benefits of the updated plan will be the ability of the campus community to better understand and quantify the risks and vulnerabilities associated with the updated seismic events that are likely to strike the Vancouver campus. A clearer and more nuanced assessment of these risks and vulnerabilities will enable UBC to move to a point where the seismic plan is a more comprehensive, best practice plan that will result in a safer campus. It will also be able to be benchmarked against other leading institutions. As part of the proposed plan, clear, measurable goals will be set which can be reported on to Executive and the Board of Governors. These goals will allow for a transparent and clear dialogue with the campus community so that all concerned will understand the priority that UBC places on safety and resilience. In addition, by engaging in a broader assessment of vulnerabilities associated with seismic resilience, some of the vulnerabilities associated with climate change or other natural hazards will be addressed. Utility vulnerabilities are a clear example where increasing storm intensities and seismic issues can all be addressed at the same time.
RISKS Financial, Operational & Reputational	The most significant risk to this project is, in fact, the risk of not updating the plan. Ignoring best practice would mean that there would be an increased risk of loss of life or serious injury to members of the campus community. Beyond that, staying at a code-based assessment methodology means that a broad assessment of business risk and business continuity associated with seismic events is not possible. While it will be necessary to complete all seismic upgrades and retrofits over a number of years, this kind of nuanced assessment will allow for a more thorough evaluation of how to optimally allocate resources. Finally, by completing both the multi-hazard assessment and utility assessment, the University will be more holistically addressing strategic risks related to seismic vulerability and interface fires.
COSTS Capital & Lifecycle Operating	The costs associated with the creation of the updated plan are covered under the Capital Renewal program for 2016/17 and 2017/18. As part of the updated plan, an estimate of the cost to upgrade the campus over a period of time will be created. These estimates will be put into a comprehensive plan that will show options for implementing the findings of the assessment work.
FINANCIAL Funding Sources, Impact on Liquidity	Until the costs have been developed, it is not possible to determine the optimal avenues for funding it. A complete proposal will be brought forward when the plan has been fully developed.

SCHEDULE Implementation Timeline	The updated plan was initially targeted for completion by the consultant team in December 2016 with the intention to present to the Board in February 2017. The investigative stage of the project took longer than anticipated so the revised plan is anticipated to be complete in May 2017, with the intention to present to the Board in June 2017.
CONSULTATION Relevant Units, Internal & External Constituencies	The work for this investigation is being led by the Seismic Steering Commmittee. This committee includes representatives from Infrastructure Development, Building Operations, Finance, Energy & Water Services, and Risk Management Services. In addition, the Seismic Steering Committee is working closely with Professor Carlos Ventura and his team in the UBC Earthquake Engineering Research Facility. Project management is being done by Project Services (Infrastucture Development).

Previous Report Date	June 14, 2016
Decision	Information
Action / Follow Up	Project team has undertaken work to update the seismic mitigation plan.