DNR Update on Washington State School Seismic Safety for the Capital Budget Committee Work Session 1/18/2022

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Summary of DNR's School Seismic Safety Project

<u>Purpose</u>: Assess the seismic safety of permanent, public, K–12 school buildings in Washington State. This assessment is based on local geology and the engineering and construction of the buildings.

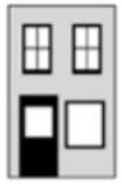
Phase 1: 2017-2019 and Phase 2: 2019-2021

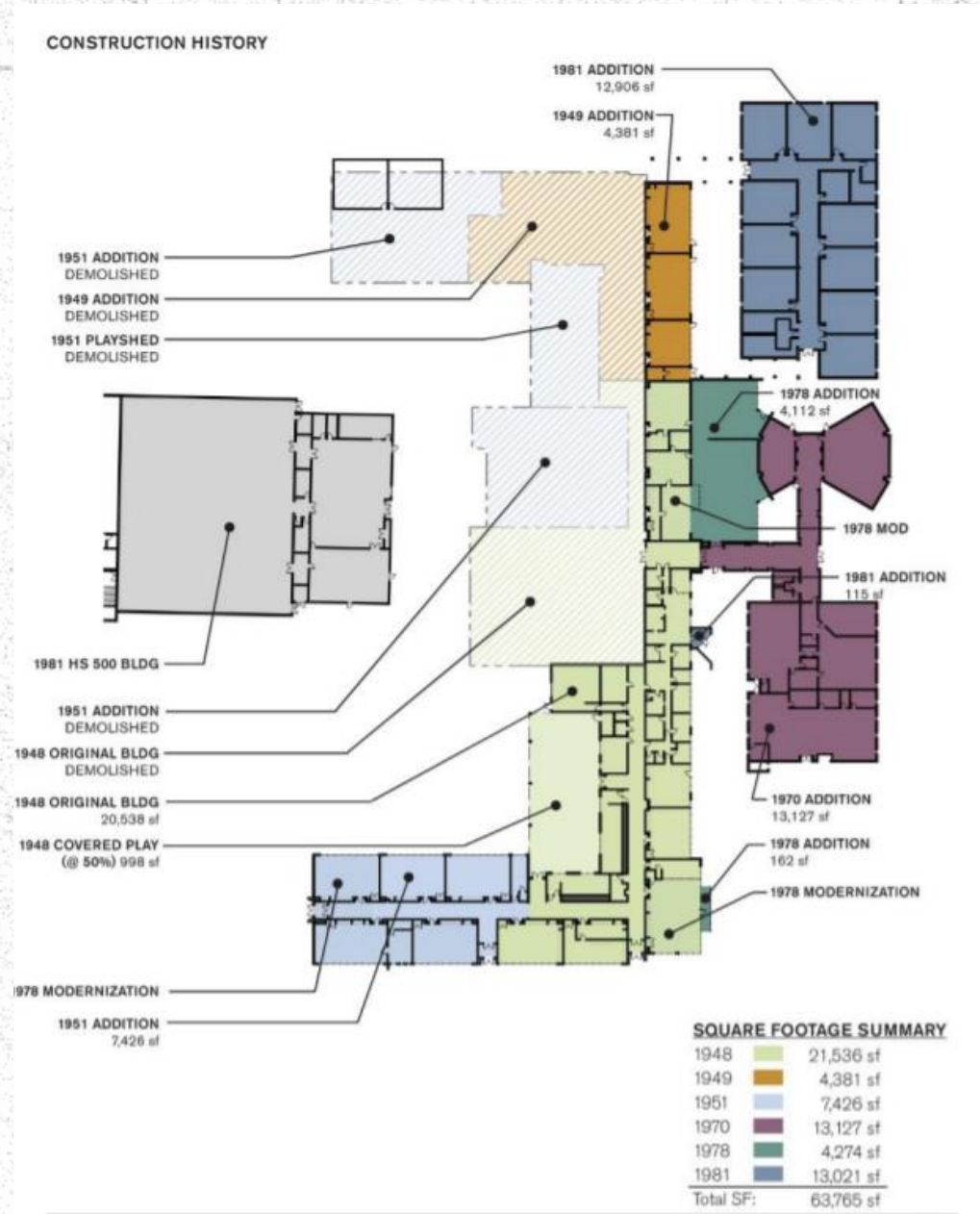
Overarching goals:

- Evaluate a representative sample of school buildings for geologic and engineering hazards (561 buildings total, 32 of which received engineering concept-level seismic upgrade designs). Funded by the Capital Budget (total of $3.4 million to DNR)
- Provide OSPI and school districts with a seismic risk ranking for future seismic retrofit considerations
- Provide the geology and engineering information to schools and to OSPI to be able to prioritize schools for seismic retrofit funding

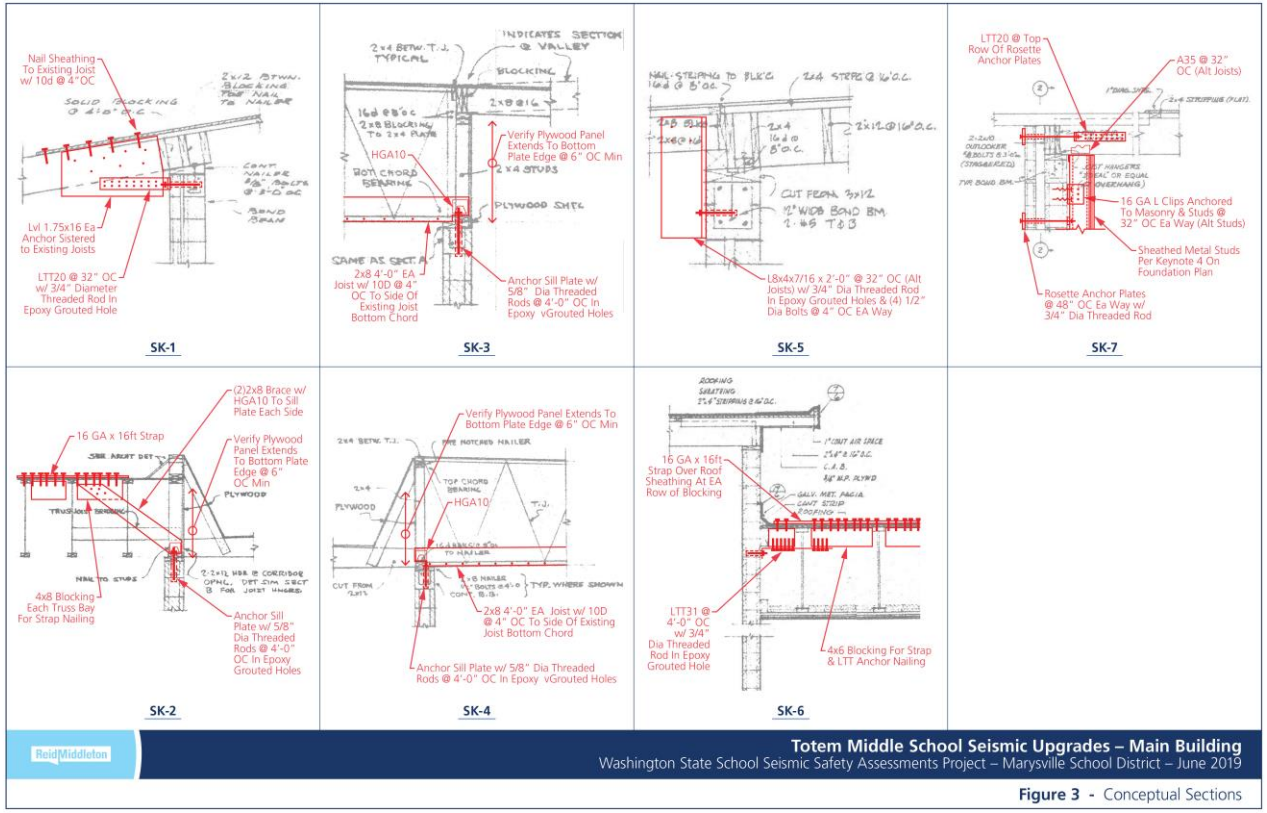
School buildings and building codes are complicated

Schools are designed to Life Safety standards for the seismic code when they were designed. They are not designed to be useable following an earthquake.

Structural Performance Level	Description of building state following a design-level earthquake	Schematic diagram of building following earthquake
Immediate Occupancy (IO)	Buildings are expected to sustain minimal damage to their structural elements and only minor damage to their nonstructural components. While it is safe to re-occupy a building designed for this performance level immediately following a major earthquake, nonstructural systems may not function due to power outage or damage to fragile equipment.	
Life Safety (LS) and Limited Life Safety (LTD-S)	Buildings may experience extensive damage to structural and nonstructural components. Repairs may be required before re-occupancy, though in some cases extensive restoration or reconstruction may not be cost effective. The risk of casualties at this target performance level is low.	
Collapse Prevention (CP)	Although buildings that meet this building performance level may pose a significant hazard to life safety resulting from failure of nonstructural components, significant loss of life may be avoided by preventing collapse of the entire building. However, many buildings designed to meet this performance level may be complete economic losses.	



Concept-Level Designs



- Engineers developed schematic designs to seismically retrofit selected buildings
- Cost estimates were developed:
  - Phase 1 concept-level design building cost estimates ranged from a median of $63K to $5.01M,
  - Phase 2 median concept level design building cost estimates ranged from $1.24M to $15.26M
- If the costs associated with the architectural, mechanical, electrical, plumbing, and fire protection elements were deleted from the cost estimates, the average seismic upgrade cost sees a 70 percent reduction**. Significant savings can be realized by combining seismic upgrades with other types of work, such as re-roofing projects or school modernizations.**

Schools in Tsunami Inundation Zones

- In total, 67 school buildings on 28 school campuses that were assessed in Phase 1 and Phase 2 are located within tsunami inundation zones.
- These schools serve approximately 7,700 students.
- Tsunami loads and impacts were not considered in the geologic or engineering assessments.
- For schools to be safe from a tsunami, they would need to be moved from the tsunami inundation zone or designed to withstand tsunami loads with options for vertical evacuation.

School Seismic Safety Ratings

- 93% of the 561 school buildings assessed have one-star Structural Safety sub-ratings based on the information available.
- 4% of the school buildings assessed have two-star ratings
- 3% of the school buildings have three-star ratings.

School building collapse in Mexico earthquake 1985. Photo credit unknown

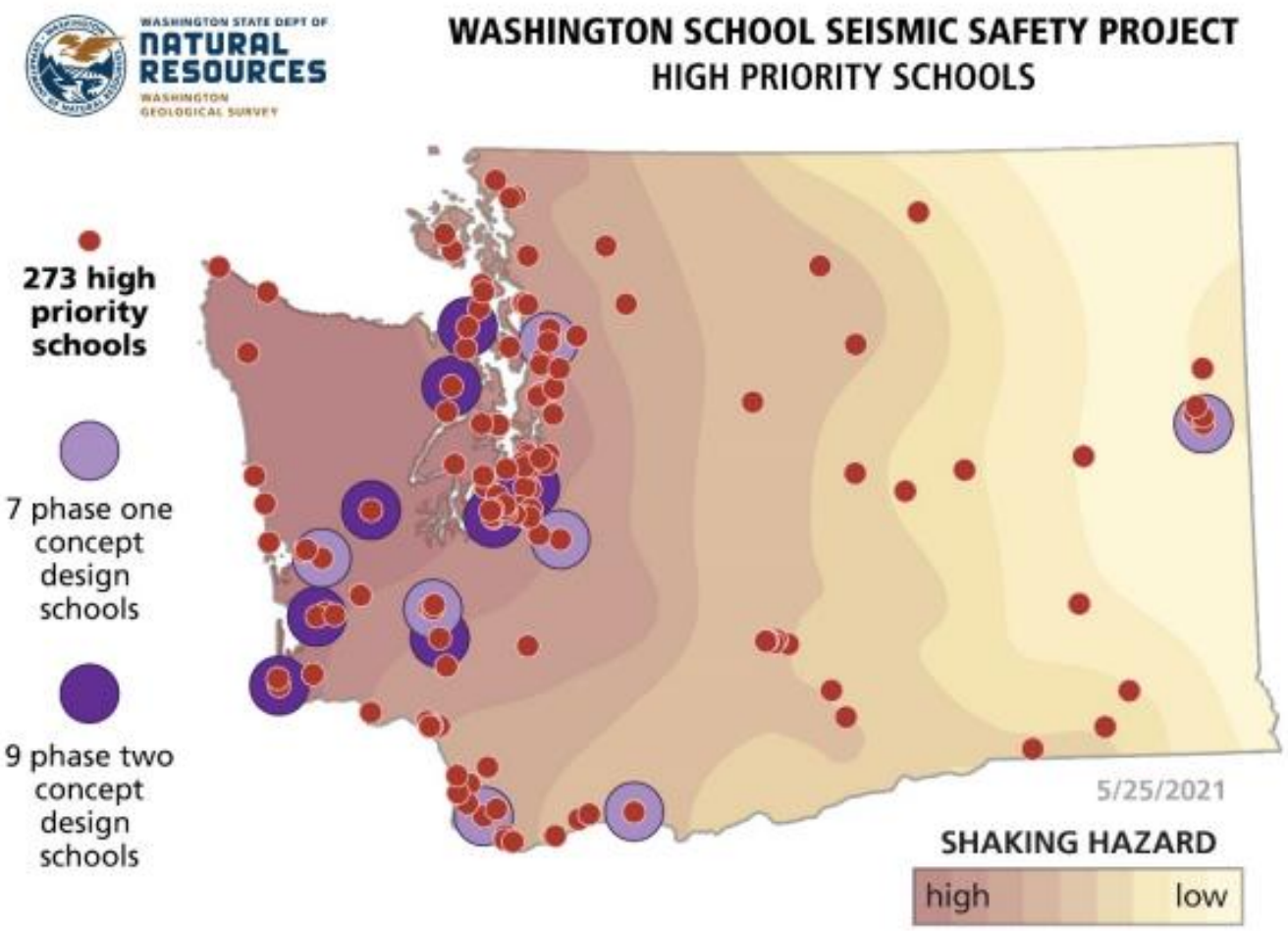
★ **Risk of collapse in multiple or widespread locations**—Expected performance as a whole would lead to multiple or widespread conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.

★★ **Risk of collapse in isolated locations—**Expected performance in certain locations within or adjacent to the building would lead to conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.

★★★ **Loss of life unlikely**—Expected performance results in conditions that are unlikely to cause severe structural damage and loss of life. A three-star rating meets the Tier 1 Life Safety (LS) structural performance objective.

★★★★ **Serious injuries unlikely**—Expected performance results in conditions that are associated with limited structural damage and are unlikely to cause serious injuries.

Prioritizing Buildings for Retrofits



Prioritization Category	Category Definition	Typical Buildings in Category
Very High Priority	These buildings have the highest seismic risk and have a clear and strong need to receive seismic upgrades. The benefits of seismic performance and structural integrity gained by performing seismic upgrades are likely to significantly exceed the cost of the upgrades by a large margin.	Typically unreinforced masonry buildings and non-ductile concrete buildings built before the 1960s and located in high seismic zones. Some very high risk reinforced masonry buildings are also in this category.
High Priority	These buildings also have a strong need to receive seismic upgrades and would greatly benefit from voluntary seismic upgrades or seismic improvements that are incorporated with other systems upgrade projects or modernizations. The benefits of seismic performance and structural integrity gained by performing seismic upgrades likely	Typically reinforced masonry and wood buildings built in the 1950s, 1960s, and 1970s and located in high seismic zones. Some unreinforced masonry buildings located in moderate and low seismic zones are also included in this category.
	exceed the cost of the upgrades.	
Moderate Priority	These buildings are not as high risk as the buildings in the High and Very High categories. Depending on level of seismicity, some buildings may or may not have a need to receive seismic upgrades. In areas of high seismicity, these buildings would still benefit from voluntary seismic upgrades that may be able to achieve seismic performance similar to modern buildings. However, the financial benefits of seismic upgrades may or may not exceed the costs.	Typically, buildings of various construction types built in the 1960s through the 1990s located in high, moderate, and low seismic zones.
Lower Priority	The benefits of seismic performance and structural integrity gained by performing seismic upgrades would likely not exceed the costs. Some buildings in this category already meet the Life Safety structural performance objective and were built to modern seismic standards where seismic upgrades would not be needed.	Typically buildings of various construction types built in the 1980s through the 2010s located in high, moderate, and low seismic zones.

Recommendations for Future Studies

- Evaluate the feasibility and cost benefit of increasing the seismic performance for the design of new school buildings to enhance the seismic resilience of communities.
- A study to identify which schools in tsunami inundation zones need vertical evacuation structures and/or relocation.
- A study of school sites suspected of having moderate to high risk of liquefiable soils, to determine cost-efficient methods of assessing the risk, and identify mitigation strategies for existing school buildings on liquefiable soils.
- Conduct a statewide inventory of school districts to collect data about which facilities have already had seismic upgrades.
- Continue to update OSPI's ICOS database with structural and seismic information about each school building (construction type, year of construction, previous seismic upgrades, site class, seismicity, seismic irregularities).
- Continue doing ASCE 41 Tier 1 seismic evaluations of school buildings.

Current DNR School Seismic Safety Projects

2021-2023 Capital Budget funding for DNR to perform site class assessments at school campuses who are participating in OSPI's Study and Survey Program with the goal to continue these efforts as funding allows and all schools have site class data.

Data will be delivered to OSPI for their ICOS database and will be delivered to schools that are assessed. Additionally all data will be publically available through our geologic information portal.

Thank you. Questions?
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Image credit: USGS