Washington State K-12 Facilities
Risk Assessments and Hazard Mitigation Planning
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Washington K-12 Schools

- Office of Superintendent of Public Instruction – State K-12 schools agency
- 295 School Districts
- 2,400+ Campuses
- 10,000+ buildings, many with multiple structurally different parts
- 1,050,000 students
- 89,000 teachers and other staff
The Problem

- Few districts have completed hazard and risk evaluations for their school facilities.
- Districts face intense budget pressures with little, if any, funding for hazard and risk evaluations.
- Many (most) districts have little or no technical expertise re: natural hazards.
The Solution

- Automate as much of the hazard and risk evaluations as possible, with:
  - All available GIS data layers
  - Limited data inputs from districts

- Develop an efficient, stepwise evaluation methodology, with clear guidance for districts and automated, understandable reports generated when districts provide limited campus- or building-level inputs
Project Scope - 1

- Multi-hazard risk assessment for 2,400+ campuses: earthquake, tsunami, volcanic hazards, floods, wildland/urban interface fires and landslides

Incorporate hazard and risk data at the campus and building level into an existing statewide school facility database: Inventory and Condition of Schools (ICOS).

ICOS is used by all 295 districts to compile facility data and other key data related to state funding of school facilities.

Hazard and risk data will be maintained in ICOS long-term and periodically updated.
More detailed risk assessments and local hazard mitigation plans for 28 planning partner (pilot) districts

Workshops, training, and other technical support for planning partner districts

Support development of 10-15 specific mitigation projects (engineering and benefit cost analyses) for FEMA grants
Project Scope – 4

- Develop “Toolkit” to help districts complete hazard and risk assessments and mitigation plans:
  - Fill-in-the-blank templates for each chapter of a district mitigation plan with pre-written (editable) text for ~90% of each chapter
  - Hazard maps to paste into district plans
  - Hazard and risk reports exported from ICOS
  - Detailed step-by-step technical guidance re: hazard and risk assessments
Project Scope – 5

- Project Overview
  - Three year project, $750K budget
  - Prime Consultant: Goettel & Associates
  - Sub-Consultants: Atkins, CCS Group, G&E Engineering, ECO Resource Group, and Antares Planning Group
Stepwise Approach - 1

1. Use GIS data to exclude some hazards from some campuses – tsunami and volcanic hazards (less ash falls)

2. Use GIS data to identify campuses with significant exposure to specific hazards, earthquakes considered for all campuses
3. Preliminary hazard and risk assessment at the campus level from GIS data only

4. Refine hazard and risk data with district inputs at the campus level (all hazards) and at the building level (earthquake and flood). OSPI provided consultant support for this step for the 28 planning partner districts.
5. GIS data and district inputs are auto-interpreted to identify situations where the next step requires engineering inputs – geotechnical, structural, or other.

6. Auto-generated reports include prioritized recommendations for next steps: engineering analysis, selection of prioritized risk reduction measures, and implementation.
1. GIS data layers for each campus:
   - USGS probabilistic ground motion data
   - WA Dept. of Natural Resources (DNR) site class estimates (site specific data, if available)

2. Outputs: ground motion data (adjusted for site class) and determination of the percentile ranking among campuses and qualitative descriptors: very high, high,... to make the results more understandable.
3. Qualitative adjustment of the earthquake hazard level based on DNR liquefaction potential estimates

4. Earthquake risk assessment is predominantly at the building level (or building part level for “buildings” with structurally-different parts)
5. Preliminary building-level risk assessments are automated, based on:

- Structural system
- UBC/IBC code year or year built if code year unknown, adjusted for code adoption date and buildings permitted before code adoption
- Rapid visual screen type parameter such as vertical or horizontal irregularities
- ASCE 31-03 benchmark years (to be 41-13)
Earthquakes -4

6. Recommendation: complete Tier 1 ASCE 31-03 evaluations for buildings that are not post-benchmark year

- Given limited resources, Tier 1 for all buildings is generally unrealistic
- For lowest seismic hazard areas in WA, recommendation is Tier 1 only for the most vulnerable building types
- Goal is to focus limited resources on buildings most likely to have substantial seismic deficiencies
Earthquakes - 5

7. Next steps based on the Tier 1 results

8. If resources do not allow further evaluation of all buildings that are non-compliant with Tier 1:

   - Rely on Tier 1 results and engineering judgment to prioritize more detailed analyses (Tier 2, Tier 3), retrofit design, and building retrofits for the buildings deemed to pose the greatest life safety risk
Earthquakes -6

9. Caveat

Benchmark years in RVS and ASCE 31-03 (41-13) are substantially inaccurate for parts of states like Washington and Oregon where seismic zones (and IBC equivalents) have changed markedly over the decades.

For example, a building which is nominally post-benchmark may have been designed for Zone 2, but the current understanding of seismic hazards is now Zone 4 (that is, IBC equivalent ground motions for design).
10. An in-development WA Benefit-Cost Analysis Tool is using seismic fragility curves interpolated from HAZUS fragility curves taking into account the time history of seismic design requirements by location within Washington State.

11. This approach will yield more accurate screening-level results than using the national RVS or ASCE 31-03 (41-13) benchmark years.
### Earthquake Campus-Level Hazard and Risk Report: Preliminary

<table>
<thead>
<tr>
<th>Campus</th>
<th>Earthquake Ground Shaking 2% in 50 Years</th>
<th>Earthquake Ground Shaking Hazard Level</th>
<th>Earthquake Site Class</th>
<th>Liquefaction Potential</th>
<th>Combined Earthquake Hazard Level</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington Elementary</td>
<td>63%</td>
<td>Very High</td>
<td>D</td>
<td>Low to Moderate</td>
<td>Very High</td>
<td>Yes</td>
</tr>
<tr>
<td>Adams Middle School</td>
<td>62%</td>
<td>Very High</td>
<td>D</td>
<td>High</td>
<td>Extremely High</td>
<td>Yes</td>
</tr>
<tr>
<td>Jefferson High School</td>
<td>25%</td>
<td>Moderate</td>
<td>C</td>
<td>Moderate</td>
<td>Moderate to High</td>
<td>Yes</td>
</tr>
<tr>
<td>Madison Elementary</td>
<td>18%</td>
<td>Low</td>
<td>E</td>
<td>High</td>
<td>Moderate</td>
<td>Limited^3</td>
</tr>
<tr>
<td>Monroe High School</td>
<td>18%</td>
<td>Low</td>
<td>B</td>
<td>Low</td>
<td>Low</td>
<td>Limited^3</td>
</tr>
</tbody>
</table>

- **Building Level Risk Assessment**
  - Yes/No
  - Priority

- **Geotechnical Evaluation**
  - Yes/No
  - Priority

1. Campus level risk is generally proportional to the combined earthquake hazard, but depends VERY strongly on the seismic vulnerability of buildings which MUST be evaluated at the building level. Thus, earthquake risk is cannot be defined meaningfully at the campus level, except by doing building-level evaluations and then aggregating building results to provide campus-level risk.

2. Earthquake ground motion measured as peak ground acceleration (PGA) relative to "g", the acceleration of gravity.

3. For campuses with "low" ground shaking hazard (2% in 50 year PGA less than 20%), building-level risk assessments are recommended only for the most vulnerable building types.
### Millard Fillmore Elementary School

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Seismic Design Criteria</th>
<th>Building Type</th>
<th>Seismic Design Basis</th>
<th>ASCE 31-03 Tier 1 Evaluation Recommended</th>
<th>ASCE 31-03 Tier 1 Evaluation Completed</th>
<th>ASCE 31-03 Compliant</th>
<th>Further Evaluation Desired</th>
<th>Mitigation Type</th>
<th>Mitigation Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Wing of Classroom Building</td>
<td>YES</td>
<td>W1</td>
<td>High Code</td>
<td>NO</td>
<td>Low</td>
<td>N/A</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>NO</td>
<td>PC1</td>
<td>Moderate Code</td>
<td>YES</td>
<td>High</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Library</td>
<td>YES</td>
<td>C2</td>
<td>Moderate Code</td>
<td>NO</td>
<td>Low</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

1. ASCE 31-03 seismic evaluations are recommended for buildings that were not designed to a "benchmark" seismic code deemed adequate to provide life safety. However, ASCE 31-03 recommends that post-benchmark code buildings be evaluated by an engineer to verify that the as-built seismic details conform to the design drawings. Most such buildings should be compliant, unless poor construction quality degrades the expected seismic performance of the building.

2. The priority for 31-03 evaluations is based on the building type, the combined earthquake hazard level (ground shaking and liquefaction potential), the seismic design basis, and whether a building has been identified as having substantial vertical or horizontal irregularities. These priorities recognize that many districts may have limited funding for 31-03 evaluations. Districts with adequate funding may wish to complete 31-03 evaluations on all pre-benchmark year buildings.

3. The earthquake risk level is low for all buildings for which an ASCE 31-03 evaluation is not recommended as necessary. For other buildings, the preliminary risk level risk level and the priority for 31-03 evaluation are based on the earthquake hazard level, the building structural type, the seismic design level and whether a building has vertical and horizontal irregularities.

4. The final determination of priorities for retrofit are based on whether a building is compliant with the 31-03 life safety criteria. If not, the priorities should be set in close consultation with the engineer who completed the 31-03 evaluation.
1. Automated hazard screening based on
   - Campus in DNR mapped tsunami inundation zone?
   - Evaluation for all campuses not just those in mapped zones based on a) campus at-grade elevation, b) distance to coast
     - Mapping is not yet complete
     - Tsunami modeling has substantial uncertainties
     - Extreme events pose risk outside of mapped zones
Tsunami -2

2. Tsunami life safety risk based on hazard assessment data and

- Distance to designated safe haven
- Estimated travel time on foot, including mobilization time
- Impediments to travel along designated routes
3. Recommendations

- Evaluate impediments to evacuation
  - Route hazards
  - Accessibility of designated safe area
- Evaluate vertical evacuation and/or relocation of at risk campus if travel time is comparable to or exceeds anticipated time between earthquake and first arrival of tsunami waves
- Evacuation planning and drills for all campuses with even low risk
Other Hazards

- Similar largely-automated stepwise hazard and risk evaluations using GIS data layers and limited district inputs

- Automated recommendations for next steps, including
  - Identifying when engineering analysis is essential
  - Mitigation priorities
  - Emergency planning, including evacuations
Questions and Discussion