School Earthquake Safety Initiative

Webinar, July 12, 2016
promoting safe buildings for school children
eeri.org/schools
About EERI

- Global earthquake engineering institute
- Nonprofit, technical membership society
- Dedicated to reducing earthquake risk
EERI’s Mission

EERI’s mission is to reduce earthquake risk by:
1. Advancing the science and practice of earthquake engineering
2. Improving understanding of the impact of earthquakes
3. Advocating comprehensive and realistic measures for reducing earthquake effects
What is SESI?

- SESI is a global and collaborative network of diverse, expert, and passionate professionals who are committed to creating and sharing knowledge and tools that enable progressive, informed decision making around school earthquake safety.

Our Goal:

- Leverage our extensive expertise and reputation to conduct regionally appropriate actions that make a tangible and positive difference in communities around the world, by protecting the lives of all who inhabit school buildings.

Our Vision:

- Serving the world as a leader in the science, public policy, and advocacy of school earthquake safety.
The SESI Network

Affiliation Types for SESI Participants

- Academic: 27.6%
- Practitioner: 25.5%
- Government: 11.2%
- Misc: 11.2%
- Retired: 7.1%
- School District: 6.1%
- Media: 6.1%
- Practitioner: 5.1%

Discipline Types for SESI Members

- Structural Engineering: 34.7%
- Emergency Management: 10.2%
- Unknown: 8.6%
- Geology: 7.1%
- Seismology: 6.1%
- Technical: 5.1%
- Geotechnical Engineering: 4.1%
- Civil: 3.6%
- Public Policy: 3.6%
- School Administration/Teaching: 2.7%
- Insurance: 2.7%
- Media: 2.1%
- School Parent & Advocate: 1.4%
- Tsunami: 1.4%
- Architect: 0.9%
- Consulting: 0.9%

100+

SESI Members as of April 2016
The SESI Network

Geographic Regions of SESI Members

- Mid-Western US: 41.4%
- Utah: 5.1%
- DC: 4%
- California: 12.1%
- New Madrid Region: 7.1%
- Oregon: 6.1%
- Washington: 4%
- New York - New Jersey: 4%
- International: 5.1%
- Colorado: 4%
- British Columbia: 4%
- Alaska: 4%
- Georgia: 4%
- Hawaii: 4%
SES I Subcommittees

• **Safety Screening, Inventory, and Evaluation**
  
  **Chair:** Ken Goettel  
  **Charge:** Promote use of screening methodologies to efficiently identify school buildings with seismic risk.

• **Code Updating and Improvements**
  
  **Chair:** Rob Jackson  
  **Charge:** Advocate for code improvements and implementation practices that will enhance school safety.

Portland, Oregon’s Franklin High School will be rebuilt using school bonds approved in 2012.

New Havens Elementary School, Piedmont, California was retrofitted in 2012.
SESJ Subcommittees

- **Classroom Education & Outreach**
  **Chairs:** Lelli Van Den Einde & Thalia Anagnos
  **Charge:** Use classroom education to develop advocates for earthquake school safety.

- **Tsunami Mitigation for Schools**
  **Interim Chair:** Yumei Wang
  **Charge:** Support schools with tsunami hazard by provide them access to experts and sharing best practices for tsunami risk mitigation.

*SESJ Members teach 4th grade students about earthquake engineering design*
2016 Goals & Action Plan

In 2016, SESI will focus on the following key efforts:

1. Establishing funding for ongoing SESI operations
2. Outreach to current SESI members and participants via the Program Committee to increase their involvement.
3. Finalize the SESI working products including screening case studies, classroom curriculum, and guidance documents.
5. Outreach to stakeholder community.
How Can I Contribute?

- Subscribe to our mailing list to stay up to date with our activities and look out for opportunities to contribute!
- Contact Barry Welliver, Subcommittee Chairs, or Heidi Tremayne to get involved.
- Anyone interested in school earthquake safety is encouraged to participate!
- Visit eeri.org/schools for more info.
1. **Introduction** by Barry Welliver, *Structural Engineer, BHW Engineers*

2. **SESI Subcommittees** by SESI Subcommittee Chairs
   - **Screening, Inventory & Evaluation** – Barry Welliver, on behalf of Ken Goettel, *Goettel & Associates*
   - **Tsunami Mitigation for Schools** – Barry Welliver, on behalf of Yumei Wang, *DOGAMI*
   - **Classroom Education & Outreach** – Lelli Van Den Einde, Professor, UC San Diego
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3. **Thurston County School Seismic Safety Evaluations** by Cale Ash, *Principal, Degenkolb Engineers*

4. **Partnering to Perform Rapid Visual Screenings of Alaska’s Schools** by Laura Kelly, *Alaska Seismic Hazards Safety Commission*

5. **Question & Answer Session**
SES I Subcommittees:
Screening, Inventory & Evaluation of Schools Subcommittee

BARRY WELLIVER, BHW ENGINEERS
(On behalf of Chair Ken Goettel)
Overview & Goals

- Facilitate and encourage implementation of risk reduction measures by developing and helping to carry out stepwise screening methodologies to identify school buildings with the highest seismic risk efficiently while minimizing the effort and expense for school districts.

- Document case studies of best practices in school safety screening and evaluations

- Use these case studies as a base to create EERI’s guidelines to new advocates of seismic safety
Action Plan

- The Screening Subcommittee recently completed documenting case studies of screening programs in several US states, including Alaska, California, Oregon, Washington & Utah.

- The next step is to create EERI’s specific guidelines for individuals who are new to the field of school seismic safety to facilitate them in making decisions about their own unique situation.

- Continue and expand outreach to school districts and other stakeholders.
Webinar Briefing Speakers & Agenda

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5. Question & Answer Session
SESI Subcommittees:
Tsunami Mitigation for Schools Subcommittee

BARRY WELLIVER
(On behalf of Chair Yumei Wang)
Overview & Goals

- Support schools with tsunami hazard by provide them access to experts and sharing best practices for tsunami risk mitigation.
- Funding provided from the Coastal Zone Foundation
- Phase 1: Identifying Schools with Tsunami Risk has been completed. 190 at-risk schools identified in Alaska, California, Hawaii, Oregon and Washington using ASCE Tsunami Design Zones and local state evacuation maps.
- 2016 Goal: Outreach and mitigation for identified schools at risk.
“Advocacy for tsunami mitigation and preparedness of U.S. schools along the pacific rim” paper submitted to the 16th World Conference on Earthquake Engineering, Chile, 2017.

Authors: Zahraa Saiyed, Shizza Fatima, Karen Izumoto, Ian Robertson, Barry Welliver, Heidi Tremayne.

The information will be shared with members of the National Tsunami Hazard Mitigation Program this month by Dr. Ian Robertson, University of Hawaii at Manoa.

Google Earth image showing locations of Schools in Huntington/Newport, Southern California
Outreach

- Each state’s tsunami leads requested to review the paper and provide feedback to SESI.
- The subcommittee members will work with state’s tsunami leads to provide info to schools in tsunami zones, and depending on the state tsunami leads, SESI may work directly with local school districts.
- If you are a tsunami mitigation professional in any of the US West Coast states, and would like to be involved, please contact Shizza Fatima at shizza@eeri.org.
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5. Question & Answer Session
Classroom Education & Outreach Subcommittee

• Use Education in the classroom to:
  o **Create ongoing dialog with parents, teachers, and administrators** about earthquake safety
  o **Grow advocates** for school earthquake safety
Curriculum Objectives

- “Grassroots” side of SESI.
- Make connections with schools to aid in future efforts.
- Incorporate Earthquake science and safety topics.

• Create a Win-Win situation.
• Give school immediate benefit.
• Satisfy latest education standards including Next Generation Science Standards and Common Core
• Complete curriculum in 2-4 visits.

• Develop exciting, hands-on, project based engineering curriculum.
• Utilize shake table technology to aid instruction.
4th Grade Curriculum

- Leverages curriculum developed at UC Berkeley under NEES education and outreach program.
- Educational curriculum specialist from local non-profit group provided guidance on appropriate vocabulary, supplemental worksheets, and delivery strategies to optimize implementation in the classroom.
- Curriculum aligned with Next Generation Science Standards (NGSS)
  - For 4th grade specifically suggests designing earthquake resistant buildings as a way to meet standard 4-ESS3-2
Visit 1: 90 min Lesson

- Introduce earthquakes, engineering process, and design elements
  - Test concepts to develop ideas for strengthening buildings.
  - Scaffolding provided through visuals of vocabulary and demonstrations, using worksheets to help students focus on key observations and develop background knowledge.

### Vocabulary List

<table>
<thead>
<tr>
<th>Engineering Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquake</td>
<td>A sudden, rapid shaking of the Earth’s surface caused by energy released from movement in the Earth’s crust</td>
</tr>
<tr>
<td>Seismograph</td>
<td>The instrument used to monitor earth movements.</td>
</tr>
<tr>
<td>Building Story</td>
<td>Any level space in a building above ground that could be used by people. For example, a two-story building has a first story above the ground and second story below the roof.</td>
</tr>
<tr>
<td>Column</td>
<td>Thin vertical elements that help support the weight of a building floor or level.</td>
</tr>
<tr>
<td>Beam</td>
<td>Horizontal elements that support the weight of a building floor or level.</td>
</tr>
<tr>
<td>Joints</td>
<td>Locations where a column, beam or brace connect together.</td>
</tr>
<tr>
<td>Brace</td>
<td>A diagonal building element that extends between two building levels and provides extra stiffness. A brace can be a single diagonal, L, V, or X shape.</td>
</tr>
<tr>
<td>Wall</td>
<td>A flat vertical element that supports the weight of a building level and provides extra building stiffness.</td>
</tr>
<tr>
<td>Shaking Table or Earthquake Simulator</td>
<td>A platform used to test building design and material performance during earthquake shaking.</td>
</tr>
</tbody>
</table>

### DATA TABLE

<table>
<thead>
<tr>
<th>Test #</th>
<th>Picture or Name</th>
<th>Weakness Notes for Observation Shake</th>
<th>Failure Notes for Earthquake Shake</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use 4 Yellow, Shorter Rods at top story</td>
<td>Describe any observed building weaknesses. Where did it move the most (top story, bottom story, side C, etc.)? Did the building twist?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Move Yellow Rods to bottom story</td>
<td>Describe the failure mechanism. How did the building move during the shake test? How did it fail?</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Use 4 of longest Gray Rods, instead of Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Add another red column story</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Visit 2: 90 min Lesson

- Students provided with challenge to design earthquake-resistant building, use data from different design choices to make group decision about final design solution.
  - Students define design problem, develop model & testing plan, test alternate ideas, analyze data and discuss solutions, communicate design solution.
  - Scaffolding provided through visuals of vocabulary and demonstrations, using worksheets to help students communicate testing results and discussion to make evidence-based conclusions.
School Earthquake Safety Initiative

4th grade curriculum
Teams compete to maximize a Performance Index (PI) based on weight (W), cost (C), and number of survived tests (N).

$$PI = \frac{25N^{1.5}}{WC^2}$$
Visit 1
Preliminary Concept Lesson

Fault Rupture

Credit: Shayne Horton

Seismic Waves

Credit: Lawrence Braile

Visit 2
Concept Lesson

Structural Systems

Lateral Force Resisting Systems
Three Main Types

Braced Frame

Moment Frame (Fixed Joint Frame)

Shear Wall

How do you think these rank in terms of stiffness?

Shake Table Demonstrations

Project Introduction

School Earthquake Safety Initiative
Visit 3

Concept Lesson

Predicting the Behavior of Structures during Earthquakes

Visit 4

Shake Table Testing & Competition Finale

Response Spectrum

How To Use This...

\[ T_n = \frac{1}{f_n} = 2\pi \sqrt{\frac{m}{K}} \]

- y-axis → Acceleration
- x-axis → Natural Period

Natural Period [s]
**Broad Implementation**

- Make use of EERI student and professional regional chapter membership to complete lesson delivery
  - > 60 EERI Student and 13 EERI Regional Chapters
  - Student chapters: civil and geotechnical engineering students obtaining undergraduate, masters and PhD degrees.
  - Regional chapters: professional engineers, geoscientists, architects, planners, public officials, and social
  - Use chapter internal organizational structures and annual leadership transfer to facilitate sustainability of program over time.
Future Work

- Advocating adoption of tool kits by additional chapters
  - Use existing pilot student chapters to train new student chapters on outreach implementation.
  - Work with teachers who can self-deliver lessons.
- A plan for broader dissemination, sustainability, sharing and maintenance of resources will be developed.
- Ongoing assessment will occur resulting in improvements to tool kit lessons and delivery strategies.
- Once 4th grade and high school curricula are well developed, a tsunami module developed by NEES@Oregon might be added.
Acknowledgements

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• Work forming basis for this publication was also conducted pursuant to a contract with the Federal Emergency Management Agency (FEMA). Substance of such work is dedicated to the public.
  o The author(s) are solely responsible for the accuracy of statements or interpretations contained in this publication. No warranty is offered with regard to the results, findings and recommendations contained herein, either by the Federal Emergency Management Agency, the Applied Technology Council, its directors, members or employees. These organizations and individuals do not assume any legal liability or responsibility for the accuracy, completeness, or product or processes included in this publication.
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• Thanks also to members of the SESI Classroom Subcommittee who are helping to further launch this curriculum in 2016, including: Eduardo Vega, Vincente Pericoli, Ivan Wong, and Barry Welliver.
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5. **Question & Answer Session**
Code Updates and Improvements: Why is this important for schools?

- The most significant code changes are often a result of the earthquakes themselves. These changes may be only in the hazard maps or may extend to the details of design and analysis. But the changes are then “after the fact.”

- Schools cannot really afford to have changes implemented “after the fact.” As has been stated and written repeatedly, the US has been very fortunate in that earthquakes have been occurring when school is not in session.

- Code changes take years to be created, reviewed, vetted and implemented. Then the code cycle may extend the time even further. Code changes are currently on a six year cycle.
Unexpected earthquakes: actually they are almost all unexpected

- **Risk mitigation.** The hazard maps are only the starting point.

- The 1882 ± 6.6M Colorado earthquake is an example of an historic earthquake that is not heavily weighted in the hazard maps.
Code Updates and Improvements: Discussion and focus items

• A **minimum Seismic Design Category** for schools?

• Risk of potentially life threatening **non-structural hazards** for children sheltering in place
  ✓ Code - suspended ceilings, pendant light fixtures, etc.
  ✓ Non-code – bookcases, file cabinets, TV monitors, etc.

• Identification and **screening** of existing school buildings especially those that are planned for use as post-earthquake public shelters (Risk Category IV).
Factors influencing the choice of Seismic Design Category A

- SDC B or higher
- Site (soil) class
- Risk Category
- Hazard Map
- Societal resistance to seismic design
- Hazard Map cutoff criteria
Quotes to ponder

“Civilizations exist based on geologic consent subject to change without notice.”  - William Durant

“Earthquake mitigation must be perceived as a ‘fundamental good.’”  - Frank McClure
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5. **Question & Answer Session**
THURSTON COUNTY
SCHOOL SEISMIC SAFETY EVALUATIONS

Cale Ash, P.E., S.E.
Office Director & Principal
Degenkolb Engineers, Seattle
Project Overview

Goal:
1. Assess earthquake risk of schools in Thurston County
2. Develop screening process for “at risk” school buildings in Washington
3. Increase awareness of earthquake risk posed by existing school buildings

Agencies & Organizations Involved:
Where is Thurston County?
Project Overview – Why Washington?

- Washington state has **second highest** earthquake risk in U.S.

- Increased understanding & awareness of risk

- We are behind & It’s time!

*Photo from U.S. Geological Society Design Maps*
Background – Washington State

1949
Damage to ~ 30 schools in Washington

1955
RCW 70.86 passed
Schools should be “designed and constructed to withstand probable earthquake intensities”

1955
RCW 19.27 passed
Washington State Building Code Act

1965
Damage to school in Alki

1974
Resilient Washington State Initiative

2010
School Seismic Safety Pilot Program in Aberdeen and Walla Walla

2011

2015
School Seismic Safety Pilot Program in Thurston County

2010

Figure 2. At Castle Rock, a high school student was killed as unanchored gable masonry cascaded to the walk outside the entrance. There could have been more casualties. (From Edwards, 1951.)

Damage outside Union Station
Photo by John Vailentyne, Courtesy MOHAI
School Seismic Safety Assessment Pilot Project

WASHINGTON STATE SCHOOL SEISMIC SAFETY PILOT PROJECT—Providing Safe Schools for Our Students

by the Washington State Seismic Safety Committee
RECOMMENDATION 1. **Make schools resilient: structurally, socially, and educationally.**

### Target States of Recovery: Washington’s Critical Services Sector

<table>
<thead>
<tr>
<th>Event occurs</th>
<th>0–24 hours</th>
<th>1–3 days</th>
<th>3–7 days</th>
<th>1 week–1 month</th>
<th>1–3 months</th>
<th>3 months–1 year</th>
<th>1–3 years</th>
<th>3+ years</th>
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<tbody>
<tr>
<td>Law enforcement</td>
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<td>Emergency response</td>
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<td>Health and medical care</td>
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<td>Food network</td>
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<td>Government administration</td>
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</tr>
</tbody>
</table>
Our Neighbors

BRITISH COLUMBIA (Canada)
$1.5B+ Seismic Mitigation Program\(^1\)

WASHINGTON
??????

OREGON
Seismic Rehabilitation Grant Program\(^2\)
$125m this year

CALIFORNIA
1933 Field Act\(^3\)

\(^1\) [http://www2.gov.bc.ca/gov/content/education-training/administration/resource-management/capital-planning/seismic-mitigation-program](http://www2.gov.bc.ca/gov/content/education-training/administration/resource-management/capital-planning/seismic-mitigation-program)

\(^2\) [http://www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/](http://www.orinfrastructure.org/Infrastructure-Programs/Seismic-Rehab/)

\(^3\) CSSC (February 2007), The Field Act and Public School: Construction: A 2007 Perspective, Publication #CSSC 2007:03, California Seismic Safety Commission
School Selection Process

**SCHOOL DISTRICTS:** YELM, TUMWATER, NORTH THURSTON

- Chose school districts with proximity to state capitol and legislature with a large geographic coverage of Thurston County.
- Chose school districts with representative school construction of Thurston County.
- Previous OSPI seismic hazard project.
- Input from school districts.
Project Approach

VOLUNTEER STRUCTURAL ENGINEERS: 
Building evaluations

- > 25 Volunteer Structural Engineers
- 20 companies
- 300 volunteer hours
- $40,000 of in kind contributions

10 Engineering Students
- St. Martins University
- Seattle University
- University of Washington
Project Approach

GEOLOGISTS/SEISMOLOGISTS:  
Site investigations

- Site classification
- Liquefaction potential
- Geological hazards
HAZUS

**INPUT**
- Building area
- Building value
- Year built or renovated
- Number of stories
- Content value
- Latitude and longitude
- City
- Foundation type
- Occupancy type
- Building construction type
- Seismic design level

**OUTPUT**
- Structural damage
- Nonstructural damage
- Economic loss estimates

(Recovery Time)
(Casualties)
START

School Selection Process

Geological Survey by WA DNR

Building Evaluations by Volunteers from EERI and SEAW

Compile HAZUS Inventory Data

Prepare Data for HAZUS

Run HAZUS

Post-Process Data
START

School Selection Process

Site-Specific Geologic and Geotechnical Survey

Acquire Building Plans

Perform Site Visit

Determine Building Framing Type

Perform ASCE 41-13 Tier 1 Evaluation

Calculate Site Class

Compile HAZUS Inventory Data
School Selection Process

Geological Survey by WA DNR

Building Evaluations by Volunteers from EERI and SEAW

Compile HAZUS Inventory Data

Prepare Data for HAZUS

Run HAZUS

Post-Process Data
Compile HAZUS Inventory Data

Select Seismic Hazard Level for HAZUS

Apply Site Class Correction Factor

Apply Governing Building Code Correction Factor for Washington State

Run HAZUS

Post-Process Data
# Building Code Correction Factor

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-Code</th>
<th>Low-Code</th>
<th>Moderate Code</th>
<th>High Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>California (Hazus Default)</td>
<td>Pre-1941</td>
<td>1942-1975 (Zone 2)</td>
<td>1942-1975</td>
<td>1975-present</td>
</tr>
</tbody>
</table>

![Maps](1970 UBC.png, 1988 UBC.png, 1994 UBC.png)
ASCE 41-13 Evaluation Results

Common Deficiencies

Common Construction Types
- Timber shear walls
- Light steel framing
- Reinforced masonry walls

Common Structural Deficiencies
- Shear stress in shear walls greater than capacity
- Unblocked diaphragms
- Inadequate wall anchorage
ASCE 41-13 Evaluation Results

Common Deficiencies

Common Nonstructural Deficiencies

- Fire suppression system not braced
- Ceilings not braced
- Shelves not anchored to walls or floors
- Computer equipment not anchored to walls or floors
Evaluation Results

<table>
<thead>
<tr>
<th>Hazus Damage States</th>
<th>Slight</th>
<th>Moderate</th>
<th>Extensive</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATC-20 Rapid Visual Assessment Tag</td>
<td>Green</td>
<td>Yellow</td>
<td>Yellow/Red</td>
<td>Red</td>
</tr>
<tr>
<td>Potential Building Damage</td>
<td><img src="image1" alt="Green House" /></td>
<td><img src="image2" alt="Yellow House" /></td>
<td><img src="image3" alt="Yellow/Red House" /></td>
<td><img src="image4" alt="Red House" /></td>
</tr>
</tbody>
</table>
Evaluation Results

- **Loss Ratio**
  - (Cost of Repair/Cost of Building)

- **Prob. Structural Damage**
  - (Extensive + Complete)

- **Decreasing probability of structural damage**
- **Decreasing loss ratio**

Diagram showing the percentage of structural damage and loss ratio for different school buildings.
Evaluation Results

Prob. Structural Damage (Extensive + Complete)

Loss Ratio (Cost of Repair/Cost of Building)
## Evaluation Results
**(500-year Earthquake/Code level shaking)**

<table>
<thead>
<tr>
<th>School No.</th>
<th>Construction Type</th>
<th>Structural Damage (Existing)</th>
<th>Structural Damage (New Equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1985 Steel Light Frame</td>
<td>46%</td>
<td>21%</td>
</tr>
<tr>
<td>2</td>
<td>1975 Concrete Shear Walls</td>
<td>42%</td>
<td>4%</td>
</tr>
<tr>
<td>3</td>
<td>2008 Wood Light Frame</td>
<td>33%</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>1985 Steel Light Frame</td>
<td>33%</td>
<td>20%</td>
</tr>
<tr>
<td>5</td>
<td>1998 Wood Light Frame</td>
<td>33%</td>
<td>20%</td>
</tr>
<tr>
<td>6</td>
<td>1998 Reinforced Masonry Bearing Walls</td>
<td>27%</td>
<td>20%</td>
</tr>
</tbody>
</table>
## Evaluation Results
(500-year Earthquake/Code level shaking)

<table>
<thead>
<tr>
<th>School No.</th>
<th>Construction Type</th>
<th>Loss Ratio (Existing)</th>
<th>Loss Ratio (New Equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1985 Steel Light Frame</td>
<td>24%</td>
<td>18%</td>
</tr>
<tr>
<td>2</td>
<td>1975 Concrete Shear Walls</td>
<td>18%</td>
<td>6%</td>
</tr>
<tr>
<td>3</td>
<td>2008 Wood Light Frame</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>4</td>
<td>1985 Steel Light Frame</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>5</td>
<td>1998 Wood Light Frame</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>6</td>
<td>1998 Reinforced Masonry Bearing Walls</td>
<td>19%</td>
<td>18%</td>
</tr>
</tbody>
</table>
Next Steps

Develop recommended thresholds for different damage states (“high”, “moderate”, and “low” risk)

What is an acceptable loss ratio? What is “unsafe”?

At what probability of structural damage do schools need seismic retrofits?

Damaged School from 1933 Long Beach Earthquake

Photo courtesy of USGS
Next Steps

- Incorporate more data into the evaluation of seismic risk
- Adjust Hazus input for specific structural irregularities
- Refine results based on WA state code adoption history
Next Steps

Incorporate other functional considerations
   Planned renovations
   Condition of building systems
   Security concerns
   Sustainability

Outreach !!
Webinar Briefing Speakers & Agenda

1. **Introduction** by Barry Welliver, *Structural Engineer, BHW Engineers*

2. **SESI Subcommittees** by SESI Subcommittee Chairs
   - **Screening, Inventory & Evaluation** – Barry Welliver, *on behalf of Ken Goettel, Goettel & Associates*
   - **Tsunami Mitigation for Schools** – Barry Welliver, *on behalf of Yumei Wang, DOGAMI*
   - **Classroom Education & Outreach** – Lelli Van Den Einde, *Professor, UC San Diego*
   - **Code Updates & Improvements** – Rob Jackson, *Supervising Structural Engineer, AECOM*

3. **Thurston County School Seismic Safety Evaluations** by Cale Ash, *Principal, Degenkolb Engineers*

4. **Partnering to Perform Rapid Visual Screenings of Alaska’s Schools** by Laura Kelly, *Alaska Seismic Hazards Safety Commission*

5. **Question & Answer Session**
PARTNERING TO PERFORM
RAPID VISUAL SCREENINGS
OF ALASKA’S SCHOOLS
Laura W Kelly, PE
USCG D17 Supervisory Engineer, CEU Juneau, AK – 2015-Present
US Coast Guard, Civil Engineer, Kodiak, AK – 2000-2014
Alaska Seismic Hazards Safety Commission, School Committee Chair, 2005-Present
e-mail: Laura.W.Kelly@uscg.mil

EERI SESI Safety Screening Inventory & Evaluation Subcommittee
July 12, 2016
<table>
<thead>
<tr>
<th>Year</th>
<th>US Coast Guard (USCG)</th>
<th>Kodiak Island Borough (KIB)</th>
<th>Alaska Seismic Hazards Safety Commission (ASHSC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>LKelly moves to Kodiak, experiences first earthquake. Mw 7.0, 2 pm, Dec. 6th (weekday, school in session). (Local ground forces greater than 1964 earthquake.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>Meet with Gary Carver, &amp; invite him to present to USCG April, 2002.</td>
<td>Carver/Kelly notify Borough of Peterson Elementary findings. (Carver discovers LKelly rec’d Alaska PE, and encourages proactive involvement.) Carver meets regularly with Borough, PTA, and School Boards with LKelly attending critical meetings.</td>
<td>House Bill 53 Establishes ASHSC.</td>
</tr>
<tr>
<td>2002</td>
<td>USCG contracts Gary Carver for Hazard Identification Project. (Ground shaking, active faults, liquefiable soils, slope and ground failure, tsunami inundation.) Completed Spring 2003. Numerous problems identified. Nov. 3, 2002 Denali earthquake, M7.0</td>
<td>RVS for all USCG structures (non-residential) in Kodiak. Incorporated with Mission Dependency Indexing. All waterlines now being replaced with HDPE to improve performance in event of an earthquake.</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>New active fault identified at Spruce Cape LORAN site near State Rocket Launch Facility.</td>
<td>RFP for Seismic Upgrades (Kodiak Middle School and High School), $2.1 Million. Five school retrofit projects continue through 2009.</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td>School Seismic Vulnerability Assessment, William Lettis &amp; Associates, G&amp;E Engineering (John Eidinger) and Goettel &amp; Assoc. (Ken Goettel)</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td>RVS for all USCG structures (non-residential) in Kodiak. Incorporated with Mission Dependency Indexing. All waterlines now being replaced with HDPE to improve performance in event of an earthquake.</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td>Draft Map - At-Risk Schools in Alaska. Presentation “Successful Implementaiton of Seismic Mitigation for Schools, Sept., 2007”</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>Peterson Elementary retrofitted.</td>
<td>Contact Commissioner Larry LeDoux, Alaska Dept. of Education &amp; Early Developement (ADEED). Request appointment of representative (Sam Kito III) to ASHSC. Year of May 12, 2008 Sichuan China Mw 7.9 earthquake.</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>New police station construction completed. Old fire station remains concern.</td>
<td>Collaboration with ADEED results in developing new capital improvement project application form that specifically addresses seismic issues. Enters trial period. Yumei Wang, Oregon DOGAMI, presents information on Oregon's Seismic Rehabilitation Grant Program. Publish map of Public Schools and Earthquake Hazards in Alaska in ASHSC Annual Report, Feb., 2010.</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
<td>Details</td>
<td></td>
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<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
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<td></td>
<td>concern.</td>
<td>project application form that specifically addresses seismic issues.</td>
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<td></td>
<td></td>
<td>Enters trial period.</td>
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<td></td>
<td>Yumei Wang, Oregon DOGAMI, presents information on Oregon's Seismic</td>
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<td></td>
<td></td>
<td>Rehabilitation Grant Program.</td>
<td></td>
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<td></td>
<td>Publish map of Public Schools and Earthquake Hazards in Alaska in ASHSC</td>
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<td></td>
<td></td>
<td>Annual Report, Feb., 2010.</td>
<td></td>
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<tr>
<td>2011</td>
<td>Bud Cassidy, KIB, joins ASHSC.</td>
<td></td>
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<tr>
<td>2012</td>
<td>USCG supports LKelly participation in revision of FEMA 154 RVS as</td>
<td>--Recommended ADEED CIP changes formally implemented. Dr. Christine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>part of working group/review panel. 2012-2013. Final release ATC-71,</td>
<td>Theodoropoulos, Univ. of Oregon speaks to ASHSC about Oregon's</td>
<td></td>
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<tr>
<td></td>
<td>Fall, 2014.</td>
<td>achievements regarding seismic risk mitigation for schools and</td>
<td></td>
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<td></td>
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<td>emergency facilities.</td>
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<td></td>
<td></td>
<td>-- Meet with Alaska PTA.</td>
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<td></td>
<td></td>
<td>-- Kito leaves ADEED.</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>USCG supports LKelly transfer to Juneau. In close proximity to other</td>
<td>Apply for HMPG funding for RVS of schools -- funding cut. PTA adds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>USCG engineers, ADEED, Prof. Engineering organizations, and</td>
<td>concern to Legislative Issues, stating their support for structurally</td>
<td></td>
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<tr>
<td></td>
<td>Legislature.</td>
<td>sound school buildings throughout the state of Alaska, for the safety</td>
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<tr>
<td></td>
<td></td>
<td>of our children, parents, teachers and community members.</td>
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<td></td>
<td>Barracks buildings, an RFP for retrofitting the most critical building</td>
<td>--Working with EERI on pilot program for RVS screening of Alaska schools.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>on base (ComSta), and backlog of other mitigation projects -</td>
<td>Modeling Utah's &quot;Schools at Risk&quot; RVS program.</td>
<td></td>
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<tr>
<td></td>
<td>improperly braced overhead steam pipes in Hangars, replace cast</td>
<td>--Suggest policy recommendation to incorporate RVS into Univ. of Alaska</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iron waterline crossings, strengthen piers, etc. Bowling alley</td>
<td>Engineering curriculum.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>structurally retrofitted during energy upgrade.</td>
<td></td>
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</tr>
<tr>
<td>2015</td>
<td>LKelly promoted GS-13 Supervisory Engineer, CEU Juneau for</td>
<td>Bud Cassidy, KIB, retires. Gary Carver retires from private sector,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maintenance of USCG shore facilities, from Ketchikan to Kotzebu.</td>
<td>but remains on ASHSC.</td>
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<td></td>
<td></td>
<td>--UAF: AK's Next Big Earthquake workgroup.</td>
<td></td>
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<td>17 bldgs/10 recommended for further review. (Cost $18,500 - BBFM paid</td>
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<td></td>
<td></td>
<td>$8500, donated $10,000)</td>
<td></td>
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<td>--Final Report - RVS Study- Kenai Peninsula Borough- Dec 2015: 15</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Schools, 47 structures, 19 recommended for further review. $21,250,</td>
<td></td>
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<td>$500/$700 per school.</td>
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</tr>
<tr>
<td>2016</td>
<td>USCG implements RVS for CA, OR, WA and remainder of AK, using</td>
<td>Preparing to screen Fairbanks. Hoping to partner with UAF, and include</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kodiak as example.</td>
<td>campus facilities.</td>
<td></td>
</tr>
</tbody>
</table>
2001-2003, Dr. Gary Carver, paleo-seismologist/geologist works with USCG to identify local seismic hazards.

Hydraulic Fill Area, USCG Base Kodiak
(Hazard analysis reveals that recent seismic retrofits did not take liquefiable soils into consideration)
Historical Panoramic Photograph of Womens Bay, Kodiak, June 1940.
2003 Report to USCG
Gary Carver/William Lettis & Associates formally identify active fault at LORAN Station, Narrow Cape, Kodiak Island (Fault changes predicted ground motions in IBC).

Lettis & Associates later become involved with school hazard identification in Kodiak. Revised ground forces from LORAN project quantified and incorporated into school analysis.
(Information excerpted from report to USCG, 2003. Structural Engineer later examines Navy drawings of 1952 school, and identifies flaws in wood ledger board connecting concrete walls to roof. Formal meeting held to notify school board and PTA, after confirming lack of retrofit with Borough Engineer.)

Peterson Elementary (Borough Property)
Age - This building was constructed by the Navy in the 1950s, and modified by 1966/1993/1998 additions which did not address structural rehabilitation of the original structure that comprises 45% of the total square footage of the building. Tsunami is a minor threat with a foundation elevation of 48 feet. It was not inundated in 1964.

Peterson Elementary:
280 Students, 40 Staff

(Approx. 200 occupants are USCG family members.)
2004-2009
KIBSD Seismically Retrofits Five Schools

2009 Kodiak Island Borough receives WSSPC Overall Award in Excellence for seismic retrofit of schools.

“Kodiak has done a truly exceptional job for a small community, from funding the bond to doing the risk assessment to developing a robust hazard mitigation plan, identifying the schools as a priority and then going forth and fixing the major problems—all in an exceptionally short time. I don’t know of any community, of any size, that has done a better job and certainly none that has done more or even anywhere near as much on a per capita basis.”

Similar risk correlation to be added to revised FEMA 154 RVS (ATC-71, Fall 2014)
Fall 2005
First meeting held by the ASHSC.
www.seismic.alaska.gov
(11 Members, budget $10K/year)

1/5 the size of the “Lower 48”
Pop. 735,000
25% under age 18
49th State, 1959
2014 USCG Base Kodiak has retrofitted 4 Barracks, demolished one and is rebuilding another.

Bowling Alley mitigated as part of energy retrofit.

An RFP has been issued for retrofit of its most mission critical Communication Station structure for Electronic Support Unit.

Piers have been strengthened.

Non-structural issues have been identified in the Hangars, including improperly supported overhead steam lines.

2006: Formal RVS of all USCG critical structures.

Liquefiable soils and tsunami inundation lines clearly mapped.
Why Identify and Mitigate????

Proof that Modern Seismic Codes in Schools Can Save Lives:

**2008** China Sichuan Earthquake, Mw 7.9 (69,000 deaths, 7,000 schools collapsed)

These two modern school buildings performed well. All occupants survived.

- **Diligence Building** – almost completely intact  
  (5-10 year old construction)

- **Learning Building** – basically intact  
  (10-15 year old construction)

Fault Surface Rupture  
(Note buildings in background collapsed into rubble.)
2010 Map of Schools and Earthquake Hazards appear in ASHSC Annual Report. Presented to members of Legislature by John Aho (ASHSC) and Sam Kito (ADEED)
DETAILS OF REGION WITH HIGHEST SEISMIC HAZARDS, AND ASHSC PLAN FORWARD

- Recognition of Problem
- Identification of Structures at Risk
- Prioritization of Mitigation
- Final Determination of Remediation Projects

Communities with Highest Potential Peak Ground Acceleration & Educational Facilities Built Prior to 1976

- Kodiak Island: PGA = 40s-50s %g

PRELIMINARY SCHOOL SEISMIC HAZARD MAP
"High dwellings are the peace and harmony of our descendants," the stone slab reads. "Remember the calamity of the great tsunamis. Do not build any homes below this point." - 600+ year old marker, ANEYOSHI, JAPAN

Through history, this community elected to not allow construction below this marker. Consequently, their homes were spared by the March 11, 2011 tsunami.

In a neighboring community, a school had been constructed 500 feet from the ocean’s edge... the children attending that school were not found.

NOTE: In some communities these markers were submerged.
2012 – After trial period, ADEED officially incorporates seismic work as a line item for school improvement projects. (Result of partnership of ASHSC/ADEED from 2009-2012)
Alaska Seismic Hazards Safety Commission - Pilot Program: Rapid Visual Screening of Alaska School Buildings

### Project Name:
ASHSC Pilot Program: Rapid Visual Screening of Alaska School Buildings

### Effective:
6/2/2014

### Ending:
1/2/2015

### Description:
The Alaska Seismic Hazards Safety Commission (ASHSC) respectfully requests the Earthquake Engineering Research Institute (EERI) to hire a consultant with an Alaska PE license to set up and implement a pilot program for conducting Rapid Visual Screenings (RVS) of Alaska schools using FEMA 154/ROVER. As part of a pilot study, identify and work with a supportive school district in or near Anchorage, AK, and screen as many at-risk schools as feasible (approximately 5-10) within allotted budget. Develop protocol for collecting, managing, and reporting final results. Make recommendations for implementing on a district-by-district basis, and potentially at the state-wide level.

### Project Scope/Deliverables
1. Work with the ASHSC to identify a school district willing to participate in a RVS pilot study. The school district must be located in Anchorage or on the adjoining road system in order to minimize travel & per diem costs. Though not required, it is preferred that as-built drawings for the school buildings be available in advance, to improve speed and reliability of screening. Upon request, the ASHSC can provide a map of Alaska school districts and seismic hazards, student attendance numbers, and database of school building information sorted by local peak ground motions, and year of construction.

2. Purchase a laptop and/or mobile device for installation, operation, collection and management of FEMA 154/ROVER software/data. Provide to ASHSC upon completion of pilot study for future use and data collection/management. FEMA ROVER software is free of cost. Upon request, the ASHSC can provide information describing ROVER software applications.

3. Perform RVS of approximately 5-10 schools considered at-risk. If schools are newly constructed and meet modern seismic code, do not screen. Screener shall have an Alaska Professional Engineering license and a strong background in structural and earthquake resistant design. Experience with RVS/ROVER preferred.

4. Compile results in a final report. Final product shall serve as a Proof of Concept, and establish protocols and a cost basis for future work. Refer to the Utah Seismic Safety Commission’s pilot test in Salt Lake City as a model. Intent is to utilize final product as an example for justifying and performing RVS in other Alaska school districts. Final report may also be used to persuade state legislators to fund a RVS program on a state-wide basis, or to obtain future grant funding. See Attachment 1, “Utah Students at Risk” by the Utah Seismic Safety Commission.

### Estimated Budget

<table>
<thead>
<tr>
<th>Description</th>
<th>Terms</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consulting (including travel &amp; per diem)</td>
<td>40 hours @ $150/hr</td>
<td>$6,000</td>
</tr>
<tr>
<td>Hardware (laptop computer/portable device/setup)</td>
<td>1 lump sum</td>
<td>$1,000</td>
</tr>
<tr>
<td>Software (ROVER) - Free from FEMA</td>
<td>No Cost</td>
<td>$0</td>
</tr>
<tr>
<td>Final Report</td>
<td>5 Hard Copies, 1 Digital CD</td>
<td>$500</td>
</tr>
</tbody>
</table>

Total Cost: $7,500
Pilot RVS – Mat-Su School District
(14% of Alaska’s student base)

February 2015

Cost of this Study:
The total cost of this study was approximately $18,500. Of this, BBFM Engineers was paid $8,500 for their work, resulting in a donated effort of approximately $10,000. Of this, $4,275 was spent on setting up the server and becoming acquainted with the software. Another $8,145 was spent reviewing drawings, visiting the schools, and entering data into the server. Finally, a little over $6,000 was spent preparing this report.

Pilot study proved that an RVS for a school structure in Alaska could be performed for approximately $600 to $800 per original structure or addition, plus costs associated with transportation.
Cost of this Study:
The total cost of this study was $21,250, at a cost of performed for just $500 to $700 per structure.

Schools located in Anchor Point, Cooper Landing, Homer, Kenai, Moose Pass, Nikolaevsk, Ninilchik, Homer, Kenai, Seward, Soldotna, Sterling, Seldovia, Kasilof.

In total, we reviewed 15 schools comprised of 47 structures, including original construction and additions. Nineteen of the 47 warrant a more detailed evaluation, while further review of the remaining 28 schools is not indicated. In other words, 40% of the structures reviewed in this study may pose an unacceptable risk of at least partial collapse during a major earthquake.
What CA school retrofits prevented during a M6 EQ.

Recent example of a successful school retrofit program was demonstrated during the magnitude 6 earthquake that struck Napa, California in 2014, producing peak ground accelerations of 60% to 100% as strong as the acceleration due to gravity. The earthquake and its aftershocks injured 90 people and caused approximately $1 billion of damage.

Engineering News-Record reported on September 3, 2014: The epicenter of the American Canyon quake was at the heart of the Napa school district’s 30 campuses. Subsequently, three architectural and engineering teams assessed "every room in every school" and observed no structural damage following the quake, says Mark Quattrocchi, principal of Kwok Quattrocchi Architects and one of the survey team members... The schools performed so well because they are built or retrofitted according to much stricter seismic codes than commercial and residential buildings.

"There was no structural damage to any school in the district, even the ones built to older codes in the 1940s, 1950s and 1960s," says Quattrocchi. "Part of this is because seismic upgrades at the schools are treated the same as building an entirely new facility," he adds. Schools fared well for three reasons: seismic building codes that are more stringent than those for commercial buildings, methodical reviews by the Division of the State Architect and "full-time" state inspection on school construction sites, Quattrocchi says.”
LESSONS LEARNED:

Earthquakes remain our greatest teacher and exert the most influence. Human nature allows us to rapidly forget; natural disasters spur short periods of action. Clearly document information & efforts – easy to forget.

Hidden seismic hazards exist, many of which have yet to be identified – especially in Alaska.

Foster and maintain professional relationships. Encourage professional development and dialog. Encourage inter-agency and cross-state communication.

The average US citizen thinks they don’t need to worry about the next earthquake – they assume our codes and engineers have already made everything safe.

Do not underestimate the ability of others to help (or occasionally hinder). Educators, eager students and proactive PTA members are great allies. Understand that some upper-level leaders will cite concerns over widespread alarm and unfunded mandates. Partner with the Departments of Education and School Districts.

The path to success is not always upward or linear. Anticipate sudden successes, unforeseen set-backs, and seeming lack of progress. Be persistent; a worthy idea will succeed over time.
Identification, Funding, Staffing & Project Implementation

IDENTIFICATION
- Recognition of Problem
- Identification of Structures at Risk
- Prioritization of Mitigation
- Final Determination of Remediation Project

Determination of Identification Strategy

Rapid Visual Screening
- Geologic Hazards
- Building Information
- Age
- Type (15 types/ combinations)
- Materials
- Lateral Force Resisting System
- Layout
- Non-structural Concerns
- Falling Hazards
- Emergency Utility Services
- Occupancy

ASCE Tier 1 Screening
- Building Description (size, materials, age, layout, structural composition)
- Site Visit, As-Built Drawing Verification
- Level of Performance Determination
- Level of Seismicity
- Building Type
- Benchmark Evaluation for Bldg. Type
- Basic Structural Evaluation
- Supplemental Evaluation Based on Bldg. Type
- Geologic Site Hazards & Foundation Evaluation
- Basic Non-structural Evaluation
- Intermediate Nonstructural Evaluation

Other
- Structural
  - Fragility & Damage State Curves
- Non-structural
  - Within the Building Envelope
    - Exits, Fuel Systems, Ceiling Tiles, Books, Computers, etc.
  - Geologic Investigation
    - Ground Motion
    - Tsunami
    - Active Faults
    - Liquefaction
    - Landslide
    - Differential Settlement
  - Geotechnical
    - Site Soils
    - Groundwater Table
    - Slope Stability
    - Foundations
Identification, Funding, Staffing & Project Implementation

FUNDING

• Federal
  – FEMA Hazard Mitigation Grant Program (HMGP) – Post Disaster
    Federal HMGP funds made available following a disaster can provide a federal share of up to 75% of the costs of an approved project.
    The remaining 25% must be met through non-federal funds such as local government funds, community development block grants, etc.
  – FEMA Pre-Disaster Mitigation Program (PDM)
    » Mitigation planning: $1M cap on Federal share, not to exceed 3 years
    » Mitigation projects: $3M cap on Federal share, not to exceed 3 years
    » Information dissemination activities not to exceed 10%, must directly relate to planning or project sub-application
    » Applicant management costs not to exceed 10%
    » Sub-applicant management costs not to exceed 5%
  – US Senators
  – US Representatives

• State
  – School Facilities Capital Improvement Project Grant (Dept. of Education)
  – State Capital Projects
    » State Senators
    » State Representatives
  – Governor

• Local
  – Bonds
  – Maintenance
  – Special Capital Projects/Special Funds (Sale of Shuyak Island)
  – General Fund (Mill Rate/Property Taxes/Severance Taxes/Intergovernmental Sources)
  – Local Government Representatives
  – Local Government Employees

• Private (In-Kind Donations)
  – Services
  – Materials/Supplies
  – Benefactors
Identification, Funding, Staffing & Project Implementation

STAFFING

- **Local Government**
  - Credentials
  - Time Commitment
  - Specialized Hire Considerations
  - Points of Contact
    » Finance
    » Record drawings (digital?)
    » Building Access
    » Public Meetings & Outreach
    » Project Management (Identification, Mitigation Grants, Construction)

- **Municipal/School Building Managers**
  - Engineers (Large Districts)
  - Architects (Large Districts)
  - Finance
  - Maintenance

- **Private Contract**
  - Evaluation
    » Geologic
    » Geotechnical
    » Structural
  - Grant Application
  - Design
  - Construction
  - Inspection
Identification, Funding, Staffing & Project Implementation

PROJECT IMPLEMENTATION

- Seismic Only
- Combined
  - Maintenance Upgrade (Roof, Mechanical, Electrical)
  - Energy Efficiency
  - Expansion
- Phased/Unphased
- Unanticipated Issues
  - Existing Conditions
    - Lead (paint, plumbing, etc.)
    - Asbestos (flooring, insulation, roofing, etc.)
    - Non-Code Compliant Electric, Plumbing, Fire, Fuel/Heat
  - Unknown Existing Conditions (Structural/Non-Structural)
  - Funding Difficulties
    - Long Stretches of Time between Identification & Construction
    - Multiple Agencies
    - Rising Construction Costs
    - Unaccounted Local Cost Factors
Thank You!

Artwork by

Eustace Ziegler (1881-1969),
Alaskan Frontier Artist

(My great grandfather’s brother.)

Note: Numerous pieces of his artwork were lost in the 1964 Valdez tsunami. Some of his surviving works can be seen at the Anchorage Museum and the State Capitol Building in Juneau.

Questions? E-mail: Laura.W.Kelly@USCG.MIL
QUESTIONS & ANSWERS SESSION
THANK YOU!

More info:
eeri.org/schools