In Harm's Way:  
School Damage in Recent Earthquakes,  
and  
Why the Lessons Are Rarely Applied  

Yumei Wang, PE  
Oregon Dept of Geology and Mineral Industries  
and  
Edward C Wolf  
Parent Advocate  

April 11, 2012  

Key Points  
School Damage in Recent Earthquakes  
Selected 2008-2012 worldwide earthquakes  
Problem with dangerous schools in U.S.  
Problem will persist without intervention  
If school hours, very high consequences  
Recommendations by APEC  
Our Choice: Apply Lessons or Not?  
NEHRP, EERI, locals, parents...
Earthquake Damage to Schools is Ongoing Worldwide Problem

- 1988 Armenia
  - >1,000 students dead
- 2003 Algeria
  - 130 schools
- 2005 Pakistan
  - 8,000 schools
  - 17k students dead
  - 20k students injured

1964 Alaska M9.2 quake
School pulled apart by landslide

2008-2012 Worldwide Earthquakes

2008 M7.9
2011 M9.0
2011 M6.3
2010 M7
2011 M5.8
2010 M8.8

4/24/2012, YWang and ECWolf
~19,000 students died in 7,000 schools

2008 Wenchuan China. Xing Fu Primary School

Source: Kit Miyamoto

Han Wang Primary School

Source: Kit Miyamoto
Yuan Wentin (袁文婷), 26, first grade teacher
She saved many students
but then building collapsed on her (upper right)

“Drop, Cover & Hold” does not work if building collapses

School Damage Statistics

2010 Haiti M7. **1,300** schools destroyed

2010 Chile M8.8. **4,000** schools badly damaged or destroyed

2011 Christchurch M6.3. **163** schools impacted. **11** seriously damaged

- ~Good overall performance.
- Total: **635 deaths** (children, students, teachers in tsunami)
- Example: Good performance. Piles at Liquefaction site.
- Example: Bad outcome. 70% fatalities by tsunami.
Japan 2011 Liquefaction Mitigation

Bridge on Kitakami River, Japan
with Okawa Elementary school in background
Tsunami hit Okawa Elementary School

74 of 108 students died
10 of 13 teachers and staff

"The question is why, again and again, even in developed nations, with a wealth of engineering expertise, schools would collapse in earthquakes . . . .

Every, that is EVERY school should be inspected and where necessary reinforced.

This is so basic to risk mitigation in a seismically active area, it seems foolish to have to write it down." (Ben Wisner)
Problem with dangerous schools in U.S.

- Built to inadequate seismic zoning
- Built to inadequate building codes
- 1,000s school buildings high risk of collapse in major U.S. e-quakes
  • Millions vulnerable students
  • If school hours, high consequences
  • Problem persist w/o intervention
  • Recommendations by APEC (GHI)

OLDER SEISMIC HAZARD ZONING & INADEQUATE BUILDING CODES

1976
(10% PE in 50 yrs)

(Algermissen & Perkins)

1994
(UBC Map)

(American National Standard for Seismic Design of Buildings (UBC))
Asia-Pacific Economic Cooperation (APEC, 2011)

Safe@School Principles (paraphrase):

1. EVERY CHILD HAS A RIGHT TO ATTEND SCHOOL IN SAFE BUILDINGS

2. GOVERNMENTS AND EDUCATION LEADERS ARE RESPONSIBLE FOR THE SAFETY OF SCHOOLCHILDREN

3. GOVERNMENTS AND EDUCATION LEADERS MUST FULFILL THAT RESPONSIBILITY

4. EFFECTIVE SCHOOL SAFETY PROGRAMS MUST BE DESIGNED AND IMPLEMENTED

8 Activities to Implement Principles

1. IDENTIFY AND MAP HAZARDS
2. PREPARE LONG-TERM RISK REDUCTION PLAN
3. ASSIGN RESPONSIBILITY FOR PLAN
4. ENFORCE BUILDING CODE FOR SCHOOL BUILDINGS
5. IMPROVE PROFESSIONAL STANDARDS
6. CONDUCT PREPAREDNESS PROGRAMS
7. IMPLEMENT NATURAL HAZARDS CURRICULA
8. ESTABLISH AND PRACTICE OVERSIGHT
Our Choice: Apply Lessons or Not?  
Who Will Build “Safe Schools” Programs in US?

NEHRP agencies role?  
- NSF Grand Challenges  
- NIST (eg, Fire Life Safety Program)  
- USGS Scenarios  
- FEMA State Programs  
EERI members, districts, parents...?  
Safe Schools Action Plan?

Japan & Cascadia “Mirror Images”

March 11, 2011 Japan Tsunami  
Hypothetical Cascadia Tsunami  
(Source NOAA)
RikuzenTakata, BEFORE TSUNAMI

RikuzenTakata, AFTER TSUNAMI