URM-FREE BY 2033: TOWARD A NATIONAL SAFE SCHOOLS AGENDA
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ABSTRACT
The United States lacks a national policy affirming the right to learn in school buildings that are safe from earthquakes. The authors review the status of school seismic safety in five high-seismic-hazard zones identified on the USGS National Seismic Hazard Maps. Efforts to support progress on school seismic assessment and mitigation in the highly decentralized U.S. public education sector are reviewed, and the authors propose a three-part national agenda to make schools safer in high-seismic-hazard regions, centered on a common goal: "URM-Free by 2033."

INTRODUCTION

“Schoolchildren have a right to learn in buildings that are safe from earthquakes” (ACEHR, 2012). These words from a recommendation to the National Institute of Standards and Technology (NIST) by a national advisory committee in a report on the National Earthquake Hazards Reduction Program (NEHRP) would strike most parents of school-age children as simple common sense. To date, the United States has no national policy that affirms this right.

Responsibility for K-12 education in the United States is highly decentralized, with great variation from state to state and a broad range of sophistication at the level of local elected school boards who bear ultimate responsibility for the condition of school facilities. With respect to structural risks, children who attend schools in earthquake zones are at the mercy of local building codes, the age of the school buildings they attend, and the willingness of local school boards to seek capital bonds to pay for seismic retrofits and upgrades.

Meanwhile, advances in the science of seismic hazard show that elevated hazard is more widespread in the United States than previously understood, and far more prevalent than commonly recognized by policymakers or the general public. An earthquake during school hours that is likely to result in significant or even mass casualties is a real possibility in areas of sixteen states that account for more than one-third of the U.S. population. The case for a national response to this widespread hazard is building steadily.

Seismic policy organizations are increasingly engaged with the issue of at-risk schools, and working to advance it on policy agendas. The Western States Seismic Policy Council (WSSPC), for example, representing 13 U.S. states, 3 U.S. territories, a Canadian territory, and a Canadian province, adopted a policy recommendation on “Identification and Potential Mitigation of Seismically

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Vulnerable School Buildings” in July 2010, and the Council will review and renew that policy recommendation in 2013. (WSSPC, 2010)

The Council’s recommendation emphasizes a three-part approach: Identify the seismic vulnerability of schools, rank facilities, and enact programs to reduce the vulnerability of schools at greatest risk. In this paper, we review five U.S. regions with high seismic hazard for evidence of progress on such steps and programs, and we propose a national framework to promote the more efficient exchange of experience and policy between regions and jurisdictions whose school buildings and school children share common vulnerabilities to high seismic hazard.

PROBLEM STATEMENT

Seismic risk combines considerations of hazard probability, vulnerability, and consequences. The National Seismic Hazard Maps, prepared by the U.S. Geological Survey and updated each six years, provide a comprehensive view of seismic hazard in the United States based on the best available science. The maps display the probability levels of earthquake ground motions, and they are used to update building codes, revise insurance rates, and inform public policies based current understanding of active faults, seismicity and ground motions. The maps provide a general picture of the regions at risk for dangerous ground shaking. (USGS, 2008)

Schools in areas of high seismic hazard can take several approaches to manage the risk. Efforts to teach and practice self-protective behavior (“Drop, Cover, and Hold On”), to address non-structural falling hazards, and to retrofit or replace non-ductile school buildings all help reduce the probability of injury or death when an earthquake strikes during school hours. Of the three, children and school staff members can be trained at modest cost, and falling hazards can be mitigated affordably if the task is integrated into preventive maintenance programs, but mitigating structural vulnerabilities requires significant capital investment. In this paper, we focus on efforts to remove the barriers to that capital investment.

Non-ductile school buildings, which are under-reinforced buildings prone to catastrophic collapse, are unfortunately common in many areas of high seismic hazard. Unreinforced masonry (URM) and under-reinforced concrete were commonly used in school construction in many parts of the United States during the early twentieth century. Non-ductile precast concrete structures are common in mid century school construction in parts of the U.S. These structural types have inherent vulnerabilities to ground shaking particularly in places where local building codes lagged behind current scientific understanding of the seismic environment.

Public school buildings constructed prior to adequate seismic building codes share seismic deficiencies common to other buildings of the same structural types in the same setting, but several considerations set school
buildings apart from their peers in terms of priority for seismic assessment and retrofit:

- First, schools are the only high occupancy public buildings other than prisons and courthouses whose occupants are compelled by legal mandate to be inside them.
- Second, school buildings in many communities tend to remain in use longer than comparable structures in private ownership, and tend to receive less frequent and less consistent capital renewal investment.
- Third, community members and public officials often hold a high (if unfounded) expectation that schools will provide community shelter or host public services in the wake of a natural disaster.

In seismic zones where time intervals between damaging earthquakes are shorter than the average lifetime of building stock, earthquakes test buildings – causing damage, necessitating repairs or retrofits, and applying almost Darwinian selection pressures to the inventory of existing buildings. Frequent earthquakes also drive a rapid improvement in building codes and standards, ensuring that turnover in the built environment advances the protection of students and other building occupants.

In zones where earthquakes are infrequent compared with the average lifecycle of buildings, including places where no earthquakes have struck during recorded history, the tendency is to complacency. Buildings unsuited to ground shaking persist without retrofit despite advances in building codes. Scientific understanding of the risk, no matter how robust, is seldom enough to drive change in such settings. Earthquakes in regions facing similar seismic risks can promote awareness, but far-away disasters do not automatically trigger changes in policies or repairs to existing infrastructure.

Despite steady advances in science and engineering, it typically takes a serious local earthquake to trigger the local changes needed to offer adequate protection to schools and children. This pattern has been repeated time after time, in the United States and throughout the world.

The challenge of adopting proactive policy with respect to earthquake safety of schools has not been fully met anywhere, but promising precedents can be shared and built upon. One of the biggest challenges is financial: correcting structural deficiencies requires capital investment, and projects that do not generate some form of financial return are difficult for public authorities, from school boards to state legislatures, to justify to the public. Projects that provide operating cost savings (e.g., energy efficiency investments) often are prioritized. This risks a misallocation of capital away from hazard mitigation investments that have compelling societal value.

Assessing inventories of school buildings to characterize their vulnerability is neither costly nor time-consuming, but such assessments may be delayed by complacency. Organizing engineering evaluations to diagnose structural problems and estimate the cost of correcting them is a more complicated step requiring action by school districts and coordination and logistical support from engineering professionals. Deploying engineering and construction talent to retrofit or repair schools at risk is still more complex and costly, requiring
significant capital investment and close coordination with local school districts and facilities managers. Policies are needed to overcome complacency, facilitate logistics, and expand access to capital for retrofits.

The typical default position – to allow the natural turnover of building stock to set the pace of modernizing schools – leaves districts two alternatives: Either force the closure of facilities that lack sufficient ductility or lateral strength, or leave large numbers of students at risk in deficient structures. Neither alternative is desirable, but both remain common in regions of high seismic hazard in the United States.

Each of the five regions of high seismic hazard discussed below offers examples of ways to address complacency, facilitate logistics, or expand access to capital. By combining promising approaches from different regions into a deliberate strategy, a national agenda to accelerate progress on school safety may be brought into clearer focus.

FIVE REGIONS AT RISK

In the continental U.S. (excluding Alaska and Hawaii), five regions possess the highest level of hazard identified on the USGS National Seismic Hazard Maps: California and Nevada, Cascadia (Washington, Oregon, and Northern California), Utah (along the Wasatch Front), coastal South Carolina, and the New Madrid Seismic Zone encompassing part of an eight-state region of the central U.S. (Figure 1.). Alaska and Hawaii each possess high seismic hazard areas as well, but lie outside the scope of this paper. Each of these five regions possesses distinct seismic hazards, and each presents unique obstacles to the “assess, rank, and mitigate” approach that the Western States Seismic Policy Council recommends for improving school safety.
Figure 1. National Seismic Hazard Map showing peak ground accelerations (Source: Petersen et al, 2008).

**California:** The state that ranks Number 2 in number of earthquakes sets the U. S. benchmark for earthquake awareness and earthquake policy. The magnitude (M) 7.8 Great San Francisco earthquake of April 18, 1906 remains the iconic modern earthquake in American consciousness, but several more recent California earthquakes have triggered significant policy innovations that have yet to be emulated by other states. Nevada, whose seismic hazard resembles California’s, is omitted from this discussion in the interest of simplicity.

With respect to school safety, the most important California earthquake of the 20th Century was the M6.4 Long Beach earthquake of March 10, 1933, which left more than 230 school buildings destroyed, significantly damaged, or judged unsafe to reoccupy. The earthquake struck on a Friday afternoon after school hours. One month later, the California State Assembly adopted the Field Act, which mandated that new public schools must be earthquake resistant and established the Office of State Architect (now known as the Division of State Architect) to oversee the safety of school construction (California Seismic Safety Commission, 2007).

One outcome of the Field Act was the banning of unreinforced masonry (URM) construction, the structural type that sustained the heaviest damage in the Long Beach earthquake. Although some URM buildings that predate 1933 remain in operation in California school districts, they are not in classroom use. Non-classroom uses do not fall under the jurisdiction of the Division of State Architect.

No injuries or deaths have occurred in a post-Field Act school building, and no school constructed according to Field Act standards has suffered partial or complete collapse in subsequent earthquakes. During the 1989 M6.9 Loma Prieta earthquake, two public schools in San Francisco’s otherwise heavily damaged Marina District served as emergency shelters and disaster assistance centers (California Seismic Safety Commission, 2007). Legislative mandates and building code revisions triggered by recent earthquakes including Loma Prieta and the 1994 M6.7 Northridge earthquake have steadily advanced earthquake engineering practice in California.

California remains an innovator in the civil society response to the risk of earthquakes to educational facilities. The California Parent-Teacher Association (CAPTA), for example, adopted a statewide resolution on non-structural falling hazards and schools in May 1989 (5 months BEFORE the Loma Prieta earthquake) (California State PTA, 1989). The Great Southern California ShakeOut of November 2008, the largest voluntary earthquake drill in the U.S. up to that point, has inspired similar large-scale drills in many parts of the U.S. including all of the states and regions discussed in this paper.

New initiatives in California, including the voluntary efforts by the Concrete Coalition (sponsored by the nonprofit Earthquake Engineering Research Institute and focused on the seismic performance of non-ductile concrete buildings), continue to assess and propose mitigation for non-ductile structures including
schools, with primary emphasis on compiling inventories of potentially hazardous buildings. A Pulitzer Prize-nominated investigative reporting project, “On Shaky Ground,” exposed failures in the regulation of seismic safety at California public schools, suggesting that school safety remains an unrealized goal even in this innovative state (California Watch, 2011).

**Cascadia:** Washington and Oregon share a moderate to high seismicity (Washington and Oregon rank #5 and #10 respectively on a USGS list of states with the most frequent earthquakes) and the regional seismicity of Northern California is well-known, but the regional vulnerability to an earthquake along the Cascadia Subduction Zone (CSZ) megathrust (fault) that parallels the coast of both states has been recognized for only 25 years (Figure 2.). The last full rupture of the CSZ occurred on January 26, 1700. Much of the existing built environment in the regions of all three states adjacent to the CSZ predates scientific understanding of the subduction zone risk. Policy and practice are slowly catching up to contemporary scientific assessments of the earthquake and tsunami hazard associated with the CSZ. Our discussion emphasizes initiatives in Oregon and Washington, states where the seismic policy environment is less advanced than in California.

Public awareness, informed by science, shaped relatively few policy initiatives relating to the subduction zone hazard in Cascadia before the March 2011 M9.0 Tohoku earthquake and tsunami generated by the megathrust off northeast Japan, often described as the "mirror image" of the CSZ. The immediacy of video images from that disaster, as well as tsunami warnings and the trans-Pacific tsunami wave that made impacts along the U.S. West Coast (including the arrival of marine debris beginning in spring 2012), have buoyed new initiatives, including a Resilient Washington State effort coordinated by Washington Emergency Management, and a legislatively directed statewide resilience planning effort directed by Oregon’s Seismic Safety Policy Advisory Commission.
Figure 2. The Cascadia Subduction Zone (Source: The Portland Earthquake Project)

School inventories in Oregon and Washington include large numbers of non-ductile school facilities built before seismic building codes, and retrofits to older structures have been largely piecemeal affairs driven by the interest of local school boards and the receptivity of local voters to school bond measures that finance replacement of existing schools. Both states have experience with large-scale risk assessments, Oregon with a statewide assessment of schools and emergency response facilities completed in 2007 (Lewis, 2007), and Washington with a seismic safety pilot project in two school districts designed to produce affordable building-specific assessments that can be used directly for engineering design for mitigation (Walsh et al., 2011).

Statewide progress on mitigation of at-risk schools is not proceeding quickly in these two states, because responsibility for school facilities is highly decentralized and state resources for mitigation remain limited. Oregon has policies in place, including a statewide database of seismic ratings for schools built prior to 1994 and voter authorization to use general obligation bonding to finance retrofits for schools at risk, but legislators have shown little inclination so far to use that authority to address the problem at a large scale.

Washington State has a larger state economy, a somewhat different system for funding public education, and a tax system more favorable for passage of local school bonds, so the rate of replacement of older school
buildings is probably higher than in Oregon. But no coordinated effort is yet in place to identify and prioritize the replacement of the most hazardous school buildings in Washington's inventory of 3,000 or so public schools.

Civil society in Washington and Oregon is increasingly engaged with the risk of significant earthquakes as well as tsunami. Both states have hosted, or are planning, large-scale ShakeOut earthquake drills that introduce large numbers of people, including students, to Drop, Cover, and Hold On practices that will save lives in the event of an earthquake. Both states are engaged in resilience planning exercises that aim to expand the policy menu beyond public safety to broader considerations of business continuity and economic recovery. The growing engagement of the business community in resilience planning and policy could lead to a new emphasis on the seismic safety of schools as one element of the integrity of the educational system, often singled out as a key priority on the business agenda.

**Utah:** The state of Utah ranks ninth in frequency of earthquakes, just ahead of Oregon, but the sparsely populated state has a concentrated region of high seismic hazard along the western base of the Wasatch Range. Although it has not generated a major earthquake since Mormon pioneers settled in the Great Salt Lake Valley in 1847, the 240-mile multi-segment Wasatch fault is believed capable of producing earthquakes of M7 and larger. Today the Wasatch Front is a rapidly growing metropolitan region stretching north and south from Salt Lake City along the Wasatch Range, accounting for about 80 percent of Utah’s 2.8 million residents (Utah Seismic Safety Commission, 2008).

Because no major earthquakes have struck along segments of the Wasatch fault in historic times, awareness of the seismic hazard did not shape modern settlement patterns, and according to the Utah Geological Survey, many urbanized areas along the Wasatch Front today are built on soft lake sediments expected to be highly vulnerable to earthquake ground shaking. Construction did not take seismic hazard into account until recently, and over 150,000 URM structures may be at risk. Vulnerable buildings include many of Utah’s 1,094 K-12 school buildings.

School safety has been a focus of the Utah Seismic Safety Commission, which led a pilot assessment of 128 public and charter school buildings using a Rapid Visual Screening method (FEMA 154) designed to identify structures in need of detailed seismic evaluation due to estimated probabilities of collapse associated with certain visual features of the structures assessed. The pilot assessment, completed in February 2011, identified 77 schools in need of further assessment, including 46 with scores indicating greater than ten percent probability of collapse in a strong earthquake and 10 considered highly likely to collapse. The high proportion of schools identified with significant risk factors supported the Commission’s call for a comparable survey of all of Utah’s 1,094 public schools and establishment of a systematic program to improve the seismic safety of Utah’s older and seismically unsafe schools (Siegel, 2011).

Little progress toward that goal had been achieved at the time of this writing (June 2012). A bill to initiate the statewide survey (HB 279) was
unsuccessful in the 2012 legislature (Utah State Legislature, 2012a). Legislators also took action during that session to weaken an existing requirement to make seismic improvements including bracing chimneys and parapets in unreinforced masonry buildings during re-roofing (Utah State Legislature, 2012b).

Civil society is shining a new spotlight on the hazard. In April 2012, Utah participated for the first time in ShakeOut events with the Great Utah ShakeOut, in which more than 940,000 Utahns participated. The statewide Drop, Cover, and Hold On drill was organized by Be Ready Utah, a statewide emergency preparedness campaign run by Utah’s Department of Public Safety. In May 2012, Utah PTA members gave unanimous support to a resolution on earthquake-safe schools at their state convention. The resolution urges the legislature to fund a statewide rapid visual screening of all public school buildings and calls on the State Office of Education to support new efforts to address schools at greatest risk (Utah PTA, 2012). Utah PTA represents more than 135,000 local members at 650 schools. More must be done to turn this public awareness into political support for action to assess and retrofit Utah’s unsafe school buildings.

**South Carolina:** Though the state is not widely known for its seismicity, the Charleston earthquake of 1886, estimated M7.3, was the most damaging earthquake ever to strike the southeastern United States. The earthquake caused extensive damage in an area with little or no known historical earthquake activity, and generated powerful aftershocks for months after the event. Shaking and liquefaction caused damage to more than 2,000 buildings in Charleston, some of the damage visible to this day (Coté, 2006).

The Charleston County School District, an urban district serving 45,000 students in 80 schools, made an unprecedented decision in May 2010 to close six schools after receiving engineering evaluations indicating the buildings’ inability to withstand an earthquake of M5.0, considerably smaller than the 1886 earthquake. The decision involved the proposed relocation of 1,331 students served by four downtown schools for up to three years, a complex logistical challenge for any school district, and one that met with inevitable community resistance (Courrégé, 2010).

The second-largest of South Carolina’s 85 school districts, Charleston County’s inventory of schools probably reflects structural types and building ages found in many of the state’s other cities and towns, but there is no indication that Charleston’s historic earthquake or the “Relocate, Rebuild, Return” project the district initiated amid controversy in 2010 has triggered broader statewide concern about the vulnerability of school facilities. URM schools and other non-ductile structures probably account for a significant proportion of the state’s 1,123 public schools, and a considerable share of the state’s K-12 enrollment of roughly 700,000 students may be at risk.

Lacking a statewide seismic commission or an organized constituency for safer schools, it is difficult to see where the initiative might arise to advocate for assessment and mitigation of South Carolina schools, and how concern might translate into political support for public investment in seismic retrofits. The South Carolina Seismic Network, hosted at the University of South Carolina in
Columbia, has a program of outreach to middle school and high school teachers to promote earth science education, but no focus on structural engineering. The College of Charleston hosts the South Carolina Earthquake Education & Preparedness Program, also with a focus on geology and not on engineering or the state’s built environment. The Structural Engineers Association of South Carolina has been in existence for less than a decade and has had little time to undertake public policy advocacy. The South Carolina Earthquake Awareness Project, founded by the author of a history of the Great Charleston Earthquake, is one effort to raise awareness and improve policy (Coté, undated).

More than 260,000 South Carolinians reportedly did participate in the first Great Central U.S. ShakeOut drill in April 2011. Although South Carolina is not a member state in the Memphis-based Central U.S. Earthquake Consortium, participation in ShakeOut was promoted and coordinated by South Carolina Emergency Management Division.

The New Madrid Seismic Zone (NMSZ): The NMSZ covers parts of an eight-state region centered on the town of New Madrid, Missouri. Over the winter of 1811-1812, a sequence of intraplate temblors shook the region with magnitudes between M7 and M8. The three major earthquakes that struck during the three-month period between December 1811 and February 1812 rank among the largest earthquakes in the recorded history of continental North America. Aftershocks followed for a period of at least five years, but because the region was sparsely populated at the time, casualties and recorded property damage were light (USGS, N.D.).

Today the region is home to approximately 11 million people and comprises some of the most densely urbanized and populated parts of the central U.S. including the city of Memphis, Tennessee. Damages caused by a repeat of the 1811-1812 temblors would be severe. FEMA has taken a keen interest in the NMSZ, and warned that a serious earthquake could result in the highest economic losses ever attributable to a natural disaster in the U.S., lasting impact due to disruption of lifeline infrastructure, and thousands of fatalities (FEMA, 2008; Frankel et al., 2009).

The City of Memphis has been a focus of special concern in the NMSZ, due to the city’s location, population, and large numbers of non-ductile and unreinforced masonry buildings. Memphis City Schools, Tennessee’s largest urban district with over 200 K-12 schools and enrollment of over 113,000 students (now in the process of merging with the Shelby County School District), has long alarmed geologists and engineers because of its large inventory of URM school buildings.

In 1997, Howard Hwang and Yang-Wei Lin of the Center for Earthquake Research and Information at the University of Memphis conducted a study titled “Expected Seismic Damage to City School Buildings.” Their survey of 542 Memphis City School buildings identified some 286 URM structures, over half the district’s inventory. White Station High School, one of the state’s highest-performing high schools with a current enrollment of over 2,200 students, was
identified to have five URM structures (the newest constructed as recently as 1967) on its nine-building campus. (Hwang and Lin, 1997).

Despite the comprehensive assessment of Memphis schools and the concentration of earthquake engineering expertise in Memphis, no action has been taken to carry out subsequent engineering assessments or to mitigate the risk to older Memphis schools, and no similar efforts have yet been proposed or carried out elsewhere in the NMSZ. The building code governing new construction in Memphis was significantly weakened by amendment, meaning that newly constructed schools also remain at risk. (Mike Mahoney, FEMA, personal communication, October 23, 2012).

Memphis City Schools was an enthusiastic participant in the first Great Central U.S. ShakeOut (Central U.S. Earthquake Consortium, 2012). The district scheduled its drill, the first-ever district-wide safety drill, for March 11, 2011 – by coincidence, the date of the M9.0 Tohoku earthquake and tsunami in northeast Japan (other Shelby County schools and other central U.S. states staged the ShakeOut drill on April 28, 2011). Tens of thousands of Memphis students participated in the minute-long Drop, Cover, and Hold On drill, many of them in aging URM schools never strengthened to withstand earthquake shaking. Memphis school authorities have yet to acknowledge the structural risk posed by their schools; the district’s current five-year capital plan makes no mention of the word “earthquake” (Bailey et al., 2011).

**REDUCING RISK IN SCHOOLS**

This survey of risk and response in the five high-seismic-hazard zones identified on the 2008 National Seismic Hazard Maps suggests several common themes in these widely disparate regions of the United States.

First, URM and non-ductile school structures remain common in the high-seismic-hazard zones of the continental United States. Unreinforced masonry took hold in school architecture in the early twentieth century, in many cases because of its “fireproof” advantages compared with the wood-frame schools it replaced. Ironically, the “fireproof schools” effort accelerated after the San Francisco earthquake of 1906 (Wolf and Bailey, 2011).

Only in California was the trend toward URM construction interrupted by the 1933 Long Beach earthquake, and even in that state undamaged URMs remained in service, although gradually shifted out of classroom use. Masonry structures, in locations untested by ground shaking, tend to remain in use; URM schools have particular longevity. Thus the exposure to risk in these structures is also long-lived.

Second, despite assessments indicating high seismic hazard, outside of California the low frequency of significant earthquakes in the recent history of other U.S. high-seismic-hazard zones makes it easy for jurisdictions and school authorities to dismiss the risk as hypothetical. Building inventories are not tested and weeded out by ground shaking, existing structures remain in use without upgrades, and communities continue to expand. People move in to areas with
significant seismic risk, with relatively few opportunities to learn how that risk relates to their lives.

This helps to explain the widespread appeal of earthquake drills and the growing popularity and success of large-scale efforts like ShakeOut. Drills impart useful information that can save lives. At comparatively modest cost, such drills give people the satisfaction of participation and the feeling they have taken a significant step to reduce risk and augment their personal safety. ShakeOut drills have attracted significant participation in each of the five regions discussed in this article, and they may represent a preliminary step toward broader public constituencies for an earthquake safety agenda that includes safe schools, residential retrofits, etc. The momentum toward constituencies with the capacity to influence policy is not yet clearly established, and so the contrary possibility must be considered: that authorities encourage public participation in safety drills as an affordable alternative to more costly commitments to earthquake safety.

Our survey also suggests that assessment, ranking, and mitigation efforts are very difficult to initiate at the individual school district level. School boards, even when motivated by a concern for student safety, are highly responsive to local electorates, which are typically deeply conservative when it comes to changes proposed for local schools. Charleston County Schools has found it very difficult to close and rebuild a small number of schools even when the risk and rationale for the school board’s decision to close them were well documented. Memphis City Schools leadership has never acknowledged the results of the comprehensive assessment of school facilities performed fifteen years ago. Finding ways to bring the issue to the attention of decision makers at higher levels of authority is key.

State legislation appears to be a better way to begin and sustain school assessment and mitigation efforts. California has the advantage of a history of legislative initiatives dating back to the 1933 Long Beach earthquake and advanced by the many subsequent earthquakes that the state has experienced. Oregon has a double advantage (described below): legislative mandate of a statewide assessment of schools and voter authorization of a funding mechanism to pay for needed mitigation. The Utah legislature has so far resisted efforts to build on the preliminary assessment of school buildings completed by the Utah Seismic Safety Commission, but has at least considered and debated legislative proposals on the topic (Utah State Legislature, 2012).

The key element needed to move legislation and enact policies is public constituencies informed, activated, and in a position to apply pressure to the policy processes that direct public investment. Public safety constituencies such as the preparedness advocates that promote and support safety drills appear to be necessary but not sufficient. These constituencies typically focus on policy implementation rather than policy formulation. Preparedness constituencies that brought ShakeOut drills to South Carolina, the states of the NMSZ, and Utah have so far failed to advance policy on assessment, ranking, and mitigation of schools in those regions. To a certain extent, their goals provide a non-controversial alternative to the policy debate.
Informed, engaged advocates with the ability to represent the interest of groups at risk are needed. For school safety, this means advocates who represent parents with children in school. National PTA is the oldest and most respected of these advocates; parents’ involvement in the reconstitution of public education after the 1906 San Francisco earthquake was one significant thread in the creation of the modern PTA. At the state level, PTAs have weighed in on seismic safety objectives by adopting resolutions in California, Oregon, and Utah, and that initial policy commitment can pave the way to advocacy. At the national level, the PTA structure is highly decentralized, with few systematic means to share initiatives among states.

Finally, implementation challenges may be encountered at the state, district, or even individual school level. California, where a commitment to school seismic safety has been institutionalized for 80 years, still receives criticism for inadequate implementation and oversight of its programs for schools at risk (California Watch, 2011). Oregon has enacted strong policies but has lacked the political will to implement them and to commit funds at the scale needed. Charleston County Schools has found it difficult, even in a situation with adequate funding for retrofits in hand, to temporarily close four schools (out of an inventory of 80 schools) in the face of public opposition. Even when the policies and resources are in place, mitigation of seismic risk may remain elusive.

**CASE STUDY: OREGON**

Oregon is further along the road toward significant public investment in seismic retrofits than most other states and regions, but the state struggles with policy obstacles and lack of political will that keep the goal of safer schools more aspirational than attainable.

Significant milestones included passage of a 2001 law (ORS 455.400) that set an aspirational target date of January 1, 2032 for the seismic rehabilitation of school buildings, subject to available funding, and a 2002 referendum adopted by Oregon voters that amended the state’s constitution to allow General Obligation bonding to fund seismic rehabilitation of public education facilities (Wang and Burns, 2006; Wang, 2010; DOGAMI, 2010).

Enabling legislation (Senate Bills 2, 3, 4, and 5) passed in 2005 created a funding mechanism, the Seismic Rehabilitation Grants Program, to make seismic retrofit grants to eligible school districts and community colleges, and directed the state’s Department of Geology and Mineral Industries (DOGAMI) to conduct a statewide Rapid Visual Screening (RVS) survey of public education and emergency response facilities and to make a comprehensive database of seismic ratings available to the public. The results, published in July 2007, were intended to help guide priorities in the allocation of seismic retrofit grant funds (Lewis 2007, Wang 2010).

The extent of risk revealed was perhaps larger than most policymakers had anticipated. According to the DOGAMI study, the RVS risk analysis identified over 1,000 school buildings whose RVS scores indicated a High or Very High probability of collapse in a strong earthquake (Lewis, 2007). The data revealed
large numbers of public school facilities of all structural types constructed prior to Oregon’s adoption of statewide building codes in 1974; well over half the school buildings assessed by the project are more than fifty years old.

The seismic grant program established by statute in 2005 was not staffed and operational until 2008. The first opportunity to authorize a bond sale for an inaugural round of seismic retrofit grants came in the 2009-2011 budget cycle. With the global financial crisis in full swing, it was the worst possible time in many years to launch a significant new program of public investment.

Nonetheless, the Oregon Legislature authorized $30 million for seismic grants, divided equally between the program for K-12 schools and a companion program to retrofit emergency response facilities. The first K-12 school grants, totaling $5.6 million for projects at twelve schools in eight school districts, were awarded in spring 2010. At around the same time, as the recession deepened and the state encountered fiscal difficulties, Governor Ted Kulongoski unilaterally rescinded $7.5 million of the original authorization for the program, limiting additional granting during 2009-2011.

Three K-12 schools (including two URM buildings) were awarded an additional $3.8 million for seismic retrofits in early 2011. These grants marked the end of the first funded cycle of the seismic grant program. A total of $9.4 million of the anticipated $15 million had been awarded to fifteen K-12 schools. The decision to continue or expand the program would be up to the 2011-2013 Legislature.

During this period, the State Treasurer advised a hiatus in issuing new General Obligation bonds, because state revenues were declining and he judged the state’s credit rating to be at risk. This policy seriously undermined legislative interest in authorizing new seismic retrofit grants.

On March 11, 2011, the Tohoku earthquake and tsunami in Northeast Japan put Oregon’s vulnerability to subduction zone risks back on the table, in the early weeks of a new legislative session. In April, the legislature passed House Resolution 3, sponsored by Rep. Deborah Boone (D-Cannon Beach), which directed Oregon’s Seismic Safety Policy Advisory Commission (OSSPAC) to lead a statewide resilience study to recommend state policies designed to reduce the impact and accelerate the recovery from a region-wide Cascadia earthquake and tsunami. The resolution did not appropriate new state funds, but did emphasize public schools as a highly vulnerable component of Oregon’s public infrastructure and a place where smart retrofit investments could mitigate the risk of mass casualties (Oregon Legislative Assembly, 2011).

During the same period, new voices began to emerge in Oregon’s civil society. The Oregon PTA considered and adopted a resolution on earthquake-safe schools at its statewide convention in April 2011, putting this respected statewide advocate for children and schools on record in favor of new investments in public safety (Oregon PTA, 2011). Legislative advocates of energy efficiency in schools, a key priority of Governor John Kitzhaber, broadened their message to point out that state-supported energy and seismic retrofits could go hand in hand (Wolf and Bailey 2011). On the final day of the legislative session in June 2011, thanks to the efforts of staunch seismic safety
advocate Sen. Peter Courtney, the legislature authorized $7.5 million in new seismic grants for the 2011-2013 biennium, keeping the seismic grant program on life support.

The new grants, announced in Fall 2011 and funded by a bond sale in July 2012, directed $7.2 million to seven more K-12 schools, bringing the total seismic retrofits funded by the state to 22 in a state in which over 1,000 school buildings have been identified as possessing high risk, or about 2 percent of the identified need. Oregon has made a start on school safety, and approved public investments that provide additional protection to approximately 8,500 schoolchildren. But future funding for the program is not assured, leadership interest has proved inconsistent at best, and the state is not on track to meet its 2032 target for seismic retrofit of all schools at risk.

One of the obstacles, despite visionary policy, remains a failure to appreciate the seriousness of the threat to life safety. In Oregon (as in most states), independent local school boards are responsible for school facilities, and few boards and local school districts have the expertise or capacity to manage the risks associated with their school facilities. Few seek assistance in understanding “new” problems like seismic vulnerability.

The statewide seismic assessment completed by DOGAMI was communicated to the public via release on the Internet, but the seismic ratings were not shared directly with Oregon’s 197 school boards or with district superintendents. Nor were those groups, or the state’s Department of Education, consulted about how the statewide screening results could be packaged and presented in a form most useful to the education community. This ultimate “constituency” for the seismic ratings – the group whose decisions the ratings were intended to inform – was not treated as a constituency.

Recognizing that a communications breakdown may have limited demand for the seismic retrofit grants, Sen. Peter Courtney introduced legislation in the 2012 session of the Oregon Legislature designed to raise the visibility of the data in the state’s possession. Senate Bill 1566, passed with bipartisan support, directs the state’s Department of Education (which communicates with parents about student achievement and school performance via an annual “report card”) to include information on that annual report letting the public know that the database of seismic ratings exists and sharing a Web link to the ratings (Oregon Legislative Assembly, 2012). Further, the bill asks school districts to advise the state’s Department of Geology and Mineral Industries when they rebuild or renovate schools, so that the state can share information about the upgrades.

These steps, although imperfect, will help to expand public awareness of the existence of the school seismic ratings. As a result, parents concerned about their children’s schools may initiate new conversations with principals, superintendents, and elected school boards. Their questions will draw attention to the existence of the grant program, so that legislators may find it harder to ignore the need for significantly increased public investment to address the schools that remain at risk.

Another barrier, related to the highly decentralized responsibility for school facilities in Oregon, is that even school districts aware of hazardous buildings
may lack the engineering assessments needed to prescribe fixes. School districts, even large urban districts, typically lack discretionary funds to hire consulting engineers for comprehensive assessments of their existing school buildings.

One proposal under consideration in Oregon offers a novel approach to this problem. Voluntary teams of structural engineers, with (as yet unconfirmed) support from the state’s Department of Education, would deploy to perform ASCE-31 seismic evaluations and prepare preliminary retrofit cost estimates at the top-priority schools identified by the state’s RVS assessment. A voluntary effort is not a viable way to address more than a limited sample of schools at risk, but the hope, as with SB 1566, is that by directing new attention to the problem and engaging professionals in a real effort to address it, public interest and support for state investment in the seismic retrofit grant program will grow.

Despite innovative policies and more than a decade of effort, Oregon is barely making progress toward school seismic safety. Some of the lessons from Oregon’s experience for states and regions just beginning this journey are clear: Comprehensive assessment of schools at risk is necessary, but not sufficient. New requests for public investment can expect to compete with existing priorities and to encounter economic setbacks. Leadership attention is limited, and cannot be taken for granted. Constituencies that command real influence with policymakers must be recruited or created, and kept engaged. All these steps take time. And in zones of high seismic hazard around the United States, time may not be on our side.

**URM-FREE BY ‘33: A NATIONAL AGENDA FOR SAFE SCHOOLS**

The principle that schoolchildren have a right to learn in buildings that are safe from earthquakes remains unfulfilled in each of five high-seismic-hazard areas in the continental United States. Yet each region can point to some progress toward school safety, and common themes suggest progress could be accelerated by better efforts to share experience and build capacity for the three-part strategy of risk assessment, ranking, and mitigation.

What’s missing is a shared goal to unite the efforts underway so that “assess, rank, and mitigate” can be seen to serve a larger-than-local purpose. Our proposal: Make public school districts in the country’s high-seismic-hazard zones URM-free by 2033.

Why frame this as a national goal? Access to public education is a fundamental tenet of American life. Public education remains the most local of Americans’ common responsibilities, but in a globalized world, educational performance and achievement have come to be accepted as national concerns. Earthquakes and other natural hazards may help Americans embrace the condition of school facilities as a national concern as well, and advance a U.S. agenda for safe schools. We selected the year 2033, just twenty years from the date of this writing, to set an aggressive aspirational goal and to mark the centennial of California’s Field Act, the first statewide legislation to require earthquake-resistant design and construction of all public school facilities.
Figure 3. Portland, Oregon’s Franklin High School is one of three URM high schools that will be rebuilt thanks to a school bond approved by Portland voters in November 2012. Photo by Yumei Wang.

As NEHRP’s Advisory Committee on Earthquake Hazard Reduction points out in its 2012 recommendation to NIST, “school buildings tend to remain in use longer than comparable structures in private ownership and tend to receive less frequent and less predictable capital renewal investment to address maintenance issues that can jeopardize structural performance. Schools also can play a critical role in a community’s recovery from disaster” (ACEHR, 2012). These twin attributes – a tendency to longevity and underinvestment, and a role in community resilience – supply themes for a national conversation about school facilities.

At the local level, school administrators and elected school boards owe it to themselves and to their constituencies to be well informed about the condition of school facilities in their care, and to take steps to prioritize safe facilities. At a minimum, school districts in earthquake hazard zones should conduct comprehensive assessments of all their buildings, identify the URMs and other non-ductile buildings, and disclose the findings in reports meaningful to parents and other school constituencies. In a society where education remains compulsory, “guilty until proven innocent” should be the presumptive standard for school facilities in which children are obligated to spend their days. URMs, widely considered the top-priority subset of non-ductile structures, are a natural place to
begin (Figure 3.) (Reitherman, 2009). Some URMs of historic significance and exceptional community value will merit special approaches to mitigation, but no URM hazard to schoolchildren should be left unaddressed.

At the state level, departments of education can serve districts and parents by acting as clearinghouses of information about the condition of school facilities, just as they act as clearinghouses of information on student achievement and educational outcomes. In this way, departments of education can support school districts that take proactive steps to address seismic hazards, encourage school districts to do more to document or address the hazard, and assist parents in understanding the issue.

State education departments can also help legislators to see the merit of state investment in seismic retrofits, a capital expense that may exceed the local means available to small rural school districts in seismic hazard zones. The vulnerability of U.S. schools cannot be reduced without capital, and states must share the responsibility for this type of public investment if local districts cannot marshal the resources to assure student safety.

At the federal level, FEMA, its parent the Department of Homeland Security, and the Department of Education can do more, together and separately, to support schools as key elements of resilient communities. If funding from the federal level remains limited, then information sharing and coordination must play larger roles. FEMA could assemble information on school districts and jurisdictions that have performed RVS surveys and develop a joint strategy with the Department of Education to publicize the results, highlight best practices, and track mitigation progress. Districts that have performed such assessments can receive some credit for their accomplishment; districts and jurisdictions just encountering the problem can find examples to follow.

A national school safety goal has proved elusive because local circumstances – seismicity, the age of buildings, building codes, and the condition of building stock – vary. Each region, however, shares the common vulnerability of unreinforced masonry. “URM-free by ‘33” sets a goal, specifies a date, and defines a target in the interest of millions of public school students and their families, beginning with high-seismic-hazard areas in sixteen states.

Removing URMs from the inventory of public schools makes sense from a safety standpoint, because URMs possess structural deficiencies that are difficult and costly to mitigate. Removing URMs from the inventory also makes sense from a community resilience standpoint, because URM buildings are unlikely to be usable for community purposes after an earthquake even if the structural damage they sustain causes no casualties.

With the addition of a clear goal, a national message can begin to unite fledgling efforts that need to grow. Identify and rank schools at risk. Mitigate high-priority schools. Remove URMs from school inventories by 2033. A national agenda built on these priorities would affirm the right of schoolchildren to learn in buildings that are safe from earthquakes. Policy will follow the principle.

* The sixteen states with high-seismic-hazard areas include Alaska, California, Hawaii, Nevada, Oregon, South Carolina, Utah, Washington, and the states of
the New Madrid Seismic Zone: Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee. The total population of these states is 107.6 million (U.S. Census Bureau, July 2011 estimates; online: http://www.census.gov/popest/data/state/ totals/2011/index.html).

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Illustrations

Figure 1. National Seismic Hazard Map showing peak ground accelerations. (Source: Petersen et al., 2008).
Figure 2. The Cascadia Subduction Zone (Source: The Portland Earthquake Project)
Figure 3. Portland, Oregon’s Franklin High School is one of three URM high schools that will be rebuilt thanks to a school bond approved by Portland voters in November 2012. (Photo by Yumei Wang.)