ATC 137-2

Proceedings:
FEMA-Sponsored Summit on Unreinforced Masonry Buildings in Utah

Applied Technology Council

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Applied Technology Council

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Prepared by

APPLIED TECHNOLOGY COUNCIL
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065
www.ATCouncil.org

Prepared for

FEDERAL EMERGENCY MANAGEMENT AGENCY
Michael Mahoney (Project Officer)
Andrew Herseth (Task Monitor)
Washington, D.C.

APPLIED TECHNOLOGY COUNCIL
Jon A. Heintz (Project Executive)
Justin Moresco (Project Manager)

ORGANIZING COMMITTEE
Sean McGowan (Chair)
Steve Bowman
Bob Carey
John Crofts
Craig dePolo
Drew Herseth
Mike Mahoney
Ryan Pietramali
Barry H. Welliver

BREAKOUT MODERATORS AND RECORDERS
Brad Bartholomew
Jon A. Heintz
Brent Maxfield
Justin Moresco
Brandon Webb
Barry H. Welliver

PLENARY SPEAKERS
Brad Bartholomew
Steve Bowman
Bob Carey
Lee dePalo
Mel Green
Robert J. Grow
Chris Hansen
Iain Hyde
Laurie Johnson
Eric Letvin
Brent Maxfield
Sean McGowan
Glen Palmer
Jonna Papaefthimiou
Audrey Pierce
Randy Silverman
Fred Turner
Judy Watanabe
Barry H. Welliver

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Preface

The northern half of Utah is divided down the middle by the 217-mile-long Wasatch fault zone, one of the longest and most active normal fault zones in the world. The fault zone cuts through or alongside the state's major cities, including Salt Lake City and Provo, and has historically produced magnitude 7+ earthquakes about every 300 years. Nearly 80 percent of Utah's population lives within 15 miles of the Wasatch fault zone, and many buildings in this region were constructed before modern earthquake-resistant design standards were adopted. For example, a 2015 study by the Utah Chapter of the Earthquake Engineering Research Institute (EERI, 2015) estimates that there are more than 147,000 unreinforced masonry (URM) buildings in Utah's 12 northern counties straddling the Wasatch fault zone. URM construction is dangerous during earthquakes because the material is heavy and brittle. Due in large part to the many URM buildings in Utah, the 2015 EERI study estimated that a magnitude 7 earthquake on the Wasatch fault segment near Salt Lake City could cause more than $33 billion in short-term economic losses, about 53,000 people to seek temporary shelter, and 2,000–2,500 fatalities. However, a more recent study conducted by the Federal Emergency Management Agency (FEMA) Region VIII indicates that the consequences of such an earthquake could be greater, causing more than $50 billion in short-term economic losses and more than 3,000 fatalities (McGowan, 2019).

Utahns have been working to reduce the seismic risk from URM buildings in their state. The Utah Seismic Safety Commission published a guide to help owners of URM homes better understand what can be done to seismically retrofit these buildings (USSC, 2016). Salt Lake City's "Fix-the-Bricks" program has been offering technical and financial support for seismic retrofits of URM dwellings.

To accelerate statewide progress on URM mitigation, on June 25–26 the Utah Division of Emergency Management and FEMA Region VIII co-convened a summit on unreinforced masonry buildings in Utah. The summit also was supported by the Applied Technology Council (ATC), the Utah Seismic Safety Commission, the Structural Engineers Association of Utah, FEMA's Federal Insurance and Mitigation Administration, and FEMA's National Earthquake Hazards Reduction Program team. The purpose of the

summit was to raise awareness about the risk that URM buildings pose to Utah communities, promote mitigation best practices, bring together diverse stakeholder groups, identify actions and solutions that should be prioritized to increase Utah's resilience against large earthquakes, use recent earthquakes outside Utah to demonstrate the realities of the recovery timeline, and highlight mitigation funding opportunities. Attendees included government officials, emergency managers, academics, researchers, leaders of nonprofits and faith-based organizations, journalists, and building design professionals.

The summit would not have been a success if not for the Organizing Committee, which was chaired by Sean McGowan and included Steve Bowman, Bob Carey, John Crofts, Craig dePolo, Drew Herseth, Mike Mahoney, Ryan Pietramali, and Barry H. Welliver. Summit moderator Bob Carey kept the summit on schedule. The plenary speakers, who are listed on the report's title page and in Appendix B, provided broad and in-depth perspectives on seismic risk posed by URMs and solutions to managing this risk. Their presentation slides are copied for reference in Appendix A. Breakout moderators and recorders Brad Bartholomew, Brent Maxfield, Brandon Webb, and Barry H. Welliver led the breakout discussions, which produced the findings and recommendations summarized in Chapter 2. The names and affiliations of all who attended the summit are provided in Appendix B.

ATC also gratefully acknowledges funding provide by FEMA for the production of these proceedings, summit logistical support provided by Bob Carey, John Crofts, and Bernadette Hadnagy (ATC), and summit logistical support and report production services provided by Carrie J. Perna (ATC).

Justin Moresco
ATC Director of Projects

Jon A. Heintz
ATC Executive Director

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Executive Summary

Utah has a large seismic risk due to the presence of the Wasatch fault and thousands of unreinforced masonry (URM) buildings constructed before modern earthquake-resistant design standards were adopted. To accelerate statewide progress on URM building mitigation, on June 25–26, 2019, the Utah Division of Emergency Management and the Federal Emergency Management Agency Region VIII co-convened a summit on URM buildings in Utah. More than 100 participants from diverse professional backgrounds attended the summit.

The summit occurred over two days. The first day included a series of plenary presentations, and the second day included three moderated breakout sessions with report outs. The three breakout topics were:

- Breakout Topic A: Financing Challenges, Opportunities, and Solutions
- Breakout Topic B: Barriers other than Cost and Potential Solutions
- Breakout Topic C: Gaining Buy-in

Key themes expressed during the breakout discussions included the following:

Barriers and Challenges

- Current market conditions do not enable homeowners to recoup the costs of retrofits when reselling their properties.
- There is a lack of perceived need for and value of mitigation among the public stemming in part from a limited understanding of the seismic hazard in Utah and the vulnerability of URM construction. Homeowners don't feel a sense of urgency to mitigate their URM dwellings.
- There are powerful stakeholders (e.g., realtors, developers, property owners) in opposition to mitigation because it affects business or the economics of property ownership and sales.
- The permitting process for retrofits is made more difficult by building officials and building contractors with limited knowledge of retrofit standards. In addition, retrofit projects can trigger unrelated upgrade requirements, such as those associated with the Americans with

Disabilities Act (ADA) and fire safety, effectively raising the cost of mitigation.

- URM buildings are not required to be retrofit, and the state legislature does not have the political will to change the status quo.
- Homeowners lack clear, concise, and easily understandable information about the steps they should take to mitigate their dwellings.

Recommendations

- There are many existing financing opportunities provided by national and local entities for mitigation projects. Decision makers, building owners, and other stakeholders should investigate these opportunities when considering mitigation projects.
- Provide tax credits and reduced construction permit fees, establish local improvement districts, and encourage the provision of shared appreciation mortgages in order to incentivize mitigation.
- Require placarding or other disclosure mechanisms for URM buildings that make their existence and risk more transparent. The disclosed information should help the public make more informed purchasing and occupancy decisions.
- Create and disseminate stories to share the benefits of mitigation. These could take the form of short documentaries or media spots. Create a demonstration house that people can visit to promote public awareness of what retrofits look like.
- Improve the permitting process to reduce the time it takes for approval of retrofit projects. Harmonize requirements for additional work (e.g., fire safety) that is triggered by retrofit projects.
- Develop and implement a strategic communications plan. The plan would include a roadmap for what to say and who to say it to and would help enable a messaging campaign that provides information on problems and solutions.
- Establish a forum that convenes regularly to facilitate communication and coordination among key organizations involved in seismic risk.
- Expand the annual ShakeOut drill in Utah to include awareness raising around URM risk.

The summit resulted in several immediate outcomes, which include the following:

- Summit moderator Bob Carey committed the Utah Seismic Safety Commission to forming an ad hoc committee to consider the recommendations that emerged during the Summit.
- The Summit was covered by several Utah-based media outlets, including *KSL.com*, *Deseret News*, *KSL-TV*, and *Fox13 News*.

Chapter 1
Introduction and Program

The Summit on Unreinforced Masonry Buildings in Utah brought together more than 100 government officials, emergency managers, academics, researchers, leaders of nonprofits and faith-based organizations, journalists, building design professionals, and other stakeholders to share perspectives and discuss solutions to the seismic risk posed by unreinforced masonry (URM) buildings in the state. A majority of participants were invited because they live and work in Utah, but individuals from across the country also were included in order to leverage experiences and knowledge gained from outside the state.

To address the challenges posed by URM risk in Utah, the Organizing Committee identified six objectives for the summit:

- Raise awareness, especially among local officials, about the threat that unreinforced masonry buildings pose to Utah communities from a large Wasatch earthquake.
- Promote mitigation best practices, including those already being pursued in Utah.
- Bring together diverse stakeholder groups to share perspectives and discuss solutions.
- Identify actions and solutions that should be prioritized by various stakeholder groups to increase Utah's resilience against large earthquakes.
- Use recent earthquakes outside of Utah to demonstrate the realities of the recovery timeline and societal impacts following large earthquakes.
- Improve the understanding of mitigation funding opportunities.

The summit took place June 25–26, 2019, in the Utah State Senate Building. The location was selected because of its convenient location, familiarity among Utahns, and symbolism as a place for deliberation and collective action within the state.

This report presents the summit agenda, summarizes the themes of the plenary presentations and breakout discussions, describes key findings and recommendations from the breakout discussions, highlights immediate

outcomes of the summit, includes plenary presentation slides, and lists summit participants.

1.1 Program

The summit occurred over two days. The first day included a series of plenary presentations by 16 speakers, and the second day included three moderated breakout sessions with report outs (Figure 1-1 and Figure 1-2). The summit was organized in this way with the hope that the presentations on the first day would provide a common understanding of the risks posed by URM buildings and would prompt ideas for discussion during the breakout sessions on the second day.

AGENDA: TUESDAY, JUNE 25, 2019
Day 1: Welcome and Presentations

7:30 am – 8:30 am	**Registration** (continental breakfast provided)
8:30 am – 9:00 am	**Welcome**: Bob Carey (moderator), Lee dePalo, Judy Watanabe
9:00 am – 9:30 am	**Seismic Hazard along Wasatch Front**: Steve Bowman
9:30 am – 10:00 am	**Risk URMs Pose to Communities—Utah Focus**: Barry Welliver
10:00 am – 10:15 am	**Break** (continental breakfast continued)
10:15 am – 11:00 am	**Risk URMs Pose to Communities—Extended Recovery, Broader Societal Impacts, and Examples from Recent Events**: Laurie Johnson
11:00 am – 11:30 am	**Utah Retrofit Solutions**: Mel Green
11:30 am – 12:30 pm	**Lunch** (provided)
12:30 pm – 1:30 pm	**Utah Retrofit Programs**: Chris Hansen, Glen Palmer, Audrey Pierce
1:30 pm – 2:15 pm	**Utah Policy Successes**: Brent Maxfield
2:15 pm – 2:30 pm	**Break** (refreshments and snacks provided)
2:30 pm – 3:15 pm	**Other Policy Successes**: Jonna Papaefthimiou, Fred Turner
3:15 pm – 4:45 pm	**Financing Opportunities Panel**: Sean McGowan (moderator), Brad Bartholomew, Robert Grow, Iain Hyde, Eric Letvin, Randy Silverman
4:45 pm	**Adjourn**

Figure 1-1 Agenda for first day of the FEMA-sponsored Summit on Unreinforced Masonry Buildings in Utah.

AGENDA: WENDESDAY, JUNE 26, 2019
Day 2: Breakout Discussions

The second day of the summit is organized to promote idea sharing across diverse stakeholder groups and identify actions and solutions that should be pursued at the organizational, institutional, local, and state levels. Participants will be divided into three groups, with breakout moderators and recorders shifting among groups to facilitate discussions. The welcome and report outs will occur in Room 210, and the breakout discussions will occur in nearby conference rooms.

7:00 am – 8:00 am	**Registration** (continental breakfast provided)
8:00 am – 8:10 am	**Welcome and Overview of Logistics**: Bob Carey

8:10 am – 8:30 am	**Quick Introductions of the Topics**
	• Breakout Topic A: Financing Challenges, Opportunities, and Solutions
	  ○ Moderator: Brad Bartholomew
	  ○ Recorder: Brandon Webb
	• Breakout Topic B: Barriers other than Cost and Potential Solutions
	  ○ Moderator: Brent Maxfield
	  ○ Recorder: Jon Heintz
	• Breakout Topic C: Gaining Buy-in
	  ○ Moderator: Barry Welliver
	  ○ Recorder: Justin Moresco

8:30 am – 9:25 am	**Breakout Period 1**
9:25 am – 9:40 am	**Break**
9:40 am – 10:35 am	**Breakout Period 2**
10:35 am – 10:50 am	**Break**
10:50 am – 11:45 pm	**Breakout Period 3**
11:45 am – 12:00 pm	**Break**
12:00 pm – 12:30 pm	**Report Outs**
12:30 pm – 1:30 pm	**Lunch** (provided)

Figure 1-2 Agenda for second day of the FEMA-sponsored Summit on Unreinforced Masonry Buildings in Utah.

Day 1 Presentations

The summit began with brief opening remarks by summit moderator Bob Carey (Utah Division of Emergency Management), Lee dePalo (FEMA), and Judy Watanabe (Utah Division of Emergency Management). The first plenary presentation, by Steve Bowman (Utah Geological Survey), described the seismic hazard along the Wasatch Front and highlighted some actions the Utah Geological Survey has taken to raise awareness about seismic risk in the state. This was followed by a presentation by Barry H. Welliver (BHW

Engineers), who described typical features of URM buildings and how these features contribute to their vulnerability to damage during earthquakes. Mr. Welliver's presentation also included loss estimation statistics from a magnitude 7.0 scenario study (EERI, 2015) and described steps taken in recent years across Utah to reduce seismic risk.

The next plenary presentation of the morning, by Laurie Johnson (Laurie Johnson Consulting), described the recovery process for Christchurch, New Zealand, following the series of earthquakes that occurred there in 2010 and 2011. Ms. Johnson also shared recovery lessons from several California earthquakes and linked these experiences back to the seismic risk faced by Utah. The final plenary presentation of the morning, by Mel Green (Melvyn Green and Associates), introduced common retrofit measures for URM buildings. Mr. Green emphasized the value of incremental seismic strengthening—the process of integrating a series of retrofit measures with other building improvements over time.

Following lunch, three presenters—Glen Palmer (Palmer Engineering), Audrey Pierce (Salt Lake City Emergency Management), and Chris Hansen (Utah Division of State History)—discussed ongoing seismic retrofit programs in Utah. Mr. Palmer summarized key elements in a guide for owners about strengthening URM homes (USSC, 2016). Ms. Pierce described the purpose, genesis, and framework of the "Fix-the-Bricks" program, which offers technical and financial support for seismic retrofit of URM homes in Salt Lake City. Mr. Hansen described some of the activities by the Utah State Historic Preservation Office to facilitate the seismic retrofit of historic buildings.

The next plenary presentation, by Brent Maxfield (The Church of Jesus Christ of Latter-day Saints), described the public policy environment in Utah related to URM buildings and summarized historical and current building code provisions adopted by the state that affect URM buildings. Mr. Maxfield also introduced the Building Occupancy Resumption Program, which can enable owners to resume occupancy of their buildings more quickly following a large earthquake. Jonna Papaefthimiou (Portland Bureau of Emergency Management) and Fred Turner (California Seismic Safety Commission), the next plenary presenters, discussed lessons learned from policy experiences outside of Utah. Ms. Papaefthimiou focused on the city of Portland, Oregon. She described the status and effectiveness of current seismic codes and recent efforts to implement more stringent policies related to URM buildings in the city. Mr. Turner shared lessons learned from statewide efforts in California related to URM buildings. He presented statistics on the effectiveness of California's URM law and shared recommendations for Utah based on his experiences.

The final session of the day was a panel discussion focused on challenges and opportunities related to financing URM mitigation activities. Each panelist—Brad Bartholomew (Utah Division of Emergency Management), Robert J. Grow (Envision Utah), Iain Hyde (Argonne National Laboratory), Eric Letvin (FEMA), and Randy Silverman (University of Utah Marriott Library)—presented brief prepared remarks followed by a question and answer session led by the session moderator, Sean McGowan (FEMA).

Slides from all the plenary presentations can be found in Appendix A.

Day 2 Breakout Discussions

The second day of the summit was organized to promote idea sharing across stakeholder groups and to identify actions and solutions that should be pursued at the organizational, institutional, local, and state levels. Participants were divided into three groups, with breakout moderators and recorders shifting among groups to facilitate discussions using a series of prepared questions.

The three breakout topics were:

- Breakout Topic A: Financing Challenges, Opportunities, and Solutions
- Breakout Topic B: Barriers other than Cost and Potential Solutions
- Breakout Topic C: Gaining Buy-in

Breakout Topic A questions included:

- What are some key challenges to financing URM mitigation in Utah for different stakeholder groups (e.g., homeowners, commercial real estate, public facilities)?
- What are current opportunities for financing URM mitigation in Utah that are not being fully utilized?
- What legislation and incentives should be pursued and by whom to increase available financing for URM mitigation projects in Utah? Consider how differences in occupancy (e.g., home, public facility) plays a role in these actions.
- What else should be done and by whom to increase available financing for URM mitigation in Utah?

Breakout Topic B questions included:

- What key barriers other than direct costs to owners have or could impede action towards mitigating URM buildings in Utah? Consider the

preservation of historic and architectural character and impacts on tenants, especially those in low-rent housing.

- What legislation and incentives should be pursued and by whom to minimize or eliminate these barriers? Consider how differences in occupancy (e.g., home, public facility) plays a role in these actions.
- What else should be done and by whom to minimize or eliminate these barriers?

Breakout Topic C questions included:

- What groups are currently involved in raising awareness about seismic risk in Utah and what groups should be involved or should be more involved?
- What more should be done and by whom to increase awareness about seismic risk from URMs in Utah?
- What more should be done and by whom to increase public support for programs that reduce risk from URMs in Utah?

Because of the format of the breakout sessions, each topic was discussed three times, or one time each by the three breakout groups. Following the last breakout period, each breakout topic moderator-and-recorder pair presented their findings to the summit participants.

In his closing remarks, summit moderator Bob Carey committed the Utah Seismic Safety Commission to forming an ad hoc committee to consider the recommendations that emerged during the summit.

Chapter 2
Findings and Recommendations

The opinions shared by breakout group participants reflected their diverse personal and professional backgrounds and experiences. This chapter summarizes key points raised during the breakout discussions, with an emphasis on the common ideas and recommendations that emerged. A summary of the findings and recommendations and the immediate outcomes of the summit are provided.

2.1 Breakout Topic A: Financing Challenges, Opportunities, and Solutions

Question 1: What are some key challenges to financing URM mitigation in Utah for different stakeholder groups (e.g., homeowners, commercial real estate, public facilities)?

Main Challenges

- Current market conditions do not enable homeowners to recoup the costs of retrofits when reselling their properties.
- There is a lack of public awareness of the potential damage from a large earthquake, the limits of governmental response, and the financial risk these conditions entail.

Other Challenges

- Many building owners don't have the financial means or know-how to complete a retrofit without major outside help.
- Homeowners who plan to sell their URMs in the short- or medium-term lack incentives to invest in retrofitting.

Question 2: What are current opportunities for financing URM mitigation in Utah that are not being fully utilized?

Main Opportunities

- U.S. Department of Housing and Urban Development's 203(k) program, which helps homeowners finance upgrades, and Community Development Block Grant program, which funds local community development activities.

- Local funding opportunities, such as those offered by the Utah Division of State History in the form of tax credits for historic preservation projects and those offered by the George S. and Dolores Doré Eccles Foundation.
- Funding channels that become available when retrofit work is combined with other objectives, such as energy efficiency improvements.

Other Opportunities

- Other federal funding opportunities, like those offered through the U.S. Small Business Administration and the U.S. Department of Agriculture Rural Development.
- Other local public and private funding opportunities, especially when used to match federal monies.
- Funding opportunities designated for low-income and other disadvantaged populations, such as those offered by the Olene Walker Housing Loan Fund and Utah's Community Development Office.
- Using risk mitigation programs to supplement larger programs with existing streams of funding.

Question 3: What legislation and incentives should be pursued and by whom to increase available financing for URM mitigation projects in Utah? Consider how differences in occupancy (e.g., home, public facility) plays a role in these actions.

Main Avenues to be Pursued

- Provide tax credits and reduced construction permit fees, establish local improvement districts, and encourage the provision of shared appreciation mortgages in order to incentivize mitigation.
- Require placarding or other disclosure mechanisms for URM buildings that make their existence and risk more transparent. The disclosed information should help the public make more informed purchasing and occupancy decisions.

Other Avenues to be Pursued

- Pass legislation and provide incentives that specifically target multi-family rental properties.
- Promote the establishment of insurance products that incentivize retrofits. For example, homes that have been retrofit should receive discounted insurance rates. Consider the establishment of a state-backed earthquake insurance pool.

- Levy taxes or issue bonds to raise money earmarked for seismic mitigation.

Question 4: What else should be done and by whom to increase available financing for URM mitigation in Utah?

Main Items to Do

- Develop a guide on potential financing opportunities for local governments. Paint a feasibility picture for communities.
- Establish a statewide funding program with a set of standards for mitigation. This program could also include an aggressive buy-out program for homes at high risk.

Other Items to Do

- Establish a sister program of the National Flood Insurance Program (NFIP) for seismically vulnerable structures.
- Seek mechanisms that spread the cost of mitigation out across the entire state population.
- Increase the awareness of lenders about the importance and value of mitigation.

2.2 Breakout Topic B: Barriers other than Cost and Potential Solutions

Question 1: What key barriers other than direct costs to owners have or could impede action towards mitigating URM buildings in Utah? Consider the preservation of historic and architectural character and impacts on tenants, especially those in low-rent housing.

- There is a lack of perceived need for and value of mitigation among the public stemming in part from a limited understanding of the seismic hazard in Utah and the vulnerability of URM construction. Homeowners don't feel a sense of urgency to mitigate their URM dwellings.
- There are powerful stakeholders (e.g., realtors, developers, property owners) in opposition to mitigation because it affects business or the economics of property ownership and sales.
- Fear of increased liability can deter owners from seeking to better understand the risk posed by URM buildings.
- Design professionals and building contractors with experience in seismic retrofitting are in short supply and can be difficult to find.

- The permitting process for retrofits is made more difficult by building officials and building contractors with limited knowledge of retrofit standards. In addition, retrofit projects can trigger unrelated upgrade requirements, such as those associated with the Americans with Disabilities Act (ADA) and fire safety, effectively raising the cost of mitigation.
- Historic districts may not allow certain retrofit options.
- URM buildings are not required to be retrofit, and the state legislature does not have the political will to change the status quo.
- Homeowners lack clear, concise, and easily understandable information about the steps they should take to mitigate their dwellings.
- Retrofit projects can require the temporary relocation of occupants, in addition to other inconveniences.
- Other societal needs, such as homelessness and the opioid crisis, are more pressing and demand the attention of decision makers and the general public.
- There has been a lack of historical natural disasters in Utah to spark motivation.

Question 2: What legislation and incentives should be pursued and by whom to minimize or eliminate these barriers? Consider how differences in occupancy (e.g., home, public facility) plays a role in these actions.

Question 3: What else should be done and by whom to minimize or eliminate these barriers?

The following statements were made in response to Question 2 and Question 3. The noted barriers were identified in response to Question 1.

- Barrier 1: There is a lack of perceived need for and value of mitigation among the public stemming in part from a limited understanding of the seismic hazard in Utah and the vulnerability of URM construction. Homeowners don't feel a sense of urgency to mitigate their URM dwellings.
- Solutions for Barrier 1:
    - Create and disseminate stories to share the benefits of mitigation. These could take the form of short documentaries or media spots. Create a demonstration house that people can visit to promote public awareness of what retrofits look like.

- Find ways to shame people into action, including making political leaders feel that it is their obligation to act.
- Require disclosure of URM construction at time of sale.
- Describe incremental programs that break down the effort into smaller steps that over time reach the desired goal.
- Show examples from earthquakes around the world and relate them to local conditions.

- Barrier 2: There are powerful stakeholders (e.g., realtors, developers, property owners) in opposition to mitigation because it affects business or the economics of property ownership and sales.
- Solutions for Barrier 2:
  - Create financial incentives, such as encouraging lenders to avoid lending for the purchase of homes on rubble foundations.
  - Assist commercial property owners in building the business case for retrofitting their buildings.
  - Ensure that any new requirements apply to all business owners to avoid certain segments feeling targeted.
  - Help building owners understand the potential cost of inaction.
- Barrier 3: Fear of increased liability can deter owners from seeking to better understand the risk posed by URM buildings.
- Solution for Barrier 3:
  - Shield governments from potential liability when they take steps to better understand the seismic risk of their property.
- Barrier 4: Design professionals and building contractors with experience in seismic retrofitting are in short supply and can be difficult to find.
- Solutions for Barrier 4:
  - Ask homeowners who have completed “Fix the Bricks” retrofits to be references.
  - Maintain a list of contractors who have done “Fix the Bricks” retrofits.
  - Ask the Structural Engineers Association of Utah to maintain list of structural engineers with experience in seismic retrofitting.

- Find ways to have social media platforms and other online resources, such as Nextdoor, maintain lists of experienced architects, engineers, and contractors.

- Barrier 5: The permitting process for retrofits is made more difficult by building officials and building contractors with limited knowledge of retrofit standards. In addition, retrofit projects can trigger unrelated upgrade requirements, such as those associated with the Americans with Disabilities Act (ADA) and fire safety, effectively raising the cost of mitigation.
- Solutions to Barrier 5:
  - Improve the permitting process to reduce the time it takes for approval of retrofit projects.
  - Harmonize requirements for additional work (e.g., fire safety) that is triggered by retrofit projects.
  - Develop more typical engineering details for retrofit projects that cover a broader set of conditions.
  - Train building officials on the laws and standards related to retrofit projects.
- Barrier 6: Historic districts may not allow certain retrofit options.
- Solution to Barrier 6:
  - Educate officials overseeing historic districts that there are retrofit techniques that maintain important architectural features of buildings.

2.3 Breakout Topic C: Gaining Buy-in

Question 1: What groups are currently involved in raising awareness about seismic risk in Utah and what groups should be involved or should be more involved?

Current Groups Involved

- Utah Seismic Safety Commission (USSC)
- Utah Geological Survey (UGS)
- Utah Division of Emergency Management (UDEM)
- Structural Engineers Association of Utah (SEAU)
- The Church of Jesus Christ of Latter-day Saints
- Utah State Office of Education

- Earthquake Engineering Research Institute (EERI)
- Federal Emergency Management Agency (FEMA)

Should Be More Involved

- Planning and emergency management officials within municipalities
- Utah League of City and Towns
- For-profit and public media outlets
- Insurance companies and Utah Insurance Department
- School districts
- Parent Teacher Associations
- Utah Association of Building Officials
- Lenders and banks
- State and local civic organizations, such as Utah Civic Action Network (UCAN), Envision Utah, and Community Emergency Response Teams (CERT)

Question 2: What more should be done and by whom to increase awareness about seismic risk from URMs in Utah?

- Develop and implement a strategic communications plan. The plan would include a roadmap for what to say and who to say it to and would help enable a messaging campaign that provides information on problems and solutions. (Who might lead this effort: Envision Utah.)
    - Identify ways to make retrofit benefits more strongly felt by homeowners. If a homeowner must choose between bracing the chimney or upgrading the kitchen, the kitchen wins because the kitchen is perceived as more valuable.
    - Connect the messaging to what people want to be part of rather than what they should be afraid of.
    - Use the economic losses from the EERI scenario study (EERI, 2015)—put the losses in terms that elected officials deal with every day.
    - Link seismic risk to economic development.
- Establish a forum that convenes regularly to facilitate communication and coordination among key organizations involved in seismic risk. (Who might lead this effort: FEMA.)

- Expand the annual ShakeOut drill in Utah to include awareness raising around URM risk. (Who might lead this effort: UDEM.)
- Develop messaging about the differences in risk between retrofit and unretrofit URM buildings. The messaging should be accessible to the general public. (Who might lead this effort: SEAU.)

Question 3: What more should be done and by whom to increase public support for programs that reduce risk from URMs In Utah?

- Tell more success stories, like the retrofit of the Salt Lake Temple. The Cherry Hills Elementary Schools are an example where a motivated individual championed action.
- Leverage earthquake-related conferences and other events, especially when occurring in Salt Lake City, to generate media attention.
- Educate the media on the seismic risk of URM buildings, the existing solutions for mitigating them, and the benefits of mitigation.
- Combine URM mitigation initiatives with revitalization efforts.
- Parent Teacher Associations are an important pressure point—they can apply pressure on school districts.
- Local hazard mitigation plans, such as those for cities, are a vehicle for building support for community-wide action.

2.4 Summary Findings and Recommendations

Key themes expressed during the breakout discussions included the following:

Barriers and Challenges

- Current market conditions do not enable homeowners to recoup the costs of retrofits when reselling their properties.
- There is a lack of perceived need for and value of mitigation among the public stemming in part from a limited understanding of the seismic hazard in Utah and the vulnerability of URM construction. Homeowners don't feel a sense of urgency to mitigate their URM dwellings.
- There are powerful stakeholders (e.g., realtors, developers, property owners) in opposition to mitigation because it affects business or the economics of property ownership and sales.
- The permitting process for retrofits is made more difficult by building officials and building contractors with limited knowledge of retrofit standards. In addition, retrofit projects can trigger unrelated upgrade

requirements, such as those associated with the Americans with Disabilities Act (ADA) and fire safety, effectively raising the cost of mitigation.

- URM buildings are not required to be retrofit, and the state legislature does not have the political will to change the status quo.
- Homeowners lack clear, concise, and easily understandable information about the steps they should take to mitigate their dwellings.

Recommendations

- There are many existing financing opportunities provided by national and local entities for mitigation projects. Decision makers, building owners, and other stakeholders should investigate these opportunities when considering mitigation projects.
- Provide tax credits and reduced construction permit fees, establish local improvement districts, and encourage the provision of shared appreciation mortgages in order to incentivize mitigation.
- Require placarding or other disclosure mechanisms for URM buildings that make their existence and risk more transparent. The disclosed information should help the public make more informed purchasing and occupancy decisions.
- Create and disseminate stories to share the benefits of mitigation. These could take the form of short documentaries or media spots. Create a demonstration house that people can visit to promote public awareness of what retrofits look like.
- Improve the permitting process to reduce the time it takes for approval of retrofit projects. Harmonize requirements for additional work (e.g., fire safety) that is triggered by retrofit projects.
- Develop and implement a strategic communications plan. The plan would include a roadmap for what to say and who to say it to and would help enable a messaging campaign that provides information on problems and solutions.
- Establish a forum that convenes regularly to facilitate communication and coordination among key organizations involved in seismic risk.
- Expand the annual ShakeOut drill in Utah to include awareness raising around URM risk.

2.5 Immediate Outcomes

The hope is that the Summit will lead to concrete actions that ultimately reduce the seismic risk posed by URM buildings in Utah and increase the seismic resilience of the state. However, the Summit already resulted in several immediate outcomes, which include the following:

- Summit moderator Bob Carey committed the Utah Seismic Safety Commission to forming an ad hoc committee to consider the recommendations that emerged during the Summit.
- The Summit was covered by several Utah-based media outlets, including *KSL.com*, *Deseret News* (Giardinelli, 2019), *KSL-TV*, and *Fox13 News*.

Appendix A
Plenary Presentations

A.1 Morning Plenary Presentations

Earthquake and Other Geologic Hazard Along the Wasatch Front: What They Are and How We Can Deal with Them, Steve Bowman A-2

Risk URM Buildings Pose to Utah Communities, Barry Welliver..... A-6

Risk URMs Pose to Communities—Extended Recovery, Broader Societal Impacts and Examples from Elsewhere, Laurie Johnson..... A-11

Unreinforced Masonry Building Summit, Salt Lake City, Mel Green A-19

A.2 Afternoon Plenary Presentations

The Utah Guide for the Seismic Improvement of Unreinforced Masonry Dwellings, 2016 Edition, Glen Palmer A-30

Fix the Bricks, Audrey Pierce A-37

Utah Division of State History, Chris Hansen A-40

Utah URM Policy Successes, Brent Maxfield A-44

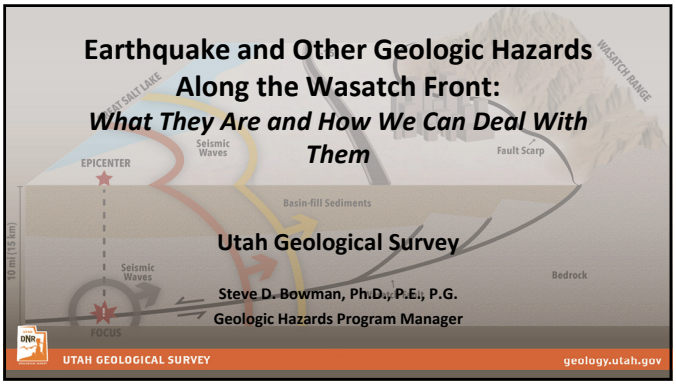
Portland, Oregon URM Retrofit Policy, Jonna Papaefthimiou..... A-52

Keys to Success: Learn from the Past, Fred Turner..... A-54

URMs, Robert Grow A-58

Earthquake and Other Geologic Hazards Along the Wasatch Front:

What They Are and How We Can Deal With Them



Utah Geological Survey

Steve D. Bowman, Ph.D., P.E., P.G.
Geologic Hazards Program Manager

Utah Geological Survey (UGS)

The Utah Geological Survey, a division of the Utah Department of Natural Resources, provides timely scientific information about Utah's geologic environment, resources, and hazards. About 70 FTE staff and the State Geologist.

- Administration
- Geologic Hazards Program
- Geologic Mapping Program
- Groundwater Program
- Energy and Minerals Program
- Geologic Information and Outreach Program

Offices
- Salt Lake City
- Cedar City

Riverdale landslide along the north bluff of the Weber River

Geologic Hazards Program

- Respond to geologic hazard emergencies and provide unbiased, scientific advice to local governments and incident commanders.
- Investigate and map geologic hazards in urban and other areas (publish and distribute PDFs and GIS spatial data).
- Provide geologic hazard related technical/educational outreach and information to inform Utah about hazards.

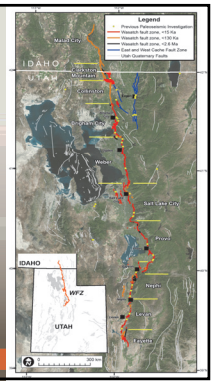
Focused on reducing Utah's life safety, property, and economic risk from geologic hazards.

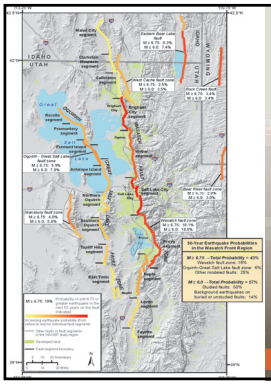
Geologic Hazards That May Be Found in Utah

- Earthquake Hazards
  - Ground Shaking
  - Liquefaction
  - Surface Fault Rupture
  - Tectonic Subsidence
- Landslide Hazards
  - Debris Flows
  - Landslide
  - Rockfall
- Problem Soil and Rock Hazards
  - Caliche
  - Collapsible Soil
  - Corrosive Soil and Rock
  - Expansive Soil and Rock
  - Ground Subsidence & Earth Fissures
    - Groundwater Withdrawal
    - Underground Mining
  - Radon Gas
  - Karst and Sinkholes
  - Piping and Erosion
  - Salt Tectonics Deformation
  - Shallow Bedrock
  - Soluble Soil and Rock
  - Wind Blown Sand
- Flooding Hazards
  - Alluvial Fan Flooding
  - Debris Flows
  - River, Lake, and Sheet Flooding
  - Seiche
  - Shallow Groundwater
  - Tsunami
- Volcanic Hazards
  - Airborne Volcanic Ash
  - Eruptions and Lava Flows

Earthquake Hazards – The Wasatch Fault Zone

- About 217 miles long from near Malad City, Idaho south to near Fayette, Utah.
- More than 85% of Utah's population lives and >75% of Utah's economy is along the Wasatch Front.
- Major regional and continental-scale corridors pass over the fault:
  - Interstates 80, 84, and 15 (shipment of goods)
  - Union Pacific Railroad lines (shipment of goods)
  - Internet and communication trunk lines
  - Natural gas and petroleum pipelines
  - Water supply pipelines



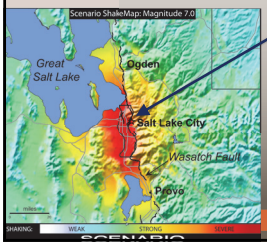


A Damaging Earthquake in Northern Utah is Likely in the Near Future

- 57% probability in the next 50 years for a magnitude (**M**) 6.0 earthquake: ***greater than one in two chance*****!**
- 40% probability in the next 30 years!
- A damaging Wasatch fault zone earthquake will significantly impact the state, the region, and the country for years afterward.
  - Initial damage, fatalities, and injuries.
  - Economic losses: businesses closed, jobs lost, etc.
  - Rerouting of the shipment of goods and telecommunications – routes already congested.

Earthquake Hazards

- Includes ground shaking, surface fault rupture, liquefaction, etc.
- Typically felt over a wide area.
- Utah has more unreinforced masonry buildings (typically brick) than most other western states.



Estimated Losses for a Magnitude 7 Earthquake

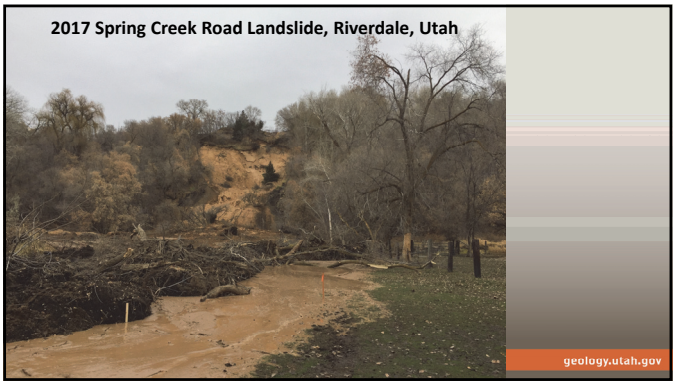
Wasatch Fault Segment	Building Losses ($ billions)	Displaced Households	Life Threatening Injuries/Fatalities
Brigham City	3	14,000	500
Weber	16	57,000	3,000
Salt Lake City	42	150,000	9,000
Provo	14	48,000	3,000
Nephi	1	4,000	200

Hazus loss-estimation modeling

2008 M6 Wells, Nevada Earthquake an Analog for Rural Utah

- Unreinforced masonry (URM) brick structures common.
- Rural economies very susceptible to impact.
- Resources more limited than urban areas.
- Damages not covered by homeowners insurance (unless extra coverage bought).

2017 Spring Creek Road Landslide, Riverdale, Utah



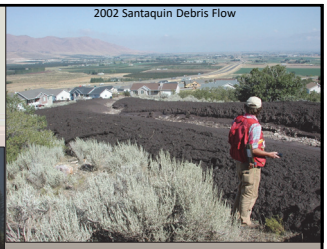
2017 Spring Creek Road Landslide, Riverdale, Utah

Four homes evacuated and condemned, landslide continues to slowly grow, and damages are not covered by homeowners insurance.

Debris Flow Hazards

- Mainly associated with recently burned areas, or where vegetation has been removed on steep slopes.
- Can travel very quickly for long distances, far from the source.

2002 Santaquin Debris Flow



- 15 deaths from debris flows since 1923.

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Rockfall Hazards

- Can be present below most slopes with rock cliffs.
- Rocks may roll or bounce for long distances from cliffs.
- Occur quickly, and often without warning.

2012 St. George Rockfall (major injury)

- 20 deaths from rockfall since 1850.

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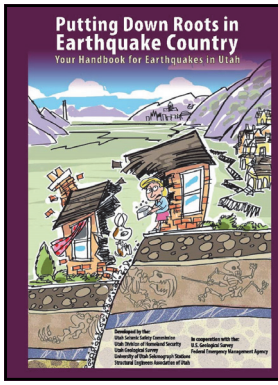

Preparing for Disaster

- Be Ready Utah (https://www.utah.gov/beready)
- Utah Seismic Safety Commission (https://ussc.utah.gov)
- Utah Division of Emergency Management (https://dem.utah.gov/)
- Utah Geological Survey (https://geology.utah.gov)
- **Plan**
- **Prepare**
- **Recover**

geology.utah.gov

What is the Utah Geological Survey Doing About Geologic Hazards?

- Outreach to the public, local governments, and professionals.
  - Website: information, reports, maps, and digital data
  - Technical presentations
  - Holds workshops, short courses, and working groups
- Creating geologic hazard maps for urban and rapidly developing areas (Wasatch Front/ southwestern Utah).
- Assisting and advising local governments on geologic hazards (high turnover of officials = ongoing education needs).
- Emergency response to events, working closely with the Utah Division of Emergency Management and local governments.
- Agency program dedicated to investigating and responding to hazards.

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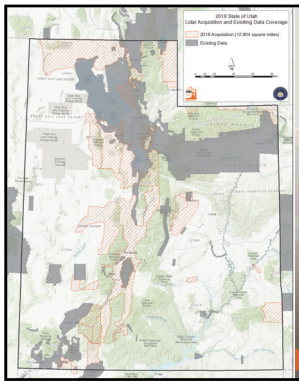
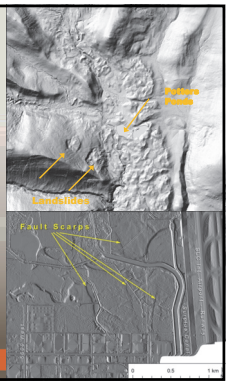


Available Utah Lidar Elevation Data

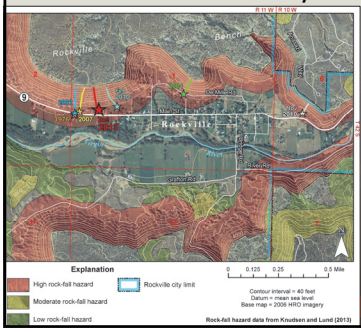
Yearly partnerships led by the State of Utah (UGS and AGRC) of local, state, and federal agencies, and other organizations.

Federal match funding typically available.

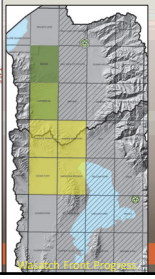
Contracting and quality control performed by the State of Utah.



Geologic Hazard Maps Critical for Informed Land-Use Decisions to Reduce Risk to Live Safety and the Economy



Typically, sets of 10 different hazard maps per area.



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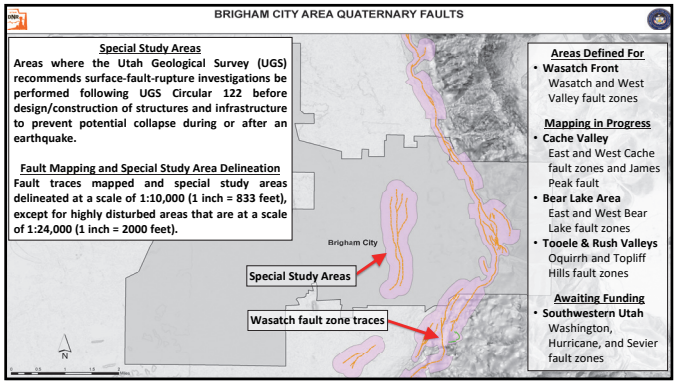


UGS Updated and New Geologic Hazard Investigation and Report Guidelines

Guidelines themselves are not regulatory, must be adopted by local governments in an ordinance.

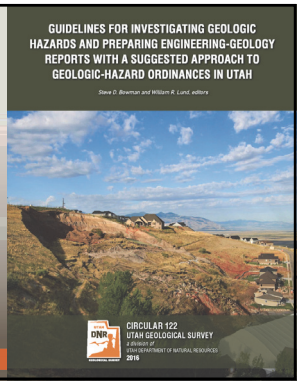
Included Guidelines:

Conducting Engineering-Geology Investigations and Preparing Reports
Surface-Fault-Rupture Hazards
Landslide Hazards
Debris-Flow Hazards
Land Subsidence and Earth Fissure Hazards
Rockfall Hazards
Creating Geologic Hazard Ordinances
Investigations and Reports for Public School Buildings

Also includes extensive background information.

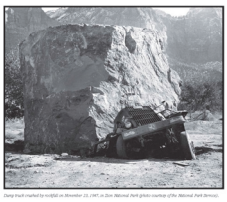
Updated guidelines will include new radon gas hazard guideline.

UTAH GEOLOGICAL SURVEY



Why are Geologic Hazard Ordinances Necessary?

CHAPTER 1
INTRODUCTION



- To protect the health, welfare, and safety of the public.
- Over 6169 fatalities from geologic hazards in Utah since 1850, and a significantly larger, but undetermined number of injuries and economic losses.

Geologic Hazard		Fatalities			
Landslide Hazards					
Landslides		4	1.2%	337	5.5%
Rockfall		15	4.5%		
Debris Flows		15	4.5%		
Snow Avalanches		303	89.8%		
Earthquake Hazards					
Ground Shaking		2	100%	2	<0.1%
Flooding Hazards					
Flooding		81	80.1%	101	1.6%
Debris Flows		15	14.9%		
Dam and Water Conveyance Structure Failure		5	5.0%		
Problem Soils					
Radon Gas	1973-2016	5729	100%	5729	92.9%
	Total:	6169			

Is Talking and Dealing With Geologic Hazards a Negative, Anti-Development Message?

- No, it is a smart development message and results in sustainable communities.
- Reduces long-term life-safety and economic costs, including emergency responses.
- All states and regions have geologic hazard impacts, some more than others; however, Utah can deal and live with these hazards.
- Implement effective geologic-hazard ordinances for land-use planning and development/construction.
- Investigate possible geologic hazards before planning and development.
- If needed, mitigate the hazard and/or modify the project before construction.
- For existing infrastructure, evaluate the hazards and risks, and prioritize mitigation.

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Questions and Discussion

Society can prepare for and deal with geologic hazards.

UTAH GEOLOGICAL SURVEY

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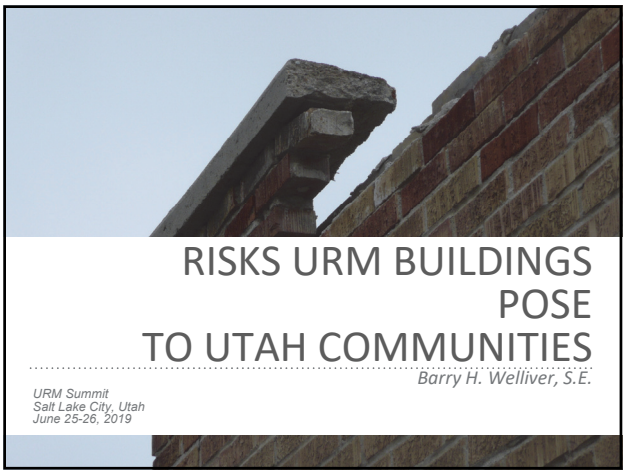


RISKS URM BUILDINGS POSE TO UTAH COMMUNITIES

Barry H. Welliver, S.E.

URM Summit
Salt Lake City, Utah
June 25-26, 2019

CONTENT

1. Vulnerability of URMs
2. Prevalence along Wasatch Front
3. What's the risk? Hazus runs - deaths, dollars, downtime
4. Mid-rise apartment buildings
5. Schools and public buildings are also at risk (self-insured)
6. Jobs, schools - overall community resilience
7. Demographic changes contributing to increased risk over next 50 years

CONTENT

1. Why are URM's so dangerous?
2. URM's – How many and where?
3. What's been done so far?
4. Summary and final thoughts.

1 WHY SO DANGEROUS?

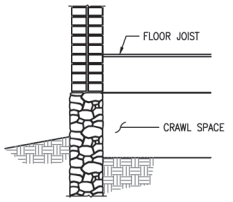
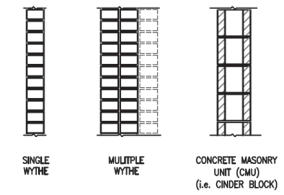


Figure 18. URM bearing wall.

- Rubble foundation walls
- Single wythe construction
- Multiple wythe construction
- Block construction (unreinforced)



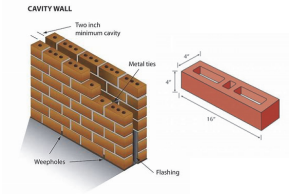
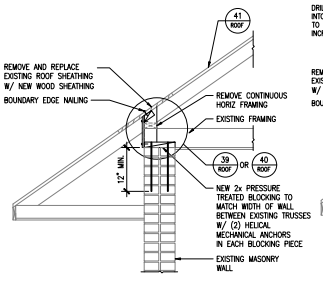
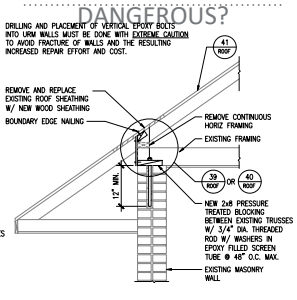


Figure 19. Vertical section through URM walls.

1 WHY SO DANGEROUS?





- Double wythe top of wall attachments

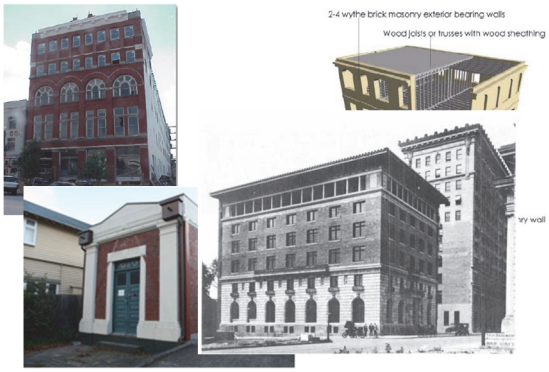
PROGRESSION OF URM DAMAGE IN MULTIPLE EARTHQUAKES

Sept 4, 2010 M7.1

Feb 22nd, 2011 M6.3

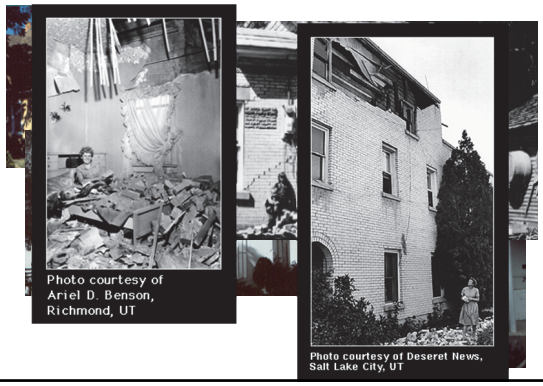
June 13, 2011 M5.5, M6.0

TYPICAL COMMERCIAL URM BUILDINGS

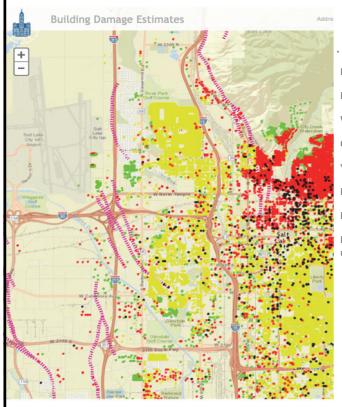


TYPICAL RESIDENTIAL URM BUILDINGS

TYPICAL URM BUILDING DAMAGE



BUILDING DAMAGE ESTIMATES



LEGEND

Building Damage Estimates

White Tag: None

Green Tag: 5-30%

Yellow Tag: 30-70%

Red Tag: 70-100%

Black: Potentially Collapsed Geologic Fault Lines

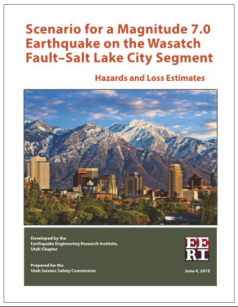
Damage Estimates using Salt Lake URM Inventory update.

2. URM'S HOW MANY/WHERE

LOSS MODELING USING HAZUS

HAZUS MH
EARTHQUAKE • WIND • FLOOD
FEMA

- Regions included:
  - Box Elder, Cache, Davis, Juab, Morgan, Rich, Salt Lake, Summit, Toole, Utah, Wasatch, Weber (12 most populous)
- 751,000 households, 2.4 million people
- 757,000 buildings
- Critical Facility Inventory
  - 47 Hospitals - 6,630 beds
  - 953 Schools
  - 208 Fire Stations
  - 104 Police Stations
  - 22 Emergency Operations Facilities
  - High Potential Loss Facilities:
    - 272 Dams - (117 "high hazard")
    - 636 Hazardous sites
- Lifeline Inventory
  - Highways, railways, light rail, airport
  - Potable water, waste water, natural gas, oil systems, electrical power, communications



LOSS ESTIMATIONS

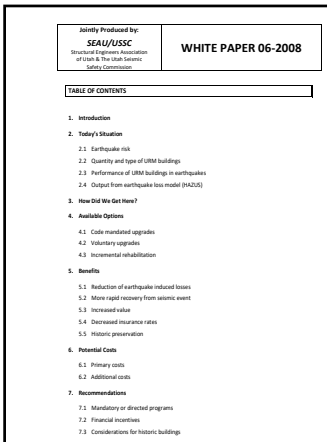
147,000 URM's in 16 county area

- 90,200 (61%) moderately or totally destroyed following M7.0 earthquake.
- After shocks will significantly affect residential re-occupancy
- Repairs to damaged URM's may not be possible
- Displaced residents and businesses will significantly affect recovery

3. WHAT'S BEEN DONE

USSC identifies URM's as dangerous buildings in series of Strategic Plans Some Highlights:

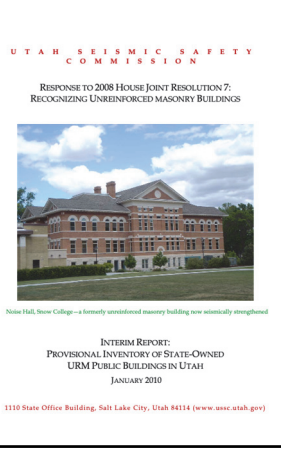
- 1995 – Reduce structural hazard of government owned buildings. (2300 of 4500 considered essential)
- 1996 – Improve safety of older homes and school buildings
- 2000 – Seismic strengthening of existing buildings (URM focus)
- 2007 – Unreinforced masonry ad-hoc committee



3. WHAT'S BEEN DONE

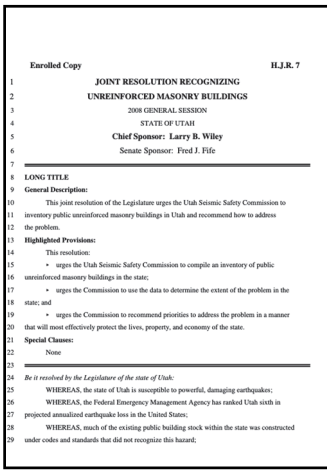
Ad-Hoc URM committee

1. Introduction
2. Today's Situation
3. How Did We Get Here?
4. Available Options
5. Benefits
6. Potential Costs
7. Recommendations



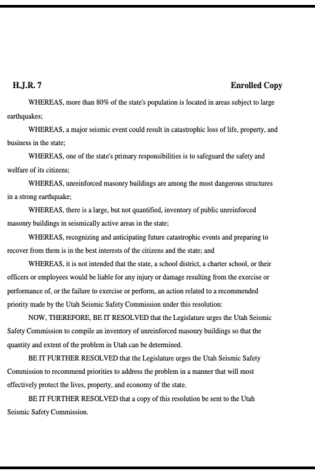
3. WHAT'S BEEN DONE

- In-session response to the Wells, NV February 21, 2008 EQ.
- Following years of lobbying the Utah legislature on RVS for schools
- Rep. Larry Wiley advocate/champion
- Utah Seismic Safety Commission and Structural Engineers Association of Utah endorsed
- Appealed to state ownership of unreinforced masonry buildings



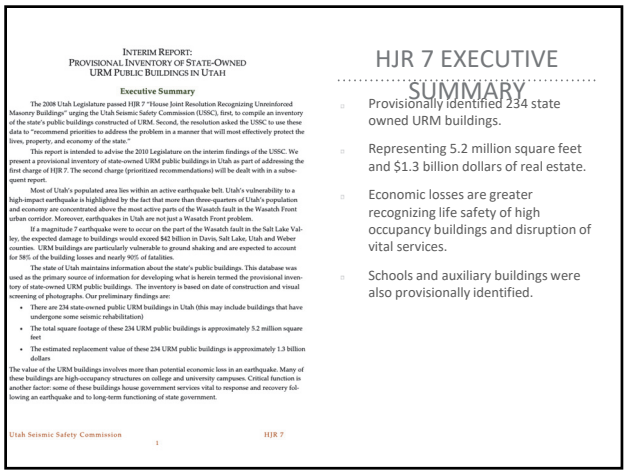
HJR 7

- Senate and House of Representatives acknowledge URM issue in Utah
- USSC to compile inventory and and make recommendations
- FEMA ranks Utah 6th in annualized losses from earthquakes (FEMA 366 - 2006 & 2017)
- State building stock has some old buildings, constructed before seismic codes were adopted.



HJR 7

- 80% of population subject to large earthquakes.
- State is responsible for safeguarding safety and welfare of citizens
- URM problem is unquantified
- "Clincher statement": No liability in identifying buildings and not retrofitting.
- Legislature urges USSC to compile list and make recommendations.
- No funding to do work.



INTERIM REPORT:
PROVISIONAL INVENTORY OF STATE-OWNED
URM PUBLIC BUILDINGS IN UTAH

Executive Summary

The 2008 Utah Legislature passed HJR 7 "House Joint Resolution Recognizing Unreinforced Masonry Buildings" urging the Utah Seismic Safety Commission (USSC), first, to compile an inventory of the state's public buildings constructed of URM. Second, the resolution asked the USSC to use these data to "recommend priorities to address the problem in a manner that will most effectively protect the lives, property, and economy of the state."

This report is intended to advise the 2010 Legislature on the interim findings of the USSC. We present a provisional inventory of state-owned URM public buildings in Utah as part of addressing the first charge of HJR 7. The second charge (prioritized recommendations) will be dealt with in a subsequent report.

Most of Utah's populated area lies within an active earthquake belt. Utah's vulnerability to a high-impact earthquake is highlighted by the fact that more than three-quarters of Utah's population and economy are concentrated above the most active parts of the Wasatch fault in the Wasatch Front urban corridor. Moreover, earthquakes in Utah are not just a Wasatch Front problem.

If a magnitude 7 earthquake were to occur on the part of the Wasatch fault in the Salt Lake Valley, the expected damage to buildings would exceed $42 billion in Davis, Salt Lake, Utah and Weber counties. URM buildings are particularly vulnerable to ground shaking and are expected to account for 58% of the building losses and nearly 90% of fatalities.

The state of Utah maintains information about the state's public buildings. This database was used as the primary source of information for developing what is herein termed the provisional inventory of state-owned URM public buildings. The inventory is based on date of construction and visual screening of photographs. Our preliminary findings are:

- There are 234 state-owned public URM buildings in Utah (this may include buildings that have undergone some seismic rehabilitation)
- The total square footage of these 234 URM public buildings is approximately 5.2 million square feet
- The estimated replacement value of these 234 URM public buildings is approximately 1.3 billion dollars

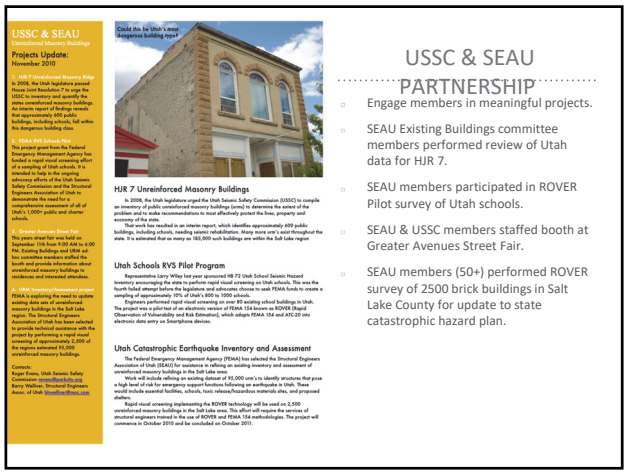
The value of the URM buildings involves more than potential economic loss in an earthquake. Many of these buildings are high-occupancy structures on college and university campuses. Critical function is another factor: some of these buildings house government services vital to response and recovery following an earthquake and to long-term functioning of state government.

Utah Seismic Safety Commission HJR 7

1

HJR 7 EXECUTIVE SUMMARY

- Provisionally identified 234 state owned URM buildings.
- Representing 5.2 million square feet and $1.3 billion dollars of real estate.
- Economic losses are greater recognizing life safety of high occupancy buildings and disruption of vital services.
- Schools and auxiliary buildings were also provisionally identified.



USSC & SEAU
Unreinforced Masonry Buildings

Projects Update:
November 2010

1. HJR 7 Unreinforced Masonry Bldgs
In 2008, the Utah legislature passed House Joint Resolution 7 to urge the USSC to inventory and quantify the state's unreinforced masonry buildings. The USSC has identified South of Utah that approximately 600 public buildings, including schools, fall within this dangerous building class.

2. FEMA RVS Schools Pilot
This project grant from the Federal Emergency Management Agency has funded a rapid visual screening effort of a sampling of Utah schools. It is intended to help in the ongoing advocacy efforts of the Utah Seismic Safety Commission and the Structural Engineers Association of Utah to demonstrate the need for a comprehensive assessment of all of Utah's 1,000+ public and charter schools.

3. Disaster Avenue Street Fair
This years street fair was held on September 11th from 9:00 AM to 4:00 PM. Existing Buildings and URM ad hoc committee members staffed the booth and provide information about unreinforced masonry buildings to vociferous and interested attendees.

4. URM Inventory Assessment project
FEMA is exploring the need to update existing data sets of unreinforced masonry buildings in the Salt Lake region. The Structural Engineers Association of Utah has been selected to provide technical assistance with the project by performing a rapid visual screening of approximately 2,500 of the regions estimated 93,000 unreinforced masonry buildings.

Contacts:
Roger Evans, Utah Seismic Safety Commission revans@utahbhp.org
Barry Welliver, Structural Engineers Assoc. of Utah bhwelliver@msn.com

Could this be Utah's most dangerous building type?

HJR 7 Unreinforced Masonry Buildings

In 2008, the Utah legislature urged the Utah Seismic Safety Commission (USSC) to compile an inventory of public unreinforced masonry buildings (urms) to determine the extent of the problem and to make recommendations to most effectively protect the lives, property and economy of the state.

That work has resulted in an interim report, which identifies approximately 600 public buildings, including schools, needing seismic rehabilitation. Many more urm's exist throughout the state. It is estimated that as many as 185,000 such buildings are within the Salt Lake region

Utah Schools RVS Pilot Program

Representative Larry Wiley last year sponsored HB 72 Utah School Seismic Hazard Inventory encouraging the state to perform rapid visual screening on Utah schools. This was the fourth failed attempt before the legislature and advocates chose to seek FEMA funds to create a sampling of approximately 10% of Utah's 800 to 1000 schools.

Engineers performed rapid visual screening on over 80 existing school buildings in Utah. The project was a pilot test of an electronic version of FEMA 154 known as ROVER (Rapid Observation of Vulnerability and Risk Estimation), which adapts FEMA 154 and ATC-20 into electronic data entry on Smartphone devices.

Utah Catastrophic Earthquake Inventory and Assessment

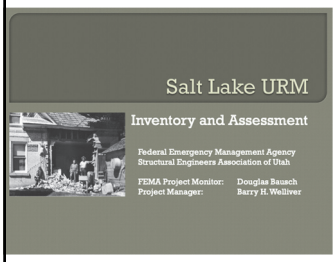
The Federal Emergency Management Agency (FEMA) has selected the Structural Engineers Association of Utah (SEAU) for assistance in refining an existing inventory and assessment of unreinforced masonry buildings in the Salt Lake area.

Work will include refining an existing dataset of 93,000 urm's to identify structures that pose a high level of risk for emergency support functions following an earthquake in Utah. These would include essential facilities, schools, toxic release/hazardous materials sites, and proposed shelters.

Rapid visual screening implementing the ROVER technology will be used on 2,500 unreinforced masonry buildings in the Salt Lake area. This effort will require the services of structural engineers trained in the use of ROVER and FEMA 154 methodologies. The project will commence in October 2010 and be concluded on October 2011.

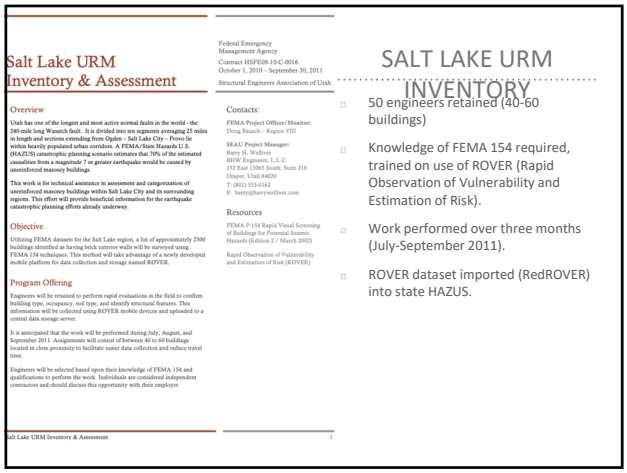
USSC & SEAU PARTNERSHIP

- Engage members in meaningful projects.
- SEAU Existing Buildings committee members performed review of Utah data for HJR 7.
- SEAU members participated in ROVER Pilot survey of Utah schools.
- SEAU & USSC members staffed booth at Greater Avenues Street Fair.
- SEAU members (50+) performed ROVER survey of 2500 brick buildings in Salt Lake County for update to state catastrophic hazard plan.



3. WHAT'S BEEN DONE

- Inventory and Assessment of URMs, which drive most of the catastrophic operational needs in a major Salt Lake City earthquake.
- FEMA contract with Structural Engineers Association of Utah to survey 2,500 brick buildings in the Salt Lake City region.
- Use inventory to update FEMA Region VIII Catastrophic Earthquake Support Plan and Utah's E.O.P.
- Specific support for ESF-9 (search & rescue), ESF-6 (mass care and housing functions, and ESF-8 (public health)



Salt Lake URM
Inventory & Assessment

Federal Emergency Management Agency
Contract HSFE08-10-C-0016
October 1, 2010 - September 30, 2011
Structural Engineers Association of Utah

Overview

Utah has one of the longest and most active normal faults in the world - the 240-mile long Wasatch fault. It is divided into ten segments averaging 25 miles in length and sections extending from Ogden – Salt Lake City – Provo lie within heavily-populated urban corridors. A FEMA/State Hazards U.S. (HAZUS) catastrophic planning scenario estimates that 70% of the estimated casualties from a magnitude 7 or greater earthquake would be caused by unreinforced masonry buildings.

This work is for technical assistance in assessment and categorization of unreinforced masonry buildings within Salt Lake City and its surrounding regions. This effort will provide beneficial information for the earthquake catastrophic planning efforts already underway.

Objective

Utilizing FEMA datasets for the Salt Lake region, a list of approximately 2500 buildings identified as having brick exterior walls will be surveyed using FEMA 154 techniques. This method will take advantage of a newly developed mobile platform for data collection and storage named ROVER.

Program Offering

Engineers will be retained to perform rapid evaluations in the field to confirm building type, occupancy, soil type, and identify structural features. This information will be collected using ROVER mobile devices and uploaded to a central data storage server.

It is anticipated that the work will be performed during July, August, and September 2011. Assignments will consist of between 40 to 60 buildings located in close proximity to facilitate easier data collection and reduce travel time.

Engineers will be selected based upon their knowledge of FEMA 154 and qualifications to perform the work. Individuals are considered independent contractors and should discuss this opportunity with their employer.

Contacts:

FEMA Project Officer/Monitor:
Doug Bausch – Region VIII

SEAU Project Manager:
Barry H. Welliver
BHW Engineers, L.L.C.
132 East 13065 South, Suite 210
Draper, Utah 84020
T: (801) 553-0162
E: barry@barrywelliver.com

Resources

FEMA P-154 Rapid Visual Screening of Buildings for Potential Seismic Hazards (Edition 2 / March 2002)

Rapid Observation of Vulnerability and Estimation of Risk (ROVER)

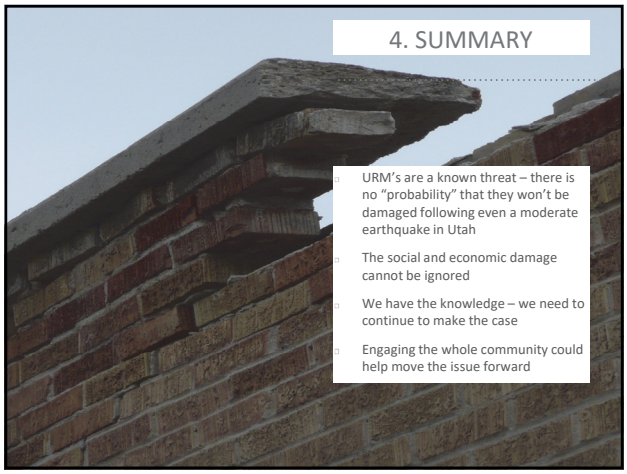
Salt Lake URM Inventory & Assessment 1

SALT LAKE URM INVENTORY

- 50 engineers retained (40-60 buildings)
- Knowledge of FEMA 154 required, trained on use of ROVER (Rapid Observation of Vulnerability and Estimation of Risk).
- Work performed over three months (July-September 2011).
- ROVER dataset imported (RedROVER) into state HAZUS.

SALT LAKE URM INVENTORY

- Salt Lake County assessor database of approx. 95,000 "brick" buildings
- Refined selection to include high occupancy multi-unit structures, schools, critical care, etc.
- Direct input of assessor data into ROVER simplified set up.
- Final survey of 2,600 buildings reduced the number of URM's for planning purposes.



4. SUMMARY

- URM's are a known threat – there is no "probability" that they won't be damaged following even a moderate earthquake in Utah
- The social and economic damage cannot be ignored
- We have the knowledge – we need to continue to make the case
- Engaging the whole community could help move the issue forward

“

A Chinese proverb advises:

If you want 1 year of prosperity, grow grain.

If you want 10 years of prosperity, grow trees.

If you want 100 years of prosperity, grow people.

It’s a People Problem

G.K. Gilbert (USGS) advised in 1883 that Salt Lake City would be “shaken down”

It’s time to take some serious action!

Risk URMs Pose to Communities—Extended Recovery, Broader Societal Impacts and Examples from Elsewhere

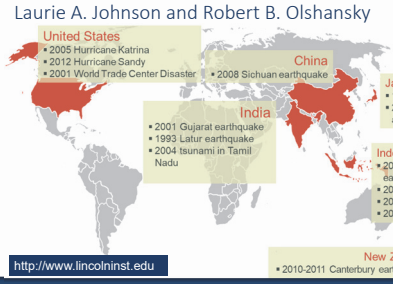
Laurie A. Johnson PhD FAICP
Utah URM Summit
June 25, 2019

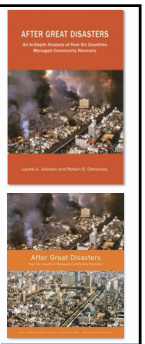
Laurie Johnson Consulting | Research

After Great Disasters

An In-depth Analysis of How Six Countries Managed Community Recovery

Laurie A. Johnson and Robert B. Olshansky





http://www.lincolninst.edu

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EQ Recovery Learning

www.eqrecoverylearning.org/

While some residents still face complex challenges five years on, much progress has been made. The people of Canterbury have demonstrated courage, determination and innovation. We can see an inspiring city emerging.

Ka oi Rūaumoko, ara ake Waitaha.
Despite the heaving earth, Canterbury will rise again.

New Zealand has an opportunity and a responsibility to learn from the Canterbury earthquakes. By sharing this learning, we can become better prepared and support others

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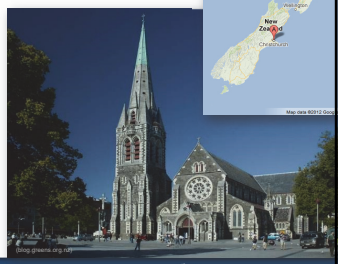
Canterbury Region: 2nd largest metro area; Christchurch 2nd largest city

- Population:
  - 4.5 million nationally
  - 550,000 Christchurch metro area
- Economy: US$174 billion GDP; US$36,500 per capita GDP
  - Christchurch – agriculture, education, tourism
- Governance: National, District Councils (i.e. regional and local)



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Christchurch before the 2010-2011 earthquakes

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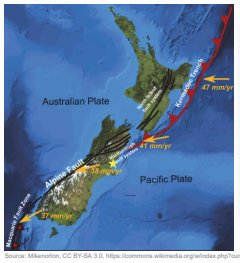
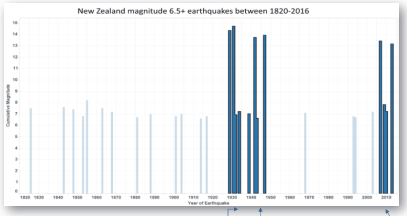
Christchurch: Moderate seismicity, tectonic plate margin





First national building code | EQC created | CES

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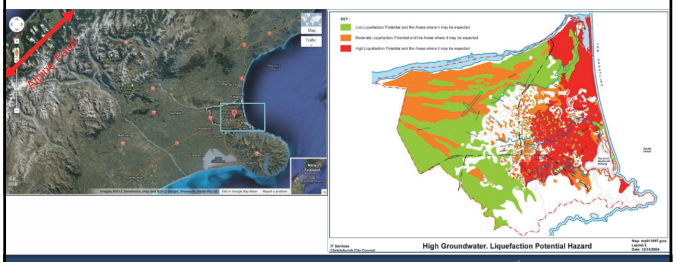
Canterbury Plains: Liquefaction potential



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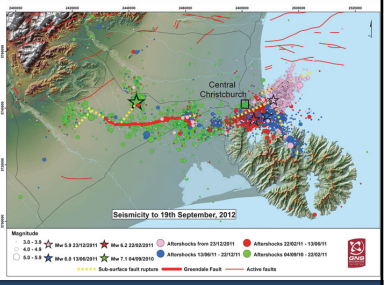
M7.1 September 4, 2010 earthquake, followed by 3 large earthquakes and thousands of aftershocks

- Sept 4, 2010, M7.1 (green): no fatalities
- Feb 22, 2011, M6.2 (red): produced notably stronger shaking; 185 fatalities
- Jun 13, 2011, M6.0 (blue): slightly offshore; no fatalities
- December 23, 2011, M5.9 (pink): further offshore; no fatalities



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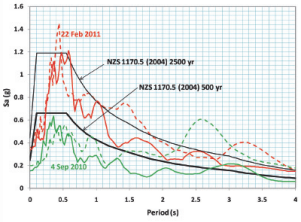
Design ground motions for buildings reached (or exceeded) multiple times



Source: Elwood, ground motion data from GeoNet, EERI Special Earthquake Report, May 2011

Extreme severity and spatial extent of liquefaction over multiple events

Figure 3. Liquefaction in February 2011 (green) and September 2010 (red contours) (courtesy of R. Green, GEER 2011).

Liquefaction in February 2011 (green) and September 2010 (red) contours

10

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Canterbury Earthquakes Sequence: Overall damage and impacts

- Deaths: 185, majority in 2 concrete-building collapses; others in URMs
- 180,000 housing units damaged
- >1,500 commercial buildings demolished; 1,000 downtown
- >1,600 community and 375+ heritage buildings majorly damaged/destroyed
- 25% of 6,000 km of network infrastructure and 35% of 2,000 km of roads repaired/replaced
- Economic Loss: NZ$40 billion (> 20% GDP)
- Insured Loss: NZ$21 billion (~50/50 split residential and commercial claims; >NZ$18 billion paid as of July 2016)

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Central City Impacts

- About 50% of all buildings unusable
  - 200 concrete and >500 masonry buildings
- Horizontal infrastructure badly damaged
- CBD cordon post-February 22nd
  - Initial cordon 114 square blocks; reduced to 75 blocks after 10 days; phased reopening over 29 months
- Nearly all businesses displaced; 75% hotel accommodation and tourism facilities disrupted/lost

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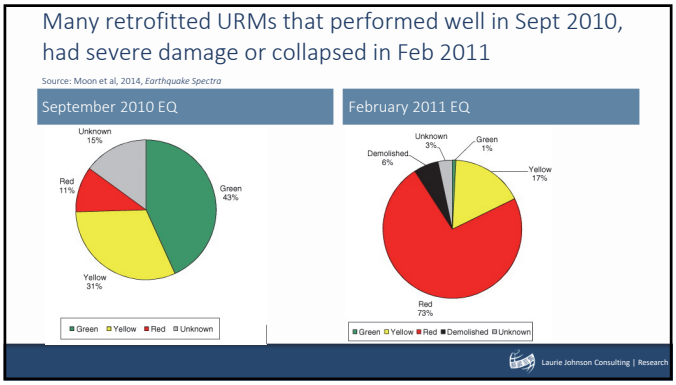
Ann Brower's story: "Parapets, Politics and Making a Difference: Lessons from Christchurch," *Earthquake Spectra*, 2017
Laurie Johnson Consulting | Research


Many retrofitted URMs that performed well in Sept 2010, had severe damage or collapsed in Feb 2011
Source: Moon et al, 2014, *Earthquake Spectra*
September 2010 EQ
Unknown 15%
Red 11%
Green 43%
Yellow 31%
Green Yellow Red Unknown
February 2011 EQ
Unknown 3%
Green 1%
Demolished 6%
Yellow 17%
Red 73%
Green Yellow Red Demolished Unknown
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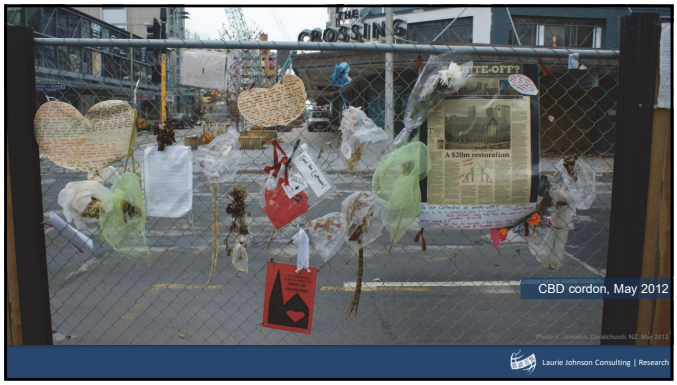
CBD cordon, May 2012
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Central City Plan
(Christchurch City Council, draft Aug 2011; final draft Dec 2011)
• Internationally acclaimed "Share an Idea" – 104,000 suggestions
• Five key principles:
– Green city
– Stronger built identity
– Compact CBD
– Live, work, play, learn and visit
– Accessible city
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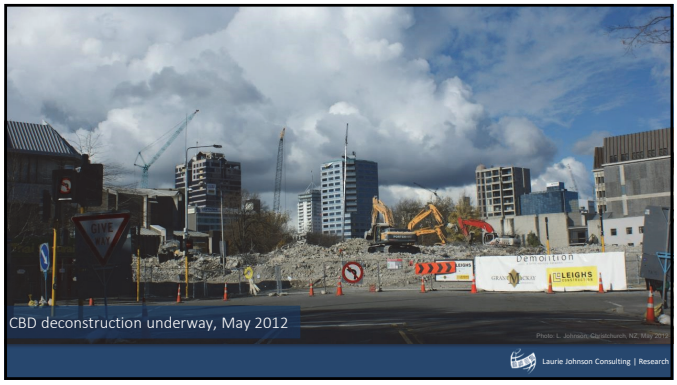
CBD deconstruction underway, May 2012
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Views of Downtown (March 2011 and August 2012)
March 2011
August 2012
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CERA Central City Development Unit (CCDU) Recovery Plan
(Aug 2012)

- 16 "Anchor" projects, including:
  - Avon River project
  - Acquisition of "Frame"
  - Convention Centre
  - Metro Sports facility

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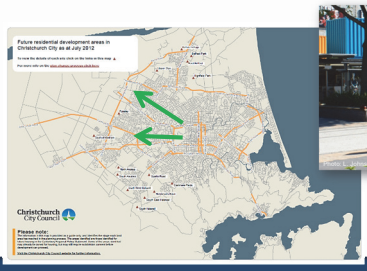
Interim Commercial Responses



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Central City
(2017/2018)

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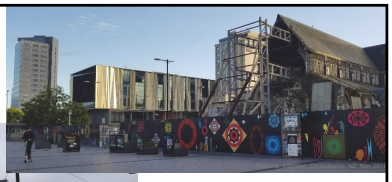
Central City
(2017/2018)



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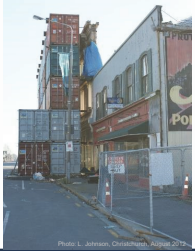
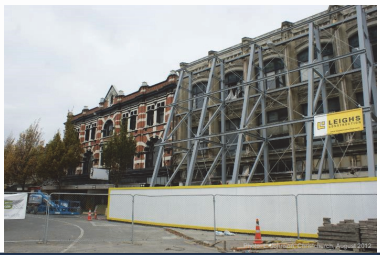
39 Deaths Caused by the Collapse of URM Buildings:
35 (90%) resulted from collapsed walls or parapets outside the buildings;
4 (10%) inside the buildings





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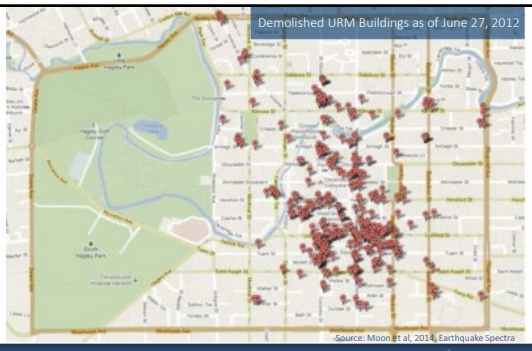
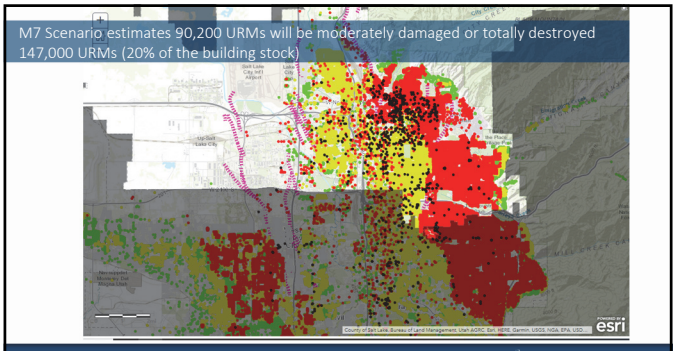
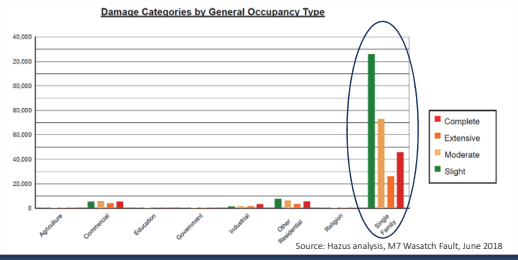




Potential Residential Impacts in Major Wasatch Fault EQ:

Casualties, concerns about habitability in aftershocks, prolonged displacement, challenges financing repairs, URM home value collapse and potential neighborhood blight



Source: Hazus analysis, M7 Wasatch Fault, June 2018

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Residential Impacts in the Canterbury EQs:

Widespread liquefaction, rockfalls, and other ground failures

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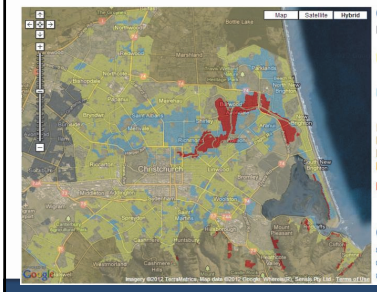
Technical Categories (TC) 1, 2, and 3, and "Red Zone"



(Announced June 2011)
30,000 TC1
80,000 TC2
30,000 TC3
7,500 Red Zone

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"Green Zone" – Technical Categories 1, 2, and 3

Table 5.1: Summary of proposed foundation solutions for rebuilt foundations or new foundations on the flat

Department of Building and Housing (www.dbh.govt.nz/)

TC1 FUTURE LIQUEFACTION UNLIKELY	TC2 MINOR LIQUEFACTION LIKELY	TC3 FUTURE LIQUEFACTION EXPECTED
NZS 3604 timber piles and floor or tied concrete slabs (as modified by B1/AS1) where good ground proven (shallow subsurface investigation required[1])	Light construction with timber floors and shallow piles as per NZS 3604 where good ground proven (shallow geotechnical investigation required[1])	Deep piles (Option 5) with specific design
otherwise	or	or
Raft foundations (Options 1-5)	Enhanced perimeter foundation wall (see section 4.2) and shallow piles as per NZS 3604 (shallow geotechnical investigation required[1])	Other specific engineering design solutions (including ground improvement)
or	or	(Deep geotechnical investigation required in all cases[2])
Specific engineering design	Raft foundations (Options 1–4)	• *Options for TC3 had to be studied, and required engineering design.*
	or	
	Specific engineering design	

Increasing engineering specificity, costs, and time

30,000 TC1
80,000 TC2
30,000 TC3

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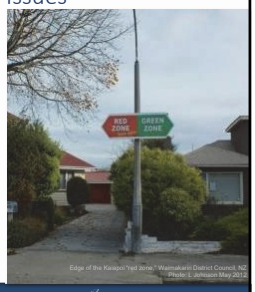
Residential Impacts: Red Zone and TC3 Issues

- Two forms of residential "Red Zone" voluntary buyouts (land only, or land + structure) initiated June 2011
- "Quake Outcasts" lawsuit forced national government to extend offers to vacant land and insured commercial properties within the "Red Zones," Sept 2012
- Some property owners elected not to sell; damaged infrastructure services still maintained in red zones but threats of decommissioning persist
- Complexity of TC3 foundation designs affected property values and caused blight in some neighborhoods
- Further complications as 4,500 homes more vulnerable to liquefaction, another 6,500 more vulnerable to a 1:100 year flood (city sank 0.5-1 meter) and 1,000 vulnerable to both



Edge of the Kaiapoi "red zone," Waimakariri District Council, NZ. Photo: L. Johnson May 2014

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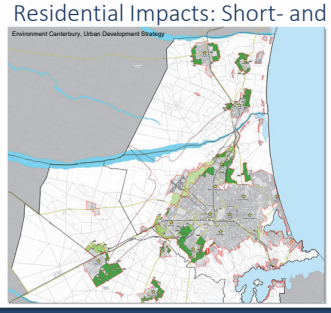
Residential Impacts: Short- and Long-term



- High proportion of lost housing units were affordable rental housing or social housing, and these households have found it particularly difficult to find affordable replacement housing
- Between 5,500 and 7,400 Christchurch residents experiencing "housing insecurity" (MBIE, March 2013)
- By 2015, housing costs (rental and owned) up >30% on average across the region; signs of market stabilization began mid-2016
- Red zone buyout "winners and losers," as comparable replacement properties more expensive than buyout offers
- Major acceleration of green field land development, especially outside Christchurch

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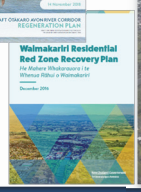
Planning for future use of Red Zone land is still ongoing




Source: EQC

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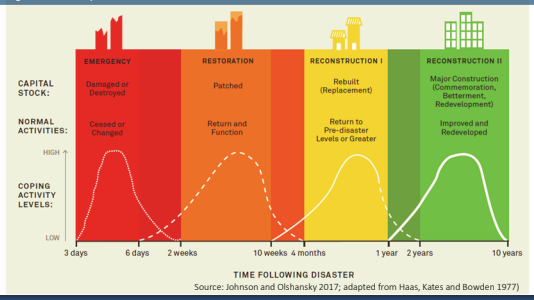
Each period of recovery takes exponentially longer than the last. The more complexity/change, the longer recovery takes.



Source: Johnson and Olshansky 2017; adapted from Haas, Kates and Bowden 1977)

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Residential Recovery Financing Challenges following Major U.S. Hurricanes

- Flood and hurricane insurance cover lacking or inadequate
- Supplemental federal recovery authorization/appropriations necessary to address unmet needs, e.g. CDBG-DR, which took months to years
- Major housing repair programs implemented by states/cities, took at least another year to roll-out
- Maximum of $150,000 to qualifying homeowners

The Road Home
Building a safer, stronger, smarter Louisiana

NYC BUILD IT BACK
Stronger & Safer

reNEW JERSEY stronger
rebuilding a lasting foundation

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URMs, A Community Resilience Dilemma: Address it now, or later? Pay now, or pay later?

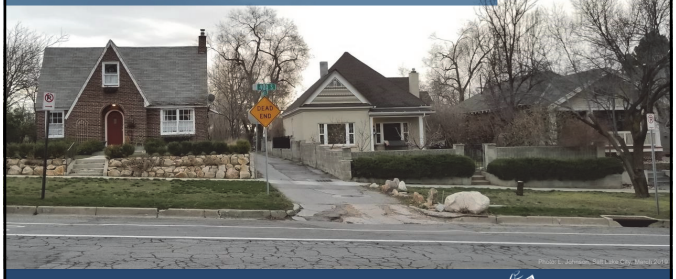

Photo: L. Johnson, Salt Lake City, March 2018

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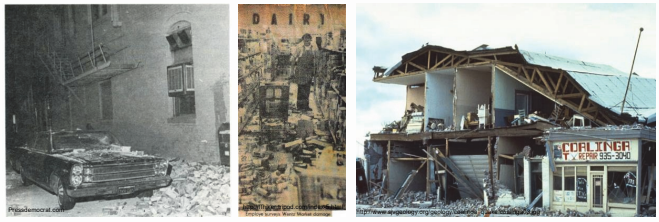
Three very different responses by earthquake-impacted California cities.

Santa Rosa, 1969 M5.6/M5.7 Oroville, 1975 M5.7 Coalinga, 1983, M6.5



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"Standing Rubble", Olson and Olson, 1988
"The Rubble's Standing Up In Oroville, California: The Politics of Building Safety," Olson and Olson, 1993

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M6 South Napa, California Earthquake, August 24, 2014

Photo: L. Johnson, Napa CA, Oct 2014

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M6.7 Northridge Earthquake, January 17, 1994

Source: Flickr

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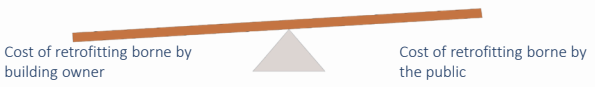
Mandatory Seismic Strengthening Policy Dilemma



Consider the property value to an owner and the community and not just the building value.

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Elements for Hazardous-Structure Abatement

R.S. Olson, "The Political Economy or Life-Safety: The City of Los Angeles and Hazardous-Structure Abatement 1973-1981," *Public Studies Review*, May 1985

Necessary Elements	Sufficient Elements
1. Insider leader	1. An earthquake forecast
2. Media attention	2. Concerns over potential liability if nothing were done and people were killed or injured in an earthquake
3. Financial incentive for retrofit	3. Lower than feared retrofit costs, and
4. Astute political strategy which assured building owners that the pace of abatement implementation would be sensitive to the size and incidence of the costs	4. Statutory permission to design retrofit to less than current code

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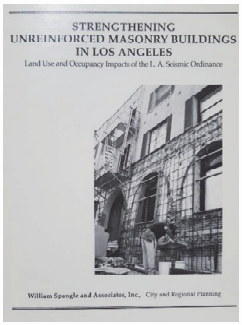
Los Angeles' URM Ordinance:

Spangle study recommendations

- Establish priorities for strengthening by area.
- Coordinate seismic strengthening with redevelopment.
- Plan for housing low-income tenants at the outset.
- Make full use of land-use regulations (i.e. parking requirements, density bonuses).
- Develop a program to help owners of historic buildings.
- Consider grants or loans to defray engineering costs.
- Consider options for training local engineers and contractors.
- Develop an interagency plan for coordination.



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"Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has."
– Margaret Mead

Ann Brower, 2016
Source: Seattle Times

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Congratulations to Salt Lake City's "Fix the Bricks" program!

It's a great start.

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UNREINFORCED MASONRY BUILDING SUMMIT
SALT LAKE CITY

Melvyn Green

Structural Engineer

June 2019

GREEN

- Many damaged buildings are demolished after an earthquake.
- Why?
  - Easier to deal with demo than with trying to determine how to fix/repair a structure.
  - Pressure of the disaster
  - EIR exemptions in a post-disaster situation
- 65% of small businesses (Main Street) in disaster struck communities never recover!

Basic Issue

RISK = f (HAZARD,VULNERABILITY)

- URM Buildings -Death and Injuries Risk for Customers and Employees
- URM Buildings - Building Damage – Could you enter or exit the structure?
- Business - Loss of Inventory – Will your stock be destroyed?
- Will your supply chain be broken?
- What if you lose your Communications and Utilities?
- Will you be able to retain your customers?

WHAT FAILS IN AN EARTHQUAKE?

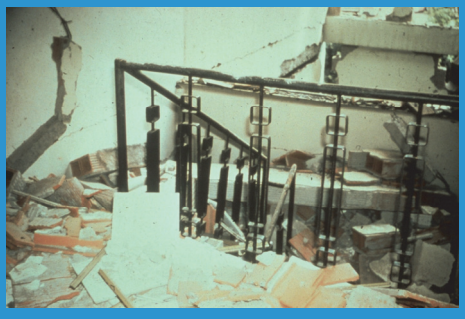
- Buildings
  - Nonstructural Elements and Contents
  - Structural
- Infrastructure
  - Utilities – Power, Water and Communications
  - Transportation

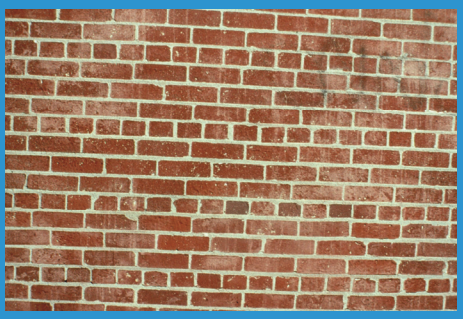
URM ISSUES

- What is a URM building?
- What happens to these buildings in an earthquake?
- How do I reduce the risk to my family, employees, my business and building?
- Is there anything unique about Utah's building stock?
- Must it be done at once or can the work be phased?


BARGAIN BARN


92 4 27





URM BUILDING RISKS

- Parapet and gable fall outward
  - On to the public way and people running out of the building.
- Wall Anchors – Physical tie between the bricks and the roof/floor
  - Steel rod used historically but not strong enough
- Wall stability (h/t)
  - Walls can buckle and collapse if too thin
- Diaphragm (floors and roof)
  - Strength and stiffness
- In-plane shear –
  - Open front buildings – typical mercantile
  - Buildings with many windows

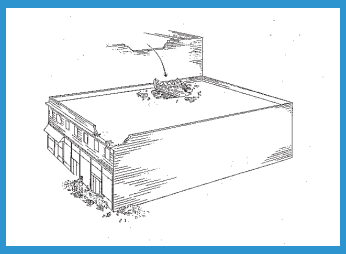


DIAGRAM OF PARAPET FAILURE

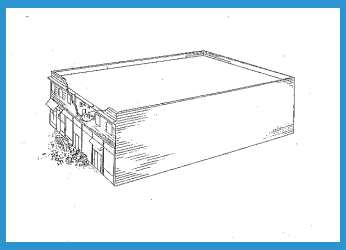


DIAGRAM OF WALL-DIAPHRAGM TIE FAILURE

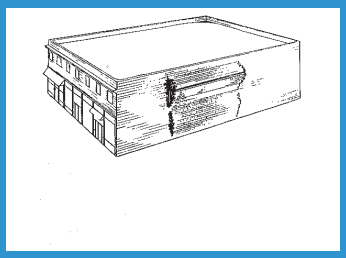


DIAGRAM OF WALL STABILITY (h/t) FAILURE

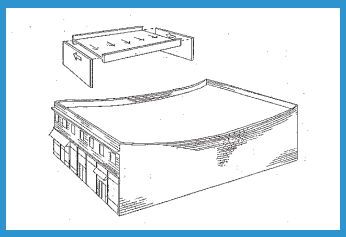


DIAGRAM OF EXCESSIVE DIAPHRAGM DEFLECTION

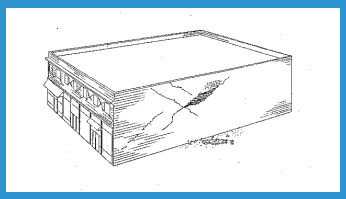
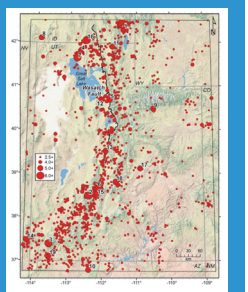
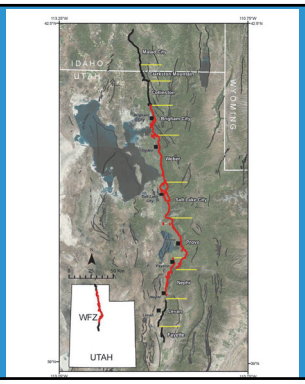


DIAGRAM OF IN-PLANE WALL FAILURE





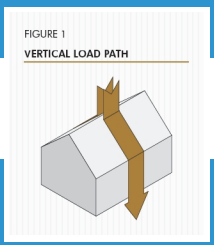


FIGURE 1
VERTICAL LOAD PATH

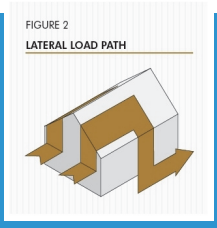
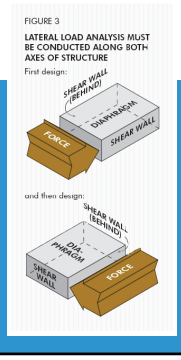
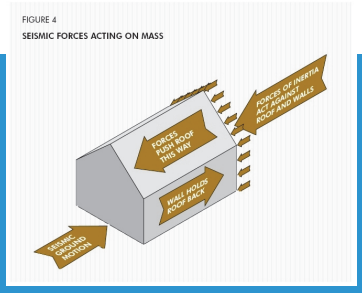
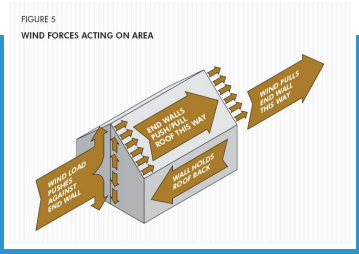


FIGURE 2
LATERAL LOAD PATH







Issues:
1. Walls not anchored for out-of-plane loads.
2. Chimneys not braced.
3. Wall Stability (h/t ratio).
4. Porch columns collapse potential.
5. Diaphragm stiffness
6. Interior features - brace

Dwelling Type - Model A

Issues:
1. Walls not anchored for out-of-plane loads.
2. Chimneys not braced.
3. Brick Gables?
4. Wall Stability (h/t ratio). Anchor at attic floor.
5. Porch posts collapse potential.
6. Diaphragm stiffness
7. Interior features - brace

Dwelling Type - Model B

Issues:
1.Walls not anchored for out-of-plane loads. Needed at both roof and second floor lines.
2. Chimneys not braced.
3. Brick Gables
4. Wall Stability (h/t ratio).
5. Porch anchorage.
6. Diaphragm stiffness.
7. Stone foundations
7. Interior features - brace

Dwelling Type - Model C

Dwelling Type - Model D

Issues:
1. Walls not anchored for out-of-plane loads. Needed at both roof and second floor lines. Possibly at the attic floor.
2. Chimneys not braced.
3. Brick Gables
4. Wall Stability (h/t ratio).
5. Porch anchorage.
6. Diaphragm stiffness.
7. Interior features – Bearing Walls. Brace features.

Dwelling Type - Model E

Issues:
1. Walls not anchored for out-of-plane loads.
3. Wall Stability (h/t ratio).
4. Diaphragm stiffness
5. In-plane shear cracking. Large windows – pier rocking.
6. Interior features - brace

Dwelling Type - Model F

Issues:
1. Walls not anchored for out-of-plane loads.
3. Wall Stability (h/t ratio).
4. Large open walls. Shear transfer needed.
5. Differential diaphragm elevations and stiffness
5. In-plane shear issue. Large windows.
6. Interior features - brace

Corner Window

Chimney

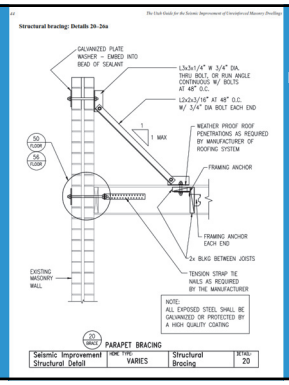
Gable

RETROFIT MEASURES

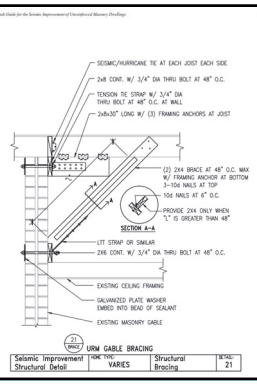
- Parapet and gable bracing
  - Brace back to the roof for parapets
  - Anchor gables on the interior side with braces or posts
- Wall Anchors
  - Install connectors of through bolts or epoxy adhered anchors with straps
- Wall stability (height to thickness ratio) bracing if required
  - Various bracing methods – similar to methods used for gables
- Diaphragm stiffness improvements
  - Overlay of plywood
- In-plane shear improvements –
  - Add – steel frames, infill wall openings, shotcrete

RETROFIT MEASURES

- **Parapet and gable bracing**
  - Brace back to the roof for parapets
  - Anchor gables on the interior side with braces or posts



Parapet Brace Example



Gable End Wall Brace Example

RETROFIT MEASURES

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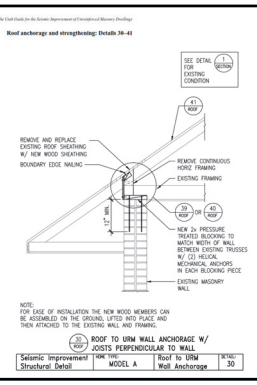
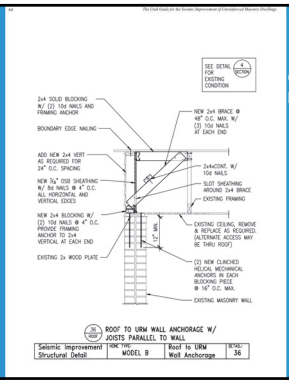
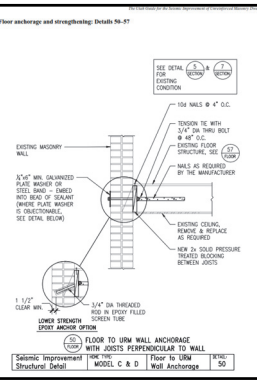


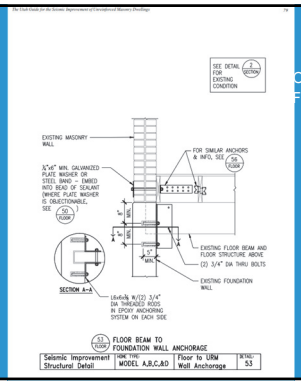
Out-of-Plane Anchor Example



Out-of-Plane Anchor Example



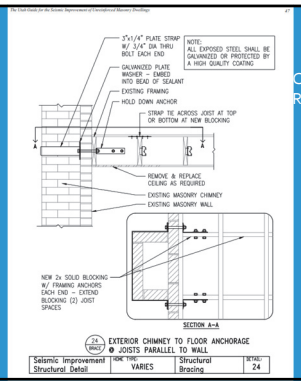
Out-of-Plane Anchor – Intermediate Floor Example



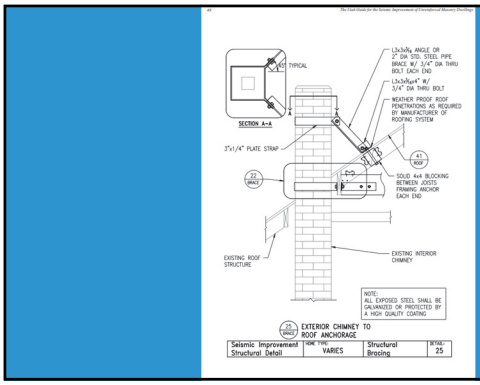
Out-of-Plane Anchor at Foundation - Example

RETROFIT MEASURES

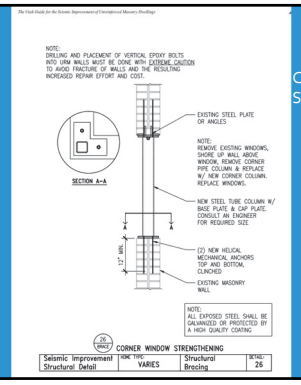
- Other Building Features
  - Chimney
  - Corner Windows
- Non-structural Building Components and Contents



Chimney Brace – Flat Roof - Example



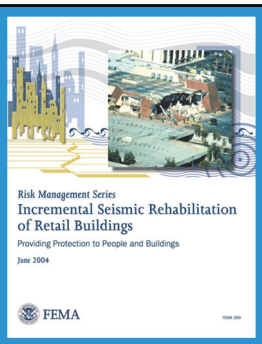
Chimney Brace – Sloping Roof - Example



Corner Window Support - Example

INCREMENTAL WORK

- Integrate with other building improvements
- Do some work at the same time as reroofing is undertaken.
  - Do some measures in phases as funding is available.
- FEMA Incremental Rehabilitation Series



RETROFIT MEASURES

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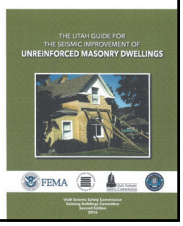
The Utah Guide For The Seismic Improvement Of Unreinforced Masonry Dwellings, 2016 Edition

"Fix-the-Bricks"



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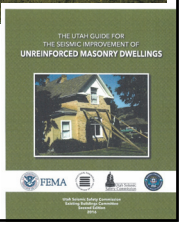
We want People in Utah to Know How Important Seismic Safety Is!



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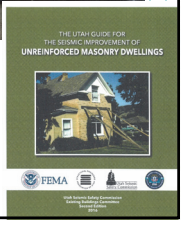
We Want this Book to Cause Owners to Question;

How Safe Is Your Home during an Earthquake?



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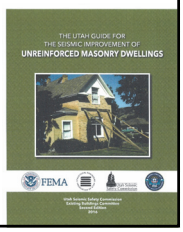
And then get the Owners to move forward with improvements to the Earthquake Safety of their Home!

Before the Big Event ! ! !

Palmer Engineering

Objectives for Utah Guide Revisions:

- The work on this book ended up providing a fully Revised and Updated edition of the "Utah Guide", easier to read and use.
- A major objective was to better target the intended audience of Home Owners and smaller Remodel Contractors.
- It has been a major volunteer effort in coordination between SEAU and USSC in the joint "Existing Buildings" Committee, as well as with Utah DEM.



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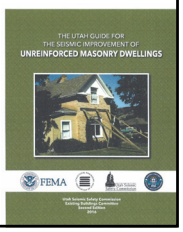
Another Use of the Guide:

- Salt Lake City has used this "Utah Guide" in developing a joint "FEMA – Salt Lake City" program for "Pre-Disaster Mitigation" in SLC.
- This program is "Fix-the-Bricks", and it helps families to implement a "Partial Voluntary Seismic Upgrade" within Salt Lake City.
- It has already been a major success for dozens of homes within the City.
- So let's review the Utah Guide briefly, and how it can be used to help owners.



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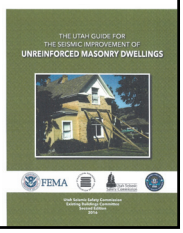
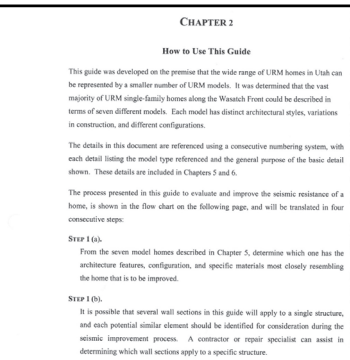
Chapter 1 is an "Introduction" to help the explain the basic concepts to the target audience.

- This helps to explain older home construction in Utah, and the potential impact of seismic activity on such homes.
- It helps to explain and illustrate the effects of weak older homes during earthquake action in Utah.
- This helps to explain & illustrate the importance of such risks for URM dwellings.



Chapter 2 explains how to use the "Utah Guide", giving simple basic steps to follow for upgrading URM homes.



CHAPTER 2

How to Use This Guide

This guide was developed on the premise that the wide range of URM homes in Utah can be represented by a smaller number of URM models. It was determined that the vast majority of URM single-family homes along the Wasatch Front could be described in terms of seven different models. Each model has distinct architectural styles, variations in construction, and different configurations.

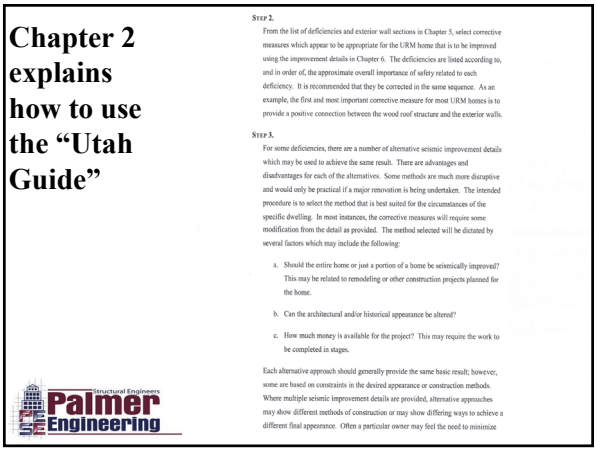
The details in this document are referenced using a consecutive numbering system, with each detail listing the model type referenced and the general purpose of the basic detail shown. These details are included in Chapters 5 and 6.

The process presented in this guide to evaluate and improve the seismic resistance of a home, is shown in the flow chart on the following page, and will be translated in four consecutive steps:

STEP 1 (a).
From the seven model homes described in Chapter 5, determine which one has the architecture features, configuration, and specific materials most closely resembling the home that is to be improved.

STEP 1 (b).
It is possible that several wall sections in this guide will apply to a single structure, and each potential similar element should be identified for consideration during the seismic improvement process. A contractor or repair specialist can assist in determining which wall sections apply to a specific structure.

Chapter 2 explains how to use the "Utah Guide"



STEP 2.
From the list of deficiencies and exterior wall sections in Chapter 5, select corrective measures which appear to be appropriate for the URM home that is to be improved using the improvement details in Chapter 6. The deficiencies are listed according to, and in order of, the approximate overall importance of safety related to each deficiency. It is recommended that they be corrected in the same sequence. As an example, the first and most important corrective measure for most URM homes is to provide a positive connection between the wood roof structure and the exterior walls.

STEP 3.
For some deficiencies, there are a number of alternative seismic improvement details which may be used to achieve the same result. There are advantages and disadvantages for each of the alternatives. Some methods are much more disruptive and would only be practical if a major renovation is being undertaken. The intended procedure is to select the method that is best suited for the circumstances of the specific dwelling. In most instances, the corrective measures will require some modification from the detail as provided. The method selected will be dictated by several factors which may include the following:

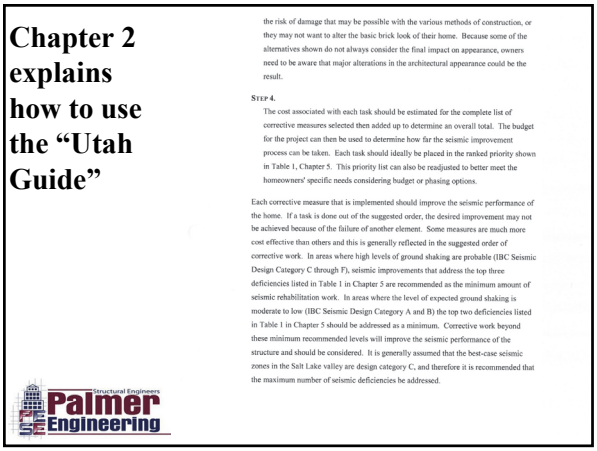
a. Should the entire home or just a portion of a home be seismically improved? This may be related to remodeling or other construction projects planned for the home.

b. Can the architectural and/or historical appearance be altered?

c. How much money is available for the project? This may require the work to be completed in stages.

Each alternative approach should generally provide the same basic result; however, some are based on constraints in the desired appearance or construction methods. Where multiple seismic improvement details are provided, alternative approaches may show different methods of construction or may show differing ways to achieve a different final appearance. Often a particular owner may feel the need to minimize

Chapter 2 explains how to use the "Utah Guide"



the risk of damage that may be possible with the various methods of construction, or they may not want to alter the basic brick look of their home. Because some of the alternatives shown do not always consider the final impact on appearance, owners need to be aware that major alterations in the architectural appearance could be the result.

STEP 4.
The cost associated with each task should be estimated for the complete list of corrective measures selected then added up to determine an overall total. The budget for the project can then be used to determine how far the seismic improvement process can be taken. Each task should ideally be placed in the ranked priority shown in Table 1, Chapter 5. This priority list can also be readjusted to better meet the homeowners' specific needs considering budget or phasing options.

Each corrective measure that is implemented should improve the seismic performance of the home. If a task is done out of the suggested order, the desired improvement may not be achieved because of the failure of another element. Some measures are much more cost effective than others and this is generally reflected in the suggested order of corrective work. In areas where high levels of ground shaking are probable (IBC Seismic Design Category C through F), seismic improvements that address the top three deficiencies listed in Table 1 in Chapter 5 are recommended as the minimum amount of seismic rehabilitation work. In areas where the level of expected ground shaking is moderate to low (IBC Seismic Design Category A and B) the top two deficiencies listed in Table 1 in Chapter 5 should be addressed as a minimum. Corrective work beyond these minimum recommended levels will improve the seismic performance of the structure and should be considered. It is generally assumed that the best-case seismic zones in the Salt Lake valley are design category C, and therefore it is recommended that the maximum number of seismic deficiencies be addressed.

Chapter 2 also includes a flow chart to help families plan the use of the "Utah Guide" in upgrading URM homes.

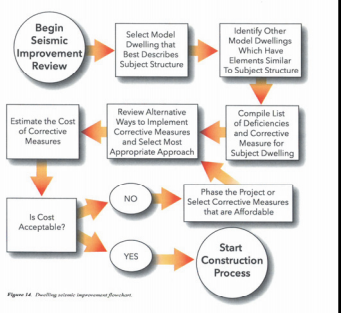
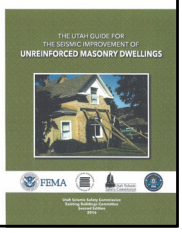


Figure 14. Dwelling seismic improvement flowchart.

Chapter 3 describes how earthquake forces act upon, and are resisted by, typical homes.

- Gives some earthquake history and details of Utah's seismic activity.
- Describes the general structural elements of a home that distribute and resist earthquake forces.
- Provides some background on why URM dwellings can have problems during earthquake events.



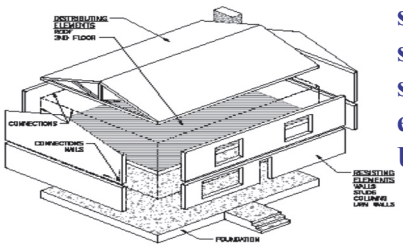
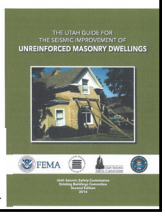


Figure 16 – Isometric view of Typical Structure

Chapter 3 shows typical structural support elements of a URM home.



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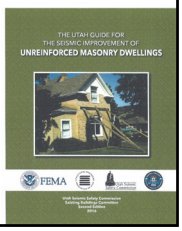
Chapter 4 describes some of the notable features of Un-Reinforced Masonry (URM) construction for dwellings.

- Provides more expaination of the various features and details of URM home construction.
- It helps explain how older URM homes were designed quite differently than newer homes.
- Gives descriptions of some of the weak structural features of URM homes.



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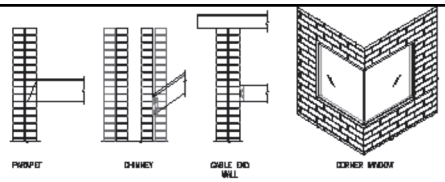
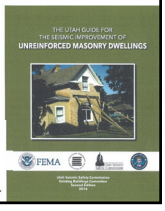


Figure 24 a) Parapet b) Chimney c) Gable End Wall d) Corner Window

Chapter 4 - Features of URM Home Construction.



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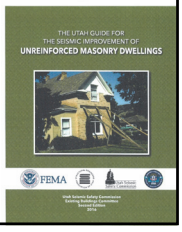
Chapter 5 describes some of the notable features of Un-Reinforced Masonry (URM) construction for dwellings.

- Describes several "Model" types that are typical of URM dwellings, including some photos of the home types.
- Provides a table of Seismic Deficiencies and a ranking of deficiency types in order of priority/risk for improvement.
- Describes deficiencies in each "Model" type of URM dwellings.



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Chapter 5 provides photos of examples of each "Model" type.

Figure 25 Representative Model Home Types

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Chapter 5 also provides a list with a ranking of deficiencies in order of priority for improvement, along with a list of helpful details for each model type.

Table 1. Typical seismic improvement details for model dwelling types A to G for various seismic deficiencies.

Seismic Deficiencies (In order of highest priority to lowest priority)	Model Dwelling Types						
	A	B	C	D	E	F	G
Strengthening and Bracing of Special Features	Details 20, 22, 24, 25, and 26						
Roof to URM Wall Anchorage	Details 30 and 35	Details 31 and 36	Details 32 and 37		Details 33 and 38	Detail 34	Details 32 and 36
Floor to URM Wall and Foundation Wall Anchorage	Details 51, 53, and 54		Details 50, 51, 53, 54, and 56		Details 52 and 55	Detail 51	Details 51 and 54
URM Wall Strengthening	Details 70 and 74						Details 75 and 76
Roof Diaphragm Strengthening	Details 40 and 43						
Floor Diaphragm Strengthening	Detail 57						
Strengthening of Major Interior Bearing Elements	Details 77 and 82						
Foundation Wall Strengthening	Detail 90						
Non-Structural Bracing and Anchorage	For bracing and anchorage of non-structural items, including water heaters, furnishings, cabinets, equipment, etc., see details 100 and higher.						

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SLC's "Fix-the-Bricks" program was set up to work only using a part of the top items listed, as these items offer the most "bang for the buck".

Table 1. Typical seismic improvement details for model dwelling types A to G for various seismic deficiencies.

Seismic Deficiencies (in order of highest priority to lowest priority)	Model Dwelling Types						
	A	B	C	D	E	F	G
Strengthening and Bracing of Special Features	Details 20, 22, 24, 25, and 26						
Roof to URM Wall Anchorage	Details 30 and 35	Details 31 and 36	Details 32 and 37		Details 33 and 38	Detail 34	Details 32 and 36
Floor to URM Wall and Foundation Wall Anchorage	Details 51, 53, and 54		Details 50, 51, 53, 54, and 56		Details 52 and 54	Detail 51	Details 53 and 54
URM Wall Strengthening	Details 70 and 74					Details 75 and 76	
Roof Diaphragm Strengthening	Details 40 and 43						
Floor Diaphragm Strengthening	Detail 57						
Strengthening of Major Interior Bearing Elements	Details 77 and 82						
Foundation Wall Strengthening	Detail 90						
Non-Structural Bracing and Anchorage	For bracing and anchorage of non-structural items, including water heaters, furnishings, cabinets, equipment, etc., see details 100 and higher.						

→ But this "Utah Guide" concept of seismic upgrades is intended as a "Voluntary Partial Seismic Improvement". It does not bring the home into current code compliance!

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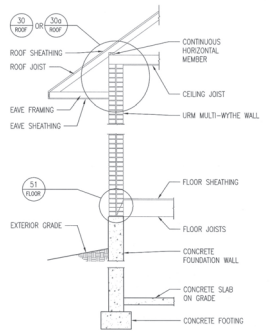
The end of Chapter 5 includes a table of contents of exterior wall sections, followed by the section details that show common construction for each "Model" type.



1 SECTION W/ JOIST FRAMING PERPENDICULAR TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL A	Exterior Wall Sections	DETAIL: 1

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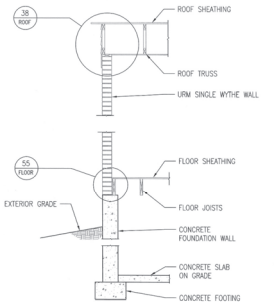
Chapter 5 wall sections include call-outs for more specific details that are shown in the next chapter.



10 SECTION W/ JOIST FRAMING PARALLEL TO WALL

Model Home Seismic Deficiencies	HOME TYPE: MODEL E	Exterior Wall Sections	DETAIL: 10

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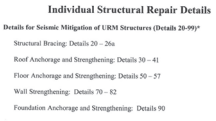
Chapter 6 provides seismic mitigation concepts and ideas, and a lot of details for upgrade of portions of URM homes.



Individual Structural Repair Details

Details for Seismic Mitigation of URM Structures (Details 20-99)*

Structural Bracing: Details 20 – 26a

Roof Anchorage and Strengthening: Details 30 – 41

Floor Anchorage and Strengthening: Details 50 – 57

Wall Strengthening: Details 70 – 82

Foundation Anchorage and Strengthening: Details 90

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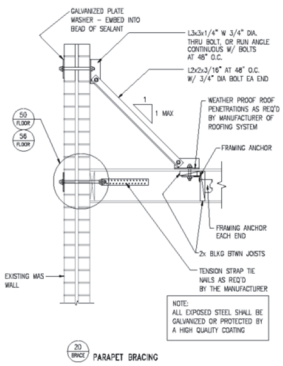
Chapter 6 Details

Remove Or Brace URM Roof Parapets →



20 BRACE PARAPET BRACING

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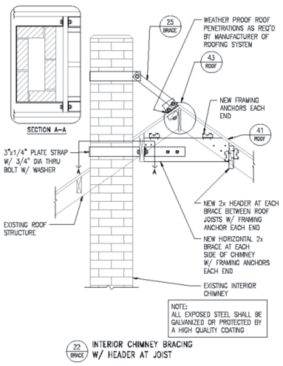
Chapter 6 Details

Brace Central URM Chimneys →



22 BRACE INTERIOR CHIMNEY BRACING W/ HEADER AT JOIST

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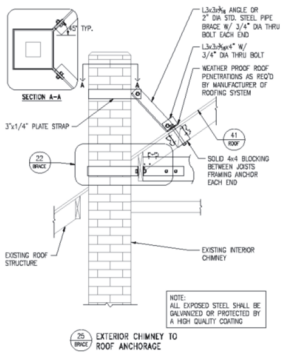
Chapter 6 Details

Brace URM Chimneys →



20 BRACE EXTERIOR CHIMNEY TO ROOF ANCHORAGE

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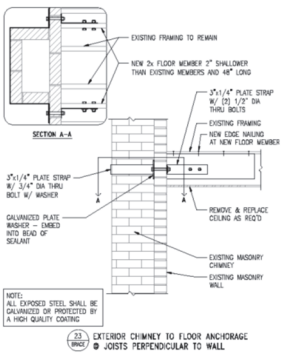
Chapter 6 Details

Tie-Back URM Chimneys at Floor Level →

Not part of the current program in "Fix-the-Bricks"



23 BRACE EXTERIOR CHIMNEY TO FLOOR ANCHORAGE @ JOISTS PERPENDICULAR TO WALL

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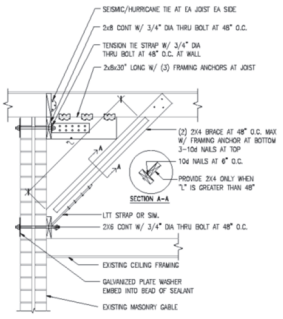
Chapter 6 Details

Brace Tall URM Walls & URM Gable End Walls →



21 BRACE URM GABLE BRACING

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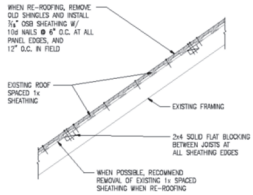
Chapter 6 Details

Tie Roof Sections Together →

Not part of the current program in "Fix-the-Bricks"



41 ROOF ROOF DIAPHRAGM STRENGTHENING

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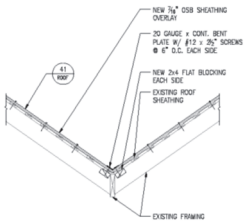
Chapter 6 Details

Tie Roof Sections Together →

Not part of the current program in "Fix-the-Bricks"



45 ROOF SHEAR TRANSFER AT VALLEY

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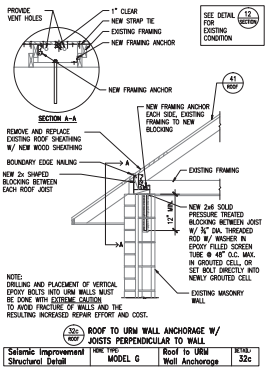
Chapter 6 Details

Roof-to-Wall Tie-In →



32c ROOF ROOF TO URM WALL ANCHORAGE W/ JOISTS PERPENDICULAR TO WALL

Seismic Improvement Structural Detail	HDM TYPE MODEL G	Roof to URM Wall Anchorage	DETAIL 32c

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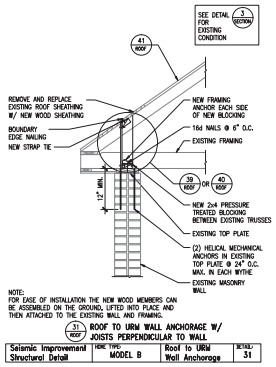
Chapter 6 Details

Roof-to-Wall Tie-In →



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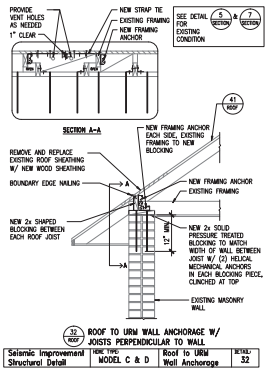
Chapter 6 Details

Roof-to-Wall Tie-In →



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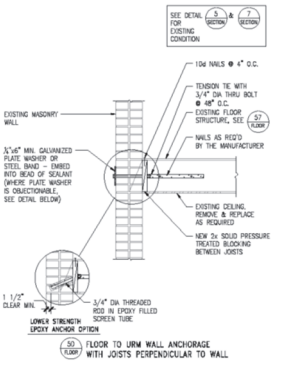
Chapter 6 Details

Floor-to-Wall Tie-In →

Not part of the current program in "Fix-the-Bricks"



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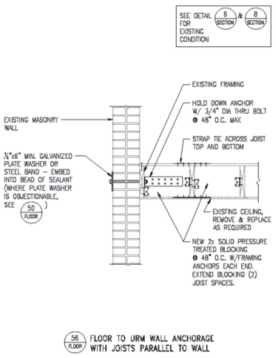
Chapter 6 Details

Floor-to-Wall Tie-In →

Not part of the current program in "Fix-the-Bricks"

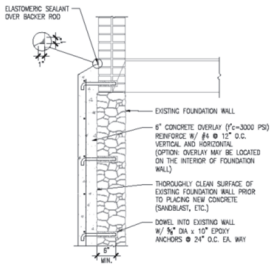


Palmer Engineering

Chapter 6 Details

Foundation Strengthening →

Not part of the current program in "Fix-the-Bricks"



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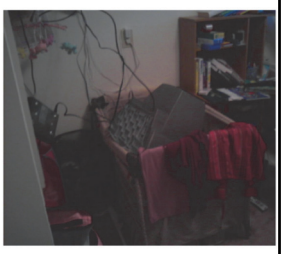
Chapter 7; Anchorage of Non-Structural Items;

- Discusses the danger of unanchored Items on shelves & on entertainment centers.
- Provides a few details for anchorage of bookshelves, tall furniture, water heaters, etc.



Palmer Engineering

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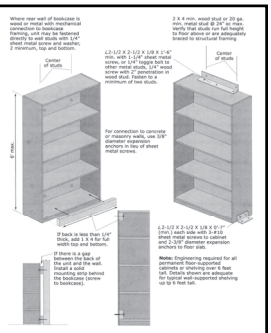

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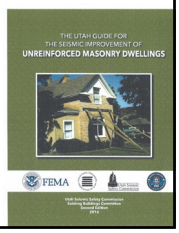
SUMMARY - The Utah Guide For The Seismic Improvement Of Unreinforced Masonry Dwellings

- This is a Revised and Updated edition for 2016.
- A major objective was to better target the intended audience - Home Owners and smaller Remodel Contractors.
- It is hoped that this Utah Guide will be valuable in reducing collapse risk for families living in URM homes, and so help save future injuries & lives!



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Our DESIRED OUTCOME – Improved Safety and Lower Risk of Collapse!

- These improvements DO NOT bring the home up to current code, it provides only Partial Seismic Upgrades!

We want Owners to ask the Question;

Are you safe and comfortable when you land at home?

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FIX THE BRICKS

SALT LAKE CITY EMERGENCY MANAGEMENT

PROGRAMS PURPOSE

- PREVENT COLLAPSE TO REDUCE NUMBER OF DEATH AND INJURIES DURING THE EXPECTED 7.0 EARTHQUAKE BY SEISMICALLY RETROFITTING UNREINFORCED MASONRY HOMES IN THE SALT LAKE CITY BOUNDARIES
- ACHIEVED BY COMPLETING TOP LIFE SAFETY PRIORITY DETAILS =ROOF TO WALL ATTACHMENTS AND CHIMNEY BRACING

HOW DID IT START

- STEERING COMMITTEE
- EDUCATIONAL OUTREACH
- IDEA PITCHED FROM TORNADO SHELTER
- MAYORS PRESS CONFERENCE
- PROGRAM IMPLEMENTATION

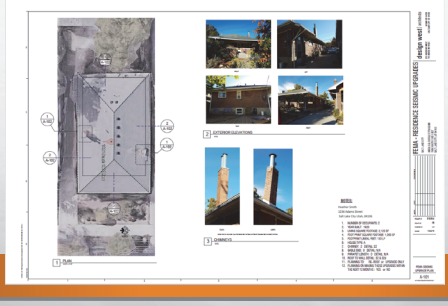
GRANT PHASES

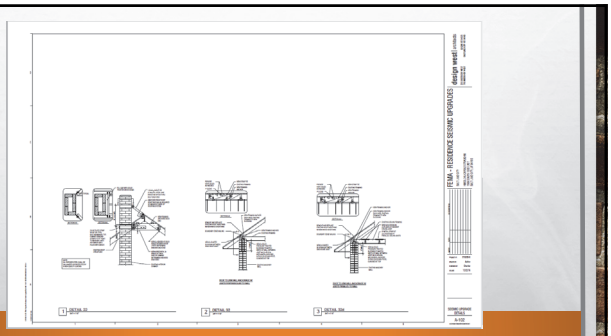
- Pre Application
  - Scopes of Work
  - Seismic EHP
  - BCA
- PDM Application / Award
- Pre Construction / Bids / Homeowner Contract
- Construction / Documentation
- Closeout / FEMA Reimbursement

PRE-APPLICATION

- SLC RESIDENTS SUBMIT REQUEST TO PARTICIPATE IN PROGRAM VIA WEBSITE
  - DURING CERTAIN TIMES OF THE YEAR, APPLICATIONS PEAK
    - EARTHQUAKE OCCURRENCE (UTAH OR WORLD)
    - NATIONAL PREPAREDNESS AWARENESS MONTHS APRIL/SEPTEMBER
- APPLICANTS NOT IN SLC BOUNDARIES ARE MAINTAINED FOR OTHER CITY'S IF THEY CHOOSE TO IMPLEMENT PROGRAM
- APPLICANTS NEVER DELETED
- MAINTAIN LISTS FOR APARTMENTS AND COMPLEXES

SCOPE OF WORK





SEISMIC EHP

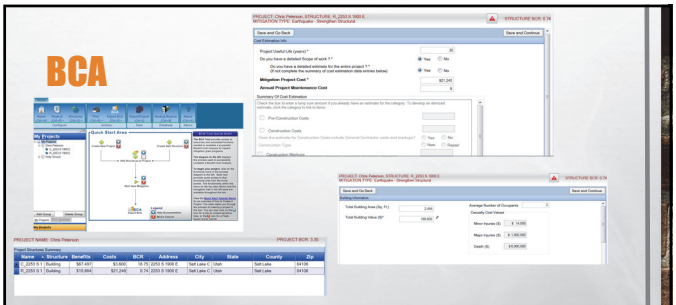
LOCAL

- GO THROUGH PLANNING DIVISION TO GET CERTIFICATE OF APPROVAL
- LOCAL HISTORIC PRESERVATION BOARD HAS ACCEPTED DETAILS AS OUTLINED IN SHPO AGREEMENT ALTHOUGH APPROVED SEPARATELY
- REQUIRES EXTRA DOCUMENTATION

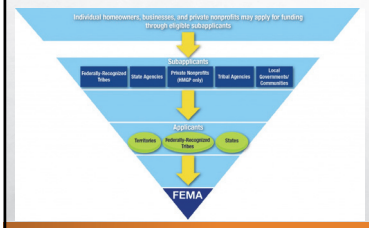
NATIONAL OR 50+ YEARS OLD

- GO THROUGH HOUSING AND NEIGHBORHOOD DEVELOPMENT
- DETAILS REVIEWED AGAINST ARE BASED ON SHPO AGREEMENT WITH STATE

BCA



PDM APPLICATION/AWARD



- CITY INTENDS TO APPLY EVERY YEAR WHEN FEDERAL APPLICATION IS OPEN
- COORDINATE WITH STATE TO DETERMINE HOW MUCH TO REQUEST

BIDS AND CONTRACTS

- WE NOTIFY PARTICIPANTS WHEN THEY CAN BEGIN LOOKING FOR BIDS
- CONTRACTORS COMPETITIVELY BID ON HOMES
- HOMEOWNER PICKS CONTRACTOR
- CONTRACTOR BID COMPARED TO OUR FORMULATED BCA

CONSTRUCTION & DOCUMENTATION

- ONCE REQUIRED DOCUMENTATION SUBMITTED, HOMEOWNERS MOVE FORWARD WITH CONSTRUCTION
- CONTRACTORS DOCUMENTATION REQUIREMENTS
  - PHOTOS OF SEISMIC WORK DURING AND AFTER CONSTRUCTION
  - STAMPED ENGINEERED DRAWINGS
  - BUILDING PERMITS
  - INVOICING
  - LIEN RELEASE

CLOSEOUT & REIMBURSEMENT

- CITY, HOMEOWNER AND CONTRACTOR CONDUCT CLOSEOUT MEETING
- CITY CHECK GIVEN TO HOMEOWNER
- HOMEOWNER SIGNS CHECK OVER TO CONTRACTOR
- EXCHANGE OF INVOICES, RECEIPTS AND LIEN RELEASE

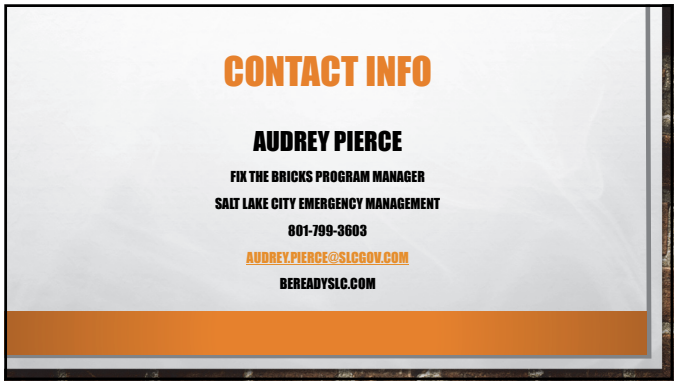
CHALLENGES

- TIMEFRAMES
- NUMBER OF APPLICANTS AND URMS
- EXPANSION
  - MULTI-FAMILY DWELLINGS
  - OTHER JURISDICTIONS

ACCOMPLISHMENTS

- FRAMEWORK AND PROCESS
- ADDITIONAL DETAILS
- PARTNERSHIPS
- WSSPC AWARD
  - EXCELLENCE IN MITIGATION EFFORTS

QUESTIONS


CONTACT INFO
AUDREY PIERCE
FIX THE BRICKS PROGRAM MANAGER
SALT LAKE CITY EMERGENCY MANAGEMENT
801-799-3603
AUDREY.PIERCE@SLCGOV.COM
BEREADYSLC.COM

SHPO – Bracing for the Big One

Introduction

– Chris Hansen, Preservation Planner and Deputy SHPO, Utah State Historic Preservation Office

– clhansen@utah.gov, 801-245-7239

– 300 S. Rio Grande Street, Salt Lake City, UT 84101

NPS Preservation Brief

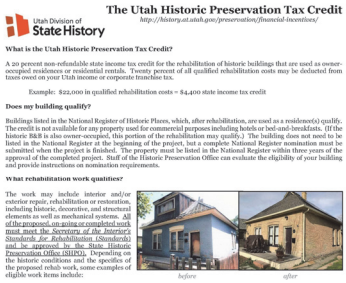
Who We Are

- Utah State Historic Preservation Office (SHPO)
- Utah Division of State History
- Department of Heritage and Arts
- Federal Law: Section 106 of the National Historic Preservation Act
- State Law: Utah Code Annotated Section 9-8-404
- SHPO funded by Historic Preservation Fund administered by the National Park Service

Utah Department of Heritage & Arts

SHPO Historical Architect Project at Work

Utah Historic Tax Credit



The Utah Historic Preservation Tax Credit

http://history.ut.utah.gov/preservation/financial-incentives/

Utah Division of State History

What is the Utah Historic Preservation Tax Credit?

A 20 percent non-refundable state income tax credit for the rehabilitation of historic buildings that are used as owner-occupied residences or residential rentals. Twenty percent of all qualified rehabilitation costs may be deducted from taxes owed on your Utah income or corporate franchise tax.

Example: $22,000 in qualified rehabilitation costs = $4,400 state income tax credit

Does my building qualify?

Buildings listed in the National Register of Historic Places, which, after rehabilitation, are used as a residence(s) qualify. The credit is not available for any property used for commercial purposes including hotels or bed-and-breakfasts. (If the historic B&B is also owner-occupied, this portion of the rehabilitation may qualify.) The building does not need to be listed in the National Register at the beginning of the project, but a complete National Register nomination must be submitted when the project is finished. The property must be listed in the National Register within three years of the approval of the completed project. Staff of the Historic Preservation Office can evaluate the eligibility of your building and provide instructions on nomination requirements.

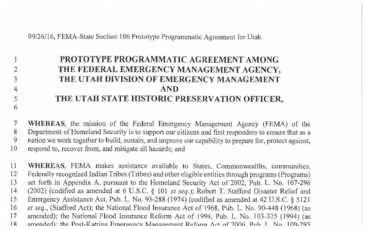
What rehabilitation work qualifies?

The work may include interior and/or exterior repair, rehabilitation or restoration, including historic, decorative, and structural elements as well as mechanical systems. All of the proposed, on-going or completed work must meet the *Secretary of the Interior's Standards for Rehabilitation (Standards)* and be approved by the State Historic Preservation Office (SHPO). Depending on the historic conditions and the specifics of the proposed rehab work, some examples of eligible work items include:

before *after*

SHPO & FEMA

- Individual Projects
  - Brigham City
  - Midway
  - SLC/Leonardo
- FEMA Programmatic Agreement (&Utah DEM)



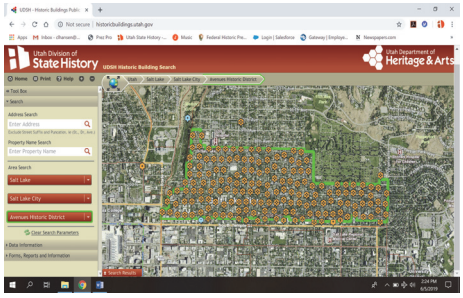
09/26/16, FEMA-State Section 106 Prototype Programmatic Agreement for Utah

PROTOTYPE PROGRAMMATIC AGREEMENT AMONG THE FEDERAL EMERGENCY MANAGEMENT AGENCY, THE UTAH DIVISION OF EMERGENCY MANAGEMENT AND THE UTAH STATE HISTORIC PRESERVATION OFFICER,

WHEREAS, the mission of the Federal Emergency Management Agency (FEMA) of the Department of Homeland Security is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards; and

WHEREAS, FEMA makes assistance available to States, Commonwealths, communities, Federally recognized Indian Tribes (Tribes) and other eligible entities through programs (Programs) set forth in Appendix A, pursuant to the Homeland Security Act of 2002, Pub. L. No. 107-296 (2002) (codified as amended at 6 U.S.C. § 101 *et seq.*); Robert T. Stafford Disaster Relief and Emergency Assistance Act, Pub. L. No. 93-288 (1974) (codified as amended at 42 U.S.C. § 5121 *et seq.*, (Stafford Act); the National Flood Insurance Act of 1968, Pub. L. No. 90-448 (1968) (as amended); the National Flood Insurance Reform Act of 1994, Pub. L. No. 103-325 (1994) (as

Historic Buildings Data



Utah Division of State History

UDSH Historic Building Search

Utah Department of Heritage & Arts

Programmatic Agreement

FEMA Projects

SHPO & Salt Lake City

- HUD/Federal Projects, SLC Programmatic Agreement, Certified Local Government

SALT LAKE CITY

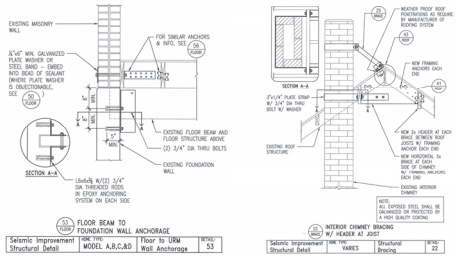
Fix The Bricks

- Undertakings on buildings 50 y/o or older, under Section 106 of the National Historic Preservation Act
- FEMA, the Lead Agency
- Salt Lake City – Delegated authority to consult via Section 106; Certified Local Government; SLC Historic Landmarks Commission, Planning Staff; local application process
- *Utah Guide for Seismic Improvement of URM Dwellings*
- Most project were exempt from SHPO review!

Questions?

- Chris Hansen
clhansen@utah.gov, 801-245-7239

The Utah Guide for Seismic Improvement of Unreinforced Masonry Dwellings, 2016



Principles to Remember

- Good Relationships
- Communication is Key
- Consult Early, Consult Often
- SHPO as a Resource

Utah URM Policy Successes

Brent Maxfield, SE

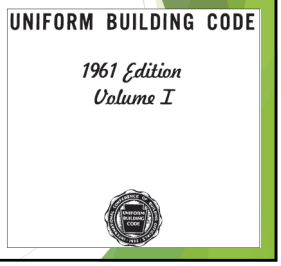
Dealing with URM Buildings

Types of Policy

- Mandatory ("You must do _____ or _____ will happen.")
- Triggers ("If you do _____, then it will trigger that you must do _____.")
- Voluntary (with or without incentives). ("This is a good ideas, so we hope you will do it.")

1961 Uniform Building Code – Outlawed URM Buildings in Seismic Areas

- "All elements within the structure which are of masonry or concrete and which resist seismic forces or movement shall be reinforce so as to qualify as reinforced masonry or concrete as specified in Chapters 24 and 26."
- Codes were adopted by individual jurisdictions.
- Many URM buildings were constructed into the 1970's in Utah.



Utah Legislature

- Pushes critical issues to local jurisdictions
- Focuses on the rights of property owners
- Avoids mandatory ordinances
- Although some efforts have been made, the Utah Legislature has not been aggressive in dealing with URM and seismic issues

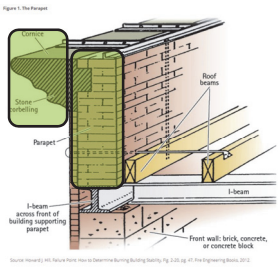
URM Parapets and Walls

2008 Wells NV
Photo Credit: *EERI*

1989 Loma Prieta. 5 People died.
Photo Credit: *James Blacklock, NISEE, U.C. Berkeley*

Utah Parapet Ordinance – 1991 Amendment to the Uniform Building Code (UBC)

- **Trigger:** Reroof



Parapets & Cornices

Spires & Towers

Parapet Ordinance

- Commercial Buildings
- Dealt with more than parapets
  - Parapets
  - Cornices
  - Spires
  - Towers
  - Tanks
  - Statuary
  - Wall to Roof Connections

Parapet Ordinance (Cont)

- On buildings constructed prior to 1975…When reroofing a commercial building
  - Engage an engineer, or, have contractor engage the engineer
  - Engineer creates details
  - Contractor performs work.
- Haphazard Enforcement
  - Many owners and contractors were not aware of the ordinance
  - Many jurisdictions did not enforce
  - Many projects did not get a building permit

2014-2016 Legislature deleted the Parapet Ordinance

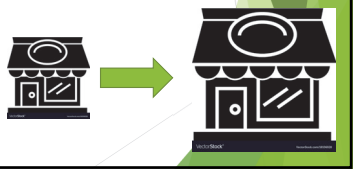
IBC Now Adopts International Existing Buildings Code (IEBC)

- The IEBC requires bracing of URM parapets when reroofing 25% of the roof.
- In essence, the IBC adopted a parapet ordinance.
- Utah amendments extend bracing of parapet to include appendages such as:
  - Cornices
  - Spires
  - Towers
  - Tanks
  - Signs
  - Statuary
- Code and Utah amendment is silent on the wall to roof connections

Change of Occupancy – Early 2000's

- **Trigger**: Change of occupancy type
- (i.e.: from a warehouse to a restaurant or apartments)

- **Trigger**: When change results in a design occupant load increase of 100% or more
- (i.e.: Restaurant, expanding into another part of building)



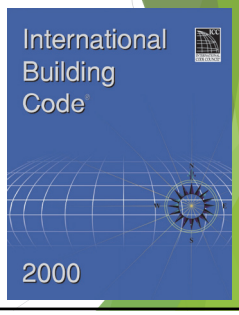
- Requires upgrade to IBC
- Allows use of upgrade standards such as ASCE 41

Change of Occupancy

- IBC and IEBC has trigger for change of occupancy type.
- Utah amendment adds the increase in occupant load within the same occupancy type.

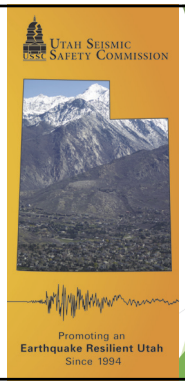
Statewide adoption of building codes (Late 1990's)

- Brought uniformity across the state among all jurisdictions
- As codes address existing building issues, they now become adopted across the state.



1994 Utah Seismic Safety Commission

- Happy 25th Anniversary!

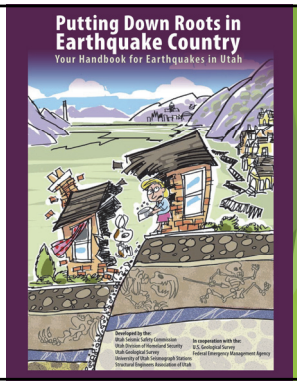


Putting Down Roots in Earthquake Country

Unreinforced Masonry Buildings

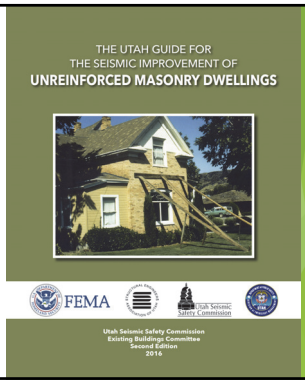
"Many residences, in addition to commercial buildings, are unreinforced masonry buildings and were constructed without knowledge of how these structures performed in earthquakes.

"Unfortunately, experience now shows this is one of the most dangerous building types and evidence of its poor performance in earthquakes throughout the world is well documented."



The Utah Guide for the Seismic Improvement of Unreinforced Masonry Dwellings

"This guide is designed to educate homeowners with respect to the effects of earthquakes on URM dwellings and addresses how individual homeowners can make their own assessment of possible seismic deficiencies and how to improve them."

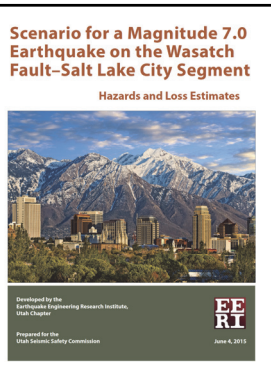


Scenario for a Magnitude 7.0 Earthquake

Reduce Loss of Life by Strengthening Weak Buildings

"One of the most significant sources of deaths, injuries, and damage resulting from a magnitude 7 earthquake is from the likely collapse of two types of buildings. The first is unreinforced masonry buildings. These are referred to as URMs. They are constructed of brick or block that does not contain any or very minimal amounts of reinforcing steel. Many older homes are constructed of URM. . . .

"Newer seismic codes do not allow these types of buildings. These buildings should be strengthened to significantly reduce the loss of life forecast in this scenario. Public education regarding these building types must be provided to allow citizens to make informed decisions about where they live or work. Strengthening weak buildings should be a high priority."



Utah Geological Survey

Produces and provides many resorces

Be Ready Utah

FEMA

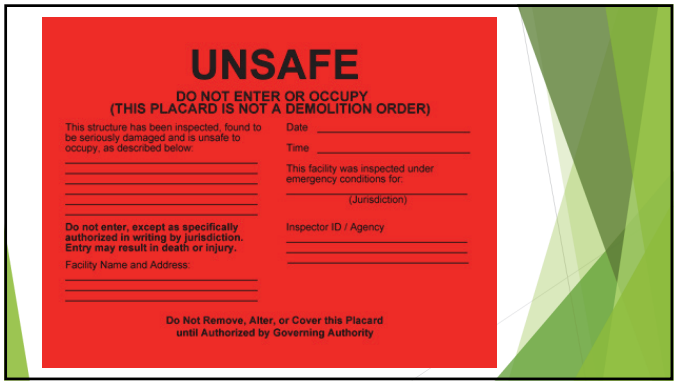
- THANK YOU FOR YOUR SUPPORT!
- Discussed by previous speakers
- Pre-Disaster Mitigation Grants (PDM Grants)

City Efforts

Building Occupancy Resumption Program (BORP)

- BORP allows an owner to resume occupancy of a building as soon as possible following a significant earthquake.

- Adopted by ordinance in:
- Salt Lake City
- Farmington
- Murray
- Others?



With BORP . . .

- Inspectors are already under contract with owner.
- Inspectors are pre-certified by jurisdiction.
- Inspection Plan: Inspectors know what, where, and how to inspect.
- Inspection is done by a structural engineer.
- Uses ATC 20 and ATC 20-2 detailed inspection.
- Inspection also includes other trained professionals.
- **Engineers can alert owner to deficiencies that can be addressed prior to an earthquake.**

BORP: Win – Win - Win

- **Owners Win** - Get back to operations significantly faster
- **Cities Win** - Fewer buildings to worry about in a chaotic environment. Business can begin operations significantly sooner - helping to restart the economy.
- **Public Wins** - Essential services will be restored sooner

Fix the Bricks

- Salt Lake City
- Federal Pre-Mitigation Grant funding
- To date nearly 4 dozen homes are in process of being strengthened

FIX THE BRICKS
SALT LAKE CITY

RE-ROOFING?
REMODELING?
It's the perfect opportunity to make seismic improvements.

School Districts

- Much progress has been made

Schools

- Salt Lake School District
  - 1993 - $70M bond
  - 1999 $136 Bond
  - Started with high schools
  - Methodically going through middles and elementary schools
- Other Districts have similar programs
- Inventory of all Utah Schools mostly complete, but continuing

The Church of Jesus Christ of Latter-day Saints

- Effort began about 20 years ago to evaluate meetinghouse and other facilities
- Process included:
  - Categorizing buildings according to risk
  - Evaluating each building
  - Creating an overall plan and plans for each building
  - Upgrade buildings as opportunities arise (Reroof and interior remodels)

California

1933 Long Beach Earthquake

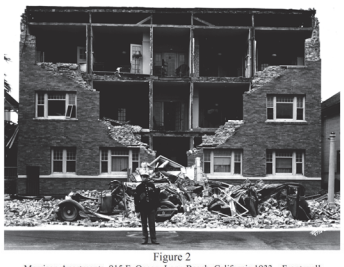


Figure 2
Morrison Apartments, 915 E. Ocean, Long Beach, California 1933 – Front wall only fell away from floors and roof onto street below due to directional properties of earthquake
(Historical Society of Long Beach, PO Box 1869, Long Beach, CA 90801, (562) 424-2270)

1933 Long Beach Earthquake

- Magnitude 6.3
- March 10, 1933
- 5:55 pm
- >230 School buildings destroyed or suffered major damage
- 115 fatalities – Mostly from falling unreinforced masonry
- Could have been thousands had school been in session

Field Act

- Passed April 10, 1933 - 30 Days after Long Beach Earthquake
- Banned URM buildings – Specifically for schools
- Established the Office of the State Architect which developed design standards, quality control procedures, and required that schools be designed by registered architects and engineers. Also required inspections of construction.
- Began the process of eliminating URM buildings throughout the State

Riley Act

- Signed into law May 26, 1933
- Commercial buildings
- Essentially stopped the construction of URM commercial buildings

1986 Unreinforced Masonry Building Law

- Required local governments in Seismic Zone 4 to:
- Inventory URM Buildings
- Establish a URM loss reduction program
- Report progress to state
- Each local government was allowed to tailor their program to their own specifications.
- 365 Jurisdictions, over 25,000 URM Buildings

Loss Reduction Programs

- Mandatory (about ½ of jurisdictions)
- Voluntary
- Notification Only
- Other

Posting Laws

Earthquake Warning.

This is an unreinforced masonry building. You may not be safe inside or near unreinforced masonry buildings during an earthquake.

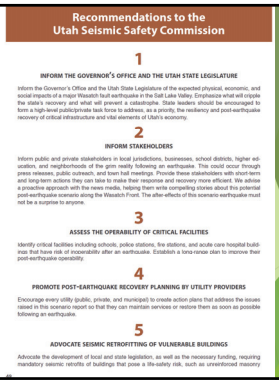
This building has been improved in accordance with the seismic safety standards of a local building ordinance that is applicable to unreinforced masonry.

If Retrofitted

Enforcement

- Laws and ordinances are good, but are of no effect if not enforced.

Future Policy


Recommendations to the Utah Seismic Safety Commission

1

INFORM THE GOVERNOR'S OFFICE AND THE UTAH STATE LEGISLATURE

Inform the Governor's Office and the Utah State Legislature of the expected physical, economic, and social impacts of a major Wasatch fault earthquake in the Salt Lake Valley. Emphasize what will cripple the state's recovery and what will prevent a catastrophe. State leaders should be encouraged to form a high-level public/private task force to address, as a priority, the resiliency and post-earthquake recovery of critical infrastructure and vital elements of Utah's economy.

2

INFORM STAKEHOLDERS

Inform public and private stakeholders in local jurisdictions, businesses, school districts, higher education, and neighborhoods of the grim reality following an earthquake. This could occur through press releases, public outreach, and town hall meetings. Provide these stakeholders with short-term and long-term actions they can take to make their response and recovery more efficient. We advise a proactive approach with the news media, helping them write compelling stories about this potential post-earthquake scenario along the Wasatch Front. The after-effects of this scenario earthquake must not be a surprise to anyone.

3

ASSESS THE OPERABILITY OF CRITICAL FACILITIES

Identify critical facilities including schools, police stations, fire stations, and acute care hospital buildings that have risk of inoperability after an earthquake. Establish a long-range plan to improve their post-earthquake operability.

4

PROMOTE POST-EARTHQUAKE RECOVERY PLANNING BY UTILITY PROVIDERS

Encourage every utility (public, private, and municipal) to create action plans that address the issues raised in this scenario report so that they can maintain services or restore them as soon as possible following an earthquake.

5

ADVOCATE SEISMIC RETROFITTING OF VULNERABLE BUILDINGS

Advocate the development of local and state legislation, as well as the necessary funding, requiring mandatory seismic retrofits of buildings that pose a life-safety risk, such as unreinforced masonry

Utah Future policy

- Educate and inform stakeholders
- Fund incentives for rehabilitation
- Consider mandatory seismic retrofits
- Pass state laws that are best addressed by the state
- Create ordinances for post earthquake repairs and reconstruction

Portland URM Policy

Presentation Overview

- URM building inventory
- Current seismic codes
- URM policy development
- Policy outcomes
- Lessons learned

Buildings and seismic risk

URM inventory

About **1,650 URMs** in Portland, **not** counting single-family homes.

9% of commercial building stock

7,200 residential units

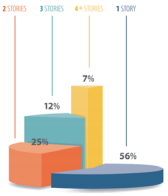
Average age is **90 years**

567 are designated historic

Buildings and seismic risk

URM inventory

URM Buildings by Height



URM Buildings by Use

Commercial	1415
Multifamily	248
Schools and community centers	54
Other	14

Current seismic codes

active trigger for upgrades

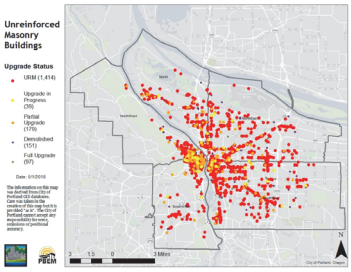
Parapets must be braced and roof tied to walls when > 50% of roof replaced.

Retrofits of URMs to ASCE 41 criteria for life safety required when:

- Work meets $ trigger ($41-$54/ SF)
- Occupancy load increases by > 149
- > 33% of the building changes to higher hazard class

Current seismic codes

effectiveness



Policy has had limited success:

- 9% partially upgraded
- 5% fully upgraded

Policy development

setting the stage

- Tohoku quake
- *Oregon Resilience Report* by Oregon State Seismic Policy Advisory Group
- *New Yorker* article
- Public broadcasting series
- Coverage in local papers

Policy development

Deliberations 2014-2018

Three committees:

- Building Performance
- Finance
- Policy

Recommendations to City Council June 2018

Policy Development

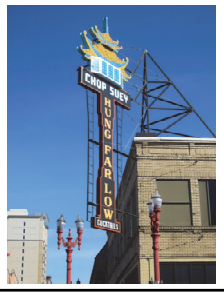
recommendations to Council

Proposed Standard	Building Types	Timeline
Immediate Occupancy (ASCE performance standard)	Critical Buildings + essential facilities	10 years
Damage Control (ASCE)	Schools, community centers	10 years – parapets 20 years – full retrofit
Collapse Risk Reduction (prescriptive standard: brace parapets; wall to roof attachments; roof sheathing)	All URM buildings not in 1,2, or 4	10 years – parapets 15 years – wall to floor
Parapet bracing only	1 and 2-story buildings with 0-10 occupants.	10 years

Policy Outcomes

Portland City Council

- Supported required retrofits to public safety buildings, schools, community centers.
- Created a new committee to address privately-owned buildings.
- Required tenant notification and building placarding (now in litigation).



Policy Outcomes

financial tools

- Authorizing legislation for tax exemption to offset costs (not yet implemented)
- State retrofit grant program, priority to non-profits (stuck in Ways and Means)
- Concepts for local financial supports:
  - Shared appreciation mortgage
  - Subsidized loans
  - Interest-rate buy-downs

Policy Outcomes

public discourse

Policy Outcomes

public discourse

- Robust media coverage
- Increased public awareness of URM risks
- Public protests against policy

Policy Outcomes

lessons learned

- Equity is an issue; consider history of US cities.
- Engage a broad group of stakeholders.
- Keep talking about public safety.

Policy Outcomes

lessons learned

- Funding is the key.
- Prioritize strategically:
  - Schools
  - Subsidized housing
  - Community-serving non-profits
  - Historic structures
  - Public buildings

URM Retrofit Policy

questions?

Jonna Papaefthimiou, AICP
Portland Bureau of Emergency Management
503-793-0737
urms@portlandoregon.gov

Keys to Success: Learn from the Past

Fred Turner, SECB
CA Seismic Safety Commission Staff
Fred.Turner@ssc.ca.gov

Lessons to Consider

- Adequately Staffed and Trained Building Departments:
  - Thorough plan reviews
  - Strict inspections
- Prevent Half-Baked Retrofits:
  - Budget for repairs
  - Demand quality in design & construction
- Avoid Overselling the Merits of Retrofits:
  - Significant Risk Reduction, Life Safety not provided,
  - Still much worse performance than new buildings
- Healthy Respect for Damaged URM buildings after Earthquakes:
  - Barricading and stabilization
  - Damaged Anchor Bolts may no longer be effective

Typical City Building Department Staffing Pop.:100,000 to 249,000

- 25 on staff: 1 Building Official, 4 Clericals, 2 Counter Techs, 4 Plan Checkers, 8 Combination Inspectors, 3 MEP Inspectors, 3 Housing Inspectors
- HS/GED Diplomas
- 3% Training Budget
- 68% of staff had training in the past 5 years

- Unreinforced Masonry Projects can be unusually complex
- Best plan checked by a Structural Engineer, Civil Engineer, or Architect with training in URM retrofit design and construction
- Inspectors should be ACI Certified as Adhesive Anchor Installation Inspectors

Retrofitted Building Performance Expectations Repairs after Sept 2010 M7.1 Darfield Earthquake

0.21g, 50 cm/sec

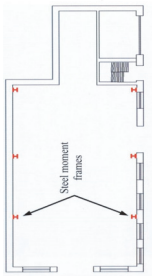
Credit: Osmar Penner October 2010

Figure 45: Joe's Garage Cafe, 194 Hereford Street.

Joe's Garage after Feb 22nd M6.2 Aftershock

Credit: Turner March 2011

0.72g, 87 cm/sec



Credit: Dmytro Dizhur et al NZSEE 2010

Joe's Garage – Damage from February 22, 2011 M6.2 Aftershock in Christchurch

0.72g, 87 cm/sec

Credit: Turner March 2011

Inadequate Wall Anchors

Lime Mortar Low Strength

Figure 6: Example of weak mortar from damaged building.

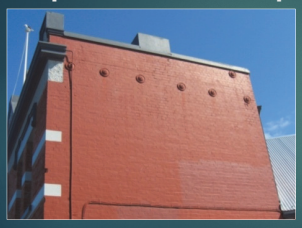
Poor Adhesion Incomplete Mortar Coverage

Progression of URM Damage in a Sequence of Earthquakes

Credit: Jason Ingham 2011

Sept 4, 2010 M7.1

Progression of URM Damage in a Sequence of Earthquakes



Sept 4, 2010 M7.1

Feb 22nd, 2011 M6.2

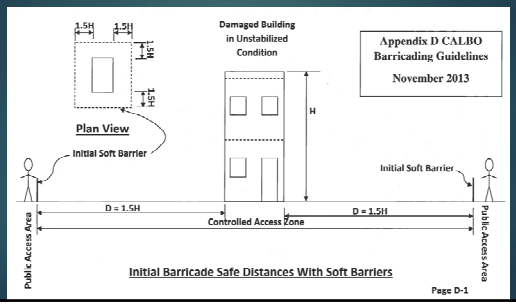
Credit: Jason Ingham 2011

Progression of URM Damage in a Sequence of Earthquakes

June 13, 2011 M5.5, M6.0

Credit: Jason Ingham 2011

Initial Soft Barricade Safe Distances



Plan to Install Hard Barriers

Image Courtesy of Jim Barnes

Status of Compliance with California's URM Law as of 2006

- 98% of URM Buildings in Risk Reduction Programs
- 15% Demolished and Generally Replaced
- 41% Fully Retrofitted to IEBC-A1 or Equivalent
- 13% Partially Retrofitted
- 70% Overall Mitigation Rate – Demolished or Retrofitted

Since 1986 11 Additional Deaths from Falling Masonry:

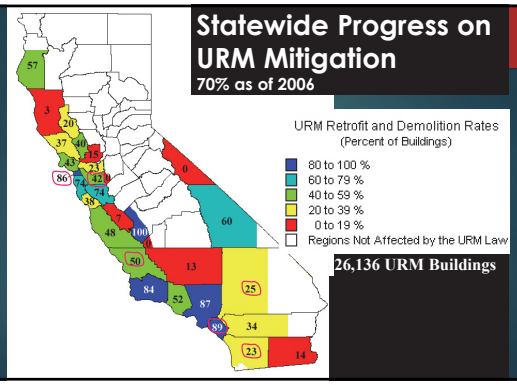
5 in San Francisco, 3 in Santa Cruz, 1 in Yucca Valley
2 in Paso Robles

Mitigation Rates Vary

- Mandatory Strengthening Programs: 87%
- Voluntary Strengthening Programs : 24%
- Notification Only Programs: 13%
- Other Programs: 26%
- Effects of Incentives In Voluntary Programs
  - WITH Incentives: 20% Retrofit Rate
  - WITHOUT Incentives: 14% Retrofit Rate

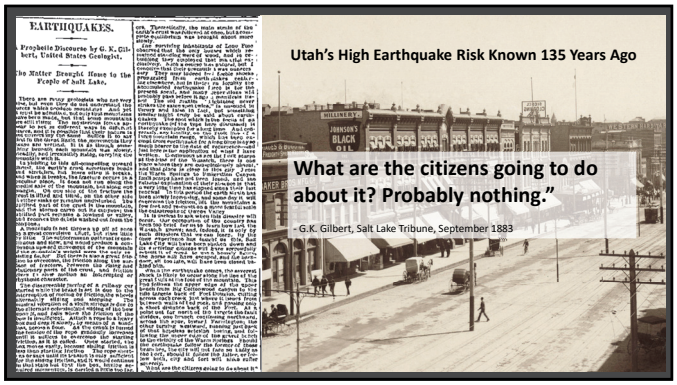
Statewide Progress on URM Mitigation

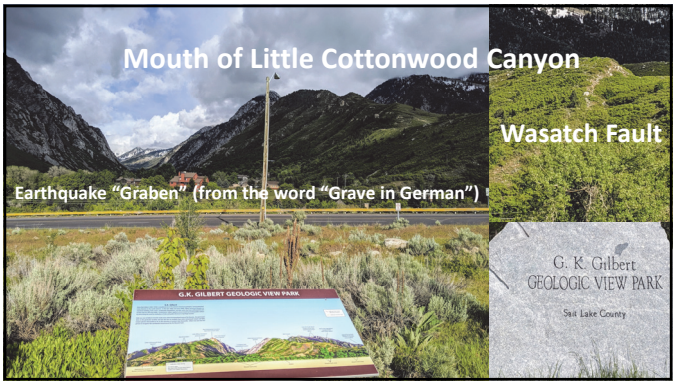
70% as of 2006



Recommendations for Utahans

1. Mandate complete retrofits to a code or standard
2. Use International Existing Building Code A1 or ASCE 41
3. Train Plan Reviewers & Inspectors about Best Practices for URM Retrofits
4. Develop incentives to help owners financially & with technical/project management advice
5. Address other collapse-risk buildings





WHO CREATED ENVISION UTAH?

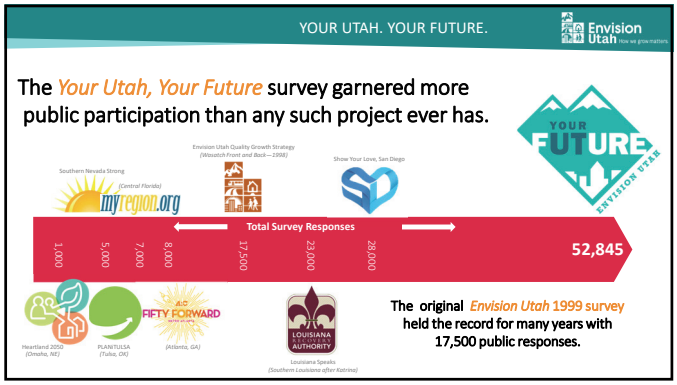
- Formed in 1997 by concerned citizens
  - Governor Mike Leavitt, Spencer F. Eccles, Mayor Tom Dolan, Commissioner Gary Herbert, Elder M. Russell Ballard, Roger Boyer, Aileen Clyde, David P. Gardner, Robert Grow, Harris Simmons, Pamela Atkinson, Kelly Matthews, Ardeth Kapp, Commissioner Dannie McConkie, John Price, Natalie Gochnour and others
- Nonprofit, nonpartisan, voluntary
- Partnership of business, government, and community
- Originally focused on the 10-County Wasatch Front and Back

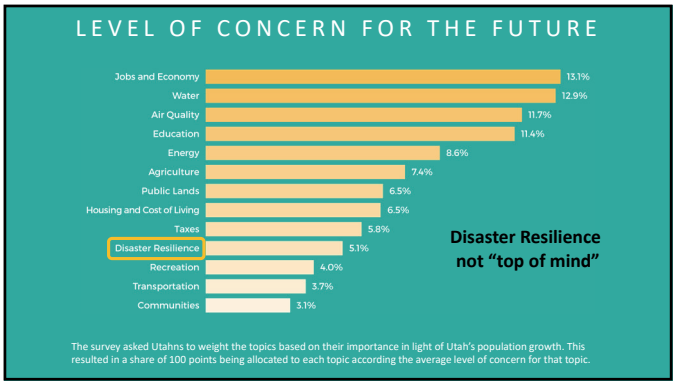
OUR MISSION

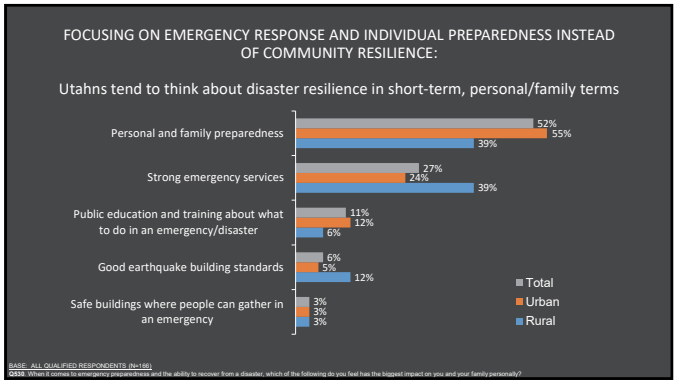
Envision Utah engages people to create and sustain communities that are **beautiful, prosperous, healthy,** and **neighborly** for current and future residents.

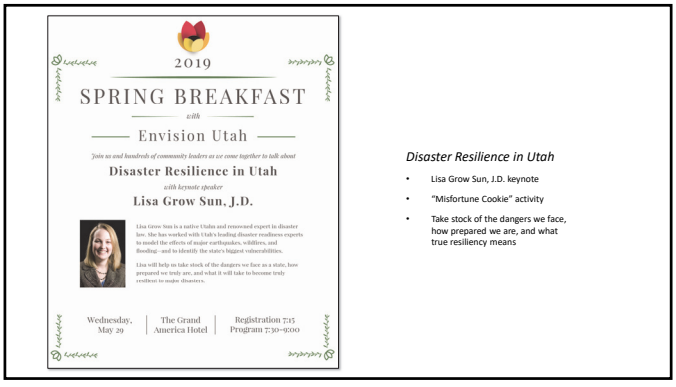

Envision Utah Process
Stakeholders
Values
Scenarios
Outreach
Vision


YOUR UTAH, YOUR FUTURE
VISION FOR 2050
Envision Utah


YOUR UTAH. YOUR FUTURE.
Envision Utah
The Your Utah, Your Future survey garnered more public participation than any such project ever has.
YOUR FUTURE
ENVISION UTAH
Total Survey Responses
1,000
5,500
7,000
8,800
17,500
23,000
28,000
52,845
The original Envision Utah 1999 survey held the record for many years with 17,500 public responses.


LEVEL OF CONCERN FOR THE FUTURE
Jobs and Economy 13.1%
Water 12.9%
Air Quality 11.7%
Education 11.4%
Energy 8.6%
Agriculture 7.4%
Public Lands 6.5%
Housing and Cost of Living 6.5%
Taxes 5.8%
Disaster Resilience 5.1%
Recreation 4.0%
Transportation 3.7%
Communities 3.1%
Disaster Resilience not "top of mind"
The survey asked Utahns to weight the topics based on their importance in light of Utah's population growth. This resulted in a share of 100 points being allocated to each topic according the average level of concern for that topic.


FOCUSING ON EMERGENCY RESPONSE AND INDIVIDUAL PREPAREDNESS INSTEAD OF COMMUNITY RESILIENCE:
Utahns tend to think about disaster resilience in short-term, personal/family terms
Personal and family preparedness 52% 55% 39%
Strong emergency services 27% 24% 39%
Public education and training about what to do in an emergency/disaster 11% 12% 6%
Good earthquake building standards 6% 5% 12%
Safe buildings where people can gather in an emergency 3% 3% 3%
Total
Urban
Rural
BASE: ALL QUALIFIED RESPONDENTS (N=186)


2019
SPRING BREAKFAST
with
Envision Utah
Disaster Resilience in Utah
with keynote speaker
Lisa Grow Sun, J.D.
Wednesday, May 29
The Grand America Hotel
Registration 7:15
Program 7:30–9:00
Disaster Resilience in Utah
Lisa Grow Sun, J.D. keynote
"Misfortune Cookie" activity
Take stock of the dangers we face, how prepared we are, and what true resiliency means

WHY DON'T WE DO MORE TO ADDRESS THE RISK?

WHY DON'T WE SPEND MORE TO REDUCE RISK?

High cost

Distributed risk

MISMATCHED TIME HORIZONS

"The difference between a politician and a statesman is that a politician thinks about the next election while the statesman thinks about the next generation."

- James Freeman Clarke

CULTURAL/POLITICAL RELUCTANCE TO REGULATE AND MANDATE SOLUTIONS

DISTORTED RISK PERCEPTION

THE IRRATIONAL WEIGHER: "BOUNDED RATIONALITY"

COLLECTIVE JUDGMENT
- If all my neighbors have houses like mine, my house must be "safe enough"

HEURISTICS
- Cognitive biases and mental shortcuts
- Manmade risks are more serious than natural risks
- "Affect"
- "Availability"
- "Optimism Bias"

CULTURAL COGNITION OF RISK

Appendix B
Workshop Participants

Federal Emergency Management Agency

Michael Mahoney (Project Officer)
Federal Emergency Management Agency
400 C Street, SW, Suite 313
Washington, D.C. 20472

Andrew Herseth (Task Monitor)
Federal Emergency Management Agency
400 C Street, SW, Suite 313
Washington, D.C. 20472

Applied Technology Council

Jon A. Heintz (Project Executive)
Applied Technology Council
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065

Justin Moresco (Project Manager)
Applied Technology Council
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065

Organizing Committee

Sean McGowan (Chair)
FEMA Region VIII
Building 710, Box 25267
Denver, Colorado 80225

Steve Bowman
Utah Geological Survey
1594 West North Temple, Suite 3110
Salt Lake City, Utah 84116

Bob Carey
Utah Division of Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114

John Crofts
Utah Division of Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114

Craig dePolo
Nevada Bureau of Mines and Geology
1664 North Virginia Street
Reno, Nevada 89557

Drew Herseth
Federal Emergency Management Agency
400 C Street, SW, Suite 313
Washington, D.C. 20472

Mike Mahoney
Federal Emergency Management Agency
400 C Street, SW, Suite 313
Washington, D.C. 20472

Ryan Pietramali
FEMA Region VIII
Building 710, Box 25267
Denver, Colorado 80225

Barry H. Welliver
BHW Engineers
13623 South Bridle Trail Road
Draper, Utah 84020

Breakout Moderators and Recorders

Brad Bartholomew
Utah Division of Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114

Jon A. Heintz
Applied Technology Council
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065

Brent Maxfield
The Church of Jesus Christ of Latter-day Saints
50 East North Temple
Salt Lake City, Utah 84150

Justin Moresco
Applied Technology Council
201 Redwood Shores Parkway, Suite 240
Redwood City, California 94065

Brandon Webb
Federal Emergency Management Agency
1110 State Office Building
Salt Lake City, Utah 84114

Barry H. Welliver
BHW Engineers
13623 South Bridle Trail Road
Draper, Utah 84020

Plenary Speakers

Brad Bartholomew
Utah Division of Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114

Steve Bowman
Utah Geological Survey
1594 West North Temple, Suite 3110
Salt Lake City, Utah 84116

Bob Carey
Utah Division of Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114

Lee dePalo
FEMA Region VIII
Building 710, Box 25267
Denver, Colorado 80225

Mel Green
Melvyn Green and Associates, Inc.,
3868 Carson Street, Suite 300
Torrance, California 90503

Robert J. Grow
Envision Utah
254 South 600 East, Suite 201
Salt Lake City, Utah 84102

Chris Hansen
Utah Division of State History
300 South Rio Grande Street
Salt Lake City, Utah 84101

Iain Hyde
Argonne National Laboratory
955 L'Enfant Plaza SW, Suite 6000
Washington, D.C. 20023

Laurie Johnson
Laurie Johnson Consulting | Research
San Rafael, California 94903

Eric Letvin
Federal Emergency Management Agency
400 C Street SW
Washington, D.C. 20472

Brent Maxfield
The Church of Jesus Christ of Latter-day Saints
50 East North Temple
Salt Lake City, Utah 84150

Sean McGowan
FEMA Region VIII
Building 710, Box 25267
Denver, Colorado 80225

Glen Palmer
Palmer Engineering, LLC
2408 North 1050 West
Pleasant Grove, Utah 84062

Jonna Papaefthimiou
Portland Bureau of Emergency Management
9911 SE Bush Street
Portland, Oregon 97266

Audrey Pierce
Salt Lake City Emergency Management
475 South 300 East
Salt Lake City, Utah 84111

Randy Silverman
University of Utah Marriott Library
295 South 1500 East
Salt Lake City, Utah 84112

Fred Turner
Alfred E. Alquist California Seismic Safety Commission
1516 40th Street
Sacramento, California 95819

Judy Watanabe
Utah Division of Emergency Management
1110 State Office Building
Salt Lake City, Utah 84114

Barry H. Welliver
BHW Engineers
13623 South Bridle Trail Road
Draper, Utah 84020

Participants

Brittany Allen
Salt Lake County

Christina Aronson
FEMA

Paul Ashton
City of Orem

Harry Audell
Park City Geotechnical

Talisha Bacon
UCHD

Brad Bartholomew
Utah Division of Emergency Management

Trenton Bennett
Price City

Leon Berrett
Salt Lake County Public Works

Brian Blake
Central U.S. Earthquake Consortium

John Bloom
UCAN

Patricia Borsos
FEMA Region VIII

Steve Bowman
Utah Geological Survey

Lara Brodetsky
Western States Seismic Policy Council

Craig Browne
Weber County

Mike Buehner
Reaveley Engineers

Jess Campbell
Saratoga Springs Fire & Rescue

Bob Carey
Utah Division of Emergency Management

Divya Chandrasekhar
University of Utah

Jessica Chappell
Reaveley Engineers

Lloyd Cheney
Bountiful City

Bill Cobabe
Pleasant View City

Michael Conway
Arizona Geological Survey

Steven Cornell
State of Utah

John Crofts
Utah Division of Emergency Management

Lee dePalo
FEMA Region VIII

Craig DePolo
Nevada Bureau of Mines and Geology

Gordon Douglass
Utah Geological Survey

Nancy Dragani
FEMA

Lynsey Eddington
Pleasant Grove Police

Tal Ehlers
Uintah County Utah

Ben Erickson
Utah Geological Survey

Michael Fazio
City of Bluffdale

Chris Garris
CEL

Jason Gilbert
Student

Angela Gladwell
FEMA/FIMA

Jeff Graviet
University of Utah Department of Public Safety

Mel Green
Melvyn Green & Associates, Inc.

Robert J. Grow
Envision Utah

Tom Grummon
Wood / Geologic Engineer

Chris Hansen
FEMA

Richard Hansen
Utah State History

Jim Hardy
Millcreek

Brandon Hayes
Utah Valley University

Jon Heintz
Applied Technology Council

Werner Hellmer
Clark County Dept. of Building and Fire Prevention

Jeffrey Herd
FEMA Region VIII

Andrew Herseth
FEMA

David Heslington
Church of Jesus Christ of Latter-day Saints

Adam Hiscock
Utah Geological Survey

Eric Hoffman
Ensign Engineering, Inc.

John Hollenhorst
KSL-TV

Daniel Horns
Utah Valley University

Valerie Humphrey
Western Governors University

Iain Hyde
Argonne National Laboratory

Michael Hylland
Utah Geological Survey

Sara Javoronok
Salt Lake City

Jared Johnson
Ogden City

Jerod Johnson
Reaveley Engineers

Laurie Johnson
Laurie Johnson Consulting | Research

Lynn Kimbrough
FEMA External Affairs | Region VIII

Nate Knapp
FEMA/ Region VIII Response

Rebecca Kurgan
Salt Lake City Emergency Mangement

Nannette Larsen
Salt Lake City

Eric Letvin
FEMA

Mayara Lima
Salt Lake City Corp

John Little
Spanish Fork City

Pam Lofgreen
Salt Lake City Emergency Management

Bill Lund
Utah Geological Survey

Rita Lund
Millcreek City

Jason Mackelprang
Sevier County Building/Zoning Dept.

Mike Mahoney
FEMA

Brent Maxfield
The Church of Jesus Christ of Latter-day Saints

Jim McClintic
Sandy City

Conor McClintock
FEMA Region VIII

Mike McComb
Park City Municipal Corporation

Sean McGowan
FEMA Region VIII

Adam McKean
Utah Geological Survey

John Meek
Clearfield City

Summer Misner
Salt Lake City Emergency Management

Ty Montalvo
South Jordan City

Justin Moresco
Applied Technology Council

Richard Myers
FEMA Region VIII

Mike Myers
Portland Bureau of Emergency Management

Miles Nelson
Price City

Richard Novasio
Millcreek

Glen Palmer
Palmer Engineering

Joel Palmer
FEMA Region VIII

Jonna Papaefthimiou
Portland Bureau of Emergency Management

Steve Patrick
City of Ogden

James Pechmann
University of Utah

Ryan Perkins
City of Ogden

Ken Peterson
City of Orem

Thomas Peterson
State of Utah

Jeanine Petterson
FEMA

Audrey Pierce
Salt Lake City Emergency Management

Ryan Pietramali
FEMA

Andrew Sabata
FEMA

Chelsea Samuelson
Utah Geological Survey

Ashley Scarff
Salt Lake City Corp.

Steven Schamel
GeoX Consulting Inc.

Tyler Seaman
Clearfield City

Randy Silverman
University of Utah Marriott Library

Amanda Siok
FEMA Region X

Trent Sorensen
Salt Lake County

Skyler Stratford
Millcreek Office of Emergency Management

Patrick Tomasino
State of Utah - DFCM

David Triplett
CRSA

Fred Turner
California Seismic Safety Commission

Judy Watanabe
Utah Division of Emergency Management

Brandon Webb
FEMA

Barry H. Welliver
BHW Engineers

Ben White
West Bountiful City

Craig Wilkinson
Reaveley Engineers

Grant Willis
Utah Geological Survey

Tyler Wiseman
Trust Lands Administration

Ivan Wong
Lettis Consultants International/California Seismic Safety Commission

Katrina Woodhams
FEMA Region VIII

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Applied Technology Council Projects and Report Information

One of the primary purposes of the Applied Technology Council is to develop engineering applications and resources that translate and summarize useful information for practicing building and bridge design professionals. This includes the development of guidelines and manuals, as well as the development of research recommendations for specific areas determined by the profession. ATC is not a code development organization, although ATC project reports often serve as resource documents for the development of codes, standards and specifications.

Applied Technology Council conducts projects that meet the following criteria:

1. The primary audience or benefactor is the design practitioner in structural engineering.
2. A cross section or consensus of engineering opinion is required to be obtained and presented by a neutral source.
3. The project fosters the advancement of structural engineering practice.

Funding for projects is obtained from government agencies and tax-deductible contributions from the private sector. Brief descriptions of completed ATC projects and reports are provided below.

ATC-1: This project resulted in five papers published as part of *Building Practices for Disaster Mitigation, Building Science Series 46*, proceedings of a workshop sponsored by the National Science Foundation (NSF) and the National Bureau of Standards (NBS). Available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22151, as NTIS report No. COM-73-50188.

ATC-2: The report, *An Evaluation of a Response Spectrum Approach to Seismic Design of Buildings*, was funded by NSF and NBS and was conducted as part of the Cooperative Federal Program in Building Practices for Disaster Mitigation. Available through ATC. (Published 1974, 270 Pages)

ATC-3: The report, *Tentative Provisions for the Development of Seismic Regulations for Buildings* (ATC-3-06), was funded by NSF and NBS. The tentative provisions in this report served as the basis for the seismic provisions of the 1988 and subsequent issues of the *Uniform Building Code* and the *NEHRP Recommended Provisions for the Development of Seismic Regulation for New Building and Other Structures*. The second printing contains proposed amendments prepared by a joint committee of the Building Seismic Safety Council (BSSC) and the NBS. Available through ATC. (Published 1978, amended 1982, 505 pages plus proposed amendments)

ATC-3-2: The project, "Comparative Test Designs of Buildings Using ATC-3-06 Tentative Provisions", was funded by NSF. It consisted of a study to develop and plan a program for making comparative test designs of the ATC-3-06 Tentative Provisions. The project report was intended for use by the Building Seismic Safety Council in its refinement of the ATC-3-06 Tentative Provisions.

ATC-3-4: The report, *Redesign of Three Multistory Buildings: A Comparison Using ATC-3-06 and 1982 Uniform Building Code Design Provisions*, was published under a grant from NSF. Available through ATC. (Published 1984, 112 pages)

ATC-3-5: The project, "Assistance for First Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting

the first phase of its program to develop trial designs for buildings in Los Angeles, Seattle, Phoenix, and Memphis.

ATC-3-6: The project, "Assistance for Second Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting the second phase of its program to develop trial designs for buildings in New York, Chicago, St. Louis, Charleston, and Fort Worth.

ATC-4: The report, *A Methodology for Seismic Design and Construction of Single-Family Dwellings*, was published under a contract with the Department of Housing and Urban Development (HUD). Available through ATC. (Published 1976, 576 pages)

ATC-4-1: The report, *The Home Builders Guide for Earthquake Design*, was published under a contract with HUD. Available through ATC. (Published 1980, 57 pages)

ATC-5: The report, *Guidelines for Seismic Design and Construction of Single-Story Masonry Dwellings in Seismic Zone 2*, was developed under a contract with HUD. Available through ATC. (Published 1986, 38 pages)

ATC-6: The report, *Seismic Design Guidelines for Highway Bridges*, was published under a contract with the Federal Highway Administration (FHWA). Available through ATC. (Published 1981, 210 pages)

ATC-6-1: The report, *Proceedings of a Workshop on Earthquake Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1979, 625 pages)

ATC-6-2: The report, *Seismic Retrofitting Guidelines for Highway Bridges*, was published under a contract with FHWA. Available through ATC. (Published 1983, 220 pages)

ATC-7: The report, *Guidelines for the Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1981, 190 pages)

ATC-7-1: The report, *Proceedings of a Workshop on Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1980, 302 pages)

ATC-8: The report, *Proceedings of a Workshop on the Design of Prefabricated Concrete Buildings for Earthquake Loads*, was funded by NSF. Available through ATC. (Published 1981, 400 pages)

ATC-9: The report, *An Evaluation of the Imperial County Services Building Earthquake Response and Associated Damage*, was published under a grant from NSF. Available through ATC. (Published 1984, 231 pages)

ATC-10: The report, *An Investigation of the Correlation Between Earthquake Ground Motion and Building Performance*, was funded by the U.S. Geological Survey (USGS). Available through ATC. (Published 1982, 114 pages)

ATC-10-1: The report, *Critical Aspects of Earthquake Ground Motion and Building Damage Potential*, was co-funded by the USGS and the NSF. Available through ATC. (Published 1984, 259 pages)

ATC-11: The report, *Seismic Resistance of Reinforced Concrete Shear Walls and Frame Joints: Implications of Recent Research for Design Engineers*, was published under a grant from NSF. Available through ATC. (Published 1983, 184 pages)

ATC-12: The report, *Comparison of United States and New Zealand Seismic Design Practices for Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1982, 270 pages)

ATC-12-1: The report, *Proceedings of Second Joint U.S.-New Zealand Workshop on Seismic Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1986, 272 pages)

ATC-13: The report, *Earthquake Damage Evaluation Data for California*, was developed under a contract with the Federal Emergency Management Agency (FEMA). It presents expert-opinion earthquake damage and loss estimates for industrial, commercial, residential, utility and transportation facilities in California. Included are damage probability matrices for 78 classes of structures and estimates of time required to restore damaged facilities to pre-earthquake usability. Available through ATC. (Published 1985, 492 pages)

ATC-13-1: The report, *Commentary on the Use of ATC-13 Earthquake Damage Evaluation Data for Probable Maximum Loss Studies of California Buildings*, was developed with funding from the

ATC Endowment Fund. It provides guidance for using ATC-13 expert-opinion data for probable maximum loss (PML) studies of California buildings. Included are discussions of the limitations on the use of the ATC-13 expert-opinion data, and appendices containing information not included in the original ATC-13 report, such as model building type descriptions, beta damage distribution parameters for ATC-13 model building types, and PML values for ATC-13 model building types. Available through ATC. (Published 2002, 66 pages)

ATC-14: The report, *Evaluating the Seismic Resistance of Existing Buildings*, was developed under a grant from the NSF. It describes a methodology for performing preliminary and detailed seismic evaluations of buildings. A precursor to the eventual ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*, it contains useful background information including a state-of-practice review; seismic loading criteria; data collection procedures; a detailed description of the building classification system; preliminary and detailed analysis procedures; and example case studies, including nonstructural considerations. Available through ATC. (Published 1987, 370 pages)

ATC-15: The report, *Comparison of Seismic Design Practices in the United States and Japan*, was published under a grant from NSF. Available through ATC. (Published 1984, 317 pages)

ATC-15-1: The report, *Proceedings of Second U.S.-Japan Workshop on Improvement of Building Seismic Design and Construction Practices*, was published under a grant from NSF. It includes state-of-the-practice papers and case studies of actual building designs and information on regulatory, contractual, and licensing issues. Available through ATC. (Published 1987, 412 pages)

ATC-15-2: The report, *Proceedings of Third U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes state-of-the-practice papers on steel braced frame and reinforced concrete buildings, base isolation and passive energy dissipation devices, and comparisons between U.S. and Japanese design practice. Available through ATC. (Published 1989, 358 pages)

ATC-15-3: The report, *Proceedings of Fourth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on postearthquake building damage assessment; acceptable earthquake damage; repair and retrofit of earthquake-damaged buildings; base-isolated buildings, Architectural Institute of Japan recommendations for design; active damping systems; and wind-resistant design. Available through ATC. (Published 1992, 484 pages)

ATC-15-4: The report, *Proceedings of Fifth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on performance goals and acceptable damage; seismic design procedures and case studies; seismic evaluation, repair and upgrade; construction influences on design; isolation and passive energy dissipation; design of irregular structures; and quality control for design and construction. Available through ATC. (Published 1994, 360 pages)

ATC-15 Series: The purpose of this project series is to conduct workshops between the U.S., Japan, and New Zealand to develop policy recommendations for improved community resilience based on the current state-of-practice, innovative engineering solutions, and new and emerging technologies in all three countries.

ATC-16: The FEMA 90 report, *An Action Plan for Reducing Earthquake Hazards of Existing Buildings*, was funded by FEMA and was conducted by a joint venture of ATC, the Building Seismic Safety Council and the Earthquake Engineering Research Institute. Available through FEMA. (Published 1985, 75 pages)

ATC-17: The report, *Proceedings of a Seminar and Workshop on Base Isolation and Passive Energy Dissipation*, was published under a grant from NSF. It includes papers describing case studies in the United States, applications and developments worldwide, recent innovations in technology development, and structural and ground motion issues in base-isolation and passive energy-dissipation. Also included is a proposed 5-year research agenda. Available through ATC. (Published 1986, 478 pages)

ATC-17-1: The report, *Proceedings of a Seminar on Seismic Isolation, Passive Energy Dissipation and Active Control,* was published under a grant from NCEER and NSF. Available through ATC. (Published 1993, 841 pages in two volumes)

ATC-17-2: The project, "Seminar on Response Modification Technologies for Performance-Based Seismic Design", was funded by MCEER. The seminar was held on May 30-31, 2002, in Los Angeles, California.

ATC-18: The report, *Seismic Design Criteria for Bridges and Other Highway Structures: Current and Future***,** was developed under a grant from NCEER and FHWA. Available through ATC. (Published, 1997, 151 pages)

ATC-18-1: The report, *Impact Assessment of Selected MCEER Highway Project Research on the Seismic Design of Highway Structures***,** was developed under a contract with the Multidisciplinary Center for Earthquake Engineering Research (MCEER, formerly NCEER) and FHWA. Available through ATC. (Published, 1999, 136 pages)

ATC-19: The report, *Structural Response Modification Factors* was funded by NSF and NCEER. Available through ATC. (Published 1995, 70 pages)

ATC-20: The report, *Procedures for Postearthquake Safety Evaluation of Buildings*, was developed under a contract with the California Office of Emergency Services (OES), California Office of Statewide Health Planning and Development (OSHPD) and FEMA. It provides procedures and guidelines for inspecting buildings that have been damaged in an earthquake, and making decisions regarding their continued use and occupancy. Written for volunteer structural engineers and building inspectors, it includes rapid and detailed evaluation procedures for posting buildings as "inspected" (apparently safe, green placard), "limited entry" (yellow) or "unsafe" (red). Available through ATC (Published 1989, 152 pages)

ATC-20-1: The report, *Field Manual: Postearthquake Safety Evaluation of Buildings*, *Second Edition*, was funded by Applied Technology Council. A companion to the ATC-20 report, the *Field Manual* summarizes postearthquake safety evaluation procedures in a concise format designed for ease of use in the field. Available through ATC. (Published 2005, 143 pages)

ATC-20-1 Bhutan: The report, *Bhutan Field Manual: Postearthquake Safety Evaluation of Buildings,* was developed in partnership with GeoHazards International and the Royal Government of Bhutan's Department of Engineering Services and Department of Disaster Management with funding from the ATC Endowment Fund and the World Bank's Global Facility for Disaster Reduction in Recovery. The *Bhutan Field Manual* is an adaptation of the postearthquake safety evaluation procedures described in ATC-20 to account for Bhutan's vernacular buildings, as well as Bhutan's cultural and governmental context. Available through ATC. (Published 2014, 246 pages)

ATC-20-2: The report, *Addendum to the ATC-20 Postearthquake Building Safety Procedures* was published under a grant from the NSF and funded by the USGS. It provides updated assessment forms, placards, and evaluation procedures based on application and use in five earthquake events that occurred after the initial release of the ATC-20 report. Available through ATC. (Published 1995, 94 pages)

ATC-20-3: The report, *Case Studies in Rapid Postearthquake Safety Evaluation of Buildings,* was funded by ATC and R.P. Gallagher Associates. Containing over 50 case studies using the ATC-20 Rapid Evaluation procedure, the report is intended for use as a training and reference manual describing how buildings are inspected and evaluated. Illustrated with photos and completed safety assessment forms and placards. Available through ATC. (Published 1996, 295 pages)

ATC-20-T: The *Postearthquake Safety Evaluation of Buildings Training CD* was developed in cooperation with FEMA. The 4½-hour training seminar includes photographs, schematic drawings, and textual information. Available through ATC. (Published 2002, 230 PowerPoint slides with Speakers Notes)

ATC-21: The FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, *Second Edition*, was developed under a contract with FEMA. It describes a rapid visual screening procedure for identifying buildings that might pose serious risk of loss of life and injury in the event of a

damaging earthquake. Available through ATC and FEMA. (Published 2002, 161 pages)

ATC-21-1: The FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*, *Second Edition*, was developed under a contract with FEMA. It provides the technical basis for the updated rapid visual screening procedure. Available through ATC and FEMA. (Published 2002, 117 pages)

ATC-21-2: The report, *Earthquake Damaged Buildings: An Overview of Heavy Debris and Victim Extrication*, was developed under a contract with FEMA. (Published 1988, 95 pages)

ATC-21-T: The report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards Training Manual, Second Edition,* was developed under a contract with FEMA. Training materials include120 slides in PowerPoint format and companion narrative coordinated with the presentation. Available through ATC. (Published 2004, 148 pages and PowerPoint presentation on companion USB)

ATC-22: The report, *A Handbook for Seismic Evaluation of Existing Buildings (Preliminary)*, was developed under a contract with FEMA in 1989. Based on the information originally developed in ATC-14, this report was revised by BSSC and published as the FEMA 178 report, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* in 1992, revised by ASCE and published as the FEMA 310 report, *Handbook for the Seismic Evaluation of Buildings – a Prestandard* in 1998. Available through the American Society of Civil Engineers as the ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*.

ATC-22-1: The report, *Seismic Evaluation of Existing Buildings: Supporting Documentation*, was developed under a contract with FEMA. (Published 1989, 160 pages)

ATC-23A: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part A: Survey Description, Summary of Results, Data Analysis and Interpretation*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 58 pages)

ATC-23B: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part B: Raw Data*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 377 pages)

ATC-24: The report, *Guidelines for Seismic Testing of Components of Steel Structures*, was jointly funded by the American Iron and Steel Institute (AISI), American Institute of Steel Construction (AISC), National Center for Earthquake Engineering Research (NCEER), and NSF. Available through ATC. (Published 1992, 57 pages)

ATC-25: The report, *Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous United State*s, was developed under a contract with FEMA. Available through ATC. (Published 1991, 440 pages)

ATC-25-1: The report, *A Model Methodology for Assessment of Seismic Vulnerability and Impact of Disruption of Water Supply Systems*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 147 pages)

ATC-26: This project, "U.S. Postal Service National Seismic Program," was funded under a contract with the U.S. Postal Service (USPS), and resulted in the following interim documents:

ATC-26, *Cost Projections for the U. S. Postal Service Seismic Program* (Completed 1990)

ATC-26-1, *United States Postal Service Procedures for Seismic Evaluation of Existing Buildings (Interim)* (Completed 1991)

ATC-26-2, *Procedures for Post-disaster Safety Evaluation of Postal Service Facilities (Interim)*. Available through ATC. (Published 1991, 221 pages)

ATC-26-3, *Field Manual: Post-earthquake Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 133 pages)

ATC-26-3A, *Field Manual: Post Flood and Wind Storm Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 114 pages)

ATC-26-4, *United States Postal Service Procedures for Building Seismic Rehabilitation (Interim)* (Completed 1992)

ATC-26-5, *United States Postal Service Guidelines for Building and Site Selection in Seismic Areas (Interim)* (Completed 1992)

ATC-28: The report, *Development of Recommended Guidelines for Seismic Strengthening of Existing Buildings, Phase I: Issues Identification and Resolution*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 150 pages)

ATC-29: The report, *Proceedings of a Seminar and Workshop on Seismic Design and Performance of Equipment and Nonstructural Elements in Buildings and Industrial Structures*, was developed under a grant from NCEER and NSF. It includes papers describing current practice, codes and regulations; earthquake performance; analytical and experimental investigations; development of new seismic qualification methods; and research, practice, and code development needs for nonstructural elements and systems. Available through ATC. (Published 1992, 470 pages)

ATC-29-1: The report, *Proceedings of a Seminar on Seismic Design, Retrofit, and Performance of Nonstructural Components*, was developed under a grant from NCEER and NSF. It includes papers on observed performance in recent earthquakes; seismic design codes, standards, and procedures for commercial and institutional buildings; design issues relating to industrial and hazardous material facilities; and seismic evaluation and rehabilitation of components in conventional and essential facilities. Available through ATC. (Published 1998, 518 pages)

ATC-29-2: The report, *Proceedings of Seminar on Seismic Design, Performance, and Retrofit of Nonstructural Components in Critical Facilities*, was developed under a grant from MCEER (formerly NCEER) and NSF. It includes papers on seismic design, performance, and retrofit of nonstructural components in critical facilities including current practices and emerging codes; seismic design and retrofit; risk and performance evaluation; system qualification and testing; and advanced technologies. Available through ATC. (Published 2003, 574 pages)

ATC-30: The report, *Proceedings of Workshop for Utilization of Research on Engineering and Socioeconomic Aspects of 1985 Chile and Mexico Earthquakes*, was developed under a grant from the NSF. Available through ATC. (Published 1991, 113 pages)

ATC-31: The report, *Evaluation of the Performance of Seismically Retrofitted Buildings*, was developed under a contract with the National Institute of Standards and Technology (NIST, formerly NBS) and funded by the USGS. Available through ATC. (Published 1992, 75 pages)

ATC-32: The report, *Improved Seismic Design Criteria for California Bridges: Provisional Recommendations,* was funded by the California Department of Transportation (Caltrans). Available through ATC. (Published 1996, 215 pages)

ATC-32-1: The report, *Improved Seismic Design Criteria for California Bridges: Resource Document,* was funded by Caltrans. Available through ATC. (Published 1996, 365 pages; also available in electronic format)

ATC-33: The project, funded under a contract with the Building Seismic Safety Council, was initiated by FEMA to develop nationally applicable, state-of-the-art guidance for performance-based seismic rehabilitation of buildings. Work resulted in the following publications:

FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (Published 1997, 440 pages). Revised by ASCE and published as the FEMA 356 report, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* in 2000. Available through the American Society of Civil Engineers as the ASCE 41 Standard, *Seismic Rehabilitation of Existing Buildings*.

FEMA 274, *NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 492 pages)

FEMA 276, *Example Applications of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 295 pages)

ATC-34-1: The project "Development of Next-Generation Seismic Design Approach(es) for

Buildings (continuation of on-going project entitled, "ATC/NCEER Joint Study of R Factors and Other Critical Code Issues")" was funded by NCEER to develop next-generation, nationally applicable, integrated seismic design approach(es) for buildings that consider reliability and probability, practical issues of concern to practitioners, and earthquake performance knowledge.

ATC-34: The report, *A Critical Review of Current Approaches to Earthquake Resistant Design***,** was developed under a grant from NCEER and NSF. Available through ATC. (Published, 1995, 94 pages)

ATC-35: The report, *Enhancing the Transfer of U.S. Geological Survey Research Results into Engineering Practice* was developed under a cooperative agreement with the USGS. Available through ATC. (Published 1994, 120 pages)

ATC-35-1: The report, *Proceedings of Seminar on New Developments in Earthquake Ground Motion Estimation and Implications for Engineering Design Practice*, was developed under a cooperative agreement with USGS. It includes papers describing state-of-the-art information on regional earthquake risk; new techniques for estimating strong ground motions as a function of earthquake source, travel path, and site parameters; and new developments applicable to geotechnical engineering. Available through ATC. (Published 1994, 478 pages)

ATC-35-2: The report, *Proceedings: National Earthquake Ground Motion Mapping Workshop*, was developed under a cooperative agreement with USGS. It includes papers on ground motion parameters; reference site conditions; probabilistic versus deterministic basis; and the treatment of uncertainty in seismic source characterization and ground motion attenuation. Available through ATC. (Published 1997, 154 pages)

ATC-35-3: The report, *Proceedings: Workshop on Improved Characterization of Strong Ground Shaking for Seismic Design,* was developed under a cooperative agreement with USGS. It includes papers on identifying needs and developing improved representations of earthquake ground motion for use in seismic design practice and building codes. Available through ATC. (Published 1999, 75 pages)

ATC-35-Series: The project, "Transfer U.S. Geological Survey Research Results into Engineering Design Practice", was funded by ATC and USGS, with co-sponsorships from ASCE, BSSC, FEMA, FHWA, International Code Council (ICC), Mid-America Earthquake Center, MCEER, National Fire Protection Association, Oregon Department of geology and mineral Industries, Pacific Earthquake Engineering Research Center, and the Structural Engineers Association of California (SEAOC).

ATC-36: The project, "Earthquake Loss Estimation Methodology and Databases for Utah," was funded by FEMA to translate and update the data and methodology developed under the ATC-13 project for use in the Salt Lake City area.

ATC-37: The report, *Review of Seismic Research Results on Existing Buildings***,** was developed in conjunction with SEAOC and California Universities for Research in Earthquake Engineering (CUREe) under a contract with the California Seismic Safety Commission (SSC). Available through the Seismic Safety Commission as Report SSC 94-03. (Published, 1994, 492 pages)

ATC-38: The report, *Database on the Performance of Structures near Strong-Motion Recordings: 1994 Northridge, California, Earthquake*, was developed with funding from the USGS, the Southern California Earthquake Center (SCEC), OES, and the Institute for Business and Home Safety (IBHS). Available through ATC. (Published 2000, 260 pages, with CD containing complete database).

ATC-39: The project, "Homeowner's Guide for Seismic Improvement of Unreinforced Masonry Dwellings," was a result of cooperation between FEMA and the State of Utah Division of Comprehensive Emergency Management (CEM).

ATC-40: The report, *Seismic Evaluation and Retrofit of Concrete Buildings***,** was developed under a contract with the California Seismic Safety Commission. It provides guidance on performance objectives, hazard characterization, identification of deficiencies, retrofit strategies, nonlinear static analysis procedures, modeling rules, foundation effects, and response limits for seismic evaluation and retrofit of concrete buildings. Available through ATC. (Published, 1996, 612 pages in two volumes)

ATC-41 (SAC Joint Venture, Phase 1): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame

Structures, Phase 1," was funded by FEMA and OES and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 1 the following documents were prepared:

SAC-94-01, *Proceedings of the Invitational Workshop on Steel Seismic Issues, Los Angeles, September 1994*. Available through ATC. (Published 1994, 155 pages)

SAC-95-01, *Steel Moment-Frame Connection Advisory No. 3*. Available through ATC. (Published 1995, 310 pages)

SAC-95-02, *Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment-Frame Structures* (FEMA 267 report) (Published 1995, 215 pages; superseded by FEMA 350 to 353)

SAC-95-03, *Characterization of Ground Motions During the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 179 pages)

SAC-95-04, *Analytical and Field Investigations of Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 900 pages in two volumes)

SAC-95-05, *Parametric Analytical Investigations of Ground Motion and Structural Response, Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 274 pages)

SAC-95-06, *Surveys and Assessment of Damage to Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 315 pages)

SAC-95-07, *Case Studies of Steel Moment Frame Building Performance in the Northridge Earthquake of January 17, 1994* Available through ATC. (Published 1995, 260 pages)

SAC-95-08, *Experimental Investigations of Materials, Weldments and Nondestructive Examination Techniques*. Available through ATC. (Published 1995, 144 pages)

SAC-95-09, *Background Reports: Metallurgy, Fracture Mechanics, Welding, Moment Connections and Frame Systems Behavior* (FEMA 288 report). Available through ATC and FEMA. (Published 1995, 361 pages)

SAC-96-01, *Experimental Investigations of Beam-Column Subassemblages, Part 1 and 2*. Available through ATC. (Published 1996, 924 pages, in two volumes)

SAC-96-02, *Connection Test Summaries* (FEMA 289 report). Available through ATC. (Published 1996, 144 pages)

ATC-41-1 (SAC Joint Venture, Phase 2): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 2," was funded by FEMA and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 2 the following documents were prepared:

SAC-96-03, *Interim Guidelines Advisory No. 1 Supplement to FEMA 267 Interim Guidelines* (FEMA 267A) (Published 1997, 100 pages; superseded by FEMA 350 to 353)

SAC-99-01, *Interim Guidelines Advisory No. 2 Supplement to FEMA 267 Interim Guidelines* (FEMA 267B, superseding FEMA 267A). (Published 1999, 150 pages; superseded by FEMA 350 to 353)

FEMA 350, *Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 190 pages)

FEMA 351, *Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 210 pages)

FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 353, *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 354, *A Policy Guide to Steel Moment-Frame Construction*. Available through ATC and FEMA. (Published 2000, 27 pages)

FEMA 355A, *State of the Art Report on Base Materials and Fracture*. Available through ATC and FEMA. (Published 2000, 107 pages; in print and in electronic format).

FEMA 355B, *State of the Art Report on Welding and Inspection*. Available through ATC and FEMA. (Published 2000, 185 pages; in print and in electronic format).

FEMA 355C, *State of the Art Report on Systems Performance of Steel Moment Frames Subject to Earthquake Ground Shaking*. Available through ATC and FEMA. (Published 2000, 322 pages; in print and in electronic format).

FEMA 355D, *State of the Art Report on Connection Performance*. Available through ATC and FEMA. (Published 2000, 292 pages; in print and in electronic format).

FEMA 355E, *State of the Art Report on Past Performance of Steel Moment-Frame Buildings in Earthquakes*. Available through ATC and FEMA. (Published 2000, 190 pages; in print and in electronic format).

FEMA 355F, *State of the Art Report on Performance Prediction and Evaluation of Steel Moment-Frame Structures*. Available through ATC and FEMA. (Published 2000, 347 pages; in print and in electronic format).

ATC-42: The project, "Joint ATC/SEAOC/JSCA/ ASCE Structural Engineering Report on Hyogoken-Nanbu, Japan, Earthquake of January 17, 1995," was funded in partnership with SEAOC, JSCA, and ASCE to archive critically needed information on the performance of buildings and transportation, port, and industrial structures and assist design professionals in Japan and the U.S. to understand the reasons for the extensive structural damage.

ATC-43: The reports, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual* (FEMA 306)*, Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources* (FEMA 307)*,* and *The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings* (FEMA 308)**,** were developed for FEMA under a contract with the Partnership for Response and Recovery, a Joint Venture of Dewberry & Davis and Woodward-Clyde. Available through ATC and FEMA. (Published, 1998 in print and in electronic format; *Basic Procedures Manual*, 270 pages; *Technical Resources*, 271 pages; *Repair Manual*, 81 pages)

ATC-44: The report, *Hurricane Fran, North Carolina, September 5, 1996: Reconnaissance Report***,** was funded by the Applied Technology Council. Available through ATC. (Published 1997, 36 pages)

ATC-45: The report, *Field Manual*, *Safety Evaluation of Buildings After Windstorms and Floods*, was developed with funding from the ATC Endowment Fund and the Institute for Business and Home Safety (IBHS). It provides rapid and detailed evaluation procedures for inspecting buildings that have been damaged in windstorms and floods, and making decisions regarding their continued use and occupancy. Presented in a concise format designed for ease of use in the field, it is intended for use by volunteer structural engineers and building inspectors in posting buildings as "inspected" (apparently safe, green placard), "restricted use" (yellow) or "unsafe" (red). Available through ATC. (Published 2004, 132 pages)

ATC-46: The project, "1st U.S.-Japan Workshop on Performance-Based Engineering," facilitated a workshop organized by a Steering Committee consisting of representatives from Japan and the United States. The workshop was conducted in January 1997 by ATC and the Japan Building Research Institute.

ATC-46-1: The project, "2nd U.S.-Japan Workshop on Performance-Based Engineering," facilitated a workshop organized by a Steering Committee consisting of representatives from Japan and the United States. The workshop was conducted in July 1998 by ATC and the Japan Building Research Institute.

ATC-48 (ATC/SEAOC Joint Venture Training Curriculum): The training curriculum, *Built to Resist Earthquakes, The Path to Quality Seismic Design and Construction for Architects, Engineers, and Inspectors*, was developed under a contract with the California Seismic Safety Commission and prepared by a Joint Venture partnership between ATC and SEAOC. Available through ATC. (Published 1999, 314 pages)

ATC-49: The 2-volume report, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges; Part I: Specifications* and *Part II: Commentary and Appendices*, were developed

under the ATC/MCEER Joint Venture partnership with funding from the FHWA. Available through ATC. (Published 2003, *Part I*, 164 pages and *Part II*, 294 pages)

ATC-49-1: The document, *Liquefaction Study Report, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges,* was developed under the ATC/MCEER Joint Venture partnership with funding from the FHWA. Available through ATC. (Published 2003, 208 pages)

ATC-49-2: The report, *Design Examples, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges*, was developed under the ATC/MCEER Joint Venture partnership with funding from the FHWA. Available through ATC. (Published 2003, 316 pages)

ATC-50: The project, funded by the City of Los Angeles Department of Building and Safety, with support from the California Office of Emergency Services and the U.S. Department of Housing and Urban Development, was initiated because of high economic losses resulting from damage to single-family wood-frame dwellings in the 1994 Northridge earthquake. Work resulted in the publication of:

ATC-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (Published 2002, revised 2007, 135 pages). Revised by FEMA and published as the FEMA P-50 report, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (ATC-71-3 Project).

ATC-50-1, *Seismic Rehabilitation Guidelines for Detached, Single-Family, Wood-Frame Dwellings* (Published 2002, revised 2007, 141 pages). Revised by FEMA and published as the FEMA P-50-1 report, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings* (ATC-68-3 Project).

ATC-50-2, *Safer at Home in Earthquakes: A Proposed Earthquake Safety Program* (Published 2002, revised 2007, 79 pages).

ATC-51: The report, *U.S.-Italy Collaborative Recommendations for Improved Seismic Safety of Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey). Available through ATC. (Published 2000, 154 pages)

ATC-51-1: The report, *Recommended U.S.-Italy Collaborative Procedures for Earthquake Emergency Response Planning for Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey, NSS). Available in English and Italian through ATC. (Published 2002, 129 pages in English; 120 pages in Italian)

ATC-51-2: The report, *Recommended U.S.-Italy Collaborative Guidelines for Bracing and Anchoring Nonstructural Components in Italian Hospitals*, was developed under a contract with the Department of Civil Protection, Italy. Available in English and Italian through ATC. (Published 2003, 164 pages)

ATC-52: The project, "Development of a Community Action Plan for Seismic Safety (CAPSS), City and County of San Francisco", was conducted under a contract with the San Francisco Department of Building Inspection. The following reports were prepared:

ATC-52-1, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts*. Available through ATC. (Published 2010, 78 pages)

ATC-52-1A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts Technical Documentation*. Available through ATC. (Published 2010, 160 pages)

ATC-52-2, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: A Community Action Plan for Seismic Safety*. Available through ATC. (Published 2010, 92 pages)

ATC-52-3, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings*. Available through ATC. (Published 2009, 60 pages)

ATC-52-3A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings Documentation Appendices*. Available through ATC. (Published 2009, 206 pages)

ATC-52-4, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Post-Earthquake Repair and*

Retrofit Requirements. Available through ATC. (Published 2010, 130 pages)

ATC-53: The report, *Assessment of the NIST 12-Million-Pound (53 MN) Large-Scale Testing Facility*, was developed under a contract with NIST. Available through ATC. (Published 2000, 44 pages)

ATC-54: The report, *Guidelines for Using Strong-Motion Data and ShakeMaps in Postearthquake Response*, was developed under a contract with the California Geological Survey. Available through ATC. (Published 2005, 222 pages)

ATC-55: The report, FEMA 440, *Improvement of Nonlinear Static Seismic Analysis Procedures*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2005, 152 pages)

ATC-56: The report, FEMA 389, *Primer for Design Professionals: Communicating with Owners and Managers of New Buildings on Earthquake Risk*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2004, 194 pages)

ATC-56-1: The report, FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks – Providing Protection to People and Buildings*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2003, 106 pages)

ATC-57: The report, *The Missing Piece: Improving Seismic Design and Construction Practices*, was developed under a contract with NIST. It provides a framework for eliminating the technology transfer gap that has emerged within the National Earthquake Hazards Reduction Program (NEHRP) that limits the adaptation of basic research knowledge into practice. Available through ATC. (Published 2003, 102 pages)

ATC-58/58-1/58-1: This series of projects, titled "Development of Next-Generation Performance-Based Seismic Design Guidelines for New and Existing Buildings," was a multi-year, multi-phase effort funded by FEMA that resulted in the publication of the following publications:

ATC-58-1, *Proceedings of a FEMA-Sponsored Workshop on Communicating Earthquake Risk*. Available through ATC and FEMA. (Published 2002, 87 pages).

ATC-58-2, *Preliminary Evaluation of Methods for Defining Performance*. Available through ATC and FEMA. (Published 2003, 99 pages).

ATC-58-3, *Proceedings of a FEMA-Sponsored Workshop on Performance-Based Design*. Available through ATC and FEMA. (Published 2003, 146 pages).

ATC-58-4, *Proceedings of a FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*. Available through ATC and FEMA. (Published 2014, 73 pages).

ATC-58-5, *Proceedings of FEMA-Sponsored Workshop on Design Guidelines and Tools to Implement Next-Generation Performance-Based Seismic Design*. Available through ATC and FEMA. (Published 2014, 85 pages)

ATC-58-6, Recommendations for Communicating Seismic Performance Considerations in Design Decision-Making. Available through ATC and FEMA. (Published 2016, 217 pages)

FEMA 445, *Next-Generation Performance-Based Seismic Design Guidelines, Program Plan for New and Existing Buildings*. Available through ATC and FEMA. (Published 2006, 131 pages).

FEMA 461, *Interim Testing Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components*. Available through ATC and FEMA. (Published 2007, 113 pages).

FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology*. (Published 2012, 319 pages).

FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology, Second Edition*. Available through ATC and FEMA. (Published 2018, 340 pages)

FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide*. (Published 2012, 365 pages).

FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide, Second Edition*.

Available through ATC and FEMA. (Published 2018, 378 pages).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation*. (Published 2012, in electronic format).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation, Second Edition*. (Published 2016, in electronic format).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation*. Available through ATC and FEMA. (Published 2018, in electronic format).

FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*. Available through ATC and FEMA. (Published 2018, 122 pages)

FEMA P-58-5, *Seismic Performance Assessment of Buildings, Volume 5 – Expected Seismic Performance of Code Conforming Buildings*. Available through ATC and FEMA. (Published 2018, 196 pages)

FEMA P-58-6, *Guidelines for Performance-Based Seismic Design of Buildings*. Available through ATC and FEMA. (Published 2018, 92 pages)

FEMA P-58-7, *Building the Performance You Need, A Guide to State-of-the-Art Tools for Seismic Design and Assessment*. Available through ATC and FEMA. (Published 2019, 28 pages)

ATC-59: The report, *Seismic Safety Inventory of California Public Schools—A Report to the Governor of California and the California State Legislature*, was prepared by for the Department of General Services mandated by California Assembly Bill 300, which requires the Department to inventory schools of concrete tilt-up construction and those with non-wood frame walls that do not meet the minimum requirements of the 1976 Uniform Building Code. (Published 2002, 43 pages)

ATC-60: The 2-volume report, *SEAW Commentary on Wind Code Provisions, Volume 1* and *Volume 2 - Example Problems,* was developed by the Structural Engineers Association of Washington (SEAW) in cooperation with ATC. Available through ATC. (Published 2004; *Volume 1*, 238 pages; *Volume 2*, 245 pages)

ATC-61: The 2-volume report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, Volume 1 – Findings, Conclusions, and Recommendations*, and *Volume 2 – Study Documentation,* was prepared for the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences, with funding provided by FEMA. Available through ATC and the MMC. (Published 2005; *Volume 1*, 11 pages; *Volume 2*, 366 pages)

ATC-62: The report, FEMA P-440A, *Effects of Strength and Stiffness Degradation on Seismic Response*, was developed under a contract with FEMA. Developed as a supplement to the FEMA 440 report, it provides additional guidance on modeling of nonlinear degrading response. Available through ATC and FEMA. (Published 2009, 310 pages)

ATC-63: The report, FEMA P-695, *Quantification of Building Seismic Performance Factors*, was developed under a contract with FEMA. It describes a methodology for establishing seismic performance factors (R , Ω_0, and C_d) that involves the development of detailed system design information and probabilistic assessment of collapse risk. Available through ATC and FEMA. (Published 2009, 420 pages)

ATC-63-1: The report, FEMA P-795, *Quantification of Building Seismic Performance Factors: Component Equivalency Methodology*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 264 pages)

ATC-64: The reports, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis* (FEMA P-646), and *Vertical Evacuation from Tsunamis: A Guide for Community Officials* (FEMA P-646A), were developed under a contract with FEMA. Available through ATC and FEMA. (*Design Guidelines*, Published 2008, 174 pages; *Guide for Community Officials*, Published 2009, 62 pages)

ATC-65: The FEMA P-455 report, *Handbook for Rapid Visual Screening of Buildings to Evaluate Terrorism Risks*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 174 pages)

ATC-66: The FEMA P-774 report, *Unreinforced Masonry Buildings and Earthquakes, Developing Successful Risk Reduction Programs*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 194 pages)

ATC-66-Series: The project, "National Earthquake Technical Assistance Program (NETAP)," was funded by the Federal Emergency Management Agency and provides support for course development, logistical coordination, training delivery, technical assistance, performance tracking, and development of tools necessary to support the effective implementation of the National Earthquake Hazards Reduction Program.

ATC-67: The *Rapid Observation of Vulnerability and Estimation of Risk* (ROVER) smartphone application was developed in collaboration with specialists from SPA Risk LLC, and Instrumental Software Technologies Inc. under a contract with FEMA. It is intended for use by building professionals (engineers, architects, firefighters, building officials, and others) to do pre-earthquake screening and post-earthquake safety evaluation of buildings in an electronic format. Available through ATC and FEMA. (Published 2014, online and in electronic format)

ATC-68: The FEMA P-420 report, *Engineering Guideline for Incremental Seismic Rehabilitation*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 94 pages)

ATC-68-3: The FEMA P-50-1 report, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-50 Project. Available through ATC and FEMA. (Published 2012, 168 pages)

ATC-69: The report, *Reducing the Risks of Nonstructural Earthquake Damage, State-of-the-Art and Practice*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2008, 144 pages)

ATC-69-1: The electronic document, *Reducing the Risks of Nonstructural Earthquake Damage, A Practical Guide* (FEMA E-74), was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 750 pages)

ATC-70: The report, NIST Technical Note 1476, *Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report*, was developed under a contract with NIST. Available through NIST. (Published 2006, 222 pages)

ATC-71: The reports, *Workshop on Meeting the Challenges of Existing Buildings, Part 1 Workshop Proceedings; Part 2: Status Report on Seismic Evaluation and Rehabilitation of Existing Buildings;* and *Part 3: Action Plan for the FEMA Existing Buildings Program*, were developed under a contract with FEMA. Available through ATC and FEMA. (*Part 1*, Published 2008, 142 pages; *Part 2*, Published 2009, 140 pages; *Part 3*, Published 2009, 118 pages)

ATC-71-1: The report, FEMA P-807, *Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings with Weak First Stories*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2012, 230 pages, including the *Weak Story Tool* in electronic format)

ATC-71-2: The report, *Proceedings: Workshop on a Rating System for the Earthquake Performance of Buildings*, was developed under a contract with FEMA. Available through ATC. (Published 2011, 102 pages)

ATC-71-3: The report, FEMA P-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-50 Project. Available through ATC and FEMA. (Published 2012, 190 pages)

ATC-71-4/ATC-71-5/ATC-71-6: The report, FEMA P-154, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, Third Edition*, and the report FEMA P-155, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation, Third Edition*, were developed under a series of contracts with FEMA. Available through ATC and FEMA. (Published, 2014; *Handbook*, 388 pages; *Supporting Documentation*, 206 pages)

ATC-72: The report, *Proceedings of Workshop on Tall Building Seismic Design and Analysis Issues*, was prepared for the Building Seismic Safety Council of the National Institute of Building Sciences, with funding provided by FEMA. The report, *Modeling and Acceptance Criteria for Seismic Design and Analysis of Tall Buildings* (PEER/ATC-72-1) was prepared for the Pacific Earthquake Engineering Research Center. Available through ATC and PEER. (*Proceedings*, Published 2007, 84 pages; *Modeling and Acceptance Criteria*, Published 2010, 242 pages)

ATC-73: The report, *NEHRP Workshop on Meeting the Challenges of Existing Buildings, Prioritized Research for Reducing the Seismic Hazards of Existing Buildings,* was developed under a grant from NSF. Available through ATC. (Published 2007, 22 pages)

ATC-74: The report, *Collaborative Recommended Requirements for Automatic Natural Gas Shutoff Valves in Italy,* was funded by the Department of Civil Protection, Italy. Available through ATC. (Published 2007, 76 pages)

ATC-75: The report, *Improvements to BIM Structural Software Interoperability*, was developed under a contract with the Charles Pankow Foundation (CPF). Available through ATC and CPF. (Published 2013, 155 pages)

ATC-76-1/ATC-76-4: The report, *Evaluation of the FEMA P-695 Methodology for the Quantification of Building Seismic Performance Factors,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-8. (Published 2010, 240 pages)

ATC-76-2: The report, *Program Plan for the Development of Seismic Design Guidelines for Port Container, Wharf, and Cargo Systems,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-19. (Published 2012, 134 pages)

ATC-76-3: The reports, *NEHRP Technical Brief No. 1, Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers* and *NEHRP Technical Brief No. 2, Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers,* were developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST (*Technical Brief No. 1*, Report GCR 08-917-1. Published 2008, 32 pages; *Technical Brief No. 2*, Report GCR 09-917-3, Published 2009, 38 pages)

ATC-76-5: The report, *Program Plan for the Development of Collapse Assessment and Mitigation Strategies for Existing Reinforced Concrete Buildings,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-7. (Published 2010, 80 pages)

ATC-76-6: The report, *Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-9. (Published 2010, 196 pages plus CD)

ATC-76-7: The report, *NEHRP Technical Brief No. 3, Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-4. (Published 2010, 30 pages)

ATC-76-8: The report, *NEHRP Technical Brief No. 4, Nonlinear Structural Analysis for Seismic Design: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-5. (Published 2010, 32 pages)

ATC-76-9: The project, "Performance of Two Full Scale Reinforced Concrete Subassemblage Tests," was funded by NIST to perform tests in support of an internal research program to develop computer models for predicting the collapse potential of reinforced concrete structures. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-77: The project, "Hurricane Hugo 20th Anniversary Symposium on Building Safer Communities – Improving Disaster," was funded by ATC. The purpose of the Symposium was to convene wind engineering researchers, practitioners and other stakeholders in a forum to

discuss what has happened in the practice of hurricane mitigation since Hurricane Hugo struck the South Carolina coast in September 1989, and to identify what still needs to happen to reduce losses from these deadly storms. (Published 2009, 319 pages)

ATC-78: The report, *Identification and Mitigation of Seismically Hazardous Older Concrete Buildings: Interim Methodology Evaluation* (ATC-78), was developed under a contract with FEMA. Available through ATC. (Published 2011, 137 pages)

ATC-78-1: The report, *Evaluation of the Methodology to Select and Prioritize Collapse Indicators in Older Concrete Buildings* (ATC-78-1), was developed under a contract with FEMA. Available through ATC. (Published 2012, 153 pages)

ATC-78-2: The report, *Seismic Evaluation for Collapse Potential of older Concrete Frame Buildings (Interim Report)*, was developed under a contract with FEMA. Available through ATC. (Published 2014, 179 pages)

ATC-78-3: The report, *Seismic Evaluation of Older Concrete Frame Buildings for Collapse Potential*, was developed under a contract with FEMA and is available through ATC. (Published 2015, 201 pages)

ATC-78-4 (LADBS): The project, "Identification and Mitigation of Non-Ductile Concrete Buildings," was funded by the Federal Emergency Management Agency and the purpose is to begin developing an assessment guideline document for older or non-ductile concrete buildings to allow identification of those buildings that present an earthquake collapse hazard so that they may be evaluated and retrofitted, in order to mitigate the risks presented by this class of buildings,

ATC-78-5/78-6/78-7: The report FEMA P-2018, *Seismic Evaluation of Older Concrete Buildings for Collapse Potential*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2019, 352 pages)

ATC-79: The report FEMA P-646, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis, Second Edition*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-64 Project. Available through ATC and FEMA. (Published 2012, 194 pages)

ATC-80: The project "U.S.-Netherlands Workshop on Risk and Reliability for MultiHazard Engineering," was jointly organized by ATC and the Civil Engineering Department at the Technical University of Delft. The Workshop was conducted in Delft on July 10, 2009, with the purpose to (a) explore state-of-the-art/state-of-the-practice methods and policies in multihazard risk and reliability; (b) open a binational dialogue on multihazard engineering research and practice; and (c) identify potential technologies and partners for future risk assessment and hazard mitigation technology transfer projects.

ATC-81: The project, "Development of Industry Foundation Classes (IFCs) for Structural Concrete Components - Strategic Plan" was funded under a grant from The Charles Pankow Foundation and the Ready-Mixed Concrete Research and Education Foundation. ATC worked with the ACI Foundation of the American Concrete Institute and the Strategic Development Council (SDC) to develop a strategic plan for the development of Industry Foundation Classes (IFCs) for Structural Concrete Components to foster interoperability between disparate Building Information Modeling (BIM) software platforms. This project produced the following three documents available online through ATC:

Strategic Plan to Develop BIM Interoperability in Structural Concrete, White Paper by the ATC-81 Project Management Committee (Published 2010, 5 pages)

ATC-81, *Development of IFCs for Structural Concrete Strategic Planning Session Report* (Published 2010, 140 pages)

ATC-81, *Development of IFCs for Structural Concrete, Strategic Plan* (Published 2010, 72 pages)

ATC-82: The report, *Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analyses*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-5. (Published 2011, 234 pages)

ATC-83: The report, *Soil-Structure Interaction for Building Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-21. (Published 2012, 292 pages)

ATC-84: The report, *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-20. (Published 2012, 302 pages)

ATC-85: The project, "Assessment of ASCE 41 First Generation Performance-Based Seismic Design Methods for new Buildings in High-Seismic Regions: Phases I-III," was funded by NIST to obtain technical assistance on the initiation of an internal research project benchmarking ASCE 41 performance-based seismic design procedures as applied to new buildings designed in accordance with ASCE 7. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-86: The report, FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*, was developed under a contract with FEMA in support of the ATC-58 Project. This report was reprinted under the ATC-58-2 project with an updated publication date. Available through ATC and FEMA. (Published 2012, 120 pages)

ATC-86-1: The project, "Environmental Benefits of Retrofitting," was funded by FEMA to develop a draft methodology to measure the environmental benefit (i.e., carbon footprint) of seismic retrofitting using the Seismic Performance Assessment Methodology developed under the FEMA/ATC-58 Performance Based Seismic Design Project.

ATC-87: The report, *NEHRP Technical Brief No. 5, Seismic Design of Composite Steel Deck and Concrete-filled Diaphragms: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-4. (Published 2011, 34 pages)

ATC-88: The report, *NEHRP Technical Brief No. 6, Seismic Design of Cast-in-Place Concrete Special Structural Walls and Coupling Beams: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-11. (Published 2011, 38 pages)

ATC-89: The report, *Cost Analyses and Benefit Studies for Earthquake-Resistant Construction in Memphis, Tennessee*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-26. (Published 2014, 227 pages)

ATC-90: The report, *Research Plan for the Study of Seismic Behavior and Design of Deep, Slender Wide Flange Structural Steel Beam-Column Members*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-13. (Published 2011, 148 pages)

ATC-91: The project, "Assessment of Nonlinear Seismic Analysis of Structures Based on Modal Superposition," was funded by NIST to obtain technical support for an internal research program investigating the use of a new approach to nonlinear analysis. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-92: The report, *Comparison of U.S. and Chilean Building Code Requirements and Seismic Design Practice 1985–2010*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-18. (Published 2012, 110 pages)

ATC-93: The project, "Ground Motion and Building Performance Data From the 2010 Chile Earthquake," was funded by NIST to develop a prototypical web-based repository for post-event data in support of the NIST Disaster and Failure Events Database initiative. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-94: The report, *Recommendations for Seismic Design of Reinforced Concrete Wall Buildings Based on Studies of the 2010 Maule, Chile Earthquake*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-25. (Published 2014, 321 pages)

ATC-95: The report, *Review of Past Performance and Further Development of Modeling Techniques for Collapse Assessment of Existing Reinforced Concrete Buildings*, was developed under a contract with NIST and prepared by a Joint

Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-28. (Published 2014, 201 pages)

ATC-96: The report, *Nonlinear Analysis Research and Development Program for Performance-Based Seismic Engineering*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-27. (Published 2014, 147 pages)

ATC-97: The report, *NEHRP Technical Brief No. 7, Seismic Design of Reinforced Concrete Mat Foundations: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-22. (Published 2012, 34 pages)

ATC-98: The report, *Use of High-Strength Reinforcement in Earthquake-Resistant Concrete Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-30. (Published 2014, 231 pages)

ATC-99-Series: The project, "Methodology to Assess and Verify the Seismic Capacity of Low-Rise Buildings," was funded by FEMA to study an alternative seismic design approach for low-rise construction in the United States.

ATC-100: The report, *Measurement Science R&D Roadmap for Windstorm and Coastal Inundation Impact Reduction*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-973-13. (Published 2014, 130 pages)

ATC-101: The report, *A Framework to Update the Plan to Coordinate NEHRP Post-Earthquake Investigations*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-29. (Published 2014, 103 pages)

ATC-102: The report, *Earthquake-Resilient Lifelines: NEHRP Research, Development and Implementation Roadmap*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-33. (Published 2014, 163 pages)

ATC-103: The report, *NEHRP Technical Brief No. 8, Seismic Design of Steel Special Concentrically Braced Frame Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 13-917-24. (Published 2013, 36 pages)

ATC-104: The project, "Assessment of the Performance of Slender Reinforced Concrete Walls under Significant Lateral Loads," was funded by NIST to obtain technical support for an internal research project investigating the behavior of reinforced concrete shear walls. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-105: The project, "Development of Annual Report for National Earthquake Hazards Reduction Program Covering Fiscal Year 2012," was funded by NIST to obtain assistance in the development of the NEHRP Annual Report in 2013. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-106: The project, "Seismic Behavior and Design of Deep, Slender Wide-Flange Structural Steel Beam-Column Members**:** Phase 2 Experimental Evaluation," was funded by NIST to perform testing in support of an internal research program investigating the behavior of steel beam-column members. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-106-1: The project, "Seismic Behavior and Design of Deep, Slender Wide-Flange Structural Steel Beam-Column Members: Phase 2 Experimental Evaluation," was funded by NIST and aimed to develop and implement a testing program to study the behavior of plastic hinges in idealized deep, slender wide-flange structural steel beam-columns undergoing significant cyclic loading.

ATC-107: The project, "Wind Speed Mapping," was funded by NIST to obtain technical assistance in the development of revised wind speed maps incorporating NIST non-tropical wind analysis at different return periods. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-108: The project, "Assessment of ASCE 41 First Generation Performance-Based Seismic Design Methods for new Buildings in High-Seismic Regions" was funded by NIST to obtain technical assistance on the completion of an internal research project benchmarking ASCE 41 performance-based seismic design procedures as applied to new buildings designed in accordance with ASCE 7. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-109: The report, *Building Safety Evaluation after the February 22, 2011 Christchurch, New Zealand Earthquake: Observations by the ATC Reconnaissance Team*, was funded by the Applied Technology Council and the ATC Endowment Fund. Available from ATC. (Published 2014, 99 pages)

ATC-110: The report, *Plan for Development of a Prestandard for Evaluation and Retrofit of Wood Light-Frame Dwellings*, was developed under a contract with the California Earthquake Authority (CEA) in collaboration with FEMA. Available through ATC and CEA. (Published 2014, 85 pages)

ATC-110 (CEA 2): The project, "Development of a Prestandard for the Evaluation and Retrofit of One- and Two-Family Light Frame Residential Buildings," was jointly funded by CEA and FEMA, this work is intended to develop an eventual prestandard for the evaluation and retrofit of one- and two-family wood light frame residential buildings, building on available technical resource documents, but extending beyond their current reach to develop a single, stand-alone engineering resource document addressing structural and nonstructural evaluation and retrofit issues specific to this class of construction. This project produced the following reports:

FEMA P-1100, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings*. Available through ATC and FEMA. (Published 2019, 290 pages)

FEMA P-1100-2A, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 2A – Plan Set for Crawlspace Dwellings*. Available through ATC and FEMA. (Published 2019, 34 pages)

FEMA P-1100-2B, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 2B – Plan Set for Living-Space-Over-Garage Dwellings*. Available through ATC and FEMA. (Published 2019, 44 pages)

FEMA P-1100-2C, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 2C – Plan Set for Masonry Chimneys*. Available through ATC and FEMA. (Published 2019, 16 pages)

FEMA P-1100-3, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 3 – Background Documentation*. Available online through ATC and FEMA. (Published 2019, 422 pages)

ATC-110 (CEA 3/CEA 4/CEA 5/CEA 6): The project, "Delivery of FEMA P-50/P-50-1 Training for the California Earthquake Authority" was funded by CEA and to conduct on-demand training for FEMA P-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*, and FEMA P-50-1, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings*, at locations selected by CEA.

ATC-111: The report, *NEHRP Technical Brief No. 9, Seismic Design of Special Reinforced Masonry Shear Walls: A Guide for Practicing Engineers*, was developed under a contract with NIST, and prepared in collaboration with CUREE. Available through ATC and NIST as GCR 14-917-31. (Published 2014, 42 pages)

ATC-112: The report, *NEHRP Technical Brief No. 10, Seismic Design of Wood Light-Frame Structural Diaphragm Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST, and prepared in collaboration with CUREE. Available through ATC and NIST as GCR 14-917-32. (Published 2014, 47 pages)

ATC-113: The project, "Development of Annual Report for National Earthquake Hazards Reduction Program Covering Fiscal Year 2013," was funded by NIST to obtain assistance in the development of the NEHRP Annual Report in 2014.

ATC-114: The project, "Analysis, Modeling, and Simulation for Performance-Based Seismic Engineering" was funded by NIST to close the gap between state-of-the-art academic research and state-of-practice engineering applications for nonlinear structural analysis, analytical structural

modeling, and computer simulation for performance-based seismic engineering. This project produced four reports:

NIST GCR 17-917-45, *Recommended Modeling Parameters and Acceptance Criteria for Nonlinear Analysis in Support of Seismic Evaluation, Retrofit, and Design*. (Published 2017, 597 pages)

NIST GCR 17-915-46v1, *Guidelines for Nonlinear Structural Analysis for Design of Buildings, Part I – General.* (Published 2017, 137 pages)

NIST GCR 17-915-46v2, *Guidelines for Nonlinear Structural Analysis for Design of Buildings, Part IIa – Steel Moment Frames.* (Published 2017, 145 pages)

NIST GCR 17-915-46v3, *Guidelines for Nonlinear Structural Analysis for Design of Buildings, Part IIb– Reinforced Concrete Moment Frames*. (Published 2017, 135 pages)

ATC-115: The report, *Roadmap for the Use of High-Strength Reinforcement in Reinforced Concrete Design*, was developed under a contract with the Charles Pankow Foundation (CPF). Available through ATC and CPF. (Published 2014, 197 pages)

ATC-116/116-1/116-2/116-3/116-4/116-5/116-6: The project, "Solutions to the Issue of Short-Period Building Performance," was funded by FEMA to advance the roadmap developed on the ATC-116 Project to: (1) identify key missing elements of current modeling practice related to short period buildings; (2) develop a methodology to improve analytical modeling of short period buildings; (3) calibrate the methodology with observed performance of short period buildings in recent earthquakes; and (4) simplify the methodology into practical solutions that can be implemented in codes and standards.

ATC-117: The project, "Next Generation Climate Change Adaptation Strategies To Create More Resilient Communities," was funded by FEMA to increase the nation's resilience against natural disasters, including floods, windstorms, earthquakes and tsunamis, by identifying strategies and approaches to encourage state and local adoption of current disaster-resistant building codes and standards, including related actions that could be undertaken by Federal agencies. The task order that authorized this effort required ATC to: (1) conduct two workshops to obtain input on the best means to encourage State and local adoption of disaster-resistant building codes and standards; and (2) develop an internal FEMA report describing the findings of the workshops by the end of March 2015.

ATC-118: The report, FEMA P-1019, *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2014, 170 pages)

ATC-119/119-1: The project, "Seismic Safety and Engineering Consulting Services for the Earthquake Safety Implementation Program (ESIP), City and County of San Francisco," was funded by CCSF to provide technical expertise in completing selected tasks from the Earthquake Safety Implementation Program (ESIP) work plan that was developed under the CAPSS project. The project produced multiple reports:

Recommendations for Mitigation of Chimney Hazards (Published 2015, 63 pages)

Study of Options to Reduce Post-Earthquake Fires in San Francisco (Published 2017, 70 pages)

Study of Earthquake Effects on Retail Businesses in San Francisco (Published 2017, 76 pages)

San Francisco Tall Buildings Study (Published 2019, 374 pages)

ATC-120: The project, "Scoping Study: Seismic Analysis and Design of Nonstructural Components and Systems," was funded by NIST to provide support for seismic analysis and design of nonstructural components and systems by bringing together relevant sources of information and formulating specific tasks to be addressed in subsequent studies. This project produced the following reports:

NIST GCR 17-917-44 report, *Seismic Analysis, Design, and Installation of Nonstructural Components and Systems – Background and Recommendations for Future Work* (Published 2017, 228 pages)

NIST GCR 18-917-43 report, *Recommendations for Improved Seismic Performance of Nonstructural Components* (Published 2018, 311 pages)

ATC-121: The report, *NEHRP Seismic Design Technical Brief No. 11, Seismic Design of Steel Buckling-Restrained Braced Frames*, was produced under a contract with NIST. Available through ATC and NIST. (Published 2015, 34 pages)

ATC-122/122-1: The report, FEMA P-1000, *Safer, Stronger, Smarter: A Guide to Improving School Natural Hazard Safety* was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2017, 282 pages)

ATC-123/123-1/123-2: The project, "Improving Seismic Design of Buildings with Configuration Irregularities," was funded by FEMA to conduct comprehensive quantitative studies of horizontal and vertical irregularity limits in current building seismic codes using the FEMA P-695 methodology.

ATC-123-3: The report, FEMA P-2012, *Assessing Seismic Performance of Buildings with Configuration Irregularities: Calibrating Current Standards and Practices*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2018, 366 pages)

ATC-124/124-1/124-2: The project, "Update of Seismic Retrofitting Guidance," was funded by FEMA to develop a new FEMA support document that would provide design examples for seismic retrofit of specific buildings using the new ASCE/SEI 41-13 consensus standard. This new document would replace FEMA 276 Example Applications document.

ATC-125: The project, "Recovery Advisories for the South Napa Earthquake" was funded by FEMA and developed three reports following the 2014 South Napa earthquake, available through ATC and FEMA:

FEMA P-1024, *Performance of Buildings and Nonstructural Components in the 2014 South Napa Earthquake* (Published 2015, 359 pages)

FEMA Recovery Advisory DR-4193-RA1, *Repair of Earthquake-Damaged Masonry Fireplace Chimneys* (Published 2015, 11 pages)

FEMA Recovery Advisory DR-4193-RA2, *Earthquake Strengthening of Cripple Walls in Wood-Frame Dwellings* (Published 2015, 25 pages)

ATC-126: The report, *Critical Assessment of Lifeline System Performance: Understanding Societal Needs in Disaster Recovery*, was developed under a contract with NIST. Available through ATC and NIST. (Published 2016, 392 pages)

ATC-127: The report, *Proceedings: ATC/USGS Seismic Hazard User-Needs Workshop*, was developed by ATC with funding from the USGS. (Published 2015, 89 pages)

ATC-128: The report, *Proceedings of Forum on Performance-Based Structural-Fire Engineering: Examples of Current Practice and Discussion on Future Directions*, was developed by ATC with funding from the ATC Endowment Fund. (Published 2015, 101 pages)

ATC-128-1: The project, "AISC-ATC Workshop on Performance-Based Structural-Fire Engineering," was intended to build on ATC's London Forum on performance-based structure-fire engineering to answer questions related to benefits and incentives for performance-based structural fire-engineering, cost savings, barriers to implementation in the United States, and strategies for implementation.

ATC-129: The project, "Development of Updated Standards of Seismic Safety for Existing Federally Owned and Leased Buildings," was funded by NIST to update ICSSC RP 8 (which was published in 2011) to harmonize with the latest reference standards and to address review comments from ICSSC Federal agencies during the development and approval phases of work.

ATC-130: The project, "Updates of NEHRP Seismic Design Technical Briefs 1-3," was developed under a contract with NIST and produced three reports, available through ATC and NIST:

NEHRP Seismic Design Technical Brief No. 1 (2nd Edition), Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers (Published 2016, 46 pages)

NEHRP Seismic Design Technical Brief No. 2 (2nd Edition), Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers (Published 2016, 40 pages)

NEHRP Seismic Design Technical Brief No. 3 (2nd Edition), Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers (Published 2016, 43 pages)

ATC-131: The report, NEHRP Seismic Design Technical Brief No. 12, *Seismic Design of Cold-Formed Steel Lateral Force-Resisting Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST. (Published 2016, 56 pages)

ATC-132: The report, *Guidelines for the Seismic Retrofit of Existing Schools and Design of New Schools in the Republic of Armenia*, was funded by the World Bank with the support of Global Facility for Disaster Reduction and Recovery's (GFDRR) Global Program for Safer Schools (GPSS). This report was printed in English and Armenian. (Published 2017, 158 pages in English; 176 pages in Armenian)

ATC-133: The report, NIST GCR 17-917-47, NEHRP Seismic Design Technical Brief No. 13, *Seismic Design of Precast Concrete Diaphragms: A Guide for Practicing Engineers*, was developed under a contract with NIST. Available through ATC and NIST. (Published 2017, 45 pages)

ATC-134: The project, "Performance-Based Seismic Engineering: Benchmarking of Existing Building Evaluation Methodologies," was funded by NIST to conduct an objective comparison of the evaluation and assessment procedures contained in ASCE/SEI 41 in regards to other design and evaluation standards and to data recorded for reinforced concrete buildings. The project will consider both the current standard, ASCE/SEI 41-13, and the more recent version currently under development, ASCE/SEI 41-17.

ATC-134-1: The project, "Performance-Based Seismic Engineering: Benchmarking of Existing Building Evaluation Methodologies" was funded by NIST to expand the scope of the ATC-134 project to conduct an objective comparison of the evaluation and assessment procedures contained in ASCE/SEI 41 with regard to other design and evaluation standards and to data recorded for reinforced concrete buildings. The project also considered both the current standard, ASCE/SEI 41-13, and the more recent version currently under development, ASCE/SEI 41-17.

ATC-135: The project, "Studies for Improving Seismic Design Procedures and Requirements for New Buildings," was funded by FEMA to develop design procedures and requirements including, but not limited to: (1) an alternate design procedure for one-story, flexible diaphragm buildings with stiff vertical elements; (2) design procedure with requirements for rocking seismic force-resisting systems; (3) the inclusion of soil structure interaction effects on the design of inelastic seismic force-resisting systems; and (4) consolidation and simplification of design requirements based upon the Seismic Design Category (SDC) assigned to a building.

ATC-136/136-1/136-2/136-3: The report, FEMA P-1091, *Recommended Simplified Provisions for Seismic Design Category B Buildings*, was developed under a contract with FEMA. (Published 2017, 80 pages)

ATC-137/137-1: The project, "National Earthquake Technical Assistance Program (NETAP) Seismic Technical Guidance Development and Support Contract," was funded by FEMA to deliver direct assistance to the public to: (1) increase local earthquake knowledge and awareness; and (2) support the effective implementation of risk reduction activities from earthquakes or related hazards.

ATC-137-2/137-3: The project, "Technical Training and Product Development" was funded by FEMA to develop and maintain educational courses, related training materials, technical and non-technical guidance materials for earthquake mitigation, and conduct those training courses/webinars on behalf of FEMA. This project also supported the update of FEMA technical design guidance products, as needed, with a focus on course development, special projects, and national webinars. The project also had funding to deliver NETAP (ATC-66-10) trainings requested by states that exceed the ATC-66-10 budget, and the project supported the planning and delivery of a summit in Salt Lake City focused on unreinforced masonry. This project produced documents available through ATC and FEMA, including the following report:

FEMA Recovery Advisory DR-4193-RA2, *Earthquake Strengthening of Cripple Walls in Wood-Frame Dwellings*. The original version of the report was developed under the ATC-64 Project. (Published 2019, 26 pages)

ATC-138/138-1/138-2: The project, "Support of Performance-Based Seismic Design of Buildings," was funded by FEMA and aimed to develop materials necessary to encourage and assist in the use of performance-based seismic design products and tools developed under previous phases of ATC-58.

ATC-139: The purpose of this project was to support the FEMA-funded Project 17 effort that is examining the basis for the national seismic design value maps and the design procedures that reference them, in preparation for the 2020 Provisions update cycle. This work investigated the effects of duration on building response and collapse behavior, which is a topic that is not currently funded within the Project 17 scope of work.

ATC-140/140-1/140-2: The project, "Update of Seismic Evaluation and Retrofit of Existing Buildings Guidance" was funded by FEMA and aimed to investigate and address technical issues regarding the evaluation and retrofit of existing buildings and develop material for the expanded FEMA design applications document that will replace the current FEMA 275 Design Examples document.

ATC-141: The project, "Reconnaissance Following the September 19, 2017 Earthquake in Mexico City" was funded by the ATC Endowment Fund and aimed to investigate damage and collect building construction information, vibration characteristics, site characteristics, and strong-motion recordings for further detailed investigation in support of ongoing ATC project funded by FEMA (ATC-78-7) and NIST (ATC-134).

ATC-142: The report, *Safety Prioritization of School Buildings for Seismic Retrofit Using Performance-Based Risk Assessment in the Kyrgyz Republic*, was developed under a contract with the World Bank Group. (Published 2019, 286 pages)

ATC-143: The project, "Update of CUREE Guidelines for Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings" was funded by the CEA and aimed to update (or complete the development of) the following Consortium of Universities for Research in Earthquake Engineering (CUREE) documents available through CUREE, and to develop training materials on the resulting documents:

CUREE EDA-02, *General Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings* (Published 2010, 371 pages)

CUREE EDA-06, *Engineering Guidelines for the Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings* (Published 2005, 203 pages)

ATC-144: The project, "Soil Structure Interaction Design Guide" was funded by FEMA to review available soil-structure interaction information and develop soil structure interaction design guidance.

ATC-145/145-1: The project, "Guide for Repair of Earthquake Damaged Buildings to Achieve Future Resilience" was funded by FEMA to review available information on repair of earthquake damage and develop and/or update repair design guidance.

ATC-146: The project, "Steel Buildings in the Central and Eastern United States Designed for Controlling Wind Loads to Evaluate their Seismic Performance" was funded by NIST and aimed to evaluate the seismic performance of two suites of archetype steel buildings designed in accordance with older building codes (circa 1980) and current building codes for specific locations within the Central and Eastern United States.

ATC-147: The project, "Computational Models for Large Outdoor Fires Roadmap Workshop" was funded by NIST to conduct a technical solutions workshop for modeling large outdoor fires and prepare a research needs report.

ATC-148: The project, "Building Technical Capacity in Central Asia to Design Risk-Informed Public Infrastructure Investments at Scale" was funded by the World Bank Group to provide technical support to World Bank's safer school initiatives in Central Asia.

ATC-149: The project, "Coastal Inundation Events in Developed Regions" was funded by the University of Notre Dame and NIST to develop and test methodologies to improve predictions of inundation hydrodynamics and loading in developed (urban) regions for both storm wave and tsunami inundation, as aligned with the National Windstorm Impact Reduction Program and the Structural Performance under Multi-Hazard Program.

ATC-150: The project, "Improving the Nation's Lifelines Infrastructure to Achieve Seismic Resilience" was funded by FEMA to review NIST CGR 14-917-33, *Earthquake Resilient Lifelines: NEHRP Research, Development and Implementation Roadmap*, and initiate activities of Program Element I.

ATC-R-1: The report, *Cyclic Testing of Narrow Plywood Shear Walls*, was developed with funding

from the ATC Endowment Fund. Available through ATC (Published 1995, 64 pages)

ATC Design Guide 1: The report, *Minimizing Floor Vibration*, was developed with funding from the ATC Endowment Fund. Available through ATC. (Published, 1999, 64 pages)

ATC Design Guide 2: The report, *Basic Wind Engineering for Low-Rise Buildings*, was developed with funding from the ATC Endowment Fund. Available through ATC. (Published, 2009, 114 pages)

ATC TechBrief 1: The ATC TechBrief 1, *Liquefaction Maps*, was developed under a contract with the United States Geological Survey. Available through ATC. (Published 1996, 12 pages)

ATC TechBrief 2: The ATC TechBrief 2, *Earthquake Aftershocks − Entering Damaged Buildings*, was developed under a contract with the United States Geological Survey. Available through ATC. (Published 1996, 12 pages)

FEMA Support for Earthquake Subject Matter Experts (SMEs): Seismic Technical Guidance Development and Support is funded by FEMA to provide overarching management of the task orders authorized under the existing FEMA Task Order Contract for Seismic Technical Guidance Development and Support, and to provide support for Earthquake Subject Matter Experts (SMEs) who report independently to FEMA. This project produced documents available through ATC and FEMA, including the following report:

FEMA P-646, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis, Third Edition*. The original version of the report was developed under the ATC-64 Project. (Published 2019, 202 pages)

Northeastern RSB: Northeastern University Multi-Hazard Resilient and Sustainable Buildings aimed to provide technical advice and assistance to Northeastern University on their NSF- funded project to develop a decision framework that accounts for both resilience and sustainability across multiple hazards with different levels of severity, while optimizing lifecycle costs throughout the design process.

STARR II JV: Strategic Alliance for Risk Reduction (STARR) II Joint Venture, Production and Technical Services (PTS) for Architect and Engineering Services Nationwide Contract aimed to provide technical assistance and support services to FEMA on Hazard Mitigation Technical Assistance Projects (HMTAP) and Technical Assistance and Research Contract (TARC) projects on an as-needed, on-demand basis.

Website for Geographic Based Design Load Parameters: This project aimed to maintain and enhance the ATC windspeed website, and to add additional functionality related to other design loads, including ground snow loads and possible future earthquake ground accelerations. This site developed into the ATC Hazards by Location website which provides users with site-specific hazard information that can be used to determine design loads for buildings and other structures.

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