

Seismic Risk of Unreinforced Masonry Buildings in Nevada

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- **Unreinforced Masonry Building Earthquake Risk**
- **Historical Examples of Damage**
- **Retrofitting URMBs**
- **URMBs in Nevada**

Unreinforced Masonry Building (URMB)

- Buildings made of brick or stone that lack steel rebar or other reinforcement. They commonly have other deficiencies beyond construction style.
- Seismic Problems:
 - little lateral resistance with smooth-faced bricks,
 - old lime-based mortar disintegrates and loses bond,
 - lack tying structure together,
 - dangerous crowning concrete beams,
 - rubble wall infills and foundations,
 - made quickly, cheaply, and sometimes without skill.
- 30-40% of URM Buildings can have partial to total collapse during strong shaking.



Rock rubble foundation; every 8th brick course in on end to tie wall together



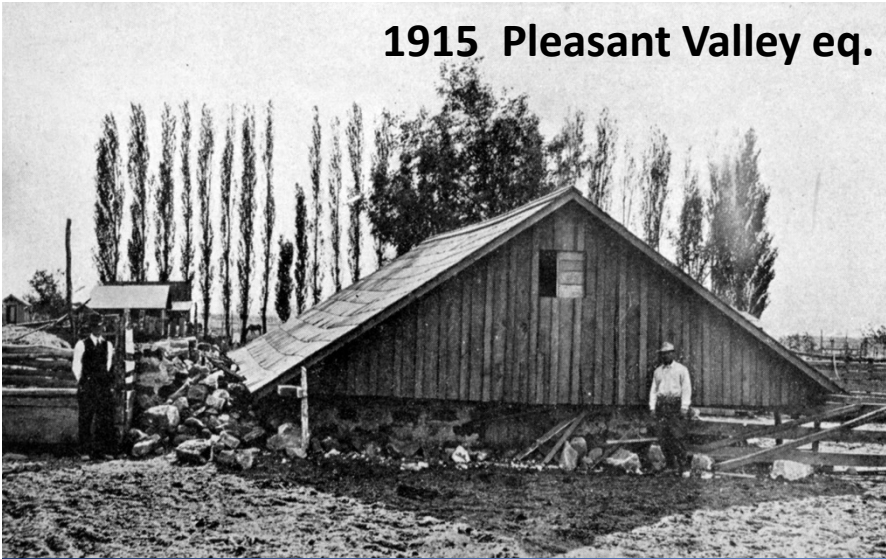


**Three-story URMB with parapet
and some earthquake cracks;
occupancy is variable**



Commercial five-story apartment building; continuous high occupancy

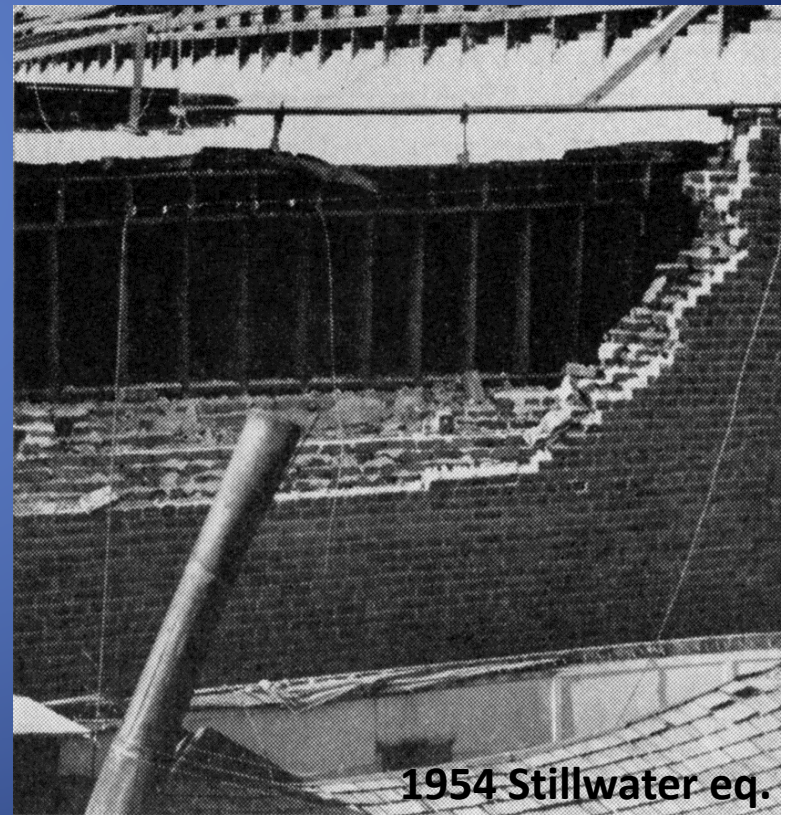
1915 Pleasant Valley eq.



1932 Cedar Mountain eq.



1934 Excelsior Mountain eq.



1954 Stillwater eq.

URM Building Damage has Occurred during Most Major Nevada Earthquakes



2008 Wells, Nevada Earthquake

2008 Wells, Nevada Earthquake





Ceiling joist pulling out of wall socket; note diagonal fire cut on end of beam

2008 Wells eq.





rubble
Infill
makes
walls
weak

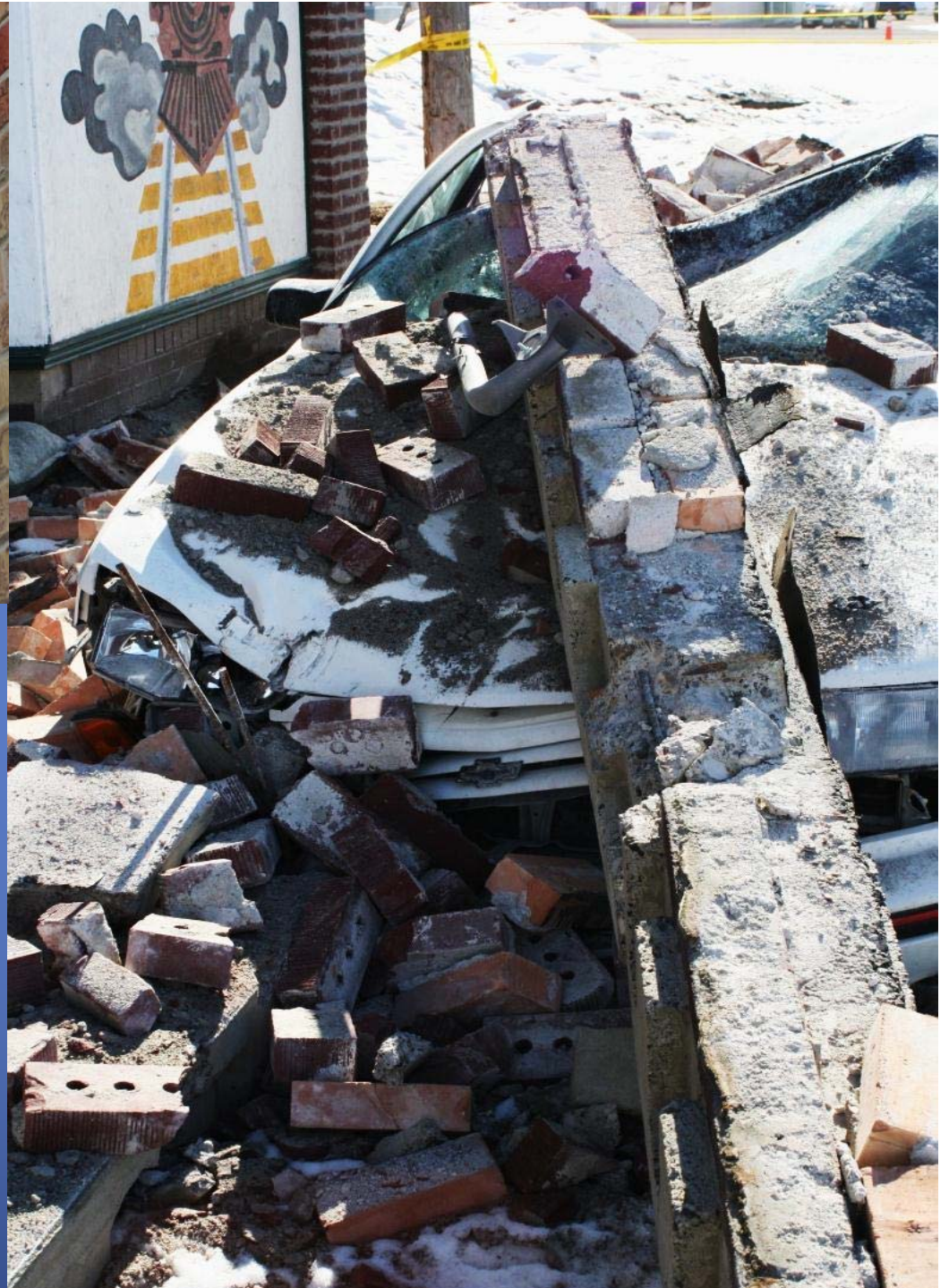
Below – Lincoln Hall has an air gap between the interior wall that holds up the floors and the outside wall that holds up the roof



beyond interior brick wall is open space

Crowning bond beam failures

2008 Wells, Nevada Eq.





2008 Wells Earthquake

Commercial Unreinforced Masonry Buildings

- **10 of 15** moderately to severely damaged (67%) – **potentially life threatening**.
- 3 of 15 partial to total collapse (20%).
- 1 of 15 potentially deadly staying inside (7%).
- 15 of 33 exits had potentially deadly debris (45%)



Christchurch, New Zealand

Sept 4, 2010 Magnitude 7.1 earthquake 25 mi (40 km away)



Feb 22nd, 2011

Magnitude 6.3 earthquake 6 mi (10 km) away



June 13, 2011 Magnitude 5.5 and 6.0 earthquakes 3 mi (5 km) away

Thought Question:

Does **time** matter in this *progressive damage to URBMs with multiple earthquakes*?

i.e.,

If these earthquakes occurred over **a day**, or if they were separated by **decades**, would the effects on the URMb be the same?

Thought Question:

Does time matter in this progressive damage with multiple earthquakes?

If these earthquakes occurred over a day or two, or if they were separated by decades, would the effects be the same?

I do think that the fragility of URMB's goes up once damage has occurred. In other words, once the bond between brick and mortar has been broken, the assumed strength of the assembly has been compromised.

Barry Welliver, 8/14/19

Utah engineer with a lot
Of URMB experience

1971
San Fernando,
CA earthquake



CMU – concrete masonry unit – *unreinforced* cinder block buildings



JRM collapse M632-22-2011-1



Brown URMB (upper right quarter) immediately before the earthquake



Near the beginning of the eq., people reacting, upper part of right-facing wall is starting to fall outwards from top. Some cracks are forming in this wall shown by dust.

M collapse M632-22-2011-1

USIVE ONNEWS



Upper part of right-facing wall has fallen out (above top ceiling joist) and is falling down the side of the building.

pse M632-22-2011-1



A major portion of the right-facing wall is peeling off and falling next to the building. One man has hands on head in awe.

32-22-2011-1



Large portion of the right-facing wall is falling on ground and dismembering. Dust rising from central part of the building indicates failure there.

Case M632-22-2011-1



Upper part of left-facing wall is starting for fail and fall.

collapse M632-22-2011-1



Large part of upper part of wall on the left-facing wall is falling off as more of the upper part of that wall fails.

se M632-22-2011-1



More of the upper part of the left-facing wall is failing in chunks.

e M632-22-2011-1



Continued failure of the upper part of the left-facing wall – chunks of Bricks continue to fall.



Damaged URMB – major failure of right facing wall exposing rooms and Failure of the upper part of the left facing wall. Debris surrounds building.

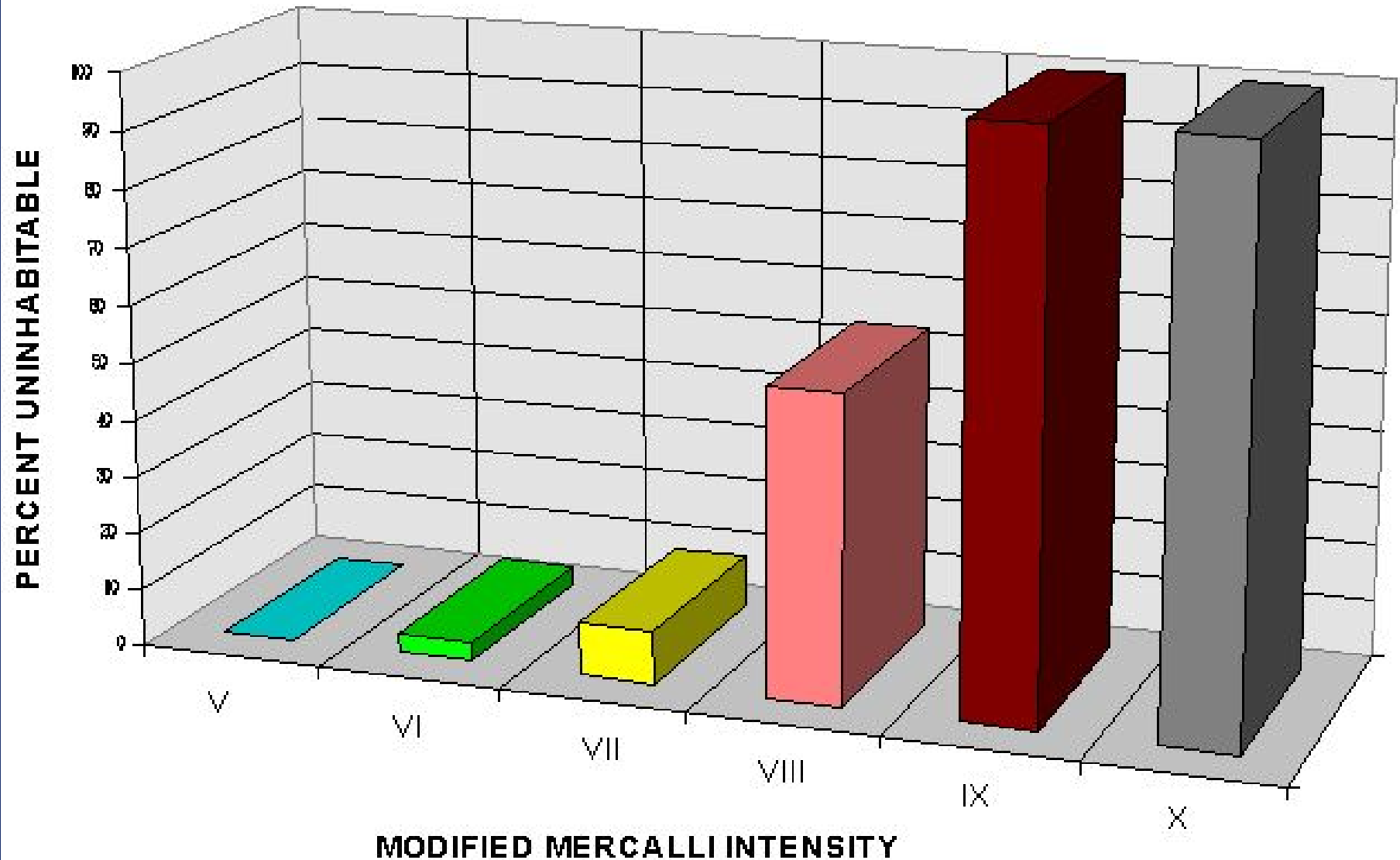


Christchurch from Port Hills Feb 22, 2012



From Ian Buckle, UNR Eq. Engineering

UNREINFORCED MASONRY PERCENT UNINHABITABLE BY MMI INTENSITY LEVEL



Source: Association of Bay Area Governments

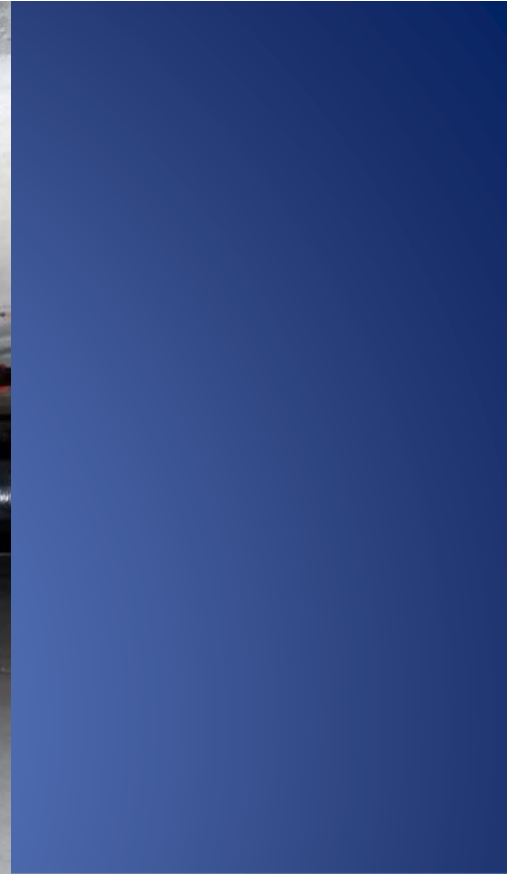
Rehabilitation of Unreinforced Masonry Construction is Achievable



Interior cross bracing helps
prevent building collapse

Bracing of URM parapets
keeps them from toppling
to the sidewalk below



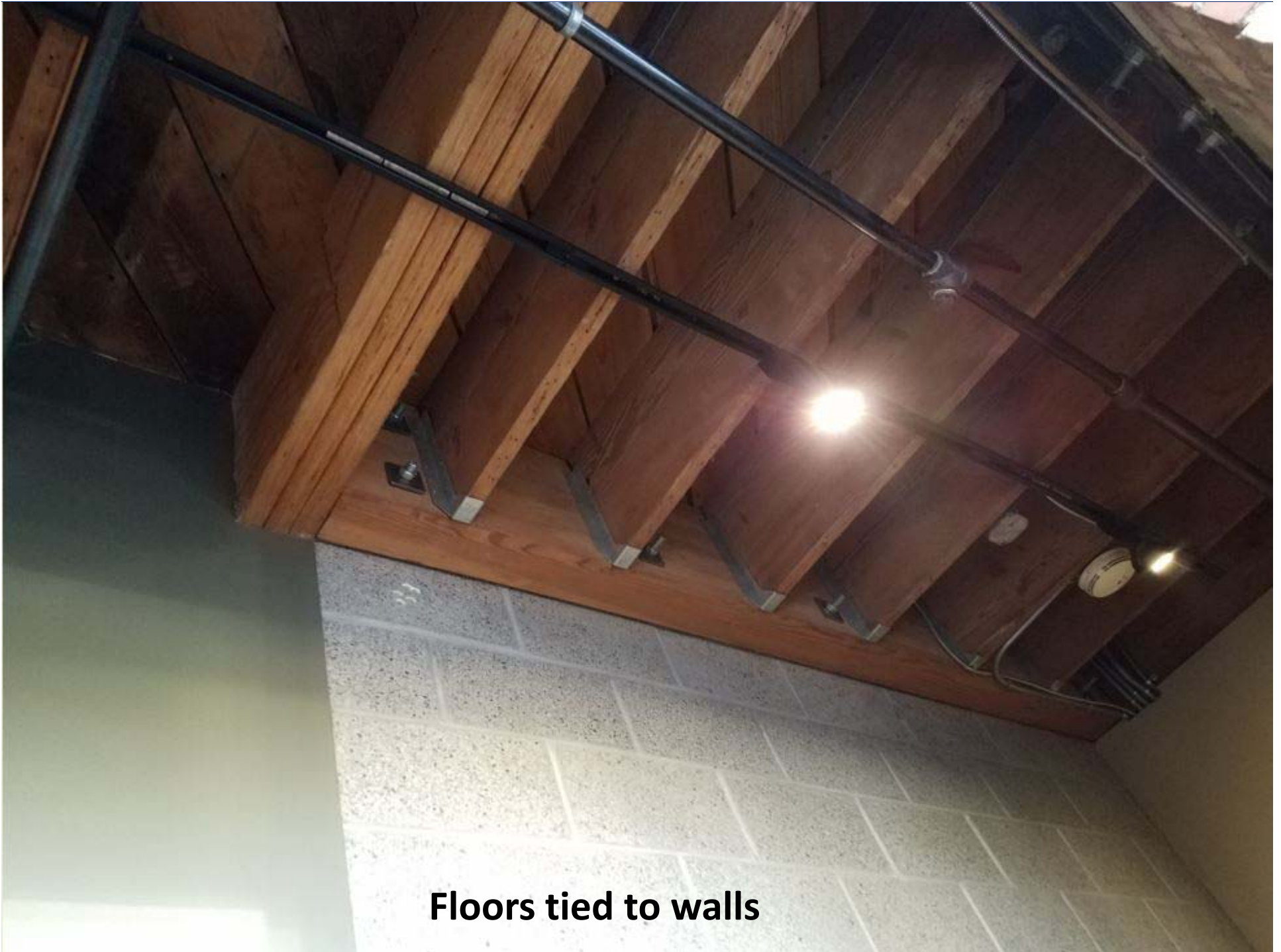


Utah State Capitol – seismic strengthening and base isolation (above)





Fiberglass mesh epoxied to bricks & tied to beam

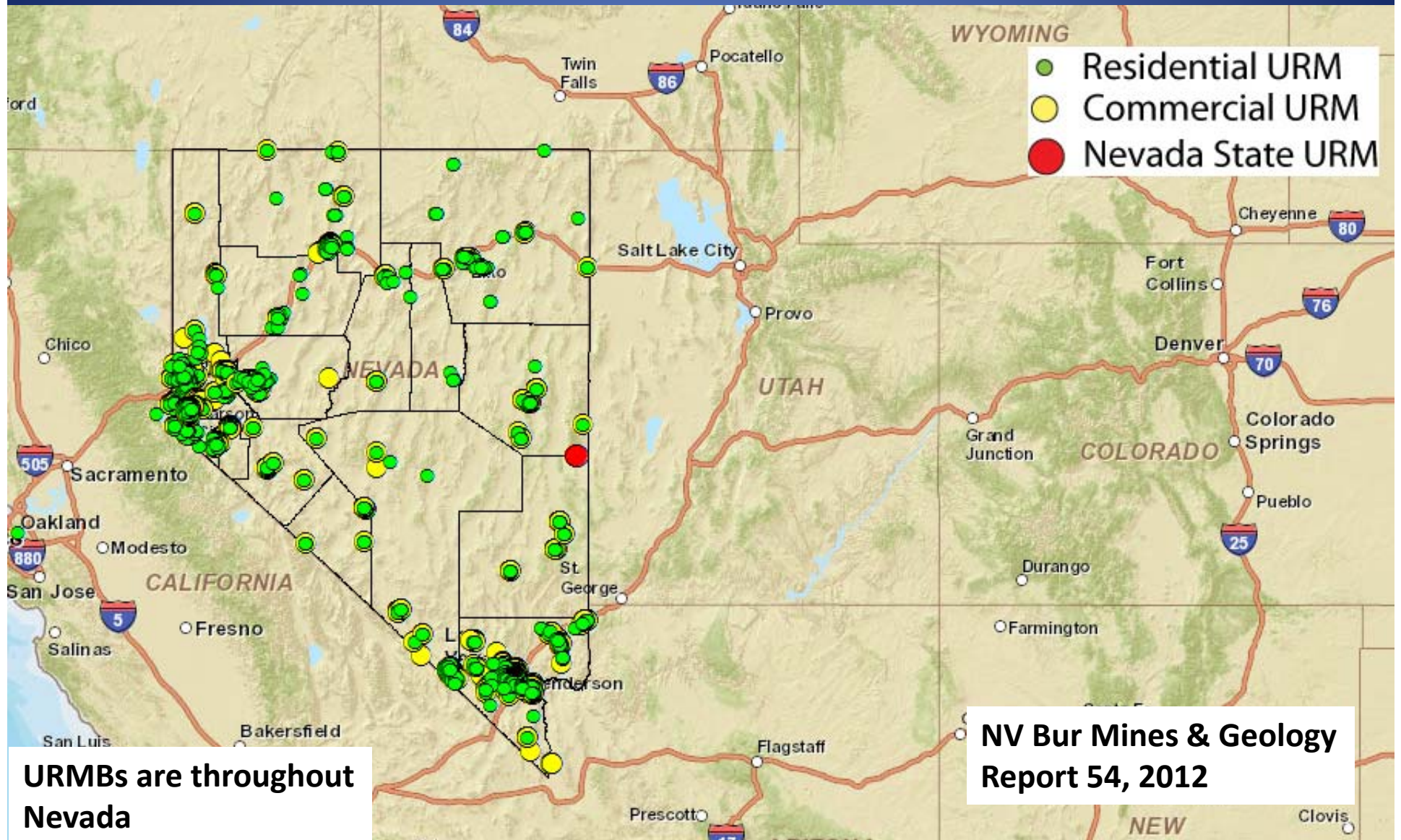


Floors tied to walls

Lincoln Hall Seismic Rehabilitation



2011-2012 Nevada URM Building Inventory; Co. Accessor's Data

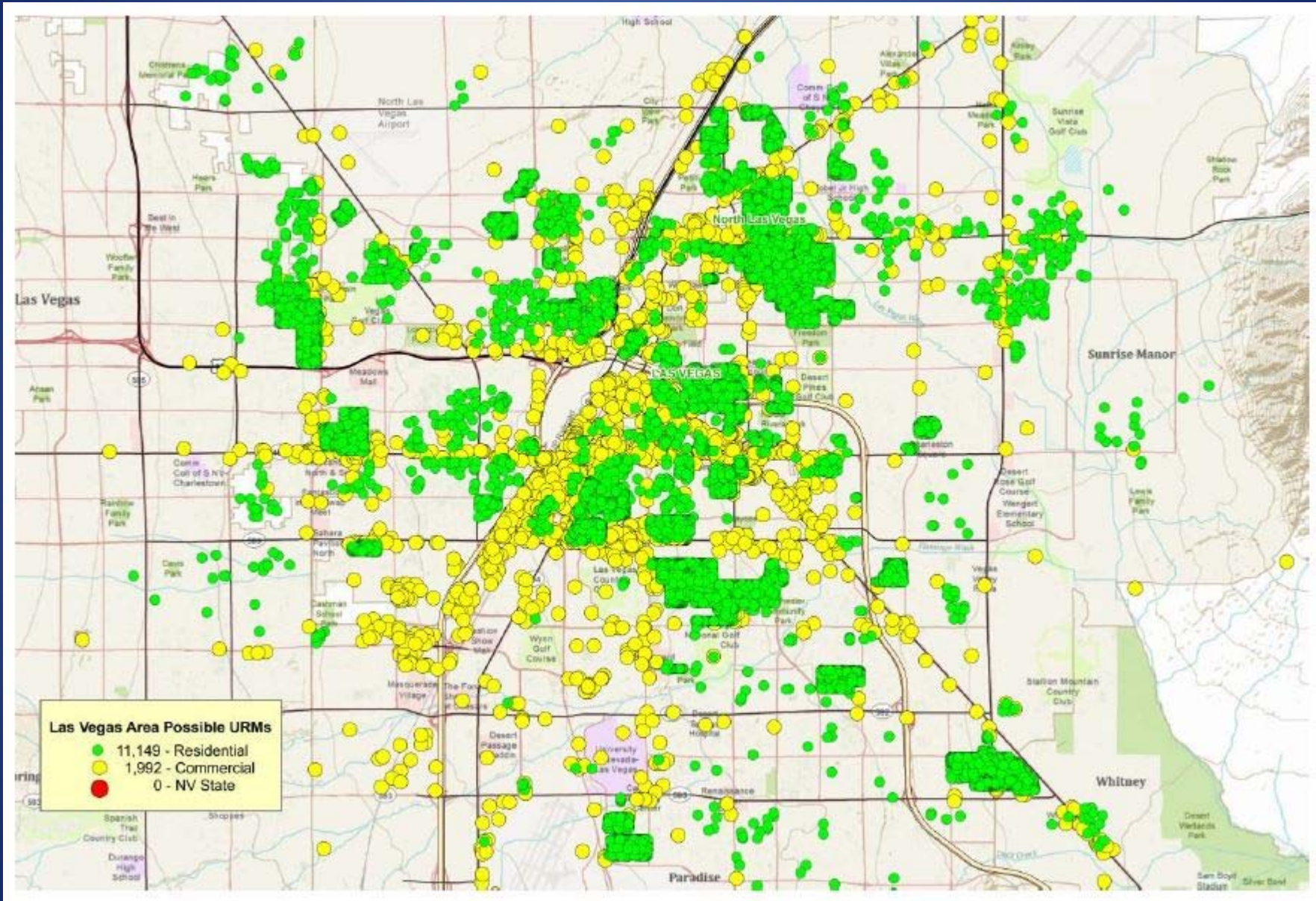


**URMBs are throughout
Nevada**

Table 2. Number of potential URM's in Nevada by county.

<u>County</u>	<u>Commercial & Public</u>	<u>State</u>	<u>Residential</u>	<u>Total[#]</u>
Carson City	487	72	175	734
Churchill	177		192	369
Douglas	114		294	408
Elko	39		23	62
Eureka	0		35	35
Humboldt	192	1	184	377
Lander	57		67	124
Lyon	234	1	175	410
Mineral	60		57	117
Pershing	37		31	68
Storey	3		21	24
Washoe	2,445	21	3,322	5,788
White Pine	<u>138</u>	<u>1</u>	<u>93</u>	<u>232</u>
Subtotal, N. Nevada	3,983	96	4,669	8,748
Clark	11,963		2,396	14,359
Esmeralda	2		14	16
Lincoln	53	2	47	102
Nye	<u>144</u>		<u>228</u>	<u>372</u>
Subtotal, S. Nevada	12,162	2	2,685	14,849
All of Nevada	16,145	98	7,354	23,597

Las Vegas Valley 2011 study results – superseded by Clark County study



Clark County Inventory Study; Clark County Building Department

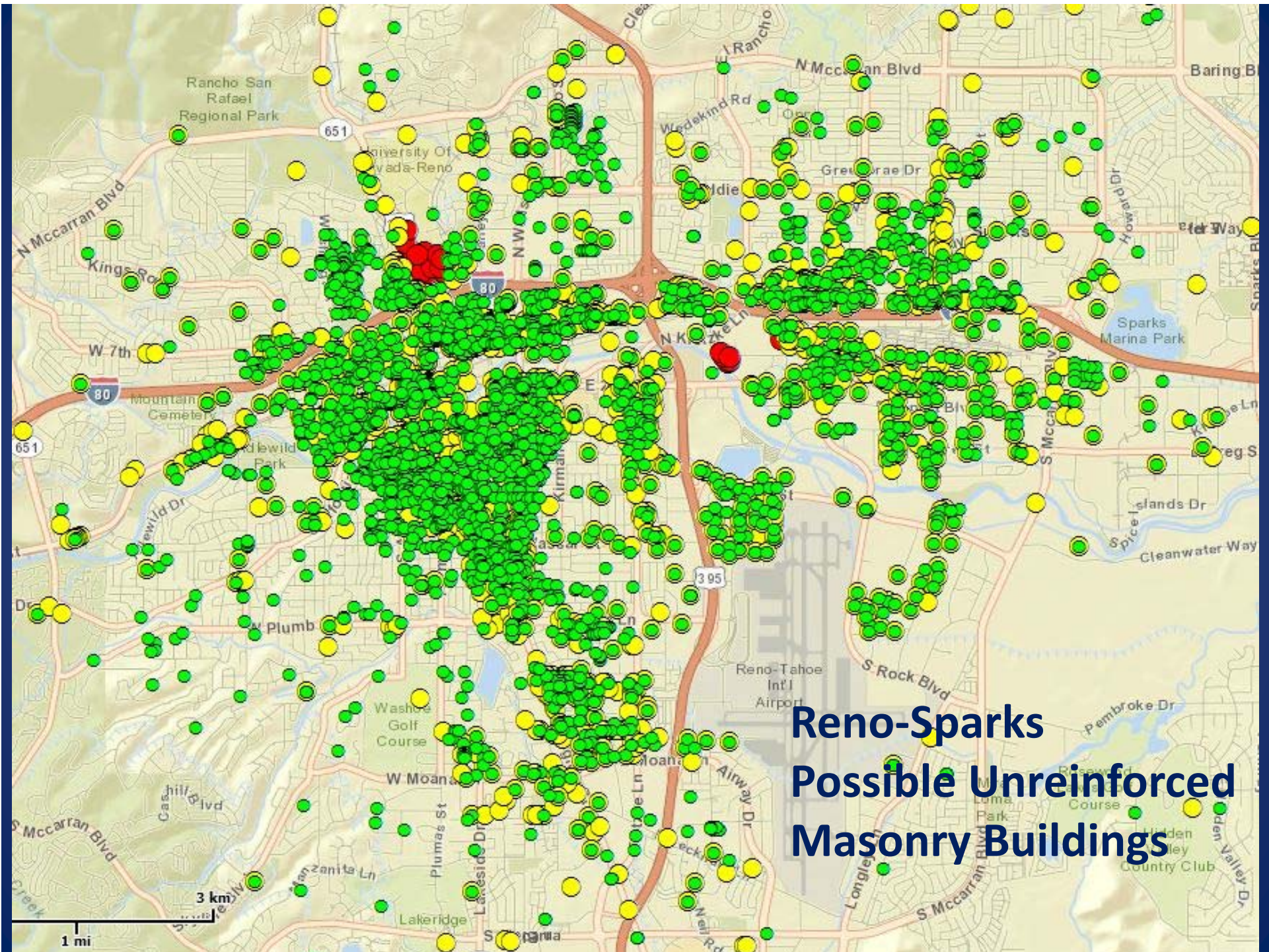
2012 NBMG study 14,359 potential URMBs

Contemporary Clark County projections: **300 to 500 commercial URMBs; 600-1000 residential URMBs**

Major benefits of Las Vegas liking to *blow up or tear down and replace* old buildings.

1961 UBC being the change point [reinforcement required] and use **1974** (similar to NBMG Report 54) as an effective date for implementation and enforcement.

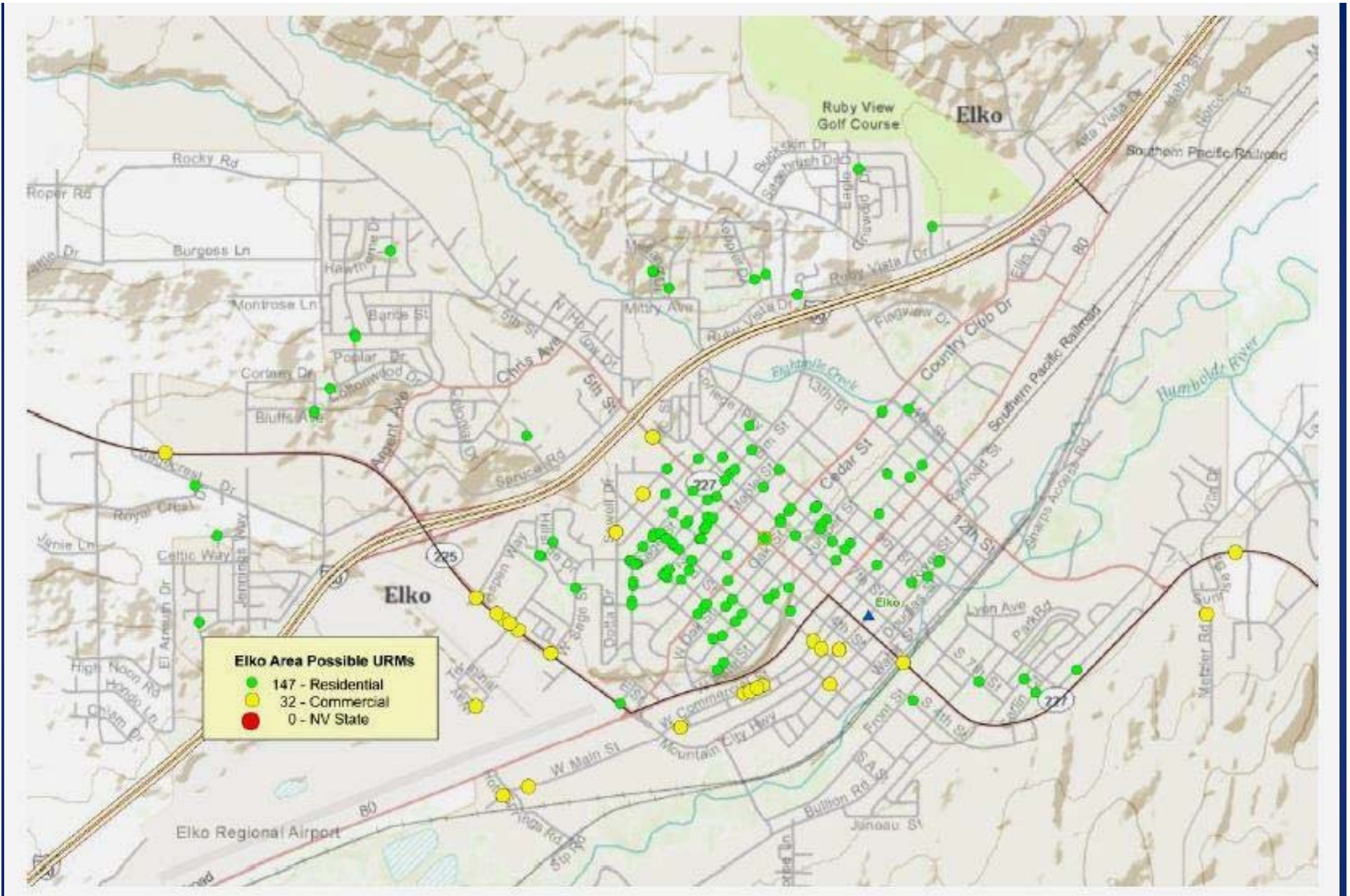
Werner Hellmer, Clark County Building Department



**Reno-Sparks
Possible Unreinforced
Masonry Buildings**



2012 study 734 poss. URMBs; Carson City survey identified about 100 prob. URMBs



Elko – 179 possible URMBs

What has been done in Nevada to reduce this risk?

- Buildings code seismic provisions have been adopted by all Nevada Counties – outlaws URMBs
- Many state URMBs have been retrofit
- About 0 to 6 buildings rehabilitated/year
- Thousands of URMBs have been torn down
- URMB Committee developed risk reduction roadmap



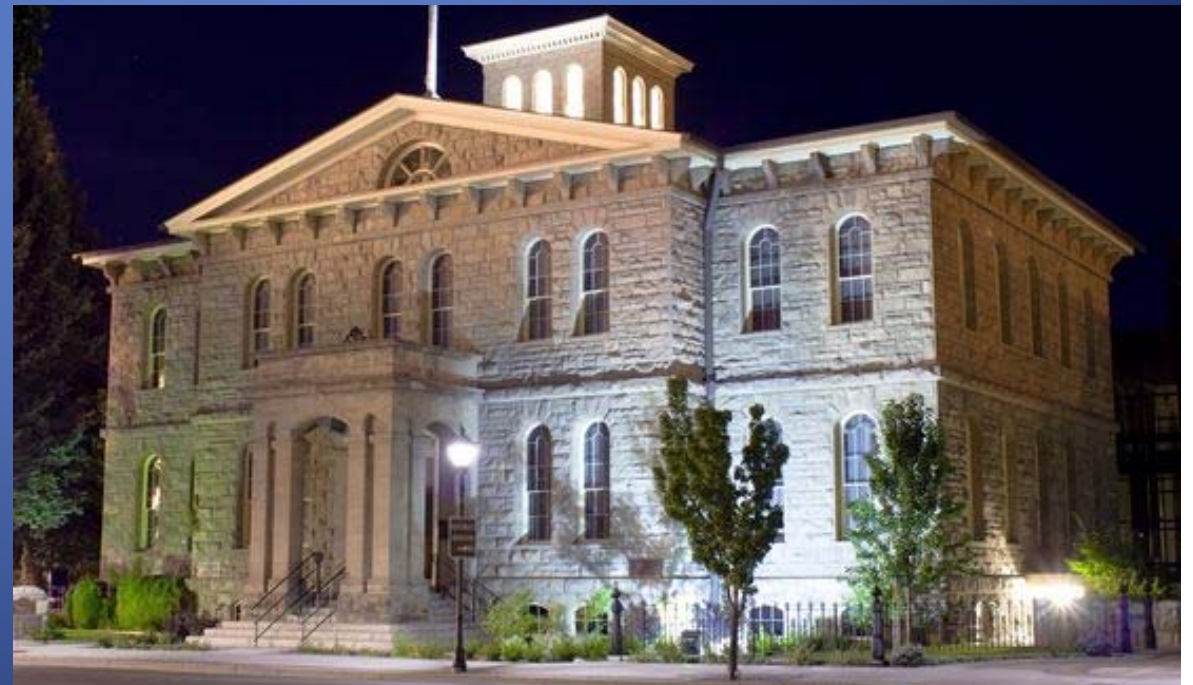
Nevada
Capitol
Building



Mackay
School
of
Mines

Carson
City
Mint

Nevada URBMs with Seismic Retrofits



Roadmap for Reducing the Seismic Risk of Unreinforced Masonry Buildings in Nevada

- 1) Complete **URMB Inventory** of Nevada and Prioritize by Seismic Risk
- 2) Initiate **Broad Educational Efforts** on the Hazards of URMBs
- 3) Develop/Summarize Effective Seismic **Retrofit Methodologies** for URMBs/URMB web site
- 4) Provide **Incentives** to Retrofit/Reduce the Seismic Risk of URMBs
- 5) **Motivate Action** that Reduces the Seismic Risk from URMBs
- 6) **Nevada Decade of Unreinforced Masonry Building Seismic Risk Reduction**
- 7) **Rehabilitate or Remove Vulnerable URMBs** and Other URM Structures

Unreinforced Masonry Buildings
are the *most difficult*
contemporary challenge in
creating an earthquake-resistant
society.

- **Social challenges** with owners, tenants, neighbors, community.
- **Money** is needed that is **rarely available**. Retrofit costs, business disruption, moving costs, increases in rent to cover the cost
- **Risk is not always compelling**. High consequence but low probability – risk is chance of earthquake times chance of damage at specific location; *low belief in local hazard*



Placard from Santa Barbara



Portland protests against placards

1925 Santa Barbara, California Earthquake Unreinforced Masonry Damage to the Hotel California

Influencing and Motivating People to Action

Carrot – incentives to the maximum degree possible, but watch out for dependencies

Reasoning – necessary approach for widespread acceptance

Social Cueing – most powerful approach, part of widespread acceptance

Champions/Leadership – someone to follow, enhance believability

Fairness/Shared Burden – could motivate reluctant owners; those who benefit from the risk reduction share the financial burden

Uniform Message from Different Agencies/Groups – powerful approach, credibility, believability

Repeated Message – reach people that aren't listening, especially if it is in a format they respond to; 7 to 9 message repeats for impact

Windows-of-Opportunity – powerful approach, includes grants, risk-reduction decade, and strong earthquakes with unacceptable URMB damage

Stick - used elsewhere, but not always the best approach for Nevada communities

Nevada has made modest progress in reducing its overall URMB seismic risk mostly through tearing down a lot of URMBs and not letting them be built anymore.

Thousands of URMBs exist throughout the state and many have been damaged by past Nevada earthquakes. Many of these buildings are in fragile and dilapidated states.

There does not exist a broad consciousness or effort to reduced the URMB seismic risk in Nevada, as there is in other states with URMB risks (e.g., CA & UT). At this point, Nevada lacks a group to promote this risk reduction.

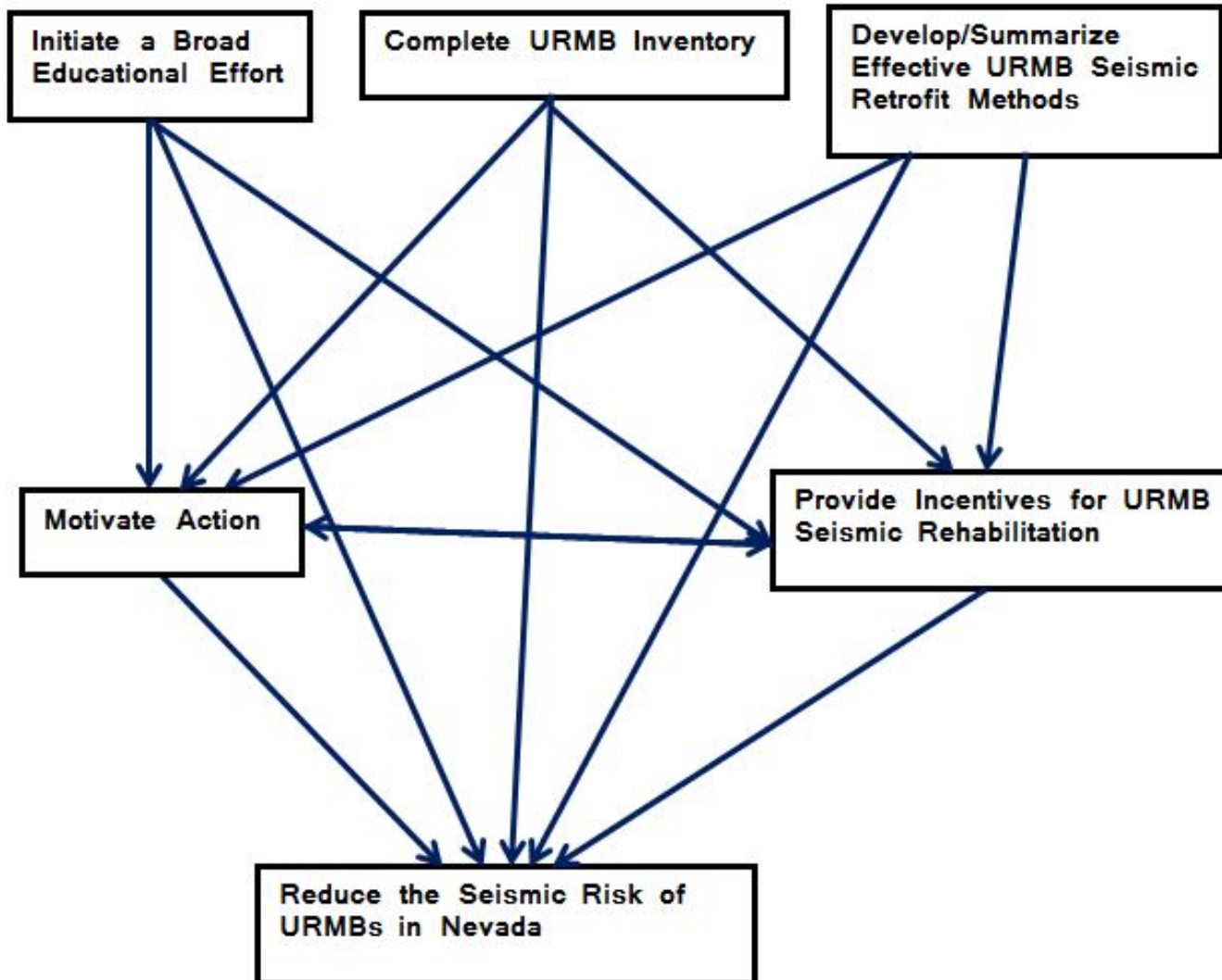
The next window of opportunity for action will probably be the next damaging/deadly Nevada earthquake.

Unreinforced Masonry Buildings (URMBs):

The Nevada Resilience Advisory Committee recognizes unreinforced masonry buildings as dangerous earthquake risks and encourages actions within Nevada to reduce this risk, with the result of saving lives, reducing injuries, and reducing property loss from earthquakes.



URMB Seismic Risk Reduction Flow Chart



Unreinforced
masonry
can *fall into*
Buildings
during earthquakes



Photo courtesy of
Ariel D. Benson,
Richmond, UT

Cost of seismic retrofit:

\$100,000s to \$Millions

Large ticket item – especially to individual owners, who might doubt an earthquake will ever occur and damage their building – come on really

Problem – strong earthquakes occur in Nevada

Shared cost – grants, bonds, contributions from those that would benefit from the risk reduction, other.
A strategy would be best.

Unreinforced Masonry Buildings (URMBs) are the most seismically vulnerable buildings in Nevada.

On the order of about a third of URMBs are expected to have failures in areas of strong shaking.