Dollars, deaths, and downtime: understand your building's seismic risk and how to evaluate it

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Don’t get your earthquake ideas here:
U.S. earthquakes are dangerous but generally don’t produce devastation. Most people and buildings survive. You can measure and cost-effectively manage seismic risk.
## Buildings are relatively safe

<table>
<thead>
<tr>
<th>Peril</th>
<th>Deaths per 100,000 population per year</th>
<th>Where, when</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
<td>194</td>
<td>US, 2010</td>
</tr>
<tr>
<td>All accidents</td>
<td>39</td>
<td>US, 2010</td>
</tr>
<tr>
<td>Occupational fatality, roofers</td>
<td>32</td>
<td>US, 2011</td>
</tr>
<tr>
<td>Auto accidents</td>
<td>11</td>
<td>US, 2009</td>
</tr>
<tr>
<td>Firearms</td>
<td>10</td>
<td>US, 2010</td>
</tr>
<tr>
<td>New buildings in earthquakes</td>
<td>0.1</td>
<td>24/7 occupancy</td>
</tr>
<tr>
<td>CA earthquakes last ~50 years</td>
<td>0.007</td>
<td>CA, 1964-2014</td>
</tr>
</tbody>
</table>
Scary 99.9% JPL prediction
USGS’s estimate: 85%
85% or 99.9%: both mean “likely”

USGS
- Happens by 2018
- Later

JPL
- Happens by 2018
- (Later)
M6-7 events matter in the short run

1987 Whittier M5.9  
$400 M USD  
3 deaths

1971 San Fernando M6.7  
$550 M USD  
64 deaths

1994 Northridge M6.7  
$40 B USD  
57 deaths
M 7-8 events matter in the long run

Hypothetical M 7.8 ShakeOut: a 150-year event, 150 years “overdue”
$209 B USD
1800 deaths
All are reasons to manage your risk
4 strategies to manage seismic risk

- Mitigate
- Measure
- Insure
- Plan
Strategy 1: measure
Strategy 2: mitigate
Strategy 2: mitigate
Strategy 2: mitigate
Seismic retrofit can be cost effective

395 public-sector seismic retrofits in 1993-2003:

- Cost: $950 M
- Saved: $1,390 M
- BCR: 1.5:1
Seismic retrofit can be cost-effective

Nonstructural retrofit 3 data centers
- Cost: $3 M
- Saves: $100 M
- BCR ≈ 33:1

Nonstructural retrofit 2 office bldgs
- Costs: $5.5 M
- Saves: $75M worth of casualties
- BCR ≈ 14:1

Anheuser-Busch Brewery retrofit
- Cost: $11 M
- Saved $350 M in losses in 1994
- BCR ≈ 30:1
Seismic retrofit can be cost effective

BCR up to 7:1
Strategy 3: insure

Costs $1.00/$1000 +
Benefit < cost
But mitigates risk of ruin
Strategy 4: plan
(emergency management & biz continuity)

Prevention strategies

Mitigation strategies, e.g., alternate workplace

Incident command system

...
Strategy 4: plan

Emergency management & business continuity planning relatively inexpensive, probably very very high BCR
Evaluating risk

Some basic principles
What the evaluator will look for

- Hazard
- Structure type
- Era of construction
- Important features
- Concealed details
Hazard
Structure type
Worst

Unreinforced masonry bearing wall
Pre-1976 reinforced concrete frame
Structure type
From worst to best

Pre-1976 tiltup concrete

Steel frame with unreinforced masonry infill cladding
Structure type
From worst to best

Pre-1994 steel frame
Structure type
From worst to best

Steel braced frame
Woodframe
Structure type
From worst to best

Concrete shearwall

Reinforced masonry
Important features

Soft story

Close to adjacent building
Important features

Sloping site

Atria & irregular plans
Newer is better, but code goal is *life safety*

Code limits collapse \[\rightarrow\] accepts impairment

51% of buildings usable after earthquake

0.8% collapse

10% unsafe

38% restricted use

¾ design level, ~100-year shaking
Evaluation procedures

Choices for PML-type studies
Steinbrugge’s PML (1970s-1999)

upper-bound loss (90 %ile) in rare earthquake (0.2% chance per year) as a fraction of construction cost considering location, structure type, and important features
PML estimation procedures

- ATC-13 (1985)
- Expert judgment + limited experience
- Foundation for seismic risk estimates around the world even to today
- Evaluators were professional engineers
1989, 1994 scared insurers & lenders
Lenders began to require PML < 20% or insurance

20th Century Insurance Out of Quake Action
June 10, 1994 | THOMAS S. MULLIGAN | TIMES STAFF WRITER

In a move certain to shake up the Southern California insurance market, earthquake-battered 20th Century Insurance Co. said Thursday that it will stop selling earthquake policies immediately and phase out all homeowner coverage over the next two years.

The big insurer's exit increases fears that consumers--especially in the Los Angeles Basin--will have trouble finding earthquake insurance.

In Orange County, 34,894 homeowner policy holders who have insurance with 20th Century will have to look elsewhere. They represent 14.7% of the company's business statewide.

The action also prompted renewed calls for a national catastrophe insurance program such as the Natural Disaster Protection Act now before Congress.

Woodland Hills-based 20th Century said it will take no new customers in either homeowner or earthquake insurance, but will concentrate on the cut-rate auto policies that form the bulk of its business and have fueled its 30 years of fast growth and high profits.
1990s: new terms muddy the waters

SEL scenario expected loss
PL probable loss
SL scenario loss

Easier to get SEL < 20%
Helps avoid buying insurance
Little incentive for rigor & QA
PML studies become a $500 box to check
2000s: new standards, same problems
ST-Risk

ATC-13 + engineering refinements + Hazus-MH + insurance loss data

Proprietary code
Enter the USRC

Goals

• Meaningful ratings
• Measuring 3Ds
• Experienced, accredited professional engineers
• Technical review
• Consistent
• Affordable
# USRC Ratings

<table>
<thead>
<tr>
<th>Safety</th>
<th>Damage</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>5★</td>
<td>5★</td>
<td>5★</td>
</tr>
<tr>
<td>Injuries and blocking of exit paths unlikely</td>
<td>Minimal damage (&lt; 5%)</td>
<td>Immediately to days</td>
</tr>
<tr>
<td>4★</td>
<td>4★</td>
<td>4★</td>
</tr>
<tr>
<td>Serious injuries unlikely</td>
<td>Moderate damage (&lt; 10%)</td>
<td>Within days to weeks</td>
</tr>
<tr>
<td>3★</td>
<td>3★</td>
<td>3★</td>
</tr>
<tr>
<td>Loss of life unlikely</td>
<td>Significant damage (&lt; 20%)</td>
<td>Within weeks to months</td>
</tr>
<tr>
<td>2★</td>
<td>2★</td>
<td>2★</td>
</tr>
<tr>
<td>Loss of life possible in isolated locations</td>
<td>Substantial damage (&lt; 40%)</td>
<td>Within months to a year</td>
</tr>
<tr>
<td>1★</td>
<td>1★</td>
<td>1★</td>
</tr>
<tr>
<td>Loss of life likely in the building</td>
<td>Severe damage (40%+)</td>
<td>More than one year</td>
</tr>
<tr>
<td>NE</td>
<td>NE</td>
<td>NE</td>
</tr>
<tr>
<td>Not Evaluated</td>
<td>Not Evaluated</td>
<td>Not evaluated</td>
</tr>
</tbody>
</table>
USRC’s 2 levels of effort

<table>
<thead>
<tr>
<th>Transaction Rating</th>
<th>Verified Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 stars, 3 dimensions</td>
<td>1-5 stars, 3 dimensions</td>
</tr>
<tr>
<td>Financial due diligence; no display</td>
<td>Display and marketing</td>
</tr>
<tr>
<td>Trained certified professional engineer</td>
<td>Trained certified professional engineer</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; party review (1 in 7, afterwards)</td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; party review (all, prior to issue)</td>
</tr>
<tr>
<td>Transparent use of national standards</td>
<td>Transparent use of national standards</td>
</tr>
<tr>
<td>Designed to prevent manipulation</td>
<td>Designed to prevent manipulation</td>
</tr>
</tbody>
</table>

$700-900 $1,000+

Adapted from Ron Mayes
USRC adapted ASCE/SEI 31 checklists

Building System

C NC N/A LOAD PATH: The structure shall contain a minimum of one complete load path for Life Safety and Immediate Occupancy for seismic force effects from any horizontal direction that serves to transfer the inertial forces from the mass to the foundation. (Tier 2: Sec. 4.3.1.1)

Building Contents and Furnishing

C NC N/A TALL NARROW CONTENTS: Contents over 4 feet in height with a height-to-depth or height-to-width ratio greater than 3-to-1 shall be anchored to the floor slab or adjacent structural walls. A height-to-depth or height-to-width ratio of up to 4-to-1 is permitted where only the Basic Nonstructural Component Checklist is required by Table 3-2. (Tier 2: Sec. 4.8.11.1)

Light Fixtures

C NC N/A INDEPENDENT SUPPORT: Light fixtures in suspended grid ceilings shall be supported independently of the ceiling suspension system by a minimum of two wires at diagonally opposite corners of the fixtures. (Tier 2: Sec. 4.8.3.2)
Highly reputable backers
FEMA P-58 for the very high end

How likely are various
- Repair costs
- Duration of repair time
- Casualties

With and without retrofit

Weigh costs and benefits in $ terms

Little reliance on judgment

Expensive--$10,000s

High-end structural engineering skills
Reconciles hazard & business timescales
Can reflect risk on a balance sheet

Expected repair cost & downtime in coming 5 years

### Example Company
**Balance Sheet**
**December 31, 2014**

<table>
<thead>
<tr>
<th>ASSETS</th>
<th></th>
<th>LIABILITIES &amp; OWNER'S EQUITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current assets</td>
<td></td>
<td>Current Liabilities</td>
</tr>
<tr>
<td>Investments</td>
<td></td>
<td>Long-term liabilities</td>
</tr>
<tr>
<td>Property, plant, and equipment</td>
<td></td>
<td>Total liabilities</td>
</tr>
<tr>
<td>Intangible assets</td>
<td></td>
<td>Owner’s equity</td>
</tr>
<tr>
<td>Other assets</td>
<td></td>
<td>Total liabilities &amp; owner's equity</td>
</tr>
<tr>
<td>Total assets</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- PML studies have been a $500 checkbox
- USRC seems able to provide solid benchmarks
- FEMA P-58 is costly, expresses risk in meaningful terms
- Acceptability criteria are still unclear
- Still no affordable balance-sheet risk assessment
- Many decisions don’t need costly risk estimates—you don’t need FEMA P-58 to justify DCHO, etc.
Thanks

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