The Great California ShakeOut – Teaching Risk & Resilience

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What is a ShakeOut?

- A 2008 USGS-led disaster scenario involving 300+ people
- Created at stakeholder request
- Severe, not-worst-case
- Science-based, societal scope
- A worldwide exercise
- To answer the question:

What could happen in the big one & how can one prepare?
150 yr return period; 300 yr since last rupture

Compare with 1994 Northridge earthquake:
- 50x smaller
- Magnitude 6.7
- 33 deaths
- $40 billion damage

Compare with 2008 Chino Hills earthquake:
- 5000x smaller!
- Magnitude 5.4
- 0 deaths
- Minimal damage
Building damage

~4% of buildings in 8 counties
~1.1% of buildings
~0.9% of buildings
Focus study: steelframe buildings

- 600 buildings, 1,000+ occupants each
- Unexpected damage in 1994
- ShakeOut: 5 collapses, 30 more red or yellow tagged

“The fact that there were no collapses in previous US earthquakes cannot be taken as evidence that there would not be collapses in this scenario. In fact, the possibility of some collapses is quite credible.” – Review panel

Kobe, Japan 1995

Mexico City, 1985
Water supply

19 reps from 8 water agencies:
- Aqueducts & tunnels rupture at fault crossings
- ≤ 10 mi. of fault: supply impaired up to 6 months
- In 3 counties, 5% lose service for 1-8 weeks
- 1/2 customers lose service for up to 1 week
- LADWP now renovating aqueducts
- Water agency staff now have desk at EOC
Deaths & injuries

1,800 killed, 50,000 injured (ER)

Northridge: 33 killed, 8,300 injured

Up to 2/3 of hospital beds unavailable in some counties

Evacuation of Sherra Cox, 1989 Loma Prieta earthquake

Olive View Medical Center, 1971 San Fernando earthquake
Fire following earthquake

1,600 ignitions
200M ft$^2$ burn ≈ 133,000 homes

*Not worst case*

Recommended new water supply system

2 fire chiefs, 2 other fire officials:
“Reasonable… if anything, a bit low.”
Monetary bottom line

Property damage: $113 billion
60% from fire

Business interruption: $96B
55% from water
10 Teaching Lessons
<table>
<thead>
<tr>
<th>Public &amp; officials</th>
<th>Engineers</th>
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</thead>
<tbody>
<tr>
<td>Not-very-rare earthquake</td>
<td>2500-year shaking</td>
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<tr>
<td>1,800 deaths</td>
<td>~0.2% collapse rate</td>
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<tr>
<td>53,000 injuries</td>
<td>10 deaths per 100,000</td>
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<td>$213 billion damages</td>
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<td>255,000 displaced people</td>
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<td>– 1 in 60</td>
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<td>1,600 fires requiring response</td>
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<td>300,000 buildings significantly damaged – 1 in 16</td>
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2. Relate to experience

1989 Loma Prieta

1989 San Francisco

1971 San Fernando

5/2/83 M6.5 Coalinga

1994 Northridge CA

1933 Long Beach
3. Avoid sensationalism

- Five highrise steelframe buildings collapse
- *Steel frame is safer than other types*
4. Use probability sparingly

“Won’t happen like this; will happen; could be tomorrow”
5. Involve everyone

- Stakeholders & scholars created the scenario
- Independent, parallel studies, cross-compared
- Considered interaction & limitations of mutual aid
- Validation by thought leaders for controversial results
- Multiple agencies, NGOs endorsed & promoted the scenario

Hudnut et al., Suess et al., Raleigh
6. Confront misinformation

E.g., “triangle of life”
Explain false assumptions
Cite rebutting authorities
7. Acknowledge limitations

Best earth science, but science evolves

Objective: reasonableness, not probabilistic risk

Some impacts purely from judgment

Computer models simplify & extrapolate, e.g., HAZUS not validated against a real Big One
8. Use activities

Shakeout.org: registration, local info, & drill scripts
Participants created their own activities
9. Defend in depth

ShakeMap
4 computer models largely agree
Vetted by 100 seismologists
Engineers tried to question it

Fire
Frightening losses, costly mitigation
Reviewed by fire officials

Highrises
Evoke 9/11
Vetted by leading practitioners
10. Offer engaging, useful resources

- Websites
- Multiple languages
- YouTube videos
- K-12 educational kits
- *Beat the Quake* online game
- Scholarly & lay publications
- Briefings & speakers’ bureau
- Social media