Earthquake Risk in Residential Buildings

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Berkeley Community Forum
February 24, 2005
A Presentation by ...

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Association of Northern California

Existing Buildings Committee,
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Bay Area Residential Buildings

- **1- & 2-family**
  - 75%: 5 million people
  - About 1.8 million units

- **Multifamily**
  - 25%: 2 million people
  - In SF, 40%: 300,000
  - About 90,000 buildings, 800,000 units

- **Cripple walls**
  - 200,000 houses
  - Hillsides

- **URM**
  - SWOF
High Risk Residential Buildings

- Unreinforced masonry
  - Built until 1933
  - 6800 in Bay Area in 1990
High Risk Residential Buildings

1989

1994

2003
Solutions

- Brace parapets
  - LA, 1949; SF, 1969
- Anchor walls to floors
- Reinforce corners and tall walls
- Retrofit structure
  - SB 547, 1986
  - See SSC reports
## Risk Reduction Status (UCBC)

<table>
<thead>
<tr>
<th>City</th>
<th>Number</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>1832</td>
<td>62% -</td>
</tr>
<tr>
<td>Oakland</td>
<td>1612</td>
<td>89% -</td>
</tr>
<tr>
<td>Berkeley</td>
<td>729</td>
<td>85%</td>
</tr>
<tr>
<td>San Jose</td>
<td>146</td>
<td>79%</td>
</tr>
<tr>
<td>Bay Area</td>
<td>6800</td>
<td>56%</td>
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</tbody>
</table>

*Many of these are not residential buildings.*
High Risk Residential Buildings

- Unreinforced masonry
- Hillside houses on stilts
High Risk Residential Buildings
Solutions

- An easy fix?
  - L.A. Div 94
- Lots and lots of bracing
- Serious structural & geotechnical engineering
High Risk Residential Buildings

- Unreinforced masonry
- Hillside houses on stilts
- SWOF Buildings
SWOF: Soft, Weak, Open Front

- 2-4 stories
- Often "tuck-under" parking
- Wood or masonry at 1st story
SWOF: Soft, Weak, Open Front

- Most residential
SWOF: Soft, Weak, Open Front

- Many built in 1960s, 70s
SWOF: Soft, Weak, Open Front

- San Francisco buildings are older
What’s wrong with a SWOF?

- Sidesway deformation
- Torsion
- Collapse
Sidesway deformation

- Heavy roofs
- Inadequate wall
- Rigid upper stories
Sidesway in SWOF buildings
Sidesway in SWOF buildings
SWOF Sidesway: 1971
SWOF Sidesway: 1989
SWOF Sidesway: 1994
Collapse in SWOF buildings

Gravity

EQ

Collapse in SWOF buildings
SWOF Collapse: 1989
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Bay Area SWOF Risk

- 15,000 buildings (1 in 6 multistory MFR)
  - 500,000 people

- San Francisco: 5700 buildings (over half)
  - 180,000 people
  - Half of S.F.’s total economic loss in 7.2 eq

- Santa Clara County: 2630 buildings (1 in 3)
  - 90,000 people
What eq risks do they pose?

- To tenants
  - Loss of life, property, housing

- To owners
  - Loss of property, business income

- To city
  - Strain on post-earthquake response
  - Loss of housing stock, tax base, good will

- Liability?
What can be done?

- Attrition
- Insurance
- Structural retrofit
  - Add walls
  - Add frame
  - Enhance existing walls
Retrofit scheme: add walls
Retrofit scheme: add frame
Retrofit scheme: enhance walls
Tradeoff: performance v. cost

- R&C study for San Jose
- Life Safety
  - $6,000 to $9,000 per unit
- Limited Downtime
  - $14,000 to $20,500 per unit
- +/- 25%, many other caveats, variables
Tradeoff: cost v. benefit

- 200-unit complex
- Damaged in 1971 San Fernando
  - Repaired & strengthened: $17,500 per unit
- 1994 Northridge performance
  - Green-tagged: safe to occupy
  - Cosmetic repairs: $500 per unit
First steps for tenants

- Awareness, education
- Self-assess risks

*What is the city’s role?*
First steps for owners

- Awareness, education
- Self-assess risks
- Professional consultation (engineer, lender, insurer, attorney?)

What is the city’s role?
First steps for local governments

- Inventory
- Recognition
  - Risk assessment
  - Public awareness, education
- Policy
  - General policy: *Performance Objectives*
  - Voluntary or mandatory?
  - Technical standards