Risk Decision Making for Buildings – From Owners to Society

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PEER Summative Meeting 13 June 2007
Defining Links Between Planning, Policy, Economics and Earthquake Engineering

Workshop in May 1998 Raised Questions:

- How to integrate disciplines and find a common language?
- Can models from various disciplines be linked?
- What should performance standards look like?
- **Can a standardized loss-accounting system be developed?**
- What are meaningful metrics?
- What are financial implications of performance standards?
- What is known about adoption, implementation and enforcement of performance based codes?
Key Milestone: Defining Loss Metrics

What the 3 D’s Mean to Decision Makers

Death
- Casualty and Injury Prevention
- Reduces Risks to Users

Dollars
- Estimated Losses in Scenarios or Annualized
- Allows Comparison of Losses vs. Mitigation Costs

Downtime
- Impact of Building Damage on Operations
- Sets value of recovery time
PEER - PBEE Methodology Components

- Decision Variable ($loss, downtime, life-safety$)
- Damage Measure (condition assessment, necessary repairs)
- Eng. Demand Param. (drift, acceleration)
- Intensity Measure (Sa, Sv, duration ...)

Loss Models
Performance (Damage) Models
Simulation Models
Testbeds Applied Methodology

<table>
<thead>
<tr>
<th>Lab</th>
<th>Floor</th>
<th>Safety</th>
<th>Operability</th>
<th>Safety</th>
<th>Operability</th>
<th>Safety</th>
<th>Operability</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>1</td>
<td>0.14</td>
<td>&lt;0.01</td>
<td>0.62</td>
<td>0.06</td>
<td>0.96</td>
<td>0.50</td>
</tr>
<tr>
<td>M</td>
<td>3</td>
<td>0.50</td>
<td>0.18</td>
<td>1.00</td>
<td>0.72</td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td>L</td>
<td>4</td>
<td>0.58</td>
<td>0.44</td>
<td>0.94</td>
<td>0.82</td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td>XL</td>
<td>4</td>
<td>0.72</td>
<td>0.36</td>
<td>0.96</td>
<td>0.78</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>XO</td>
<td>5</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Expected NPV (Structural) | Downtime | Deaths |
---------------------------|----------|--------|
Do nothing                | $0       | 16 days| 0.13   |
Moderate retrofit          | $142,178 | 7.6 days| 0.06   |
Extensive retrofit         | -$61,319 | 3.2 days| 0.02   |
# Benchmark Project Integrated Loss Studies

<table>
<thead>
<tr>
<th>Discussion Point</th>
<th>Beck, Mitrani-Reiser, &amp; Porter</th>
<th>Miranda, Aslani, &amp; Ramirez</th>
<th>Moehle, Stojadinovic, Der Kiureghian, &amp; Yang</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition of damageable components</strong></td>
<td>Group damageable building components into <em>assembly groups</em></td>
<td>Divided by building components by floors</td>
<td>Group damageable building components into <em>performance groups</em> sensitive to the same EDP.</td>
</tr>
<tr>
<td><strong>Casualty</strong></td>
<td>Use Shoaf and Seligson data to estimate value of a statistical life</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Downtime**     | Use Comerio data | ABAG/Building Department Data on Wood Residential Buildings:  
2 Years to Repair  
4 Years to Rebuild  
Stanford and UC Case Study Experience:  
2-3 Years Min Repair of Large Buildings  
Plus Mobilization Time and External Conditions |                                             |
## Benchmark Study Integrated “3 D” Losses

<table>
<thead>
<tr>
<th>Design Description</th>
<th>EAL ($)</th>
<th>EALD ($)</th>
<th>EALF ($)</th>
<th>EAL TOTAL ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A:</strong> Baseline perimeter frame design.</td>
<td>66,585</td>
<td>20,519</td>
<td>4,900</td>
<td>92,004</td>
</tr>
<tr>
<td><strong>B:</strong> Same as A, but with code-min strengths.</td>
<td>95,656</td>
<td>28,362</td>
<td>4,550</td>
<td>128,568</td>
</tr>
<tr>
<td><strong>C:</strong> Same A, but with uniform beam/column throughout.</td>
<td>51,933</td>
<td>22,207</td>
<td>5,600</td>
<td>79,740</td>
</tr>
<tr>
<td><strong>D:</strong> Same as C, but no SCWB provision.</td>
<td>112,930</td>
<td>32,726</td>
<td>79,800</td>
<td>225,456</td>
</tr>
<tr>
<td><strong>E:</strong> Baseline space frame design.</td>
<td>49,422</td>
<td>19,517</td>
<td>3,500</td>
<td>72,439</td>
</tr>
</tbody>
</table>

Ref: J. Mitrani Reiser
UCB Implementation of Performance Goals

- Risk Management: Building-Specific and Inventory Performance Objectives
- No closure > 30 days
## UC Risk Reduction – Seismic Retrofits (2000-06)

<table>
<thead>
<tr>
<th>Source and Loss Parameter</th>
<th>Scenario Earthquake Level</th>
<th>Occasional (50%/50 Yrs.)</th>
<th>Rare (M7.0)</th>
<th>Very Rare (M7.25)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic losses w/Closure ($ millions) - 10 Buildings (approx. $1.1 billion)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before Seismic Retrofit</td>
<td>$171</td>
<td>$568</td>
<td>$761</td>
<td></td>
</tr>
<tr>
<td>After Seismic Retrofit</td>
<td>$31</td>
<td>$219</td>
<td>$337</td>
<td></td>
</tr>
<tr>
<td>Risk Reduction</td>
<td>$140</td>
<td>$349</td>
<td>$424</td>
<td></td>
</tr>
</tbody>
</table>

| **Deaths and Serious Injuries based on ECO (approx. 1,350 people)** | | | |
| Before Seismic Retrofit | 23 | 104 | 153 |
| After Seismic Retrofit | 0 | 3 | 7 |
| Risk Reduction | 23 | 101 | 146 |

Ref: C. Kircher
ATC 58 Products Use PEER Methods

Guidelines for Seismic Performance

Recommendations for:
- building officials
- building owners
- lenders
- tenants
- insurers

how to take advantage of PBEE

Ref: R. Hamburger
Performance Goals for Risk Management

- Non-owners Use Performance to Set and/or Limit Annualized Losses
  - Insurance and Re-insurance

- Real Estate Owners Use Performance Goals to Manage Assets Pre- and Post-Disaster
  - Government, Institutions
  - Lenders, Portfolio Managers
  - e.g. St. Louis Art Museum
    - Set Design Criteria for Addition
  - e.g. Arden Realty, LA
    - Requires Tenant Insurance
    - Plans for Downtime in Leases
PEER Established a Performance Vocabulary

- Defining and Costing Damage to Structural and Nonstructural Systems and Contents
- Defining and Incorporating the Risk to Life in Financial Terms
- Defining Mobilization and Repair Time; Establishing Baseline Data
- Used by Engineers, Owners, Insurance, Portfolio Managers, Government, etc.