Performance Based Earthquake Engineering as a Resilience Option

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What is Performance Based Earthquake Engineering?

- PBEE focuses on consequences of earthquake damage to a building

  **FEMA P-58 calculates:**
  - Structural damage
  - Non-structural damage
  - Repair cost
  - Repair time
  - Chance of unsafe placard
  - Casualties
  - Carbon impacts of repairs

- This information can be used to guide decision making
Comparison of PBEE approach to code-based approach for design

<table>
<thead>
<tr>
<th>Type of Loss</th>
<th>Code</th>
<th>FEMA P-58</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural damage</td>
<td>Damage at or below level for safety</td>
<td>Evaluates</td>
</tr>
<tr>
<td>Nonstructural damage</td>
<td>Some components designed to remain in place</td>
<td>Evaluates</td>
</tr>
<tr>
<td>Casualties</td>
<td>Safety expected in newer buildings</td>
<td>Evaluates</td>
</tr>
<tr>
<td>Financial losses</td>
<td>Not evaluated</td>
<td>Evaluates</td>
</tr>
<tr>
<td>Chance of unsafe placard</td>
<td>Not evaluated</td>
<td>Evaluates</td>
</tr>
<tr>
<td>Repair time</td>
<td>Not evaluated</td>
<td>Evaluates</td>
</tr>
<tr>
<td>Environmental impacts</td>
<td>Not evaluated</td>
<td>Evaluates</td>
</tr>
</tbody>
</table>
How can PBEE be used?

<table>
<thead>
<tr>
<th>New Buildings</th>
<th>Existing Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Designing for High Performance</td>
<td>3. Risk Evaluation</td>
</tr>
<tr>
<td>2. Improved Design Flexibility (Code Equivalency)</td>
<td>4. Seismic Retrofit</td>
</tr>
</tbody>
</table>

Most common usage currently
Comparing PBEE process to code based process

- Define performance goals
- Design building to meet code standards
- Check if meet performance goals, adjust as needed

Code based process → Performance based process
What matters to building decision makers?

Building decision makers consider many issues when undertaking a building project.
Upfront Cost Considerations

- Aspects that can affect upfront cost:
  - Time needed to set goals
  - Time needed for additional analysis
  - Structural elements for higher performance
  - More resilient components
  - Knowledgeable team members

- Not always more expensive, but can be more complex
Using PBEE to enhance resilience

- Most likely users:
  - large corporations, institutions, governments

- Most likely to use for buildings where:
  - Quick reoccupancy is important
  - Building represents significant financial investment
  - High value assets or activities inside
  - Seek to maintain long-term interest
  - Historic, cultural, symbolic, or brand importance
PBEE in the future

- PBEE analysis methods are improving
- Ease of use is improving
- Cost of use is decreasing
- Awareness of resilience concerns increasing
- Questions about adequacy of code standards increasing