Effect of Modeling Parameters on Collapse Behavior of RC Building

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### Rehabilitation Objective

#### Target Building Performance Levels

<table>
<thead>
<tr>
<th>Earthquake Hazard Level</th>
<th>Operational Performance Level (1-A)</th>
<th>Immediate Occupancy Performance Level (1-B)</th>
<th>Life Safety Performance Level (3-C)</th>
<th>Collapse Prevention Performance Level (5-E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%/50 year 72 yrs</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>20%/50 year 225 yrs</td>
<td>e</td>
<td>f</td>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td>BSE-1 474 yrs (~10%/50 year)</td>
<td>i</td>
<td>j</td>
<td>k</td>
<td>l</td>
</tr>
<tr>
<td>BSE-2 2475 yrs (~2%/50 year)</td>
<td>m</td>
<td>n</td>
<td>o</td>
<td>p</td>
</tr>
</tbody>
</table>

### ASCE-41 Standard

#### Acceptance Criteria

- Maximum Considered Earthquake

#### Modeling Parameters

- Deformation ratio
- Component or element deformation acceptance criteria

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FEMA P695 Methodology

Equivalent safety against collapse for buildings with different seismic force resisting systems

Collapse Safety Margin → Design Criteria for Building Codes (i.e. $R$, $C_d$, and $\Omega_0$ seismic performance factors)

Median Collapse: One-half of the structures have some form of collapse

Local Instability → Global Instability

Collapse Margin Ratio, $CMR = \frac{SA \text{ Median collapse-level ground motions}}{SA \text{ of } MCE \text{ ground motions}}$

NEHRP: Structure should have a low probability of collapse for $MCE$ (1.5 times the design level earthquake)
CMR is established through Incremental Dynamic Analysis
Building Description

- Seven-story RC Building in Van Nuys, CA
- Designed in 1965 and constructed in 1966
- Exterior moment-resisting frames
- Interior gravity load flat slab system
- Strong motion records from:
  - 1971 San Fernando
  - 1987 Whittier
  - 1990 Upland
  - 1992 Sierra Madre
  - 1994 Northridge
- Light structural damage during the 1971 San Fernando Earthquake, severe column damage during the 1995 Northridge earthquake.
Building Plan

- **35 x 50 cm ext. columns**
- **40 x 56 cm spandrel beam around perimeter (40 x 75 cm first floor)**
- **45 cm square int. columns**
- **19.1 m**
- **45.7 m**

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Lumped Plasticity Model for Frame Structure

Moment rotation relationship for nonlinear rotational spring of second story column of RC Building
Evaluation Ground Motion

- 1994 Northridge record SE Corner E-W
- PGA 0.45 g
Collapse Simulation Results EW Direction

Drift Ratio

Moment (kip in.) vs. Rotation (radians)

- ASCE 41-13 column
- ACI 369 column
- ASCE 41-13 beam
- New beam model
ASCE 41-13

ACI 369
Conclusions

• Changes in modeling parameters for beams and columns affected the distribution of damage of the case-study building.

• The intensity measure corresponding to lateral instability for the model with ASCE 41-13 modeling parameters was 1.63 (0.77 g), whereas the maximum intensity measure for the model with ACI 369 modeling parameters was 2.71 (1.27 g).

• The effect of beam modeling parameters on the intensity measure corresponding to lateral instability was not significant for the case-study building, although the maximum story drift ratios before lateral instability did increase by approximately 1%.

• While the intensity corresponding to lateral instability increased significantly by adopting modeling parameters representative of the mean response of component tests, the level of damage expected to occur in gravity-load frames increased significantly as well.