Earthquake-Resistant Design of Unbonded Precast Wall Systems

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Post-Tensioned Precast Concrete Rocking Walls

Single Rocking Walls
Kurama et al. 1999
Perez et al. 2003
Henry et al. 2009

Jointed Walls
PRESSS program (Priestley et al. 1999)

Hybrid Walls
Kurama 2002;
Restrepo and Rahman 2007

PreWEC system
Aaleti & Sritharan 2007

ACI ITG.5: Min. hysteretic energy dissipation ratio of 12.5% (Equivalent to 8% viscous damping).

1- ITG.5 requirements prevent the use of Single Rocking Walls in high seismic zones!
2- Design Criteria in ITG.5: FBD, with an R-factor of 5 (bearing wall) or 6 (building frame). This criterion does not account for the energy dissipation capacity of different rocking wall systems!
Performance of rocking walls imposed by multiple-level earthquake motions (Frequent, Occasional, Rare, Maximum Considered Event)?

- Energy Dissipation Components
- Design Recommendations (R-Factor?)
- Simplified Analytical Model

### Proposed Equations for Damping Ratio and R-factors

#### Equivalent Damping Ratio of Test Walls at Design Drift

![Graph showing damping ratio](image)

**TOTAL DAMPING RATIO AT DESIGN DRIFT**

For SRWs: 5.7%  
For PreWECs: 8.7% to 15.6%

- **Damping due to deformation of O-connectors:**
  \[
  \xi_{\text{hys,Dr}} = \frac{N_{\text{conn}} \times F_{c,\text{ave}} \times (l_{\text{con}} - \Delta_{c,y})}{\pi \times V_{D\%} \times H_s}
  \]

- **Displacement-based Assessment of Seismic Resistance**

**PREWEC**

- **DDBD:** Test units designed corresponding to their damping capacities performed satisfactorily in terms of drift.

**Verification of the R-Factors through a Parametric Analytical Study**

\[
FF : R = 0.46 \times \xi_{eq} + 0.93
\]

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• Parametric Study
  (Experimentally-verified Analytical model)

- Seismic zone 4 and soil type SC
- Lateral load-resisting system in the orthogonal direction: Max of Six SRWs or PreWECs ($\xi_{eq}$: 13%, 18%).
- Design shear force: New sets of R-factors

Typical Plan View

Scaled Ground Motions
Verification of Results and Conclusions

- In this paper: Results of 6-story building are presented.

<table>
<thead>
<tr>
<th>Building ID</th>
<th>R-Factor/No. of walls</th>
<th>Design force/wall (Kips)</th>
<th>Area of PT tendon (in²) / Initial PT stress</th>
<th>Type-number of connectors*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRW6</td>
<td>3.7/4</td>
<td>583</td>
<td>13.6 / 0.65fₚᵤ / -</td>
<td>-</td>
</tr>
<tr>
<td>PreWEC6-13</td>
<td>7.0/3</td>
<td>387</td>
<td>7.4 / 0.7fₚᵤ / 2.8 / 0.8fₚᵤ</td>
<td>A-22</td>
</tr>
<tr>
<td>PreWEC6-18</td>
<td>9.3/3</td>
<td>281</td>
<td>1.9 / 0.68fₚᵤ / 3.0 / 0.8fₚᵤ</td>
<td>B-24</td>
</tr>
</tbody>
</table>

* per joint; connectors A and B have, respectively, yielding and ultimate force and deformation properties of A-yield (17kip, 0.25in.), A-ult. (18kip, 4in.), B-yield (17kip, 0.1in.), and B-ult. (18kip, 4in.).

- Dynamic Results:

- Conclusions:

1. The seismic performance of the rocking structures designed with the new sets of R-factors satisfied the performance limits of the maximum lateral drift for design-level far-field earthquake motions.

2. Drift ratios generally decreased with increasing hysteretic damping ratios of the rocking wall buildings of different heights for all levels of applied ground motions. The additional hysteretic damping also confirmed rapid decay of the building response compared to those with SRWs.

3. SRWs with the low amount of energy dissipation capacity responded satisfactorily when designed with the recommended R-factor.
Acknowledgement

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Today Poster Session:

Time: 5:15 – 7:00 pm

Room: Pasadena (Exhibit Hall)

Poster location: Location 023