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“BEHAVIOR OF PRECAST STRUCTURAL WALLS POST-TENSIONED BY UNBONDED TENDONS IN SHAKING TABLE TESTS ON ACTUAL-SIZE 4-STORY PRESTRESSED CONCRETE BUILDING”

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1.- INTRODUCTION

2010 E-Defense Shaking Table test on actual-size 4-Story RC and PT Concrete Building

3-directional input motion.
Loading sequence:
1) JMA-Kobe: 10, 25, 50 and 100%
2) JR-Takatori: 40 and 60%
2.- DESCRIPTION OF PRECAST WALLS

Unbonded Post-Tensioned Precast Walls

Plan view

Elevation of wall

Precast Panels

ED bars

Tendons (10φ15.2mm)
2. - DESCRIPTION OF PRECAST WALLS

INSTRUMENTATION IN WALLS

Location of transducers at base joint

Transducer location at first floor

Load cells
3.- PERFORMANCE OF WALL SYSTEM

Uplift at the sides of base joint

![Graph showing uplift at the sides of base joint with peak values.
Peak West: 40mm
Peak East: 37mm]

Base rotation angles

![Graph showing base rotation angles with peak values.
Peak-SW: 0.41%
Peak-NW: 0.27%]

Residual < 0.06%

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3.- PERFORMANCE OF WALL SYSTEM

Vertical displacement profile of base joint during peak opening

Almost linear profile

ACI ITG-5.2 assumes a plane section for large gap openings.
3.- PERFORMANCE OF WALL SYSTEM

Out-of-plane Base rotation angle in South Wall

Peak $\theta$: 1.9%
Peak $\theta_{out}$: 0.9%
Peak $\theta$: 1.2%
3.- PERFORMANCE OF WALL SYSTEM

Effects of in-plane base rotations

Cracks in roof slab

Condition at toes

Wall anchorages

Roof slab

JMA 100%

South Wall
North wall

West Side
East Side

West Side

East Side

South Wall
North wall

NW
SW

Uplift (mm)

Compressive strain (%)

Base rotation (% rad)

Base rotation (% rad)

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3.- PERFORMANCE OF WALL SYSTEM

Stresses in tendons of South Wall

Strand properties:
\[ f_{py} = 1821 \text{ MPa} \]
\[ f_{pu} = 2004 \text{ MPa} \]

Nominal properties:
\[ f_{py,n} = 1601 \text{ MPa} \]
\[ f_{pu,n} = 1882 \text{ MPa} \]
\[ f_{po} = 0.53 f_{py} \]

Cyclic loading effects on strand-anchorage systems – Test requirements

<table>
<thead>
<tr>
<th></th>
<th>NZS3101</th>
<th>ICC-ES</th>
<th>AIJ</th>
<th>Test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress (f_{pu,n}/f_{pu})</td>
<td>0.50 – 0.80</td>
<td>0.40 – 0.80</td>
<td>0.50 – 0.90</td>
<td>0.50 (0.48) – 0.67 (0.64)</td>
</tr>
<tr>
<td># Cycles</td>
<td>50</td>
<td>50</td>
<td>200</td>
<td>26</td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>-</td>
<td>1 – 3</td>
<td>-</td>
<td>2.11</td>
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</tbody>
</table>
3. PERFORMANCE OF WALL SYSTEM

Performance of tendons in South Wall

- **Elastic Region**
  \[ f_p \leq f_{py_n} \] (ACI ITG-5.2)
  \[ \varepsilon_p \leq 1\% \] (Walsh & Kurama 2010)

**Self-centering Capacity**

- **Base rotation (%rad)**
  - JMA 100%
  - PT-East
  - PT-West

- **Strain (%)**
  - JMA 100%-SW
  - PT-East
  - PT-West

**Stress in PT strand (f_p/f_{py})**

- **Base rotation (%rad)**
  - JMA 100%
  - PT-East
  - PT-West

**Strain (%)**

- **Stress in PT strand (f_p/f_{py})**

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CONCLUDING REMARKS

• The walls supported large drift without serious damage.
• South wall sustained larger deformations (2 times larger) than north wall.
• Steel fibers controlled the concrete spalling at the north wall.
• Significant out-of-plane base rotation angle (3.7% in the SW).
• Damage was observed in the slabs due to the rocking motion of walls.
• Stresses in the PT strands of the south wall remained in the elastic range (max stress 0.7fpy).
• Test results revealed some issues:
  – Out-of-plane rocking motion
  – Damage in slabs and other components
  – Influence of fiber content in concrete panels.
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