Experimental Response of T-Shape RC Walls
Effect of confinement and discontinuity

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Tuesday, June 26 – Friday, June 29
Introduction: Maule 2010 Earthquake.

Observed damage:
- Loss of concrete cover.
- Buckling of rebar.

Due to mainly:
- Lack of confinement at boundary elements.
- Discontinuities at wall base.
- Complex sections (e.g. T)

Chilean Codes Modifications:
- Better detailing in boundary elements.
- Damage Limit.
- No consideration of discontinuity.

Massone and Rojas, 2012
Motivation: Experience in Chile

Previous Experimental Studies of T-Walls

Important effect:
- Confinement
- Discontinuities

Only two previous Studies in Chile in Rectangular Shape Walls

Chile 2016: Flag Walls.

Manriquez et al. 2016
Motivation: Experience in Chile

Previous Experimental Studies of T-Walls

Important effect:
- Confinement
- Discontinuities

Only two previous Studies in Chile in Rectangular Shape Walls

Chile 2017: Central Discontinuities.
Main objective

Study three RC T-walls

- Design and construction
- Experimental behavior with cyclic loading
- Validation of Numerical Models

Project N°: 11140429
First Experimental T-Walls in Chile

Load Transfer Beam

Slabs

ET3

Confinement

Discontinuity

ET1 v/s ET2

ET3 v/s ET2

\[ \rho_{\text{web}} \] 2.5 %

\[ \rho_{\text{flange}} \] 1.8 %

\[ \rho_{\text{center}} \] 0.32 %

ET3 Reduction of 20%

Effect
Experimental Setup

Structures Laboratory: Dept. of Civil Engineering, University of Chile

Cyclic Lateral Load
Max. 100 Tonf ± 25 cm

Axial Load

Restriction Frame

<table>
<thead>
<tr>
<th>T-Wall</th>
<th>Axial Load</th>
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</thead>
<tbody>
<tr>
<td>ET1</td>
<td>9.4 %</td>
</tr>
<tr>
<td>ET2</td>
<td>8.3 %</td>
</tr>
<tr>
<td>ET3</td>
<td>11.9 %</td>
</tr>
</tbody>
</table>
Experimental Setup

Loading Protocol (ACI374.1)

<table>
<thead>
<tr>
<th>Drift [%]</th>
<th>0.05</th>
<th>0.075</th>
<th>0.1</th>
<th>0.15</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.75</th>
<th>1</th>
<th>1.25</th>
<th>1.6</th>
<th>2.0</th>
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</thead>
<tbody>
<tr>
<td>Displacement [mm]</td>
<td>0</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td>700</td>
<td>800</td>
<td>900</td>
<td>1000</td>
<td>1100</td>
<td>1200</td>
</tr>
</tbody>
</table>

Instrumentation

LVDT’s first floor

Web and flange
Experimental Setup

- Strain Gages
- Photogrammetry
Experimental Setup

Cameras
External Flange

Internal Flange

ET2

DAQ System

Control LVDT
Experimental Results ET1

- Lack of boundary confinement:
  - Rapid loss of capacity.
  - Excessive buckling of bars.
Video ET1 and Strain Profiles
Experimental Results ET2

- Boundary confinement:
  - Increase ductility.
  - Buckling restrained.

End of the test
Video ET2 and Strain Profiles
Experimental Results ET3

- Discontinuity and special boundary confinement:
  - Increase ductility.
  - Damage concentrated below discontinuity.

Drift 1.25 %
Drift 1.6 %
End of the test

Drift 1.25
End of the test
Drift 1.6 %
Video ET3 and Strain Profiles

[Graphs showing strain profiles for ET3 with various distances along the web and external flange, indicating strain values and profiles for different materials or conditions.]
Validation with Models Safe-TB (Rojas, 2012)

Concrete:

\[ \sigma(\varepsilon_c) = f \left( \frac{\varepsilon_c}{\varepsilon_{cr}} \right) \frac{n}{n-1 + \left( \frac{\varepsilon_c}{\varepsilon_{cr}} \right)^n} \]

Thorenfeldt et al. (1987)

Belarbi y Hsu (1994)
Validation with Models Safe-TB (Rojas, 2012)

Steel:

Menegotto and Pinto (1973) and modified by Filippou (1983)

Massone y Moroder (2009)

Concrete Layers

Reinforcement Steel Layers

Middle plane

Strain

Bar with initial imperfection before load application

Plastic hinge bar model after load application
Validation with Models Safe-TB (Rojas et al., 2016, 2018)
Conclusions

- The ET2, in terms of capacity, shares the same characteristics of the ET1, but a remarkable increase in the maximum displacement (~50%).

- The behavior for flange in compression is similar for all three walls (consistent strength and large maximum displacement).

- The discontinuity in the ET3 produced a higher concentration of strains and stresses in the height of the discontinuity.
Conclusions

- Although ET3 was more flexible (reduction of the length of the web), this reached a lower ductility, compared with ET2.

- It is important to note that the reduction on the capacity of ET3, it was not only due to the reduction of the length of the web, but also because the reduction on the capacity of the compression strength of the concrete.
Thank You

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