FINITE ELEMENT STUDY ON THE SEISMIC PERFORMANCE OF NONSTRUCTURAL PARTITION WALLS

By:

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Outline

1. Introduction
2. The Proposed Analytical Model of Partition Walls
3. Validation of the Proposed Analytical Model
4. Fragility Analysis
5. Summary and Conclusions
Cold-Formed Steel-Framed Gypsum Partition Walls

- Stud – Top Track Connection
- Stud-to-Bottom Track Screw Connection
- Gypsum-to-Stud Screw Connection
- Top Track-to-Concrete PAF Connections
- Track-to-Concrete PAF Connection

Studs

Tracks

Gypsum Boards
Partition Damage During Past Experiments

**UB Experiments, Davies et. al., 2011**

- Damage in transverse wall top track
- Damage to Boundary Studs
- Tearing along top-track fastener
- Hinge forming in studs (commercial)
- Buckling of diagonal braces

**UNR Experiments, Rahmanishamsi et. al., 2014**

- Damage in gypsum-to-stud connections
- Hinge forming in field studs
- Damage to the top track of return walls
- Damage at the partition wall corners
Partition Walls Model, In-Plane & Out-of-Plane

- Gypsum-to-Stud Connection Hysteretic Spring
- Stud-to-Track Connection Hysteretic Spring
- Gypsum-to-Stud Contact Element
- Stud Flexural Hysteretic Spring
- Gypsum-to-Gypsum Contact Element
- Track-to-Concrete Connection Hysteretic Spring
- Stud Element
- Gypsum Board Element
- Concrete Node
- Track Element
- Node
Component-Level Experiments

- Six series of component-level experiments
- More than 140 monotonic and cyclic tests on the in-plane and out-of-plane behavior of connections with various properties.

Gypsum-to-Stud
- Screw
- Gypsum boards
- Top Stud
- Bottom Stud

Stud-to-Track
- Axial Load Cell
- Movable Grip
- Stationary Grip
- Stud

Track-to-Concrete, Tension Tests
- PAF
- Track
- Concrete Block

Track-to-Concrete, Shear Tests
- Track
- Concrete Block
- PAF
The “Pinching4” uniaxial material along with a "zeroLength" element (OpenSees)
Partition Walls Model, In-Plane & Out-of-Plane

- Gypsum-to-Stud Connection Hysteretic Spring
- Track-to-Concrete Connection Hysteretic Spring
- Stud-to-Track Connection Hysteretic Spring
- Gypsum-to-Stud Connection Hysteretic Spring
- Stud Flexural Hysteretic Spring
- Gypsum-to-Gypsum Contact Element
- Stud Element
- Gypsum-to-Concrete Contact Element
- Track Element
- Gypsum Board Element
- Concrete Node
- Stud Element
- Node
Validation of the Proposed Analytical Model

- Configurations 1, 2, 4, and 5 of the UB experiments.
- Configurations 1, 4 and 5 included three nominally identical specimens
- Configuration 5 no return wall

After Davies et. al., 2011
Validation – UB Specimens

Backbone Curve

- Displacement (mm)
- Force (kN)

Specimen 1
Specimen 2
Specimen 3
Analytical Model

Hysteresis Energy

- Cumulative Displacement (mm)
- Dissipated Energy (kN-mm)

Specimen 1
Specimen 2
Specimen 3
Analytical Model

Configuration 1

Configuration 4
Validation – UB Specimen 5
Fragility Analysis

Connection Damage States

Gypsum-to-Stud Connections

Track-to-Concrete Connections
Fragility Analysis

- To relate the local connection damage to wall overall behavior a specific wall with the same material and dimension was considered.
- Geometry and construction detailing was borrowed from UB experiment.
- 24 different scenarios were considered.
- The scenarios in terms of edge distance and construction quality.

After Davies et. al., 2011
Wall Backbone Curve and Damage States

**GSC**

- **CTC (Shear):**
  - Drift Ratio (%): -3 to 4
  - Force (Kips): -3 to 4
  - DS1 → DS2 → DS3

- **CTC (Tension):**
  - Drift Ratio (%): -3 to 4
  - Force (Kips): -3 to 4
  - DS1 → DS2 → DS3

**STC**

- **CTC (Shear):**
  - Drift Ratio (%): -3 to 4
  - Force (Kips): -3 to 4
  - DS1 → DS2 → DS3

- **CTC (Tension):**
  - Drift Ratio (%): -3 to 4
  - Force (Kips): -3 to 4
  - DS1 → DS2 → DS3
Connection Fragility Curves

GSC

CTC (Shear)

CTC (Tension)

STC
Partition Wall Fragility Curves

<table>
<thead>
<tr>
<th></th>
<th>Analytical Result</th>
<th>PACT</th>
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<tr>
<td></td>
<td>Median Dispersion</td>
<td>Median Dispersion</td>
</tr>
<tr>
<td>DS1</td>
<td>0.51 0.15</td>
<td>0.5 0.4</td>
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<tr>
<td>DS2</td>
<td>0.88 0.19</td>
<td>1.0 0.3</td>
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<tr>
<td>DS3</td>
<td>2.07 0.12</td>
<td>2.1 0.2</td>
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</tbody>
</table>
Summary and Conclusions

- A detailed and yet computationally efficient analytical model of cold-formed steel-framed gypsum partition walls is proposed.
- The model can be used to predict force-displacement response and damage mechanisms of partition walls with various properties.
- Fragility curves of connections were developed.
- A new methodology was developed that can predict the overall seismic fragility of gypsum partition walls using analytical models.
Thank You!