One-on-one Technical Support

The WoodWorks team includes technical advisors who are available to discuss specific issues and have the expertise to provide a wide range of architectural and engineering support.

If you have a project that requires technical expertise in wood design please contact a member of our field team in your region.

RISA Design Software Training

Learn how to design a complete structure in timber using the RISA building system software and current building codes. Interactive, fast-paced modules cover RISA-3D and RISAFloor modeling basics with an emphasis on wood design, as well as more advanced topics like interaction between RISAFloor and RISA-3D.

Common architectural & structural design details

Architectural drawings sorted by building element and available in several formats for wall, floor and roof types of wood construction, along with a collection of three types of common structural drawings.

Learning Objectives

1.) Participants will develop an understanding of performance-based seismic design of woodframe building

2) Participants will be able to qualitatively assess the correlation between inter-story drift and damage following a seismic event

3) Participants will be able to articulate the differences between the behavior of low-rise and mid-rise woodframe building during ground shaking

4) Participants will know the shortcoming of current state-of-the-art numerical models as well as the benefits.

Objective

The objective of the NEESWood project was

1. the development of a new logical performance-based seismic design philosophy for mid-rise woodframe construction, thus enabling such construction to be an economic option in seismic regions in the U.S. and around the world;

2. to provide a better understanding of the dynamic behavior of taller woodframe construction, specifically distinctions from low-rise woodframe construction.

Full-scale shake table testing of a six-story 14,000 sq ft woodframe building: How high can we go?

Prof John W. van de Lindt, Ph.D.
The University of Alabama

Woodworks August 2011
The Need

Mid-rise woodframe construction has several attributes including:

- Rapid, economical, and sustainable construction
- Excellent option for urban infill
  - Parking under
  - Parking as a building core

Many 4, 5, and a few 6-story woodframe buildings have been built already: Need to better predict their behavior and understand how it is different than low-rise.

NEESWood Project Components

- Full-scale 3-D testing – years 1 and 4
  - UB - Benchmark
  - E-Defense - Capstone
- Numerical model development/refinement - ongoing
- PBSD development – years 1 - 3
- Inclusion of response modification devices
- Societal risk/decision making/impact
- Outreach and education
- International collaboration with Japan – E-Defense (NIED) and Prof. H. Isoda (Shinshu Univ.).

The Project Team

“NEESWood: Development of a Performance-Based Seismic Design Philosophy for Mid-Rise Woodframe Construction”

John van de Lindt
- Project Director
- Software Development
- Numerical Modeling
- PBSD
- Education/Outreach
- Benchmark Testing at UB
- Component tests at CSU
- Capstone tests in Japan

Andre Filiatrault
- Benchmark Testing at UB
- Numerical Modeling

Rachel Davidson
- Societal Impact
- Decision Making

David Rosowsky
- PBSD
- Numerical Modeling

Michael Symans
- Seismic Protective Systems
- Benchmark Testing at UB
- Component Testing at RPI
Benchmark Results

Qualitative results: Is performance of design to recent code acceptable?

Yes, the performance was generally good. There was no risk to life seen in the testing. Structural damage did occur at high ground motions levels. Damage should be repairable, but repair may be costly.

Quantitative results: Effect of GWB and stucco on response and performance

Effect was quantified and found to be significant, as anticipated.

Benchmark Report and Papers

Report now available at:
PDF: http://jwv.eng.ua.edu/neeswood_reports.html
Hard Copy:
http://mceer.buffalo.edu/publications/catalog/categories/report-types/NEESWood%20Reports.html

Journal Paper (Summary of Testing and Analysis) available in:

SAPWood V2.0
Seismic Analysis Package for Woodframe Buildings

- Inclusion of out-of-plane rigid body DOF’s for floor diaphragms
  - Diaphragm is assumed to be rigid
  - The global overturning effect is considered
- Provides a way to include hold-down systems in between stories
  - Continuous hold-down systems
- Automatically includes the effect of vertical excitation
  - Triaxial records can be used, also enables the modeling of other vertical-load-controlled devices such as a Friction Pendulum base isolation systems.
- Other improvements: improved hysteretic model behavior, fully compatible to V1.0

Example (Benchmark Structure)

- Global displacement comparison (Phase 4, Level 2, E-W)

  SAPWood prediction agrees well with test results
Example (Benchmark Structure)

- Global displacement comparison (Phase 4, Level 2, N-S))
  
  N-S direction is much softer, resulting in longer vibration period and larger displacements.

Example (Stacked wall system)

- Stacked shearwall system
  - Typically used in 3 story or higher light frame wood construction in high seismic zones.
  
  - Pre-fabricated continuous hold-down system (e.g. Simpson Strong-Tie ATS)

Example (Stacked wall system)

- Shake table testing of a 3-story shearwall system
  - Uniaxial shake-table at the Simpson Strong-Tie Company Stockton, CA laboratory

  244 X 244 in (620 x 620 mm) shearwall at each story
  Tension rods
  Shearwall at each story

Example (Stacked wall system)

- Comparison of absolute displacements
  
  - Large displacement at upper stories
  - Prediction matches the test result well
  - Global & local overturning the same
Example (Stacked wall system)

- Inter-story drifts and shear contribution
  - Maximum inter-story drift for all three stories were close
  - Shear deformation decreases in higher stories

Test results indicated the trend in shear contribution

Numerical model agrees well with observation

SAPWood Availability

- No charge
- Location of software and users manual in NEEShub
  http://nees.org/resources/sapwood
- Sample buildings included
- Contact the authors

Please send email to: shiling.pei@sdstate.edu
cc: jwvandelindt@eng.ua.edu

CAPSTONE Tests in Miki, Japan

The Capstone Team

The University of Alabama
Simpson Strong-Tie
South Dakota State University
Maui Homes
NIED
Izumi Nakamura
Tim Ellis
Doug Allen
Kate Pfretzschner
Kazuki Tachibana
Tomoya Okazaki

Shinshu University

NIED
Simpson Strong-Tie
Colorado State University
Colorado State University
University of Tokyo
Shinshu University
Capstone Test Objectives

- **Objective 1:** To confirm that a representative mid-rise woodframe structure designed using the NEESWood PBSD philosophy satisfies the performance objectives, as pre-defined during the design process. These performance objectives seek to limit damage and losses while protecting life safety.

- **Objective 2:** Provide a general understanding of the behavior of a mid-rise woodframe structure similar to those currently in place in the Western U.S.
Seismic Intensity Levels for Design

Level 1: Earthquake intensity having a 50% chance of being exceeded in 50 years. This corresponds to a 72 year return period.

Level 2: Earthquake intensity having a 10% chance of being exceeded in 50 years. This corresponds to a 475 year return period. Corresponds approximately to the Design-Basis Earthquake (DBE).

Level 3: Earthquake intensity having a 2% chance of being exceeded in 50 years. This corresponds to a 2500 year return period. Corresponds to the Maximum Credible Earthquake (MCE).

Level 4: Optional Near Fault: Un-scaled near fault ground motions. This is an optional seismic hazard for use depending on the location of a building with respect to the fault and/or the owner’s desired performance expectation.

Performance Expectations

<table>
<thead>
<tr>
<th>Performance Expectations</th>
<th>Corresponding Peak Inter-story Drift (%)</th>
<th>Wood Framing and OSB/Plywood Sheathing</th>
<th>Gypsum Wall Board (GWB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level A</td>
<td>0.1 – 1.0%</td>
<td>Minor splitting and cracking of sill plates (some propagation)</td>
<td>Slight cracking of GWB Cracking at ceiling-to-wall interface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slight shear nailing withdraw</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crack deformation at sill plates</td>
<td></td>
</tr>
<tr>
<td>Level B</td>
<td>1.0 - 2.0%</td>
<td>Permanent differential movement of adjacent panels</td>
<td>Crushing at corners of GWB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corner sheathing withdrawal</td>
<td>Cracking of GWB taped/mud joints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracking of sill plates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracking of sill plates</td>
<td></td>
</tr>
<tr>
<td>Level C</td>
<td>2.0 - 4.0%</td>
<td>Splitting of sill plates equal to anchor bolt diameter</td>
<td>Separation of GWB corners in ceiling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cracking of studs above anchor bolts</td>
<td>Buckling of GWB at openings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possible failure of anchor bolts</td>
<td></td>
</tr>
<tr>
<td>Level D</td>
<td>4.0 - 7.0%</td>
<td>Severe damage across edge nail lines, separation of sheathing</td>
<td>Large pieces separated from framing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vertical posts uplifted</td>
<td>Entire joints separated and dislodged</td>
</tr>
</tbody>
</table>

Design Objectives / Drift Expectations:

<table>
<thead>
<tr>
<th>Performance Level</th>
<th>Seismic Hazard</th>
<th>Performance Inter-story Drift Limit</th>
<th>Non-exceedance Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>50%/50yr</td>
<td>1%</td>
<td>50%</td>
</tr>
<tr>
<td>Level 2</td>
<td>10%/50yr</td>
<td>2%</td>
<td>50%</td>
</tr>
<tr>
<td>Level 3</td>
<td>2%/50yr</td>
<td>4%</td>
<td>80%</td>
</tr>
<tr>
<td>Level 4</td>
<td>Near-Fault</td>
<td>7%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Level 3 Example

Design Limit State for Inter-story Drift:

\[
P_{NE} (\theta < \theta_{lim} | H) \geq NE \]

"Capacity" Requirement
Non-exceedance (NE) Probability 80%

Target NE Probability 80%

E-Defense
E-Defense
**Instrumentation**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Location</th>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute acceleration</td>
<td>Each floor</td>
<td>String Potentiometer</td>
<td>38</td>
</tr>
<tr>
<td>Diagonal shear wall drift</td>
<td>Selected shear walls</td>
<td>String Potentiometer</td>
<td>53</td>
</tr>
<tr>
<td>Out of plane diaphragm deformation</td>
<td>Third floor diaphragm</td>
<td>String Potentiometer</td>
<td>13</td>
</tr>
<tr>
<td>Shear wall end stud uplift</td>
<td>Selected shear walls</td>
<td>String Potentiometer</td>
<td>8</td>
</tr>
<tr>
<td>ATS node-dam strain</td>
<td>Selected shear walls</td>
<td>Strain Gage</td>
<td>78</td>
</tr>
<tr>
<td>Absolute displacement</td>
<td>Building exterior</td>
<td>3D Optical tracking</td>
<td>50</td>
</tr>
</tbody>
</table>

Instrumented all Shear walls on Left side of 1st Story

Three selected Walls instrumented All the way to top story.

**Shake Table Test Program**

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Building Configuration</th>
<th>Earthquake Return Period (LA, CA)</th>
<th>Ground Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 22</td>
<td>Move to table</td>
<td>Lift Frame + building</td>
<td>1994 Northridge Canoga Park</td>
<td></td>
</tr>
<tr>
<td>June 30</td>
<td>Test 1 &amp; 2</td>
<td>SMF+Wood</td>
<td>72 &amp; 475 yrs</td>
<td>1994</td>
</tr>
<tr>
<td>July 6</td>
<td>Test 3 &amp; 4</td>
<td>Wood</td>
<td>72 &amp; 475 yrs</td>
<td>Northridge Canoga Park</td>
</tr>
<tr>
<td>July 14</td>
<td>Test 5</td>
<td>Wood</td>
<td>2500 yrs</td>
<td>1994 Northridge Canoga Park</td>
</tr>
<tr>
<td>July 17</td>
<td>Remove building</td>
<td>Lift Frame + building</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Level 3 movie (Optical tracking)

Seismic Level 3 – Long Direction

Seismic Level 3 – From above

2500 year shake – Inside the top floor
Averaged Time History Response: Roof Level

Averaged Time History Response: Selected results

Average global hysteresis

Optical Tracking
Conclusions

- Light-frame wood buildings can be constructed six stories tall and perform well in a major earthquake, i.e. 2500 year event.

- Designing for a certain level of performance using PBSD is possible and thus, to the extent one test can, validates the design approach developed within NEESWood.

NEESWood Acknowledgements

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