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NEESWOOD

Developing a Performance-Based Seismic Design Philosophy for Mid-Rise Woodframe Construction

NEESWood News

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The Practitioner View

By Kelly Cobeen, P.E., S.E., Cobeen and Associates

For practicing structural engineers, the NEESWood project is providing exciting opportunities for improved understanding of the earthquake response of light-frame wood buildings. With the structural engineering profession moving in the direction of design based on performance, the engineer's simplified analysis and design approaches need to be augmented with real building performance information. The NEESWood project has already begun providing performance information with the benchmark shake table test of a full-size townhouse unit, currently in progress at SUNY Buffalo. The first phase of testing gave an indication of interesting information to come, with shear walls at the garage front nearly reaching code-permitted story drift during a ground motion of approximately half that anticipated by code design. Still to come at later stages of the project are additional component and shake table tests, recommendations for performance design philosophy, and improved analysis tools.

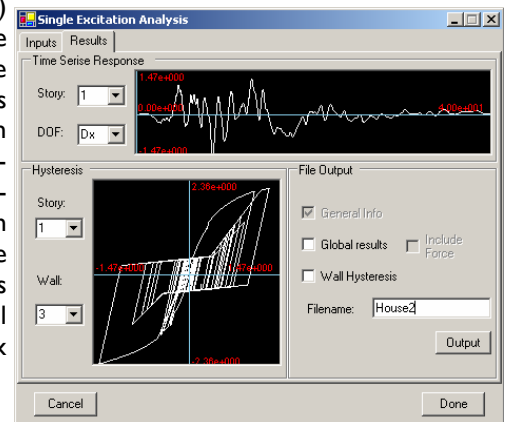
Upcoming Events

- NEESWood reports Series coming soon— Approximately 12 reports expected over the next 4 years.
- Press Day is November 14th at the NEES@BUFFALO site. Many local news stations and newspapers will be present.
- Wall-to-Wall Productions Ltd., based in London will be featuring the NEESWood benchmark test structure in a Discovery Channel Series. More to come in the next issue.

SAPWood Software—Available now!

By Shiling Pei and John W. van de Lindt, Colorado State University

The first release version (Beta version) of the Seismic Analysis Program for Woodframe structures (SAPWood) is now available for free download from the NEESWood website. This nonlinear analysis program, developed based on the SAWS-CASHEW platform, is aimed at providing researchers and practitioners with a user-friendly software package which can perform nonlinear seismic analysis of light woodframe residential structures. The software package is still under development and program updates will become available approximately every six months.



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<http://www.engr.colostate.edu/NEESWood> or Google "neeswood"

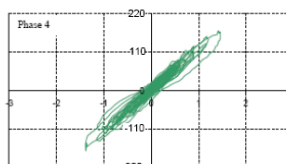
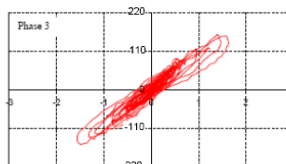
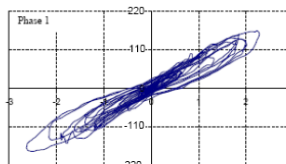
Phase IV Benchmark Tests Completed!

NEESWOOD

By John van de Lindt, Colorado State University and Andre Filiatrault, University at Buffalo

Phase 3 and 4 of the benchmark tests was completed in September of 2006. Phase 3 consisted gypsum wall board installed only on the structural walls. In phase 4 drywall was added to the non-structural partition walls and ceilings. The difference in response was negligible, reinforcing the NEESWood researchers belief that non-structural partition walls can be neglected in nonlinear whole-structure (system level) models.

The effect of adding gypsum wall board to the structural walls was significant. Comparison can be made at the level 2 testing during Phase I (OSB only with structural mass equivalent to the completed structure) and Phase 3 (OSB + drywall on structural walls and mass equivalent to completed structure). The stiffness was increased by about 30% and comparison of the global hysteresis in the short direction of the structure is shown in the plots to the right.



Research Experience for Undergraduates (REU)—Student Survey Results

A major objective of the NEESWood project is earthquake engineering education for both graduate and undergraduate students. The four REU (undergraduate) students involved with the NEESWood project (Two at UB, one at CSU, and one at RPI) were each asked the same set of four questions and the highlights are presented below.

1. What have been your primary duties related to the NEESWood project this summer?

Charles Ekiert: "the design of an apparatus to test common connections in the NEESWood house, conducting the testing and analyzing the data of the specimens, helping with the installation of the damper provided from RPI, and any reconstruction [repair] of the NEESWood house."

James Foreman: "The constructing and shake-table-testing of very strong wood frame walls."

Jamie Hong: "My primary duties related to the NEESWood project has been to help out with damage inspections after each test on the shake table and help with construction in between phases."

James Lucas: "Before phase 2 testing at UB I was primarily involved in constructing the pre-fab damper walls to be tested. Since the completion of these tests I have been processing the data obtained."

2. We're you familiar with earthquake engineering before this summer?

Charles Ekiert: "Yes, I participated in the MCEER REU program last year"

Jamie Hong: "...having been born and raised in California, earthquakes have been a part of my life and building for

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Donations Made To NEESWood

Thank you to the following organizations/companies for their donation to NEESWood:

- APA - The Engineered Wood Association
- B&L Wholesale Supply Inc.
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- Phillip Line, American Forest & Paper Association
- Rakesh Gupta, OSU

FOCUS ARTICLE

APPLICATION OF SEISMIC PROTECTION SYSTEMS TO WOODFRAMED BUILDINGS by Michael D. Symans



Within the NEESWood Project, the major research activities at Rensselaer Polytechnic Institute (RPI) focus on the development and application of seismic protection systems to light woodframed buildings. The major seismic protection systems to be investigated include seismic isolation systems and seismic damping systems. Recent efforts have focused on the application of fluid viscous damping devices to the two-story townhouse benchmark structure (Phase 2 of the benchmark study) which is being tested on the dual shaking table system at SUNY Buffalo. Dr. Michael Symans, an associate professor at RPI and Co-Principal Investigator on the NEESWood Project, is directing the research on applications of seismic protection systems to wood-framed structures.

Phase 2 of the benchmark structure testing involves implementation of a seismic damping system via prefabricated modular damper wall units. The damping system was designed using the SAVS computer software (modified by the SUNY Buffalo research team to incorporate discrete viscous damping elements). Subsequently, the dampers were manufactured (by Taylor Devices, Inc) and installed within modular wall units that were fabricated at RPI. The modular wall units were then shipped to SUNY Buffalo for installation within the townhouse benchmark structure (see photo below). Since the structure had already been constructed for Phase I of the benchmark study, the implementation of the modular damper wall units may be regarded as a retrofit application.



Modular Damper Wall Units installed in First and Second Story of Benchmark Structure

The modular damper wall units are constructed of wood framing around the perimeter and steel bracing within the central region (see photo below). The width of each wall unit was 4 ft to accommodate the standard width of wood sheathing panels. As the top of the wall displaces laterally with respect to the bottom of the wall, the damper is stroked and dissipates a portion of the seismic input energy, thereby reducing the hysteretic energy dissipation demand on the wood framing within the structure.



Modular Damper Wall Unit installed in Benchmark Structure (view from inside of garage)

The fluid dampers used in the townhouse structure were nonlinear velocity-dependent devices (force output nonlinearly related to velocity). Within the U.S., such dampers have been implemented within numerous steel and concrete buildings. However, the testing of such dampers within the NEESWood benchmark structure represents the first application within a full-scale wood-framed building. In that sense, one of the objectives of the benchmark structure testing was simply to establish the feasibility of implementing a seismic damping system within a full-scale, three-dimensional building.

The Phase 2 benchmark tests were recently completed and thus a complete assessment of the results is not yet available. However, a preliminary review of the data suggests that the inclusion of the dampers improved the performance of the building (e.g., reduced peak interstory drift response). However,

due to the inherent flexibility in the wood framing system and difficulty in tightly coupling the modular wall unit and the main wood framing system, the engagement of the dampers was limited and thus the full effectiveness of the dampers was not realized. Based on what was learned from the Phase 2 testing, a new design for the modular damper walls is under development with plans to incorporate the new modular walls in the benchmark structure during the final testing phase.

Acknowledgments

The numerical simulations and design of the modular damper wall units were performed by Damon Reigles (post-doctoral student) and the wall units were constructed by Damon Reigles, James Lucas (undergraduate research assistant) and Jayesh Shinde (doctoral student). Dr. Andre Filiatrault, professor at SUNY Buffalo and Co-PI on the NEESWood Project, provided valuable input regarding design of the dampers, design of the prefabricated modular wall units, and the test sequence for the seismic shaking table tests. The fluid viscous dampers were manufactured and donated by Taylor Devices, Inc. with technical assistance provided by Mr. Douglas Taylor (President) and Mr. John Metzger (Engineering Manager).

Researchers Travel to NEES/E-Defense Meeting as part of U.S. Delegation

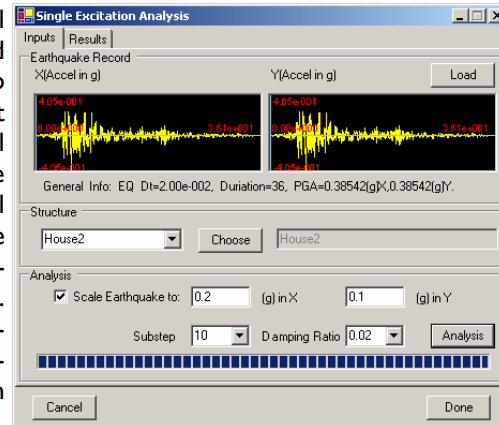
Five US Wood researchers, including three from the NEESWood project, traveled to Kyoto and Kobe Japan for the 5th US-Japan NEES/E-Defense Planning Meeting. The meeting consisted of a plenary session, two seismic wood breakout sessions, and observation of two different shake table tests. The US wood delegation consists of PAC member Steve Pryor (Simpson Strong-Tie Co), Assistant Professor Yue Li (Michigan Tech), and NEESWood researchers David Rosowsky, Andre Filiatrault, and John van de Lindt.



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SAPWood Software – Available now! - continued

The SAPWood program, in its Beta Version, uses the same structural model/framework as the SAWS program. SAWS users can load SAWS input files (.dat file) directly into SAPWood, if they choose to do so. However, only the structural model information of the input file will be loaded. Starting from there, the user can perform bi-axial time domain analysis on any ground excitation given the earthquake acceleration record. The user can also easily conduct incremental dynamic analysis (IDA) and multi-record IDA (IDA using multiple earthquake records and different structural configurations for comparison of structural designs) with the tools provided in SAPWood. A new analysis type, termed SDOF identification analysis, is also provided in SAPWood which allows the user to investigate the hysteretic behavior of the entire story as a single-degree-of-freedom nonlinear oscillator—this can be done for any DOF also. Currently, four types of hysteretic models are supported by SAPWood to model shearwall (or other lateral resisting) elements within a woodframe structure, including linear, bilinear, the 10-parameter SAWS, and a newly developed EPHM (evolutionary parameter hysteretic model) (paper by Pang et al. in review currently). The users have the option to use different types of elements within the same system model and the user can also construct and analyze simple shear building models with these elements. The full user's manual is distributed with the software package. Recommendations and bug reports related to SAPWood are welcomed.



Available at: www.engr.colostate.edu/NEESWood/SAPWood/

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REU Student Survey

seismic activity familiar to me.

3. Has your REU changed your academic plans, i.e. graduate school or other. If so, how ?

Jamie Hong: "After this program I would like to [further] my studies in Earthquake Engineering specifically."

James Lucas: "My REU has not changed my academic plans." "NEESWood, though, has given me a taste of what is involved in research projects if I were to pursue an advanced research degree."

4. Would you recommend an REU to other students ?

Charles Ekiert: "Yes, for example last semester some juniors asked me about the program and I told them that it was a great experience, especially if you were thinking about graduate school."

James Foreman: "Yes I would. I think it is a good idea for students considering grad school to get some research experience early, so they'll have a better idea of what they want to do in grad school."

Jamie Hong: "Yes, I would defiantly recommend an REU to other students. I have learned a great deal about research and earthquake engineering, but also I had the chance of working with students from all over the country."

To sign up for the NEESWood News email list please email: John W. van de Lindt at:
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