By Jill Andrews, SCEC – Manager, Woodframe Project Education and Outreach

LOS ANGELES - On March 5th and 6th, 1999, managers of the CUREe-Caltech Woodframe Project’s Testing and Analysis Element conducted The Invitational Workshop on Seismic Testing, Analysis and Design of Woodframe Construction. The workshop, planned by Prof. André Filiatrault of UC San Diego, brought together experts and allowed them, through structured feedback, to influence the Project’s testing program. The intended outcome was development of a technically sound research program that will be followed over the course of the remaining 2-1/2 years of the project.

After opening remarks by Prof. Frieder Seible (UC San Diego), Manager of the Woodframe Project’s Testing and Analysis Element, and Prof. John Hall (Caltech), Woodframe Project Manager, a series of presentations was made by experts from consulting firms and universities in the United States, New Zealand, Australia, Italy, Japan, and Canada.

Participants were led through an overview of test procedures on woodframe component studies, ongoing for over fifty years, as well as results from some of the more recent studies (Edwin Zacher, H.J. Brunnier Associates, San Francisco). Suggestions for testing structures and components were presented based on Northridge Earthquake failures and other recent Southern California earthquakes (G.G. Schierle and Dimitry Vergun, School of Architecture, University of Southern California).

Prof. J. D. Dolan, Director, Center for Integrated Systems in Housing, Virginia Polytechnic Institute, presented a history of the current design values for shearwalls and diaphragms. The history included values currently in the model building codes, the NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, the International Building Code, and the International Residential Code. Dolan addressed gaps in current knowledge and made recommendations for needs in the testing and analysis projects. Of utmost importance, according to Dolan, is the need for test protocol and subsequent analytical methods to be robust and as materially neutral as possible, which will provide a basis for an unbiased comparison between different structural systems and materials. In commenting on the Project as a whole, Dolan stated that he believes this is a “special opportunity…the first project that is large enough to really make large strides in the understanding of wood buildings. If half of the items outlined at the workshop are accom-
plished, the exposure to loss from future seismic events will begin to decrease noticeably.”

Overviews of foundation retrofit, anchorage, and cripple wall foundations, as well as retrofit of existing woodframe multifamily residential buildings with a soft first story, were offered in presentations by Robert Sonntag (Sonntag Engineers & Associates, Pasadena, CA) and Tim McCormick (City of Santa Monica). Sonntag recommended whole building pushover analyses and dynamic testing of existing structures to address building irregularities and weaknesses of foundations. He stated that dynamic testing of retrofit anchors and anchorage systems and devices need to be made with different species of wood, different sizes, and different preservative treatments. Testing of cripple wall applications before and after retrofits, he said, would provide valuable information on the nature and response of the presently recommended retrofit solutions. McCormick covered a variety of issues with respect to the poor performance of soft story structures – e.g., lack of adequate shearwall strength, excessive deflection of lateral force resisting elements and secondary columns, absence of lateral force resisting elements at large ground floor openings, and errors and omissions in construction and design.

The remainder of the first day’s presentations consisted of perspectives from New Zealand, Australia, Europe, Japan, Canada, and the United States.

Andrew King (Building Research Association of New Zealand) described his country’s approach – i.e., a provision in the NZ Building Code – to ensure its woodframe structures retain “amenity function” (not experience damage that requires repair) following common events (small to moderate earthquakes) and to avoid collapse or instability during the rare events (large earthquakes). King addressed the challenge of quantifying post-elastic response of woodframe systems in a manner that verifies its dynamic response.

Prof. Ario Ceccotti (University of Florence, Dept. of Civil Engineering) offered an overview on European codes for designing woodframe structures in seismically active zones. Ceccotti discussed evaluation of structural behavior using a nonlinear seismic analysis program and covered comparisons between actual ARF (action reduction factor) and design ARF – pointing out that “the definition of the yield point can be a delicate issue, especially for wood structures.” Shearwalls, symmetric and non-symmetric buildings, and conceptual design processes were discussed. Ceccotti’s concluding remarks indicated that calculation alone is never sufficient for safe structures, and that conceptual design and structural detailing are “very important issues for wood structures in seismic areas to guarantee the flow of the actions through the entire resistant structure from the foundations and the ground to the roofing and vice versa; and

The presentations from the international researchers were a good idea. It shows that other countries have advanced the “state-of-the art” in terms of testing, analysis and design. CUREe should closely consider these contributions so as not to “re-invent the wheel.”

-Thomas D. Skaggs, APA - The Engineered Wood Association
Hisashi Okada (Building Research Institute, Ministry of Construction, Japan) described code development and a new research and development program on timber structures in Japan. Last year, the Japanese government revised its Building Standard Law and moved from code-driven specifications to a performance-based code—according to Okada, an urgent need in Japan. Testing and evaluation methods on the physical properties of timber materials and their joints were published as part of their technical regulations. For performance-based code adherence, the code requires confirmation as to whether the building design satisfies target performances. Target performances include structural safety, property protection, and serviceability. In addition to revisions to codes, BRI is launching a five-year study on hybrid wood structures or wood-based composite structures.

The Canadian perspective was presented by Erol Karacabeyli (Forintek Canada Corporation, Vancouver, BC) and Helmut Prion (Dept. of Civil Engineering, University of British Columbia, Vancouver, BC). Researchers at UBC and Forintek have conducted major investigations on seismic resistance of timber structures and are responsible for the first design code for such structures (the Canadian Limit States design code). The Workshop presentation described the testing programs and reliability studies conducted by these groups in order to establish appropriate performance factors to match newly implemented loading provisions and material strength data. An extensive survey of performance of woodframe buildings in recent earthquakes showed the authors that while most wood structures perform well compared to other types of structures, significant problems surfaced for multi-story / multi-unit buildings—especially those with a weak (soft) first-story feature—including significant damage, collapse, and loss of life. Topics covered included testing of shearwall components, unblocked shearwalls, capacity of anchor bolts, use of gypsum wallboard, strength of shearwalls with openings, bracing techniques, testing protocols, and design implications. Prion emphasized the need for research directed at seismic resistance of woodframe structures to “incorporate the behavior of connections.” Topics include reinforcing techniques to improve ductility, establishing criteria for brittle failure of multiple fastener connections, and development of innovative connections. “This is a golden opportunity to make a major impact on woodframe construction worldwide,” said Prion during a workshop breakout session. Addressing the issue of component testing vs. “whole building” tests, Prion maintained that the CUREe Project managers should consider spending time “gathering existing data on component tests...there is a wealth of information available and only targeted tests may be needed...Whole building tests are very rare and this would be a great opportunity to evaluate the 3-D response of buildings subjected to uni-directional and multi-directional shaking.”

An overview of testing and analysis of woodframe structures in the United States was given by Prof. Gerry Pardoen (Dept. of Civil & Environmental Engineering, UC Irvine, Irvine, CA). Pardoen, in describing state-of-the-art testing in the U.S., stressed that it is important that the experimental data “increases understanding and improves performance...under earthquake loading yet provides fundamental results that can be used to develop, refine and calibrate analytical models.” The data, he said, must be useful to practitioners as well as building code writers.

Woodframe construction has been used for many decades without sound technical/engineering research. Therefore, this project is essential and timely after the losses observed during recent earthquakes.

- John Osteraas, Exponent Failure Analysis

-The Project has great potential to bring some fresh thinking and exciting new ideas to a neglected aspect of earthquake and structural engineering.

- Joel P. Conte, UCLA

-Fahim Sadek, NIST

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significant impact on the profession by filling in the gaps in testing, analysis, and code development.” Pardoien reviewed shearwall and diaphragm test methods (static or monotonic loading, dynamic or reversed cyclic loading); shearwall and diaphragm connection tests (strength, stiffness, and ductility characteristics of connectors); and analytical models (behavior of wood joints and structural systems, nonlinear behavior of timber shearwalls, shearwalls with openings, tilt-up wall buildings, etc.).

Lessons learned from the management of the FEMA-sponsored Phase 2 Program to Reduce Earthquake Hazards in Steel Moment-Resisting Frame Structures were discussed by Stephen Mahin (UC Berkeley, Berkeley, CA and Chair, Project Management Committee, SAC Joint Venture). The SAC Joint Venture partners (represented by the acronym “SAC”) are the Structural Engineers Association of California (SEAOC), Applied Technology Council (ATC), and CUREe. Mahin described the project’s research and products foci and issues related to administration, day-to-day management of the project, written guidelines, technical studies coordination, quality assurance, and communications. Mahin’s conclusion stressed the “tremendous amount of management effort and commitment to communication” and “open management approach,” all necessary in order to focus final products on the concerns of stakeholders and to facilitate adoption of design guidelines.

The second day of the workshop was dedicated to conducting three separate task group sessions. Group A, led by Prof. Chia-Ming Uang (Division of Structural Engineering, UC San Diego, La Jolla, CA) addressed Testing. Group B, led by Prof. André Filiatrault (Division of Structural Engineering, UC San Diego, La Jolla, CA), focused on Analysis. Group C, led by John Coil (Thornton-Thomasetti / Coil & Welsh Engineers, Tustin, CA), discussed Design issues. Each submitted reports that are included in the final proceedings and are briefly summarized here.

**Session A – Testing**

Three issues surfaced during the presentations and panel discussion – issues that need to be addressed to provide useful information for analysis and design. First, loading protocols that reflect realistic demand for both long-duration and near-fault ground motions need to be established, and acceptance criteria for consistent reporting of strength and deformation demand are needed. Second, component testing should fill the gap of current knowledge, not duplicate available test results. Third, a carefully planned and properly executed shake table testing of full-scale woodframe buildings can provide useful information on 3-D behavior and the interaction of different components, to complement component testing.

**Session B – Analysis**

In addressing various aspects of the modeling of woodframe construction under seismic loading and the needs of practicing engineers involved in the seismic design of woodframe structures, group presenters, panelists, and participants recognized that a large gap potentially exists between analytical researchers and designers. The group concluded that three levels of modeling must be considered: modeling of connectors, modeling of structural components, and modeling of structural systems. In addressing design issues, the group concurred that existing analytical models of woodframe structures are used primarily for research rather than as design tools. This gap creates difficulties for practicing engineers. The research needs identified by this group include 1) an urgent need to develop general and simple analysis tools for structural systems; 2) a natural period of vibration formula must be developed for different types of woodframe buildings; and 3) a reliable method to estimate building drift must be developed.

**Session C – Design**

Presentations during this session focused on topics such as the dilemma resulting from the various analysis assumptions available to the designer and the large disparity of results obtained depending on which assumption or method was used; the need for developing relatively straightforward procedures that result in designs that are easy to effect in the field and easy to explain and incorporate into existing methodologies; methods for determining the reliability of using research data on elements

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Order Form

The Proceedings of the Invitational Workshop on Seismic Testing, Analysis and Design of Woodframe Construction is now available.

Fifty-six experts in the field participated in the Workshop, which was held March 5 and 6, 1999 in Los Angeles. The 175-page Proceedings contains a total of 24 papers, summary reports on the three group sessions, and a collection of comments by the workshop participants.

To purchase a copy of the Proceedings, please send a check or money order (no credit cards), payable to CUREe, to:

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Invitational Workshop on Seismic Testing, Analysis and Design of Woodframe Construction

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A common issue in structural experimentation is the relationship of part to whole, or component to system. Arguments for and against emphasizing component testing (e.g., testing of an individual shearwall) versus system testing (e.g., reaction wall or shake table testing of multi-story 3-D models of buildings) were voiced at the Workshop. Some of the Workshop participants thought that extensive component testing should precede any system-scale testing. For example, Prof. J. Daniel Dolan of Virginia Polytechnic University suggested that the Project begin with component testing, using past Japanese full-scale testing as a reference point, "and follow the component testing with a potential full-scale building at the end of the project rather than at the beginning," a view echoed by Thomas Skaggs of APA and Robert Hanson of FEMA. Others, such as Prof. Helmut Prion of the University of British Columbia emphasized the need for "whole building tests," which are very rare and "would be a great opportunity to evaluate the 3-D response of buildings subjected to uni-directional and multi-directional shaking." Several of the practicing engineers were enthused about the value of full-scale and dynamic testing, because system-level issues of the interaction among components are considered major uncertainties in their current design procedures.

Conclusion and Next Steps

A recommended research plan based on outcomes from this workshop will be featured in the next Woodframe Project Newsletter. Manager of Testing and Analysis, Frieder Seible, reported that “very few numerical models capable of analyzing the seismic behavior of 3-D woodframe structures currently exist. Also, only limited experimental data have been generated at the system level. Recognizing these deficiencies, it is proposed to emphasize the testing and analysis at both the component level and system level in the research program.”

The preliminary research strategy will be discussed in more detail in the next issue of the Newsletter. The proposed plan incorporates five main research tasks, with shake table tests of large-scale woodframe systems to be conducted in both the early and later stages of the Project.

Perhaps the most common critical comment about the Workshop was that there was insufficient time to engage the participants in discussion on the second day. This compression of the agenda was one of the ramifications of confining the Workshop agenda to a day and a half, rather than two or more full days, out of consideration to the Workshop participants. This was a trade-off between allowing participants more time at the Workshop but at the expense of taking up more of their valuable time elsewhere and perhaps decreasing the acceptance rate for invitations. The critique that a more complete airing of the Workshop topics would have been useful is being taken into account in the planning of future workshops.
A major issue in any testing program involving simulation of earthquakes or other dynamically generated demands is the precise loading protocol to be used. More than one protocol has been used in wood component seismic testing in recent years in test programs in Japan, Italy, Canada, New Zealand, Australia, and the United States, and unanimity does not exist among the experimental community as to the best choice. Shown above are some of the protocols presented at the Workshop for possible application in the Woodframe Project’s Testing and Analysis Element.
Requests for Proposals (RFPs) for several engineering testing topics are available from CUREe. Based on the Woodframe Project Committee’s review of the initial submit-tals and selection of highest-ranked proposals, requests for final proposals will be issued. Because of the Federal and State Hazard Mitigation Grant Program regulations under which the CUREe-Caltech Woodframe Project is funded, proposing organizations (universities, companies, non-profit entities) must be located in the state of California. Approximately $700,000 in total budget will be involved with these RFPs (which includes a mandatory 20% cash and/or in-kind cost-sharing contribution by each subcontractor). The topics are: foundation anchorage, cripple walls, nonstructural components, innovative systems, and connections. Initial proposals, which will emphasize qualifications of the personnel and laboratories where the testing will be done (with not-to-exceed fixed price amounts that will be specified in the RFPs) will be due July 15, 1999. The highest-ranked proposers will subsequently be asked to develop more detailed final proposals. The set of five testing RFPs are available on the CUREe website: http://www.curee.org. The package of five RFPs can be mailed on request by contacting Ericka Holmon at the CUREe office: tel. 510-231-5684; fax 510-231-5664; e-mail ericka@curee.org.

**WCTE 2000**

The World Conference on Timber Engineering will be held July 31st-August 3rd, 2000 in Whistler, British Columbia. The objective of WCTE 2000 is to provide a forum for the exchange of the latest technological advances, research results, and design innovations. The theme “Engineered Wood Building Technology for the New Millennium” expresses the wide range of issues to be addressed at this conference. It is targeted towards practicing engineers and architects, researchers, educators, manufactures and building officials who have a desire to learn more about the innovative use of wood in building construction.

The deadline for abstracts is fast approaching. Contact: WCTE 2000 Conference Secretariat Venue West Conference Services Ltd. #645 - 375 Water Street Vancouver, BC, Canada V6B SC6 tel: 604-681-5226 fax: 604-681-2503 e-mail: congress@venuewest.com http://www.wood.ubc.ca/news/events.html

**SEAONC Cost Sharing Contribution**

The Structural Engineers Association of Northern California (SEAONC) has proposed to make a portion of the proceeds from their June 1999 seminar on San Francisco Amendments to the 1997 UBC available to the CUREe-Caltech Woodframe Project. These proceeds will be used toward determining the effects on shearwall performance of box nails or similar gun nails used in lieu of common nails for fastening of shearwall sheathing. This issue is of particular interest to practicing structural engineers because construction with an improper nail type is often claimed as a deficiency in post-construction litigation, contributing to large settlements. Limited testing conducted recently suggests that shearwall performance with box nails may be the same or slightly better than with common nails. Expansion of this limited testing is needed.

The CUREe-Caltech Woodframe Project is seeking additional cost sharing. For every $1 in cash or in-kind contribution, the FEMA-OES funding provides $3. Arrangements can involve contribution of cash, materials, or labor. If you are interested in assisting with cost sharing or know of someone who might be, please contact Robert Reitherman, Executive Director for CUREe, at 510 231-9557 or Prof. John Hall of Caltech, Project Manager at 626-395-4160.

**New URL for CUREe Website**

For more information on the Woodframe Project, see the CUREe website at: http://www.curee.org
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