Dissemination of Earthquake Related Research Activities through the use of Online Educational Modules

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SUMMARY:
The Educational Outreach and Training (EOT) component of NSF-NEES projects can be a vital tool in disseminating earthquake engineering research findings. A well-developed EOT component can expedite the adoption of research findings into professional practice, public policy, and facilitate technology transfer. As part of the EOT task of the NEES-Soft research (NSF Grant No. CMMI-1041631), educational online streaming modules are being produced. These modules, in a format first developed as part of a Virtual Learning Environment within the Wood Education Institute, are compact synthesized blocks of information from the NEES-soft research most beneficial to practicing engineers, researchers, graduate students, faculty, and research sponsors. This paper describes the background of the Virtual Learning Environment and discusses the format, content development, and deployment of the EOT online modules for the NEES-Soft project and the potential of using this approach as a standardized educational outreach model for earthquake related research.

Keywords: Education Outreach, WEI, NEES, Soft-Story, Pedagogy

1. INTRODUCTION

A significant amount of research in the United States related to natural hazard reduction is enabled through NEES, the George E Brown, Jr. Network for Earthquake Engineering Simulation organized by the US Congress under NEHRP and funded by the U.S. National Science Foundation. As a part of its mission, NEES has developed NEEShub, a clearinghouse of information developed through NEES research. Within the NEEShub, the NEESacademy provides easy access to EOT (Educational Outreach and Training) materials created by NEES researchers. However, because each NEES project has a different strategy and methodology for EOT, the outreach efforts and materials vary from project to project. The standardization of even a portion of the EOT could result in access improvement and ultimately an acceleration of the dissemination process. The primary benefit of accelerating the dissemination of earthquake-related research is a faster response time for the adoption of research findings into professional practice, public policy, and technology transfer activities resulting in a direct impact on earthquake related loss of life and property.

A streamlined and consistent EOT (within the NEESacademy) would allow varying stakeholders (students, researchers, faculty, public policy makers, news media, and laymen) interested in the state of practice of earthquake engineering research to access appropriate levels of information and detail particular to current (and/or past) earthquake engineering research projects. The EOT format presented herein, while applicable to many types of stakeholders, is specially directed to undergraduate educational programs in civil engineering and continuing engineering education for practicing engineers. The EOT format developed as part of this research is in the form of packaged streaming rich-media online educational modules. In general, the educational modules described herein can be created specifically for any target audience. For example: content appropriate modules targeting K-12 or the general public could focus on general earthquake engineering knowledge; modules addressing disaster and post-disaster management concerns targeting undergraduate college education could focus on the basics of structural dynamics, behaviour of non-linear systems, and fundamentals of earthquake engineering; finally, from the same research, modules can be created targeting the research and/or the professional practice community with emphasis on disseminating research findings. Should educational modules of this type be adopted as a standard EOT format, it is envisioned that multiple content appropriate modules be created for each project specific to a particular target audience. Generalized modules illustrating basic earthquake engineering concepts applicable to variety of NEES projects could then be available for reuse and linked to modules presenting more complex ideas specific to a particular research project. Eventually, as more educational modules are developed, they can be interlinked electronically forming a database of dependant research. Furthermore, these EOT modules could be supplemented with academic learning outcomes and assessments thus providing the rich-media content within a pedagogically structured Virtual Learning Environment. As a Virtual Learning Environment, the final product is useful in higher education, professional training, continuing education, and literature review for newcomers in existing areas of earthquake engineering research.

EOT modules have been developed within a Virtual Learning Environment as part of the Wood Educational Institute (WEI, 2012) and are being developed as part of the EOT component task for the NEES-Soft project. This paper will discuss the format, content development, and deployment of these rich-media online modules. In addition, this paper will outline the Virtual Learning Environment and the potential use of this approach as a standardized educational outreach model for training in earthquake related research.

2. WEI – THE WOOD EDUCATION INSTITUTE

The educational online streaming modules were first introduced in the context of the Wood Educational Institute (Gershfeld and Chadwell 2009). In response to a public need to improve education in wood engineering, the Wood Products Council (WPC), a cooperative venture of the major wood associations in North America in partnership with research organizations and government agencies, launched the WoodWorks initiative in February, 2008. This initiative was designed to support the use of wood in non-residential building applications. The WoodWorks initiative was formed with the intent to provide a one-stop access to the widest possible range of information on the use of wood in non-residential structures to design professionals.

In July of 2008, WoodWorks announced an educational partnership with California State Polytechnic University Pomona and provided a seed investment grant to fund and create Wood Education Institute (WEI) program. The pilot program was a virtual learning model intended to assist in offering wood education for undergraduate, graduate, and continuing education programs nationwide. At the time of authorship of this paper the WEI has (1) developed a significant portion of the educational content that focuses on undergraduate programs interested in offering a course in wood design; (2) started development of modules targeting various stakeholders in cooperation with NEES-Soft as described herein; and (3) began development of a hybrid course with 12-weeks of 100% online activities and an in person two-day weekend hands-on workshop as part of a continuing education program for practicing professionals.

For delivery of the completed modules, the WEI began a cooperative project with NEES (Network of Earthquake Engineering Simulation) to host the WEI developed courseware on their NEESacademy powered by the NEEShub infrastructure. Starting in late 2010, the intent of the collaboration was to apply developed methodologies to the NSF sponsored NEES Education Outreach and Training programs. In the spring quarter of 2011, the pilot program was launched using Moodle, an open-source learning management system, housed and maintained by NEES (www. nees.org). The pilot program, using the online course content provided by WEI, launched the hybrid/blended timber undergraduate design courses at two separate universities (California Polytechnic State University, Pomona and California Polytechnic State University, San Luis Obispo) as a first step toward implementation on a broader scale. Evaluation of student survey results suggested that overall; these modules were effective in disseminating the requisite material and were overall positively rated by students (Gershfeld et. al., 2012).

At the time of this authorship, certain aspects of the framework used in creation of the educational modules for the WEI are being applied to the NEES-Soft EOT tasks. The WEI framework consists of a Virtual Classroom, Virtual Laboratory, and Virtual Studio as three pillars of the Virtual Learning Environment. The work proposed within NEES-Soft involves development of the content for the Virtual Classroom component of the Virtual Learning Environment.

3. THE VIRTUAL LEARNING ENVIRONMENT

3.1. Approach

The learn-by-doing approach to engineering education practiced by the Cal Poly University, San Luis Obispo and Pomona are currently done in a traditional classroom environment consisting of lectures, lecture notes, homework, exams, and testing/design lab activities. An early challenge in development of Virtual Learning was to develop a model that can replicate the learn-by-doing classroom success in an online or hybrid learning environment. The model adopted and implemented as part of the WEI effort is based on a three prong approach. The three prongs of the Virtual Learning Environment are the Virtual Classroom, Virtual Laboratory, and a Virtual Design Studio (Figure 1).

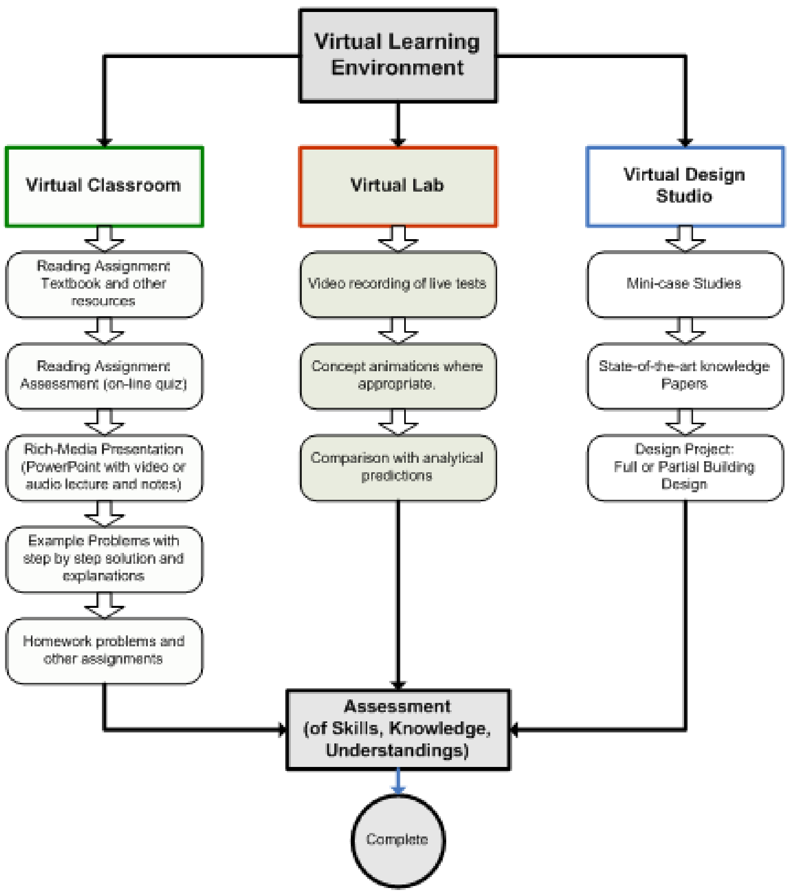

Figure 1. Virtual Learning Environment

Each of three parts of the Virtual Learning Environment utilizes various methods of instruction to support learning with understanding. The Virtual Classroom provides rich-media productions to familiarize students with basic facts and concepts associated with the learning objectives. Traditional classroom lectures extend these lessons through didactic teaching and discussion with students to support their conceptual understanding. Virtual Laboratories engage learning in experiments were they use what they know to predict, observe an experiment in action, then explain results. The final application of their knowledge is tested in a Virtual Design Studio where learned skills are synthesized to various realistic design conditions.

3.2. Virtual Classroom

The Virtual Classroom content could either be used to refine the activities of a traditional classroom by introducing digital media into the instructional sequence or be offered as a fully integrated virtual learning environment. In the context of a fully integrated learning environment from a pedagogical perspective (as part of training or continuing education in earthquake engineering), it is proposed that the students be required to:

- Complete reading assignments (or supporting modules)
- Participate in the assessment of the assignments
- Proceed to viewing lecture content consisting of a rich-media Web-based asynchronous presentation, similar to what is being offered in growing number of educational webinars
- Take a short online quiz focused on key concepts to be learned
- Participate in forum discussions where areas of difficulties are identified and discussed
- Complete homework assignment graded by the course instructor or facilitator
- Participate in the final assessment

The Virtual Classroom content developed as part of the EOT tasks within the NEES-Soft research consists of streaming modules that are designed to disseminate the NEES-Soft findings to a variety of stakeholders. Completed modules will either remain standalone entities, be linked into short training seminar, be presented in part of a series, or become part of a larger educational training package (as described above).

The modules developed within the WEI and as part of the NEES-Soft project are narrated streaming slides that introduce key concepts, vocabulary, illustrate difficult concepts using animations, and contain fully worked out examples (as necessary). The modules are set up to allow users, at any time, to stop and go back or forward to review the material. These dynamic, compliant (conforming to the USA American Disabilities Act) educational modules are packages of content approximately 20 to 60 min long. The modules are developed within a PowerPoint presentation supplemented with detailed notes for each slide, include voice over recording, and where appropriate, include video footage as well. While there are alternative commercially available products for development of these types of modules, the software Adobe Presenter© and Adobe Connect© have been adopted for the work described herein. Figure 2 shows screen shots of sample modules developed as part of the WEI.

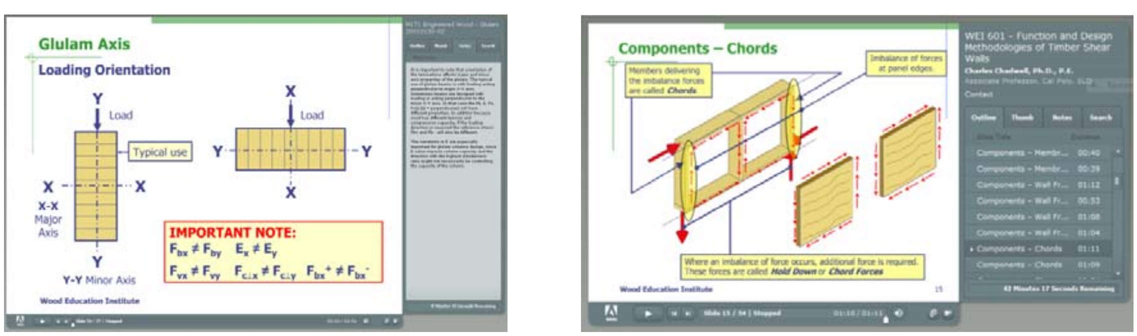

Figure 2. Screenshot examples of developed modules

3.3. Virtual Laboratory

One of the challenges of the Virtual Learning Environment is the lack of access to “hands on” laboratory experiments. In a traditional education setting, this creates a void in the ability to achieve desired academic outcomes. There is a similar challenge in disseminating NEES research. In the context of the NEES EOT, the idea of a Virtual Laboratory can be used to illustrate the experiments performed by researchers. The Virtual Laboratory would allow stakeholders to view experiments in real time highlighting the important aspects of the experiment. This could include real time shaking synchronized with model simulation and real time hysteresis. However, in the Virtual Laboratory, as opposed to the real laboratory, the user has control of the experiment and can slow the experiment in an effort to understand the behaviour. In addition, the Virtual Laboratory can be coupled with voiceovers and/or written text describing the key concepts both investigated and observed.

As an example, the physical experiment of a wood beam bending test is provided in a Virtual Laboratory environment. In this Virtual Laboratory produced by the WEI, the page contains video clips of actual experiments conducted in a laboratory as well as real time data collection. The video is an edited compilation of footage showing the overall experiment, close ups of the failure location, and a live speaker highlighting the key concepts consistent with the learning objectives of the experiment. A screen shot from a virtual laboratory module related to wood beam testing is shown in Figure 3. It is divided into four windows: the test sequence window, the load-deformation curve window, the actual test video window and test animation video window.

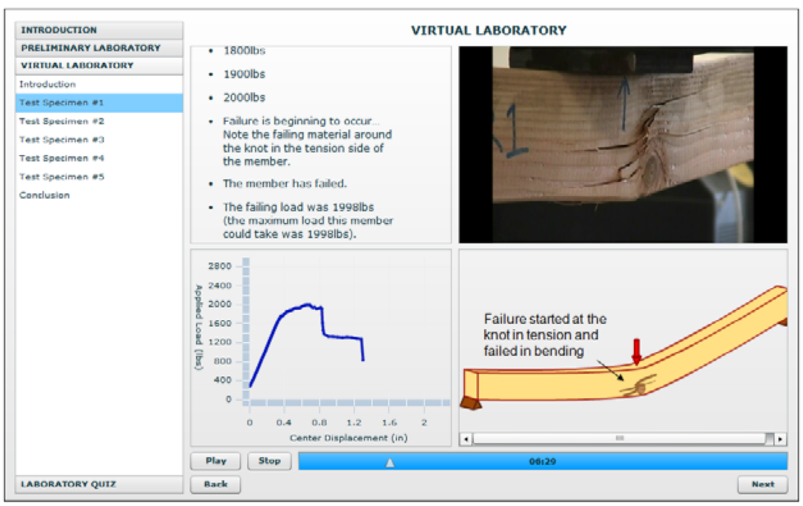

Figure 3. Screenshot of a Virtual Laboratory Module

3.4. Virtual Design Studio

The final prong in the Virtual Learning Environment is the Virtual Design Studio. The purpose of the Virtual Design Studio is to provide users with the opportunity to synthesize learned skills and knowledge in a “near” real life design environment. This particular element of the Virtual Learning Environment is highly dependent on collaborative online access to Computer Aided Design (CAD), Building Information Model (BIM), and design and analysis software. This phase of the project is still in conceptual stages and is therefore not included in detail.

4. NEES-ACADEMY

At the time of authorship of this paper, the content hosting and delivery of the WEI modules for the Virtual Learning Environment is provided by NEES. The NEES cyber-infrastructure is designed to support the research community's ability to share resources and build new knowledge through data sharing. The infrastructure capability to develop and effectively deliver online content was pilot tested through WEI-NEES collaboration and is being adopted for the dissemination of modules created as part of the NEES-Soft EOT task described herein. The NEESacademy portion of the NEEShub website (NEES, 2012) offers a learning management system (LMS) capable of supporting online courses of various formats and uses. This is accomplished by integrating Moodle, an open source LMS, into the NEEShub architecture. This structure is used to deliver the rich-media NEES-Soft EOT content as standalone modules or as a part of a Virtual Classroom in a Virtual Learning Environment.

5. NEES-SOFT PROJECT

The NEES-Soft project (van de Lindt et. al, 2012) is motivated by public policy concerns associated with post-disaster management of a large number of archaic wood structures with soft/weak story structural deficiencies (Figure 4). The NEES-Soft project is a five-university, multi-partner, three-year U.S. National Science Foundation (NSF) funded project that will (1) enable seismic retrofit of soft-story woodframe buildings based on performance, (2) experimentally validate recently proposed economical concepts for retrofit of soft-story woodframe buildings, and (3) provide a fundamental understanding of the way woodframe buildings collapse through a systematic experimental program consisting of full-scale whole building testing at two Network for Earthquake Engineering Simulation (NEES) equipment sites.

Figure 4. Typical Soft-Story building retrofit

The project involves component testing, hybrid testing, and shake table testing. Pre-test efforts include development of the test structure (Figure 5), retrofit alternatives, numerical modeling, and evaluation of numerical and test data. Project highlights include: sophisticated hybrid testing set up that allows test verification of large number of retrofit options and effective selection of most viable alternatives prior to final testing; the refinement of the 3-D finite element non-linear numerical model capable of predicting system behavior through a collapse mechanism; investigation of the use of energy dissipation devices for retrofitting; the refinement of the direct displacement methodology by incorporating torsion; and use of rich-media modules for educational outreach. The synergetic collaboration of NEES-Soft, WEI, the Applied Technology Council, Simpson Strong Tie, and several others, is intended to leverage available resources towards EOT content development.

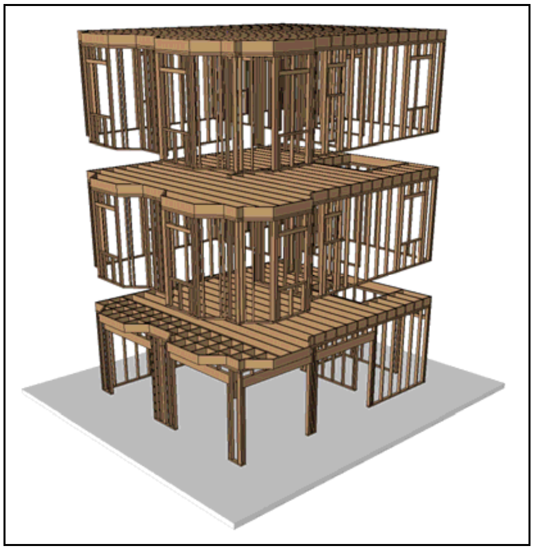

Figure 5. REVIT model of the NEES-Soft test structure

6. NEES-SOFT-EOT EDUCATIONAL MODULES

This part of the NEES-Soft project EOT component task will serve as a pilot for rich-media standardised content development for NEES projects through the NEEShub Learning and Outreach component.

The four modules being developed as part of the NEES-Soft EOT component task are:

- Classification, typical construction and behaviour of soft story wood frame buildings
- Understanding of design options for retrofit of weak/soft story buildings
- Design Example of weak/soft story retrofit using ATC 71-1
- Design Example of weak/soft story retrofit using Direct Displacement Design Methodology

6.1. Classification, Typical Construction and Behaviour of soft story wood frame buildings

This module targets audiences unfamiliar with soft-story collapse mechanisms and retrofit techniques and provides general background for the NEES-Soft research project. It describes basic engineering concepts, qualitatively and quantitatively, related to wood-frame soft-story/weak-story type structures and informs decision makers regarding public policy concerns surrounding buildings of this type. Through demonstration, the module will educate in the seismic behavioural differences between buildings with and without soft-stories. In addition, the module outlines wall and floor assembly's particular to the wood frame buildings of the early 20th century in the San Francisco greater area that are classified as soft-story structures. The basic cyclic behaviour of the historic wall assemblies are compared quantitatively to typical, present day woodframe wall construction. Finally, the behaviour and characteristics of historically constructed floor diaphragms are described.

This module is intended to be an educational tool for future (and past) projects associated with soft-story behaviour. It could be integrated in any course describing the fundamentals of structural dynamics, earthquake engineering, or seismic hazard. Parts of this module can also be used to illustrate to policy makers and insurance agencies the basic differences between modern day and archaic construction and seismic performance ramifications.

6.2. Understanding of design options for retrofit of weak/soft story buildings

The intent of this module is to review currently available retrofit options and design methodologies for soft-story systems and outline strengths and weaknesses of each approach. The NEES-Soft retrofit test structure, as described earlier, is used as a design example to illustrate their application.

While this module is sequential in the group of modules developed as part of the NEES-Soft EOT component, it could also be integrated into a Virtual Learning Environment for continuing education for practicing engineers. Furthermore, this module could be used in graduate courses that teach earthquake engineering, linked with the Virtual Design Studio as part of WEI, and/or to future modules developed as part of NEES projects that evaluate retrofit options of different types of structural systems.

6.3. Design Example of weak/soft story retrofit using ATC 71-1

Using NEES-Soft test structure, this module will focus on the soft story retrofit methodology developed by the Advanced Technologies Council project 71-1 (ATC 71-1, 2008). The module will highlight design philosophy, methodology, and critical assumptions made in ATC 71-1. It will also demonstrate the use of a Weak Story Tool, developed as part of the ATC 71-1 effort, through an example of retrofit, analysis, and design. One of the educational components of this module is the comparison of the design solution to the analytical results from actual test data of the prototype building.

The target audience for this module is similar to the previous module. However, as this technique is new, the emphasis will be on the details of the procedure and the evaluation of the design and test data. In addition, active researchers wishing to continue the work by ATC would also be able to utilize the information provided in this module.

6.4. Design Example of weak/soft story retrofit using Direct Displacement Design Methodology

This module will primarily focus on the Direct Displacement Design (DDD) Methodology. It will demonstrate the use of the DDD methodology in a step-by-step process.

This group of four modules, as presented herein, is intended to enable implementation of the research performed by the NEES-Soft research team in an easily digestible educational outreach format. It is intended to be a compact synthesis of the information attained from the NEES-Soft project that would be most beneficial to practicing engineers, researchers, graduate students, faculty, and research sponsors. This module can be linked with the WEI; other NEES past, on-going, and future research; ATC outreach; and continuing education in earthquake engineering in a Virtual Learning Environment.

7. CONCLUSION

EOT is an important component of many earthquake engineering projects including NSF funded NEES research. Its format and methodologies, however, vary from project to project. In some instances, it results in K-12 resources in the form of classroom activities, sometimes it's software developed for the purposes of demonstration of particular concepts, and sometimes it's in the form of undergraduate researcher testing scenarios. Within the NEESacademy, EOT is currently divided into target audiences of: students, teachers, public, and professionals. For each audience, different content, resources, and activities are provided. While there certainly is a need for a myriad of various types of educational tools and options, there is also a need for a consistent modular EOT component format that can be uniformly used across different research activities for various stakeholders. The rich-media online streaming modules developed first within the WEI and now being developed as part of the NEES-Soft EOT component task is an attempt to address this need. It is well matched with the

NEESacademy environment and has the necessary infrastructure to deliver the content across various earthquake engineering research activities and for various target audiences.

In the context of work done by the WEI, the use of these modules in a blended learning environment proved to be pedagogical valuable and the Virtual Classroom modules are being tested in the Virtual Learning Environment. The modules provide sufficient flexibility to either be used as standalone entities, linked into short training seminar presented, be part of a series be seminars or integrated into an entire course. In the context of the NEES-Soft project, the modules are effective in providing background information; aiding in undergraduate and graduate education; fostering professional development for practicing design professionals; and providing a succinct synopsis of the research conducted and conclusions drawn. In a broader sense, producing consistent modules in this format for different projects targeting different stakeholders can provide a starting point for a variety of people interested in earthquake engineering research, and can expedite the adoption of research findings into professional practice, public policy, and assist in accelerating the technology transfer.

AKCNOWLEDGEMENT

This project is supported by the National Science Foundation under Grant No. CMMI-1041631 (NEES Research) and NEES Operations. NEES Operations is managed through a cooperative agreement between the National Science Foundation and Purdue University for the period of FY 2010-2014 under NSF Award (0927178) from the Civil, Mechanical and Manufacturing Innovation (CMMI) Division. The initial support for concept development was supported by Wood Products Council, a cooperative venture of the major wood associations in North America, research organizations and government agencies, thorough Woodworks initiative. The authors would like to acknowledge the support of NEEShub technical staff Jason Lambert and Jared Gray West, the developers of some of the WEI modules, Rakesh Patel and Jenifer Cover, and assistance of Sean Brophy in modules assessment. The authors would like to recognize the contribution of all NEES-Soft team members and collaborators whose work is being incorporated into educational modules. Any findings, statements, conclusions, and opinions presented in this report are those of the authors and do not necessarily represent those of the National Science Foundation or Wood Products Council.

REFERENCES

van de Lindt, J.W., M.D. Symans, W. Pang, X. Shao, M. Gershfeld. (2012). "The NEES-Soft Project: Seismic Risk Reduction for Soft-Story Wood Frame Buildings." , *Prof 15th World Conference on Earthquake Engineering*, Lisbon, Portugal.

Gershfeld, M., Chadwell, C.B. (2009). "Wood Education Institute – The entrepreneurial spirit of cooperation between the wood industry and the university system", *2009 Structures Congress*, Austin, Texas, USA.

Gershfeld, M., Chadwell, C.B., Sean Brophy. (2012). "Online Modules for Wood Design Courses through NEES", *2012 ASEE*, San Antonio, Texas, USA.

Network for Earthquake Engineering Simulation (NEES) website. [URL] nees.org. Last viewed April 2012

Wood Education Institute (WEI) website. [URL] woodeducationinstitute.com. Last viewed April 2012

Applied Technologies Council (ATC), Project 71-1 (2008). "Development of Simplified Guidance for Seismic Rehabilitation of Soft-Story Wood-Frame Buildings". [URL] www.atcouncil.org. Last viewed April 2012