NHERI
Natural Hazards Engineering Research Infrastructure

QUARTERLY NEWSLETTER
NEWS FROM THE NHERI COMMUNITY
JULY 2018

INSIDE THIS ISSUE

COMING EVENTS

July 30 – Aug. 3
36th International Conference on Coastal Engineering 2018, Baltimore, Sponsor: ASCE

July 30 – Aug. 3
NHERI SimCenter Programming Bootcamp, Richmond, CA, Sponsor: UC Berkeley and NHERI SimCenter

Aug. 12 - 14
5th American Association for Wind Engineering (AAWE) Workshop, Miami, Sponsor: AAWE and NHERI WoW

Sept. 26 - 28
Tornado Hazard Wind Assessment and ReducTion Symposium (THWARTS), Urbana-Champaign, IL, Sponsor: University of Illinois

Visit the events calendar on the **DesignSafe-CI website: NHERI Community Events**

HELP SPREAD THE WORD ABOUT NATURAL HAZARD ENGINEERING!

DESIGN SAFE RADIO

Building under construction at UCSD. (Photo: UC San Diego Jacobs School of Engineering)

Tall Wood Buildings

Pursuing Earthquake Resilience and Sustainability

The NHERI Tall Wood project aims to change the way American cities build up.

In an effort to enable the construction of seismically resilient tall buildings using sustainable wood material, structural engineers are exploring ways to construct buildings as tall as 20 stories using mass timber systems.

This six-university collaborative project is led by Shiling Pei, associate professor of civil and environmental engineering at the Colorado School of Mines.

DEVELOPING A NEW SEISMIC DESIGN

The project features the use of cross-laminated timber (CLT) panels in tall building design. CLT is essentially glue-laminated wood panels made by gluing layers of solid-sawn lumbers in an orthogonal pattern. CLT and mass timber products are gaining traction to serve as a sustainable alternative for steel and concrete material in large commercial building design. But currently there is no seismic design method in the U.S. for such systems.

The goal is to develop a seismic design methodology that will enable wood buildings to perform significantly better than existing building structures in large earthquakes. The research group is eyeing a building height range up to 20 stories.

The research work involves both analytical and experimental investigations. At the beginning of the project, Pei and his team conducted a full-scale shake table test of a two-story building with post-tensioned CLT rocking wall system in order to obtain system level dynamic response

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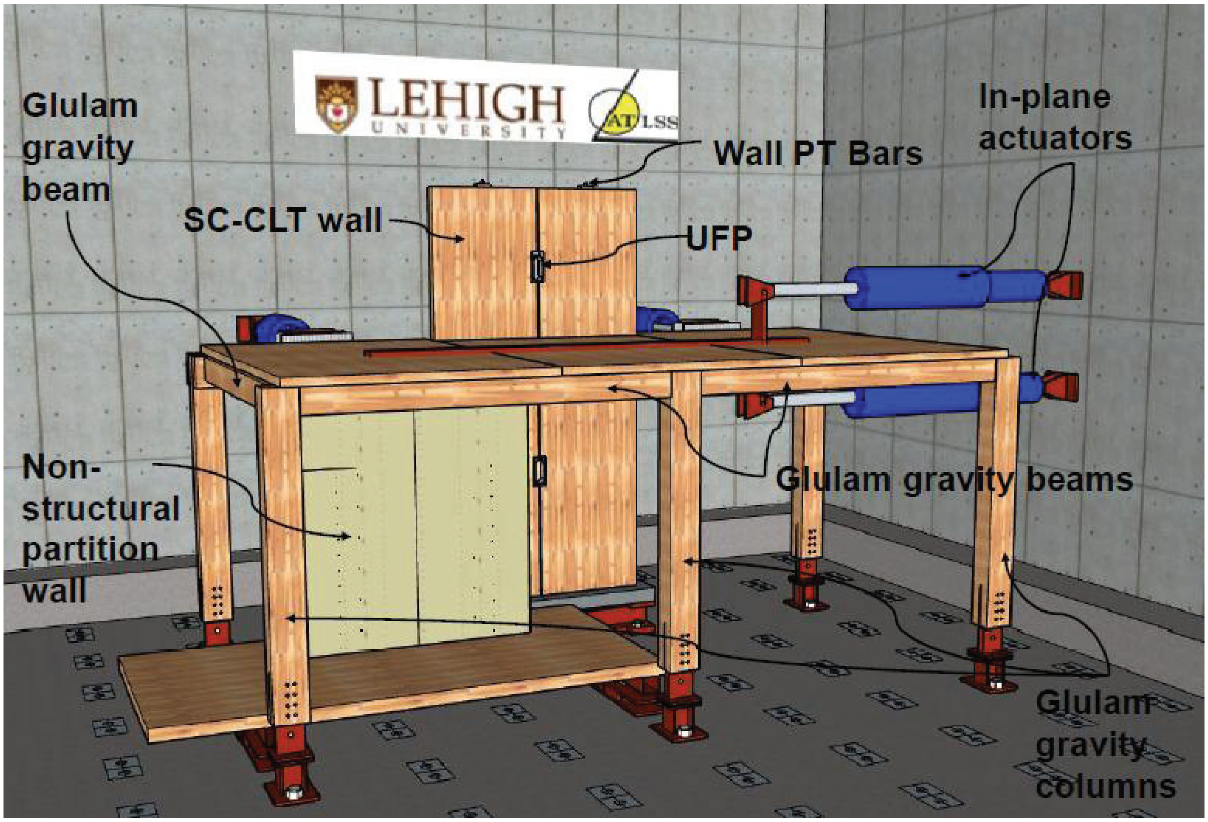
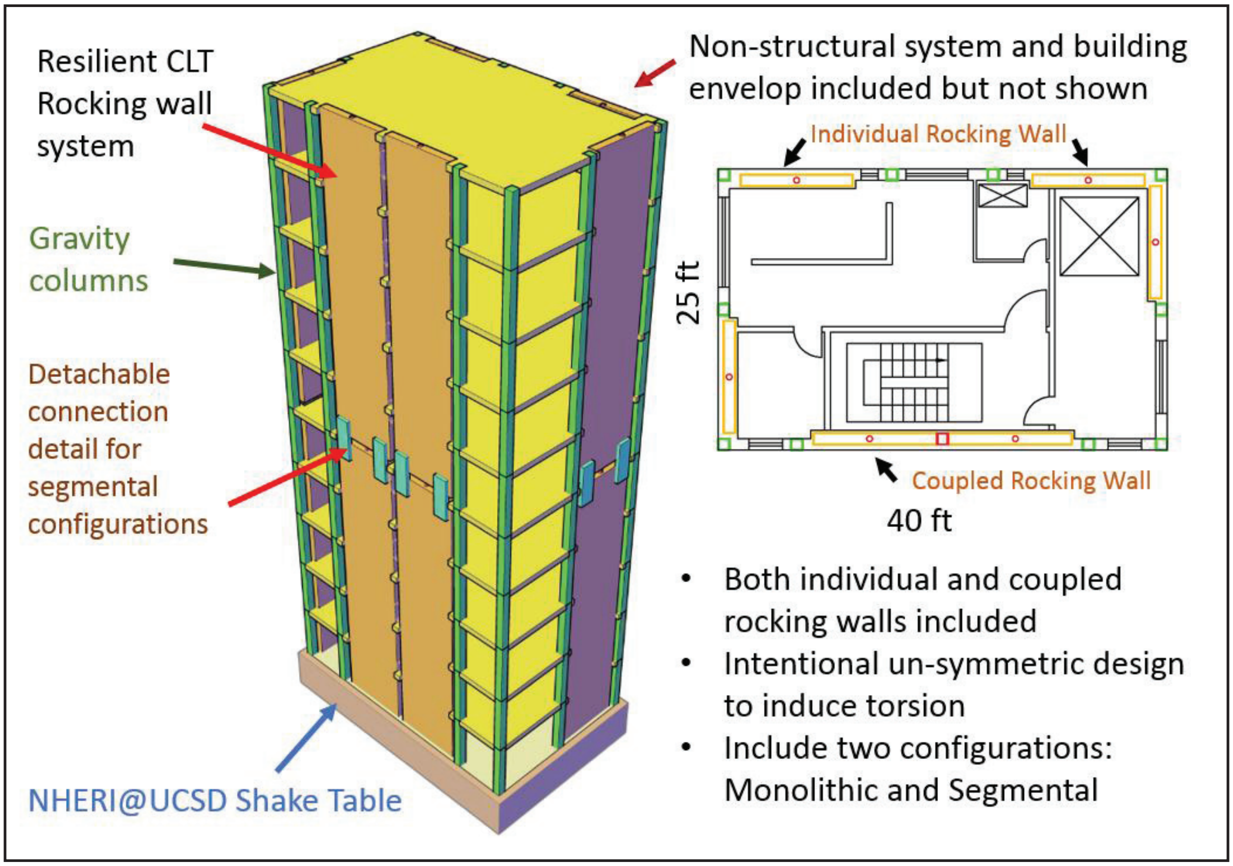
RESEARCH



Plan for the 2018 Lehigh test.



Concept of the 10-story building test planned in 2020.

data of the proposed wood building system. The specimen was subjected to a series of 14 earthquake tests, including 5 powerful MCE level earthquakes.

NOVEL SHAKE TESTS

Ultimately, the building was essentially damage-free for most of the tests, only experiencing repairable damage in MCE level events. It was the first time a full-scale timber building with post-tensioned rocking walls was tested on a shake table.

The experiments took place July 2017 on the UC San Diego LH POST shake table, one of the NSF-funded Natural Hazard Engineering Research Infrastructure (NHERI) experimental facilities.

UNDERSTANDING MASS TIMBER PERFORMANCE

The next step of the project is to conduct a series of bi-axial loading tests of a mass-timber rocking wall and floor system assembly at NHERI's Lehigh experimental facility starting by the end of 2018. The objective of this test is to understand the kinematics and load-resistance characteristics of the proposed mass timber system under biaxial load configurations. Data from the Lehigh test will help the team in the numerical modeling phase of the project and help in the development of a novel design methodology for tall wood buildings.

TALL WOOD 2020

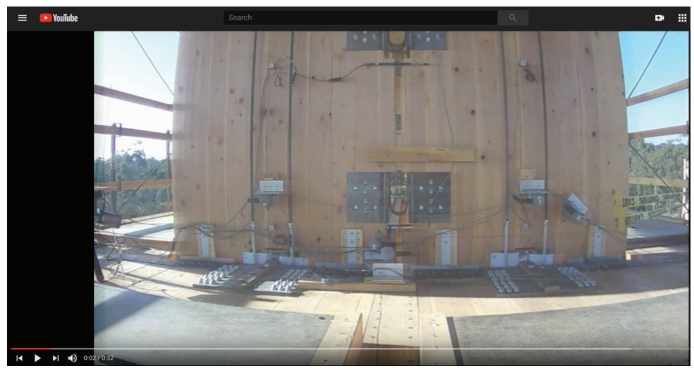
In 2020, the research team will return to NHERI's UC San Diego shake table to construct a full-scale 10-story mass timber building. The building will be furnished and tested to validate the resilience objective of the design methods proposed.

It will be the world's largest wood building to be tested at full scale.

Even as the project is still on-going, significant of tangible outcomes and new knowledge has been generated. The experimental data obtained from the 2-story test is scheduled to be made available through the NHERI DesignSafe-ci.org Data Depot by the end of 2018.

The Tall Wood project is currently open to solicit industry and academic collaborators (as well as payload testing ideas) for the 10-story test in 2020. For details and updates about this project, visit the project website: http://nheritallwood.mines.edu/ or contact PI Shiling Pei: spei@mines.edu

This three-minute video from the Jacobs School of Engineering provides an excellent overview of the project and of the July 2017 shake at UC San Diego.



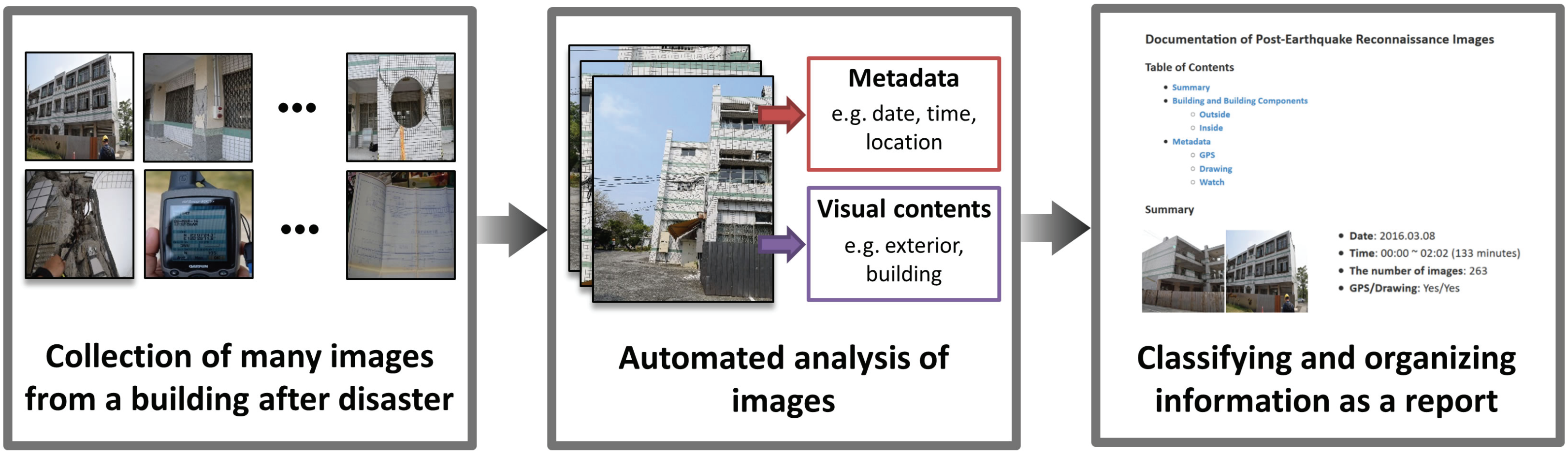
Shake table footage of the two-story mass timber test, July 2017.

PI and students involved in the two-story testing. (Photo: UCSD Jacobs School)

Collaborative Research: A Resilience-based Seismic Design Methodology for Tall Wood Buildings. Award #1636164.

This research project is supported by the National Science Foundation through a number of collaborative awards including: CMMI 1636164, CMMI 1634204, CMMI 1635363, CMMI 1635227, CMMI 1635156, CMMI 1634628. ■

RESEARCH



Credit: Chul Min Yeum, Purdue University.

Novel Deep Learning Approach Allows Rapid Analysis of Visual Disaster Data

In the aftermath of a natural disaster, engineers arrive on the scene to document the consequences of the event on buildings, bridges, roads and pipelines. Aiming to learn from structural failures, reconnaissance teams take around 10,000 photos each day, moving quickly to capture crucial data before they are destroyed. Then, every image must be analyzed, sorted and described — tasks that take people a tremendous amount of time.

In the first-ever implementation of deep learning for automating reconnaissance image analysis, Purdue University civil engineering researchers Shirley Dyke and Chul Min Yeum have created a way for computers to analyze visual data describing damage from natural hazards — faster and more consistently than humans. Specifically, the Purdue team has deployed deep learning algorithms to develop an online tool that automatically classifies images collected after disasters, a tool that directly supports field teams as they gather important perishable data.

Deep learning refers to artificial neural network algorithms that use numerous layers of computations to analyze specific problems. Researchers integrate domain knowledge to "train" these algorithms to recognize scenes and locate objects in images. Once each image is automatically analyzed, these complex, unstructured image sets can be organized into a format helpful to field teams in just a couple of minutes, saving them a great deal of time.

To develop suitable algorithms for classifying post-disaster imagery, Dyke and Yeum started with an unstructured 8,000-image data set from several past hazard events. They designed suitable classes for engineering purposes, and they carefully assigned labels to photographs – for instance, showing building components that were either collapsed or not collapsed, and areas affected by spalling, where concrete chips off structural elements due to large tensile deformations. After training is completed, the algorithm can automatically classify images and organize them for use by the field teams.

"Deep learning algorithms are quite powerful, but domain expertise is an essential ingredient needed to successfully perform the fundamental research to address their use for building image classification," Yeum says.

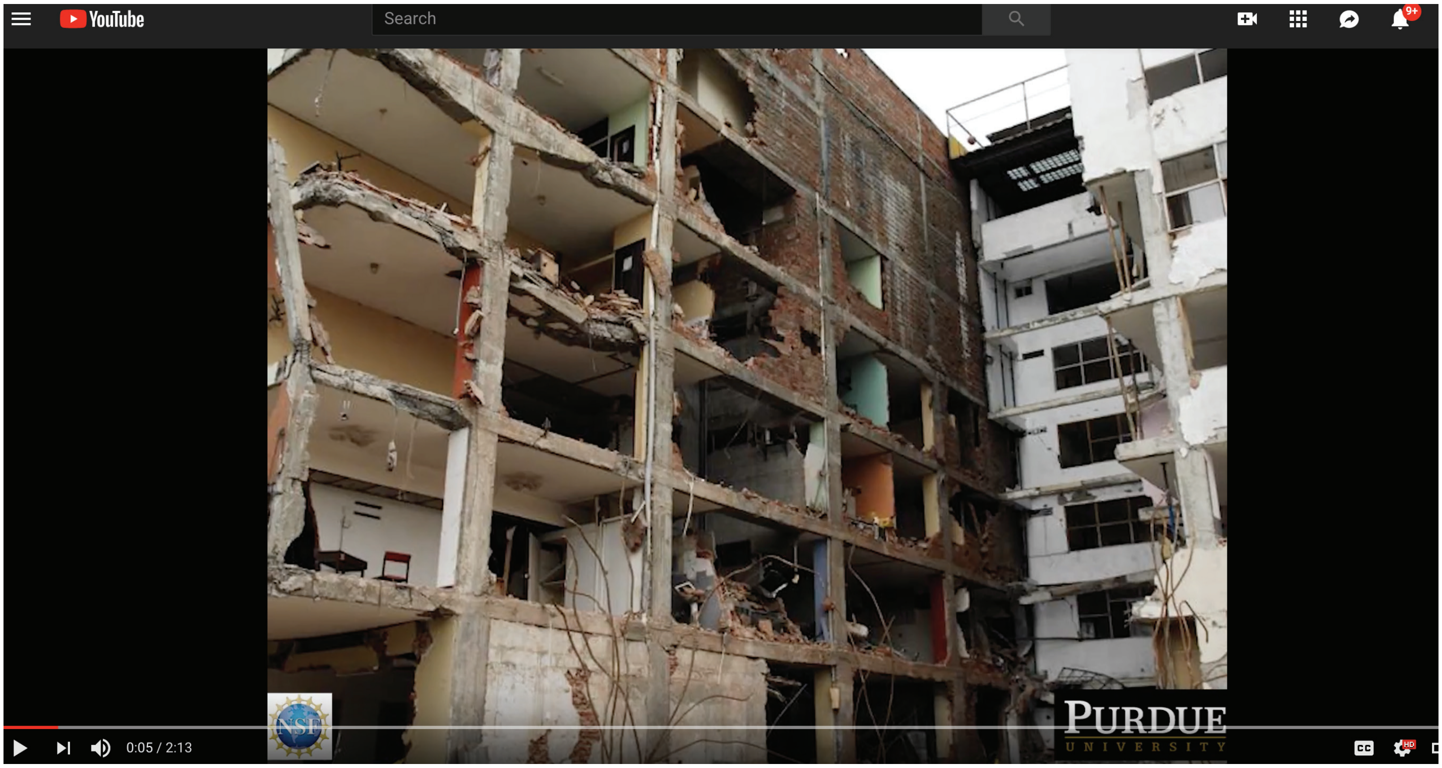
The team has gathered and trained their algorithms on about 140,000 digital images, including from recent earth-quakes in Nepal, Chile, Taiwan and Turkey.

Using deep learning techniques, the Purdue team has created an online visual data analysis tool called the Automated Reconnaissance Image Organizer, or ARIO. In the field or after a reconnaissance mission, researchers can upload images to ARIO where they are automatically analyzed and organized into a sharable online report to support real-world disaster reconnaissance missions. A prototype is available for testing and initial use by field teams.

"Often, design codes for buildings are based on lessons derived from these data," Dyke says. "If these data could be organized more quickly, more high-quality data can be gathered and used, leading to safer infrastructure and more resilient communities."

The team includes the computational expertise of Bedrich Benes and PhD student Mathieu Gaillard in Purdue's Department of Computer Graphics Technology, and Tom Hacker, in the Department of Computer and Information Technology. The team works closely with Santiago Pujol, who, as director for the Center for Earthquake Engineering and Disaster Data, surveys and collects damage from major disasters around the world. For details, contact Shirley Dyke.

Award #1608762 CDS&E: Enabling Time-critical Decision-support for Disaster Response and Structural Engineering through Automated Visual Data Analytics, July 15, 2016 – June 30, 2019 (estimated).



The team's two-minute video demonstrates ARIO in action. (Credit: Purdue University College of Engineering.)

Purdue researchers Shirley Dyke and Chul Min Yeum train their algorithms to understand and identify aspects of damage imagery that are important for natural hazard damage reconnaissance. (Photo: Mark Simons, Purdue University)■

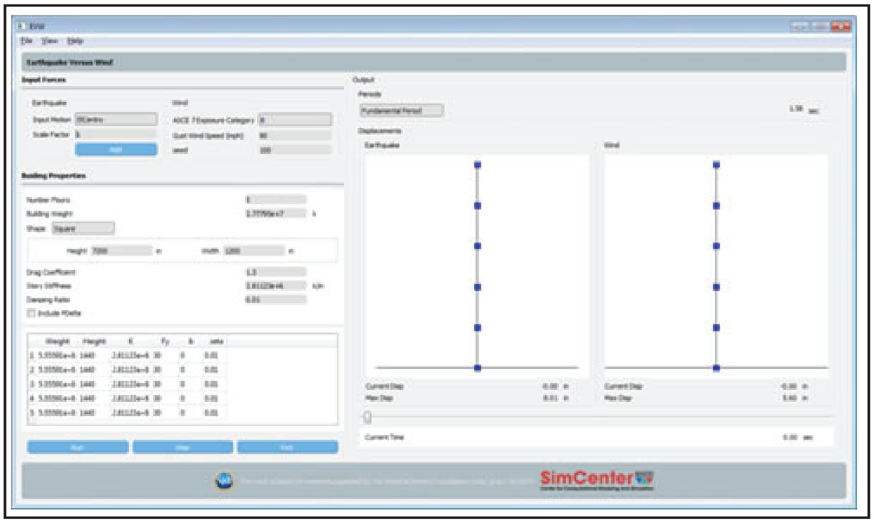
NHERI SimCenter Releases Four New Software Tools

Applications for Educators and Researchers in the Natural Hazards Community

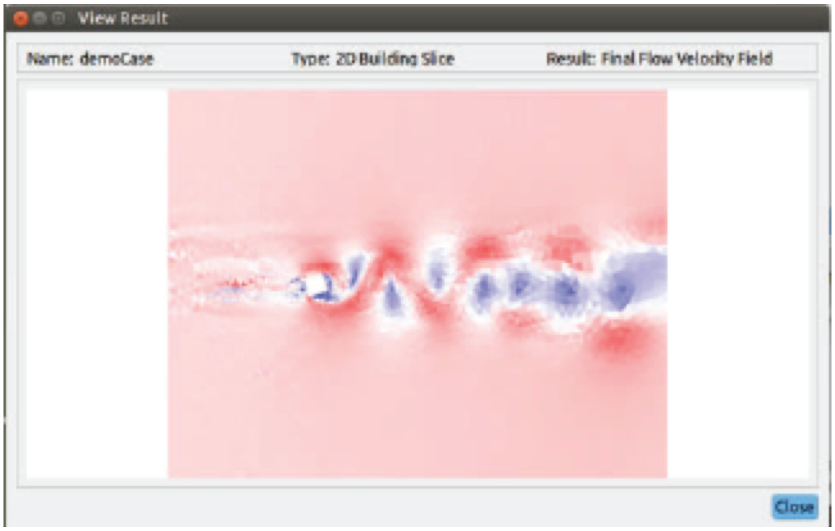
The goal of the NHERI SimCenter is to provide the natural hazards engineering research and education community with access to next-generation computational modeling and simulation software tools, user support, and educational materials needed to advance the nation's capability to simulate the impact of natural hazards on structures, lifelines, and communities.

As a natural hazards tool developer, the SimCenter enables leaders to make informed decisions about the need for, and effectiveness of, potential mitigation strategies.

The NHERI SimCenter has just released three research tools and its third educational tool that support natural hazards engineering. Details of the tools and apps are below.



*Download the **Earthquake Versus Wind** application app and user manual from the SimCenter website.*



*Download **Computational Wind Engineering – Uncertainty Quantification** tool app and user manual from the SimCenter website.*

LEARNING TOOLS

The educational tools target undergraduate and graduate students, providing these students with the opportunity to investigate the impact of various modeling parameters and assumptions about system behavior and natural hazard demand on the behavior of the engineered system. A teacher in a high school engineering course could also use the tools to introduce these concepts about modeling, system behavior, and hazard demand to their students.

EARTHQUAKE VERSUS WIND APPLICATION

EVW — The Earthquake versus Wind application allows the user to compare the responses of buildings subjected to earthquake and wind loading. The user models the building including floor weights, story properties, and geometry to observe structural dynamics in a side-by-side loading comparison. Earthquakes are selected from a series of predefined ground-motion acceleration records or user-provided motions. Wind forces are determined at floor levels using a stochastic process that takes into account gust speed, exposure category, drag coefficient, and building height and width. Building dynamic properties, base shear, and moment diagrams are produced along with the visual time-history response in the graphical user interface.

RESEARCH TOOLS

COMPUTATIONAL WIND ENGINEERING – UNCERTAINTY QUANTIFICATION TOOL

CWE-UQ — The Computational Wind Engineering – Uncertainty Quantification tool is a computational fluid dynamics (CFD) analysis software, based on OpenFOAM, for analyzing the effect of wind on rigid body structures and attendant response.

Continued on next page

It interfaces with HPC resources at DesignSafe-CI to perform the CFD calculations and alleviate computational overhead from the user's local machine. The ability to include user-defined inflow conditions and future releases that account for uncertainty quantification are intended to support and enhance CWE research.

UNCERTAINTY QUANTIFICATION FINITE ELEMENT APPLICATION

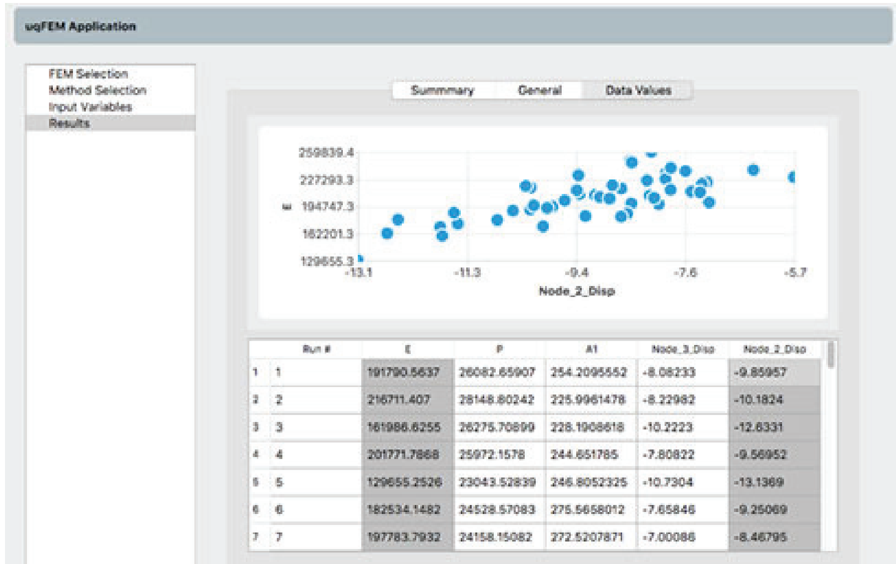
uqFEM — The Uncertainty Quantification Finite Element application advances the use of uncertainty quantification in the field of natural hazards engineering by combining existing finite element (FE) applications with uncertainty quantification (UQ) applications behind a simple user interface.

Using this app, an engineer can apply UQ methods to a new or existing FE model by identifying and flagging the random variables of interest. To overcome the issue of computational overhead, which typically precludes these types of probabilistic analyses from being performed, the user has the option of specifying that the simulations take place on HPC resources, such as the TACC Stampede supercomputer available through DesignSafe-CI, instead of executing them on their local machine.

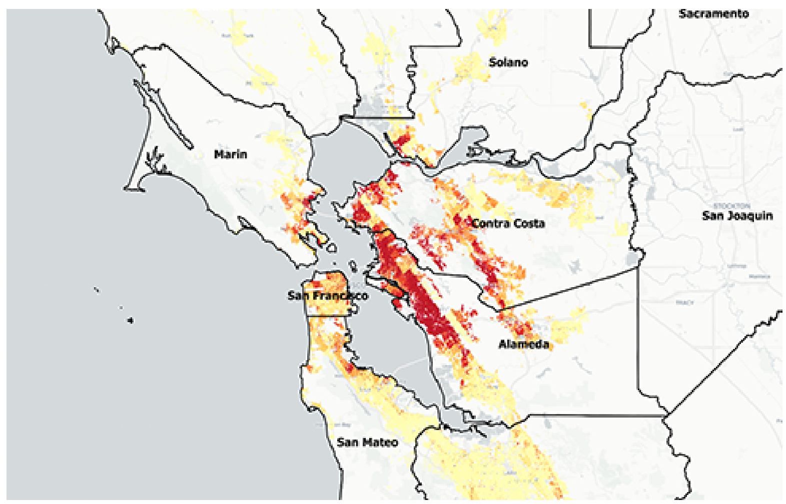
REGIONAL EARTHQUAKE WORKFLOW AND TESTBED

The Regional Earthquake Workflow is the first demonstration of the SimCenter's Application Framework that supports natural hazards engineering research. The extensible framework is next-generation software aimed at advancing regional-scale simulations.

The application's framework includes specifications for building information models, hazard events, loss calculations, and the APIs that interface between other applications that perform simulations. While the workflow is designed for HPC, a local version supports development and testing.



*Download the **Uncertainty Quantification Finite Element** application, user manual, and see the video tutorial from the SimCenter website.*



*Download the **Regional Earthquake Workflow** source code and documentation from the SimCenter website.*

The Regional Earthquake Workflow application is used to study the effects of earthquakes on society at the regional scale.

One demonstration of the Workflow is the SimCenter's Earthquake Testbed, which evaluates a M7.0 earthquake's impact on the San Francisco Bay Area. Accounting for the region's 1.8 million buildings, damage and loss for the region are calculated from fragilities and software provided through the user community.

Although the testbed is comparable to similar regional hazard scenarios, this one is intended to inspire the user community's adaptation and expansion of the workflow into their research.

To learn more about the testbed, expanding workflow capabilities, or extending to other hazards, please contact NHERI-SimCenter@berkeley.edu. ■

NCO Update. Greetings and best wishes for a great summer! The latest quarter of the FY 2018 has been full of activity, and we would like to bring you up to speed.

Julio Ramirez
Director, NHERI NCO

2018 Structures Congress

In April, several of the NHERI components got together to participate in a session during the 2018 ASCE-SEI Congress in Fort Worth, TX. As we reported, that session was well received, and you may now access the presentations in on the DesignSafe-CI Data Depot.

NHERI REU

June was full of activity as well with the start of the REU program and the NHERI Summer Institute in San Antonio, TX, from June 4-6. The REU program this year received more than 100 applications, easily surpassing the target set by the NCO. We want to thank all the faculty and students for the great support of this program and the facilities for the strong partnership with the NCO to make this program a success.

We look forward to a successful completion of the current phase of the REU program and to a successful program next year. We also want to thank the Education and Community Outreach Committee with members from the facilities, NCO and the User Forum for organizing the program.

SUMMER INSTITUTE

Similarly, the Summer Institute was very well received by the attendees. Focusing on early career researchers and practitioners, the NCO was able to fund 23 participants this year from the earthquake, wind and coastal engineering communities, as well as social scientists. A total of more that 70 individuals, including NSF, facilities, NCO and self-supported participants joined in the 3-day program. The Summer Institute focuses on building the NHERI community, discussing the Science Plan, and building NHERI research and education.

Los Angeles SAVI PREEMPTIVE participants outside the base-isolated Cathedral of Our Lady of the Angels during a technical tour of protected iconic structures.

11th National Conference in Earthquake Engineering

NHERI was well represented at the 11tCEE in Los Angeles with a session on NHERI research activities and cyberinfrastructure; the NCO represented NHERI on the panel: "Federal efforts to embed seismic policy into broader initiatives."

At the end of the 11NCEE, I had the pleasure of representing NHERI at the USC-hosted 4th PREEMPTIVE SAVI Workshop from June 29 to July 1.

More than 25 researchers participated in active breakout sessions and attended a half-day tour of iconic base-isolated buildings in Los Angeles, including the famous Los Angeles City Hall retrofitted in 2002 using an ingenious combination of rubber and hydraulic dampers.

This was the last workshop in the program and during it various strategies to continue the relationship were discussed and evaluated. We hope to hear more great news soon about this program led by Prof. Erik Johnson from the University of Southern California and Rich Christenson from the University of Connecticut. ■

The 2018 NHERI Research Experience for Undergraduates program is in full swing. Students in REU Block 1 and Block 2 have started their summer research projects. Block 1 started on May 30 and Block 2 started on June 18.

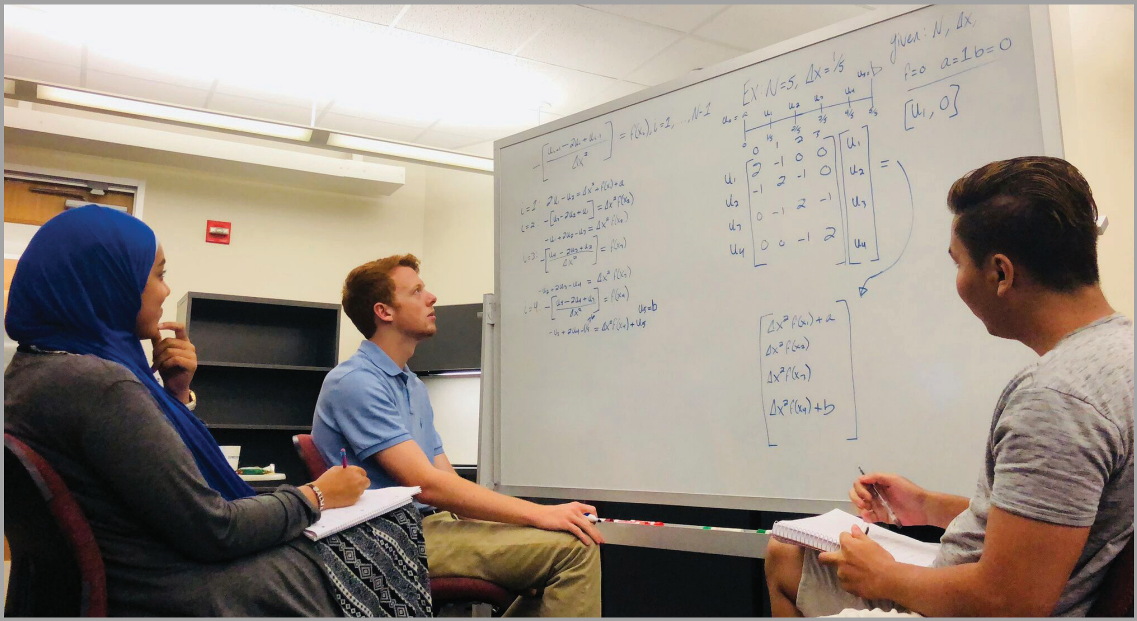
This year, we welcomed the University of Washington RAPID facility to the REU program. There are 2-4 REU students per NHERI site for a total of 29 young researchers. Students meet weekly over the Zoom videoconferencing software to discuss their research. They also meet weekly to engage in career preparation including writing resumes, cover letters and personal statements, and to participate in a NHERI career panel.

Faculty and graduate student mentors have been very involved in helping all students feel welcomed at the sites, challenged, and supported in their research projects.

All REU students will meet in person at Oregon State University's NHERI site on August 6-7 to present their research, network with their peers and tour the site.

Students have been participating in a weekly picture challenge and are excited to find out who will win. Visit the NHERI Facebook page to see some of the photos taken by our REU students.

Karina Vielma, EdD
NHERI Education and Community Outreach



At the University of Texas, DesignSafe REU students Salwa Badr, Jack Gaither and Nilo Espinoza solving a linear algebra equation using Python in Jupyter notebook. (Photo: Nilo Espinoza)

University of Florida REU students Daniel Perez, Victoria Chan and Stephanie Boggs in front of the wind tunnel on their first day of the program. (Photo: Kurt Gurley)

At Florida International University, students Walker Hood, Enrique Rubio Delgado, Ahmed Saleh testing the wind-resistant strength of signal-light hangers. (Photo: Walker Hood)

RESEARCH

NHERI AWARDS, APRIL 1 THROUGH JUNE 30, 2018

Natural Hazards Reconnaissance Facility
RAPID/Collaborative Research: Japan-U.S. Collaboration on the Seismic Resilience of Wood-frame Building Systems. Award #1829433. Principal investigator: Maria Koliou, Texas A&M Engineering Experiment Station. Co PIs: Keri Ryan, Shideh Dashti. NSF Org: CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: May 11, 2018. Awarded Amount: $187,000.

Natural Hazards Reconnaissance Facility
RAPID/Collaborative Research: Japan-U.S. Collaboration on the Seismic Resilience of Wood-frame Building Systems. Award #1829412. Principal investigator: Chris Pantelides, University of Utah. NSF Org: CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: May 11, 2018. Start Date: May 15, 2018. Awarded Amount: $12,999.

NHERI Centrifuge Facility at UC Davis
Collaborative Research: Soil-Structure-Water Interaction Effects in Buried Reservoirs - Centrifuge and Numerical Modeling. Award #1762749. Principal investigator: Youssef Hashash, University of Illinois at Urbana-Champaign. NSF Org: CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: June 04, 2018. Start Date: July 01, 2018. Awarded Amount: $325,644.

Wall of Wind Facility at Florida International University
Collaborative Research: Downburst Fragility Characterization of Transmission Line Systems Using Experimental and Validated Stochastic Numerical Simulations. Award Number: 1762918. Principal investigator, Abdollah Shafieezadeh, Ohio State University. NSF Org: CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: May 14, 2018. Start Date: August 01, 2018. Awarded Amount: $209,596.

NHERI Centrifuge Facility at UC Davis
Collaborative Research: Soil-Structure-Water Interaction Effects in Buried Reservoirs - Centrifuge and Numerical Modeling. Award #1763129. Principal investigator: Katerina Ziotopoulou, UC Davis. NSF Org: CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: June 04, 2018. Start Date: July 01, 2018. Awarded Amount: $439,096

Wall of Wind Facility at Florida International University
Collaborative Research: Downburst Fragility Characterization of Transmission Line Systems Using Experimental and Validated Stochastic Numerical Simulations. Award Number: 1762968. Principal investigator: Amal Elawady, Florida International University. NSF Org: CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: May 14, 2018. Start Date: August 01, 2018. Awarded Amount: $307,752

Wall of Wind Facility at Florida International University
Understanding Particle Scale Motion Initiation Physics for Loose-laid Building Rooftop Aggregates in Severe Windstorms. Award 176#0999. Principal investigator: Nigel Kaye, Clemson University. NSF Org CMMI Div Of Civil, Mechanical, & Manufact Inn. Initial Amendment Date: May 15, 2018. Start Date: January 01, 2019. Awarded Amount: $369,968

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