NHERI
Natural Hazards Engineering Research Infrastructure

QUARTERLY NEWSLETTER
NEWS FROM THE NHERI COMMUNITY
NOVEMBER 2018

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COMING EVENTS

Dec. 3, 2018
Lehigh and FIU Joint User Workshop
Bethlehem, PA Sponsor: NHERI

Dec. 6-7, 2018
FIU and Lehigh Joint User Workshop
Miami, FL Sponsor: NHERI

Dec. 10-14, 2018
AGU Fall Meeting
Washington, DC
Sponsor: American Geophysical Union

Dec. 13-14, 2018
UC San Diego Annual User Workshop
San Diego, CA Sponsor: NHERI

March 5-9, 2019
EERI 2019 Annual Meeting
Vancouver, BC, Canada

March 24-27, 2019
Geo-Congress 2019
Philadelphia, PA Sponsor: ASCE

April 22-25, 2019
National Hurricane Conference
New Orleans, LA Sponsor: NHC

HELP SPREAD THE WORD ABOUT NATURAL HAZARD ENGINEERING!

DESIGN SAFE RADIO

T-Rex on the Hobson Avenue Bridge over Interstate 195 in Hamilton Township, New Jersey.

Using Large Mobile Shakers for Non-destructive Infrastructure Testing

With recent onsite tests, Rutgers University's Nenad Gucunski hopes to improve bridge testing methodologies using the T-Rex mobile shaker from the NHERI facility at University of Texas, Austin.

Gucunski and his colleagues aimed to overcome limitations of existing dynamic testing methodologies for structural systems with his EAGER project, "Informing Infrastructure Decisions through Large-Amplitude Forced Vibration Testing," CMMI 1650170.

While cost-effective, conventional Structural Identification (St-Id) suffers from a reliance on low-amplitude, uni-directional excitation, which is unable to overcome intermittent stick-slip mechanisms or to induce appreciable responses within the substructure-foundation system, as illustrated in Figure 1 (next page).

Therefore, to overcome these low-level mechanisms in a controlled manner, and to improve the reliability of the resulting safety assessment, the research team used the large-amplitude mobile shaker, named T-Rex, available from the NHERI@ UTexas facility.

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Nenad Gucunski Professor and Chair, Department of Civil and Environmental Engineering, Rutgers University

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T-Rex provides opportunities for pushing the structural-foundation system beyond low-level responses to reveal performance characteristics that are more representative of the expected behavior under safety limit states.

The objective of the study was to apply low- to moderate-magnitude shaking to a bridge using T-Rex to capture the dynamic response and features, especially the resonant frequencies and their corresponding mode shapes.

This shaking induces structural demands and load distributions that are much closer to the destructive testing limit, or actual levels of seismic loads, (as described in Figure 1) compared to conventional St-Id methods.

The Hobson Avenue Bridge, a bridge over Interstate 195 in Hamilton Township, New Jersey, was selected for the study. It is a 67.4 meter (221 feet) two-span, steel girder jointed bridge with a three-hammerhead pier on a shallow continuous reinforced concrete (RC) footing.

“It was fascinating to feel the bridge vibrations, and observe shaking of the secondary structures from one side, and have full confidence in the control of that motion to the levels far below safety limits from another,” Gucunski says.

“The use of large mobile shakers opens new opportunities in the evaluation of dynamic characteristics of bridges, and large structures in general, in what I would call ‘global NDE,’” he says.

The primary findings are as follows:

(1) Mobile shakers are an effective testing tool for structural health monitoring, or for global non-destructive evaluation (NDE), to assess the dynamic response of bridges.

(2) From the experimental frequency sweep, the tested bridge exhibited two different dominant modes of transverse vibration at 4.41 and 4.64 Hz. The experimental results confirm that consideration of dynamic soil-structure interaction (DSSI) in the finite element model is necessary to capture this behavior.

(3) Increasing the dynamic load magnitude leads to clearer transfer functions and phase angle measurements, allowing a better identification of dynamic characteristics such as resonant frequencies.

A side view of the Hobson Avenue Bridge over Interstate 195 in Hamilton Township, New Jersey.

NEXT STEPS

The successful demonstration of large mobile shakers in this project is leading to the investigation of another potential beneficial application.

The Region 2 University Transportation Center, led by Rutgers’ Center for Advanced Infrastructure and Transportation (CAIT), is sponsoring a project that will examine the use of large mobile shakers in characterization of unknown bridge foundations.

While the two projects have been demonstrations on bridges because of the ease of deployment, Gucunski hopes to expand their application to other structures that equally necessitate evaluation of their dynamic characteristics and ability to withstand anticipated dynamic loads.

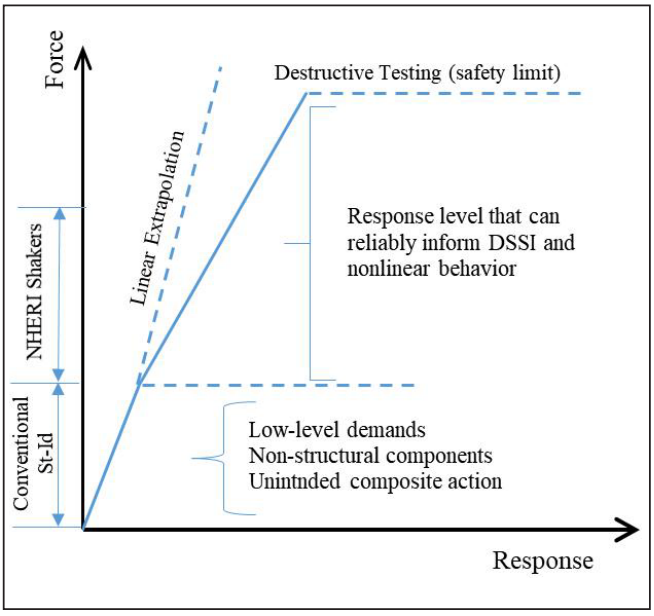

Figure 1. Comparison between conventional St-Id techniques with the proposed use of NHERI shakers.

New CONVERGE Center to Augment NHERI

To enhance the diversity of research underway in natural hazards, the National Science Foundation recently created CONVERGE, a $3 million research center at the University of Colorado Boulder. The center is a resource for the 11-member, NSF-funded Natural Hazards Engineering Research Infrastructure, known as NHERI.

One of the NSF's 10 Big Ideas, "convergence" describes the merging of scientific disciplines in a coordinated, reciprocal way that fosters the robust collaborations needed for successful inquiry. For NSF, convergence research is driven by a compelling problem that can be solved by deep integration between disciplines.

The CONVERGE facility will build and support the research partnerships and creative thinking needed to address complex problems that are posed by natural hazards, unsustainable development and rising economic inequality.

"As a resource, CONVERGE catalyzes the efforts of the NHERI users through coordination of the various reconnaissance groups organized by the community with the support of NSF," said Julio Ramirez, director of the NHERI Network Coordination Office and the Karl H. Kettelhut Professor of Civil Engineering at Purdue University.

Members of the NSF-funded INCLUDES Minority SURGE Capacity in Disasters program learn about structural damage to housing following Hurricane Maria in the U.S. Virgin Islands. NSF INCLUDES is a comprehensive initiative to enhance U.S. leadership in science and engineering discovery and innovation by proactively seeking and effectively developing STEM talent from all sectors and groups in our society. (Photo: ©Hans Louis-Charles, 2018)

Lori Peek, Principal Investigator of CONVERGE, also directs the Natural Hazards Center at the University of Colorado Boulder.

AUGMENTING NSF SUPPORT OF NATURAL HAZARDS RESEARCH

Lori Peek, professor of sociology and director of the Natural Hazards Center at UCB, is the principal investigator for CONVERGE. She said the facility is aligned with NSF's goals for research convergence, as well as with NHERI's mission to improve the resiliency of the nation's civil infrastructure to withstand natural hazards.

The center is dedicated to bringing together engineering, social sciences, and interdisciplinary teams to reduce hazards losses and improve social wellbeing. Peek said the goal of risk reduction and enhanced resilience is central to the NHERI mission, and the CONVERGE center will help advance that through its focus on research collaboration and coordination.

"Convergence science is about bringing together diverse people, perspectives, and skill sets to solve the world's toughest challenges," Peek said. "CONVERGE will allow us to link various research communities, to develop and share best practices for the ethical conduct of research, and to promote social science, engineering, and interdisciplinary natural hazards research to reduce vulnerability."

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BROAD GOALS

The CONVERGE center functions as a resource for the broader social science and engineering communities. “We are engaging in several crucial tasks that are meant to advance the broader research enterprise,” Peek explained. These tasks include:

- Creating the first-ever reconnaissance Leadership Corps, including the leaders of the geotechnical, social science, and structural engineering extreme events reconnaissance (EER) networks and associated NHERI facilities. The Leadership Corps will develop best practice guidance for reconnaissance researchers and research teams and will help to establish effective communications protocols with the media and with local, state, and federal government officials in the event of a major disaster.

- Identifying, connecting, and coordinating social science researchers and interdisciplinary research teams through the Social Science Extreme Events Research (SSEER) and Interdisciplinary Science and Engineering Extreme Events Research (ISEEER) networks.

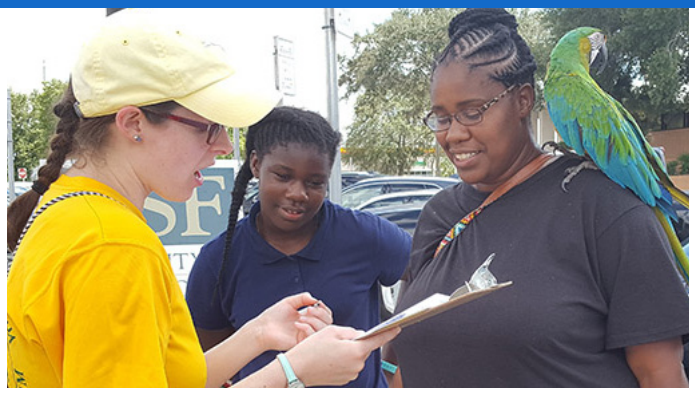
- Developing a series of training modules and research briefing sheets for students and researchers who are new to the hazards and disaster research space.

- Funding social science and interdisciplinary quick response research teams with a special emphasis on democratizing the research process and engaging researchers from historically underrepresented groups.

- Collaborating with the NHERI DesignSafe Cyberinfrastructure, located at the University of Texas-Austin, to develop a novel natural hazards and disaster focused social science data model for curating, publishing and sharing of open data. This will serve as a central repository for social science research instruments, data collection and sampling protocols, and datasets.

- Collaborating with NHERI RAPID facility, based at the University of Washington, to advance social science and interdisciplinary mobile applications for research.

- Collaborating with the NHERI Network Coordination Office, located at Purdue University, to help develop the next generation of researchers and scientists focused on mitigating the exposure of civil infrastructure to natural hazards and to disseminate the impact of the efforts of current and future NHERI users.



University of South Florida graduate student Michelle Saunders interviews a family evacuating with their pet parrot before Hurricane Irma. Saunders was part of a team of NSF-funded Quick Response researchers led by Professor Jennifer Collins. The Natural Hazards Center at the University of Colorado Boulder administers the NSF-supported Quick Response Research program, which provides small grants to facilitate perishable data collection in the aftermath of disaster. (Photo: ©Emily Cerrito, 2017)

CONNECTING SOCIAL SCIENTISTS AND ENGINEERS

In an era marked by climate change and rising social and economic inequality, disasters are becoming more intense and severe. “My vision for CONVERGE is for us to come together as social scientists and engineers to see how we can turn the tide and reduce the harm and suffering from these extreme events,” Peek said.

Shortly, CONVERGE will release the Social Science Extreme Events (SSEER) map and a series of quick response research briefing sheets. Currently, the team is conducting the first-ever census of social science hazards and disaster researchers. Find out more about the census at the Natural Hazards Center website.

THE TEAM

CONVERGE is located at the Natural Hazards Center at the University of Colorado Boulder, one of the nation’s oldest social science and multidisciplinary academic hazards research centers.

Members of the Natural Hazards Center team are helping get CONVERGE off the ground. Moving forward, the center will hire two postdoctoral scholars and identify members for various advisory committees.

CONVERGE also involves collaborations with the Center for Environmental Journalism at the University of Colorado Boulder. In addition, the CONVERGE team will partner with the Bill Anderson Fund and the NSF-funded Minority SURGE program to ensure that emerging scholars from historically underrepresented groups are engaged in future reconnaissance efforts.

CONVERGE: Coordinated Social Science, Engineering, and Interdisciplinary Extreme Events Reconnaissance Research, CMMI #1841338.

University of Florida Research Quantifies Tornado Loads on Residential Housing

Project gathers tornado and wind damage data, develops design provisions, educates communities and future engineers

The damage to residential structures from tornadoes is a large problem that has not received adequate attention from the structural engineering community. In 2011, two deadly tornadoes hit Tuscaloosa, Alabama, and Joplin, Missouri, resulting in over 220 fatalities and $6 billion in economic losses.

These events were the urgent motivators for principal investigator David Prevatt, wind engineer at the University of Florida, to initiate this research.

The primary objective of the project, *Tornado-Resilient Structural Retrofits for Sustainable Housing Communities* (CMMI #1150975), was to determine and quantify the tornado-induced loads on residential structures. This is the first step required to developing design guidelines for these structures.

Prevatt and his team collected data to help engineers and builders understand the interactions of tornadoes with residential structures, and the project developed approaches for predicting the magnitude of damage.

Educating the community about damage mitigation was a concomitant goal. Over the course of the project, construction professionals, communities and a cohort of student wind engineers learned about design provisions and technologies to mitigate losses.

SIMULATED AND FORENSIC DATA

Starting with very limited data on the strength of tornadoes or wind speed variations within them, the team primarily used two sources.

The first was the experimental results from Iowa State University's Tornado Simulator. The tornado simulator data consisted of surface pressure coefficients on buildings impacted by a tornado-like vortex that enabled the team to estimate the wind loads on exterior walls and roofs of buildings.

David O. Prevatt
Associate Professor
Department of Civil and Coastal Engineering, University of Florida

Before and after view of damage from December 2015 tornado in Rowlett, Texas. (Sources: Google Streetview, WFAA-TV)

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The second source was forensic information collected on reconnaissance missions following several tornadoes. The team collected geo-located information for tornado-damaged structures in several locations including Moore, Oklahoma, in 2013, and Dallas, Texas, in 2015.

In parallel to these activities, the project team also developed a theoretical tornado using mathematical principles of vortex behavior which enabled the prediction of peak wind velocities throughout the footprint of a tornado path.

CHANGING CODE, INSPIRING FUTURE WIND ENGINEERS

With the data collected, the team created mechanisms to predict and estimate tornado wind loads, which have contributed to the development of the first tornado wind design provisions included in the ASCE 7-16 Commentary. Larger national thrusts include the tornado design wind guideline that was included into the ASCE 7-16 Minimum Design Guide for Buildings.

Another major contribution of this research project was the development of human capital: undergraduates, graduate students, and teachers. The project supported three graduate students, including Dr. David Roueche, now assistant professor at Auburn University and notable wind hazards researcher, and Dr. Xinlai Peng, a practicing forensic engineer in Miami.

Eight undergraduates participated in the research, four of whom went on to pursue graduate degrees. Over summers, the project also hosted two middle school teachers, who now incorporate wind hazards science into their curricula.

DATA GATHERING PROTOCOL

The project was initiated during a period of resurging interest in wind hazards and community resilience, and the research addressed these needs in a unique way. Prevatt formed a Wind Hazard Damage Assessment Group (WHDAG) that educated and trained students on wind engineering and natural hazards.

Over the course of the project, which lasted six years (2012-18), the WHDAG self-published 17 Preliminary Damage Reports following the occurrences of tornadoes, hurricanes and straight-line wind events.

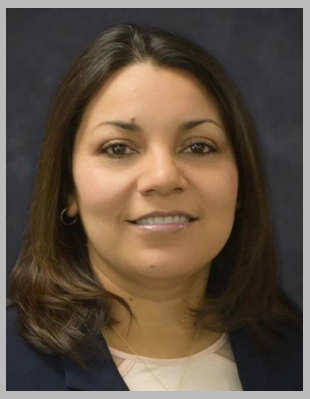
Reinforced concrete post, toppled by a tornado, May 2013, Moore, OK. (Photo: David Prevatt)

"The effort is important to the goal of structural and civil engineers. We are about engineering, education, and engagement. Our products must make life better for communities. We start by directly communicating with the public," Prevatt says.

For the team, it was crucial to communicate the importance of designing for wind hazards. By project's end, the yield was nearly 90 research-related communications, including two monographs (on the Joplin, MO and the Moore, OK tornadoes), 14 peer-reviewed papers, 40 conference papers and three media interviews—plus one on NPR's *Science Friday* program.

Prevatt is pleased to note that in 2015, Moore, Oklahoma, became the first community in the U.S. to adopt tornado-resilient structural design provisions. Positive change, stimulated in part by this research, is underway.

Complete destruction of home with anchor bolts just south of Hwy 377 & N. of Acton Highway in Granbury, TX. Although anchor bolts were used, the use of small washers reduced the impact of this reinforcement. Further, the lack of metal ties connecting the studs to the sill plate resulted in a weak link in the vertical load path from the studs to the sill plate. (Image: NOAA Southern Regional Headquarters)



Karina Vielma, EdD
NHERI Education and Community Outreach

"The number one reason students applied to the NHERI REU program was because a faculty member personally recommended that they apply."

On behalf of the Education and Community Outreach (ECO) Committee, I'm happy to report that our 2018 REU program was a huge success! Twenty-nine undergraduate students conducted research at 10 NHERI facilities. In two research blocks, students participated from May 30 through August 7 and June 18 through August 24.

Thank you for your continued support recruiting excellent students, providing mentorship, and cheering on our students as they conducted valuable research for the natural hazards engineering community. Your support was key to the success of our summer program!

During the NHERI REU Program, students attended virtual orientations, joined weekly Zoom research meetings, and attended career development workshops online. The highlight of their experiences was meeting their peers in person at the research symposium. Students travelled to Corvallis, Oregon, where they presented their research projects and scientific posters — and had a chance to tour Oregon State University's NHERI facilities.

From the REU post-assessments, we learned that students gained valuable research skills that solidified their career goals.

STUDENT OUTCOMES

All 2018 REU students gained experience preparing and presenting engineering research. Participants also increased their academic and practical understanding of real-world, hands-on engineering research.

100 percent of our 2018 REU students said the program added to their previous confidence in the engineering field as well as to their knowledge of the Natural Hazards Engineering Research Infrastructure community.

MENTORSHIP EXPERIENCE

100 percent of 2018 REU students said they gained experience collaborating on research projects with an experienced mentor and engaging in quality mentorship. We are grateful to all of the faculty, staff and graduate students at the NHERI EFs who shared their knowledge and time with future natural hazards engineers!

Overall, the REU Summer Program was a huge success. Students delivered high-quality research papers, research posters, and presentations, and they provided positive feedback on their summer experiences.

Also, for the first time this summer, NHERI REU students participated in a social media challenge. They submitted photos working with their peers at their sites which were posted on the NHERI Facebook page. The challenge was a fun way to see their camaraderie in action as well as share their research experiences with the world. We look forward to sharing with you next year's REU Facebook challenge!

The 2019 REU applications are now available online on the DesignSafe website. The applications are due Feb. 1, 2019. Please encourage your undergraduates to apply.

In the past two years, we found that the number one reason students applied to the NHERI REU program was because a faculty member personally recommended that they apply.

If you or your students have any questions about the program, feel free to reach out to us at nheri-reu@utsa.edu.

The NHERI REU is an outstanding experience for college students with limited research opportunities and for students looking to explore the field of natural hazards engineering research including earthquake, wind, tsunami and coastal engineering as well as research in cyber-infrastructure, computer simulation, and disaster reconnaissance. We welcome all majors interested in these areas to apply.

We look forward to another successful REU program in 2019. Thank you again for all your continued support.

Lehigh University REU students touring the High Steel Structures fabrication plant. From left, REU students Natalie Rosato, R. Bailey Bond, Ben Zager, and Peter Guadagno, with Peter Bryan of the Lehigh EF.

Florida International University REU students Ahmed Saleh (in white) and Walker Hood (in orange) installing the load cells for a Department of Emergency Management project. The structure would be tested under high speed wind to investigate its response under such drastic conditions.

NHERI REU students sitting on the Liquidator mobile shaker at the NHERI@UTexas site. From left: Jack Gaither, Nilo Espinoza, Salwa Badr and Emma Donnelly-Bullington. Photo: Jorge Salazar.

Greetings, everyone. We are pleased to report a number of positive developments in the area of international partnerships.

Julio Ramirez
Director, NHERI Network Coordination Office,
Karl H. Kettelhut Professor of Civil Engineering,
Purdue University

In addition to the letters of agreement signed in Year 1 between Purdue University on behalf of NHERI with the National Research Center on Earthquake Engineering (NCREE) of Taiwan and the National Research Institute for Earth Science and Disaster Resilience (NIED) of Japan, the NCO in Year 2 finalized a letter of agreement with the EUCENTRE Foundation at the University of Pavia, in Italy.

The first research planning meeting of this collaboration on earthquake engineering research was held Oct. 29, 2018 in Washington, DC, at the Embassy of Italy.

The outcomes of the meeting, including the agreement, will be made available to the NHERI community at:

https://www.designsafe-ci.org/facilities/nco/partnerships/eucentre/

A second letter of agreement, currently under review by NSF, is in the coastal engineering area with the Wallingford Hydraulics Research Laboratory in the United Kingdom. Both the EUCENTRE and Wallingford agreements cover the important elements of access to facilities, research collaborations, data exchanges, and educational activities.

Under the NHERI and NIED agreement, two meetings were held. One was held on July 13-14, 2017 to establish the framework for the research collaboration and to sign the agreement. The second meeting was on Oct. 31 and Nov. 1, 2017 to kick-start the research planning under the collaboration. Reports from both meetings, including presentations, are posted here:

https://www.designsafe-ci.org/facilities/nco/partnerships/nied/

FACILITIES UPDATE

During this quarter the RAPID facility at the University of Washington in Seattle under the leadership of PI Joe Wartman officially began serving the needs of the NHERI community. Already at the end of this reporting period, 37 days of utilization by six different teams were reported.

The breadth of missions is impressive. It ranges from Alaska landslides to Hurricane Michael. This NHERI facility has also begun serving the needs of the coordinating teams for event reconnaissance teams with GEER and StEER in the geotechnical and structural engineering specialties, respectively. Certainly it is a great start, and congratulations are in order to Joe and his team!

EDUCATION AND COMMUNITY OUTREACH

The recruiting phase for the REU program in Year 3 has started! Applications for the Summer 2019 program will close Feb. 1, 2019. Letters of recommendation are also due at that time. Notification of decisions will be sent by March 2019.

After the extremely successful recruitment phase of the 2018 REU program, with more than 100 applications, the NCO has decided to once again try to support additional REU students partnering with the sites and to place three students at each component. Apply now at:

https://www.designsafe-ci.org/learning-center/reu/

Plans are being developed for the third NHERI Summer Institute, June 5-7, 2019, in San Antonio, Texas. Stay tuned!

EUCENTRE and NHERI representatives during the October 2018 research planning meeting at the Italian Embassy in Washington, D.C.

Q3 NHERI Grant Awards July-Sept 2018

UC SAN DIEGO

Natural Hazards Engineering Research Infrastructure: Upgrade of the Large High Performance Outdoor Shake Table to Six Degrees of Freedom

Award Number: 1840870; Principal Investigator: Joel Conte; Co-Principal Investigator: Tara Hutchinson, Jose Restrepo, Yael Van Den Einde, J Luco; Organization: University of California-San Diego; NSF Organization: CMMI; Start Date: 10/01/2018; Award Amount: $8,500,000.

UNIVERSITY OF WASHINGTON

EAGER: Operationalization of the Structural Extreme Events Reconnaissance (StEER) Network

Award Number: 1841667; Principal Investigator: Tracy Kijewski-Correa; Co-Principal Investigator: Ian Robertson, Khalid Mosalam, David Prevatt, David Roueche; Organization: University of Notre Dame; NSF Organization: CMMI; Start Date: 10/01/2018; Award Amount: $358,932.

UNIVERSITY OF COLORADO, BOULDER

CONVERGE: Coordinated Social Science, Engineering, and Interdisciplinary Extreme Events Reconnaissance Research

Award Number: 1841338; Principal Investigator: Lori Peek; Organization: University of Colorado at Boulder; NSF Organization: CMMI; Start Date: 09/01/2018; Award Amount: $3,000,000.

UNIVERSITY OF FLORIDA

EAGER: Exploring Machine Learning and Atmospheric Simulation to Understand the Role of Geomorphic Complexity in Enhancing Civil Infrastructure Damage during Extreme Wind Events

Award Number: 1841979; Principal Investigator: Forrest Masters; Co-Principal Investigator: Luis Aponte; Organization: University of Florida; NSF Organization: CMMI; Start Date: 08/15/2018; Award Amount: $299,952.

FLORIDA INTERNATIONAL UNIVERSITY

MRI: Acquisition of a Three Component Particle-Image Velocimetry System to Enable Fundamental Research in Wind Engineering and Fluid Mechanics

Award Number: 1828585; Principal Investigator: Arindam Chowdhury; Co-Principal Investigator: Ioannis Zisis, Peter Irwin, Amal Elawady, Maryam Refan; Organization: Florida International University; NSF Organization: CMMI; Start Date: 09/15/2018; Award Amount: $466,076.

Collaborative Research: Hybrid Experimental-Numerical Methodology and Field Calibration for Characterization of Peak Wind Effects on Low-Rise Buildings and Their Appurtenances

Award Number: 1824995; Principal Investigator: Dorothy Reed; Co-Principal Investigator: Gregory Lyman; Organization: University of Washington; NSF Organization: CMMI; Start Date: 08/01/2018; Award Amount: $349,008.

Collaborative Research: Hybrid Experimental-Numerical Methodology and Field Calibration for Characterization of Peak Wind Effects on Low-Rise Buildings and Their Appurtenances

Award Number: 1825908; Principal Investigator: Arindam Chowdhury; Co-Principal Investigator: Peter Irwin; Organization: Florida International University; NSF Organization: CMMI; Start Date: 08/01/2018; Award Amount: $217,747.

UNIVERSITY OF TEXAS, AUSTIN

System Level Seismic Performance of Steel Gravity Framing

Award Number: 1825691; Principal Investigator: Patricia Clayton; Co-Principal Investigator: Todd Helwig, Michael Engelhardt, Eric Williamson; Organization: University of Texas at Austin; NSF Organization: CMMI; Start Date: 09/15/2018; Award Amount: $649,976.

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