



INSIDE THIS ISSUE

- 1** NHERI Means Business, Forms Technology Transfer Committee
- 2** Hurricane Season 2017: A Coordinated Reconnaissance Effort
- 4** Building Cladding as Multi-Hazard Protection
- 6** NCO Update: A Year in Review from the NHERI Council
- 7** Interest Surges in NHERI REU Program

COMING EVENTS

- Joint Wall of Wind and RAPID Experimental Facilities User Workshop**
Miami, FL, May 17-18
- Structures Congress 2018**
Fort Worth, TX, April 19-21
- NHERI Summer Institute**
San Antonio, TX, June 4-6
- Geotechnical Earthquake Engineering and Soil Dynamics Conference**, Austin, TX, June 10-13
- International Symposium on Computational Wind Engineering**
Seoul, South Korea, June 18-22
- 11th U.S. National Conference on Earthquake Engineering**, Los Angeles, CA, June 25-29
- 36th International Conference on Coastal Engineering 2018**, Baltimore, MD, July 30-Aug 3
- Tornado Hazard Wind Assessment and ReducTion Symposium** University of Illinois at Urbana-Champaign, Sept. 26-28

HELP SPREAD THE WORD ABOUT
NATURAL HAZARD ENGINEERING!



NHERI Means Business, Forms Technology Transfer Committee

In the fall of 2017, NHERI's Network Coordination Office ramped up efforts to help turn research into practice by instituting a Technology Transfer Committee.

The TTC is group of volunteer practitioners and decision-makers focused on strengthening ties between NHERI researchers and the implementers of NHERI-developed technology. TTC members are experienced in contributing to the development of design guidelines, technical briefs, building/ infrastructure codes and standards, and technical seminars.

A primary task for the TTC will be to review the results of NHERI research projects and identify findings that could immediately lead to improvements in the design process that will result in mitigation of risk due to natural hazards. The committee will identify other tasks for strengthening ties between NHERI researchers and the user community.

The Technology Transfer Committee was formed by the NCO in November and December 2017, under the leadership of Bill Holmes, who is committee chair. Holmes, a senior consultant at Rutherford + Chekene, is also active on NHERI's Strategic Committee.



Bill Holmes leads NHERI's technology transfer effort. Holmes, who is also active on NHERI's Strategic Committee, is a senior consultant and past principal at Rutherford and Chekene. He is also a member of the National Academy of Engineering.

Over the last 30 years, many improvements to the seismic code provisions have resulted from laboratory research.

As examples, Holmes points to the arrangement of reinforcing steel in concrete structures, the configuration and design rules for steel braced frames and steel moment frames. Similar insights have been realized for design of structures to resist tsunami/ storm surge forces, and high winds and for the design of foundations under various conditions.

Continued on page 6



The Charilaos Trikoupis bridge in Greece is an example of a structure engineered to account for seismic activity, the probability of tsunamis as well as the expansion of the Gulf of Corinth due to plate tectonics. During an earthquake, the piers can move laterally on the sea floor with a gravel bed to absorb the energy. The bridge decking is connected to the pylons using jacks and dampers to absorb movement. (Source: Wikipedia)

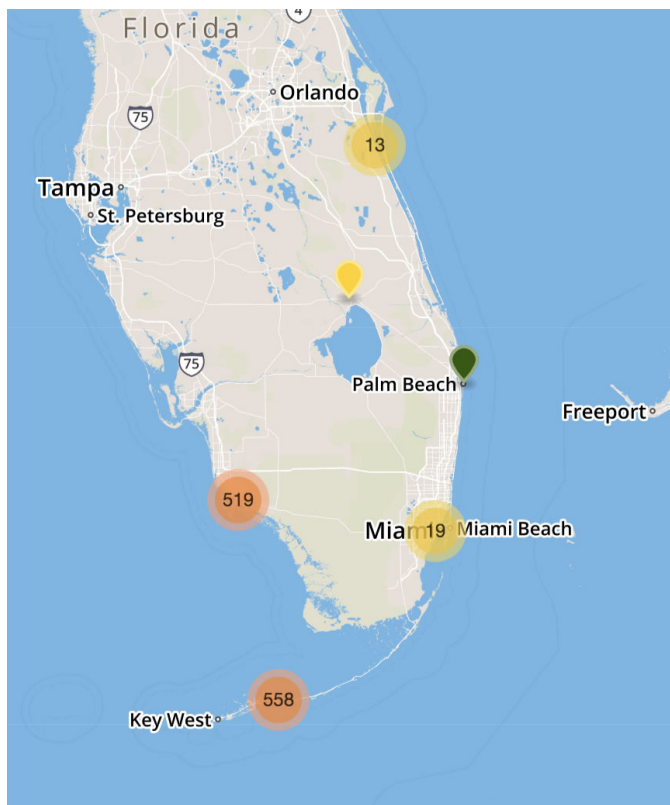
COMMUNITY

Hurricane Season 2017: A Coordinated Reconnaissance Effort

NHERI-led researchers collect data for assessing structures in vulnerable coastal zones

Post-disaster reconnaissance is one of the most powerful means to understand the effects of natural hazards on our built environment. The natural hazards engineering community's ability to advance design and construction standards is greatly informed by systematically documenting the performance of homes, businesses and other civil infrastructure under such real-world conditions.

Tracy Kijewski-Correa was the principal investigator on two NSF awards funding reconnaissance missions for Hurricanes Harvey and Irma; with Hurricane Maria's arrival, Kijewski-Correa and her teams ended up covering 3 storms — of various intensity, all over U.S. territory. The reconnaissance efforts started September 8 in Texas and concluded November 20 in Puerto Rico. The teams' investigations included unmanned aerial surveys (UAS), coastal surveys, door-to-door structural assessments to classify buildings and evaluate exterior component damage levels, portable LiDAR/imaging laser scanning of individual structures, and mobile LiDAR scanning of larger inventories and coastlines.



Fulcrum Community cluster map showing the number of assessments in each region of Florida relative to Irma's track. (Source: Fulcrum Community. View online.)



A collapsed and destroyed mobile home in Rattlesnake Point, Rockport, Texas. (Image: Kara Peterman)

The University of Notre Dame served as a coordinating node for this widespread structural wind and coastal engineering reconnaissance effort, assembling teams from across the research community and establishing a network of regional nodes organizing local teams in areas affected by Irma and Maria.

"Reconnaissance is a powerful experience for our teams — a chance to witness first-hand the forces of nature we hope to model and ultimately mitigate," recalls Kijewski-Correa. "It reconnects us with the reason we became engineers, and at times sends a sobering reminder that there is still much work to do."

Leveraging Fulcrum

The large, geographically distributed effort required the development of unified data standards and digital workflows to enable the swift collection and curation of perishable data in DesignSafe. Auburn's David Roueche, the team's Data Standards Lead, was especially enthusiastic about the team's customized Fulcrum mobile smartphone applications to support standardized assessments of continental U.S. and Caribbean construction typologies, as well as observations of hazard intensity and geotechnical impacts.

It worked so well that the team transitioned their efforts into a pro-bono Fulcrum Community site that supports crowdsourced damage assessments from the public at large with web-based geospatial visualization in real time. This feature enabled coordination with teams from NIST, FEMA, and ASCE/SEI. Dedicated data librarians at each regional node executed a rigorous QA/QC process on the backside of the Fulcrum database, led by Roueche.



Hurricane Harvey Team 1 members (from left) Richard Wood, Kara Peterman and graduate student Yijun Liao in front of damaged hangar at Aransas County Airport (Image: Chao Sun)



Work for the U.S. Virgin Islands team included an extensive coastal survey of Hurricane Maria's damage to local infrastructure. (Image: Richie Slocum)

Damage assessment in Texas after Hurricane Harvey

Hurricane Harvey made landfall August 25, 2017 as a Category 4 near Rockport, Texas. With maximum winds of 130 mph, Harvey was the first Category 4 hurricane to make landfall in the U.S. in over a decade. A team was assembled to (i) execute coastal surveys to establish high water marks and inundation extent, (ii) conduct door-to-door damage assessments using the Fulcrum App, and (iii) capture 3D point clouds of individual structures obtained through portable LiDAR/imaging laser scanners, (iv) collect 3D point clouds of entire blocks using a mobile LiDAR van, and (v) coordinate UASs of select residential areas.

The reconnaissance effort was led by four sub-teams deploying in three coordinated waves from September 8-17. A pair of teams worked sequentially to conduct door-to-door damage assessments in Rockport, Port Aransas, Aransas Pass, and Bayside, supplemented by UAS and portable scanners. These teams were flanked by a coastal scout team measuring high water marks as far east as Palacios. This was followed by block-level scans of these same neighborhoods using the mobile LiDAR van.

The Harvey field teams were led by Tracy Kijewski-Correa (Notre Dame), Jie Gong (Rutgers), Andrew Kennedy (Notre Dame) and J. Arn Womble (West Texas A&M).

Recon efforts in Florida, post-Hurricane Irma

Hurricane Irma left a path of considerable destruction across the Caribbean, eventually making its first landfall in the continental U.S. at Cudjoe Key in southern Florida on September 10, with Category 4 winds, followed by its second landfall later that afternoon as a Category 3.



Damage to an 11-story unreinforced masonry building on Mustang Island, a barrier island on the Texas coast. (Image: Kara Peterman)



House damage in Cudjoe Key. (Image: Ioannis Zisis)

Continued on page 6

RESEARCH

Building Cladding as Multi-Hazard Protection

A collaborative research project between Lehigh and Iowa State aims to expand the role of traditional building cladding

Building facades typically consist of cladding that is placed on the outside perimeter of the structure. Traditionally, cladding has served two roles. As an architectural element, it provides a building envelope. As a serviceable element, it provides protection from outside elements.

In this project, Lehigh University faculty James Ricles and Spencer Quiel and Iowa State faculty Simon Laflamme envision cladding systems as multifunctional structural units. Not only would the cladding serve its traditional purposes, but it would also be engaged as an engineered system to protect the structure against multiple hazards, including seismic, high-to-extreme wind, and blast loads. Cladding serves both as the point of application of externally applied lateral loads, such as wind and blast, as well as a contributor of added inertia due to seismic or wind-induced vibrations. Specifically, this project will explore the use of semi-active controlled connections between cladding and the structural framing of a building, and these connections will be capable of providing variable damping to mitigate the effects of extreme loading.

The project is a collaborative effort between Lehigh University, Iowa State University, and Taylor Devices Inc. (lead by its founder and CEO/President, Douglas Taylor). The focus of this project is the experimental and computational response of a prototype semi-active damping device, installed between the cladding and structural frame, to variable loading frequencies and intensities from multiple hazards. The objective of the proposed system is twofold: (1) to engage the cladding as a mass damper to mitigate inter-story drift due to lateral load vibrations; and (2) to utilize the device as an energy dissipator to mitigate the transfer of reactions from cladding to the structure under lateral loads. The project consists of five major research tasks.

Task 1: Selection of prototype buildings and cladding systems.

For Task 1, prototype buildings with 4, 10, and 24 stories were designed according to current code requirements for wind, earthquake, and blast loading. Computational models of the buildings were developed using the computer program OpenSees. For design of the cladding, the research team has been interacting with Eastern Wall Exterior Systems (EEWS), an industrial partner specializing in the design and construction of building cladding systems. The team met with EEWS to review designs and to get updated information

about current cladding design practice and details. “Our industrial partners at EEWS have helped us identify cladding connection modifications that can accommodate the use of semi-active damping devices,” says Spencer Quiel, co-PI on the project.

Task 2: Design and Construction of a Semi-Active Control System.

Under Task 2, characterization testing was performed at Iowa State University for a small-scale prototype version of a semi-active cladding connector damping device (see Figure 1). This device acts as the lateral connection between the cladding and the building frame, providing a source of damping from hysteretic energy that is dissipated by friction. A semi-active friction mechanism in the toggle’s geometry is used to provide a variable damping force, and an impact rubber bumper is utilized to absorb pounding energy under extreme events. The purpose of the characterization testing is to establish the performance and dynamic properties of the device considering the effects of excitation frequency and displacement stroke. The testing included quasi-static and dynamic cyclic experiments as well as experiments involving device displacement histories based on earthquake time histories.

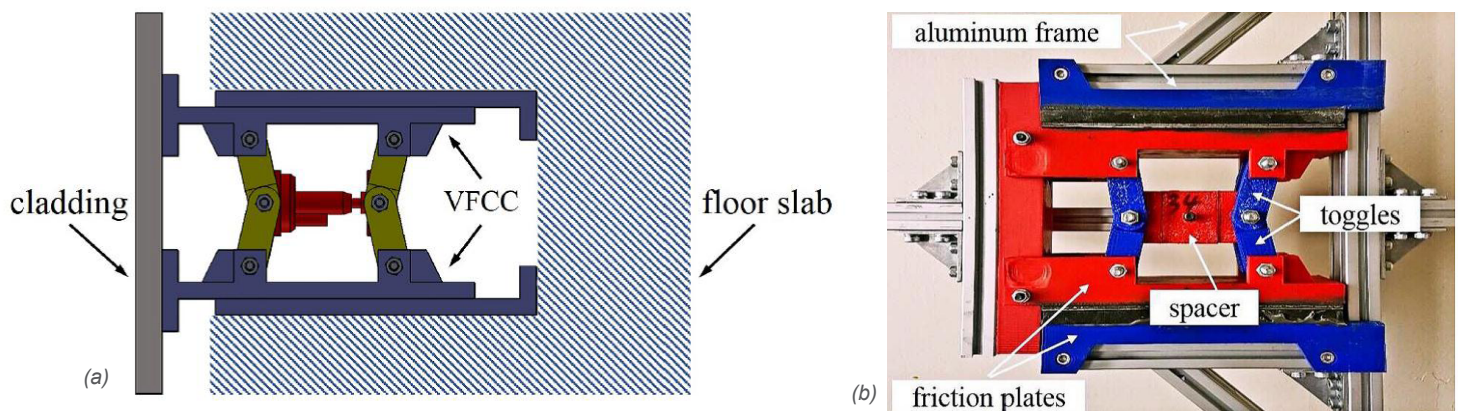


Figure 1 – Plan view of the prototype variable friction cladding connector (VFCC): (a) conceptual sketch and (b) 3-D printed prototype tested at Iowa State University.

Task 3: Analytical and Computational Calibration of Control System Design

With Task 3, the team conducted numerical simulations of the 4-story and 10-story prototype building models with the cladding connector damping devices. These simulations subjected the models to earthquake loading scaled to the 500-year return period hazard level, in addition to wind loading associated with the 700-year return period. The cladding connector damping devices for these numerical simulations had a passive control law. The wind load pressure was obtained by constructing 1:120 scale models of the 4-, 10-, and 24-story buildings via 3-D printing at the University of Florida NHERI Experimental Facility (see Figure 2); each model was subsequently placed in the wind tunnel and subjected to wind forces.

“Collaborating with the NHERI site at the University of Florida allowed us to obtain realistic loading input for our numerical simulations of buildings exposed to wind,” Quiel says.

Task 4: Experimental Validation of Control System Designs

For Task 4, the team performed experimental validations on the 4-story prototype building using real-time hybrid simulations at Lehigh’s ATLSS Laboratory (see Figure 3). The friction devices in the cladding connectors were replaced with a nonlinear viscous damper. The



Figure 2 – The 24-story building model (1:120 scale) placed in the wind tunnel for testing at the University of Florida.

experimental results validated the numerical simulations for earthquake and wind hazards. “We found that an elastic member in parallel with the damper in the cladding connector is needed in order to self-center the cladding with respect to the building during a wind storm,” Quiel says.

Task 5: Validation of Analytical and Computational Models for Design

For Task 5, the team is developing performance-based design procedures to promote implementation of the research results. A performance-based

design procedure for blast mitigation is complete. The procedure contains three steps: (1) blast load design, (2) cladding design, and (3) friction damper and impact rubber bumper design. The performance-based design procedures for wind and earthquake mitigation are under development.

The project has provided support for two Ph.D. students and two M.S. students (one of each at both Lehigh and Iowa State), who have gained valuable experience in earthquake engineering, blast engineering, and wind engineering for buildings. Five undergraduate students have been involved with the project at Iowa State, focusing on the use of 3D printing technology to create energy mitigation devices. Lehigh also hosted an REU student in Summer 2017 from the California State University at Fullerton who conducted blast-resistant design of the cladding prototypes that will be used in upcoming phases of the project.

Collaborative Research: SemiActive Controlled Cladding Panels for Multi-Hazard Resilient Buildings. CMMI 1463497 – PI James Ricles, Lehigh University; co-PI Spencer Quiel, Lehigh University.

Collaborative Research: SemiActive Controlled Cladding Panels for Multi-Hazard Resilient Buildings. CMMI 1463252 – PI Simon Laflamme, Iowa State University.

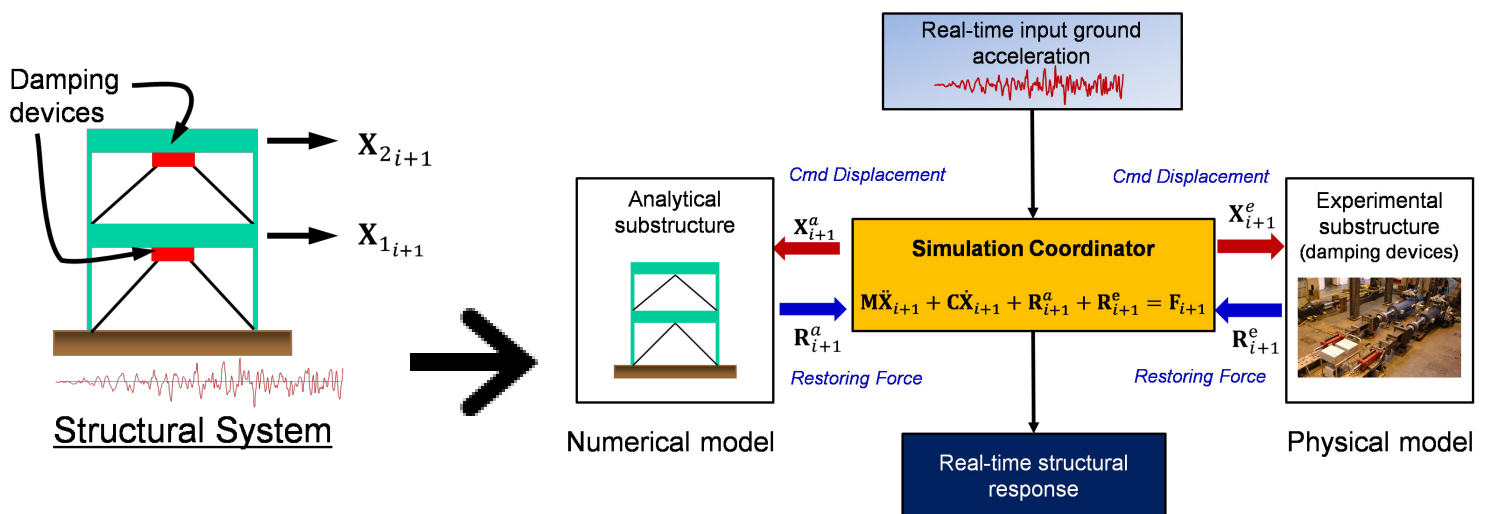


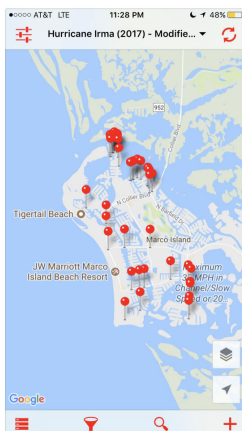
Figure 3 – Framework for real-time hybrid simulation as implemented at Lehigh’s ATLSS Laboratory.

Hurricane Season 2017: Coordinated Reconnaissance Effort

Continued from page 3

In response to this event, the regional reconnaissance nodes at three local universities deployed teams to Florida's Gulf Coast, Atlantic Coast and the Keys/Miami in the first wave of rapid reconnaissance from September 15-20. A second, more exhaustive campaign was then conducted in the Florida Keys on September 22-25. These investigations employed primarily door-to-door damage assessments using the Fulcrum App. At select locations, UAS generated additional aerial imagery, 3D point clouds and 3D textured meshes.

The Irma field teams were led by Jean-Paul Pinelli (FIT), Ioannis Zisis (FIU), and Kurt Gurley (UF).



Fulcrum App visualization of records acquired on Marco Island (Daniel Smith)

Observations from Puerto Rico and the Virgin Islands after Maria

Hurricane Maria has been termed the worst natural disaster on record in Dominica and Puerto Rico, as the third consecutive major hurricane to threaten the Leeward Islands in a two-week period. The storm caused catastrophic damage and numerous fatalities across the northeastern Caribbean, before making its landfall on September 20 near Yabucoa, Puerto Rico, as a strong Category 4 hurricane. A regional node was established to organize local reconnaissance efforts between October 6 and November 18, with a separate reconnaissance campaign for the U.S. Virgin Islands on November 9-14, connecting briefly with the team in Puerto Rico.

Investigations on all four islands employed primarily door-to-door damage assessments using the Fulcrum App. At select locations, additional UAS aerial imagery and 3D point clouds were acquired. The U.S. Virgin Islands campaign also included an extensive coastal survey to document surge and wave levels, impacts to coastal infrastructure and sediment transport in St. Thomas and St. Croix, working collaboratively with a team from the Japanese Society of Civil Engineers.

The Maria field teams were led by Daniel Cox (OSU), David Prevatt (UF) and Luis D. Aponte-Bermudez (UPRM).

Turning data into knowledge

The datasets from all three missions are currently undergoing QA/QC and curation within DesignSafe, while members of the team continue their data analysis to characterize the hazards in these hurricanes, explore the geospatial distribution of observed damages, and assemble case studies that highlight common failure modes.

RAPID: Coordinated Structural Engineering Reconnaissance for 2017 Hurricane Irma. Award Abstract #1761461.

Collaborative Research: Geotechnical Extreme Events Reconnaissance (GEER) Association: Turning Disaster Into Knowledge. Award Abstract #1266418.

NHERI Means Business, Forms Technology Transfer Committee

Continued from page 1

“Typical technology implementers, such as codes and standards committees or professional organizations, in general do not have systematic programs to follow research results from NSF awards — as a result, practical insights from such research can be missed,” Holmes says.

Tech Transfer Committee members were nominated by the NCO Strategic Committee and approved by the NHERI Council. The committee consists of nineteen volunteers. An executive sub-committee was formed consisting of the committee chair and a representative of each interest group: earthquake, tsunami/storm surge, wind and geotechnical.

The first meeting of the Tech Transfer Executive Committee took place on January 24, 2018, at which time ongoing NHERI research awards were assigned to the appropriate interest groups and subsequently distributed to the committee members for familiarization; reviews will be ongoing and completed near the end of each award.

The process of transferring research to practice is a long-term endeavor. Holmes expects the committee will contact project PIs once it is clear that results from the research can be implemented quickly.

In the meantime, PIs are welcome to contact the Tech Transfer committee, which is composed of members well-versed in design practice, codes and standards.

NCO UPDATE: A YEAR IN REVIEW FROM THE NHERI COUNCIL



*Julio Ramirez
Director, NHERI
NCO*

Each year the NHERI Council, composed of representatives from all awardee facilities, respectfully submits to the community a report on the state of NHERI. The report includes a review of the governance groups, highlights of the major program activities of the year, and a look at priorities for the upcoming program year.

Please take a moment to visit the DesignSafe site and read the NHERI Year 1 Council report, released March 1, 2018.

Questions about NCO activities? Send us a note.

Interest Surges in NHERI REU Program

When it comes to education, the National Science Foundation provides outstanding opportunities to college-level engineers with its Research Experiences for Undergraduates, or REU, program.

The NHERI REU is particularly attractive because it provides hands-on summer internships at 10 experimental facilities (EFs) — at top-tier universities across the nation.

This year, over 100 undergraduates applied for 30 REU positions.

NHERI's REU coordinator, Dr. Karina Vielma, reports that the Education and Community Outreach Committee used data from last year's assessment to strategize this year's recruitment techniques. "Students in last year's cohort informed us that getting personal guidance from professors encouraged them to apply."

The ECO team contacted engineering faculty at the NHERI experimental facilities and asked them to urge students to apply, especially those who would most benefit from the experience. The team also used databases such as Pathways to Science to promote the application. They also promoted the program heavily on Facebook and Twitter.

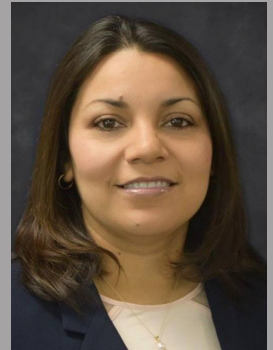
In addition, the team recruited undergraduates at minority-serving institutions with degree programs fitting the natural hazard engineering communities, and they continued to connect with civil engineering undergraduate programs throughout the U.S. — all of which helped the NHERI ECO reach their desired metric.

"For me, the most exciting part of the program is learning from last year's experiences and instituting improvements, such as including a structured mentoring curriculum for faculty and graduate student mentors — which will improve students' experiences."

Vielma says the biggest challenge is getting the word out and encouraging students to apply. "Many students from the 2017 cohort reported they did not believe it was possible to conduct research at a state of the art experimental site."

She says exciting events are in the works this summer, such as the group visit to Oregon State University on August 6-7, when students will tour the EF, present their research, and meet their peers working at other sites in person. Prior to this meeting, students meet weekly online using distance learning applications.

"This year, we will have three students at all 10 NHERI sites, and the RAPID facility at the University of Washington will be joining the REU program."



*Karina Vielma, EdD
NHERI Education and
Community Outreach
Research Fellow and
Education Specialist
University of Texas,
San Antonio
College of Engineering*



NHERI programs are funded by the National Science Foundation (NSF). The NHERI Quarterly Newsletter is prepared by the NHERI Network Coordination Office (NSF award #1612144). All official online NHERI content including monthly and quarterly publication issues are hosted by DesignSafe-CI which is supported by a grant from the NSF (award #1520817).