Natural Hazards Engineering Research Infrastructure

QUARTERLY NEWSLETTER
NEWS FROM THE NHERI COMMUNITY
DECEMBER 2017

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Coastal Reconnaissance, September 2017

In the wake of hurricanes Harvey and Irma, retinues of hazard researchers arrived on the scene to gather valuable, perishable data.

Among them were Nina Stark, assistant professor of civil and environmental engineering at Virginia Tech, and Stephanie Smallegan, assistant professor of civil, coastal and environmental engineering at Southern Alabama University. They sought to document the storms' geotechnical impacts in coastal zones and riverine environments, in particular those related to scour and erosion. Both participated in reconnaissance efforts of the [Geotechnical Extreme Events Reconnaissance] (GEER) association.

GEER is an NSF-funded volunteer organization comprised of geotechnical engineers, engineering geologists, and earth scientists from academia, industry, government organizations, and non-profit organizations. Volunteers respond to geotechnical extreme events, conduct detailed reconnaissance, and document their observations.

Stark led GEER reconnaissance teams in Texas and in Florida during the 2017 hurricane season.

"My research focuses on the geotechnical aspects of coastal and subaqueous erosion and sediment remobilization processes, as well as the geotechnical site characterization of coastal areas. So these reconnaissance missions were very much in line with my research interests," she says.

The teams were equipped with cameras, measuring tools, high resolution GPS devices, field penetrometers, a field vane shear, and an acoustic scour monitor.

Post-Harvey Texas. On September 2-5, Stark and her team covered a large area, from Corpus Christi to Galveston, including some sites west of Houston. Team members included Navid Jafari (LSU), Nadarajah Ravichandran (Clemson), Iman Shafii (Texas A&M) as well as Stephanie Smallegan (U South Alabama). The group was assisted at locations around

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Erosion at a beach house at Sombrero Beach, FL. GEER team members Inthuorn Sasanakul (University of South Carolina) and Luis Arboleda Monsalve (University of Central Florida) on the right. (Photo: Nina Stark)

RESEARCH

Coastal Reconnaissance

CONTINUED FROM PAGE 1

Galveston and Freeport by Patrick Bassal (WSP) and Jens Figlus (Texas A&M). Lee Wooten of GEI Consultants Inc. co-led the team.
“In the interest of people living in those regions, I was hoping to find minor geotechnical damages that do not pose significant risks and that could be fixed easily,” Stark says.

“We found some severe erosion that led to damage of infrastructure or risks to infrastructure. This included severe river-bank erosion and failure, scour, as well as beach erosion.” The team’s report is available on the GEER website.

Smallegan’s research focuses on morphological changes of sandy beaches, particularly on barrier islands and changes due to both ocean-side and bay-side hydrodynamics during hurricanes, and the interaction of coastal infrastructure with those processes.

Infilled scour holes at the San Luis Pass. (Photo: Stephanie Smallegan)

“In terms of those research interests,” she says, “I was expecting to find significant changes to the beaches, such as lowered dune heights, significant overwash fans, and scour or other signs of impact on the sediment transport from infrastructure — roadways, buildings and such.” She was looking for high water marks and clear evidence of surge damage to structures on both oceanfront and bay front buildings.

“Fortunately for the communities we visited, we found noteworthy changes to the beaches mostly in areas that were not residential, but in those areas, we observed road undercutting and we saw that very large volumes of sediment had been mobilized, creating “channels” on the beaches,” she says.

Post Irma Florida. From September 24-28, Stark’s second GEER-supported team covered another large area, from Cape Coral to Key West. The travelling team included Luis Arboleda (U Central Florida) and Inthuorn Sasanakul (U South Carolina). Nick Hudyma (U of North Florida) co-led the team. They were assisted by members of the U.S. Army Corps of Engineers and the city of Key West.

“Again, I was hoping to learn from what we may find, but not find too devastating impacts. We found severe erosion of beaches that required nourishment, failure of sea walls, undermining and erosion of streets, as well as severe sediment relocation events that led to houses being flooded with water and sand, and foundations being exposed,” she says. The team’s report is available at the GEER website.

DESIGNSAFE TOOLS

While collecting their data, Stark and her team used the Designsafe-CI data portal to store and share their findings.

“DesignSafe made access to all data easy for the entire team. We used Slack to provide updates to the interested community. I found this useful because we could quickly share information, in real-time, without writing a lot of emails to different people, or overwhelming someone’s account on a public social network — which may also reach the wrong audience.

Slack allows quick social-media type communication with interested researchers. We also used HazMapper, one of the DesignSafe software tools, to communicate our investigation sites.” HazMapper enables first responders to quickly identify, record, and share a common operational picture of a post-disaster scene.

Smallegan agrees: “HazMapper could be hugely beneficial if you could use it as an app, where you could pinpoint your location and tag photos. Or make a Slack post directly on the map. And, if the data uploaded in a HazMapper app could be automatically backed up or uploaded onto a user defined folder in DesignSafe-CI, that would be a huge time saver.”

GEER Team Harvey (from left): Iman Shafii (Texas A&M), Nadarajah Ravichandran (Clemson), Navid Jafari (Louisiana State), Nina Stark (Virginia Tech), and Stephanie Smallegan (Southern Alabama) in Rosenburg, TX. (Photo: Iman Shafii)

"Just having a place where we can all simultaneously upload data and build upon that platform by adding analyses and reports is an incredible tool," Smallegan adds.

FUTURE MISSIONS

Stark is eager to conduct more reconnaissance missions. "I am particularly looking forward to potentially using equipment from the NHERI RAPID facility," she says, "But I also envision using multiple NHERI facilities for related research projects and physical simulation."

For geotechnical and coastal engineers doing post-disaster reconnaissance, Stark and Smallegan both emphasize the importance of having a multidisciplinary perspective. "We need more cross-disciplinary communication and collaboration in our research communities. I think our recon missions were a very positive example for this," Smallegan says.

Smallegan also highlights the importance of leadership, and the ability to adapt to working with different groups to accomplish their mission. "Being one of the first groups in, we met one obstacle after another. Many things did not go as planned. However, largely due to Nina's leadership and having a very flexible functional group, our mission's effectiveness was not compromised," she says. "We just kept moving forward and quickly learned to expect and accept quick changes."

Disaster reconnaissance groups should be prepared to improvise, she says. Other tips from Smallegan include:

- Have a list of target locations to keep the team focused and efficient.
- Get to sites as soon as safely possible after the storm.
- Take as many measurements as possible.
- Be sure to get accurate pre-storm data, which is vital for valid analyses.

GEER Team Irma: Inthuorn Sasanakul (University of South Carolina), Luis Arboleda Monsalve (University of Central Florida) and Nina Stark (Virginia Tech) at the Southernmost Point in Key West, FL. (Photo: Nina Stark)

Tsunami Waves and Offshore Islands: Recent Experiments at Oregon State University Confirm Unexpected Amplification Effect

Field survey reports after recent tsunamis suggest that local residents in mainland areas believe that nearby islands protect them from tsunami waves. Alarmingly, results from recent “active learning” numerical studies suggest just the opposite: in most cases, offshore islands actually amplify tsunamis in the shadow zones behind them.

Experimental setup for water depth of 0.5m. Full conical island installed in basin. Vertical structures are wave gauges mounted to the aluminum bridge spanning the basin.

Professor Jim Kaihatu of Texas A&M University is leading a project to discover if this amplification effect is real, given that the active learning methodology requires about 100,000 times fewer computations than conventional mathematical approaches. In the summers of 2016 and 2017, Kaihatu and his team studied the physical manifestation of this effect during comprehensive wave tank testing at the O.H. Hinsdale Wave Research Laboratory, a NHERI experimental facility.

On this effort, Kaihatu worked in tandem with a University of Southern California research team, led by Costas Synolakis and Patrick Lynett.

EXPERIMENT SETUP

For the tests, a series of four sheet metal islands were constructed to represent the offshore islands impacted by tsunamis. All islands had a diameter of 2m at the waterline. One set of islands was configured for a 0.5m water depth, while the other was for a 0.3m water depth. The islands were conical; for each set of two islands for the same water depth, the island was either fully conical (representing an emergent island) or truncated at the water line (representing a low-lying reef-like structure).

Each island was placed along a line centered in the wave tank. Behind the island was a 1:10 sloping metal beach, on which inundation levels were measured. Each island was placed in three positions: one abutting the toe of the beach slope (referred to as “1D case”); one located one island diameter away from the toe of the slope (“2D case”); and then one placed two island diameters away from the beach toe (“3D case”).

WAVE TESTS

In these tests, two representations of tsunamis were generated in the Directional Wave Basin at the Hinsdale Laboratory.

One was a solitary wave, which is a classical representation of a propagating tsunami. It was desired to run solitary waves whose lengths were integer multiples of the island diameter at the water line; this allowed the scaling of the solitary wave lengths with the island geometry, as well as varying the wave height. Another was a “full stroke” wave, in which the wavemaker traversed the maximum paddle displacement distance over a given time.

The resulting wave is considered to be a proxy for a tsunami front at landfall, with higher waves possible with shorter times associated with the full stroke.

Measurements consisted of wave gauges mounted on the bridge spanning the wave tank; acoustic Doppler velocimeters (ADVs) mounted on metal frames close to the beach and behind the island; and ultrasonic gauges mounted on the beach behind the island to measure depth of the inundation.

In addition, one ADV was mounted in the lee of the island at all positions, as numerical model results have shown high velocities in this location. Furthermore, video cameras mounted on the bridge were used to measure the level of inundation of the beach caused by tsunami waves. As the inundation levels were of primary interest, these were the focus of the initial preliminary analysis.

Figure 1 shows the level of inundation (measured as vertical distance from the mean water surface) for three different locations of the larger, fullcone island during a specific solitary wave condition. While the inundation levels appear to show some amplification for all island locations, they appear to be most pronounced for the case where the island was closest to the beach (the 1D case).

However, the majority of cases — for both the solitary waves and full stroke waves — did not exhibit any wave breaking until the wave propagated past the island and reached the shoreline. One exception was for the case of the fastest full wavemaker stroke; in this case the wave broke prior to encountering the island. This result is shown in Figure 2. In this case, the maximum inundation occurs when the island is furthest away from the beach.

However, in all cases, the inundation is amplified, not reduced, on the beach in the lee of an offshore island. In other words, the physical experiments performed by Kaihatu and his team confirm the numerical idealizations of the active learning tests. This research will help save lives by better targeting educational campaigns to at-risk populations. For example, it will be determined if coastlines shadowed by offshore islands along the Pacific Coast of the U.S. are more vulnerable than earlier believed.

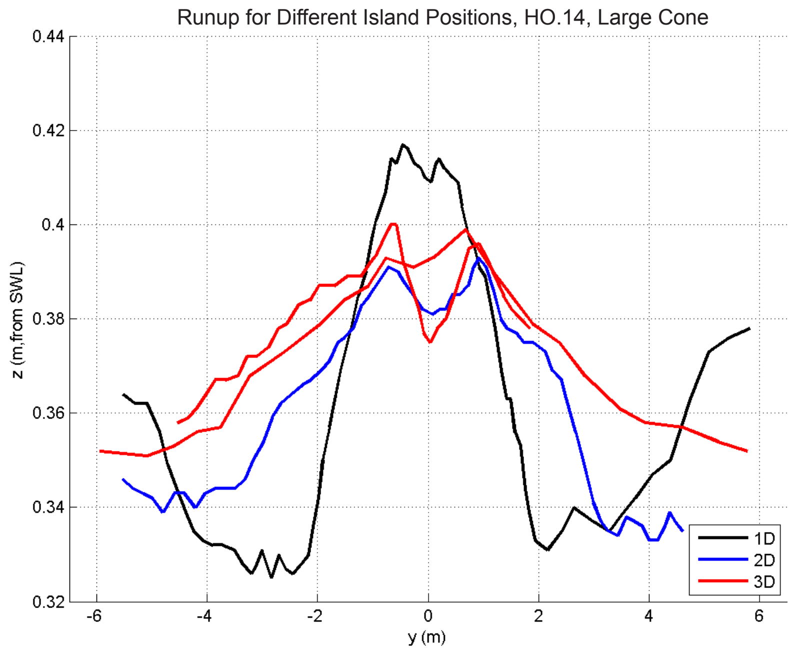


Figure 1. Maximum beach inundation elevation (measured vertically from the mean water surface) for cases where nonbreaking waves impact the island; here a solitary wave with a height of 0.14 m is impacting a full conical island in a water depth of 0.5 m. The location y=0 is directly behind the offshore island. Colors indicate the island distance from the toe of the beach; multiple lines of the same color indicate additional runs of this wave condition.

ASSESSMENT OF ACTIVE LEARNING

The results will help validate active learning as a mathematical procedure for uncertainty reduction at greatly reduced computational cost. The validation will help determine the parameters in the phenomena (island configuration/distance, wave type and height) which appear to have the greatest influence on inundation, and as such should help increase the certainty and optimization of these active learning algorithms.

Also, the team is developing a substantial laboratory data set that will be developed to help benchmark numerical computations for interacting breaking wave fronts, under conditions as yet unstudied. The data sets for the 2016 experiment are presently uploaded to DesignSafe; the 2017 experimental results will be uploaded soon.

An outreach campaign is planned to educate populations at risk and improve the awareness of emergency managers on this unusual amplification phenomenon.

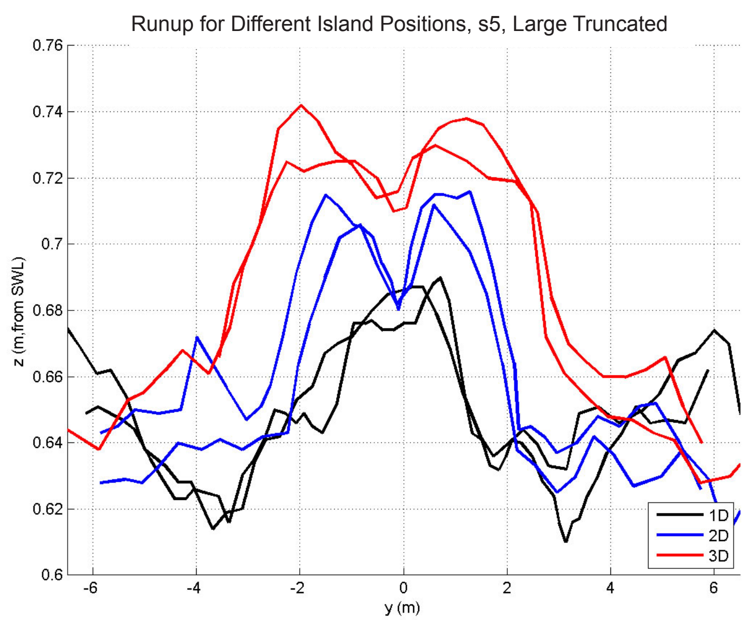


Figure 2. Maximum beach inundation elevation (measured vertically from the mean water surface) for cases where breaking waves impact the island; here a full-stroke wave with a stroke time of 5 seconds is impacting a full conical island in a water depth of 0.5 m. The location y=0 is directly behind the offshore island. Colors indicate the island distance from the toe of the beach; multiple lines of the same color indicate additional runs of this wave condition.

ADDITIONAL UNDERSTANDING

The early numerical results from active learning are only applicable for non-breaking waves. While many existing numerical codes attempt to model mild long-wave breaking, as they sometimes do, it is unclear how well they perform when scattered long waves break and interact. The present experiments suggest that the trends between high levels of inundation, and island distance from shore, during breaking wave cases are opposite of those for nonbreaking waves.

It is equally unclear if the isthmus between islands scatters the wave energy or focuses further in the mainland behind them, or under what geographical conditions either effect prevails. Experiments performed during the summer of 2017 at the same facility were designed to investigate this, and the results are presently being analyzed.

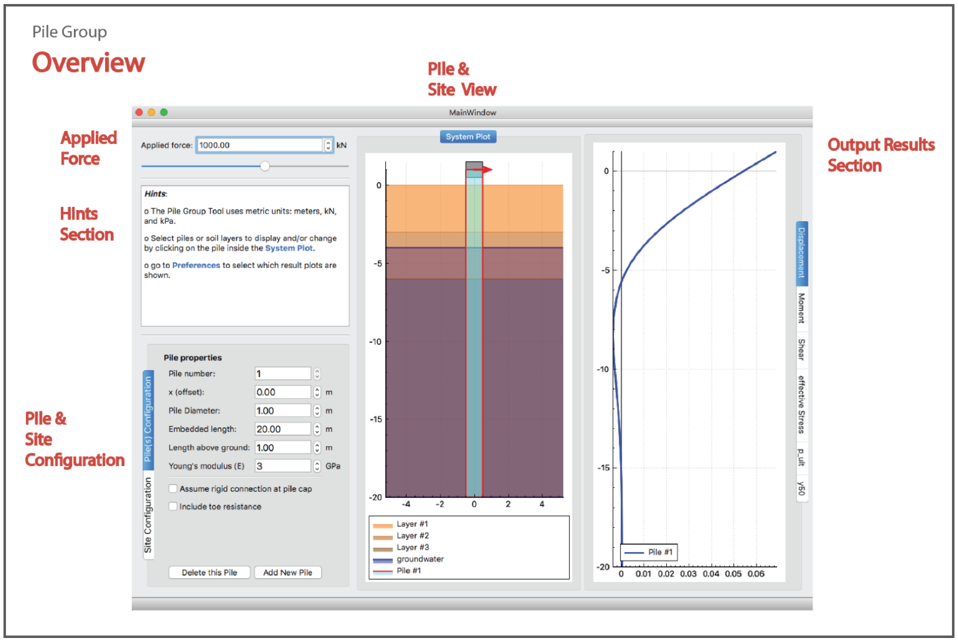
Award #1538190. Collaborative Research: Nonlinear Long Wave Amplification in the Shadow Zone of Offshore Islands, PI James Kaihatu. In collaboration with Award #1538624, Principal investigator Costas Synolakis, University of Southern California.

FACILITIES

SimCenter Releases Two New Learning Tools: Multiple-Degrees-of-Freedom Application and Pile-Group Application

The NHERI SimCenter announces the release of two new learning applications for structural and geotechnical engineering.

The Multiple-Degrees-of-Freedom (MDOF) Application is a structural dynamics tool for educational purposes, and the Pile-Group Application is for geotechnical engineering applications.



The Multiple-Degrees-of-Freedom (MDOF) Application provides a dynamic interface to study the behavior of a stick-model building subjected to earthquake excitation. Intended users are students, researchers, and practicing engineers interested in exploring the fundamentals of structural dynamics through a hands-on, graphical tool. Users can interactively observe the building's time history response to changes in the following:

- Floor weights
- Story properties
- Damping ratio
- Ground motion acceleration records (included).

Response results include:

- Time history response: floor displacements, story forces
- Nonlinear effects due to P-delta and soft-story mechanisms.

The Pile-Group Application provides a dynamic interface to study the behavior of a pile or pile group in layered soil. Intended users are graduate students, researchers, and practicing engineers interested in soil–pile dynamics. Users can interactively observe the pile system's response to changes in the following:

- Soil structure (up to 3 layers of variable thickness) and soil properties.
- Position of the ground water table.
- Pile stiffness, embedment length, connection type to the pile cap.
- Number of piles in the group (one to three piles).
- The applied horizontal force at the pile cap (pushover analysis).

Response results include:

- Lateral displacement of all piles.
- Moment and shear diagrams for each.
- Vertical soil stresses.
- Ultimate strength and stiffness parameters for the employed p-y springs.

The MDOF Application and video introduction can be downloaded from the SimCenter Learning Tool site at simcenter.designsafe-ci.org/learning-tools/multiple-degrees-freedom-application.

The Pile-Group Application and video introduction can be downloaded from the SimCenter Learning Tool site at simcenter.designsafe-ci.org/learning-tools/pile-group-application. PC and Mac versions for both applications are available.

The NHERI Computational Modeling and Simulation Center (SimCenter) provides researchers access to next-generation computational modeling and simulation software tools, user support, and educational materials needed to advance the capability to simulate the impact of natural hazards on structures, lifelines, and communities.

The SimCenter's cyberinfrastructure framework will allow collaborative simulations from various disciplines to be integrated, while accounting for probabilistic uncertainties.

More information about the NHERI SimCenter can be found at simcenter.designsafe-ci.org.

NHERI COMMUNITY

SimCenter Welcomes Dr. Wael Elhaddad to the Development Team

The NHERI SimCenter is pleased to announce that Wael Elhaddad, PhD, has joined the development team.

Dr. Elhaddad is an experienced software engineer formerly with the analytical modeling group in Bentley Systems, a software development company that provides software tools to facilitate the design and management of civil infrastructure.

He graduated from the University of Southern California with a PhD in structural engineering, where his main research focus was on nonlinear structural dynamics, structural control, and finite-element model updating.

His research in graduate school was inherently multidisciplinary, encompassing structural mechanics, scientific computing and high-performance computing.

This multidisciplinary approach has been extended in his career as a software engineer, where he has experience in cloud computing, machine learning, and efficient database management.

His combined experiences in academia and industry make him a valuable addition to the SimCenter development team.

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EDUCATION CORNER

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

Educating Hazard Engineers, Current and Future

Preparations for the 2018 NHERI REU program are underway. The application and instructions are available on the DesignSafe website. Already, undergraduates are applying for a chance to conduct hands-on research at NHERI's experimental facilities.

NHERI researchers: please help us recruit a strong cohort of REU students. Share information about this tremendous opportunity in your undergraduate courses and with students who would benefit from obtaining research experience. Download our flyer and spread the word!

The curriculum for NHERI's second annual Summer Institute is also taking shape. The 2018 event takes place June 4-6 at the downtown campus of the University of Texas at San Antonio.

Please help us spread the word to early career faculty, grad students, and engineering professionals interested in learning more about using NHERI network resources in their research grant proposals. The deadline to apply for a travel stipend is Feb. 15, 2018.

Questions about these or other Education and Community Outreach activities? Send us an email.

RESEARCH

NHERI Grants, Quarter 3

Award dates July-Sept. 2017

OREGON STATE UNIVERSITY

Collaborative Research: Wave, Surge, and Tsunami Overland Hazard, Loading and Structural Response for Developed Shorelines. Award #1661015. Principal investigators, Andrew Kennedy, Notre Dame University. Co-PIs: Pat Lynett, University of Southern California; R. Gahnem, University of Southern California; Andre Barbosa, Oregon State University; Dan Cox, Oregon State University. NSF organization: CMMI. Start date: Aug. 1, 2017. Award amount: $228,222.

Vertical Evacuation Structures Subjected to Sequential Earthquake and Tsunami Loadings. Award #1726326. Principal and co-principal investigators: Dawn Lehman, Pedro Arduino, Michael Motley, Charles Roeder. Academic organization: University of Washington. NSF organization: CMMI. Start date: July 15, 2017. Award amount: $1,007,491.

Transient Rip Current Dynamics: Laboratory Measurements and Modeling of Surfzone Vorticity. Award #1735460. Principal and co-principal investigators: Nirnimesh Kumar, Melissa Moulton. Academic organization: University of Washington. NSF organization: OCE Division of Ocean Sciences. Start date: Sept. 15, 2017. Award amount: $716,960.

FLORIDA INTERNATIONAL UNIVERSITY

Model to Full-Scale Validation of Peak Pressure Mechanisms in Buildings that Cause Cladding Failures and Windstorm Damage. Award #1727401. Principal investigator Chris Letchford, Rensselaer Polytechnic Institute. NSF Organization: CMMI. Start Date: Aug. 1, 2017. Award amount: $371,753.

UNIVERSITY OF TEXAS, AUSTIN

Collaborative Research: Bridging the In-situ and Elemental Cyclic Response of Transitional Soils. Award #CMMI-1663654. Principal investigator Armin Studlein, Oregon State University. NSF Organization: CMMI. Start date July 1, 2017. Award amount: $634,391.

Collaborative Research: Bridging the In-situ and Elemental Cyclic Response of Transitional Soils. Award #1663531. Principal investigator Kenneth H. Stokoe II, University of Texas at Austin. NSF Organization: CMMI. Start date: July 1, 2017. Award amount: $474,892.

LEHIGH UNIVERSITY

Collaborative Research: Shear-Buckling Mechanics for Enhanced Performance of Thin Plates. Award #1662886. Principal investigator: Maria Garlock, Princeton University. NSF Organization: CMMI. Start Date: July 1, 2017. Award amount: $366,137.

Collaborative Research: Shear-Buckling Mechanics for Enhanced Performance of Thin Plates. Award #1662964. Principal investigator Spencer Quiel, Lehigh University. NSF Organization: CMMI. Start Date: July 1, 2017. Award amount: $352,483.

Advancing Knowledge on the Performance of Seismic Collectors in Steel Building Structures. Award #1662816. Principal investigator Robert Fleischman, University of Arizona. Co PIs: Chia-Ming Uang (University of California-San Diego), James Ricles (Lehigh University), Richard Sause (Lehigh University). NSF Organization: CMMI. Start Date: Aug. 1, 2017. Award amount: $797,965.

UNIVERSITY OF CALIFORNIA, DAVIS

Collaborative Research: Novel Measurement of Shear Strength Evolution in Liquefied Soil and Calibration of a Fluid Dynamics-based Constitutive Model for Flow Liquefaction. Award #1728199. Principal investigator: Scott Olson, University of Illinois at Urbana-Champaign. NSF Organization: CMMI. Start date: Sept. 1, 2017. Award amount: $304,845.

Collaborative Research: Novel Measurement of Shear Strength Evolution in Liquefied Soil and Calibration of a Fluid Dynamics-based Constitutive Model for Flow Liquefaction. Award #1728172. Principal investigator: Mandar Dewoolkar; Co PI: Darren Hitt. Academic organization: University of Vermont & State Agricultural College. NSF Organization: CMMI. Start date: Sept. 1, 2017. Award amount: $377,339.

CONFERENCES

Dec 11-15. 2017 **American Geophysical Union Fall Meeting**, New Orleans, LA

Jan 23-26. **World of Concrete**, Las Vegas, NV

Feb 14-16. 1**st International Conference on Infrastructure Resilience**, Zurich, Switzerland

March 22-23. **20th International Conference on Wind Engineering**, Prague, Czechoslovakia

June 4-6. **NHERI Summer Institute**, San Antonio, Texas.

Jun 10-13. **5th Geotechnical Earthquake Engineering and Soil Dynamics Conference**, Austin, TX

June 18-21. **16th Conference on Earthquake Engineering**, Thessaloniki, Greece

June 18-22. **International Symposium on Computational Wind Engineering (CWE 2018)**, Seoul, South Korea

June 25-29. **11th National Conference on Earthquake Engineering**, Los Angeles, CA

July 30-Aug. 3. **36th International Conference on Coastal Engineering 2018**, Baltimore, MD

UPDATE FROM THE NHERI NCO

Forging International Partnerships With Japan, Taiwan

Julio Ramirez

International partnerships connect NHERI to complementary research efforts underway across the globe.

That is why the NHERI Network Coordinating Office (NCO) has renewed earthquake engineering research collaborations between the U.S. and Japan and established new ones between the U.S. and Taiwan.

The NHERI NCO and Japan's National Research Institute for Earth Science and Disaster Resilience, NIED, reached a formal agreement last summer. (See details here.)

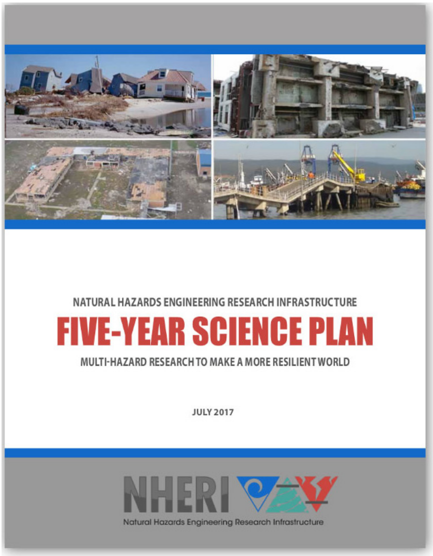
The first annual meeting of NHERI and NIED took place Oct. 31-Nov. 1 in Tokyo. It was a great success. The preliminary draft of the final report will be posted on the DesignSafe-CI website. It will enable researchers to become informed on potential topics of collaboration, possible research proposal topics and the process of establishing collaboration with the lead researchers of the Tokyo Metropolitan Resilience Project, which serves as the basis for the collaboration using NHERI and E-Defense facilities.

More than 20 researchers attended the meeting where a variety of possible research topics were discussed under the themes of wood, steel plus protective systems, reinforced concrete and non-structural components.

Our partners in Japan are led by Prof. Akira Nishitani from Waseda University and Dr. Koji Kajiwara from E-defense. Ultimately, the NHERI-NIED/E-Defense relationship will inform the global vision of earthquake, wind, and coastal inundation risk mitigation and leverage the experimental facilities in the U.S. and Japan.

Please be sure to check the NHERI-NEID partnership page in the first week of December for a report on this collaboration.

Questions about NCO activities? Send us a note.



The **NHERI SCIENCE PLAN** serves as a roadmap to guide future hazard engineering research and ensure that researchers in related disciplines work together to achieve common research goals — all aimed at keeping the civil infrastructure, and its human inhabitants, safe.

Hazard researchers preparing grant proposals to NSF are urged to consider tenets of the Science Plan when developing their proposals.

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).