NHERI
Natural Hazards Engineering Research Infrastructure

QUARTERLY NEWSLETTER
NEWS FROM THE NHERI COMMUNITY
JULY 2017

CONFERENCES

August 1, 2017
Multi-Axial Subassemblage Testing Laboratory (MAST) Training
Category: Webinar Online session
Sponsored by: U Minnesota (umn.edu)

August 3-4, 2017
Structural Testing Workshop with UTexas and T-Rex
Sponsored by: Rutgers University (rutgers.edu) and University of Texas (utexas.edu)
New Brunswick, New Jersey

September 5-7, 2017
EVAN Conference: Advances in Extreme Value Analysis and Application to Natural Hazards
Sponsored by: National Oceanography Centre (noc.ac.uk), Southampton, UK

October 2-3, 2017
Retirement Symposium: Celebrating the Career of Anil K. Chopra
Berkeley, California
Sponsored by: University of California, Berkeley, Civil and Environmental Engineering (ce.berkeley.edu)

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www.facebook.com/NationalHazardsEngineeringResearch Infrastructure

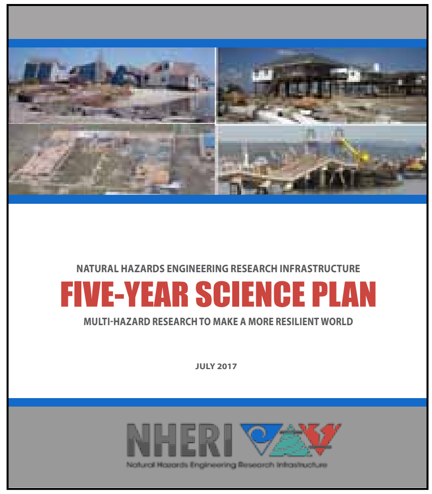
INSIDE THIS ISSUE

NHERI Five-Year Science Plan Published July 2017

One of the NHERI NCO's fundamental responsibilities is to oversee the development of a formal Science Plan. The NHERI Science Plan serves as a roadmap to guide future research and help 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.

The plan is designed to be read by all hazard community stakeholders and researchers — including faculty, staff, students, practitioners and policy-makers. Researchers preparing grant proposals to NSF are urged to consider tenets of the plan when developing their proposals.

The Science Plan describes Grand Challenges, Key Research Questions and examples of needed research. Appendices describe the NHERI experimental facilities and examples of research that can be conducted at each. The appendix incorporates descriptions of the CyberInfrastructure and SimCenter, as well.



The plan, now available on the DesignSafe website, was developed by members of the NHERI Science Plan Task Group. Input was provided by community during a public comment period. A living document, the plan will be assessed and periodically updated.

REU students at the NHERI at UC San Diego facility are part of the LHPOST shake table test aiming to develop a seismic design methodology for tall wooden structures. Find details and video on the project: http://nheri.ucsd.edu/projects/current.shtml

Update from the NHERI NCO

Julio Ramirez

JoAnn Browning

The NCO team continues to actively engage in building community, coordinating the other NHERI facilities, and leading network-wide education and community outreach efforts.

The activation of the NHERI Governance consisting of the Council, User Forum and the Network Independent Advisory Committee (NIAC) is complete. Find minutes and reports on group activities on the NHERI/DesignSafe site. Especially exciting is the first-annual user survey, which was conducted by the User Forum in June. Results will be reported shortly. The Annual Community Council Report will be out sometime next month, too.

Also in the past quarter, researchers throughout the network participated in the 13th Americas Conference on Wind Engineering, hosted by the University of Florida EF.

We also initiated the first cohort of students in NHERI's Research Experiences for Undergraduates program. The REU students are now gaining hands-on experience at our experimental sites.

We we pleased to host a number of the NHERI community at the 1st Annual Summer Institute, being held at the University of Texas at San Antonio, July 24-28, 2017.

Keep an eye open for the NHERI podcasts that will begin this fall. The NCO is creating this program to share insights into natural hazards engineering with a broad range of our community. We are growing our presence on social media, as well, more than doubling our Facebook following last month. If you have not done so already, like NHERI on Facebook and Twitter to get the latest updates on NHERI research and education. It's fun, too!

On July 13 and 14 a delegation of the NHERI community met in Tokyo at the Kabori Research Complex with the leadership of the Tokyo Metropolitan Resilience Project and NIED/E-Defense to begin planning the research collaboration under the Letter of Agreement between NHERI and Japan's National Research Institute for Earth Science and Disaster Resilience on earthquake engineering research using E-Defense and NHERI Facilities. The agreement was signed of July 13. E-Defense is the largest multi-degree shake table in the world. Please stay tuned to the NHERI website for more information in how to participate in this important collaboration.

In addition, we are pleased to remind you that the 5-Year NHERI Science Plan — developed with the leadership of the NCO, a Task Group of the NCO, and broad community representation — is now available on the NHERI/DesignSafe website. This living document outlines the most challenging hazard engineering questions according to NHERI experts and will guide our research community to propose programs for solving these challenges.

EDUCATION CORNER

Karina Vielma
NHERI Education and Community Outreach (ECO), Research Fellow and Educational Specialist, University of Texas, San Antonio

Over the past five months, the Education and Community Outreach (ECO) Committee planned and welcomed undergraduate students to the Natural Hazards Engineering Research Infrastructure's (NHERI's) first Research Experiences for Undergraduates (REU) Summer Program.

In June, 17 REU students enthusiastically started their research projects and are currently at nine equipment facilities across the country. Through mentorship and guidance from faculty and graduate students, they are engaging in a wide range of natural hazards work from liquefaction studies to data reconnaissance to experimental wind tests on home models.

REU students are also preparing a lesson plan to engage K-12 students in learning about their research area. They will present their research projects and lesson plans during the first week of August. Stay tuned to the Announce email list for details!

In addition, the ECO Committee has been hard at work planning a useful program for early career faculty, K-12 teachers, graduate students, members of the NHERI leadership groups, and all those interested in learning about natural hazards engineering. The inaugural Summer Institute took place on the campus of the University of Texas, San Antonio, July 24-28.

Attendees learned about the NHERI equipment facilities and ways to use them for their research work. Participants networked with engineers across natural hazards communities including wind, tsunami, earthquake, and coastal engineering along with data simulation, cyber infrastructure, and the rapid response team.

NHERI COMMUNITY

The Importance of Data Publishing

Q&A with Ellen Rathje, Director of DesignSafe

Q: What is data publishing?

A: Publishing data involves the formal publishing of data, in the same way that journal papers are formally published. The key to data publishing is providing electronic, open-access to the data, as well as a permanent Digital Object Identifier (DOI) that can be used to locate and cite the data in the future.

Q: How can NHERI and DesignSafe help me publish high-quality and discoverable data?

A: DesignSafe is the cyberinfrastructure for NHERI and provides formal data publishing through its data repository, called the Data Depot. The Data Depot includes a private My Data space, a collaborative My Projects space, along with the publicly available Published space. To publish your data, you first create a Project, upload your data, and provide information about the project (e.g., authors) and data (e.g., sensor locations). After meeting the minimum metadata requirements as described in the DesignSafe Curation Guidelines, you can publish your dataset to the publicly accessible Published space. The DOI and appropriate citation language to use when referencing the data is automatically provided with the publicly available dataset.

Q: How can I make sure people know about my published data?

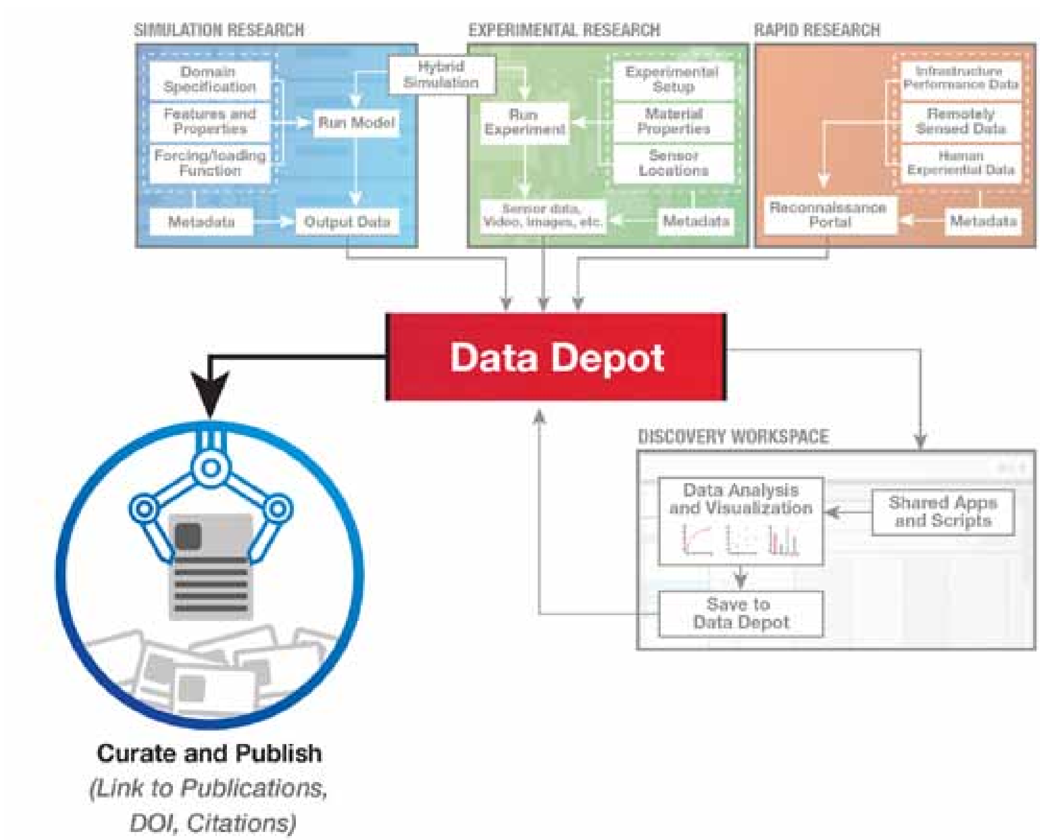
A: As with all information, marketing is key, and there are multiple strategies for promoting data papers.

- Researchers should include published datasets within the publications section of their CV.
- Researchers should formally cite data within the references section of their journal papers, using the formal citation language and DOI.
- Announce your data paper on the experimental facility website, in the NHERI community news page, on your Slack channels, or any other public forum your colleagues may visit.

You can also publish a data paper within a journal. The goal of a data papers is to promote useful data sets by describing both the collection of the datasets and their potential use to the research community. Interpretation and analysis of the data generally is not within the scope of a data paper. Some journals have a specific manuscript type for a data paper, such as EERI's Earthquake Spectra. For other journals, you may need to contact the editor to discuss how to submit a data paper.

Q: How can I find data for re-use in my research?

A: The DesignSafe Data Depot includes a simple search interface that allows you to search for data using keywords, authors, etc. The Published section of the Data Depot includes data from NSF-funded ENH projects, data from the NSF-funded NEES program, as well as data published from non-NSF projects. The search interface can help you find relevant data for your research. These data can be downloaded for analysis on your desktop or copied to your My Data space or My Projects space for use with the cloud-based DesignSafe tools. Visit www.designsafe-ci.org to learn more about the DesignSafe functionalities and its vision for natural hazards research.



RESEARCH WORKBENCH

Project Aims to Revolutionize Design in Wind Engineering

Combined Cyber-Physical Optimization Approach Will Speed Up the Design Process for Wind Engineers

Researchers at the University of Maryland and University of Florida are collaborating on a project to develop a cyber-physical systems approach to optimal design in wind engineering. The principal investigator on the project is Brian Phillips, assistant professor of Civil and Environmental Engineering at the University of Maryland.

"Cyber-physical systems link the real world to the cyber world, using digital computers to monitor and control physical attributes in real time," Phillips explains. "This application of cyber-physical systems combines the accuracy of physical wind-tunnel testing with the ability to efficiently explore design alternatives using numerical optimization algorithms." Through actuation, he says, the specimen in the wind tunnel morphs to create candidate designs. Because the specimen (model) is undergoing physical changes as it approaches the optimal solution, this approach is referred to as "loop-in-the-model" testing.

PIONEERING WORK

"Traditional trial-and-error design approaches are inefficient. They require extensive iterations between architects and structural engineers," Phillips says. "Our pioneering work will combine wind tunnel testing with computer-augmented design to produce optimal structural designs faster and with greater confidence than purely experimental or purely computational methods."

The research team has designed an objective and fully automated approach for the boundary-layer wind tunnel (BLWT) at the University of Florida's NSF-sponsored Natural Hazard Engineering Research Infrastructure (NHERI) Experimental Facility. Cyber-infrastructure, including a high-performance computer (HPC), was added to a traditional wind tunnel to coordinate turntable control, specimen actuation, data acquisition, data analysis, and the execution of scripted optimization algorithms.

Anticipated outcomes include:

- The combination of accurate experimental testing and numerically driven optimization for wind engineering.

Continued on next page

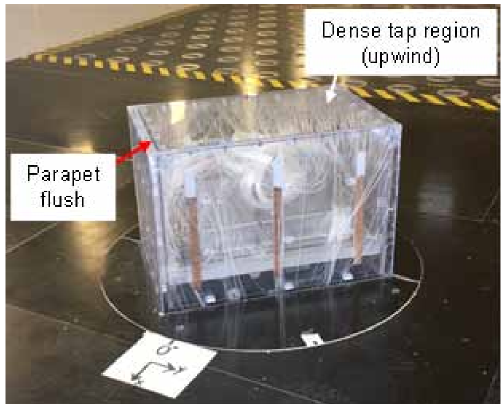
University of Florida wind engineering class visits with researchers in the boundary-layer wind tunnel (BLWT).

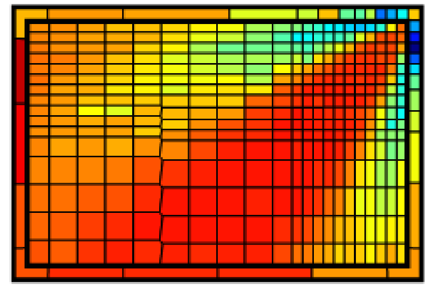
- The advancement of optimization in a practical engineering setting.
- The discovery of new design and detailing features to achieve cost-effective structures under wind loads.

A low-rise building model with a parapet wall of variable height was created as a proof-of-concept for the optimization approach. "The sharp edges on bluff bodies, in particular the windward roof edges on low-rise structures, cause a separation of the boundary layer and generate vortex flow with large suction loads," Phillips explains.

Parapet walls reduce these suction loads, preventing roof gravel and other loose material from becoming wind-borne debris that can damage a building's envelope and lead to wind and rain intrusion. In the wind tunnel, the parapet height of a building model is adjusted using servo-motors to create and evaluate candidate designs guided by heuristic search algorithms. The objective is to mitigate extreme roof pressures.

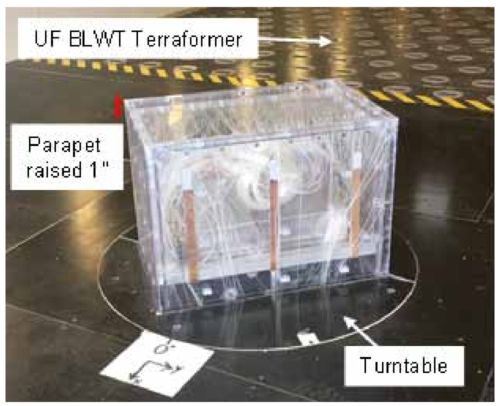
This proof-of-concept, completed in February 2017, was the first cyber-physical optimal design in wind engineering.

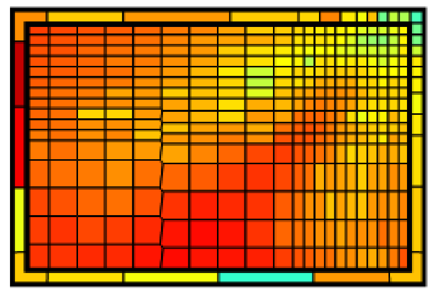




Roof suction
blue = high suction; red = low suction

BLWT model with no parapet wall, 45° approach wind angle, and a qualitative distribution of extreme roof suction.





Roof suction
blue = high suction; red = low suction

BLWT model with a 1 inch parapet wall, 45° approach wind angle, and a qualitative distribution of extreme roof suction.

ONGOING EXPERIMENTS

Currently, the team is preparing a series of tests to optimize the structural members carrying the wind load on the low-rise building model with adjustable parapet. Envelope wind pressures measured in the wind tunnel will be used as input to a finite element model of the structure.

The goal is to minimize user-specified objectives (e.g., material use) while ensuring strength and serviceability requirements constraints are met (e.g., code requirements for drift and acceleration).

NEXT STEPS

The next phase of the project involves the consideration of aeroelastic models with multiple design variables. Aeroelastic models enable accurate physical modeling of fluid-structure interaction, useful when buildings dynamically respond to wind action (e.g., slender high-rise buildings, long-span bridges). The benefits of a cyber-physical approach to design will be clearly shown for a structure where the optimal solution may not be obvious and cannot be determined with traditional experimental or computational methods.

This project is funded by NSF award #1636039, and it leverages the BLWT and HPC resources of the University of Florida NHERI site, supported by NSF award #1520843. Co-PI is Forrest Masters, professor and associate dean for Research and Facilities at the Herbert Wertheim College of Engineering, University of Florida.

Brian Phillips is assistant professor of Civil and Environmental Engineering at the University of Maryland: http://www.phillips.umd.edu/images/phillips.jpg

RESEARCH WORKBENCH

Design Guidelines for Roof Pavers Against Wind Uplift

Results from WOW Facility Research Expected to Improve Design Standards

In the 1970s and 1980s, Canadian researchers R.J. Kind and R.L. Wardlaw performed pioneering wind-load research on roof pavers. That research provided the foundation for the paver criteria that is in the International Building Code (IBC).

Subsequent experimental and numerical studies for investigating wind loading mechanisms on roof pavers have provided more insights on paver wind loads; however, that research has not been transformed into practice. Although pavers often provide adequate wind resistance, they can blow off roofs and pose safety threats.

To address the problem, Maryam Asghari Mooneghi and her team at Florida International University conducted a series of studies to investigate the wind loading mechanism on air-permeable roofing systems including roof pavers. Investigations took place in 2013-14, as part of Mooneghi's PhD research.

Maryam Asghari Mooneghi, PhD, Structural Analyst in Advanced Technology and Research Team, Arup, San Francisco

The project built upon previous research by conducting large-scale experiments that were not possible prior to the existence of the Wall of Wind at FIU. The objective was to develop simple guidance, in code format, for design of loose-laid roof pavers against wind uplift. "Roof systems experience the most wind loading compared to any other building component," Mooneghi says.

Major international codes and standards for wind loads in the U.S. and Canada (NBCC; ASCE 7) specify roof wind pressures for typical roof geometries, but there are no specific provisions on how to apply such pressures to roof pavers. "We conducted a series of studies to investigate the wind loading mechanism on roof pavers and developed simple design guidelines suitable for inclusion in codes and standards," she says.

EXPERIMENTAL METHODS

Mooneghi and her team performed large-scale experiments to investigate the wind loading on concrete roof pavers on the flat roof of a low-rise building in the Wall of Wind facility at FIU.

"The Wall of Wind facility at FIU can generate up to a Category 5 hurricane wind speed and is suitable for full-scale and large-scale destructive testing of roofing systems," she explains.

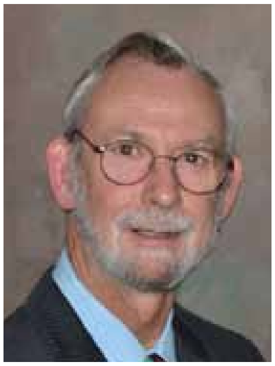
Experiments included wind blow-off tests and pressure measurements on the top and bottom surfaces of pavers. The basic test procedure consisted of first conducting wind blow-off tests. The aim was to provide guidance on the location where paver blow-off, i.e. failure, first occurs, which could then be used to decide on the pressure tap layout for detailed pressure measurements.

DEVELOPING DESIGN GUIDELINES

Based on the experimental results, simplified guidelines were developed for design of loose-laid roof pavers against wind uplift and published in 2016 ("Towards guidelines for design of loose-laid roof pavers for wind uplift," Wind and Structures, Vol. 22, No. 2, 133-160).

The guidelines are formatted so that designers can make use of the existing information in codes and standards such as ASCE 7-10 standard's pressure coefficients for components and cladding. The effects of the pavers' edge-gap to spacer height ratio and parapet height to building height ratio are included in the guidelines as adjustment factors.

Shortly after the design guidelines were published, they were put to use by Tom Smith, a roof consultant investigating a case in which pavers blew off a 25-story building. "The design criteria developed by Maryam and her team at FIU were vital for developing a solution to the blow-off problem. The reroofing work involved installation of pedestals to optimize the paver gap/spacer height ratio and connecting the pavers with straps to distribute the uplift load to adjacent pavers," Smith says.

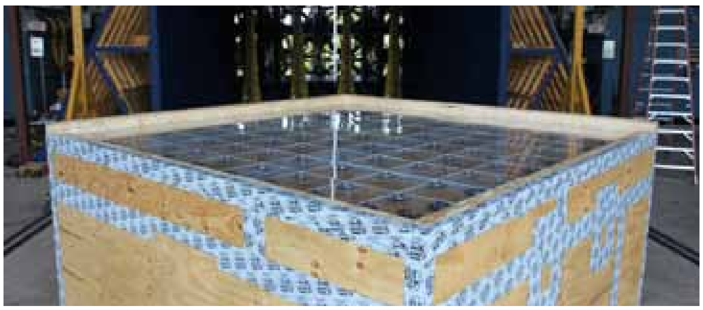


Tom Smith, AIA, RRC, F.SEI TLSmith Consulting Inc.

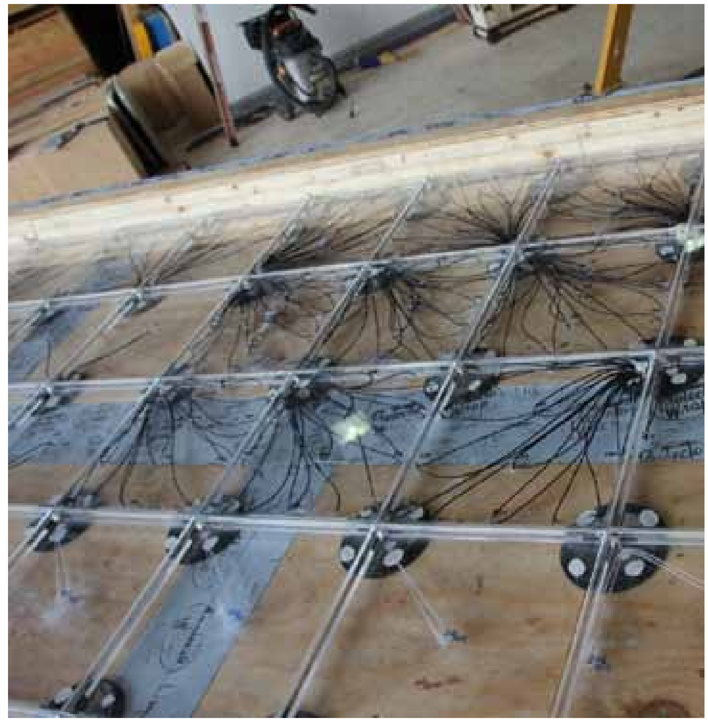
The guidelines will be balloted later this year for inclusion in ANSI/SPRI RP-4 (2013), Wind Design Standard for Ballasted Single-ply Roofing Systems, which is referenced in the IBC.

Until the RP-4 changes are made, designers can use the design guidelines referenced above. The specific changes that have been recommended to RP-4 appear in a recent paper published by Mooneghi Arindam, Smith, Peter Irwin, and Gan Chowdhury: "Concrete Roof Pavers: Wind Uplift Aerodynamic Mechanisms and Design Guidelines – A Proposed Addition to ANSI/SPRI RP-4," in the Proceedings of the 32nd RCI International Convention and Trade Show, March 2017.

This research was supported by the Florida Division of Emergency Management and the National Science Foundation (Award #1151003) through the 12-fan Wall of Wind flow simulation laboratory at Florida International University.



Test building for pressure measurement experiments.



Plastic pavers instrumented with pressure taps.

Maryam Asghari Mooneghi installing roof pavers for large scale wind testing at the Wall of Wind facility, Florida International University.

EXPERIMENTAL FACILITIES

Hazard Researchers Embrace Biogeotechnics

UC Davis Engineers Deploy Natural Processes to Mitigate Natural Hazard Damage

Hazard engineers at UC Davis are involved in a rich new subfield of geotechnical engineering: biogeotechnics. Bio-geo researchers discover ways to harness existing natural biogeochemical processes, such as microbial soil cementation. They also adapt designs inspired by natural processes, such as tree roots that naturally stabilize soil to adapt to environmental loads from wind and earthquakes.

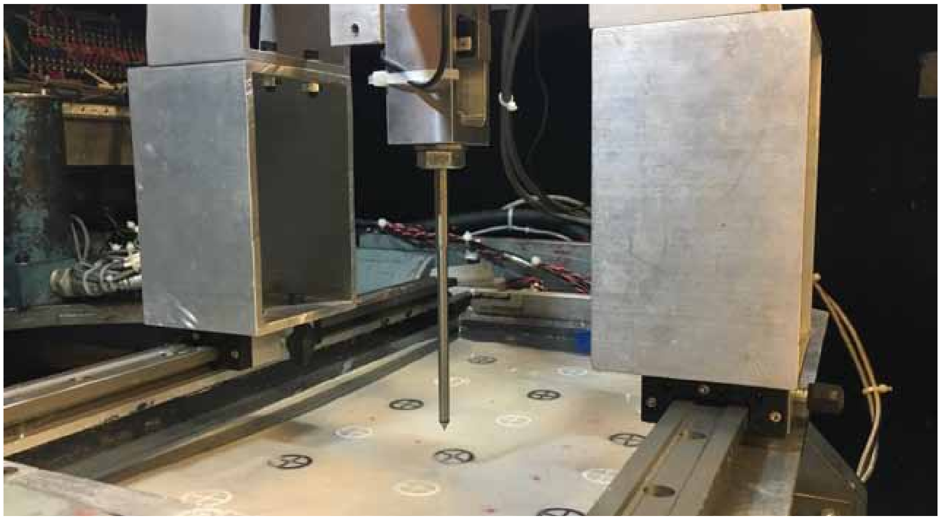
UC Davis is part of a national NSF-funded effort called the Center for Bio-mediated and Bio-Inspired Geotechnics, headquartered at Arizona State University (NSF award #1449501). The CBBG team at UC Davis is headed by Jason DeJong, a geotechnical engineering professor of engineering.

“Bio-inspired techniques offer unique solutions to problems,” DeJong says. “Natural systems provide unique and efficient engineering solutions that require minimal energy expenditure.”

For more than a decade, DeJong has studied ways to exploit natural microbial processes to prevent soil liquefaction. Microbially induced calcite precipitation (MICP) has shown great promise, he says. In one of the current NSF CBBG projects, he is testing ways sandy soils can be modified by natural microbial activity that strengthens and stiffens soils. Certain microbes facilitate the precipitation of calcite between sand particles, producing a material much like sandstone. Liquefiable sand can be transformed into sandstone-like material in a matter of days. Another technique which generates small bubbles of nitrogen gas is being tested in parallel. This component of the project is being led by CBBG collaborators Profs. Ed Kavazanjian and Leon van Paassen at ASU.

Using the centrifuges at the NHERI-funded facility at the Center for Geotechnical Modeling, DeJong and his colleagues seek to better understand and quantify how microbial calcification and desaturation can change the resistance of soil to earthquake loading. Ideally the results will how both treatments can increase the resistance to liquefaction occurring for most earthquake events and reduce the consequence if liquefaction is triggered during extreme events.

As well as improving liquefaction-prone soils, the biomediated processes may prove a sustainable, inexpensive method of preventing earthquake damage to geotechnical and structural systems.



Cone penetration testing in small centrifuge model of loose liquefiable sand. (Photo: Trevor Carey)

Jason DeJong holds a piece of sandstone-like material created in his lab by the action of microbes on loose sand.

Kate Darby (back), graduate student, and Dexter Harris, NHERI REU student from Morgan State University, measuring shear wave velocity in MICP treated centrifuge model.

Other UC Davis engineers involved in biogeotechnical research to prevent damage from natural hazards include Dan Wilson, Ross Boulanger and the UC Davis graduate student cohort.

For more details on the bio-mediated soil improvement work underway at UC Davis, visit the Center for Bio-Mediated and Bio-Inspired Geotechnics (CBBG).

NHERI COMMUNITY

NHERI Grants, Quarter 2: Award Dates April-June 2017

DESIGNSAFE CYBERINFRASTRUCTURE

RCN: Research Network in Hybrid Simulation for Multi-Hazard Engineering. Award #1661621; PI: Shirley Dyke; Co-PI: Narutoshi Nakata; Organization: Purdue University; NSF Organization: CMMI Start Date:05/01/2017; Award Amount: $500,000.

FLORIDA INTERNATIONAL UNIVERSITY

Model to Full-Scale Validation of Peak Pressure Mechanisms in Buildings that Cause Cladding Failures and Windstorm Damage. Award #1727401. PI: Chris Letchford, Rensselaer Polytechnic Institute; NSF Organization: CMMI Start Date:08/01/2017; Award Amount: $371,753.

LEHIGH UNIVERSITY

Collaborative Research: Shear-Buckling Mechanics for Enhanced Performance of Thin Plates. Award #1662964; PI: Spencer Quiel; Organization: Lehigh University; NSF Organization: CMMI Start Date: 07/01/2017; Award Amount: $352,483.

Collaborative Research: Shear-Buckling Mechanics for Enhanced Performance of Thin Plates. Award #1662886; PI: Maria Garlock; Organization: Princeton University; NSF Organization: CMMI Start Date: 07/01/2017; Award Amount: $366,137.

UC SAN DIEGO

Collaborative Research: Seismic Resiliency of Repetitively Framed Mid-Rise Cold-Formed Steel Buildings. Award #1663348; PI: Benjamin Schafer, Johns Hopkins University; NSF Organization: CMMI Start Date:05/01/2017; Award Amount: $340,000.

Collaborative Research: Seismic Resiliency of Repetitively Framed Mid-Rise Cold-Formed Steel Buildings. Award #1663569; PI: Tara Hutchinson, University of California-San Diego; NSF Organization: CMMI Start Date:05/01/2017; Award Amount: $589,998.

Collaborative Research: Resilient Seismic Retrofit by Integrating Selective Weakening and Self-Centering. Award #1663063; PI: Pinar Okumus; Co-PI: Mettupalayam Sivaselvan; Organization: SUNY at Buffalo; NSF Organization: CMMI Start Date:08/01/2017; Award Amount: $290,000.

Collaborative Research: Resilient Seismic Retrofit by Integrating Selective Weakening and Self-Centering. Award #1662963; PI: Sriram Aaleti, University of Alabama Tuscaloosa; NSF Organization: CMMI Start Date:08/01/2017; Award Amount: $120,000.

UNIVERSITY OF FLORIDA

EAGER/Collaborative Research: Aeroelastic Real-Time Hybrid Simulation for Wind Engineering Experimentation. Award #1732213; PI: Richard Christenson, University of Connecticut; NSF Organization: CMMI Start Date:06/15/2017; Award Amount: $118,262.

EAGER/Collaborative Research: Aeroelastic Real-Time Hybrid Simulation for Wind Engineering Experimentation. Award #1732223; PI: Steve Wojtkiewicz, Clarkson University; NSF Organization: CMMI Start Date: 06/15/2017; Award Amount: $101,763.

Benchmark Study of Tornado Wind Loading on Low-Rise Buildings with Consideration of Internal Pressure. Award #1663363; PI: Delong Zuo; Co-PI: Darryl James; Organization: Texas Tech University; NSF Organization: CMMI Start Date:05/01/2017; Award Amount: $350,001.

UNIVERSITY OF TEXAS, AUSTIN

Collaborative Research: Bridging the In-situ and Elemental Cyclic Response of Transitional Soils. Award #1663654; PI: Armin Stuedlein; Co-PI: T. Matthew Evans; Organization: Oregon State University; NSF Organization: CMMI Start Date:07/01/2017; Award Amount: $634,391.

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