

CBBG

Center for Bio-mediated & Bio-inspired Geotechnics

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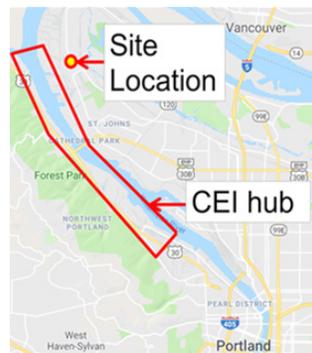
As I See It: View from Director's Chair

Hi-Ho, Hi-Ho (Off to the Field We Go)

As CBBG approaches its 5th year of operation, and as some of our initial technologies mature, a number of CBBG projects are moving out into the field, or to field-scale testing. In Year 4, we completed a field demonstration of microbial desaturation via denitrification (the Toronto field work) and successfully created field-scale biocemented columns in the test pit on the ASU Polytechnic campus. Evaluation of the biocemented columns is in progress and we are in the planning stages for several additional field experiments, including MICP (microbially induced carbonate precipitation via hydrolysis of urea) for ground stabilization, MID (microbially induced desaturation via denitrification) for mitigation of earthquake-induced liquefaction, EICP (enzyme induced carbonate precipitation via hydrolysis of urea) for fugitive dust control, EICP for coastal protection, BUROS (Bio-inspired Underground self-ReactiOn System), and removal of phosphorus and nitrogen from impacted water. All of these projects have substantial support from Industry Partners, the NSF NHERI (Natural Hazard Engineering Research Infrastructure) Program, or other public agencies.

In collaboration with Industry Partners Hayward Baker and Geosyntec, the UC Davis group, led by Jason DeJong, are preparing a field scale demonstration of MICP. The project is authorized but waiting for identification of an appropriate site at which to conduct the demonstration. There are several additional potential sites for demonstrating this technology under discussion in the Richmond, British Columbia area, where dikes along the Fraser River are underlain by potentially liquefiable soils.

An ASU group, led by Leon van Paassen, is partnering with Portland State University, the University of Texas at Austin NHERI team, and Industry Partner Geosyntec Consultants on two test plots for liquefaction mitigation via microbially induced desaturation (MID). One of the goals of this project is to demonstrate the potential for non-disruptive mitigating liquefaction in silty soils beneath oil storage tanks in the Port of Portland "Critical Energy Infrastructure Hub". Mitigation of the potential for liquefaction in the Energy Hub and at other sites in the Port of Portland and along the Willamette River is identified as a critical issue in the "Oregon Resilience Plan: Reducing the Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami" report to the legislature authorized by the Governor's Office.



Port of Portland Critical Energy Infrastructure Hub

The EICP for coastal protection project contributes to the same Oregon resiliency initiative as the MID project. In collaboration with Oregon State University (OSU) and North Carolina State University (NCSU), an ASU team will be employing EICP to stabilize a coastal sand dune against wave attack for scale model testing using the Tsunami wave basin at OSU, a shared use facility operated under the NSF NHERI (Natural Hazard Engineering Research Infrastructure) program. The EICP test section will be tested in parallel with a sand dune stabilized using MICP by the NCSU / OSU team. Use of EICP for dust control is also moving out into the field. In collaboration with Industry Partners Freeport McMoRan, Republic Waste Services, and the Salt River Landfill and with the Healthy Urban Environment program of the ASU Global Institute of Sustainability, an ASU team led by Nasser Hamdan will be deploying EICP for dust control at two sites within Maricopa County. ASU has also teamed with the Bureau of

Reclamation (BoR) Yuma office to submit a proposal to the BoR internal research program for mitigation of potentially toxic fugitive dust from the Salton Sea area.

In the BUROS, project, the UC Davis team led by Alejandro Martinez is developing a system to increase the maximum depth that a cone penetrometer exploration systems probe can realize without increasing the weight of the rig. The UC Davis work, conducted in collaboration with industry partner Cone Tec, is a bio-inspired concept in which a subsurface expandable bladder is used to provide additional resistance for the probe to react against during penetration. This will be the first bio-inspired technology to be deployed by CBBG.

New Industry member Geo-Logic Associates (GLA), through their subsidiary Kunkel Engineering, is providing a substantial amount of services-in-kind for civil design of a field trial of CBBG technology to remove phosphorus and nitrogen from impacted water, in this case agricultural drainage. Excess phosphorus and nitrogen in agricultural runoff is the major cause of eutrophication of lakes and streams throughout the US. We are partnering with local farmers on the field trial and the local Fox Lake Community Association and Wisconsin Department of Natural Resources (DNR) are engaged in the project.

Taken in aggregate, these field and field-scale projects represent significant progress in bringing biogeotechnical engineering into the mainstream of geotechnical engineering practice after a relatively short 4 years of CBBG operations.

Important Dates

Pacific Northwest National Laboratories Information Session
August 28, 2019, 12:00PM MST
GWC 137 & ZOOM Conference

NSF Site Visit to CBBG
October 28, 2019: Rehearsal Day
October 29-31, 2019: Site Visit

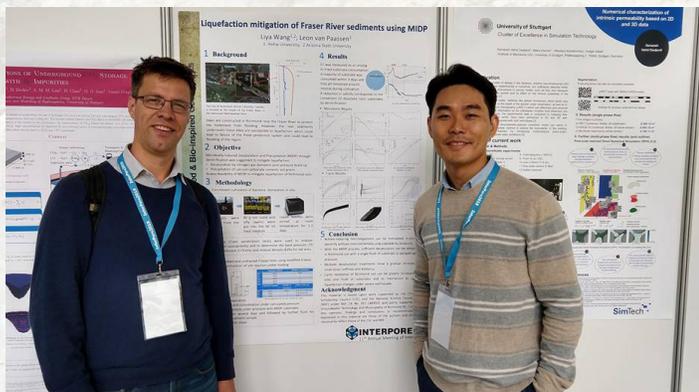
YR5 CBBG Mid-Year Meeting
April 5, 2020: Student Retreat
April 6-7, 2020: Mid-Year Meeting

Research Highlights

More Field Trials on Bio-Based Ground Improvement in 2019

Following the field trials in Toronto, which were performed in the summer of 2018 and in which both the potential of Microbially Induced Carbonate Precipitation (MICP) by urea hydrolysis and of Microbially Induced Desaturation and Precipitation (MIDP) by denitrification for ground stabilization was evaluated, more field trials are currently in preparation. Together with Groundwater Technology, member of the industry advisory board, we have been preparing a field trial for the municipality of Richmond, BC Canada. Lab tests have identified the potential of using MIDP for liquefaction mitigation and currently the municipality has identified a test site and is working on the environmental permits to allow the injection of the required substrate solutions. At the same time Groundwater Technology has obtained a project in their home country, The Netherlands, to evaluate whether they can use MICP by urea hydrolysis, to stabilize dune sand and allow for a vertical excavation next to an existing building. Our other partners Sotanche Bachy, Golder, Geosyntec and Hayward Baker also have several trial projects in preparation. Most recently Arash Khosrafiyar and his colleagues at Portland State University obtained a RAPID grant in collaboration with CBBG, ASU and UT Austin to perform a field trial to test the potential of MIDP for liquefaction mitigation and use the T-Rex shaker for quality assessment in the Portland area. The project will take place during summer of 2019 and receives significant support from our industrial partners.

Sessions on Bio-Mediated Ground Improvement at Interpore 2019 in Valencia Spain



Left to Right: Dr. Leon van Paassen and Daehyun Kim

May 6-10 the Interpore conference took place. Together with colleagues from Montana State University and ETH Zurich, Leon van Paassen (ASU) hosted three sessions on bio-mediated ground improvement. The conference brought together many scientists and engineers dealing with applied and fundamental aspects of porous media research. With 7 abstracts (2 oral and 5 poster presentations), CBBG and ASU were well represented.

CBBG Partners With Industry and Community Stakeholders on Wisconsin Field Demonstration Project to Treat Agriculturally-Impacted Waters

The CBBG is in the advanced planning stages of a field-scale demonstration project on farmland in Beaver Dam, WI with industry partners and community stakeholders. The project is called "Removal of Phosphate and Nitrate from Impacted Waters via Mineral Precipitation and Microbial Transformation," and the goal is to reduce phosphorus (P) and nitrate (N) levels in agriculturally-impacted waters using CBBG technology.

New CBBG Industry Partner, Geo-Logic Associates, through their subsidiary Kunkel Engineering Group in Beaver Dam, is providing a substantial amount of services-in-kind through civil design services. In-kind services for materials are being provided by Phoenix Services, a former CBBG Industry Partner. The demonstration site, field services and data collection for the project will be provided by local farmers, field specialists and college students. The project also engages local community groups such as the Fox Lake Protection & Rehabilitation District and has attracted the attention of the WI Department of Natural Resources. CBBG Senior Investigator Treavor Boyer, co-Senior Investigator Nasser Hamdan and graduate student Michael Edgar are also engaged in this project.

CBBG Gets International Recognition in the Netherlands Through Field Trials



Following the successful implementation of Microbially Induced Carbonate Precipitation (MICP) by urea hydrolysis and Microbially Induced Desaturation and Precipitation (MIDP) at the field sites in Toronto during summer 2018, industrial partner Groundwater Technology gained publicity in the Dutch press through several articles in professional magazines, in which the collaboration with CBBG is emphasized. The successful collaboration continues in fall 2019 year, since the tendering and permitting for the field trials in Richmond, BC are currently ongoing. In addition, another biocementation field trial is scheduled to take place later this year, which should enable a steep excavation near the foundation of a hotel in the sand dunes in the Netherlands.

CBBG Hosts Industry Partner Haley & Aldrich at ASU

CBBG hosted industry partner Haley & Aldrich (H&A) at ASU to discuss industry practices and career opportunities at H&A. The event was webcast to our partner institutions GT, NMSU and UC Davis. H&A representatives Steve Rakowski, Suzanne Bell, Sade Simien and Sarah Cooper shared their broad range of experiences, and discussed industry practices and career opportunities in engineering consulting at H&A. The meeting was held in early July and included CBBG students, teachers and faculty. CBBG summer research participants in the Research Experience for Teachers (RET), Research Experience for Undergraduates (REU) and Young Scholars (YS) programs were also in attendance. The H&A team spent time after the seminar to speak with CBBG students individually about internships and career opportunities at H&A. It was a wonderful event and exceptional effort by the H&A Team.



GT CBBG REU student Sarah Trapp (left) and GT CBBG YS student Marin Londe (right) measuring the dimensions of ant hill nest aluminum castings. The project aimed to fully characterize the features of these tunnel structures and correlate them with the soil stratigraphy and properties.



Georgia Tech Summer Program Highlights

GT CBBG REU student Lillian Ehrhart preparing a spiderweb inspired geogrid that was 3-D printed for load testing in a hexagonal frame she designed and fabricated. The project aimed to identify a new generation of geogrids for soil reinforcement.



GT CBBG REU student Lilliana Delmonico preparing a specimen for interface shearing. The project aimed to quantify the influence of engineered surface features on the interface friction between particulate materials and 3-D printed surfaces.



GT CBBG REU student Liam Groom injecting silicone into a mold he made using 3-D printing. The project aimed to develop a peristaltic probe that advances in a tube.



Dr. Nariman Mahabadi Accepts New Position at University of Akron

Dr. Nariman Mahabadi, Assistant Research Professor and former Post-Doc of CBBG-ASU is joining the University of Akron as an Assistant Professor of Civil Engineering in August 2019. Nariman holds a Ph.D degree in civil engineering from ASU and received two master's degrees in civil engineering from Wayne State University, and in hydraulic structures from Amirkabir University of Technology, Iran. His research at the University of Akron will be focused on multiphysics coupled processes in porous media with applications primarily in the areas of subsurface energy, geomechanics, and geo-environmental engineering. He taught undergraduate and graduate level geotechnical engineering courses at ASU, and his research was funded by DOE, NSF, and ADOT.

Out & About

International Workshop on Bio-Inspired Geotechnics



This NSF funded workshop brought together 60 researchers and students that are technically and demographically diverse, who collectively cover expertise in soil mechanics, biology, mechanical engineering, robotics, and other fields, and demographics from established senior investigators to assistant professors to underrepresented graduate students. The workshop took place from May 19 to 22, 2019 at the Asilomar Conference Grounds in Pacific Grove, CA. The workshop was designed in a structure to scaffold the development a mutual foundation of discipline understanding, sharing of current research and brainstorming new opportunities, and identification of the necessary developmental steps required to grow this interdisciplinary field. An informal environment that fostered discussion, brainstorming, free sharing of ideas, and development of collaboration relationships was incorporated into the workshop agenda.



Many of our CBBG community participated in this conference, including the following:

Members of University of California, Davis: Alejandro Martinez, Jason DeJong, Ross Boulanger, Dan Wilson, Kyle O'Hara, Lin Huang, Yuyan Chen, Matt Burrall

Members of New Mexico State University: Paola Bandini, Douglas Cortes, Ale Aleali

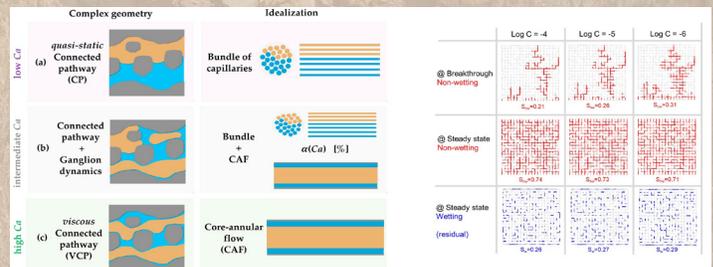
Members of Georgia Tech: David Frost, Sheng Dai, Rodrigo Borela

Members of Arizona State University: Julian Tao, Leon van Paassen, Sichuan Huang

Members of our Industry and Scientific Advisor Board: Chris Hunt and Jamie Sharpe (Geosyntec), Lisheng Shao (Hayward Baker), and Allen Marr (SAB)

The outcomes of the workshop will be summarized in a journal paper that will be submitted to a leading geotechnical engineering journal. Other more informal outcomes include development of collaborations between the participants, cross-pollination of ideas between the fields of geotechnical engineering, biology, and robotics, and identification of promising applications for industry.

Arizona State University and Stanford Research Collaboration



Dr. Nariman Mahabadi of ASU visited Stanford University as a research collaboration between ASU (Dr. Mahabadi and Dr. van Paassen) and Stanford (Dr. Ilenia Battiato and Dr. Davide Picchi). The objective of this collaboration is to develop a new pore-network model to simulate the behavior of immiscible multiphase flow regimes particularly in the form of large ganglia dynamics. The proposed model will extend the current state of the art of predictive models by allowing for the coexistence of different pore-scale flow regimes in complex geometry while accounting for capillary and viscous limits in the dynamics. The development of this model will help to improve the prediction and scaling of relative permeability in multiphase flow systems which is critical in many industrial applications, such as petroleum engineering, carbon sequestration, water resources, and modern energy storage technologies.

Grand Opening of the Microbial Nursery



The first microbial nursery, developed by microbiologist Ferran Garcia-Pichel and his research team, was unveiled on May 8th at the ASU Polytechnic campus. This project was supported by the NSF, Biodesign Institute, and CBBG.



The five-year long project that was a finalist for the 2018 Arizona Governor's Celebration of Innovation Award was developed out of a need to discover new ways to keep natural topsoil from being dispersed into the air. In Arizona, soil erosion and degradation rates are increased by factors such as anthropocentric causes, agriculture, and dust storms.

The loss of natural topsoil and the dispersal of it into the air can result in serious problems such as air pollution due to increased particulate matter, respiratory issues, and decreased performance of solar panels. The purpose of the microbial nurseries, then, are to cultivate microbes that will be able to slow down the erosion of topsoil.

The microbial nursery consists of three shipping containers, all of which contain the equipment needed to nurture microbial life. Within the nursery, Ferran Garcia-Pichel and his research team will be able to cultivate native strains of microbes that will develop faster than naturally occurring microbes in the soil. The microbes will then be used to restore and fertilize degraded topsoil. The shipping containers are all mobile, and will be moved to various locations in the Southwest (Mesa, Tucson, New Mexico, etc.) in order to better mimic the natural environment and conditions that the microbes will eventually be in.

ASU Young Scholar Ayesha Raman Spotted on Local News



CBBG was surprised and delighted to see one of the ASU Young Scholars, Ayesha Raman, on the local news the other night. Ayesha was called upon to provide her opinion on how to win a debate for that night's Democratic candidate debate. Not only is she learning and experiencing bio-mediated and bio-inspired research projects, she is also a political science advisor!

Georgia Tech Students Travel the World



Current GT CBBG PhD student Karie Yamamoto spent the summer in Paris collaborating with researchers at ENPC in DEM modeling of ant hill tunnel structures. Her research internship was supported by an NSF IRES project. When not focused on the screen of her computer, Karie found time to attend a FIFA Women's World Cup soccer match.



Current GT CBBG PhD student Nimisha Roy took a couple of weeks off in the summer to return to India and get married. Nimisha is working on fundamental research related to pores and pore networks and studying how they influence the movement of probes and tunnels in the subsurface.

Education & Outreach

ASU Summer Program Reception



The ASU Research Experience for Teachers (RET) and Young Scholars Program (YSP) summer interns celebrated a successful month of research and learning, along with their mentors and CBBG faculty and staff. A closing reception was held Thursday, June 27th at the ASU Memorial Union. Young Scholars presented posters and shared their research while RETs presented the lesson plans that they developed based on research they did with their mentors. It was the culmination of a productive and fun month of learning, research and collaboration.

CBBG Research Presented in Hong Kong



CBBG Education Coordinator, Kim Farnsworth, attended the Hong Kong Association for Educational Communications and Technology (HKAECT) annual conference held June 17-19, 2019 in Hong Kong, China. HKAECT is a branch of the U.S.-based national AECT organization and promotes dissemination of educational knowledge and research. Kim was able to share the findings of CBBG research, conducted in partnership with CBBG faculty, staff, Indiana University, and industry, into problem-based learning in civil engineering undergraduate courses.

SEE@ASU Students Learn About CBBG Research

ASU's Summer Engineering Experience (SEE@ASU) includes motivated high school juniors and seniors for an exciting introduction to the engineering profession, faculty, students and the innovative programs offered at the Ira A. Fulton Schools

of Engineering. SEE@ASU participants were presented research conducted by CBBG summer REU, RET, and Young Scholar interns, including live demonstrations as they toured CBBG labs and learned about the Center.

June 26th - ASU Polytechnic Tour



CBBG researchers, Dr. Ana Giraldo Silva, Eric Escoto, and Kimberly Martin gave tours and explained their research projects to the ASU Summer Engineering Experience (SEE) high school students at the Field Soils Laboratory on the ASU Polytechnic campus. The 70 SEE students observed, first-hand, how the work of these CBBG researchers are investigating sustainable ways to solve engineering challenges.

Dr. Giraldo Silva explained that one benefit of restoring natural microbial communities is they can assist in mitigating fugitive dust. The students were introduced to the mobile lab where the communities are examined and cultured. Eric explained how the rain simulator will be controlled to simulate the rain conditions that occur during the monsoon storms in the Southwest desert, allowing efficient testing of various bio-mediated engineering solutions that can reduce soil erosio



Kimberly explains how the EICP tests were conducted.

Jasmyne Johnson was the teacher in the Research Experience for Teachers (RET) and Sam Sawyer was the Young Scholar working with Kimberly this summer. Together, they explained how they have been constructing and testing bio-cemented columns in the pit using enzyme induced carbonate precipitation (EICP) to demonstrate that it can provide a cost effective and sustainable alternative to Portland cement for soil improvement.



Sam and Jasmyne presenting the bio-cemented soil column.

June 27th & July 11th - ASU Tempe Tours

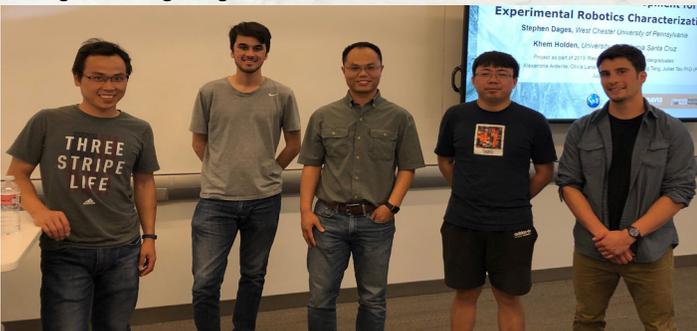
SEE@ASU participants toured the ASU Tempe campus and attended presentations of CBBG research. Approximately 70 students attended each day and were able to learn about CBBG and what it is that we do.

On June 27th, graduate students Sooraj Nair and Emily Ford along with CBBG summer interns, Savannah Orth (REU), Mark Calhoun (RET), and Jasmine Goode (YSP) presented their research of bio-deposition as a surface treatment method to increase concrete durability. They also conducted a live demonstration of a sieve analysis.



Left to Right: Mark Calhoun (RET), Emily Ford (grad student), Savannah Orth (REU), & Jasmine Goode (YSP) presenting their research to SEE@ASU students.

On July 11th, two CBBG REU summer interns, Stephen Dages and Khem Holden, shared the research they had been conducting of bio-inspired self-burrowing robots under the guidance of CBBG faculty member Dr. Julian Tao and graduate students, Sichuan Huang and Yong Tang.



Left to Right: Sichuan Huang (grad student), Khem Holden (REU), Dr. Julian Tao, Yong Tang (grad student), & Stephen Dages (REU)



Wilhelmina Savenye Thanks All

Willi Savenye officially retired after serving from its inception to 2018 as CBBG's founding Education Director, and for 28 years as a Professor of Educational Technology at Arizona State University, having graduated 27 PhDs and many Master's students. Willi says: "I am indebted to Director Ed Kavazanjian, Deputy Director Claudia Zapata, and every member of CBBG for bringing me into the biogeotechnical fold and for being the most amazing group of

researchers and collaborators one could have. The past four years with CBBG have been among the most exciting, rewarding and enjoyable times of my career. I would like to particularly thank Bob Brier, Jean Larson, Claudia, Ed and all of our amazing students, faculty, postdocs, researchers and partners of CBBG for giving me a wonderful sendoff. So many of you have made a point of coming by or touching base and wishing me well, which I have so enjoyed. I am enjoying retirement, traveling, enjoying family and friends, camping, hiking, kayaking and whale watching, and also continuing my research on learning design, online technologies, evaluation, and informal learning in museums. However, I hope to see all of you often, as I look forward to continuing collaborations with the IDEA group and everyone at CGGB."

Georgia Tech Mentors, REU and YS Students Explore Atlanta



Georgia Tech CBBG Mentors, REU and YS students enjoying an evening at the rooftop carnival at Ponce City Market, Atlanta. Photo includes (back row left to right) Liam Groom (REU), Sangy Hanumasagar (PhD), Rod Borela (PhD), Nimisha Roy (PhD), Mahdi Roozbahani (faculty) and Seth Mallett (PhD) (front row left to right) Sean Rager (YS), Lillian Ehrhart (REU), Catherine Lemons (YS), Sarah Trapp (REU) and Lilliana Delmonico (REU).

Honors & Awards



Miriam Woolley Selected as Recipient of the 2019 Trent R. Dames and William W. Moore Fellowship

Miriam Woolley has been selected by the American Society of Civil Engineers' Society Awards Committee as the recipient of the prestigious 2019 Trent R. Dames and William W. Moore Fellowship. Trent R. Dames and

William W. Moore were the founders of Dames and Moore, one of the preeminent geotechnical consulting firms in the world for at least four decades.



Kimberly Martin Awarded Deep Foundations Institute Fellowship

Kimberly Martin has been selected by the Deep Foundations Institute (DFI) as one of the recipients of the 2019 DFI Educational Trust At Large Scholarships. DFI is a nonprofit association of professionals involved in the deep foundations industry.

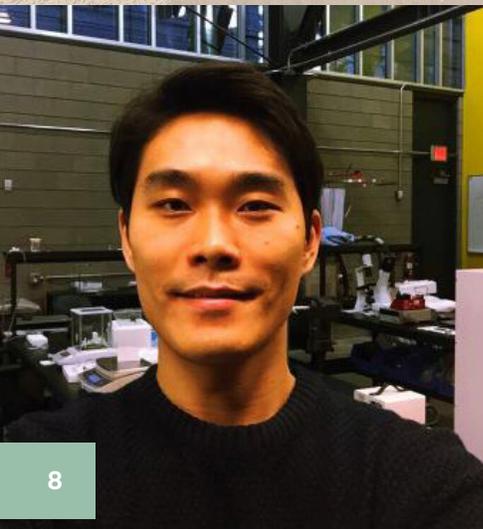
New Faculty Positions for Former CBBG Students



Former GT CBBG PhD student and May 2018 graduate, Mahdi Roozbahani, is now a faculty member in Computational Science and Engineering at Georgia Institute of Technology. Mahdi teaches undergraduate and graduate courses in Machine Learning and Data & Visual Analytics.



Former GT CBBG post-doctoral fellow, Prashanth Vangla, and his wife Raveena at the naming ceremony for their daughter, Aruhi. Prashanth is now an Assistant Professor at the Indian Institute of Technology in Delhi where he is continuing research on bio-inspired geotechnics.



Daehyun Kim is Moving to Switzerland!

Please join CBBG in congratulating Daehyun Kim's new position as a Postdoctoral Fellow at the Laboratory for Soil Mechanics (LMS) of the Swiss Federal Institute of Technology, Lausanne (EPFL). In this position, Daehyun will be part of the research project, BIOGEOS (Bio-mediated Geo-material Strengthening), funded by an Advanced Grant of the European Research Council. Daehyun will contribute his research background and experience to this project and hopes to play a role in future collaborations between CBBG and BIOGEOS. We will greatly miss Daehyun here at ASU and we wish him luck and warmth as he moves from the desert to a snowy landscape.

Publications

- Chandler, J. L. S. & Larson, J. (2019). Center for Bio-mediated and Bio-inspired Geotechnics (CBBG) Short-term, Lab-based Engineering Mentor Guide. Tempe, AZ. doi: 10.13140/RG.2.2.23819.69927
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- Weldon, B.D., Bandini, P., McGinnis, M.J., Davila, E., Garcia Vera, D.I. (2019). Laboratory study on the strength behaviour of two laterally loaded adobe walls. Infrastructures 4(1), doi: 10.3390/infrastructures4010001

Industry & Innovation

US EPA, Geo-Logic Associates and the City of Phoenix Join CBBG!

The **EPA Office of Research and Development (ORD)**, headquartered in Cincinnati, is the scientific research arm of EPA, whose leading-edge research helps provide the solid underpinning of science and technology for the Agency. ORD supports six research programs that identify the most pressing environmental health research needs with input from EPA offices, partners and stakeholders.

Geo-Logic Associates (GLA) is an employee-owned, multidisciplinary, consulting geologic, geotechnical, civil and environmental firm. They provide engineering services through 26 US office locations, including Wisconsin where they are providing services in kind on a CBBG field demonstration project (see accompanying article on page 2) and an office in Peru.

The **City of Phoenix Public Works Department** handles collection and disposal of trash and recyclables for more than 350,000 households in the fifth largest city in the United States. Public Works is committed to creating a sustainable Phoenix through positive resource management. In 2013, the department launched its waste diversion initiative, "Reimagine Phoenix," with a citywide goal of diverting 40 percent of trash from the City landfills by the year 2020. In partnership with Public Works, the CBBG aims to work on biogeotechnical solutions to help the City of Phoenix meet its sustainability goals.



City of Phoenix



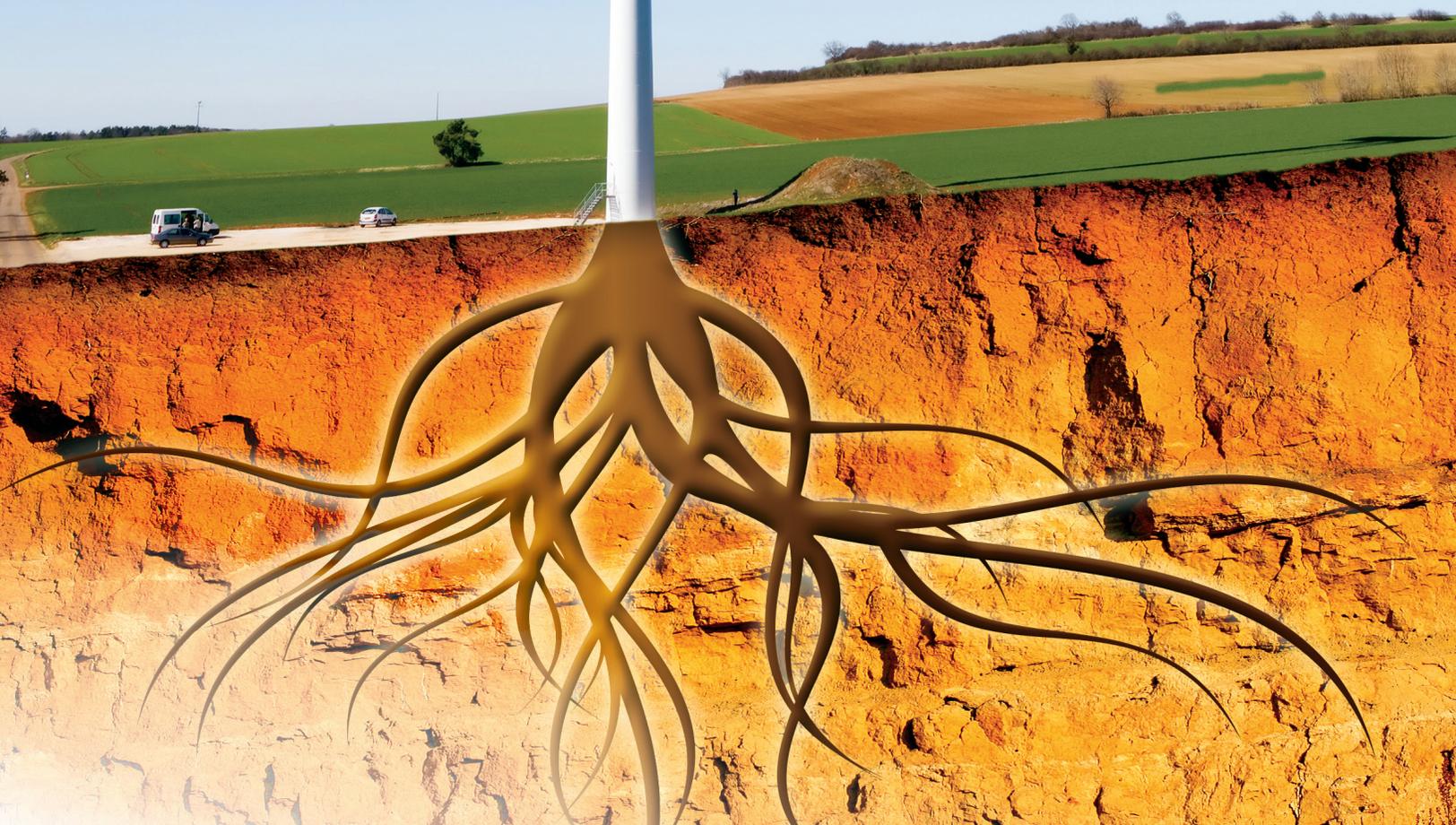
Partner Universities

UCDAVIS
UNIVERSITY OF CALIFORNIA

ASU ARIZONA STATE
UNIVERSITY

NM
STATE
UNIVERSITY

 **Georgia Institute
of Technology**



How does nature do it?

Nature has developed elegant, efficient and sustainable biologically-based solutions to many challenges that vex geotechnical infrastructure systems. Examples include ant excavation processes that are 1000 times more energy efficient than man-made tunneling machines, carbonate cemented sand that is exceptionally resistant to erosion and earthquakes, and self-sensing and self-healing tree root structures that are 10 times more efficient than any mechanical soil reinforcing/foundation system yet devised.

The NSF Engineering Center for Bio-mediated and Bio-inspired Geotechnics (CBBG) will focus on ecologically friendly, cost-effective solutions, inspired by nature, for development and rehabilitation of resilient and sustainable civil infrastructure systems. It will serve as a nexus for two transformative trends in engineering: biologically-based design and sustainability.



CBBG is a National Science Foundation (NSF) Engineering Research Center funded in 2015 under cooperative agreement EEC-1449501, and headquartered at Arizona State University.



biogeotechnics.org

ASU Ira A. Fulton Schools of
Engineering
Arizona State University