



Center for Bio-mediated & Bio-inspired Geotechnics

Newsletter • Winter 2019 • Volume 14



As I See It: View from Director's Chair

Moving Forward, Not Looking Back!

After a successful Annual Meeting in October, the CBBG can now look forward to 6 more years (actually 5.5 years now) of continuing NSF support. While not official yet (there are still some NSG internal approvals needed), the Site Visit Team unanimously recommended the CBBG be funded for 5 additional years. An important activity over that period of time is preparation for a transition by the end of that period to self-sufficiency, to continuing to function as a team without dedicated NSF funding, as ERCs are eligible for just one 5-year extension from NSF.

Actually, preparation for the transition to self-sufficiency has already begun. Formal preparations began with the development of a Financial Sustainability Plan for incorporation into the Year 4 annual report. Informally, the transition to self-sufficiency began in Year 1 with the formation of our Industry Advisory Board and continued in subsequent years with the increasing engagement of our industry partners in CBBG research, as this is an essential element of the formal transition plan.

Increased industry engagement is just one element of the CBBG Sustainability plan. But to my mind it is perhaps the most important element with respect to maintaining CBBG as a multi-

institution endeavor, i.e., it is the glue that will keep us together as a Center. That is not to say that there would be no reason for collaboration among the four CBBG partners without an Industry Partnership program, but rather that the Industry Partnership program is the one element of the Center, and of the Sustainability Plan, that could not be accomplished by the Center academic partners acting as separate, individual entities. We have projected Industry Membership fees to essentially double from Year 5 to Year 10, providing discretionary revenue we can use to fund mid-year and annual meetings, CBBG presence at industry events (e.g., the ASCE GeoCongress, the annual meeting of the ADSC-IAFD), coordination and administration of short courses, webinars, and workshops, and other joint activities, hopefully with a little money remaining for some small grants for junior faculty with innovative ideas. Of course, the success of this element of the Sustainability Plan relies upon retaining existing partners and recruiting new partner. To do this, we must continue to provide and enhance the value of CBBG membership to our Industry Partners through both technology and workforce development, including preferred access to our students.

Other elements of the CBBG Sustainability Plan, beyond increasing Industry Membership revenue, include: increasing industry engagement in our research, both through cash contributions, services in kind, and strategic input; NSF funding from non-ERC sources, including the Education Directorate, special programs like Signals in the Soil, and through the traditional unsolicited proposals route; funding from other federal agencies, including NIH, DOD, DOE, and FHWA and from local, regional, and state agencies; fee-for-service for laboratory testing, facility use, treatability studies, and LCSA's; fee-based Continuing Education and Professional Development programs; and funding for education and diversity activities from charitable organizations and intra-University sources. We believe that through these varied sources, by Year 10 of CBBG operations we will have

surpassed the \$4 million in base NSF funding we will receive in Years 6-8 (funding tapers down in Years 9 and 10) as well as associated University cost-sharing.

One confounding factor as we plan for this transition to self-sufficiency is that we no longer "own" the biogeotechnics space. There are many other groups around the country and around the world working on similar technologies, in many cases building upon foundational research conducted by CBBG. In this sense, we are to some extent the victims of our own success. One of the objectives of CBBG was to establish biogeotechnics as a recognized sub-discipline in the geotechnical field, and as evidenced by the special sessions and Geotechnical Special Publication on biogeotechnics at this year's ASCE GeoCongress, the formation of a European Center on BioSoils, and the deluge of papers on biogeotechnics from journal publications and conferences we are asked to review and that are appearing in print, we have succeeded in accomplishing in this objective. To maintain our primacy in this space, we need to continue moving forward, advancing our technologies and expanding our portfolio of biogeo techniques to stay one, or more, steps ahead of our colleagues. We must continue looking, and moving forward. To paraphrase Satchel Paige (look him up!), don't look back (or rest upon our laurels), because someone might be gaining on us.

Important Dates

GeoCongress Conference
Minneapolis, MN
February 25-28, 2020

YR5 CBBG Mid-Year Meeting
University of California, Davis
April 5, 2020: Student Retreat
April 6-7, 2020: Mid-Year Meeting

IAB-CBBG Leadership Meeting
Arizona State University
May 5-6, 2020

Research Highlights

Undergraduate Entrepreneur Makes Great Deal with Sharks



NMSU student, Pascual Camacho, pitched his invention and agreed with one of the sharks to a \$100,000 investment deal for 11% equity in his business during the fifth annual Aggie Shark Tank. The sharks are local investors and nationwide venture capitalists eager to see new businesses. The event was sponsored by the Hunt Center for Entrepreneurship and hosted by Arrowhead Center at New Mexico State University on October 3rd at the ASNMSU Center for the Arts.

Camacho's invention, Vita Health, is a dispensing device aimed at reducing the abuse of prescription medications. The funds raised will be used to further develop the device and the supporting cloud platform. Camacho's team includes a mechanical engineer and two experienced Doctors of Pharmacy. Learn more about Camacho's device, company and entrepreneurship experience at www.projectvitahealth.com and https://www.youtube.com/watch?v=nkp8misTo_A

Aggie Shark Tank is based on the popular Shark Tank television show and offers entrepreneurs working with NMSU Arrowhead Center's student business accelerator, Studio G, a chance to pitch their businesses to local business leaders for possible investment.

Camacho is a civil engineering senior at NMSU and New Mexico AMP Undergraduate Research Scholar in a CBBG project. His plans after graduation include a master's degree with emphasis in structural at Stanford University and a career at ExxonMobil.

CBBG Researchers at UC Davis Performed a Large Centrifuge Test to Further Evaluate the Seismic Response of MICP Treated Sands in a System Level



In October 2019, CBBG Postdoctoral researcher, Atefeh Zamani, led a large centrifuge test at UC Davis to evaluate the seismic response of MICP treated soils in system level. A centrifuge model was designed and prepared to study the efficiency of MICP treatment to reduce total and differential settlement of shallow foundations. The model was instrumented with vertical arrays of pore pressure transducers (PPTs), accelerometers (ACCs), and linear potentiometers (LPs) to measure the dynamic response of the soil during shaking. Shaking was performed by applying multiple shaking events of uniform 1Hz sinusoidal waves with progressively increased levels of peak base acceleration (PBA). Cone tip resistance of the soil was measured prior and after all shaking events. Preliminary results show that MICP treatment improves the liquefaction resistance of soils and mitigates the surficial effect of liquefaction. The total and differential settlement of MICP treated soil foundations decreased compared to the untreated soil foundation with the deeper treatment obtaining a larger reduction.

Field Trials on Microbially Induced Desaturation in Portland

In summer 2019, CBBG researchers at ASU, Elizabeth Stallings Young, Ed Kavazanjian and Leon van Paassen, joined forces with Arash Khosravifar and Diane Moug, of Portland State University to perform field trials on Microbial Induced Desaturation for liquefaction mitigation in the Portland area. The project was funded through an NSF RAPID grant and supported by several local authorities, consultants and contractors. Two sites along Willamette and Columbia river, containing alluvial silty sands, silts and clayey soils by circulating groundwater through injection and extraction and stimulating indigenous nitrate reducing bacteria to produce nitrogen gas bubbles and desaturate the soil by feeding them with a solution containing calcium nitrate and calcium acetate. Liquefaction mitigation at the field sites was evaluated by in-situ shaking using NHERI field equipment of University of Texas in Austin before and after treatment. After 5 weeks of treatment both sites showed significant desaturation. The preliminary results were presented to the local geotechnical community in a workshop in Portland.



Soil characterization in Portland (feat Elizabeth 2nd from the right)



Presenters at NHERI Workshop on Bio-based liquefaction mitigation in Portland September 10, 2019, including Ed Kavazanjian and Leon van Paassen



Big T-REX shaker demonstration by University of Texas got significant local news coverage

CBBG Partners with Industry for EICP Dust Mitigation Project

The EICP dust control project is in the field demonstration stage at one of two demonstration sites in Maricopa County. The project is being conducted in collaboration with Industry Partners Freeport McMoRan, Republic Waste Services, and the Salt River Landfill. The CBBG Team which includes the Healthy Urban Environment program of the ASU Global Institute of Sustainability is led by Nasser Hamdan.



Students and faculty from CBBG and ASU's Healthy Urban Environment calibrate dust collection sensors. Left to right: Matthew Fraser (faculty), Jason Miech (graduate student), Leslie Bautista (undergraduate student) and Miriam Woolley (graduate student).

EPA Webinar: Innovations in Remediation at the CBBG

In December, Dr. Ed Kavazanjian, Dr. Rosa Krajmalnik-Brown, and Dr. Anca Delgado were presenters in an EPA-sponsored webinar titled "Innovations in Remediation at the CBBG". An overview of CBBG environmental research and Industry Partner programs were given, followed by an in-depth presentation on bioremediation of chlorinated solvents. A case history on remediation of trichloroethene and perchlorate via application of innovative remediation techniques developed by CBBG researchers for a challenging Superfund site in the Phoenix metropolitan area was discussed as well. Presentation slides and an audio recording from the webinar are available online: <https://cbbg.engineering.asu.edu/education/webinar-series/>

SAB Member Highlight



Corale L. Brierley provides technical and business consultation in minerals bioleaching. She has over 90 technical publications and 5 patents and is internationally recognized. Her career comprises: 25+ years as an international consultant; ~2 years with Newmont Mining Corporation; 8 years managing Advanced Minerals Technology Inc., a metal's biotechnology company; and 10 years of applied R&D at New Mexico Institute of Mining and Technology (NMIMT). She is a member of the Society for Mining, Metallurgy & Exploration (SME) and has served on numerous boards, panels and committees for several organizations. She was inducted in 1999 as a member of the U.S. National Academy of Engineering (NAE) and is currently Vice President; NAE election is among the highest professional distinctions accorded an engineer. Awards include: NMIMT Alumni Association's Distinguished Achievement Award (1999) and the President's Medal (2018); American Institute of Mining, Metallurgical & Petroleum Engineers' James Douglas Gold Medal Award (2008); SME's Milton E. Wadsworth Award (2012); American Mining Hall of Fame 'Medal of Merit' (with James A. Brierley) (2014); Extraordinary Ordinary Woman, Montana State University (2018). Dr. Brierley has a Ph.D. (Environmental Sciences, University of Texas (Dallas)), M.S. degree (Chemistry, NMIMT). B.S. degree (Biology, NMIMT).



Elizabeth A. Edwards, PhD, P. Eng., Professor, Department of Chemical Engineering and Applied Chemistry, and Cell and Systems Biology (Status only), University of Toronto. Dr. Elizabeth Edwards holds Bachelor's and Master's degrees in Chemical Engineering from McGill University, Montreal, and a PhD degree (1993) in Civil and Environmental Engineering from Stanford University. She is internationally known for her work on anaerobic bioremediation, the application of molecular biology and metagenomics to uncover novel microbial processes, and the transition of laboratory research into commercial practice to develop bioremediation and bioaugmentation strategies for groundwater pollutants. Over the two decades, Dr. Edwards' research team has discovered and characterized novel microbial cultures such as the now commercial KB-1® consortium that metabolize pollutants previously thought to be recalcitrant. This discovery led to the founding of SiREM Laboratories (www.siremlab.com) in Guelph in 2002 that has been deploying bioaugmentation cultures and associated technologies for nearly two decades at hundreds of sites worldwide. She has received many awards including most notably an NSERC Synergy Award for Innovation with Geosyntec Consultants (2009), and the Killam Prize in Engineering (2016). She is a Fellow of the AAAS (2011) and was inducted into the Canadian Academy of Engineering (2011) and the Royal Society of Canada (2012). She is also the founding director of BioZone, a Centre for Applied Bioscience

and Bioengineering Research founded on principles of collaboration and openness and holds a Tier 1 Canada Research Chair in Anaerobic Biotechnology.



W. Allen Marr, PhD, PE, DGE, NAE. Dr. Marr founded and leads Geocomp, one of the foremost providers in USA of real-time, web-based performance monitoring of civil engineering structures, including dams, levees, deep excavations, retaining walls, tunnels, buildings, bridges and utilities. Allen also has extensive experience in testing to measure the mechanical properties of earthen materials, designing earth structures, determining the causes of poor performance of geotechnical structures, developing cost effective remedial measures for troubled projects, and risk management. He is a member of the US National Academy of Engineers and the Moles. He recently served as the President of the ASCE Academy of GeoProfessionals.



James K. Mitchell, Sc.D., P.E., Dist. M. ASCE, NAE, NAS. Jim Mitchell received his B.S. in Civil Engineering from Rensselaer Polytechnic Institute in 1951 and the S.M. and Sc.D. degrees from the Massachusetts Institute of Technology in 1953 and 1956. From 1958 to 1994 he was on the CEE faculty at the University of California, Berkeley, and served as Department Chair 1979-1984. His teaching, research and consulting activities focused on soil behavior, soil stabilization, ground improvement, lunar soil mechanics, environmental geotechnics, and mitigation of seismic risk. He joined the faculty at Virginia Tech in 1994 and now is University Distinguished Professor Emeritus and Consulting Geotechnical Engineer. He was the 2006 recipient of the ASCE Outstanding Projects and Leaders Award (OPAL) in Education. He is an elected member of the United States National Academy of Engineering and the National Academy of Sciences.



R. Kerry Rowe, O.C., PhD., D.Eng, DSc (hc), NAE, FRS, FEng, FRSC, FCAE. Educated at the University of Sydney (BSc, BE, PhD, D.Eng), Australia, Rowe worked with the Australian Government Department of Construction from 1971-1978, prior to immigrating to Canada. From 1979-2000 he was a professor, Associate Dean (Research and Graduate), and served 8 years as Chair of the Department of Civil and Environmental Engineering at The University of Western Ontario, London, Canada. From 2000 to 2010, he served as Vice-Principal (Research) at Queen's University in Kingston. Since 2010 he has held the Canada Research Chair in Geotechnical and Geoenvironmental Engineering at Queen's where he is also the Barington Batchelor Distinguished University Professor. His professional practice and research has covered contaminant migration through soil and rock, hydrogeological/geotechnical/civil engineering aspects of landfill design, containment and remediation of contaminated sites from the Arctic to Antarctic, geosynthetics (including geotextiles, geomembranes, geogrids, geonets etc.), hydro dams, tailings storage facilities and tailings dams, reinforced embankments and walls, tunnelling in soft ground, the failure of slopes and excavations, and piles in soft rock. He is a past President of the International Geosynthetics Society, the Canadian Geotechnical Society and the Engineering Institute of Canada. He has received numerous awards and been elected a Foreign Member of the US National Academy of Engineering and a Fellow of the

Royal Society (London, UK), UK Royal Academy of Engineering, the Royal Society of Canada, and the Canadian Academy of Engineering. He has been appointed an Officer of the Order of Canada (O.C.).



Professor **Vern Schaefer**, Ph.D., P.E. is the James M. Hoover Professor of Geotechnical Engineering in the Civil, Construction and Environmental Engineering Department at Iowa State University. He teaches a variety of courses in the civil engineering curriculum, primarily geotechnical engineering courses. He has a B.S. in civil engineering from South Dakota State University, a M.S. in geotechnical engineering from Iowa State University, and a Ph.D. in civil engineering from Virginia Tech. Prof. Schaefer has over 140 publications and numerous research reports from 52 funded research projects between 1987 and 2019, with research expenditures over \$9.5 million. Research sponsors include the U.S. National Science Foundation, numerous state departments of transportation, FHWA, SHRP 2, U.S. Geological Survey, and U.S. Bureau of Reclamation. His research interests include landslides and slope stability, foundations, earth retention systems, and ground improvement. As the Principal Investigator and Project Manager for the SHRP 2 R02 project Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform, Prof. Schaefer led a team of 12 researchers and over 40 graduate students in the development of a system for geotechnical solutions for transportation infrastructure between 2007 and the present time. GeoTechTools has been online for over six years and is a widely regard-

ed web-based information and guidance system for more than 50 ground improvement and geoconstruction technologies. His recent efforts include leading the update of the FHWA/NHI Ground Modification Manual released in late 2016 and partaking in the National Cooperative Highway Research Program (NCHRP) study on Geotechnical Asset Management for Transportation Agencies, just released in early 2019. Prof. Schaefer has been very active in committee work in ground improvement in the Geo-Institute as a long-time member of the Soil Improvement Committee (chair for six years), in the Deep Foundations Institute's Ground Improvement Committee, and as an executive member of TC 211 Ground Improvement, the ISSMGE committee.



Kenichi Soga is the Donald H. McLaughlin Chair in Mineral Engineering and a Chancellor's Professor at the University of California, Berkeley. He is also a faculty scientist at Lawrence Berkeley National Laboratory. He obtained his BEng and MEng from Kyoto University in Japan and PhD from the University of California at Berkeley. He was Professor of Civil Engineering at the University of Cambridge before joining UC Berkeley in 2016. He has published more than 400 journal and conference papers. His current research activities are Infrastructure sensing, Performance based design and maintenance of underground structures, Energy geotechnics, and Geomechanics. He is a Fellow of the UK Royal Academy of Engineering and a Fellow of the Institution of Civil Engineers. He is the recipient of several awards including George Stephenson Medal and Telford Gold Medal from the Institution of Civil Engineers and Walter L. Huber Civil Engineering Research Prize from the American Society of Civil Engineers. He is the chair of Technical Committee TC105 "Getechnics from Micro to Macro" of the International Society for Soil Mechanics and Geotechnical Engineering and is an editor-in-chief of ICE Smart Infrastructure and Construction Journal. He is a Bakar Fellow of UC Berkeley, promoting commercialization of smart infrastructure technologies.

Out & About

CBBG Museum Partnerships



CBBG IDEA staff have been actively developing our science center and museum partnerships. Willi Savenye, Claudia Zapata, Jean Larson, Mary Bankhead, and Kim Farnsworth met with representatives of the Arizona Science Museum and the Children's Museum of Phoenix, along with members of the STEM committees from the Junior League of Phoenix (JPL), who lead and coordinate many educational activities at both museums (thank you to Mary, who helped us contact these representatives).

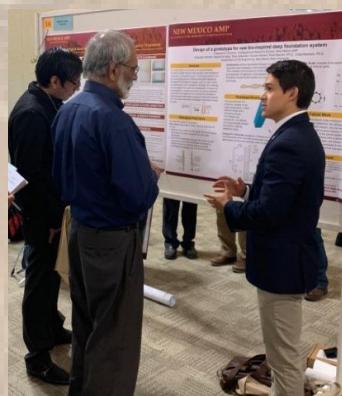


Subsequently Willi Savenye was invited to represent CBBG at the Arizona Science Center's "Educate to Innovate" Teacher Day for professional development, August 23, 2019, which was held at the Create makerspace building. Over 100 teachers participated, with most being from Title 1 schools. We were very fortunate to have a table in the Innovation Hallway, where lunch was served buffet style, so all the teachers and many Center staff and JPL volunteers were able to learn more about CBBG and our free biogeotechnical engineering curriculum materials.

Willi Savenye and Joe Springer were invited to visit with the JPL STEM Rockets group as they held their first fall First Fridays event at the Children's Museum of Phoenix, Friday, September 6, 2019. The JPL volunteers hosted several amazing STEM demos, and families had a great evening with them. Willi will be meeting with the Rockets group shortly to begin planning a CBBG demo at a spring First Friday event at the museum.

We will be developing demos and outreach curriculum materials that we will test with museums this year and, in years to come, will disseminate to other museums.

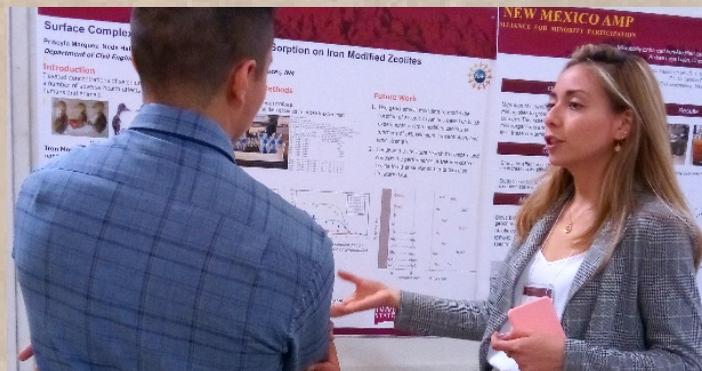
NMSU Undergraduates Present CBBG Research



Pascual Camacho presenting his CBBG research poster

Priscyla Marquez and Pascual Camacho presented their CBBG research posters at the New Mexico Alliance for Minority Participation (AMP) Student Research Conference, held at the Las Cruces Convention Center on October 11th. They are both civil engineering seniors at NMSU and New Mexico AMP's Undergraduate Research Scholars.

Priscyla's poster described her research on surface complexation modeling of selenium sorption on iron modified zeolites (Faculty mentor: Dr. Lambis Papelis). Pascual's poster described the design and bench-scale testing of a bioinspired pile prototype (Faculty mentor: Dr. Paola Bandini).



Priscyla Marquez presenting her CBBG research poster

Study Abroad, a Lifechanging, Fulfilling Experience for NMSU Student

Lucas Rivera, a civil engineering undergraduate at NMSU, took a break from his engineering curriculum and spent the fall semester abroad to learn the language of his parents and grandparents in a Spanish-immersion program in the historic city of Cusco, Peru. Soon after arriving to Cusco, Lucas sought out service opportunities in the community that was welcoming him. His trip soon took a deeper meaning and the experience reinforced his interest in pursuing the Peace Corps program after graduation and a master's degree with emphasis in water resources engineering.

Lucas also spent two weeks at an orphanage in Sucre, Bolivia helping with childcare, meal time, and many other duties

this fall. He raised over \$1,900 dollars for these children from friends, family, and even complete strangers. "The unconditional love from the amazing children I met at the orphanage changed my life!" said Lucas. "In the future, I want to use my engineering skills to lead water implementation projects for those who do not have access to potable water." In summer 2019, Lucas was one of the project managers of the Aggies Without Limits club that went to Guatemala to build a 2-mile-long water system for the small town of San Jose Lote 19, the only water source for this community. Previously, families in that town walked up to 5 miles round trip in mountainous terrain to access water.



Lucas with orphanage children during his trip to Bolivia

From a very small town in Northern New Mexico, Lucas hopes to serve as an example to individuals of similar backgrounds that international travel is an attainable goal and not to be discouraged. He has worked community service projects in seven countries. In spring 2020, Lucas will be project lead for a bridge maintenance project in Nicaragua through Aggies Without Limits.

Lucas is a junior in the NMSU civil engineering program and a New Mexico AMP Undergraduate Research Scholar. He is a member of the CBBG team that develops a method for runoff erosion control using enzyme induced carbonate precipitation at NMSU and is a co-author of a Geo-Congress 2020 paper with his graduate student mentor Rashidatu Ossai and faculty mentor Paola Bandini.



Lucas in the Ausangate Rainbow Mountains in the Peruvian Andes

ERC Biennial Meeting in Washington, D.C. - October 23-25, 2019

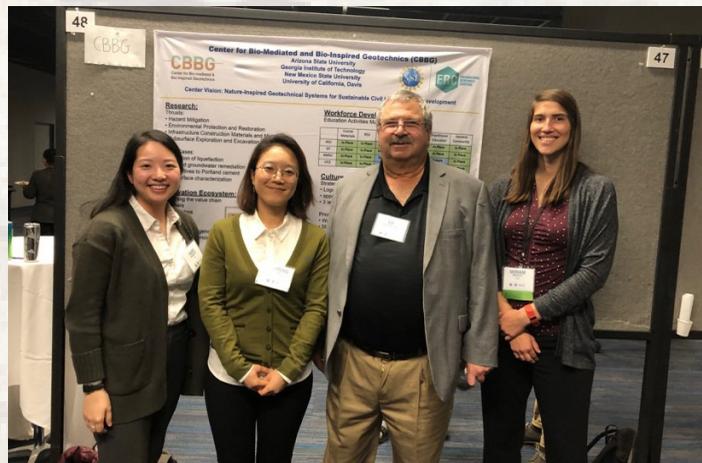
ERC Directors and students were invited to the 2019 ERC Biennial Meeting held in Washington, DC. on October 23-25. CBBG Center Director, Ed Kavazanjian, Administrative Director, Bob Brier, and Education Director, Jean Larson joined four CBBG students (outgoing SLC President, Peter Zelkowski, incoming SLC President, Boyoung Jeong, and graduate students Miriam Woolley and Karie Yamamoto).

Tri-ERC Workshop

Dr. Jean Larson, Education Director, and Dr. Megan O'Donnell, CBBG External Evaluator, facilitated a workshop with other members of the ASU Tri-ERC Consortium at one of the ERC Biennial Meeting breakout sessions. The interactive workshop entitled Establishing a Common Set of Tools for Evaluating Educational Programs Within and Across ERCs gave participants an opportunity to experience creating a joint instrument to evaluate ERC educational programs. Participants, using evaluation instruments they brought from their ERCs, underwent an abbreviated overview of the procedures used by the ASU Tri-ERC Consortium in creating a new instrument to measure the impact of ERC education programs.

CBBG Poster

CBBG Director, Ed Kavazanjian, and graduate students Karie Yamamoto, Boyoung Jeong, Miriam Woolley, and Peter Zelkowski (not pictured) presented a poster at the Biennial meeting sharing information about CBBG, our vision and research.



Perfect Pitch

After an internal competition, CBBG graduate student Miriam Woolley was selected to represent our Center at the Perfect Pitch competition during the ERC Biennial meeting. Miriam did an amazing job on her One-and-Done Carbonate Dust Control pitch and made us all proud!



ASTA Workshop



Summer 2019 Mentor RET Scott Currier presented a hands-on concurrent session at the Arizona Science Teachers Association (ASTA) annual conference held on November 8, 2019 at the Challenger Space Center in Phoenix, AZ. RET Olivia Lansing, Education Director Jean Larson, Education Coordinator Kim Farnsworth and graduate student Miriam Woolley provided hands-on support during the session entitled Soil Castles. The workshop engaged K-12 teachers in a model activity, based on a CBBG lesson, creating soil castles using different types of soil. Scott Currier presented info about CBBG, his summer experience, and how such a hands-on activity can be implemented in science and engineering K-12 activities with students.



Updates on Seth Mallett



CBBG researcher Seth Mallett defended his PhD in October and began an appointment as a post-doctoral researcher at the Port and Airport Research Institute in Yokosuka, Japan. He was recently joined there for research meetings by his former advisor, CBBG Co-PI David Frost, for research discussions with CBBG collaborator, Dr. Satoshi Matsumura. While there, Frost and Mallett attended

a US-Japan Workshop on Resilience and observed the testing of a three-story reinforced concrete building on the E-Defense shake table. The picture below shows Seth ready to climb the structure post-shaking to observe damage patterns.

Katerina Ziotopoulou Lectures at National Chung Hsing University

Katerina Ziotopoulou, assistant professor at UC Davis in the department of Civil and Environmental Engineering, was invited to the National Chung Hsing University (NCHU) in Taichung, Taiwan to meet with faculty and to give three lectures. One of the lectures was on the "Bio-mediated ground improvement for liquefaction mitigation", which with help from Jason DeJong and Mike Gomez was a big success and attracted the interest of the attendees!



Ana Giraldo Silva and Ferran Garcia-Pichel Attend 2019 Annual Meeting of the Society for Restoration Ecology

Last summer, Ana Giraldo Silva and Ferran Garcia-Pichel organized a symposium on "Microbial Restoration Ecology" within the frame of the 2019 Annual Meeting of the Society for Restoration Ecology taking place in Cape Town, South Africa. The meeting was intended to highlight the role of microbes in ecological restoration, brought together speakers from five countries, and addressed the potential of using microbes for a good cause in areas ranging from arid to temperate lands, and in environments from arid soils to mine tailings. It was well attended, reportedly a "welcome surprise" to ecologists and practitioners in the field alike, spearheading much cross-pollination and still ongoing conversations and exchanges. To be continued...

Beachrock in Vietnam

Leon van Paassen (ASU) participated in a site visit to Hanoi, Vietnam to set-up a new project on “Beachrock, bio-inspired coastal erosion mitigation”. The project was initiated by Akiko Nakano, Assistant Professor at Kyushu University in Fukuoka, Japan and CBBG visiting scholar at ASU, and funded by the Japanese Society for the Promotion of Sciences (JSPS). Together with Vinh Pham (Assistant professor at Thuyloi University, Hanoi in Vietnam) they investigate natural ways to control coastal erosion along the coast of the Red River delta southwest of Hanoi in Vietnam. At the site we evaluated current erosion mitigation measures, investigated scour around bamboo pile foundations and got bio-inspired by sand bubbler crabs creating sand balls on the beach.



Research team from left to right (Akiko, Leon, Vinh)



Scour around bamboo pile (left), Sand bubbler crab (right)



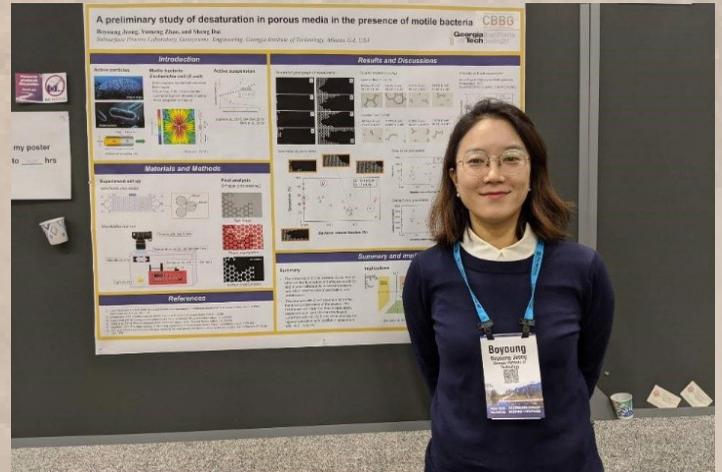
Current coastal erosion mitigation measures using sand filled synthetic geotubes (left), Current coastal erosion mitigation measures using concrete covered embankments and tetrapods (right)

GT PhD Students Study Abroad in France

CBBG PhD student researcher, Rodrigo Borela, has just returned from spending 3 months at Universite Grenoble Alpes in France where he was conducting X-ray CT experiments on peristaltic probes in granular materials. Similarly, CBBG PhD student researcher, Nimisha Roy, also spent 3 months at Universite Grenoble Alpes conducting X-ray CT experiments on granular assemblies. The goal of her research was to study the evolution of pores during shearing. While in France, Rod and Nimisha also attended the ALERT Materials Conference in Aussois and found some time to visit a few European landmarks.



Boyoung Jeong Presents Research at American Geophysical Union Meeting



CBBG graduate student researcher and SLC President, Boyoung Jeong, presented her research on “Desaturation in porous media in the presence of motile bacteria” during a poster presentation at session H33N: Pore-Scale Processes in Porous and Fractured Media: Recent Advances in Experimental and Computational Methods IV Posters at the AGU Fall meeting 2019 (9-13 December 2019) in San Francisco.

Education & Outreach

Dr. Jennifer Chandler Named CBBG Assistant Director for Diversity and Leadership

Dr. Jennifer Chandler has been named the CBBG Assistant Director for Diversity and Leadership. Dr. Chandler is a familiar member of CBBG as she has served on the IDEA Working Group since 2015 and has developed and conducted several mentoring and leadership training sessions for CBBG. For example, she led the development of the original *CBBG Mentor Guide* and leads the ongoing



advancements to it. Additionally, she conducted a workshop using her model for revealing and examining dominant social norms for CBBG participants. She has also conducted her workshop at several national conferences such as the *1st Annual Collaborative Network for Engineering and Computing Diversity (CoNECD)* Conference in Arlington, VA sponsored by the National Association of Multicultural Engineering Program Advocates (NAMEPA), Women in Engineering Pro-Active Network (WEPAN), the American Society for Engineering Education's (ASEE) Minorities in Engineering Division (MIND), and ASEE Women in Engineering Division (WIED) where Dr. Jean Larson also co-facilitated the workshop.

High Schoolers Learned About Engineering, Sustainability and Bioinspired Design



Twenty-six high school students, mostly from southern New Mexico, participated in CBBG's two-day activity on Bioinspired Resilient Earthen Construction this summer at NMSU. The participants learned about sustainability concepts, bio-inspired design, and infrastructure resilience. Dr. Brad Weldon facilitated this outreach activity during the 2019 NM PREP High School Academy, a two-week Pre-Freshman Engineering (PREP) summer residential camp for diverse, high-achieving students interested in engineering.

The students used their STEM knowledge and creativity to design and construct small-scale adobe walls, made of tiny soil blocks, incorporating bioinspired reinforcing elements using only natural materials and fibers. Their miniature adobe walls were tested on a shake table simulating earthquake loading to explore the mitigating effects of their designs against natural hazards. Teams gave presentations to explain their bioinspired designs to peers, teachers and student mentors. The participants included 85% ethnic minorities including Hispanic/Latino(a) students and 54% female students from various public and charter schools. CBBG graduate students Eduardo Davila and Judit Garcia were PREP mentors during this outreach activity. This engineering camp is organized and hosted yearly by Engineering New Mexico Resource Network of the NMSU College of Engineering with industry sponsorship, at no cost to the participants.



Phoenix College STEAM Day

Education Director Jean Larson and Education Coordinator Kim Farnsworth participated in Phoenix College's STEAM Day with the help of ASU CBBG graduate students Sri Mohana Rangan and Evelyn "Moni" Miranda. Jean and Kim shared information about CBBG programs and recruited potential REUs and RETs for the summer 2020 experience. Sri and Moni presented a live demo of bio-mediated remediation of contaminated water, answering questions about their research and CBBG. We had a great response from the Phoenix College community, a founding CBBG Educational Partner.



ASU Homecoming Block Party



Arizona State University CBBG faculty, students and staff participated in engineering outreach at the ASU Homecoming Block Party on November 23, 2019. Many people of all ages stopped by and were intrigued by the tactile activities. Big hits were the soil liquefaction demonstration performed with compressed air and the soft robotic razor clams. Participants included: CBBG Director Edward Kavazanjian, Deputy Director Claudia Zapata, faculty members Julian Tao, Leon van Paassen, and Hamed Khodadari, as well as, Education Director Jean Larson, Education Coordinator Kimberly Farnsworth, Senior Education Advisor Willi Savenye, and CBBG students Yong Tang, Sichuan Huang, Oniya Silas, Joel Ramirez, Ahmad Sayed Mostafa, Mayank Bagtharia, Vinay Krishnan, Alexandria Ardente, Robin Cheng, Yi Zhong and Amanda Clarke.



A Day in the Life of...Field Trip to CBBG



"A Day in the Life of... Field Trip Days" at ASU offers 3rd-12th graders a unique ASU experience. The students spent half a day rotating through a series of STEM-related activities on ASU campus with current engineering students as their guides. CBBG undergraduate, Jeremy Nez, and graduate students, Ahmad Sayed Mostafa and Mayank Bagtharia, shared information about CBBG and their research with Dr. Claudia Zapata on the use of rice husk ash to stabilize expansive soils. The team also provided a live demonstration of the steps to create sodium silicate from rice husks.

Association for Educational Communications and Technology Presentations

Willi Savenye made two presentations at the annual meeting of the Association for Educational Communications and Technology, including one with many CBBG researchers:

Savenye, W., Chandler, J. L. S., Larson, J., Farnsworth, K., Zapata, C., Bronner, C., Hong, Y-C., Archambault, L., Elwood, K., Nielsen, M., Strand, E., Spector, M., & Dalal, M., (2019). Building Up the Next Generation Through Mentoring: Lessons Learned and Best Practices from Three Perspectives. Paper presented at the annual meeting of the Association for Educational Communications and Technology, Las Vegas, NV, October 19-25, 2019.

Savenye, W. (2019). Implementation & Evaluation of Instructional Technology Projects. Part of a Presidential Panel Session, with Richard Clark and M. David Merrill – Reminiscing & Forecasting: Considering the Impact of Technology on Teaching, Learning and Instruction. Presentation at the annual meeting of the Association for Educational Communications and Technology, Las Vegas, NV, October 23, 2019.

Grad Student Updates



Neda Halalsheh completed her Ph.D. program (environmental engineering) at NMSU in May 2019. She joined the faculty of Hashemite University in Jordan as tenure-track Assistant Professor in the Department of Civil Engineering. Dr. Halalsheh's doctoral research studied the effects of geochemical conditions and microbial activity on selenium oxyanion transport in iron-coated porous media (Advisors: Dr. Lambis Papelis and Dr. Yanyan Zhang).



Enrique Asmar-Barbosa received his B.S. in civil engineering at NMSU in May 2019 and is now pursuing a master's degree in structural engineering at Stanford University. At NMSU, Enrique was recognized as the Spring 2019 Outstanding Graduating Senior (Civil Engineering). He competed at the NCAA Division I (Men's Tennis) for four years, earning multiple WAC (conference) titles and

two appearances in the NCAA Nationals. He was a CBBG research assistant in Dr. Cortes' lab.



Cyrena Ridgeway received her B.S. in civil engineering at NMSU in May 2019 and is currently a master's student. Her research is on Bioinspired Enhanced Geothermal Ground Heat Exchangers (Advisor: Dr. Douglas Cortes). Cyrena started her research involvement in Dr. Cortes' lab when she was a community college student and continued after transferring to NMSU main campus. She is the SLC

Outreach co-Coordinator at NMSU and serves in the Graduate Advisory Committee of the Department of Civil Engineering.



Eduardo Davila received his M.S. in civil engineering at NMSU in May 2019 and is now in the PhD program (Advisors: Drs. Brad Weldon and Paola Bandini). His CBBG research develops methods to increase resilience of earthen construction against weather and natural hazards while maintaining its sustainable and economic advantages. Eduardo is the SLC Graduate Lead at NMSU.



Sheldon John received his B.S. and M.S. (geotech) degrees at NMSU. Earlier this year, Sheldon joined DiGioia Gray Consulting Engineers & Scientists in Gilbert, AZ. His masters research started the development of the first generation of a utilitarian subterranean bioinspired geo-probe in Dr. Cortes' lab. Sheldon served as the SLC Graduate Lead at NMSU.



Annie Carrillo received her B.S. in civil engineering at NMSU in May 2019 and joined Souder, Miller & Associates (SAM). She is a US Army veteran and participated in the CBBG's Research Experiences for Veterans (REV) program with the mentoring of Dr. Cortes. Her team won 1st place award in the Open Task at the 29th WERC Environmental Design Contest with the project "Enhanced water recovery and membrane scaling

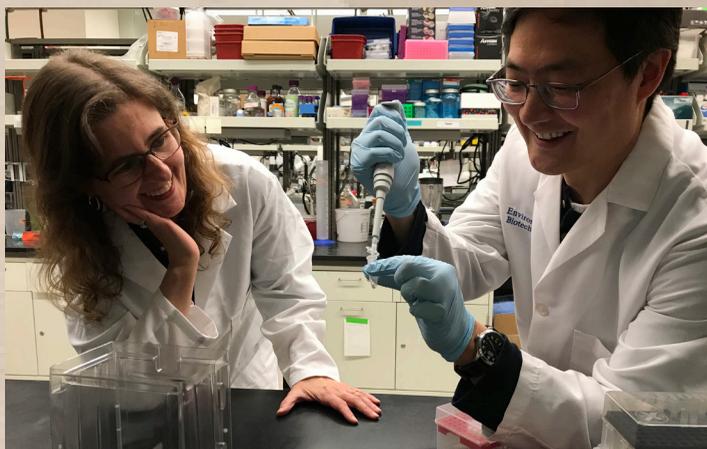
mitigation for desalination using innovative electromagnetic field (EMF) and 3D printed membranes."



Daehyun Kim completed his PhD program in civil and environmental engineering at Arizona State University in December 2019. His dissertation was titled "Pore-scale Study of Bio-mineral and Bio-gas Formations in Porous Media" and he was also involved in the CBBG EICP Fugitive Dust Control and Liquefaction Mitigation via Microbial Denitrification projects. For Daehyun's post-graduation plans, he has accepted a post-doctoral research scientist position at the Soil Mechanics Laboratory with the Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland.

Honors & Awards

Rosa Krajmalnik-Brown Named Recipient of Distinguished Alumni Award at UAM



Congratulations to Professor Rosa Krajmalnik-Brown, who received the Distinguished Alumni award from her alma mater, Universidad Autonoma Metropolitana, Iztapalapa (UAM) in Mexico!

Saenz Elected to Executive Council of the SPSSI



Congratulations to CBBG Diversity Director, Delia Saenz, who has been elected to the Executive Council of the Society for the Psychological Study of Social Issues, a premiere professional organization in Psychology.

Papelis Appointed CEMRC Faculty Fellow at NMSU



Professor Charalambos Papelis of New Mexico State University (NMSU) was appointed CEMRC Faculty Fellow. Prof. Papelis will be a liaison between the NMSU engineering faculty and staff and the Carlsbad Environmental Monitoring and Research Center (CEMRC) staff to foster joint research and academic opportunities.

CEMRC is a 26,000 ft² facility that conducts environmental and human health monitoring for the U.S. Department of Energy's Waste Isolation Pilot Plant (WIPP)—the nation's only deep geologic repository for defense-related transuranic nuclear waste. CEMRC also provides analytical assistance and laboratory space for Sandia National Laboratories, Los Alamos National Laboratory, and WIPP Laboratories. The WIPP facility is located about 40 miles outside of Carlsbad, NM. It is the world's only active nuclear-waste repository.

Mitchell Named 2019 McDonald Mentor



Prof. Martha C. Mitchell was named the 2019 McDonald Mentor by Tau Beta Pi, The Engineering Honor Society at the 114th Annual Convention in Columbus, Ohio, held October 11, 2019. The award celebrates excellence in mentoring and advising among Tau Beta Pi educators and engineers who consistently support the personal and professional development of their students and colleagues. McDonald Mentors have

shown true concern for individuals, supporting an environment for developing talents, and have earned respect and recognition for their contributions to their field and to the greater community. The award includes \$1,000, an engraved medallion, and pin, and an additional \$1,000 grant to the nominating New Mexico Alpha Chapter of Tau Beta Pi.

Dr. Mitchell is a professor in the Department of Chemical and Materials Engineering at NMSU. She served as CBBG Diversity Director (2015-2016) and Diversity Assistant Director (2016-2019). Congratulations!

CBBG Student Wins 2nd Place at the 16th Arizona Pavements / Materials Conference

Congratulations to Elizabeth Stallings Young for winning 2nd place for her research poster "MIDP Mitigation of Earthquake-Induced Liquefaction Portland Field Trial, Summer 2019" in the student poster competition at the 16th Arizona Pavements / Materials Conference.

CBBG REU Student Wins Award at American Geophysical Union Virtual Poster Showcase

Congratulations to former REU student, Victor Font Bartumeus, whose poster submission "Life Cycle Assessment of Earthen Construction Materials" won first place in the undergraduate poster showcase.

Willi Savenye Selected as Adjunct Graduate Advisor at University of North Texas

CBBG Education Advisor Willi Savenye has been selected to serve the Learning Technologies Distributed PhD program, in the College of Information Sciences at the University of North Texas, as an Adjunct Graduate Advisor. She is also serving on the Faculty Professional Development committee at the ASU Mary Lou Fulton Teachers College.

2019 Regina Sanborn Award Recipients

Regina Sanborn CBBG Student Awards were given to students for outstanding achievements during the fourth annual meeting on October 29-31, 2019:

Outstanding Volunteer Awards:

- Sichuan Huang (ASU)
- Karie Yamamoto (GT)
- Judit Garcia (NMSU)
- Maya El-Kortbawi (UCD)

Outstanding Research Poster Awards:

- **1st Place** – Kyle O'Hara (UC Davis) for the poster entitled *Cyclic Load Transfer at Snake-inspired Interfaces*
- **2nd Place** – Liya Wang (ASU) for the poster entitled *The Combined Effects of Biogas, Biomass and Biominerals on Permeability of Soils treated with MIDP*
- **3rd Place** – Sichuan Huang (ASU) for the poster entitled *Self-Burrowing Robot Inspired by Nature*

Alexandria Ardeno Selected as Fellow for FURI

Alexandria Ardeno, a CBBG undergraduate research assistant, was selected as a fellow for the Fulton Undergraduate Research Initiative (FURI) for Spring 2020. She will continue to work in Tao's group and her research topic will be on bioinspired burrowing robots. Congratulations!

CBBG Awarded and Filed Patents in 2019

Two patents awarded:

US10392767B2

Title: Soil Improvement by Carbonate Precipitation Using Agricultural Urease

Brief description: Soil strengthening/ improvement via carbonate mineral precipitation using plant derived urease

Institution: Arizona State University

US10399130B2

Title: Methods and Systems for In-situ Temporary Containment of Shallow Contaminated Soils

Brief description: Bioinspired and reversable in-situ containment of shallow contaminated soils.

Institution: Arizona State University

Provisional Patents Filed:

Title: Bio-inspired Deep Foundation Piles and Anchorage Systems

Brief description: Bio-inspired deep foundation piles and anchorage systems to enhance pile and anchorage capacities

Institution: New Mexico State University 2019

Title: Enzyme Extraction Methods

Brief description: Enzyme extraction methods used in biocementation systems and methods

Institution: Arizona State University

Title: Bio-inspired Deep Foundation Piles and Anchorage Systems

Brief description: Bio-inspired deep foundation piles and anchorage systems to enhance pile and anchorage capacities

Institution: New Mexico State University

Publications

- Al Aqtash, U. and Bandini, P. (2020). Wall thickness and water content contribution to the out-of-plane instability of adobe walls. REHABEND 2020: Proc., 8th Euro-American Congress on Construction Pathology, Rehabilitation Technology and Heritage Management, Granada, Spain. (In press)
- Altizer M, Delgado AG, Krajalnik-Brown R, Torres CI, Wang J, Cox E. The influence of electrokinetic bioremediation on subsurface microbial communities in perchloroethylene contaminated soil. Battelle Eleventh International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Palm Springs, CA, April 2018.
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- Cecillon S, Vogel TM, Altizer M, Delgado AG, Krajalnik-Brown R. Dehalococoides social networks in chlorinated solvent environments. Battelle Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies, Miami, FL, May 2017.
- Chen T, Delgado AG, Yavuz BM, Maldonado J, Zuo Y, Kamath R, Westerhoff P, Krajalnik-Brown R, Rittmann BE. Interpreting interactions between ozone and residual petroleum hydrocarbons in soil. Battelle Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies, Miami, FL, May 2017
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- Edgar, M., Ray, H., Grubb, D.G., van Paassen, L.A., Hamdan, N. and Boyer, T.H. (2019). "Removal of Phosphorus and Nitrogen from Impacted Waters via Mineral Precipitation and Microbial Transformation." *J. of Sustainable Water in the Built Environment*.
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- Mohana Rangan S, Ibrahim I, Delgado AG, Krajalnik-Brown R. Enriching microorganisms for metabolic chromium reduction. The First International Symposium on "Bio-mediated and Bio-inspired Geotechnics" (B2G), Georgia Tech, GA, September 2018.
- Mohana Rangan S, Mouti A, Delgado AG, Krajalnik-Brown R, Lowry GV, LaPat-Polasko L, Brenton H. Trade-offs in utilizing zero-valent iron for synergistic biotic and abiotic reduction of trichloroethene and perchlorate. Battelle Eleventh International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Palm Springs, CA, April 2018
- O'Donnell, S.T., Hall C.A., Kavazanjian E., Rittmann B.E. "Biogeochemical Model for Soil Improvement by Denitrification." *Journal of Geotechnical and Geoenvironmental Engineering*, vol. 145, no. 11, 2019.
- Ossai, R., Rivera, L., and Bandini, P. (2020). Experimental study to determine an EICP application method feasible for field treatment for soil erosion control. Proc., Geo-Congress 2020, Minneapolis, MN. (In press)
- Savenye, W. (2019). Implementation & Evaluation of Instructional Technology Projects. Part of a Presidential Panel Session, with Richard Clark and M. David Merrill – Reminiscing & Forecasting: Considering the Impact of Technology on Teaching, Learning and Instruction. Presentation at the annual meeting of the Association for Educational Communications and Technology, Las Vegas, NV, October 23, 2019.
- Savenye, W., Chandler, J. L. S., Larson, J., Farnsworth, K., Zapata, C., Bronner, C., Hong, Y-C., Archambault, L., Elwood, K., Nielsen, M., Strand, E., Spector, M., & Dalal, M., (2019). Building Up the Next Generation Through Mentoring: Lessons Learned and Best Practices from Three Perspectives. Paper presented at the annual meeting of the Association for Educational Communications and Technology, Las Vegas, NV, October 19-25, 2019.
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- Zhao, Z., Barnard, W., Carberry, A., Cook-Davis, A., Jordan, M., Larson, J., O'Donnell, M., & Savenye, W. (2019). Creating common tools to evaluate education and diversity impacts across three engineering research centers. 2019 IEEE Frontiers in Education Conference (FIE), Cincinnati, OH, October 16-19.

Industry & Innovation

CBBG Students Gained Industry Experience

S. Ali Aleali (NMSU Ph.D. student) interned four months in the Las Cruces office of Wood, performing geotechnical design under the supervision of a professional engineer.

Oscar Gallegos (NMSU civil engineering senior) was a 2019 summer intern for Granite Construction in Tucson, AZ. Oscar will graduate in December 2019 and plans to take a job in the civil infrastructure industry.

In Summer 2019, Pascual Camacho and Lucas Rivera (NMSU civil engineering seniors) were interns in ExxonMobil Corporation, Global Projects Division and Midstream Operations respectively. Both students plan to continue with their graduate education.

Judit Garcia (NMSU M.S. student) is a half-time co-op in the Engineering Department of the City of Las Cruces. She will complete her master's degree in the spring and will continue into the Ph.D. program.

In spring and summer 2019, Diego Garcia-Vera (NMSU M.S. student) worked in the field and office for infrastructure projects during his internship with MANS Construction.

New Industry Partner ArcelorMittal

ArcelorMittal is a global steel and mining company. ArcelorMittal supplies steel products in all major markets including automotive, construction, household appliances and packaging. ArcelorMittal is present in 60 countries and has an industrial footprint in 18 countries, which includes iron ore mining activities and steel production across the globe. They were the largest producer of steel in North and South America, Africa, and the European Union. ArcelorMittal has major research centers worldwide and with a budget of \$290 million in 2018.



Job Opportunities

The San Francisco Bay Area (Oakland) branch of Geosyntec is looking to interview outstanding candidates in Geotechnical Engineering for opportunities within our Geoengineering Group, working on projects in geotechnical and geoenvironmental engineering. We are also looking for geotechnical candidates in other offices around the country.

Geosyntec was founded in 1983 and is practice-centered and employee-owned. We provide technical leadership, innovation, and exceptional project execution in the fields of geotechnical and geoenvironmental engineering, environmental restoration and operations, natural resources management, and safety and risk evaluation, planning and mitigation. The experience, skill, and insight of Geosyntec's nationally recognized consultants within these practice areas are the reason for the firm's successful performance on sensitive, high visibility, technically challenging projects throughout the United States and abroad. Geosyntec ranks among Engineering News Record's Top 50 US Design Firms (#47) for 2019 based on gross revenues. Additional information about Geosyntec can be found on our website at <http://www.geosyntec.com>.

We are looking for candidates with a desire to become outstanding consultants. Interested applicants should have strong technical capabilities, an ability to write clearly and effectively communicate with others, a willingness to learn new concepts, and a strong desire to work within a collaborative team environment with other engineers and scientists. A Staff Engineer or Senior Staff Engineer in our Geoengineering Group can expect to be challenged with many of the following activities:

- Geotechnical Field Investigation
- Site Characterization
- Foundation Engineering
- Slope Stability Analysis and Evaluation
- Earthquake Engineering
- Landfill Design and Permitting
- Dam and Levee Engineering
- Construction Quality Assurance
- Development of Construction Documents
- Geosynthetics Design
- CAD Design
- Report Writing and Presentations

Interested applicants should apply online for the "Entry-Level Geotechnical Engineer" position in Oakland (#02223) at the job board, which can be reached by clicking the "Careers – Career Opportunities" link at <http://www.geosyntec.com>. Submissions should include both a cover letter and a resume.

Golder is an independent, 100 percent employee-owned company with a global reach that makes a local impact. We care deeply for each other, our clients, and the communities in which we live and work. We're driven to excel in our chosen markets through technical leadership and expertise. We have the following entry-level openings that may be of interest to CBBG students and friends:

Sacramento, CA - Civil Engineer I Intern

Position yourself for success by working side by side with global engineering and environmental industry experts. Learn from Ph.D.s, Fellows, Professional Engineers, Inventors, Project Management Professionals, and others eager to share their business acumen and technical expertise with you. Visit <https://www.golder.com/careers/> for more information and to submit an application.

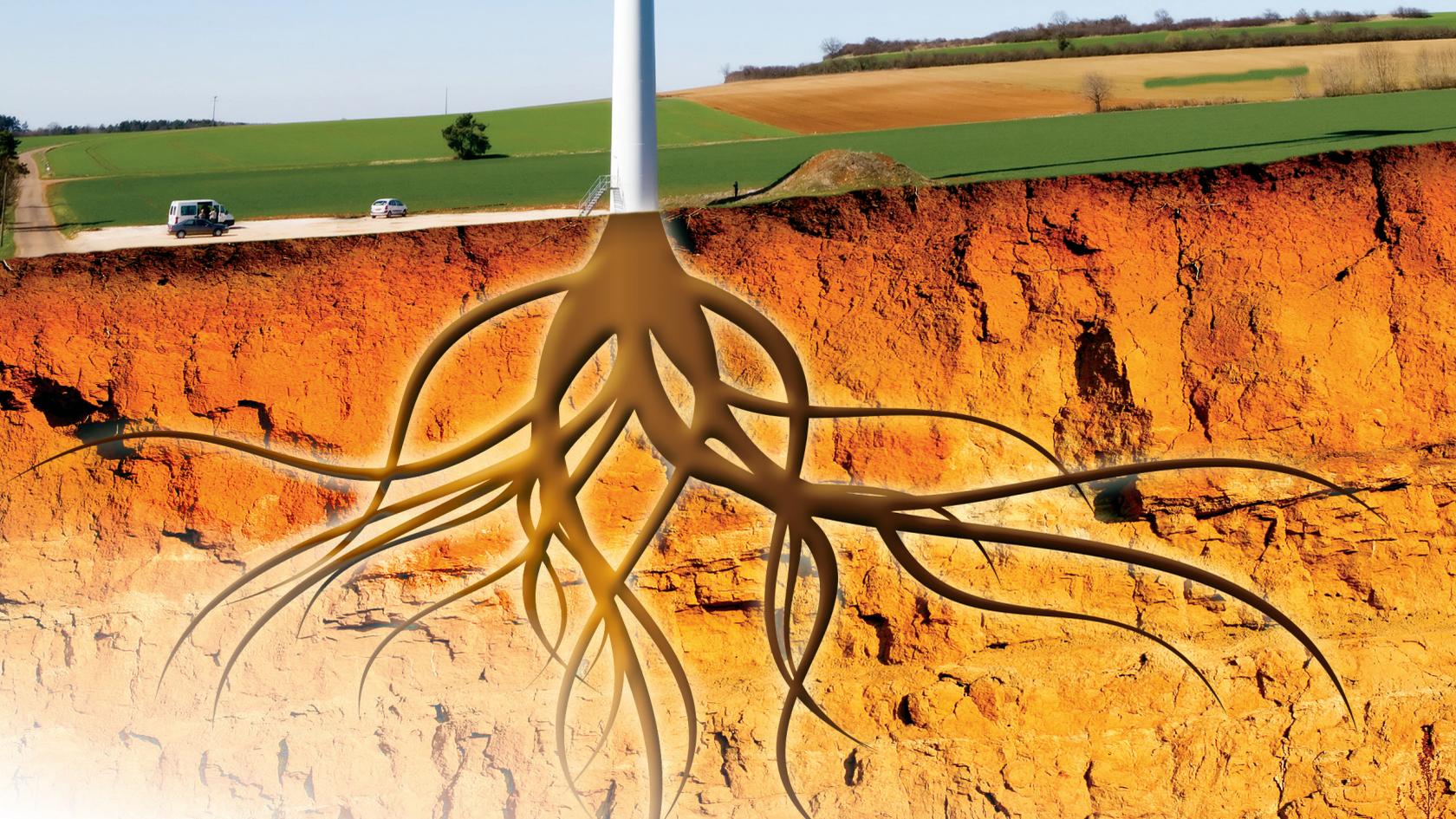
Partner Universities

UC DAVIS
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