



Center for Bio-mediated & Bio-inspired Geotechnics

Newsletter • Winter 2020 • Volume 17



As I See It: View from Director's Chair

The fall (and summer) of our disconnect (and discontent)

It has been a weird, and trying, summer and fall for all of us. We remain disconnected from our colleagues, friends, and family members due to the pandemic, and discontent has swirled around us from a variety of sources, including racial unrest and an election that is still playing out. As I write this, the restrictions imposed upon us due to COVID-19 on working in our labs and offices, on travel, on gatherings of any sort, and on many other aspects of our daily lives have hindered our productivity and reminded us, by the absence of inter-personal interactions, what a social animal we are. On top of these stresses on our psyche, we have had to deal with unrest due to the killing of George Floyd, a contentious presidential election, and the aftermath of the election in which partisan politics threatens to disenfranchise a large number of voters and undermine our democracy.

Given these circumstances, it has been difficult to stay focused entirely on our research enterprise, and perhaps justifiable not to do so. These external events are to some extent related and remind us of the importance diversity, equity, and inclusion play in our enterprise, our daily lives, and a just society. The protests surrounding George Floyd's death brought equity issues to the forefront of our thinking.

These equity issues have been brought to the forefront not only by inequities on how minorities are treated by some law enforcement agencies but also by the inequities associated with the impact of COVID-19 on our society, e.g., the disproportionate number of minorities affected by the virus and the disparity in medical care and educational programs available to minorities. Efforts to disenfranchise millions of voters across the US, not just in the aftermath of the recent election but in actions taken in a variety of states prior to the election, also disproportionately affect under-represented minorities.

Equity, of course, is intimately related to diversity and inclusion. At CBBG, we have been proud of the diverse and inclusive nature of our workforce, citing statistics showing CBBG to be at or above national norms in almost every category that is tracked in our annual report to NSF. But, that does not mean we cannot, and should not, be doing better, as many of these statistics show that while we are above norms for higher education research programs, representation of under-represented minorities in CBBG activities still lags the proportionate representation of these groups in the overall US population. While we have tried to address this inequity in recruiting student from under-represented groups through our various programs, including graduate research assistantships, research experience for undergraduates (REU), research experience for teachers (RET), and outreach programs, we have not really "moved the needle" since the inception of the CBBG. I think we have been successful in recruiting under-represented groups for our REU and RET programs, but we have still have a way to go in our graduate study programs, in particular with students of color.

Perhaps I am just being impatient and we need more time for our efforts at the REU and RET level and our outreach programs to have an impact at the graduate student level. But I don't think we can wait around hoping that this will happen. We have had discussions at the leadership level on how we can enhance

our graduate recruiting of under-represented students, but we have not come to any firm conclusions, other than it is even harder to do so now, prior to the era of COVID-19. We are open to any suggestions you may have on how CBBG can effectively recruit qualified students from under-represented groups for our graduate student research programs. Meanwhile, as we try to develop more effective programs for recruiting graduate students from under-represented groups, I think the members of our extended CBBG family are, and will continue to be, our best recruiters. I ask you all to spread the word on the exciting work we are doing and the fulfilling career opportunities available to students in our research programs.

May you all have a happy and healthy holiday season as we look towards a return to something close to normal in the second half of 2021.

Important Dates

2021 Mid-Year Meeting

April 11, 2021 - Student Retreat
April 12-13, 2021 - YR6 Mid-Year Meeting
Georgia Institute of Technology
Atlanta, GA

Research Highlights

IAB Member Haley and Aldrich Supports Two New Projects

Industry Partner Haley & Aldrich (H&A) is supporting two new CBBG projects through cash and in-kind support. On the first project, “Mole Rat Inspired Bidirectional Propeller for Self-Excavating Probes,” researchers are developing a robot that mimics the unique tunneling abilities of the mole rat, a technique that should facilitate optimization of horizontal directional drilling (HDD) practices. Geotechnical Engineer Carrie Layhee will lead H&A’s involvement in the project, working with CBBG Senior Investigator Chloe Arson. On the second project, “Enhanced Control of Microbial Activity and Substrate Delivery via Inhibitors for In-situ Contaminant Treatment,” H&A Senior Associate Engineer Jacob Chu will work with CBBG Senior Investigator Anca Delgado. On this project, researchers seek to develop methods for controlling subsurface microbial processes in space and time, reducing bio-clogging and allowing remediation treatments to reach areas farther downgradient.

“We are thrilled to partner with CBBG on these projects,” said Michael Basel, H&A’s liaison with CBBG. “Both projects show great promise for solving some of the toughest challenges our clients face in their geotechnical and remediation work.” [Additional details on both projects can be found elsewhere in this newsletter.](#)

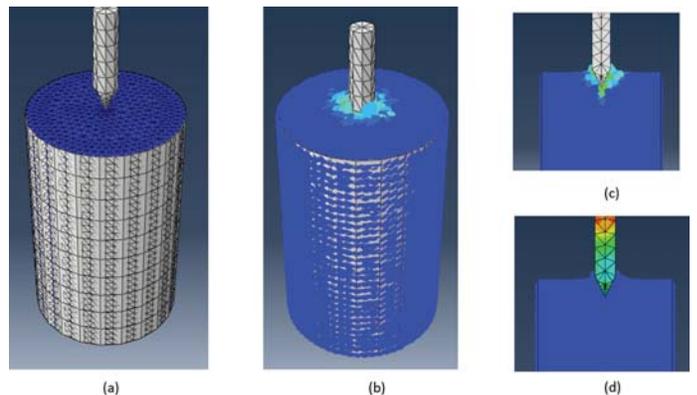
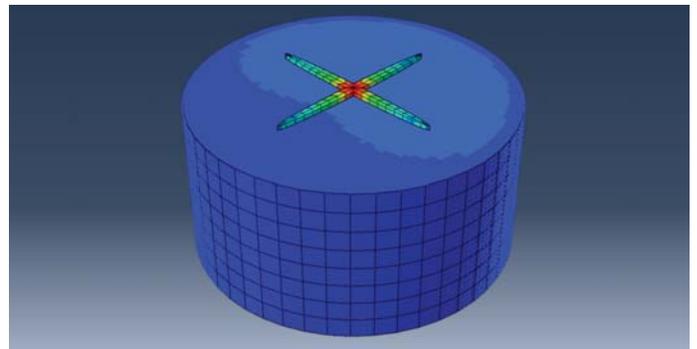
Enhanced Control of in-situ Contaminant Treatment

One of the two projects Industry Partner Haley and Aldrich is collaborating with CBBG on is our Enhanced Control of In-Situ Contaminant Treatment project. The project seeks to enhance control of microbial activity and substrate delivery for in-situ contaminant treatment by evaluating and selectively employing microbial inhibitors. Project Senior Investigator (SI) Anca Delgado and her Co-SI Jacob Chu from Haley & Aldrich and Nasser Hamdan (CBBG) hope to gain a better understanding of the inhibition mechanisms at work and use this knowledge to improve substrate distribution and utilization in the subsurface. During year 1, the project will focus on trichloroethene bioremediation through aerobic cometabolism. Trichloroethene is a regulated carcinogenic compound and among the most ubiquitous groundwater contaminants worldwide. The knowledge gained from this work has potential applications to other CBBG technologies that would benefit from improved substrate delivery including EICP, MICP and MIDP. The project Team also includes graduate research students Justin Skinner (lead) and Aide Robles and undergraduate student Alia Raderstorf.

Towards a Mole Rat - Inspired Bidirectional Propeller for Self-Excavating Probes

The second project on which CBBG researchers are collaborating with Haley & Aldrich is to understand why mole rats can move forward and backward with ease in the tunnels that they burrow. The project seeks to understand how mole rats anchor themselves in the soil to move uphill and downhill.

Answering this question will provide clues to the development of a bidirectional propeller for self-anchored probe retrieval by allowing the probe to move forward, backwards, and turn. The research team is developing a modeling approach that can be used to simulate anchor penetration and pull out at reasonable computational cost. The smoother particle hydrodynamics (SPH) method is used to simulate the soil close to the penetration zone where large deformation of soil takes place. The portions of the model where only small strains are generated (e.g., the far-field soil) are simulated by the finite element method (FEM) to improve the computational efficiency. FEM+SPH cone penetration simulations were benchmarked successfully against FEM results, which proved the concept of the proposed numerical approach.



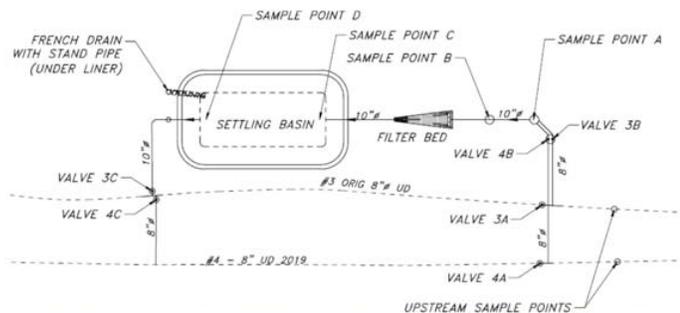
CBBG Project Moves from Laboratory to Field Demonstration

In October 2020, the CBBG completed construction of the first phase 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 phosphate (PO_4^{3-}) and nitrate (NO_3^-) levels in agriculturally impacted waters using CBBG technology.

CBBG Industry Partner Kunkel Engineering has provided civil design services and [\(continued on page \)](#)

Phoenix Services, a former CBBG Industry Partner, have provided materials for the treatment system. Local farmers and field specialists have assisted with field construction and data collection and a local community group, the Fox Lake Community Association, has provided \$10,000 to support the project.

The first phase of this field-scale demonstration utilizes a filter bed packed with steel slag, an abundant industrial byproduct from the steel manufacturing industry that facilitates calcium phosphate mineral precipitation by increasing pH and leaching calcium, magnesium, and iron. The filter is followed by a settling basin which allows for mineral precipitates to form and settle out of solution before the water is discharged, see images below.



Initial testing has shown the filter operated as intended and decreasing P concentrations were seen through the slag filter and settling basin. Since the ground thawed in March 2020, samples results have shown low PO_4^{3-} concentrations ($< 0.2 \text{ mg/L P}$) and high alkalinity ($> 200 \text{ mg/L CaCO}_3$). Chemical equilibrium modeling results show that increased calcium, magnesium, and iron concentrations from the slag are improving P removal, and precipitate formation is clearly visible in the settling pond shown below.



The filter will operate continuously until the pond freezes in the winter. During this time lab-scale experiments will be run in parallel to the field demonstration to provide insight on field results, and the design of phase 2 (NO_3^- removal) will occur. With high nitrate levels in the tile drainage water ($> 30 \text{ mg/L NO}_3^-$), a downstream denitrification system scheduled for construction in the spring will be a very beneficial addition to this demonstration. Key CBBG personnel on this project include co-Senior Investigators Treavor Boyer and Nasser Hamdan, and CBBG Ph.D. student Michael Edgar.

CBBG Rainfall Simulator Enters Calibration Phase

Construction of the Large Outdoor Rainfall and Infiltration Simulator (LORIS), one of the final pieces of CBBG research infrastructure, is now complete. The facility, located at the CBBG research station on ASU's Polytechnic campus, has entered the calibration testing phase prior to the start of



LORIS (Large Outdoor Rainfall and Infiltration Simulator) tipper with wind screening

experimentation to produce solutions to land erosion and surface water infiltration problems.

LORIS is the focus of research being conducted by CBBG researcher Eric Escoto as part of his doctoral studies in ASU's School of Earth and Space Exploration. Escoto, currently supported on a National Science Foundation Graduate Research Fellowship, has spent nearly three years designing and building the simulator to meet and exceed compliance with standards set by the American Society of Testing and Materials, known as ASTM. The simulator is designed to direct rainfall in specific amounts to a soil test bed. Infiltration of water into the soil, percolation of water through the soil, and runoff from the soil test bed will then be measured by sensors to determine the loss of sediment that is induced by erosion and the infiltration and storage of water in the soil.

Escoto's primary advisor for his PhD studies is Professor Enrique Vivoni, who holds appointments to both the School of Earth and Space Exploration and the School of Sustainable Engineering and the Built Environment. CBBG Director Ed Kavazanjian will co-Advise Escoto with Professor Vivoni.

Georgia Tech CBBG Student to Work on SiTS Project

GT PhD candidate Fernando Patino successfully defended his PhD in November, 2020. His advisor was Dr. Chloe Arson. His thesis was titled "Infrastructure network enhancement inspired by nature". Beginning in January, 2021, Fernando will be assuming a post-doctoral research position at Imperial College London working with Dr. Catherine O' Sullivan as part of the team working on the NSF-UKRI funded SiTS project that is being co-led by Dr. O'Sullivan (ICL) and Dr. Arson (GT). This SiTS project is a CBBG affiliated project that is seeking to develop a rapidly deployed multi-functional modular sensing system in soil.

Georgia Tech CBBG Student Poster Recognized at ASCE

Georgia Tech geosystems graduate students participated in the ASCE Georgia Section Geo-Institute Annual poster/fast-pitch event in November, 2020. A total of 6 posters were selected from amongst more than 35 submitted for recognition. Nine of the posters/fast-pitches were delivered by CBBG supported students. The presentations were judged by industry practitioners under three different categories. The top award in all 3 categories was awarded to CBBG students and 2 of the 3 runner-up awards were also awarded to CBBG students. In particular, CBBG students receiving awards were John Huntoon (root-inspired ground anchor), Karie Yamamoto (effect of obstacles on ant excavation behaviour), Shaivan Shivaprakash (using nanoparticles as microbial transport vectors), Yumeng Zhao (morphological advantage of angel-wing shells in rock drilling) and Rodrigo Borela (x-ray tomography of earthworm-inspired locomotion in sand).

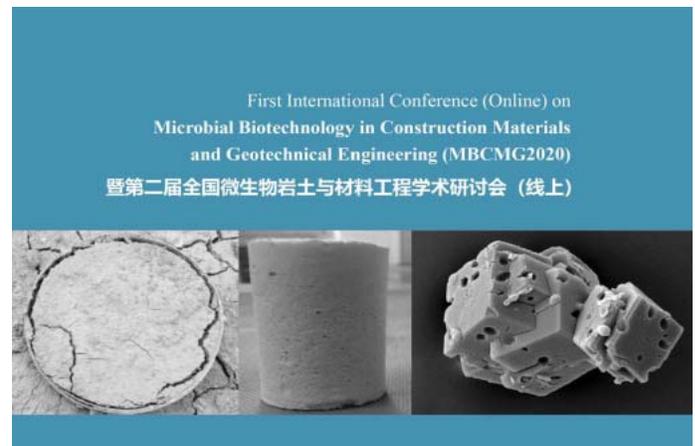
CBBG Student Part of UGA-GT Collaboration

Universite Grenoble Alpes (UGA) PhD Candidate Floriana Anselmucci who spent 6 months at Georgia Tech as part of the UGA-GT bio-geotechnics collaboration successfully defended her PhD in November, 2020. Her co-advisors were Dr. Luc Sibille (UGA) and Dr. Chloe Arson (GT). Her thesis was titled "Root-soil interaction: effects on soil microstructure".

Out & About

CBBG Researchers Give Keynote Lectures at MBCMG2020

Jason DeJong and Leon van Paassen were invited to give keynote lectures at the First International Conference on Microbial Biotechnology in Construction Materials and Geotechnical Engineering (MBCMG2020) at Southeast University, Nanjing, P. R. China, on 6 and 7 November 2020. Jason presented his most recent work on ground improvement using Microbially Induced Carbonate Precipitation by urea hydrolysis, Leon shared the results from the recent field trials on Microbially Induced Desaturation and Precipitation through denitrification. Former CBBG Ph.D. student Michael Gomez, now Assistant Professor at the University of Washington, was also invited to give a lecture at the conference. Mike presented his recent findings on the kinetics and crystal morphology of calcium carbonate precipitation through urea hydrolysis.



Education & Outreach

Phoenix College Virtual STEAM Days

CBBG education partner Phoenix College held its annual STEAM Days with a 2020 twist! The virtual event was held November 9th-10th, 2020 and CBBG was invited to participate in an asynchronous outreach format. In a virtual lobby, participants entered the Main Room (image below) where they could select different booths to view.



Take a look at CBBG's online booth below. A video from Director Ed Kavazanjian was shared about CBBG and biogeotechnics, as well as a video from Dr. Jason DeJong describing bio-mediation and bio-inspiration. Participants were also able to view online demos and download handouts. Overall, it was a great opportunity to continue to share information about CBBG in a socially distanced way.



Connecting Research to the Broader Community

CBBG successfully completed a 5-week, one-credit course across the four CBBG partner universities, delivered live to 28 graduate and senior undergraduate level students and a few students from U. of Washington. The course, taught by Drs. Sheng Dai (Georgia Tech), Alissa Kendall (UC Davis), Delia Saenz (ASU), Jennifer Chandler (ASU) and Jean Larson (ASU), included modules on Entrepreneurship, Life Cycle Assessment, Leadership, Diversity, Equity & Inclusion and Professional Development. Learning objectives for the foundational course for CBBG student researchers included protection of intellectual property and commercialization, conducting and critically interpreting a life cycle sustainability assessment, recognizing differences and inter-relationships between management and leadership, applying inclusive practices in the

classroom and work environment, and practicing networking and other skills needed to advance professionally.

This course will be offered annually and will be mandated for all new CBBG student researchers. As part of CBBG's commitment to continual improvement, Dr. Megan O'Donnell from CBBG's external evaluation team (ASU's College of Research and Evaluation Services Team, or CREST), surveyed the students on the final day of class and has provided immediate feedback to the team for enhancing the course next year.

CBBG RET Travis Martin's Students at Work on MICP for the Masses

Read more about the project here (<https://bit.ly/3mjfu00>) and how undergraduates from CBBG PUI Partner Lafayette College have been participating from various locations.



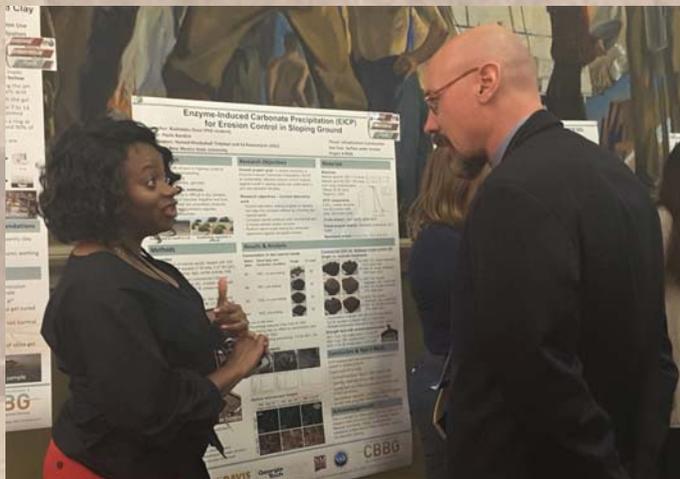
CBBG Students Soar in Virtual NMSU Research and Creativity Week Presentations

Seven NMSU students presented their CBBG research projects at the virtual 2020 Research and Creativity Week (RCW) in November. Four of these students placed in the top 10 of all student presentations (42 total) of the College of Engineering and received awards.

The student, their presentation, and placement are as follows:

- S. Ali Aleali, Bio-inspired Laterally Expressive Deep Foundations: Numerical Simulation, second place.
- Lucas Rivera, Design and Calibration of a Portable Rainfall Simulator for Soil Erosion Testing, tie for third place.
- Saeedeh Naziri, Bio-inspired Self-Excavating Solutions for Extraterrestrial Subsurface Exploration, tie for third place.
- Judit Garcia, Effect of Bio-Enhancements on Adobe Walls: Fiber Reinforcement and Biopolymer, eight place.
- Other CBBG student presenters are Rashidatu Ossai, Peter Zekowski, and Ishani Kulasekara. CBBG Senior Investigators Douglas Cortes and Paola Bandini are mentors of several of these students.

“This year has been particularly detrimental to the academic community because the outlets we typically use to share our research have been either canceled or postponed,” Cortes said. “The NMSU Research and Creativity Week came at the right time to give our students a chance to share their research work.”



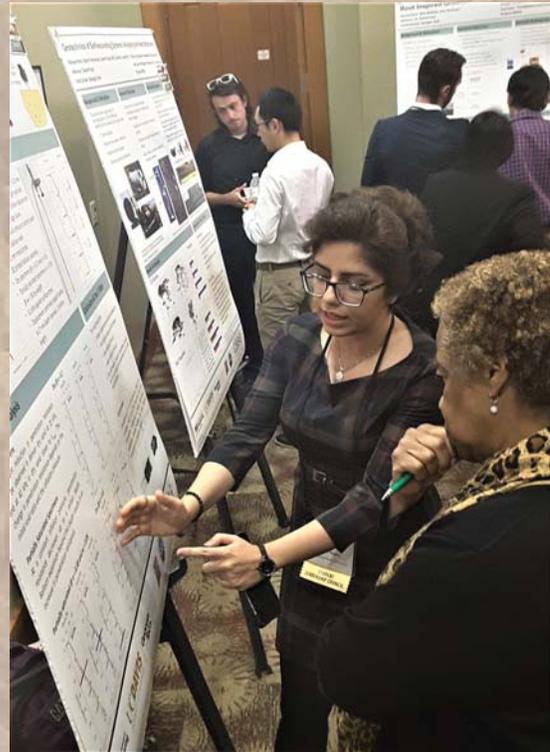
Rashidatu Ossai (NMSU) presents her poster at the 2019 CBBG Annual Meeting

The opportunity to present at the virtual RCW was also appreciated by the student researchers. “I am very pleased that there was a platform to share our research with other students and faculty in different majors at NMSU,” said Saeedeh Naziri, geotechnical engineering Ph.D. student and CBBG researcher advised by Dr. Cortes.

“I am very grateful for the opportunity to participate in undergraduate research in a CBBG project,” said Lucas Rivera, CE senior, New Mexico AMP Undergraduate Research Scholar

and CBBG undergraduate researcher mentored by Dr. Bandini. “I attribute my desire to further my education and pursue a master’s degree to the support from my mentors and my CBBG research work experience during my undergraduate program in civil engineering.”

Bandini said, “I strongly encourage our students to participate in events like the RCW. Sharing their findings with faculty and peers helps students develop presentation and analytical skills. Listening research presentations outside our field of study can be a powerful learning experience.”



Saeedeh Naziri (NMSU) presents her poster at the 2019 CBBG Annual Meeting

Honors & Awards

Delia Saenz Selected as 2020-21 ASU Graduate College Fellow



Congratulations to Delia Saenz, who was selected as the 2020-2021 Graduate College Fellow at Arizona State University! For further information about the Graduate College Fellows, take a look at this article: <https://bit.ly/2KjmTiN>.

Kavazanjan Selected as 2022 Terzaghi Lecturer



The American Society of Civil Engineers (ASCE) has notified CBBG Director Ed Kavazanjan that he has been selected as the 2022 Terzaghi Lecturer. Selection as the Terzaghi Lecturer is the most prestigious honor bestowed by ASCE for geotechnical engineering. Director Kavazanjan was cited for “significant contributions

to earthquake engineering, the design of waste containment systems, and in leading the emerging field of biogeotechnical engineering” by the selection committee. He has previously been recognized as the Peck Lecturer, with the Terzaghi and Middlebrooks awards, and as a Distinguished Member by ASCE. He will deliver his Terzaghi lecture at ASCE’s Geo-Congress 2022 in Charlotte, NC, March 20-23, 2022.

Narayanan Neithalath Awarded NSF AccelNet Grant



Congratulations to Narayanan Neithalath (ASU) and the 3DConcrete grant project team, who have been awarded \$2 million from the National Science Foundation to support their work and research into 3D concrete printing. For further reading about the grant, take a look at this article: <https://bit.ly/3aaU1Ec>

Jennifer Chandler Nominated for CCI Catalyst Award



Congratulations to Jennifer Chandler, who was a faculty nominee for the 2020 ASU CCI Catalyst Award. The CCI Catalyst Awards seek to honor individuals, groups, teams, organizations, and university programs that foster and promote diversity and inclusion at ASU and beyond.

Ferran Garcia-Pichel awarded 2021 D.C. White Award by the American Society for Microbiology



Congratulations to Ferran Garcia-Pichel (ASU), who was awarded the 2021 D.C. White Award by the American Society for Microbiology (ASM). The D.C. White Award recognizes individuals with distinguished accomplishments in interdisciplinary research and mentoring in the field of microbiology. For further reading about the

award and Professor Garcia-Pichel’s research, take a look at this article: <https://bit.ly/3mh8PDJ>.

Alejandro Martinez Selected as Winner for DFI Conference Paper Competition



Alejandro Martinez and Kyle O’Hara were selected as winners of the DFI Young Professor’s Paper competition for our paper entitled “Skin friction directionality in monotonically- and cyclically-loaded bio-inspired piles in sand.” This work is based on Kyle’s centrifuge pile load tests!

Katerina Ziotopoulou Named 2021 Recipient of the Arthur Casagrande Award



Katerina Ziotopoulou received the ASCE’s Geo-Institute 2021 Arthur Casagrande Professional Development Award for outstanding contributions to the advancement of constitutive models for soils in earthquake engineering applications, the promotion of validation protocols in nonlinear deformation analyses, and her dedicated ser-

vice to the mentoring of students and women through critical transitions in engineering.

Alena Raymond Receives UC Davis Prize for Excellence in Geotechnical Engineering



Congratulations to Alena Raymond, who received the UC Davis Prize for Excellence in Geotechnical Engineering (June 2020)!

IAB Leadership Highlight

CBBG Thanks Outgoing IAB Chair Dr. Tanner Blackburn



The CBBG Leadership Team thanks Tanner Blackburn Ph.D., P.E. from Industry Partner Keller for his exceptional service and commitment to the IAB and CBBG. Of course, Tanner continues to be involved in CBBG and Keller remains one of CBBG's Founding Members. Thank you, Tanner!

The IAB Chair for 2021 is Christopher Hunt, Ph.D., P.E., G.E., Geosyntec Consultants.



Dr. Hunt is a Senior Principal Engineer with Geosyntec Consultants, Inc., based in California, with over 20 years of experience managing and supporting a variety of geotechnical and earthquake engineering projects. His project portfolio includes foundation investigations and designs for pile-supported structures and shallow foundations, safety reviews for dams and levees, analysis and mitigation of landslides, and design and construction of landfills. He has performed geotechnical investigations and provided recommendations for facilities subject to liquefaction, lateral spreading, and other seismic hazards, and has worked on numerous seismic soil-structure interaction projects evaluating the effect of geohazards on existing structures and pipelines.

The IAB Vice-chair for 2021 is Michael Basel, Ph.D., P.E., Haley & Aldrich, Inc.



Michael Basel is a Principal Consultant for Haley & Aldrich, Inc. with over 30 years of experience evaluating and implementing soil, water, and air treatment technologies. Dr. Basel received his B.S. in Mechanical Engineering from Kansas State University and M.S. and Ph.D. in Mechanical Engineering from the University of California at Berkeley. He has assisted with the development of many patented technologies including in-situ thermal remediation, dual phase extraction, free phase product recovery, in-situ chemical oxidation, enhanced bioremediation, and adsorptive synthetic media for treatment of 1,4-dioxane and other compounds. Dr. Basel also has extensive expertise with integration of sustainability concepts with remedial solutions and coordination of projects with local communities, including aspects of community involvement, student education programs, and development of parks, green spaces, and wildlife habitats.

Recent Publications

- Al Aqtash, U., and Bandini, P. (2020). Influence of wall thickness and water content on the out-of-plane stability of adobe walls. *Infrastructures*, 2020, 5(9), 78.
- Al Aqtash, U. and Bandini, P. (2020). Wall Thickness and Water Content Contribution to the Out-of-Plane Instability of Adobe Walls. *Proceedings of 8th Euro-American Congress on Construction Pathology, Rehabilitation Technology and Heritage Management, REHABEND 2020, September 28-October 1, 2020, Granada, Spain.*
- Aleali, S. A., Bandini, P., and Newton, C. M. (2020). Multifaceted bioinspiration for improving the shaft resistance of deep foundations. *Journal of Bionic Engineering*, 5 (In press).
- Burrall, M., DeJong, J.T., Martinez, A., and Wilson, D.X. (2020) "Vertical Pullout Tests of Orchard Trees for Bio-inspired Engineering of Anchorage and Foundation Systems." Accepted for publication in *Bioinspiration and Biomimetics*.
- Khodadadi Tirkolaei, H.*+, Javadi, N.*+, Lakshminarayanan, V.*+, Kavazanjian, E., Jr. +, Hamdan, N.+ (2020) "Crude Urease Extract for Biocementation," *ASCE Journal of Materials in Civil Engineering*, DOI: 10.1061/(ASCE)MT.1943-5533.0003466
- Khosravi, A., Martinez, A., and DeJong, J.T. (2020). "DEM simulations of CPT measurements and soil classification." *Can. Geotech. J.*, Vol. 57, No. 9, 1369-1387. <https://doi.org/10.1139/cgj-2019-0512> *Editor's choice*

- Krishnan, V.*+, Khodadadi Tirkolaei, H.x+, Martin, K.K.+ , Hamdan, N.x+, van Paassen, L.A.+ , and Kavazanjian, E., Jr.+ (2020) "Variability in the Unconfined Compressive Strength of EICP-Treated "Standard" Sand," *Journal of Geotechnical and Geoenvironmental Engineering*, DOI: 10.1061/(ASCE)GT.1943-5606.0002480 (In Press)
- Ma, Y., Evans, T.M. & Cortes, D.D. (2020). "2D DEM analysis of the interactions between bio-inspired geo-probe and soil during inflation–deflation cycles." *Granular Matter*, 22, Article No. 11. <https://doi.org/10.1007/s10035-019-0974-7>
- Martin, K.K.*+, Khodadadi Tirkolaei, H.x+, Kavazanjian, E., Jr.+ (2020) "Enhancing the Strength of Granular Material with a Modified Enzyme-induced Carbonate Precipitation (EICP) Treatment Solution," *Building and Construction Materials*, DOI: 10.1016/j.conbuildmat.2020.121529
- Martinez, A., DeJong, J.T., Jaeger, R., and Khosravi, A. (2020). "Evaluation of self-penetration potential of a bio-inspired site characterization probe by cavity expansion analysis." *Can. Geotech. J.*, Vol. 57, No. 5. <https://doi.org/10.1139/cgj-2018-0864>
- Martinez, A., DeJong, J., Akin, I., Aleali, A., Arson, C., Atkinson, J., Bandini, P., Baser, T., Borela, R., Boulanger, R., Burrall, M., Chen, Y., Collins, C., Cortes, D., Dai, S., DeJong, T., Del Dottore, E., Dorgan, K., Fragaszy, R., Frost, D., Full, R., Ghayoomi, M., Goldman, D., Gravish, N., Guzman, I.L., Hambleton, J., Hawkes, E., Helms, M., Hu, D.L., Huang, L., Huang, S., Hunt, C., Irschick, D., Lin, H., Lingwall, B., Marr, W.A., Mazzolai, B., McInroe, B., Murthy, T., O'Hara, K., Porter, M., Sadek, S., Sanchez, M., Santamarina, C., Shao, L., Sharp, J., Stuart, H., Stutz, H.H., Summers, A.P., Tao, J., Tolley, M., Treers, L., Turnbull, K., Valdes, R., van Passen, L., Viggiani, G., Wilson, D., Wu, W., Yu, X. and Zheng, J. "Bio-inspired Geotechnical Engineering: Principles, Current Work, Opportunities and Challenges". Accepted for publication in *Geotechnique*.
- Mostafazadeh-Fard, S., Samani, Z., Bandini, P., and Shukla, M. (2020). "Effect Liquid Organic Fertilizer and Zeolite on Plant Available Water Content of Sand and Growth of Perennial Ryegrass (*Lolium perenne*)," *Journal of Soil Science and Plant Nutrition*. <https://doi.org/10.1007/s42729-020-00379-8>
- Moug, D.+*, Khosravifar, A.+ , Preciado, M., Sorenson, K.+ , Stokoe, K. + , Menq, F.+ , Zhang, B + , van Paassen, L.+ , Kavazanjian, E.+ , Stallings Young, E.+ , Wang, Y.+ (2020) "Field Evaluation o Microbially Induced Desaturation for Liquefaction Mitigation of Silty Soils," *Proceedings, 17th World Conference on Earthquake Engineering*, Sendai, Japan
- O'Hara, K.B., and Martinez, A. (2020) "Monotonic and Cyclic Frictional Anisotropy in Snakeskin-Inspired Surfaces and Piles." *J. Geotech. Geoenv. Eng.*, Vol. 146, No. 11. [https://doi.org/10.1061/\(ASCE\)GT.1943-5606.0002368](https://doi.org/10.1061/(ASCE)GT.1943-5606.0002368)
- Rangan, Srivatsan Mohana, Aatikah Mouti, Laurie LaPat-Polasko, Gregory V. Lowry, Rosa Krajmalnik-Brown, and Anca G. Delgado. "Synergistic Zerovalent Iron (Fe0) and Microbiological Trichloroethene and Perchlorate Reductions Are Determined by the Concentration and Speciation of Fe." *Environmental Science & Technology* (2020).
- San Pablo, A.C.M., Lee, M., Graddy, C.M.R., Kolbus, C.M., Khan, M., Zamani, A., Martin, N., Acuff, C., DeJong, J.T., Gomez, M.G., Nelson, D.C. "Meter-Scale Biocementation Experiments to Advance Process Control and Reduce Impacts: Examining Spatial Control, Ammonium By-Product Removal, and Chemical Reduction." *Journal of Geotechnical and Geoenvironmental Engineering* (2020).
- Xiao, Y, Stuedlein, AW, Pan, Z, Liu, H, Evans, TM, He, X, Lin, H, Chu, J and van Paassen, LA (2020), Toe-Bearing Capacity of Precast Concrete Piles through Biogrouting Improvement, *Journal of Geotechnical and Geoenvironmental Engineering*, 146, 12, doi: 10.1061/(ASCE)GT.1943-5606.0002404

Industry & Innovation

Groundwater Technology Soil Stabilization Project

CBBG Industrial partner Groundwater Technology B.V. teamed up with foundation specialists BE Inject (Franki Grondtechnieken BV) to pioneer a new injection technique for a project by Studio Marco Vermeulen in The Netherlands. To learn more about this landscape art project, take a look at this article: <https://bit.ly/3millwf>.



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.tech

ASU Ira A. Fulton Schools of
Engineering
Arizona State University