

# Center for Bio-mediated and Bio-inspired Geotechnics

How  
does  
nature  
do it?



NSF Award EEC-1449501





**The goal of the Center for Bio-mediated and Bio-inspired Geotechnics (CBBG) is to develop biologically based designs for geotechnical aspects of civil infrastructure systems, including:**

- ▶ **environmental protection and restoration**
- ▶ **hazard mitigation**
- ▶ **infrastructure construction**
- ▶ **subsurface exploration and excavation**

As a National Science Foundation (NSF) Engineering Research Center (ERC), the goal of the **Center for Bio-mediated and Bio-inspired Geotechnics (CBBG)** is to learn from nature how to harness or mimic natural biological processes to transform the engineering of geotechnical systems to mitigate risks and address challenges associated with urbanization, global climate change and use of natural resources.

## **CBBG Mission:**

- ▶ **To develop innovative technologies to serve civil engineering industry**
- ▶ **To educate and train future engineers in the multidisciplinary field of biogeotechnics**

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**Edward Kavazanjian, PhD, PE, NAE**

Regents' Professor and Ira A. Fulton  
Professor of Geotechnical Engineering  
Director, Center for Bio-mediated and  
Bio-inspired Geotechnics  
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**Edward Kavazanjian** returned to academia with an appointment at ASU in 2004 after 20 years in engineering practice. His industrial experience includes working for a large (over 2,000 employees) international firm specializing in civil infrastructure design; a small, entrepreneurial geotechnical specialty consulting firm; and 10 years with a geoenvironmental consulting firm that grew from 100 to over 400 people during his tenure. At the geoenvironmental consulting firm, he served on the board of directors, was discipline leader for geotechnical and landfill engineering, managed multidisciplinary engineering services contracts of up to \$8.4 million in value (for the City of Los Angeles Department of

Public Works), and managed geotechnical services on Superfund design/construct remediation projects with total value from \$13 million to over \$150 million. Professor Kavazanjian was elected to the National Academy of Engineering (NAE) in 2013 for his work as a consulting engineer, and in 2018 recognized as a distinguished member of the American Society of Civil Engineers (ASCE). He is widely recognized for his research on waste containment systems, seismic analysis and design of geotechnical features for transportation systems and in the emerging field of biogeotechnical engineering.

## Center for Bio-mediated and Bio-inspired Geotechnics

- ▶ **CBBG** is creating strong, bi-directional partnerships with small/medium/large businesses, nonprofit, government, and educational organizations. Its partners are integral contributors to the innovation pipeline. With academia, industry, and government working hand-in-hand, discovery will result in significant advances in the emerging field of bio-geotechnics.
- ▶ **CBBG** is providing state of the art education and training for today's and tomorrow's workforce, including K-12 outreach, pre-college and community college mentoring, and a robust interdisciplinary undergraduate and graduate university program.
- ▶ **CBBG** is committed to creating a culture of inclusivity. **Arizona State University, New Mexico State University, Georgia Institute of Technology,** and the **University of California, Davis** provide nationwide depth and breadth to CBBG efforts to reach out to under-represented groups. These four partner Universities are working together to create a diverse community of engineers and scientists that will transform geotechnical practice through development and implementation of biogeotechnical techniques.
- ▶ **CBBG** domain and discipline experts leverage fundamental science research, practice-oriented knowledge, and experience to develop innovative and cost-effective solutions to geotechnical challenges and provide entrepreneurial opportunities for our partners.

**Claudia Zapata** is an Associate Professor in the School of Sustainable Engineering and Built Environment and the CBBG Deputy Director. As Deputy Director, she is responsible for the CBBG program on Innovation, Diversity, and Education Activities (the IDEA program), including training of CBBG faculty and students in these areas and outreach efforts to broaden the participation of K-12 and under-represented populations in the field. These outreach efforts encompass more than 30 public events and three summer programs each year. Her technical expertise is related to unsaturated soil behavior, characterization of problematic soil properties, thermo-hydro-

mechanical behavior of soils due to static and repeated loading, empirical modeling of fluid flow and volume change of soils applied to pavement structures and residential foundation systems, and environmental effects on soil behavior. She is the past Chair of the Transportation Research Board committee on the Behavior of Unsaturated Geomaterials and current Guest Lead Editor for the Geosciences Journal. Her consulting expertise include the evaluation of airfield design procedures, forensic investigations of pavement failures, and the assessment of environmental effects on pavement design.



**Claudia Zapata, PhD**

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## ► Thrust 1

### Hazard Mitigation

The Hazard Mitigation thrust is currently focused on increasing soil resistance to earthquake induced-liquefaction and reducing the consequences if liquefaction does occur. This is being achieved through the development of bio-mediated technologies, including microbially induced calcite precipitation and microbially induced desaturation and precipitation. Experimental, numerical, and analytical tools are being used by microbiologists and geotechnical engineers to control the fundamental governing bio-geo-chemical processes, to evaluate the magnitude and uniformity of improvement from particle scale to field scale, and to develop models that will enable prediction and design for field implementation.



**Jason DeJong, PhD**

#### Thrust 1 Lead

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**Jason DeJong** is a Professor of Civil and Environmental Engineering at the University of California, Davis. DeJong is on the CBBG leadership team and serves as the CBBG Hazard Mitigation Thrust lead and the UC Davis Co-PI. DeJong was an early pioneer in the field of bio-mediated geotechnics, leading advancements in microbially induced calcite cementation and organizing international workshops to accelerate maturation of the emerging field of biogeotechnics. Through interdisciplinary collaborations his research has since expanded into other bio-mediated processes as well as into new bio-inspired geotechnical technologies. DeJong also has expertise in geotechnical site characterization, laboratory testing, equipment design, earthquake engineering, with research recently focusing on gravelly and intermediate soils. He has received several research awards, gives short courses on site characterization, and serves as a consultant on industry projects.

## ► Thrust 2

### Environmental Protection and Ecological Restoration

The Environmental Protection and Ecological Restoration thrust uses bio-mediated processes to remediate soil and groundwater contamination and manage contaminant migration through a combination of microbial and abiotic processes. Projects in this thrust are also looking at employing the same processes to precipitate minerals and reduce nitrates in surface water. Investigators use bench and full-scale demonstrations, often working in collaboration with industry partners, to develop and evaluate technologies and methods for integrated microbial and abiotic remediation.



**Rosa  
Krajmalnik-Brown, PhD**

#### Thrust 2 Lead

Professor, School of Sustainable  
Engineering and the Built  
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**Rosa Krajmalnik-Brown** is a Professor in the School of Sustainable Engineering and the Built Environment and the Swette Center for Environmental Biotechnology at Arizona State University. Krajmalnik-Brown is on the CBBG leadership team and serves as the CBBG Environmental Protection and Restoration Thrust lead, CBBG co-PI, and ASU campus lead. She is an international leader on bioremediation and on applying molecular tools to understand microbial community interactions. She has a PhD in environmental engineering from Georgia Tech. She was awarded an NSF CAREER award, selected as one of 40 under 40 leaders in Phoenix, and has funding for her research from many federal agencies including NIH, DoE, DoD, and NSF. She is author of three patents and more than 90 peer-reviewed publications. She specializes in molecular microbial ecology for bioremediation, the use of microbial systems for bioenergy production, and the human intestinal microbial ecology and its relationship to health and disease.



### ► Thrust 3

## Infrastructure Construction

The Infrastructure Construction Methods and Materials thrust focuses on the development and implementation of technologies for the construction of sustainable, resilient civil infrastructure. The thrust currently has two lines of emphasis: induced carbonate precipitation and bio-inspired soil reinforcement and anchorage. The projects in this thrust use purposefully designed laboratory- and field-scale tests, numerical modeling, and state-of-the art instrumentation and sensing tools to advance the research to field implementation. Projects in this thrust are working on test-pit and mid-scale prototype testing and are progressing towards field demonstrations at the systems level leading to adoption in practice.



**Paola Bandini, PhD**

#### Thrust 3 Lead

Associate Professor,  
Department of Civil and  
Geological Engineering  
New Mexico State University  
[Paola@nmsu.edu](mailto:Paola@nmsu.edu)

**Paola Bandini** is the Wells-Hatch Associate Professor of Civil Engineering at New Mexico State University (NMSU). Bandini is on the CBBG leadership team and serves as the Infrastructure Construction Thrust Lead, CBBG co-PI, and NMSU campus lead. She has MS and PhD degrees in civil engineering from Purdue University. Her current research focuses on the development of bio-mediated and bio-inspired methods for ground improvement and foundations; resilient earthen construction; sustainable use of new and recycled materials in geotechnical engineering; and experimental characterization of soils. Bandini is a licensed professional engineer (PE), former President of the New Mexico Section of ASCE, and former chair of two standing committees of the Transportation Research Board (TRB). She has filed two U.S. provisional patent applications from her research work.

### ► Thrust 4

## Subsurface Exploration and Excavation

The Subsurface Exploration and Excavation thrust seeks to use bio-inspiration to stimulate new ideas for development of transformational technologies for exploring and developing underground spaces. From sensing probes that are inspired by worms and clams to excavation techniques that seek to emulate the tunneling and chamber excavation approaches of ants and termites, projects in this thrust are using bench, test-pit and full-scale experiments along with advanced dynamic numerical simulations to develop and evaluate alternative technologies and methods that yield disruptive and energy efficient techniques for subsurface infrastructure development.



**David Frost, PhD**

#### Thrust 4 Lead

Professor, Geosystems  
Engineering, School of Civil and  
Environmental Engineering  
Georgia Institute of Technology  
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**David Frost** is the Elizabeth & Bill Higginbotham Professor in the School of Civil and Environmental Engineering at the Georgia Institute of Technology. He is CBBG Co-PI and Georgia Tech coordinator as well as lead of the Subsurface Exploration and Excavation Thrust. His research focuses on the development of digital data collection systems for studying subsurface infrastructure problems related to natural hazards at multiple scales and he has received two U.S. patents for multi-sensor systems he has developed. He has served on NSF supported post-disaster study teams in the U.S., Turkey, India, China, Chile and Japan as well as at the World Trade Center following the 9/11 attacks. He has graduated about 35 PhD students, half of whom have gone on to academic careers. He co-founded a software company that supplies and supports clients with field data collection tools developed by his research group. He is a Registered Professional Engineer in Canada and the U.S. and is a Fellow of ASCE.

# Benefits of partnership

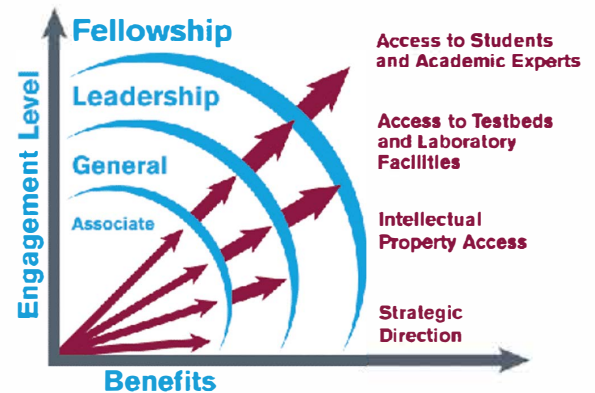
## Develop bio-mediated and bio-inspired solutions to address challenging geotechnical problems in a sustainable, cost-effective and environmentally sensitive manner.

- ▶ **Participate** in setting strategic direction for the Center, including:
  - Reduced overhead costs on research projects associated with the Center
  - Improved small business innovation research/small business technology transfer (SBIR/STTR) funding opportunities
  - Establishing research priorities
  - Development of cooperative research projects
  - Enhancing workforce development and diversity
- ▶ **Preferred access to students** via internships, poster sessions at the annual meeting, and a resume library.
- ▶ **Access to an exceptional team** of researchers with expertise in geotechnical and environmental engineering, microbiology/microbial ecology, biogeochemistry, chemical engineering, materials, and lifecycle analysis.
- ▶ **Early exposure to innovative ideas and technologies** and new developments through workshops, webinars, and direct contacts with center researchers.
- ▶ **Network** with like-minded small, medium, and large-sized businesses and top-tier international universities.
- ▶ **State of the art research facilities** and qualified staff attached to a project for a sustained time.
- ▶ **Competitive** reduction in licensing fees and royalties.
- ▶ **Engage** in cutting-edge research, working directly in state of the art labs with student and faculty researchers who are enabling infrastructure to become more resilient and sustainable.
- ▶ **Encourage students** to become 21st century successes, excited and motivated about Science, Technology, Engineering, and Math (STEM) education.
- ▶ **Facilitate** summer research experiences for high school and community college students through the Research Experience for Undergraduates (REU) and Young Scholars programs, and for K-14 teachers through the Research Experience for Teachers (RET) program.
- ▶ **Connect** with researchers and industry to provide webinars, workshops, demonstrations, and lab tours.
- ▶ **Collaborate** on the development of STEM-focused learning materials to foster STEM engagement centered on solving real-world problems.
- ▶ **Contribute** to an inclusive climate by fostering an understanding and awareness about underrepresentation, promoting skills-building in the practice of inclusion, and engendering an appreciation for the tangible value of diversity and inclusion within STEM disciplines more broadly.



# Interested in becoming a partner?

**The CBBG Industry partner program** engages geotechnical specialty firms, multidisciplinary engineer/architecture design firms, geotechnical specialty contractors, facility owners, and government agencies to provide input or research direction to CBBG investigators and on research priorities to the leadership team. **The Industry Partnership Program** is structured in a multi-level manner with benefits and privileges based upon membership level. Annual partnership fees start at \$2,000 at the General Membership level for small firms and go up to \$50,000 for larger firms at the Fellowship Membership level.



**Jafar Razmi, PhD**

**Industrial Liaison Officer & Research Professor**

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**Jafar Razmi** is the **CBBG Industrial Liaison Officer (ILO)**, and responsible for CBBG's industry collaboration and innovation programs. He is also a Research Professor in the School of Sustainable Engineering and the Built Environment Arizona State University (ASU). His work experience spans academia and industry, including more than a decade of industry experience in mechanical design, industrial construction and management, power stations, and Quality Assurance and Environmental Management Systems (EMS) auditing of industrial designs and processes.

Razmi's received his B.S. in Mechanical Engineering and M.S. and Ph.D. degrees in Civil Engineering from the James A. Clark School of Engineering at the University of Maryland at College Park. His research focused on engineering structures and infrastructure design under transportation, environmental, and other dynamic loads. His interests include material behavior, fatigue, and damage. He is also interested in Additive Manufacturing (AM) and its numerous applications such as in the fabrication of new materials, process optimization for AM of metals, and experimental characterization of metallic powders.



**Jean Larson, PhD**

**Assistant Research Professor**

School of Sustainable Engineering and the Built Environment, Arizona State University

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**Jean Larson** is the **CBBG Educational Director** and an Assistant Research Professor in both the School of Sustainable Engineering and the Built Environment and the Division of Educational Leadership and Innovation at Arizona State University. She has a PhD in Educational Technology, postgraduate training in Computer Systems Engineering, and experience teaching and developing curriculum in various learning environments.

Larson is experienced in the application of instructional design, delivery, and evaluation, and specializes in eLearning technologies for training and development. Her research focuses on the efficient and effective transfer of knowledge and learning techniques, innovative and interdisciplinary collaboration, and strengthening the bridge between K-12 learning and higher education in terms of engineering content.





Industry partners represent  
a wide range of local  
and international  
stakeholders, including:

**Large Corporations**  
**Engineering/Architect Firms**  
**Specialty Contractors**  
**Consulting Firms**  
**Start-Ups and**  
**Independent Consultants**  
**Public Agencies**  
**Not for Profits**  
**International Universities**

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**Center for Bio-mediated &**

**CBBG**

**Bio-inspired Geotechnics**

**ASU**  
Arizona State  
University

**UC DAVIS**  
UNIVERSITY OF CALIFORNIA

**Georgia**  
**Tech**

**NM**  
**STATE**  
UNIVERSITY



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