Summer 2017 Project Descriptions

Arizona State University

**Enzyme Induced Carbonate Precipitation (EICP) for Soil Improvement**

**Description:** The use of agriculturally-derived urease enzyme as a catalyst for precipitation of calcium carbonate in soils is being investigated as a practical alternative to the use of Portland cement to strengthen soil. Laboratory testing will be conducted to optimize the EICP solution "recipe" for various soil types. Field testing will be conducted to determine a practical way to inject EICP into the soil to create bio-inspired cemented columns for ground improvement. Work on this project will include preparation of EICP-improved soil specimens in the laboratory that will be strength-tested through destructive and non-destructive testing, optically analyzed through the use of a scanning electron microscopy, and analyzed for calcium carbonate content using analytical methods. The field testing component will involve physical activity in the Arizona summer heat as we will be preparing our test pit, preparing the solution, injecting the solution, monitoring cementation with geophysical methods, load testing the columns, and coring the columns for further analysis in the laboratory.

**Suggested Background/Interests:** geotechnical engineering, construction, sustainability

**Principal Investigator:** Dr. Ed Kavazanjian

**Student Mentor:** Kimberly Martin

**Fugitive Dust Control**

**Description:** Wind-blown soil particles, or fugitive dust, is a significant health hazard in the southwestern United States and many other parts of the world. Maricopa County is a designated as an air quality non-attainment zone by the US Environmental Protection Agency because of fugitive dust levels. Available methods for controlling fugitive dust include: using a water truck to keep the soil wet, which uses large quantities of potable water and vehicle fuel and is of limited effectiveness in the summer; application of a salt solution, which can adversely impact surface and ground water quality; and application of synthetic polymers, which are expensive and potentially toxic. In this project, the use of enzyme induced carbonate precipitation (EICP) is being explored as a “one-and-done” solution for fugitive dust control through use of the ASU/NASA Planetary Wind Tunnel (to develop an optimal EICP recipe) and a device that accelerates the ageing of materials using ultra-violet radiation (to evaluate durability).

**Suggested Background/Interests:** geotechnical engineering, wind erosion, fugitive dust control, biopolymer enhancement for soils (hydrogels)

**Principal Investigator:** Dr. Ed Kavazanjian

**Student Mentor:** Miriam Woolley

**Fluid Flow Models for Microbial Induced Carbonate Precipitation (MICP) for Soil Improvement**

**Description:** The use of the microbial denitrification process to precipitation of calcium carbonate in soil is being investigated as a practical alternative to the use of Portland cement to stabilize soil. Denitrification uses concepts from chemistry, biology, unsaturated soil mechanics and fluid flow analysis. Laboratory testing is being conducted to determine a method for determining the unsaturated permeability in a soil column as calcium carbonate precipitation occurs. Work on this project will include preparation of MICP-improved soil specimens, saturated and unsaturated permeability testing, development of soil water characteristic curves, and testing of engineering properties of MICP-improved soil.

**Suggested Background/Interests:** geotechnical engineering, fluid flow, microbiology, unsaturated soils

**Principal Investigator:** Dr. Ed Kavazanjian and Dr. Claudia Zapata

**Student Mentor:** Elizabeth G. Stallings
Biodeposition as a Surface Treatment Method to Increase Concrete Durability

**Description:** This study intends to explore if Portland cement based systems can be surface treated with biodeposition using carbonate precipitating bacteria to enhance the long term durability of such systems, especially in the built infrastructure. The idea is to develop bio-based coating systems for concrete subjected to chloride penetration, sulfate attack, and carbonation induced corrosion. The bio-based system will be compared to a system coated with sodium silicates. The waterproofing properties of the coating system including its microstructure and properties will be subjected to in-depth study using advanced characterization tools.

**Suggested Background/Interests:** Engineering students with interest in novel materials, mechanics of materials, and the application of civil engineering materials for unique applications. Should have a junior standing or higher, in civil, mechanical, chemical, or materials engineering.

**Principal Investigator:** Dr. Narayanan Neithalath

**Student Mentors:** Aashay Arora and Matthew Aguayo

Electrokinetic Transport for Ground Stabilization

**Description:** Electrokinetics can overcome the transport limitations that hinder utilization of other geoenvironmental technologies. It can extend the application of bioremediation and stabilization technologies to silt and clay soils, which previously required expensive and disruptive ex-situ remediation and environmentally taxing grouts. In particular, electrokinetic transport for ground stabilization promises to reduce costs, risk to human health and disruption to the site by avoiding expensive ex-situ technologies. The first step in applying this technology is understanding how species like calcium chloride and sodium bicarbonate are transported via electrokinetics and react in the subsurface. Work on this project will include bench scale column testing to investigate transport and geotechnical testing to measure the extent of ground improvement.

**Suggested Background/Interests:** environmental engineering, chemical engineering, geotechnical engineering, electrochemistry

**Principle Investigators:** Rosa Krajmalnik-Brown and César Torres

**Student Mentors:** Megan Altizer

The Role of Metabolic Chain Elongation in Carbon Cycling in Soils

**Description:** This study explores the ability of soil microorganisms to build complex, larger organic molecules from simple organic and inorganic substrates through the process of chain elongation. We seek to understand how metabolic chain elongation by soil microorganisms contributes to carbon cycling and sequestration in soils or how it affects bioremediation approaches through biostimulation with organic substrates. The laboratory testing will consist of anaerobic soil microcosm experiments with various biogeochemical characteristics and diverse microbial communities. Metabolic chain elongation substrates and products will be analyzed using liquid and gas chromatography techniques. Soil microbial communities performing chain elongation will be enriched and characterized through deep-sequencing.

**Suggested Background/Interests:** environmental engineering, microbiology, sustainability, soil microbial processes

**Principal Investigator:** Dr. Anca Delgado

**Student Mentors:** Sayalee Joshi