BIO-TRAPPING UREOLYTIC BACTERIA ON SAND TO IMPROVE THE EFFICIENCY OF BIOCEMENTATION

Thesis Defense

Elif Ugur

Montana State University
Department of Mechanical and Industrial Engineering
Bozeman, Montana

Tuesday, August 22
10:00 am
Roberts Hall 321

Microbially induced calcium carbonate precipitation (MICP) has emerged as a novel biocementation technique for its potential solution to sustainable construction. Although current MICP approaches made significant progress, achieving spatial control over biomineralization is a challenge due to its complexity which is affected by many factors such as microorganisms, reaction kinetics, and environmental factors. Spatially controlling biomineralization for building or targeted repair of materials can significantly improve efficiency and sustainability while achieving desired outcomes. The purpose of this thesis was to assess whether biomineralization can be enhanced through surface pre-treatment of sand using amino silanes, such as 3-aminopropyl-methyl-diethoxysilane (APMDES), which is one form of spatial control of biomineralization through prescribing the location of the microbes. Moreover, a preliminary study was conducted to assess whether biomineralized sand, with and without the APMDES treatment, can be recycled and reused for biomineralization of subsequent generations. The impact of APMDES treatment on bacterial adhesion on sand, growth, and urease activity was analyzed. Biocementation efficiency was evaluated by comparing compressive strength and calcium gain of APMDES-treated sand with untreated sand.

APMDES treatment promotes abundant and immediate trapping of bacteria on sand surfaces through increased electrostatic interaction that attracts negatively charged walls of bacteria to positively charged amine groups. While APMDES treatment compromises microbial viability, it preserves the urease enzyme for catalyzing urea hydrolysis. APMDES-treated sand achieved comparable strength with fewer bacterial injections compared to untreated sand. APMDES-treated sand biocemented using three injections of bacteria and cementation media gained the same strength as seven injections. Biomineral gain of APMDES-treated sand was similar compared to untreated sand, which shows calcium accrual in the structure may be influenced by additional factors, such as the distribution of calcite, differences in the calcite precipitation patterns, and morphology. Overall, APMDES treatment has the potential to improve the efficiency and sustainability of MICP by spatially controlling biomineralization.

Co-Chair: Dr. Chelsea Heveran/ Dr. Adrienne Phillips