Engineering With Nature Project Fact Sheet

Sustainable, Tunable, and Bioreceptive Cementitious Materials for EWN® Infrastructure Solutions

Background

The proposed solutions would contribute to multiple USACE Top Ten R&D Priorities, including (1) Mitigate and Adapt to Climate Change by providing material solutions to mitigate risks to shoreline and coastal areas, (2) Ensure Environmental Sustainability and Resilience by implementing a holistic approach to protect shorelines and their associated ecosystems, and (3) Modernize our Nation's Infrastructure by extending service life of shoreline and coastal reinforcement solutions.

Objectives

This project proposes to develop innovative concretes with environmentally sustainable alternative binders that deliver excellent chemical and mechanical resilience with significantly increased biological compatibility for freshwater and marine shoreline environments. Laboratory evaluations of four alternative binding materials will assess their mechanical and chemical durability, referenced to conventional portland cement concrete, and correlate analyses of microstructures to describe cementing phases, alkalinity, pore structures, and substrate surfaces. Based on these results, candidate concretes will be selected for field studies to evaluate in situ durability and bioreceptivity through establishing novel, standardized characterization methods, which will serve as a benchmark for the broader concrete community of practice.

Approach

Task 1 will focus on development and production of new environmentally efficient concrete materials including reactive glass binders modeled on ancient Roman concretes, CO2-infused binders as well as commercially available binders. In Task 2 will evaluate the mechanical and environmental durability of the trial materials after fabrication. Mechanical and chemical resilience of the bulk material will be quantified using traditional ASTM methods for strength testing, water absorption and permeability, chloride permeability, freezing and thawing cycles, and abrasion resistance. Task 3 will also apply an arc fracture test to gain insights into mechanical durability, regenerative repair processes, and interactions between mechanical damage and chemical decay — all significant determinants of service life. In Task 4, cured concrete samples will be deployed in freshwater or marine systems at select locations and incubated. Upon removal, samples will be subjected to the proposed analyses to quantify the total bioreceptivity and determine which species could be most compatible with the specific alternative concrete materials, structural configurations and hydrologic environments.

Outcomes

The project aims to demonstrate the successful performance of innovative concrete technologies that utilize alternative binders to produce ecologically friendly freshwater and marine shoreline structures. A multidisciplinary team of scientists and engineers will (1) develop and execute a comprehensive framework for laboratory-scale evaluation of mechanical and chemical resilience, durability, and bioreceptivity of trial concretes, (2) down select suitable candidate concretes for successful execution in specific environmental solutions, and (3) scale up and deploy the candidate concretes in field trials. Both environments and formulation details of the innovative concretes will be selected to maximize relevant properties and performance in structures designed to improve coastal resilience and enhance ecosystem development.

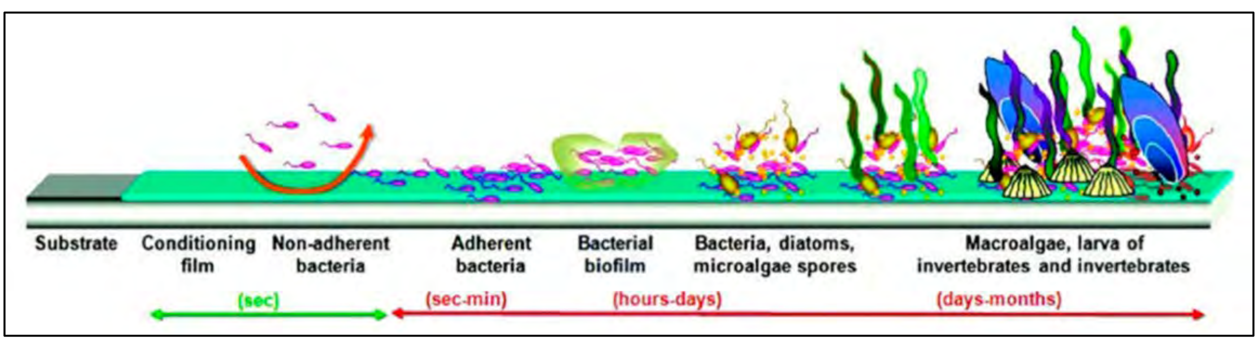

Figure 1. Schematic diagram showing bioreceptivity progression on a concrete substrate. Adapted from Hayek, M. et al, 2021, Influence of the Intrinsic Characteristics of Cementitious Materials on Biofouling in the Marine Environment: Sustainability, 13 (5), 2625.

Point of Contact: *Charles A. Weiss, Jr. (GSL)*

Charles.A.Weiss@erdc.dren.mil

601-634-3928