Engineering With Nature Project Fact Sheet

Removing "Artificial" from Artificial Habitat: 3D Printing Natural Materials to Unlock Complex Nature-inspired Infrastructure

Background

Figure 1. Conceptual model for 3D Printed Nature-Inspired Infrastructure using natural materials from small to large printing scales.

Engineering design focusing solely on geometrically simple functionality misses opportunities to realize nature-based ecological and societal benefits. Infrastructure planning would benefit from use of natural, locally available biocompatable materials and nature-inspired design to improve aesthetics and function for habitat creation and dissipation of storm energy to reduce flood risk. Traditional manufacturing constrains the creativity of engineers and scientists to generate nature-inspired infrastructure (NII). The design freedom of additive manufacturing (AM), or 3D printing (3DP), unlocks the potential to integrate geometrically complex structures needed to mimic nature. USACE requires dedicated focus, personnel and knowledge to advance the prospect of 3DP natural materials, including beneficial use of dredged material as printed feedstock for existing infrastructure enhancements and optimizing ecological and other benefits.

Objectives

3DP-NII structures using natural materials promote EWN® and USACE sustainable infrastructure goals for broadening social, environmental, and economic benefits (e.g., nutrient sequestration, habitat restoration, flood risk reduction, storm energy dissipation). The research need is to understand material selection feasibility, sustainability, resilience and process controls for achieving optimized 3DP structural morphologies to inform successful habitat functionality and biocompatibility to achieve EWN principles. The objectives are to establish interagency partnerships enabled by the unique principles and synergistic collaborations available in the EWN® community. This will foster intelligent planning and unlock the full ecosystem and infrastructure benefits of 3DP-NII through collaboration and demonstration of the use of natural material feedstocks to improve geometrically complex habitat design through hydrodynamic simulation.

Approach

The project delivery team will collaborate with partners to identify logical paths for various AM technologies and natural material feedstocks through stakeholder workshops. Technical work includes process modeling controls of green materials (e.g., plant extracts, printable sediments) for automated habitat creation, iterative improvements through physical habitat models and hydrodynamic simulation while determining the resiliency and life cycle in natural systems at different experimental scales. Project objectives will be accomplished by four interrelated tasks: (1) stakeholder workshops to identify and prioritize opportunities; (2) process modeling of biocompatible feedstock substrate selection; (3) iterative bio-inspired hydrodynamic/flume substrate feature design optimization; and (4) habitat structure life cycle efficacy and resiliency.

Outcomes

3DP-NII offers innovative opportunities to rapidly prototype diverse materials and geometries to optimize the final nature-based habitat feature performance through iterative design improvements. It promotes use of locally available natural materials that offer more environmentally sustainable solutions (e.g., beneficial use), or addition of material to existing designs that promote ecological enhancement, contaminant reduction and multifunctional anti-fouling material composites. Knowledge will be disseminated through presentations, publications, podcasts, and videos. A technology roadmap for suitable natural materials for printable nearshore habitat enhancements, including user guides, protocols, equipment and processing will be disseminated. Availability of such capability and materials provides the 2-prong benefit of readily available feedstocks to print infrastructure at the dredging site and cost savings by reducing the amount of dredged material that must be transported or managed.

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