Thesis Project Portfolio

3D-Printing a Concrete Canoe: Is it a Feasible Alternative to Canoe Construction?

(Technical Report)

SUSTAINABLE CONCRETE TECHNOLOGY ADOPTION

(STS Research Paper)

Commented [BS1]: Insert your STS Research paper title

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Yajaira Membreno Lara

Commented [BS2]: Replace with your full name (make sure it is bold!)

Spring, 2025

Department of Civil and Environmental Engineering

Table of Contents

Executive Summary

3D-Printing a Concrete Canoe: Is it a Feasible Alternative to Canoe Construction?

Sustainable Concrete Technology Adoption

Prospectus

Executive Summary

Introduction

The link between my capstone project and STS research lies in their shared focus on sustainability in construction. While the capstone addressed hands-on challenges in developing sustainable, post-tensioned concrete structures, my STS research analyzed how social and technical systems can shape the adoption of sustainable concrete technologies. Though the connection between the two projects is not one of direct collaboration, both explore pathways toward reducing the environmental impact of traditional construction practices with regard to concrete at different levels. My interest in the sustainability aspect of concrete during the capstone led me to question what sustainability innovations and materials are being used and how widely adopted they are and could be in the industry. This curiosity became the driving force behind my STS research, where I examined not just the technical potential of these materials but the broader dynamics that affect their integration into mainstream construction.

Capstone Project Summary

My technical capstone project focused on developing a post-tensioned, 3D-printed concrete canoe for the ASCE Concrete Canoe Competition. The goal was to create a sustainable, replicable method for constructing concrete canoes using additive manufacturing. However, technical limitations with the 3D printer required a shift toward sectional molding while maintaining the post-tensioning system as a key structural component.

The project was divided into three teams: Hull Design, Mix Design, and Construction. The Hull Design team developed geometric curves, performed structural and buoyancy analyses, and created digital models for 3D printing. The Mix Design team experimented with sustainable

and printable mixes using lightweight aggregates such as pumice, targeting a balance between strength, sustainability, and printability. The Construction team designed and tested a post-tensioning system using threaded rods and tubing embedded during casting.

The team ultimately produced a scaled prototype that demonstrates a viable alternative to a traditional mold-based construction. The project sets a foundation for future UVA teams to continue exploring 3D concrete printing as a sustainable and innovative construction technique.

STS Research Paper Summary

My STS research paper, Sustainable Concrete Technology Adoption, examines how sociotechnical systems facilitate or hinder the adoption of low-carbon concrete materials. Using the Social Construction of Technology (SCOT) framework, the research analyzes how different groups shape the perception and implementation of technologies like 3D-concrete printing, geopolymer concrete, and recycled concrete aggregates.

The study finds that technical merit alone does not guarantee adoption. Instead, successful integration depends on how social groups interpret the value and risk of each innovation. For example, while 3DCP is seen as efficient and eco-friendly by engineers, contractors often view it as risky and costly. Regulatory hurdles and a lack of standardization further slow adoption. Through a literature-based analysis and case studies, the paper emphasizes the importance of stakeholder alignment and social negotiation in transforming experimental materials into accepted construction norms.

Ultimately, the paper argues for targeted interventions, such as updated codes, financial incentives, and awareness campaigns, to bridge gaps between technical potential and real-world adoption, especially in the construction industry under increasing environmental pressure.

Concluding Reflection

Working on both the capstone and STS research projects simultaneously provided a deeper and more multidimensional understanding of sustainable engineering. The capstone allowed me to engage with the hands-on challenges of material selection, mix testing, and structural design, while the STS research contextualized these efforts within a larger sociotechnical system. I realized how technical innovations face barriers rooted in economics, regulation, and perception.

This integrated experience helped me see that engineering is never just about solving problems in isolation; it's also about navigating the societal systems in which those solutions operate. Through the capstone, I engaged directly with the technical challenges of designing sustainable concrete systems, while the STS research allowed me to step back and examine the structural and cultural barriers that influence the adoption of such innovations. I gained a better understanding of sustainability advances and a more critical approach to innovation.