Thesis Project Portfolio

Concrete Canoe

(Technical Report)

Social Implications of Sustainable Concrete in Haiti

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The convergence of engineering innovation and social analysis is where the most impactful solutions emerge. When addressing infrastructure challenges in vulnerable regions like Haiti both concepts must be considered in order to formulate a well-rounded solution. My capstone project and STS research paper, though distinct in their methodologies, are deeply interwoven through a shared focus on sustainable construction. While the capstone project tackled the technical development of a concrete canoe using low-cost, environmentally friendly materials and 3D printing, the STS paper explored the social, political, and economic barriers that influence the adoption of these same technologies in Haiti. Together, these projects address a central sociotechnical challenge: how to implement infrastructure solutions that are not only technically feasible but also culturally embedded and socially accepted. By working on both projects in tandem, I was able to explore how design choices, material testing, and construction methods interact with the broader systems of meaning, power, and trust that shape real-world adoption.

The capstone project focused on developing a 3D printed post-tensioned concrete canoe, intended as a proof-of-concept for sustainable, replicable concrete construction. The project began with the goal of using UVA's 3D concrete printer to fabricate a canoe in segments, which would then be joined using a post-tensioning system. This involved sub-teams dedicated to mix design, hull design, and construction methods. The mix team tested various aggregates and cementitious materials to create a lightweight, durable, and printable concrete. The hull design team developed the canoe's curves and geometry and explored the translation of CAD models into G-code for 3D printing. The construction team devised a method to join multiple printed segments while preserving structural integrity. However, due to equipment failures and limitations of the current 3D printer, the team pivoted to a mold-based approach, hand-casting sections while preserving the research on 3D printability, tensioning systems, and material sustainability. Despite the shift in execution, the technical project maintained its core goal: demonstrating a replicable method for building lightweight, scalable concrete structures with sustainable materials. This also provided knowledge that can inform disaster-resilient infrastructure design.

The STS research paper investigated why the adoption of sustainable concrete in Haiti has been inconsistent, despite its potential to improve affordability, durability, and environmental outcomes. Using the Social Construction of Technology (SCOT) framework, the research showed that the success or failure of sustainable infrastructure initiatives depends on how technologies are interpreted, accepted, and embedded within local practices. Through thematic analysis of different actors I was able to explore how interactions between NGOs, government officials, informal builders and local communities can assign different meanings to green concrete beyond its structural capabilities. These meanings often clash, with international donors emphasizing carbon reduction and innovation, while local builders prioritize familiarity, affordability, and speed. The analysis revealed that alignment between technological innovations and social values is essential for meaningful adoption. Rather than viewing green concrete as a purely technical solution, the research positions it as a socially constructed tool whose success depends on participatory design, trust-building, and community engagement.

Working on both projects simultaneously created a connection between technical problem-solving and social inquiry. The hands-on process of mix development and structural analysis in the capstone gave me a clearer understanding of the physical challenges involved in adopting sustainable concrete technologies. For example, our difficulty in identifying workable lightweight aggregates and the unreliability of the 3D printer mirrored real-world supply chain issues in Haiti, where sustainable materials may be technically sound but logistically inaccessible. At the same time, my STS research sharpened my awareness of how technical innovations can fail if they don't align with the needs and values of those expected to use them. These ideas motivated myself along with the rest of the capstone team to think beyond technical performance. Our team made a conscious effort to explore materials that are not only strong but also locally available and affordable. Those efforts offered insight into some of the difficulties and benefits that go into making concrete without the ability to access premium grade aggregates.

Ultimately, the concurrent development of these two projects allowed me to approach infrastructure challenges not just as an engineer, but as an actor embedded within the system. I gained a deeper appreciation for the non-technical forces such as policy, culture, and power that shape how technologies travel from laboratory to field. The capstone project provided a tangible context in which to explore sustainable materials and construction strategies, while the STS paper helped me frame those efforts within a broader sociotechnical narrative. Together, they taught me that solving real-world problems requires more than technical expertise; it requires a commitment to understanding and working within the social worlds where those problems exist. This integrated approach not only enriched both projects but also shaped how I will think about engineering solutions going forward: as tools that must be technically sound and socially meaningful.