Thesis Project Portfolio

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

(Technical Report)

Decarbonizing Concrete and The Push for Clean Energy

(STS Research Paper)

An Undergraduate Thesis

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The Concrete Canoe Capstone team led advanced research and development in 3D printed concrete (3DPC) to develop the first ever process for designing and building a 3D printed post-tensioned concrete canoe. The team consists of three sub-teams: Mix Design, Hull Design and Construction. The developments made by all teams will be used to create a repeatable process for creating a full-size, 3D printed, post-tensioned, concrete canoe.

The Mix Design team was tasked with researching, developing, and testing a concrete mix design that adheres to construction standards while also being printable. They made multiple mix tables; performed compression, flexural beam, and dog bone testing; and mixed the concrete that was used in molding the canoe. Through this research and mix testing, the Mix Design team accumulated valuable knowledge on lightweight printable aggregates.

The Hull Design team designed and analyzed the shape of the canoe hull. The team formulated curve equations, modeled the canoe in AutoCAD, and performed structural and buoyancy calculations. The calculations included stresses and strains, freeboard, and volumes and weights of different canoe types. They also designed a reusable mold that could be used to replicate the process of 3D printing concrete canoes.

The Construction team designed the canoe molding process and the post-tensioning system that was used to attach the molded pieces of the canoe. They designed a solution for successfully attaching the molded pieces, so that the canoe remained strong and hydrodynamic.

The construction analysis included performing post tensioning calculations, spacing calculations, and torque wrench calculations. At the end of the process, the Construction team oversaw the creation of the final prototype.

STS Project Abstract

My research focuses on exploring the potential for reducing carbon emissions in concrete production by focusing on one construction method. This practice includes altering the types of aggregates used in concrete mixes for construction purposes. Specifically, I examine the feasibility and environmental benefits of replacing conventional aggregates with low-carbon alternatives, such as recycled aggregates or those derived from sustainable sources. I also aim to explain how sustainable aggregates help decarbonize concrete practices and how they positively affect local communities and global markets while creating a push for clean energy sources.

My thesis suggests that by shifting towards sustainable aggregate options, the construction sector could significantly reduce its carbon footprint. In turn, this reduction in emissions could create a broader transition to clean energy sources. The objectives of this study are to identify the environmental benefits of different aggregate alternatives, assess the positive impacts of their use, and analyze the potential economic and policy changes needed to implement this alternative solution on a large scale. The significance of my research is in its ability to influence sustainable construction practices globally, offering a pathway towards a low-carbon future for the building sector. By analyzing the environmental benefits of low-carbon construction, my research may encourage a broader shift in policy and investment, ultimately leading to a more integrated, sustainable energy system that includes clean energy production and sustainable construction practices.

STS and Technical Project Relation

Both my research and the Concrete Canoe Capstone project focus on improving concrete construction methods with a larger emphasis on sustainability and long-term impact. The capstone team worked on developing the first-ever process for building a 3D printed, post-tensioned concrete canoe, combining design with new construction practices. This project was developed by three main teams including Mix Design, Hull Design, and Construction which all aimed to create a repeatable, efficient, and durable building process. The Mix Design team, in particular, developed and tested concrete mixes using lightweight, printable aggregates. This directly connects to my research, which focuses on how changing the types of aggregates used in concrete can reduce carbon emissions and support cleaner construction practices.

While the capstone project was focused on a single prototype, the work completed supports the larger goals of my study by showing how new materials and methods can be successfully applied. My research looks more broadly at how sustainable aggregates, such as recycled or low-carbon alternatives, can reduce the environmental impact of concrete. I also explore how these changes could influence policy, benefit local communities, and support a transition to clean energy systems. In this way, the capstone project provides a real-world example of how innovative materials and construction processes can contribute to more sustainable practices in the industry.

Together, both projects highlight different parts of the same solution. The Concrete Canoe team shows how these ideas can be applied in a practical setting, while my research looks at how they can create impactful change throughout the construction sector. By combining hands-on experimental work with environmental research, they are both working toward a future where concrete construction is not only more efficient but also more sustainable.