Concrete Canoe

(Technical Paper)

Social Implications of Sustainable Concrete in Haiti

(STS Research Paper)

A Thesis Prospectus

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On my honor as a university student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction: Sociotechnical Problem/Challenge

Haiti has endured numerous natural disasters, including the devastating 2010 earthquake that killed 200,000 people and displaced 1.5 million. Situated on a fault line between the North American and Caribbean tectonic plates, the country frequently experiences destructive earthquakes that leave communities in urgent need of resilient and sustainable infrastructure. However, Haiti faces critical challenges, including a lack of durable, affordable housing compounded by economic constraints and environmental vulnerabilities. This Prospectus explores the technical and societal barriers that have prevented the development of infrastructure capable of protecting Haitian communities and asks: ***How can low-cost, environmentally friendly concrete help build stronger communities in Haiti?*** The technical project centers on 3D printing a concrete canoe, serving as a proof-of-concept for using low-cost, resilient materials to produce durable structures capable of withstanding disasters like earthquakes. A streamlined 3D printing process would benefit Haiti's actor networks, including local labor forces, humanitarian organizations, and government agencies, by facilitating the adoption of innovative construction techniques. Skills developed during this project could empower local builders and artisans, while increased access to affordable, sustainable infrastructure could support broader disaster recovery and housing efforts. By using recycled waste and natural fibers in concrete, this approach also addresses the high environmental and financial costs of traditional concrete production Ramsden (2020), providing a scalable and eco-friendly solution tailored to Haiti's needs. Complementing the technical project, the STS (Science, Technology, and Society) research investigates the cultural, economic, and political factors influencing the adoption of sustainable concrete. These social dimensions are critical for ensuring that technical innovations are not only viable but also widely accepted and beneficial. By integrating technical and social

analyses, this research aims to address Haiti's sociotechnical challenges holistically. The findings will inform strategies for implementing sustainable construction, contributing to disaster resilience, community development, and a scalable model for other resource-constrained regions. Together, these efforts align with the broader goal of creating resilient, affordable, and sustainable infrastructure in Haiti.

Technical Research Project

Problem Definition

Haiti faces significant challenges in constructing durable, disaster-resistant infrastructure due to the high cost and environmental impact of traditional concrete production. Earthquakes frequently destroy critical structures, leaving communities vulnerable and perpetuating cycles of rebuilding. Current building practices are resource-intensive and fail to meet the demand for scalable, affordable, and sustainable solutions. Additionally, limited access to innovative construction techniques hinders the ability of local labor forces to address these infrastructure challenges effectively. This project seeks to address these issues by leveraging 3D printing technology to streamline construction processes and empower actor networks such as local labor, humanitarian organizations, and government agencies. By demonstrating how 3D-printed technologies can produce durable, sustainable structures tailored to Haiti's environmental and socio-economic context, this approach holds the potential to revolutionize building practices, fostering resilience while reducing environmental harm. This project combines cutting-edge 3D printing technology with the urgent need for sustainable, disaster-resilient infrastructure in Haiti. By incorporating alternative materials such as recycled waste and natural fibers into concrete, the project intersects with broader themes of environmental stewardship, technological innovation,

and community empowerment. This approach not only addresses Haiti's immediate infrastructure challenges but also contributes to global knowledge on sustainable construction. The methods and materials explored here could serve as a scalable model for disaster-prone and resource-constrained regions worldwide, promoting resilience, sustainability, and affordability in the built environment.

Research Methods and Theoretical Framework

The technical project employs experimental and analytical methods to develop a 3D-printed concrete canoe. Key materials to be tested include waste products such as fly ash, slag, and recycled aggregates, which mitigate the environmental impact of concrete production while improving its mechanical properties. Natural fibers like coconut coir and bamboo are local materials in Haiti that could possibly be incorporated to enhance tensile strength and durability. These experimental approaches aim to optimize the concrete mix for performance and sustainability, with practical applications for disaster-prone areas like Haiti. The theoretical foundation of this research draws on sustainable construction principles and the circular economy. Sustainable construction, as articulated by Kibert (2008), emphasizes minimizing environmental impact and optimizing resource efficiency throughout a building's lifecycle. The circular economy, McKinsey & Company. (2015), focuses on reducing waste and reusing materials to create closed-loop systems. These frameworks guide the development of a low-cost, environmentally friendly concrete that aligns with global efforts to combat climate change and promote sustainable development. A review of existing literature establishes a strong theoretical and practical foundation for the project. Sandanayake et al. (2020) highlights the benefits of incorporating waste materials into concrete production, noting improvements in sustainability and performance metrics. This aligns with the project’s goal of integrating fly ash and slag,

showing that waste materials can yield eco-friendly and durable concrete. Al-Hamrani et al. (2021) further supports the integration of green concrete within the framework of the circular economy, emphasizing its potential for durability and resource efficiency. Together, these studies demonstrate how recycled materials in construction can bridge the gap between sustainability goals and enhanced structural performance. Bbosa (2024) offers a roadmap for future sustainable concrete strategies, aligning closely with the project's objective to develop innovative, low-cost solutions for infrastructure needs. Bbosa's emphasis on practical applications mirrors the technical project's real-world focus on producing a functional 3D-printed concrete canoe. Sivakrishna et al. (2020) adds to this narrative by exploring the structural benefits of natural fibers in green concrete, which directly supports the project's focus on improving tensile strength and durability with materials like coconut coir and bamboo. These studies collectively validate the use of alternative materials in sustainable construction, linking waste reduction, material performance, and practical implementation. This interconnected body of research ensures that the technical project is grounded in proven principles while pushing the boundaries of innovation in 3D printing and sustainable construction. Ultimately, the integration of these frameworks and materials could offer Haiti a transformative pathway to resilient and affordable infrastructure.

Expected Outcomes and Impact

The anticipated outcome of this project is the creation of a 3D-printed concrete canoe that is both affordable and environmentally sustainable. Rigorous testing of the canoe's mechanical properties, durability, and environmental impact will determine its viability for construction in Haiti. If successful, this research could provide a scalable model for reducing construction costs and carbon emissions while building resilient infrastructure. This project has the potential to

transform building practices in resource-constrained and disaster-prone regions, advancing sustainable construction methods and benefiting local communities.

STS Research Project

Problem Definition

The adoption of sustainable concrete technology in Haitian communities faces significant challenges rooted in cultural, economic, and political dynamics. While experimentation can establish the technical viability of these materials, their success depends on acceptance and integration within local social contexts. Factors such as cultural preferences for traditional building methods, economic constraints, and political barriers to infrastructure development can hinder the widespread use of this technology. Addressing these social dimensions is essential to ensure that innovative solutions meet community needs, align with local priorities, and contribute to long-term resilience. This research is critical because it bridges the gap between technical innovation and practical application, focusing on how societal factors influence the adoption of sustainable materials. The project examines the complexities of introducing new technologies in real-world settings, where success relies as much on social acceptance and institutional support as on technical performance. By identifying barriers such as cultural resistance, limited economic resources, and political inefficiencies, the study ensures that technical solutions are not only viable but also socially equitable and impactful. The societal implications of this research are far-reaching. It provides insights into how sustainable technologies can be effectively implemented in disaster-prone, resource-constrained regions like Haiti, addressing interconnected infrastructure and social vulnerabilities. The findings will serve as a roadmap for aligning technical advancements with community needs, fostering resilience

and improving quality of life. This research also offers a broader framework for integrating sustainable technologies into similar contexts worldwide, making it a significant contribution to the study of science, technology, and society.

Research Methods and Theoretical Framework

The research includes an in-depth analysis of Haiti's social and political context, to evaluate the social factors influencing the adoption of sustainable concrete. To frame this analysis, the study draws on three theoretical perspectives: the Social Construction of Technology (SCOT), Actor-Network Theory (ANT), and Langdon Winner's theory of Technological Determinism, as articulated in "Do Artifacts Have Politics." These frameworks provide complementary lenses to deepen the understanding of the social and technical challenges in implementing sustainable concrete in Haiti, while also exploring potential solutions. The SCOT framework emphasizes that technology is shaped by the needs, values, and negotiations of social groups, making it critical to examine the perspectives of stakeholders such as local communities, government agencies, and construction professionals, Wafai (2022). By focusing on these groups, the research highlights how cultural perceptions of traditional building methods and economic limitations may shape the adoption of new materials. Engle (2018), for example, illustrates the role of trust and collaboration in post-earthquake Haitian rebuilding efforts, demonstrating how the involvement of local communities in decision-making is key to successful implementation. Applying SCOT, this research positions sustainable concrete as a technology that must align with the cultural and economic realities of Haitian society to ensure its relevance and acceptance. ANT complements this by emphasizing the interconnected network of human and non-human actors that influence technological adoption, Halicioglu (2020). This includes not only social groups but also the material properties of the concrete, the environmental conditions in Haiti, and

the policies governing construction practices. Kijewski-Correa and Taflanidis (2012) underscores this interplay by highlighting how technical innovations in Haitian housing must navigate a complex web of social and institutional factors to achieve both sustainability and hazard resilience. Similarly, Moore and Doyon (2023) emphasizes the importance of policy and community engagement in driving sustainable housing transitions, reinforcing the need for a multi-faceted approach that integrates diverse actors and their interactions into the development process. ANT helps this research trace these relationships, identifying points where interventions—such as policy adjustments or community workshops—could facilitate broader adoption. Technological Determinism, as discussed by Winner (1980) adds another layer of analysis by examining how technologies can embody social values and exert power dynamics. Winner's argument that technological artifacts can have political implications is especially relevant in Haiti, where infrastructure technologies often reflect and reinforce existing inequalities. Slapakova et al. (2024) extends this discussion by exploring how emerging technologies shape culture, offering insight into how sustainable concrete might challenge or perpetuate existing cultural norms in construction. Integrating Winner's framework, the research considers how adopting sustainable concrete could redistribute agency within Haitian communities—empowering local labor forces and reducing reliance on costly imported materials—or, conversely, how it might fail to disrupt entrenched power structures if not carefully implemented. By weaving together these frameworks, the research identifies critical factors that influence the adoption of sustainable concrete in Haiti and highlights actionable solutions. For example, SCOT and ANT emphasize the need for policies that align technical innovations with community priorities, while Winner's Technological Determinism draws attention to the potential long-term social and political consequences of implementing this

technology. Together, these perspectives deepen the analysis, ensuring that the research not only addresses the technical and environmental aspects of sustainable concrete but also its cultural, social, and political dimensions, paving the way for a truly inclusive and resilient infrastructure strategy.

Expected Outcomes and Impact

This research aims to uncover the social factors influencing the adoption of low-cost, environmentally friendly concrete in Haiti and develop strategies to overcome barriers to implementation. By identifying key stakeholders, including local labor forces, humanitarian organizations, and government agencies, the study will analyze their concerns, priorities, and resistance to adopting sustainable materials. Examining cultural, economic, and political dynamics will reveal systemic challenges such as resource limitations, policy gaps, and preferences for traditional building methods. The study will provide actionable recommendations, including education campaigns to highlight the benefits of sustainable concrete, policy reforms to incentivize its use, and partnerships with international donors to fund and scale projects. Pilot programs integrating sustainable concrete into disaster recovery or affordable housing initiatives may also emerge, offering opportunities to test and refine its implementation. By addressing both technical and social dimensions, this research contributes to building resilient communities in Haiti and informs global sustainable construction practices. It provides a replicable framework for integrating innovation into disaster-prone, resource-constrained regions.

Conclusion

In conclusion, addressing Haiti's need for resilient, affordable, and sustainable infrastructure requires integrating technical innovation and social analysis. The technical project demonstrates the feasibility of using 3D printing technology and alternative materials to create low-cost, environmentally friendly concrete tailored to Haiti's challenges. Complementing this, the STS research highlights the social, cultural, and political factors critical for the adoption and long-term success of this technology. Together, these approaches provide a comprehensive solution that bridges the gap between technical feasibility and societal acceptance. This research could yield an optimized concrete mix and actionable strategies for integrating sustainable materials into Haitian housing and disaster recovery efforts. Potential outcomes include scalable pilot projects, policy recommendations, and community engagement initiatives to overcome barriers such as cultural resistance and resource limitations. Beyond Haiti, this work contributes to the global discourse on sustainable construction, offering a replicable model for other disaster-prone, resource-constrained regions. By aligning technical advancements with societal priorities, this research empowers communities, reduces vulnerabilities, and sets a precedent for building a sustainable future.

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