Undergraduate Thesis Prospectus

A Proposed Entry in the AISC Steel Bridge Competition

(technical research project in Civil Engineering)

The Struggle to Increase Tree Cover in US Cities

(sociotechnical research project)

By

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Technical project collaborators:

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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STS Advisor: Peter Norton, Department of Engineering and Society

General Research Problem

How can civil engineers better serve human needs?

Civil engineering covers a large number of disciplines within engineering and shapes the infrastructure we use and rely on every day. As both urban and rural areas grow, civil engineers face the challenge of designing sustainable and efficient infrastructure that better serves human needs while addressing environmental issues. There are about 19,500 cities in the US that require constant maintenance and strategic planning as they expand.

Advancements in technology and innovation present opportunities for solving infrastructure challenges through automation, artificial intelligence, and resource-efficient design, as highlighted in "The Techno-Optimist Manifesto" by Marc Andreessen (2023). While Ward's "Only One Earth" (1973) emphasizes that we must recognize the finite capacity of our planet and design within its limits to avoid irreversible damage. The role of civil engineers is crucial in bringing these two perspectives together to create infrastructure that supports daily life and improves our quality of life and environment.

A Proposed Entry in the AISC Steel Bridge Competition

How can a scaled down steel bridge for the Steel Bridge Competition be designed to maximize load-bearing capacity and minimize assembly time while adhering to strict competition constraints?

This is a group capstone project in the civil engineering department. Our faculty advisor is Professor Jose Gomez and my group mates are: Zoe DeGuzman, Cooper Davenport, Ben Van Zandt, Bear Matheson, and Eric Venner. Our industry partners for this capstone are a professional

structural engineer from Dunbar Structural and individuals from Liphart Steel, a steel manufacturer.

The most important piece of this technical research problem, for the civil department, is to reestablish steel bridge as a team and capstone at the University of Virginia. This capstone provides experience on a practical, hands-on steel design and construction project that grows our professional skills, encourages innovation, and creates relationships between students with faculty, industry professionals and professional organizations. This technical research problem provides a necessary behind the scenes look into structural engineering as we interview for jobs within the civil engineering field.

Our ultimate goal is to fabricate a steel bridge to compete and place in the regional competition held at West Virginia University Institute of Technology. Along with that, we hope to establish steel bridge as a club similar to concrete canoe.

For this technical research problem we are constrained by the facilities here at UVa, the amount of money we are able raise from the University and from outside sources, the knowledge of the competition, and the skills that we possess as a group. For the competition our constraints are the following: The bridge must be constructed solely from members, loose nuts, and bolts, with no cables permitted in the design. It should include two continuous stringers, with the north stringer spanning at least 15 feet 6 inches and the south stringer extending a minimum of 19 feet. The height of each stringer from the top of the footing should not exceed 1 foot 11 inches, and each member must fit within a box measuring 3 feet 6 inches by 6 inches by 4 inches. Additionally, the bridge is required to provide a clearance of 7 inches above the ground. During the competition, only six builders are allowed to participate in the construction process, 4 of

which are allowed to be on “barges” and no builder is permitted to be in a designated protected island area surrounded by a river on either side specified in the problem statement. The bridge cannot sway more than ¾ of an inch during lateral load testing or we will be disqualified. Lastly, the bridge must be able to support a load of 2,500 pounds with minimal deflection.

The Student Steel Bridge Competition (SSBC) represents the current state of the art in preparing future civil engineers for real-world situations in design, fabrication, and construction. Utilizing 3D modeling tools like Revit and SAP2000 for structural design and analysis. Using a variety of methods for fabrication to create quality and efficient designs. The competition emphasizes modular construction, as teams must design bridges that can be rapidly assembled, reflecting modern construction methods aimed at creating efficiency on the job site. Like the real world, the problem changes and designs cannot be reused. Constraints of the problem, like an area that no “builders” are allowed to disturb or a limit on the size of members. Innovations in connection design could further enhance structural efficiency.

To solve our technical research problem, we started with modeling it in Revit. Then we’ll use our professional advisors for feedback and use RAM as an analysis tool. Between our analysis model, previous experience, and the professional advisors, we will be able to finalize a design to create shop drawings that will be used to fabricate the steel bridge. Using Lacy Hall and the equipment there we will be able to complete almost all of the tasks that will be required to build our steel bridge. We may also need the help of Liphart Steel to perform specialized tasks that Lacy Hall is not equipped to handle. Upon completion of our bridge, we will be able to test it before competition in the lab space located in the basement of Thorton D Wing. There is a large hydraulic press that can simulate the forces that will be applied to our steel bridge.

If we succeed, my group mates and I will have left a sort of legacy at UVa and have something to show for four years of hard work. If we are successful, we will have competed in a competition that not only promotes the field of Civil engineering but also be able to represent our university. We will have also created a club that will continue to compete and hopefully grow to be as competitive as concrete canoe.

The Struggle to Increase Tree Cover in US Cities

In US cities, how have residents, advocacy groups, and nonprofits petitioned local governments, businesses, and communities to expand tree cover in urban environments?

Urban tree canopies provide vital environmental and social benefits, including reducing urban heat islands, improving air quality, and managing stormwater runoff. They promote healthier communities by enhancing mental well-being and reducing cardiovascular stress, as shown by studies like Wang (2023) and Kondo (2020). Despite these advantages, there are large disparities in tree cover across U.S. cities, often reflecting socioeconomic inequalities. Underserved neighborhoods frequently face greater challenges, including limited funding, spatial constraints, and systemic inequities, which hinder efforts to expand tree coverage. Addressing these barriers requires collaborative solutions between a variety of stakeholders to create equitable and sustainable solutions.

Historically, low-income neighborhoods have faced greater exposure to heat and pollution due to limited tree cover. Decades of neglect, lack of resources, and competing urban priorities have left these areas vulnerable to climate and health risks (Bajwa, 2023; Podyma, 2022). Expanding tree canopies in these neighborhoods requires intentional, equity-driven approaches that address historical injustices and current funding barriers.

Residents and environmental organizations often lead urban initiatives, leveraging local knowledge to address specific community needs. Groups like Reforest Richmond mobilize residents to plant trees and advocate for long-term canopy expansion. In Richmond's Iron Triangle neighborhood, advocacy efforts have focused on reversing decades of neglect by hosting tree-planting drives and educational campaigns (Chiang, 2023). These initiatives foster community engagement and create momentum for addressing disparities in tree coverage.

In North Carolina, residents collaborated with local government leaders to restore declining tree canopies. According to Salmons (2024), advocacy campaigns prioritized underserved areas, demonstrating how local action can drive equitable urban greening. Such efforts highlight the power and importance of community-driven projects in creating sustainable change.

Nonprofit organizations provide critical expertise, funding, and strategic planning for urban forestry. The Arbor Day Foundation's "Canopy Report" (2024) emphasized the economic and environmental returns of investing in urban forests, while Trees Virginia's "Throwing Shade VA" program (2023) focused on improving equity through outreach and education. By connecting policymakers and residents, nonprofits play a crucial role in addressing funding gaps and implementing data-driven strategies.

For example, Michigan's forestry projects, supported by $400,000 in funding, illustrate the success of nonprofit-led initiatives in driving large-scale greening efforts (Aimery, 2024). These projects show the success that can result from partnerships among nonprofits, governments, and local businesses.

Local governments are key players in making equitable tree canopy expansion actually happen. Strategic plans, such as Richmond's "Richmond 300" and Fort Collins' "Rooted in Community," integrate urban forestry goals into broader urban development frameworks (City Council, 2023; City of Fort Collins, 2024). These plans prioritize equitable access to green spaces, aligning tree canopy objectives with housing, transportation, and climate resilience policies.

Despite their potential, urban forestry plans face challenges during implementation. For example, Rhoades (2023) noted that Oakland's urban forest plan encountered significant public resistance and while Nace (2024 reported the vandalism of newly planted trees in St. Paul. These incidents demonstrate the importance of community engagement and public education to ensure the success of these initiatives. Cities must build trust within communities and allocate sufficient funding for long-term maintenance.

The private sector also plays a role in urban greening efforts, recognizing the economic and aesthetic benefits of tree-lined streets. Businesses often collaborate with municipalities to fund tree-planting programs in commercial areas. For instance, local retailers in Michigan partnered with nonprofits to support statewide greening efforts, demonstrating how economic incentives can align with environmental goals (Aimery, 2024).

Mapping tools such as GIS are essential for identifying canopy gaps and prioritizing resources. Szantoi (2012) emphasized the importance of considering socioeconomic factors when planning urban forests. Cities like Philadelphia and Richmond use similar tools to guide canopy goals, ensuring that underserved neighborhoods receive adequate attention (Kondo, 2020; Chiang, 2023).

Education campaigns are vital for fostering community support and participation in urban forestry. Programs like Trees Virginia's "Throwing Shade VA" educate residents about the benefits of tree cover, encouraging active involvement in tree-planting initiatives (Trees Virginia, 2023). These campaigns also build awareness of the broader environmental and health impacts of urban greening.

Sustainable funding is critical for expanding urban tree cover. Federal programs like the Urban Forestry Action Fund provide essential grants, but long-term success requires integrating canopy goals into comprehensive urban planning frameworks. Richmond's "Richmond 300" demonstrates this approach by aligning tree-planting initiatives with broader policies on housing and transportation (City Council, 2023). Public-private partnerships play a key role in ensuring financial sustainability for urban forestry projects.

Expanding tree cover in U.S. cities is a complex challenge, requiring collaboration among residents, nonprofits, local governments, and private enterprises. Addressing disparities in urban tree canopies demands data-driven planning, public engagement, and innovative solutions. By prioritizing equitable access to green spaces and securing sustainable funding, cities can overcome challenges and create healthier, more resilient communities. As examples from Richmond, Raleigh, and Michigan demonstrate, collective action can transform urban landscapes, improve our environment, and promote healthy communities.

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