Undergraduate Thesis Prospectus

Río K'ellu Mayu Suspended Footbridge

(technical research project in Civil Engineering)

The Fight for Choice: Advocating for Walkability

(sociotechnical research project)

by

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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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General Research Problem

How can walking trips be promoted in communities?

The ability to walk is important due to health, social, and environmental benefits, and importantly for rural Latin American communities, it is free and reliable. In many communities in the Americas, walking is not supported by infrastructure as a viable mode of transportation. According to Conderino, et al. (2021), walkability of the 500 largest cities in the United States is low on average, especially in the south where population is booming. In rural Latin America, some parts of communities are often cut off from essential services due to high water levels in rivers, which worsens poverty (Engineers in Action, n.d.). Walking infrastructure like a pedestrian bridge would solve this problem.

Connecting Communities with a Suspended Footbridge in Rural Bolivia

How can the design of a pedestrian bridge in rural Bolivia be optimized for usefulness, reliability, and cost?

This is a capstone project within the Civil and Environmental Engineering department at University of Virginia and is given by Engineers in Action (EIA). The technical advisor is Jose Gomez, and the collaborators are Gabriel Witter, Jessie Brown, Sacha Choubah, Ronald Orellana, and Calvin Reeves.

This project is the design and preconstruction work of a suspended pedestrian footbridge across Rio K'ellu Mayu in the Pocona municipality in rural Bolivia. Rio K'ellu Mayu is impassible 150 days of the year, and a bridge over it would directly benefit 190 individuals and

indirectly benefit another 220, connecting residents to schools and medical facilities. Suspended bridges are different from suspension bridges in that cables are anchored into the ground and overtop a masonry abutment on both sides, and the deck is hung from the sagging cables. Suspension bridges utilize steel towers instead of masonry abutments, and the shape of the deck arcs over the water below instead of sagging, allowing for a higher freeboard (Engineers in Action, n.d.). Structural analysis of masonry abutments, steel cables, and anchors are all necessary as well as a geometric layout given site conditions. Figure 1 below shows a typical suspended bridge in the style of this project.

Figure 1. A photograph of a suspended bridge designed by Engineers in Action (Engineers in Action, n.d.).

The goal of this project is to design a suspended footbridge to be used by pedestrians, with bicycles, motorcycles, wheelbarrows, and livestock. The bridge will be made of cables and utilize local materials, and the members of the community will be involved in the construction of

the bridge as well as responsible for maintenance. The bridge design will include the design of timber, wire rope, reinforced concrete, geotechnical, and masonry systems. Deliverables include a full drawing set and calculation package, design report, construction schedule, material, and cost estimate.

Unusual constraints include the inability to visit the site, construction material availability in rural Bolivia, and the skills and participation of community members for the construction of the bridge. Constructability is a greater consideration than for a typical project.

The state of the art for this project is the unimproved condition of the proposed bridge site across Rio K'ellu Mayu. See figure 2 below for a photograph of the site in a crossable state. Residents have constructed makeshift crossings in the past that are not engineered and fail, injuring and sometimes killing those who attempt to cross. An example of a makeshift bridge can be seen in Pete Rogers' (2020) video, in which he constructs a simple beam bridge over a narrow stream using logs, milled lumber, and metal fasteners. An unengineered bridge may work for his purposes, but the Rio K'ellu Mayu crossing is roughly 30 meters wide, and consequences of structural failure are high. When the water is high, children cannot attend school and healthcare is inaccessible to those who need it. The community is severed; friends and family cannot meet, and goods and services cannot be shared for 150 days per year.

Figure 2. A photograph of the proposed bridge site while the water is low (Engineers in Action, n. d.).

Methods for this project include utilizing education modules and design standards given by Engineers in Action to create designs for the footbridge in Autodesk Civil 3D. The bridge will

then be constructed using locally available materials and labor from community members. Non-design deliverables will be created using spreadsheets and word processors.

A successful end to the project is if all deliverables are submitted on time and the designed bridge is deemed constructable, which would allow the designed bridge to be built in the future, benefiting hundreds of people.

The Fight for Choice: Advocating for Walkability

How have advocacies fought for walkability in greater Richmond, Virginia?

In Richmond, Virginia, citizens are interested in walkability, but many neighborhoods are not conducive to doing so. For this project, bikeability and other forms of micromobility will exist under the definition of "walkability," as their advocates all work to reduce car dependency. Walkable communities are associated with health benefits, reduced carbon emissions, and increased sociability. According to Adhikari, et al. (2021), walkability correlates with lower rates of hypertension. A study performed by Walters and Ewing (2009) found that increased urban density and walkability reduces vehicle miles traveled by 13% to 61%. According to van den Berg et al. (2022), "perceived walkability" improves "neighborhood-based social interaction." The benefits of walkability are clear.

One related published study explored the efficacy of pedestrian safety political advocacy for communities in the U.K. that were unsafe for pedestrians relative to other communities. The advocacy included informational mail sent to politicians that included pedestrian safety statistics from their constituency. Lyons, et al. (2013), found that targeting local politicians was "effective in increasing their interest… in advocating for improved safety measures," but was not effective

at implementing safety features at the time scale of the study, 25-30 months. This study suggests that formal advocacy in this style for pedestrian safety may be effective at the scale of years.

Another related study analyzes the impacts of compact and mixed development on land values in Richmond, VA. The study found that accessibility to jobs and stores increases land values more than development patterns, compact development and mixed land use affect land values according to the “nature of existing land uses and land values,” and access to public transportation can improve land values, but not consistently in Richmond (Suen, 2018). These findings are relevant because the improvements that Richmond walkability advocates fight for may affect land values in a fashion studied in this research.

Participants include advocacy groups, municipalities, local businesses, university programs, and grassroots groups. For advocacy groups, an example is Bike Walk RVA: "Bike Walk RVA is a program of Sports Backers that advocates for comfortable and connected places to bike and walk for people of all ages and abilities" (Sports Backers, 2023). For municipalities, the prime example for this project is Richmond, Virginia. A representative primary source is a capital improvement project showcased on their website: "The City of Richmond is currently designing a shared-use trail along Gillies Creek" (City of Richmond, 2020). For local businesses, an example is Carytown Bicycles in Richmond, VA. "Mitchell McKenna at Carytown Bicycle Company says more cyclists are being forced to share the roads, so he thinks the city needs more protected corridors" (Wyant, 2022). A university program that promotes bikeability is RamBikes, a free bike shop funded by Virginia Commonwealth University. RamBikes performs tune ups, installs parts, gives advice, and even lends out bikes, all for free (Virginia Commonwealth University, 2023). Finally for grassroots groups, an example is Broad Street Bullies, a critical mass bike ride in Richmond with hundreds of weekly participants. A founding

member, Amon, says in an interview by Harris (2023) "…you can ride in the city safely because you're surrounded by other bikers." These primary sources showcase the participants and their agendas.

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