BRIDGES BETWEEN WORLDS: TECHNOLOGY AND SOCIETY

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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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More than one billion people around the world live with no or limited access to modern healthcare and markets. In some communities this isolation is caused by geographic features, such as a gorge or river, of which passage is dangerous. Access to education and opportunity is limited by fear that children will drown on their way to school, or the elderly will die in route to medical care. This problem is remedied by a pedestrian footbridge, which creates safe and reliable access to neighboring communities, allowing for expansion of population and economic opportunity, including a previousely observed and recorded 75% increase in farm profits, 12% increase in children enrolled in school, and 18% increase in healthcare treatment (EIA, 2020c). Fortunately for rural areas that are not able to reliably self design and build their own structures, a company exists that solely develops these projects with the purpose of social advancement in mind.

Bridges to Prosperity (BTP) is a program run by Engineers in Action (EIA), partnered with the Thornton Tomasetti Foundation, and exists as a non-profit organization dedicated to the construction of footbridges with the purpose of connecting rural and isolated communities. These companies have all worked on infrastructure improvement and water quality services in underserved communities, and now have operating field offices in Bolivia and Eswatini, and have hosted previous projects in Panama and Nicaragua (EIA, 2020c). To garner support for their work, EIA has promoted and supports several university chapters across the United States, and the capstone project to be discussed here is the founding effort of the University of Virginia Chapter of Bridges to Prosperity. First the researcher will present an overview of the technical challenge that is a precursor to construction so the reader may understand the collaborative effort

required for the task, followed by the research of why this project is more complex than previous iterations, then close with how these challenges will be overcome.

Technical Overview

The fourth-year civil engineering student members of this newly founded team are myself, Marlene McGraw, Robert Peacock, John McClorey. The university advisor is Jose Gomez, PhD, professor of structural engineering at the University of Virginia, who invited UVA alumni Leo Fernandez and Rupa Patel to advise the students in their development of the chapter, along with EIA staff Ethan Gingerich and Brenton Kreiger. Ethan Gingerich is Bridge Program Director, has traveled to Guatemala and Nicaragua to repair and construct pedestrian footbridges, and communicates with all chapters to ensure smooth cooperation for ongoing projects. Brenton Kreiger is Bridge Program Coordinator, and coordinates the online instruction of the various university chapters so that all designs and projects are equally well crafted so that future members of the program are able to sufficiently train the upcoming interested classes.

The task given to the University of Virginia Chapter is to design and implement a suspended footbridge over the Pojo river in the Carrasco province of Bolivia. The location name is Guayabitos and was selected based on the needs of the surrounding community for increased agricultural and economic opportunity, along with statistics concerning the deaths and injuries caused by regular river crossings. In order to improve the safety of crossings and ensure that the goals of a benefitted community are met, a multi-tier suspended bridge is being designed by the team, with tower-raised cables to support the walkway and concrete based anchors to secure the varying load. The steel or wood walkway is supported on both ends by a three-tier abutment on

the left bank and a two-tier abutment on the right bank. The components of abutment design are more easily understood in a plan view of a previously designed footbridge similar to ours, pictured in Figure 1 below.

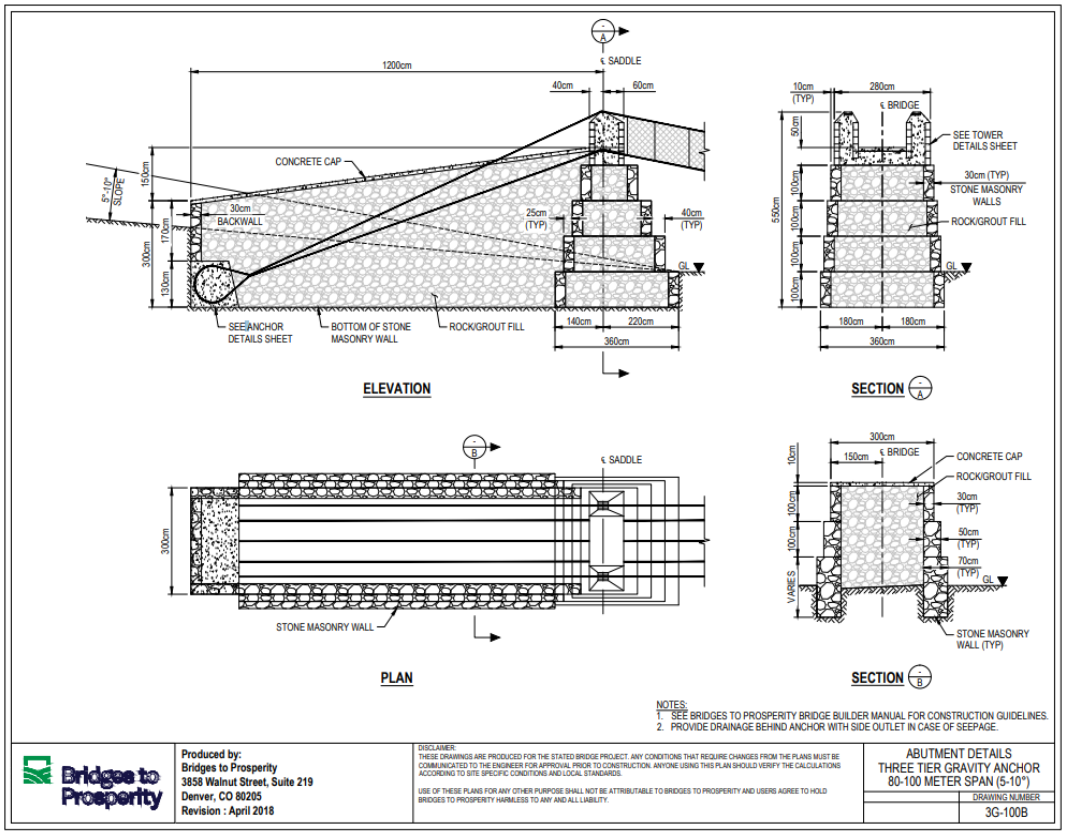

Figure 1: Abutment Design. Three tier design for suspended bridge abutment, meant to span a river of 80-100 meters in width. This design could be mirrored on the opposite bank or designed with reduced tiers to compensate for a change in landscape. This is an example of the designs used to develop a bridge suitable for the site as surveyed (EIA, 2020a).

The primary design objectives are safety, durability, and serviceability. The schedule designed by EIA spans two regular semesters, and consists of a weekly basis of completing learning modules, and 3 review calls with the Bridge Program Director, Review Call 1 in the fall semester of 2020 and Review Calls 2 and 3 in the spring semester of 2021 and directly before travel to the construction site, respectively. These tasks, along with a University required final capstone report, make up the body of the technical project. However, due to the continued

influence of COVID-19, EIA has been in constant communication with the UVA chapter, and must keep updating a fluid schedule as dates for modules and travel opportunities change. Unfortunately, travel opportunity for the team is quickly diminishing, but our efforts to complete our part for this service are not reduced.

Despite the continuous schedule fluctuations, the capstone team will have completed the online bridge learning modules by the end of their fourth year of education (2021). This will allow EIA to travel to the Guayabitos site that summer, and supervise the construction of the designed bridge. The funding for the bridge and engineer residency will be provided by the local government of the Pojo Municipality, with the team members required to fundraise for their own contribution. Concrete materials, laborers, transportation, and heavy machinery will also be provided by the municipality. With the bridge constructed, the economic capability of the region will greatly expand. The footbridge provides safe access for neighboring regions to expand their business and agricultural operations to within reach of the city Cochabamba, a large city with modern communications and services (EIA, 2020b). The previously witnessed and anticipated outcome of the project is a community with greater access to modern medical supplies, improved education, and general improvement to quality of life without the fear of losing one's life making what should be a routine route to work or school. The workings and outcomes of the project will be drafted in a technical paper created by all team members and their calculations, contributions, and experiences.

The Need For Progress

The effects of a bridge built in the selected site are not byproducts of the construction: they are the purpose. The Guayabitos site in Bolivia was selected with careful examination of the surrounding economy, and the after effects of a turbulent political situation place even more necessity on this community for connection. In November of 2019, President Evo Morales stepped down from office, and his party Movement Towards Socialism (MAS) was replaced in the seat of power by the Democrat Social Movement, an unpopular and "Christian-fundamentalist" party, and its president Jeanine Áñez (Hylton, 2019). Hylton (2020) states that a period of violence followed, followed by a regime of repression of ideas and traditions, along with discrimination against blue collar unions and agricultural workers, that resulted in bloody protests and street clashes for months on end. The unrest was only worsened by the COVID-19 pandemic, which Áñez used as a reason to postpone the regular May presidential election to September (Hylton, 2020). Public health services faltered, with infrastructure too weak to handle the influx of pandemic patients. Another postponement of the election to October sparked new protests, consisting of labor unions, farmers, and indigenous populations persecuted by the overzealous party. Following the revolving door of Bolivian politics shown in figure 2, leftist groups demanded Áñez resign, and called for the return of MAS once more, as they did over a decade previous when the last reign of a discriminatory government occurred (Faiola, 2020).

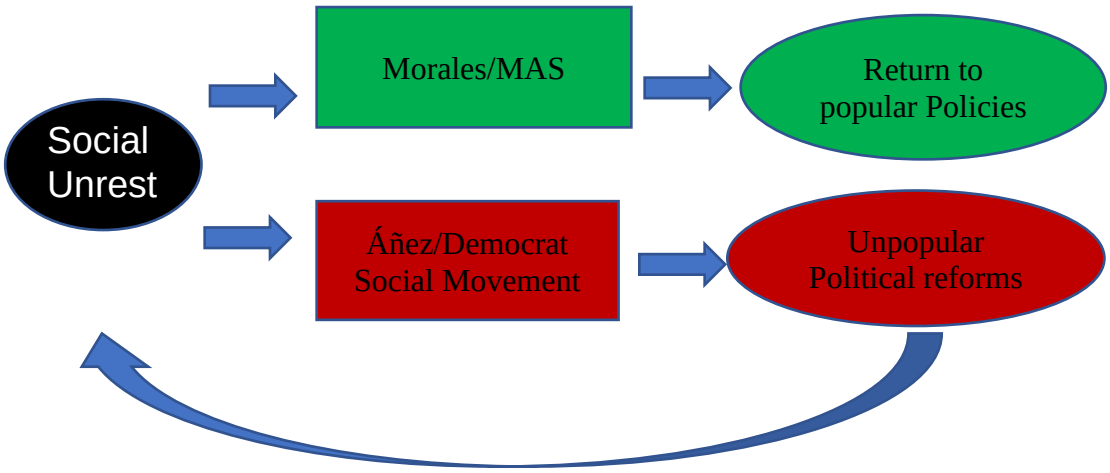

Figure 2: Revolving Door of Politics. The looping nature of Bolivian politics in 2019 and 2020 show how inconducive to political stability the population is at this time. The same population that grew tired of the policies of MAS was the same as the voters that re-elected the party after being shown the alternative party's approach to governing the nation (Hetland, 2020).

Fortunately, in the October election MAS and its new representative Luis Arce won back the presidency, and were able to, with a population majority, oust Áñez and her now despised regime. Hetland (2020) discusses that during Áñez's presidency there was an uprising of extreme democratic values, which led the same agents that removed MAS to reinstate them, along with giving them a senate majority. For the previous 14 years of governance before Áñez, there was sustained economic development, and there is reason to believe that Arce will reinstate similar policies to try and restimulate Bolivian economics. However, the old policies did not have the challenge of COVID-19. The virus continues to hold the nation in a health crisis that drags down the economy significantly, and will make it difficult for the well-known policy-makers of MAS to adapt in ways all people will support (Hetland, 2020).

Guayabitos Bridge: More Than Just A Physical Connection

As it stands, the nation of Bolivia is still very much divided. Hetland (2020) states, although current opinions are high and supportive of MAS after Áñez lost the election, that:

> …voters are more committed to Morales's program than to Morales himself. Per official results, Morales won 47 percent of the vote in 2019, 5 percent less than Arce's apparent tally. The most likely reason for Morales's failure to score an outright majority last year was the widespread, though far from universal, rejection of his controversial decision to stand for reelection after losing a 2016 referendum to allow the president to run for a fourth term. It is also possible Arce benefited from the widespread disgust provoked by Áñez (Hetland, 2020).

This indicates that the challenges to Arce as a new president during the COVID-19 era will not become gradually easier to solve; they will only become more difficult as time goes on. The population was indeed in majority for Áñez's removal, but was not near united in re-election of the deposed party. This leads to a nation politically and culturally divided, with indigenous populations and blue-collar workers recovering from harsh repression at the hands of their old government, and all peoples still gripped in a pandemic with only newly attended healthcare programs. That's not to forget the lack of sanitary services and running water to entire regions, and neglect of deceased body care and disposal (Hylton, 2020).

What is critical to Bolivia, now more than ever, is connection. As developed areas will adapt under a supportive government and begin to improve their infrastructure and utility, it is necessary for the isolated communities that have truly felt the hand of the pandemic to be connected to modern resources. In Cochabamba, the closest city to the site of the current EIA bridge project, medical workers have just ended a strike to protest the backlog of virus testing kits and funeral homes, both of which contribute to the steady spread of contagion (EIA 2020a). With new opportunities for improved handling of the virus, the city must become accessible to those who are accustomed to those conditions on a regular basis. Figure 3 shows the capabilities of isolated communities connected to an economic and technological modern city such as Cochabamba:

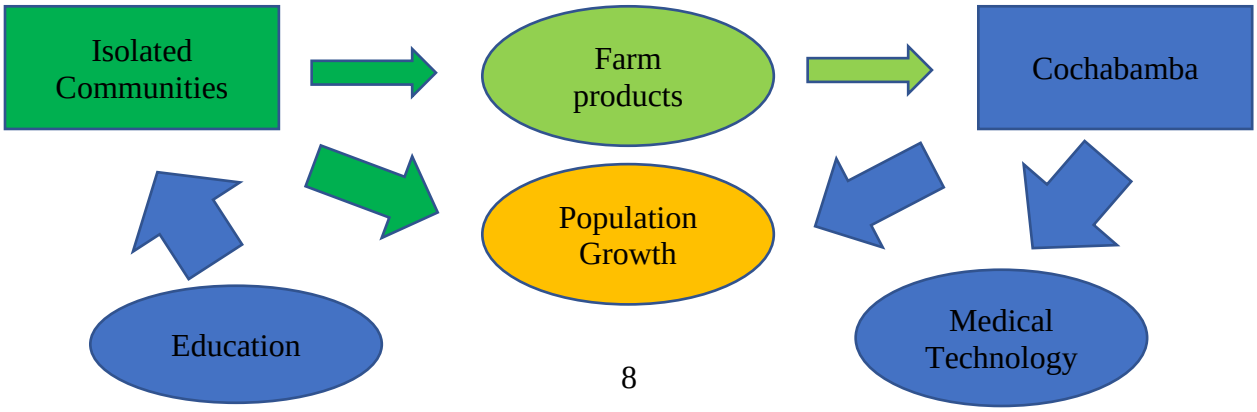

Figure 3: Symbiotic Relationships. Isolated communities benefit greatly from increased access to the modern technologies offered by an industrialized city. However, access to rural farms and populations allow for gradual merging of communities, and growth of both populations culturally and economically (Narayan, 1999).

The 30 person Guayabitos community is 30 km away from the nearest city, 20 km from the nearest health center, 10 km from the nearest school, and 30 km from the nearest market (Barnes et al, 2020). The river floods during the rainy season and in its normal state requires a tractor to cross safely. Access to city of Cochabamba assits the communities primary economic activity, agriculture (tomatoes, green beans, potatoes, beans), by allowing developement when exposed to markets for farmers to sell their surplus product (Barnes et al. 2021). The question that stands is: can engineer intervention and assistance by installation of a pedestrian bridge benefit the community past the previousely witnessed benefits of such a project?

The approach used will center on Pacey's Triangle of Technology Practice (Pacey, 1983) as shown in Figure 4. This STS analysis procedure best fits the scenario of this capstone; utilizing three aspects of the project. Each of these will be discussed with research cited previousely, and new information obtained through the researchers studies and work with EIA.

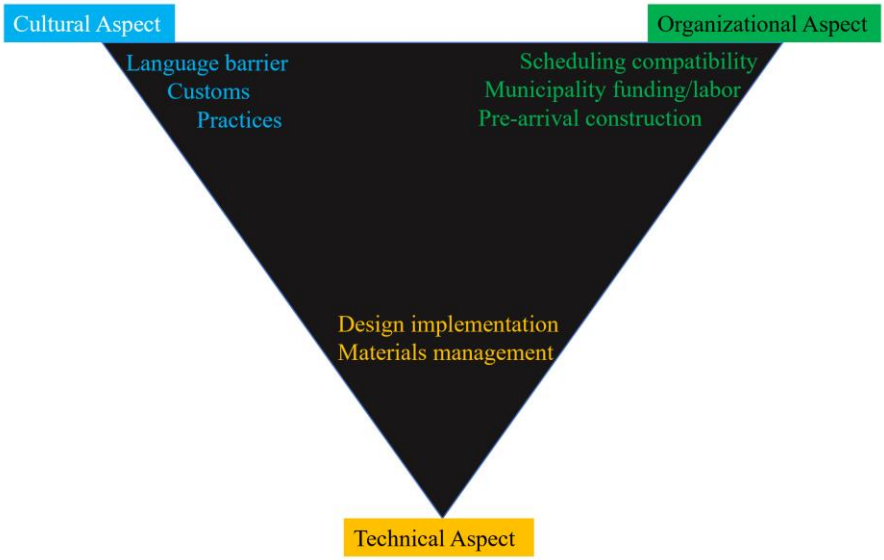

Figure 4: Paceys Triangle of Analysis. Applied to this project to compartmentalize and examine the important aspects of on-site work and interaction between engineers and local peoples and authorities (Pacey, 1983).

Technical Aspect

Benefitting from the mentorship of experienced EIA engineers, our team has a plethora of learning material and previousely developed bridge information. Along with the commitment to this work for our own gain, we are driven to be abundantly thorough in our detail checks of the bridge, since we know this bridge is meant to serve a community in need, and it is part of our service as civil engineers to provide the most safe and well-functioning device possible to any community in need of it. The team is in the process of design checks and finalizations, and will confidently provide a sound structure.

Cultural Aspect

With engineers arriving from the United States, bringing with them their own attitudes, experiences, and customs, there is high possibility for conflict between local volunteers that are assisting with the labor (EIA, 2020c). Additionally, although there will be at least one translator on-site, the language barrier serves as a significant source of possible contention. However,

previous engineers have developed practices to solve these problems before construction even begins. The researcher has acquired the experiences of the team's alumni mentors, who describe the methods used. Meetings attended by the visitors and the community immediately after arrival allows for an extensive briefing with all project workers in one setting, and involves the safety guidelines to be explained, team members from the U.S. to introduce themselves, and the community to become familiar and more comfortable with the rules and personalities at the head of the task. This has worked well for past projects, and people understand that EIA engineers are there to provide their community a service, and are more than willing to do what it takes to benefit their livelihood.

The challenge of this project will be the mindfulness practiced by the visiting engineers in regards to the loss suffered by this community. Although not impacting the effectiveness of the bridge itself, the long standing good cultural relations developed by a deeply community involved project of this type could be difficult to achieve if the U.S. team does not practice patience and understanding with a tiny community that may have suffered close, personal losses from the pandemic (Andreoni et al. 2021). This is increasingly less likely to occur, though, because of our training. Our team leader is required to take an extensive cross-cultural competency course, and instruct the rest of the team as they progress through it. In this way, we will all have done training and practiced various problem-solving scenarios, so we will all be prepared for arrival and mindful interaction with a community shaken by hardship.

The residents of Guayabitos are a community suffering, possibly without awareness, from social and technologicl isolation. This bridge will serve as a connecting device between the community and the opportunities provided by the technologies in the near city of Cochabamba. This is an application of Contagion Hypothesis, described by Monge et al. (2008) as a study of

the diffusion of innovation in the perspective of a social network, influenced by physical and social proximity, in which individuals choose whether or not to adopt a particular innovation. A phenomena to be occurred after the completion of this paper, and the construction of the bridge, will be to observe how the isolated culture of Guayabitos accepts, or conversely rejects, the possibilities provided by connection to a developed city.

Organizational Aspect

Scheduling a set time for several EIA engineers and university chapters to all converge on one site on a separate continent is no easy feat, and takes a year of coordination and planning. However, the biggest challenge for this project does not fall upon EIA, but the municipality of Pojo. They are providing the funidng and equipment for construction, and allowing the community members of Guayabitos to use it under the supervision of qualified U.S. engineers. This may seem like an acceptable occurrence for the benefit the bridge will provide, but finances are not to be played down in significance. Even with the upward curve of the quality of political leadership, the economy is still in recovery from the previous coup and ongoing pandemic, and Bolivia has had a recent history of hyperinflation and economic difficulties (De la Barra et al. 1995). A possible conflict upon arrival to the job site could be discovering unforseen discrepancies between the budgeting of EIA and the provisions from the municipality. In order for long term relations to be good, the community and engineers working with it must spend every effort to compromise with the neighboring government. If, once this community is connected to the rest of the municipality, they are rejected socially and economically, then the project will have been for nothing.

Structural Soundness in All Aspects

A shaky economy, doubted political leadership, crippled infrastructure from a pandemic; Bolivia's recovery will develop through connection. Discussed earlier is the potential for the rallying of isolated communities and their inclusion in the recovery and rebuilding of Bolivia's economy and society. Standing in the way are geographical and language barriers, technically challenging construction work, and communities harmed by loss and cultural seclusion. However, people given the opportunity to progress technologically and economically are, although known to do so slowly, generally accepting the opportunity (Monge et al. 2008). The Pojo municipality has shown willingness to provide funding despite the obstacles, and the design of the bridge is feasible and safe. Because of the outcomes of previous projects, and the research done on the capability of isolated communities to seek betterment when given the opportunity, the researcher believes that with the implementation of this pedestrian footbridge in the Guayabitos community, its people will benefit economically and socially.

In the future, all engineers working with EIA must be cogniscant of the problems unique to this project. The effects of the pandemic on rural communities is not unique to Guayabitos, or Bolivia. Many other communities lack the connection they need to advance socially and economically with the cities around them. More projects such as this are vital, not just in connecting villages and towns, but in connecting us all as humans from different backgrounds and perspectives. As civil engineers we exist to serve all communities, and we would be doing our title a disservice if we chose to remain in isolation ourselves.

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