**Design and Construction of a Suspended Footbridge in Rural Bolivia**

**Analysis of the Florida International University Bridge Collapse in Miami, Florida**

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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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## Introduction

The Coilolo and Tipa Tipa communities, located in Central Bolivia, have an approximate total population of 800 inhabitants (R. Galvez, personal communication, September 7, 2022). Portions of these communities are separated from each other and the surrounding town of Zudáñez by the Coilolo River. During the rainy season, which lasts from November until April, the Coilolo River floods, making it nearly impossible for those who live on one side of the river to safely reach essential resources such as schools, healthcare facilities, and markets on the other side (Garcia & Braza, 1987, p. 337).

The communities' current approach to crossing the Coilolo River consists of placing planks or tree trunks across the river on its banks (Walsh-Dilley, 2012, p. 11). However, this simple footbridge design does not consider a variety of engineering and environmental factors and results in a bridge that is susceptible to structural failure in certain environmental conditions. Therefore, to address the technical deficiencies of this current design, I will propose a footbridge design solution that considers these engineering and environmental factors to ensure the safety and stability of the new footbridge.

While these technical factors will be predominantly considered during the footbridge design and construction process, other organizational and conceptual actors exist that must be considered to ensure the successful implementation of this project. In the case of the Florida International University (FIU) Pedestrian Bridge collapse, several non-technical factors, such as the lack of an adequate design review system and construction safety response plan, in conjunction with technical design errors, contributed to the bridge's collapse (Ayub, 2018, pp. 113-115). If certain non-technical factors such as these are not considered during the design and construction of the Coilolo River Pedestrian Bridge, it is less likely that the footbridge design solution will meet the goal of providing community members with safe access to essential resources.

To successfully design and construct the Coilolo River Pedestrian Bridge, attention must be paid to both the technical and non-technical aspects of the bridge design and construction process. In what follows, I elaborate on a technical process for designing and constructing a suspended footbridge that considers a variety of environmental and engineering factors. In addition, I will analyze how organizational and conceptual actors contributed to the FIU Pedestrian Bridge Collapse, and I will consider how these non-technical factors can dictate the success of infrastructure projects such as the Coilolo River Pedestrian Bridge Project.

## Technical Project Proposal

Rural footbridges in developing regions of Bolivia are instrumental in providing members of isolated communities with access to essential resources such as healthcare, education, and markets (Gibbs et al., 2019, p. 1). Although some Bolivian communities in these regions follow a detailed procedure to design safe, functional footbridges, it is often determined that many of these footbridges are constructed without consideration of a variety of engineering and environmental factors (Gibbs et al., 2019, p. 2). These factors may include the bridge's span length and deflection, construction material properties, the floodplain of the river in which the footbridge crosses, and the geotechnical properties of the supporting bank soil.

The most popular footbridge design and construction approach utilized by members of these isolated Bolivian communities involves placing planks or tree trunks on the banks of impassable rivers (Walsh-Dilley, 2012, p. 11). This current approach is inadequate and limited, however, as it does not consider the many technical factors described previously. In particular, the majority of these current simple Bolivian footbridge designs do not account for rising water levels caused by flash floods during the rainy season, which often lasts from November until April (Garcia & Braza, 1987, p. 337). Therefore, many of these footbridges are damaged or destroyed after rainstorms, leaving members of the community isolated from essential resources for nearly half the year.

Members of the Coilolo and Tipa Tipa communities in Central Bolivia often face these same challenges associated with flash flooding during the rainy season. Their current approach to crossing the Coilolo River involves using a simple footbridge; however, members of these communities are often left isolated from markets, schools, and healthcare facilities in the wake of rising water levels. In order to assist the Coilolo and Tipa Tipa communities, the goal of the technical project is to develop a detailed design and construction plan for a suspended footbridge across the Coilolo River. This detailed design will take into consideration the engineering and environmental factors that have not been addressed in the original footbridge design. Upon implementation of this improved footbridge design, members of the Coilolo and Tipa Tipa communities will have year-round, safe access across the Coilolo River, regardless of the presence of flash flooding in the Central Bolivia region.

In order to successfully design and construct a suspended footbridge across the Coilolo River, our team will produce two project deliverables. The first of these deliverables will involve the completion of a suspended footbridge design drawing set. This set will include considerations with regards to the bridge geometric layout, bridge anchor and abutment details, tower details, and cable and decking details. Specific data that will be analyzed during the design process includes the type, condition, and bearing capacity of soils located on-site, the high-water line (HWL) of the Coilolo River, and the material properties and loading capacity of all structural components within the suspended footbridge system.

The completion of the second deliverable will involve the development of a detailed suspended footbridge construction plan, consisting of a bill of quantities and project budget, construction schedule, safety plan, and quality control plan. Specific information that will be analyzed to complete this construction plan includes the availability and cost of locally-sourced construction materials, the availability of a local construction labor workforce, and the accessibility of each side of the river for construction.

Finally, our team will construct a mock-up of the designed bridge abutment on-Grounds in order to test the multiple assumptions that we will make throughout the design process. This analysis, in conjunction with the two design deliverables described above, will allow our team to effectively design and construct a suspended footbridge across the Coilolo river.

## STS Project Proposal

On March 15th, 2018, the Florida International University (FIU) Pedestrian Bridge, which spanned over an eight-lane highway in Miami, Florida, collapsed during construction, killing six individuals and injuring ten more (National Transportation Safety Board, 2018, p. xiv). The purpose of the pedestrian bridge was to provide members of the City of Sweetwater community with safe access to the FIU campus by avoiding the dangers associated with crossing US 41, a busy highway in the Miami area (US Department of Transportation, 2020). Prior to the collapse, a construction crew re-tightened the post-tensioned rods within a diagonal member of the concrete truss to connect the bridge's canopy and deck at its northern end (National Transportation Safety Board, 2018, p. 87). Disaster struck immediately following this tightening procedure, when the nodal connection to this diagonal member failed, resulting in the subsequent collapse of the bridge (Doing, 2020, p. 16). Given that six lanes of US 41 remained open during the construction of the bridge, eight vehicles were positioned directly below the bridge at the time of collapse (National Transportation Safety Board, 2018, p. xiv). This significantly contributed to the death toll that resulted from the bridge failure, as five of the six individuals who died as a result of the collapse were vehicle occupants (Doing, 2020, p. 2).

Many writers and forensic structural engineers often claim that the FIU Pedestrian Bridge collapse occurred as a result of design and calculation errors made by FIGG Bridge Engineers (Crawford, 2019, p. 12). These analysts argue that the unprecedented decision to use reinforced concrete in a truss structure, in conjunction with a lack of redundancy among truss members, resulted in the catastrophic structural failure of the bridge (American Concrete Institute, 2020). Although the technical design decisions and errors that were made by FIGG contributed to the collapse of the FIU Pedestrian Bridge, considering only these technical factors overlooks the role played by other organizational actors, such as the Florida Department of Transportation (FDOT), Magnum Construction Management, Bolton Perez and Associates Consulting Engineers, Louis Berger, and Florida International University, in the fatal failure of the bridge project. If we continue to attribute the FIU Pedestrian Bridge's collapse only to the technical design and calculation errors made by FIGG prior to the bridge's construction, then we will fail to gain a more comprehensive understanding of the organizational and conceptual actors that contributed to its collapse. This negligence, in turn, will reduce the likelihood that we will be able to prevent a tragedy such as this from occurring in the future.

I argue that FIGG's technical design and calculation errors, combined with non-technical factors, such as the lack of an adequate independent peer review system for the bridge design, the lack of a mid-construction design change review upon the decision to re-tighten the post-tensioned rods, and the lack of an adequate construction safety response to the observation of cracks in the truss structure, resulted in the monumental engineering and construction disaster that we analyze today (Ayub, 2018, pp. 113-115). By utilizing the science, technology, and society (STS) framework of actor-network theory, which analyzes how a network builder recruits both human and non-human actors to join a larger heterogeneous network and achieve a certain goal, I will offer a more comprehensive overview of the technical, social, and conceptual actors that contributed to the FIU Pedestrian Bridge's collapse (Cressman, 2009, p. 3).

In particular, I will use the concept of translation, which outlines the process in which an actor-network is formed and maintained, to explain how FIU created the Pedestrian Bridge Project actor-network and to determine how the network subsequently failed (Callon, 1984, p. 196). To perform this analysis, I will utilize evidence from the FIU Pedestrian Bridge Collapse Incident Reports issued by the National Transportation and Safety Board (NTSB) and the Occupational Safety and Health Administration (OSHA) in addition to federal and state bridge design guidelines, such as the FDOT Plans and Preparation Manual (PPM), Florida Administrative Code (FAC), and AASHTO LRFD Bridge Design Specifications.

## Conclusion

The deliverables for the technical problem discussed in this paper will include a suspended footbridge design drawing set, consisting of a geometric bridge layout and design details, and a detailed plan of construction, consisting of a project budget, schedule, safety plan, and quality control plan. Through the use of actor-network theory, the STS research paper will aim to determine how a combination of technical and non-technical factors contributed to the collapse of the FIU Pedestrian Bridge during construction. Through this STS analysis, I will gather a broader understanding of how non-technical factors, such as design review and safety planning, play a role in the successful completion of infrastructure projects. The technical design and construction of the suspended footbridge, in conjunction with insights gained from the STS analysis, will allow for the successful completion of the Coilolo River Pedestrian Bridge Project and will provide members of the Coilolo and Tipa Tipa communities with year-round access to essential resources.

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