El Puente Hamaca Escondido, Joyabaj, Guatemala

Project Description:

This project challenged students to find a sustainable solution to an issue that affects a lot of the world. Rural isolation brings economic hardships, and creates countless safety concerns. The communities of El Bosque and Piedras Blancas in Joyabaj, Guatemala faced these hardships everyday due to a 20-meter deep gorge surrounding a violent river that separated them. The proposed solution was a 40-meter cable-suspended footbridge using only materials and equipment available in rural Guatemala.

Collaboration:

A diverse student team from multiple engineering disciplines, including Civil, Environmental, Construction, Mechanical, and Biomedical, worked with five licensed Professional Engineers, including a faculty member. The team also communicated and collaborated with translators, professors of Latin American history, the communities, the local municipal government, contractors, and masons in Guatemala.

Public Health, Safety & Welfare:

The primary goal of this project was to provide safe access to schools, healthcare, markets, and jobs. After a priest was killed attempting to cross the gorge at the current bridge location, it became clear that a safe, reliable solution was necessary. This bridge is allowing the communities of El Bosque and Piedras Blancas to be in charge of their own safety, health, and well-being.

Knowledge and Skills Gained:

The students learned valuable lessons about leadership and time management as they designed this bridge as an extracurricular project. They learned important aspects and impacts of geotechnical engineering, bridge design, cost estimating, construction scheduling, construction processes, and writing technical reports. Furthermore, both the mentors and students learned how to effectively communicate with a culture very different from their own, and how to help them meet their needs.

Sustainability:

This project served as a classroom for the beneficiary communities. The student and mentor team that traveled to Guatemala taught the community key aspects of construction, including how to read a plan set and the desirable water-cement ratio when building with concrete. This will ensure the community can provide routine maintenance on the bridge. Additionally, the student team will continue to monitor the functionality of the bridge, and its affects on the communities for years to come.

Abstract: El Puente Hamaca Escondido

In order to access schools, healthcare, markets and jobs, two communities in Joyabaj, Quiche, Guatemala were tasked with crossing a 20-meter deep gorge surrounding a violent river. After a priest was killed attempting to attend church across the river, it became evident that a reliable solution was crucial to the safety of the communities. However, the municipal government of Joyabaj lacked the engineering expertise and funding to provide them with a solution. Thus, an Engineers Without Borders student chapter, in collaboration with Bridges to Prosperity, stepped in to help the communities. El Puente Hamaca Escondido, a 40-meter cable-suspended pedestrian bridge, was their solution.

El Puente Hamaca Escondido was managed and overseen by students alongside their regular academics. They worked in collaboration with mentors such as faculty members, licensed professional engineers, stakeholders, end users, translators, and the municipal government of Joyabaj. Two student project leaders appointed smaller leadership roles to students in discipline-specific positions: 1) hydrology and hydraulics, 2) geotechnical, 3) structural, 4) construction, 5) safety, 6) quality assurance and control, 7) project shadows, and 8) project monitoring and evaluation. From there, the students took initiative to bring this project to life. The mentors guided the students, and reviewed the design calculations, plan sheets, paperwork, and decisions made regarding the structural integrity of the bridge. Additionally, the students kept in close contact with the beneficiary communities throughout the entire process, including interviewing them and the local municipal government to gauge their needs and desires for the bridge.

The students gained knowledge and invaluable skills over the course of this project. Many students were able to see the engineering project process from conception to construction, including the design and continuous monitoring, for the first time. They were introduced to the importance of contracts, agreements, paperwork and other red tape items that must occur in order to complete a successful project. They learned about construction processes, scheduling, budgeting, bridge design, leadership, and communication. Many of these items can be taught individually in a classroom, but this project was able to provide a full-scale, real-world experience that a class cannot teach. El Puente Hamaca Escondido provided the students with the knowledge and skills to work on and lead engineering projects in the future.

El Puente Hamaca Escondido solved a persistent safety, health, and welfare issue for the communities in Joyabaj, Quiche, Guatemala. The bridge also provided an invaluable opportunity to the students who designed it and those who were able to travel to Guatemala to help construct it. Over the course of this project, the students discovered the meaningful and positive impact that the utilization of their education can create.

El Puente Hamaca Escondido

Project Description

El Puente Hamaca Escondido ("The Hidden Hammock Bridge") connects El Bosque and Piedras Blancas, two communities in rural Guatemala separated by the Rio El Temal. It is a 40-meter cable-suspended bridge over a 20-meter deep gorge that was designed and built by a student chapter of Engineers Without Borders in collaboration with Bridges to Prosperity. The community of El Bosque is a small community of about 200 people, with very little infrastructure. El Bosque lacked safe, reliable access to the city center with schools, markets, jobs, and healthcare. The people of Piedras Blancas lacked the ability to expand their work outside of their community.

Completed El Puente Hamaca Escondido

The beneficiaries are rural, indigenous Mayan communities. Seventy percent of indigenous communities in Guatemala are impoverished, and a majority of the time it is due to isolation and lack of infrastructure to accommodate rough terrain. This affects young people and households headed by women the most.

The 20-meter deep gorge exemplifies how easy it is for communities to become isolated in the rough terrain of Guatemala without proper infrastructure. Although people were taking a risk and crossing the gorge daily, they were unable to carry large, heavy objects with them to buy or sell at the markets. Pregnant women could not make it to the hospital during labor or other pregnancy complications. Children could not attend school on a regular basis. A priest was killed attempting to cross the violent Rio El Temal on his way to church. This bridge ended the isolation, and allows the two communities to be in control of their own safety, lives, and well-being.

Collaboration of Faculty, Students and Licensed Professional Engineers

Were licensed professional engineers (P.E.s) involved?

Five licensed professional engineers were involved. Each P.E. had several years of experience within different specialties of civil engineering. These included one P.E. from the disciplines of Hydrology and Hydraulic Engineering, Geotechnical Engineering, and Construction Engineering, and two from the discipline of Structural Engineering. Additionally, two licensed P.E.s traveled with the student team and provided on site engineering advice during construction.

How did the students, faculty and P.E.s interact?

The faculty and P.E.s involved went to great lengths to give the students project ownership. The students worked to resolve problems, to the best of their abilities, and contacted the faculty and

P.E.s via phone or e-mail conversations for advice, suggestions, or to answer questions when the students deemed it necessary. Overall, the student members collaborated amongst themselves at least once a week, and many times a P.E. was present at those meetings. The students remained in contact with the faculty and P.E.s throughout the project at least once per month. The P.E.s reviewed all calculations and design documents with the students during the design process, and as field changes were made based on field conditions that were unexpected.

What did the students learn through the collaboration that would not have been learned in the classroom?

Value of Data Collection and Stakeholder Input

In addition to the collaboration between faculty, students, and licensed P.E.s, the project team collaborated extensively with the communities that were directly impacted by El Puente Hamaca Escondido and the local municipal government throughout the project process. Community members, leaders, and teachers from El Bosque and Piedras Blancas were surveyed prior to the construction of the bridge to gauge the needs, desires, and other input. The community expressed their desired location for the bridge, and the economic, technical, and environmental impacts were evaluated to ensure this location was feasible. Through this process, the students learned the value of listening to their stakeholders and using a combination of technical and social data to determine the preferred project type and location.

Stakeholder Agreements

The student team wrote and signed a Project Agreement, Implementation Agreement, and a Maintenance Agreement with the communities of El Bosque and Piedras Blancas, the Engineers Without Borders-USA Guatemala office, and the municipal government of Joyabaj. These agreements outlined the roles, responsibilities, and financial contribution requirements for each party. Additional land use agreements were signed in order to allow public access to the bridge. The students learned the value of these agreements, and that the negotiation process helps to build ownership in the project and clarify the expectations of each stakeholder and their needs.

Development and Execution of a Quality Process

The student team utilized a quality control process that required calculations, plan sheet drawings, and technical reports to be checked by a student teammate, and then submitted to the P.E.s and faculty mentors to be reviewed. During the construction process, a quality control student manager was selected to consistently check the construction processes with the designs and plans, and document the progress. The students learned the importance of the quality control plan, and how to navigate the time required to successfully execute it.

Construction Process

The student team learned that construction does not always go as planned. A shortage of rebar occurred while the team was building in Guatemala, which challenged them to respond quickly and reasonably. They bundled together smaller-sized rebar that lead to a design change during construction, and were able to get the plans approved while in Guatemala by the P.E.s and faculty involved. Additionally, the students learned about safety on site. The 20-meter drop and steep slopes of the gorge created a particularly unique and dangerous situation that had to be continuously discussed. The students also learned about the importance of proper coordination. They were required to communicate and coordinate with other Engineers Without Borders chapters in the region of Guatemala to ensure the labor and materials would be available while the project was being built. The students learned the importance of construction engineering, and the need to timely address differing site conditions in a disciplined manner.

Cultural Immersion

The student team, along with two P.E.s, traveled to Guatemala to help build El Puente Hamaca Escondido. They lived with the President of the community in El Bosque. They interacted with the communities professionally while they were working, and socially while dining and playing soccer. The students learned how to work and communicate with people from a very different culture than their own.

Protection of the Health, Safety and/or Welfare of the Public

Did the project include aspects that affect the health, safety and/or welfare of the public?

El Puente Hamaca Escondido ensured safe passage to healthcare, education, and economic opportunity for approximately 1,200 people. The bridge circumvented the need to scale the 20-meter deep gorge and cross a violent, dangerous river. The bridge specifically improved the lives of the elderly and pregnant women who now have a reliable route to the hospital, children who can now attend school regularly, and men and women who want to sell goods at the market in the city center.

Which project features raised student's awareness about the impact of the engineering decisions?

During the design and construction of this project, it became evident to the student team that all of the decisions they made would deeply affect the two communities impacted by the bridge. For example, the initial location selection was crucial to ensure community members could easily access and utilize the bridge for its intended purpose.

Did the project highlight how engineering can help solve problems faced by communities nationally or worldwide?

In the United States, there are an abundance of resources and technology that are utilized daily to allow engineering projects to continuously improve. However, many individuals lack this type of development. This project taught the student team how to design with limited resources, experience, and construction equipment. The knowledge to innovate and solve problems with limited resources is critical to solving the world's toughest problems.

Did the project foster student self-reliance, cooperation, or responsibility?

The mentors wanted to ensure that the students took the lead on the project, and acted mainly as guides. They let the students learn from their mistakes without compromising the structural integrity of the bridge. The students were able to pave the path for themselves throughout the project process, rather than being told where to go. Additionally, the students made a conscious effort to foster self-reliance for the community members of El Bosque and Piedras Blancas. Throughout the construction process, the students taught the community members how to read a plan set, and proper construction techniques. This was done so that the community would feel comfortable maintaining the bridge, and building more infrastructure in the future.

Multidiscipline and/or Allied Profession Participation

Was more than one engineering discipline involved? Was more than one branch of a particular engineering discipline involved?

The scope of the project included site survey, hydraulic analysis, geotechnical analysis, bridge design, estimating, scheduling, life cycle cost analysis, quality control and assurance, and sustainability. Therefore, this project primarily involved civil engineers and the sub disciplines of civil engineering. However, the student members ranged from mechanical to biomedical engineering students.

Did the project include other professions?

Outside of engineering, the team looked to contractors and masons for technical support. The team relied on interpreters and a Latin American history professor to understand the language and cultural context of the communities in which they worked. Additional support and collaboration came from mentors well-versed in fundraising in order to ensure this project could become a reality.

Knowledge or Skills Gained

Leadership

Each student team member learned how to be a leader while navigating the engineering project process. The team analyzed what needed to be done to successfully complete the project, and took the initiative to do so. Each student member was required to research solutions to problems via resources such as books, papers, past reports, and the mentors. The students also delegated work when necessary, and ensured a quality control mechanism was in place throughout the process. The students learned how to act boldly, and complete project steps without explicit direction from a higher up.

Geotechnical

During the survey of the bridge site, test soil pits were dug and the soil type was analyzed for constructability. Additionally, rock samples were gathered and the rock type was classified for its building integrity. The students then designed bridge anchors that would not slide or overturn based on a geotechnical analysis. The students saw firsthand the critical importance of geotechnical data and how it affects the design of the bridge.

Bridge Design

The bridge was designed using standards provided by Bridges to Prosperity. The manuals gave standard loading values and design considerations for footbridges, and they were adjusted and analyzed to ensure that they fit the specific project.

Constructability and Construction Engineering

Limited heavy machinery or construction equipment was available during construction, so the design needed to ensure that the project was buildable using locally available materials and equipment. Additionally, special considerations needed to be made for the specific job site. For example, materials were passed along the gorge using a cable car constructed from a large cable and a cart.

Cost Estimate

The importance of accurate cost and materials estimations was emphasized because the team needed to raise the funds for this project. The students understood that significant price changes would impact the agreements with the municipality and community, and could ultimately jeopardize the project.

Construction Scheduling

The time available to construct this project was limited, and thus the need for a detailed and accurate construction schedule was critical to the success of the project. Each task was broken down, and the material and labor necessary to complete each task was identified so that construction could progress on a daily basis. The team planned to complete the bridge in sixteen days, but finished in only ten.

Writing Reports

As protocol of Engineers Without Borders-USA and Bridges to Prosperity, the student team was required to submit both technical and non-technical reports to be reviewed by project engineers. This required pre and post assessment and implementation paperwork, along with an alternatives analysis report, and project monitoring and evaluation paperwork. The students learned how to effectively communicate their design and ideas to others not directly involved in the design and construction of the project.

How were the knowledge/skills gained important to professional practice?

Reading a Plan Set

This project was many students' first experience with an engineering or construction project, and some were not civil engineers. The team ranged from freshman to seniors, and so for some, it was not only the first time creating a plan set, but it was also the first time seeing one. The students were able to learn this skill properly in a controlled environment.

Risk Analysis

The students gained important knowledge on how to weigh risks during the design and construction process. For example, the materials selected were analyzed based on their integrity and their cost. The students learned the value of assessing risks, and balancing them with their benefits.

Quality Design

The construction of this project took place on a remote site with limited availability, equipment, and time, which made a quality design critical in order to create a sustainable project. The students were aware that if the construction schedule, plans, and maintenance requirements were not clear, it could significantly impact the success of the project.

Sustainability

The importance of considering project sustainability is highlighted when the team is working in a region with few resources. It was important that the design of the bridge utilized materials that were locally sourced to ensure the community would be able to purchase replacement parts if necessary. Additionally, the student team taught the community members the proper construction techniques while in-country, and left them with resources on how to maintain the project.

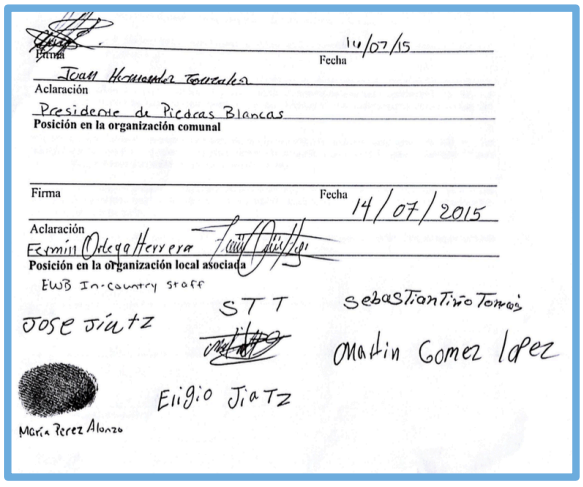
Coordination of Full Scale Projects

This project was many students' first opportunity to follow a project completely from start to finish. The students were able to assess a project site, determine the preferred alternatives from multiple proposed, complete the design, and build the bridge from the ground up. The student team was able to gain a strong understanding of the full engineering project process.

Did the project include consideration of professional practice concepts such as project management, ethics, contracts or law?

Contracts

The project included multiple agreements with the municipality, Engineers Without Borders-USA in Guatemala, and the two communities. The students learned the importance of these contacts when it came to effective communication, and understanding the roles and responsibilities of each party.



Signed Project Agreement

Time Management

Time management was crucial on this project because it was not a senior design project, or related to academics in terms of credits received. This project was an extracurricular project alongside schoolwork for the students. Each student team member had to manage their time effectively to produce a quality project, while keeping up with their classes.

Continuous Learning

The student team members learned to seek technical guidance, and balance their time researching solutions and asking for help when necessary.

Ethical Use of Engineering Skills

This project was a reminder of how engineering projects can make a real difference in the world. The team realized their obligation to use their skills to improve the lives of those in needs, and provide a safe and effective solution to their problem.

Building Local Construction Capacity

A goal of this project was to build the construction skills of the local masons, and even the community members. The project was utilized as a classroom for the masons and community members to enhance their understanding of important engineering principles. For example, key lessons were taught on water-cement ratio and its impact on strength.

Communication

The students learned to communicate effectively amongst themselves, with professional mentors, community members, stakeholders, municipal leaders, and end users who did not speak the same language. They learned how to present their work in the form of reports, presentations, and posters to engineers and non-engineers to secure funding and educate the public.