Bridge Building for Rural Developing Communities

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ABSTRACT

Bridges to Prosperity (B2P) is a non-profit organization that focuses on being a primary depository and training centre for low cost, robust, long-span bridge structures for rural applications. Bridging the Gap Africa (BtGA), another non-profit bridge building organization, concentrates efforts on providing safe river crossings for rural communities in East Africa. The two organizations focus on building cable-supported bridges over impassable rivers to provide access to health care, education and market opportunities while decreasing risk of injuries or death.

Keywords: bridge, cable-supported, long-span, rural infrastructure, international development, appropriate technology, suspension, suspended, footbridge, www.bridgestoprosperity.org, Bridges to Prosperity, Bridging the Gap Africa, www.bridgingthegapafrica.org, B2P, BtGA, Kenya.
1. INTRODUCTION

1.1 Living in a Walking World

An estimated 900 million rural people in developing countries do not have reliable, year-round access to road networks and every third person is without motorized access [1]. Aid dollars and infrastructure improvements often focus on paved highways and major vehicular bridges, serving only those with a standard of living appropriating vehicular use. As a result, 300 million of the remaining rural citizens are without access to the most basic services and opportunities.

A country's ability to maximize its economic potential is closely linked to the efficiency of its transportation system [2]. Investment in rural transport improvements would help to alleviate poverty by improving access to markets, medical clinics, and opportunities for education. Unfortunately, many programs prioritize paved roads as they lack the infrastructure capacity to link feeder roads and rural paths, leaving a significant portion of the rural population without year-round access.

In African rural communities, walking is still the main, and often the only, means of transportation. In the last ten years, many studies have been done to determine what type of development will help these rural "off road" communities that do not use motor vehicles as a main form of transportation. One study looking at communities in Zimbabwe found:

- A typical rural household spends on average 70 hours travelling per week.
- The majority of the trips (approximately 86%) undertaken are on foot.
- The travel time is excessively long despite the short distances travelled.
- Women carry a disproportional amount of the travel and transport burden and predominantly through headloading (e.g. 95% of water transportation is carried by women and girls.)
- The average amount carried by a household for subsistence needs by all modes equals to 60 tonne kilometres per year out of which 48 tonne-kilometres was the responsibility of women.[3]

Animal attacks are also a constant risk for many in African communities. In 2010, in one small village, six people were killed by crocodiles in just under a year. [4] Although hippos are not carnivorous, and therefore not hunters, they aggressively protect their territory and often attack boats or people who encroach on their space. Despite their harmless appearance, hippos kill nearly 100 people per year just in Tanzania. [5]

1.2 Pedestrian Bridges

Stranded from feeder roadways and pedestrian paths during annual floods, rivers and streams isolate and inhibit many rural communities. Many of the world's poorest people are faced with the disadvantage of having no direct access to basic amenities or an adequate infrastructure system necessary to reach them. River crossings can be located miles downriver and reaching a school or market may take hours or even a full day, and often, flooding and animal attacks can prove to be life threatening. Lack of access reinforces the cycle of poverty for nearly 50% of the world's people living in rural isolation [6]. Several development strategies have been proposed that give priority to providing reliable, year-round access [2,7]. Pedestrian bridge crossings are low-cost opportunities to provide access to those with the greatest need in the most remote locations.

1.3 Bridges to Prosperity
With over 100 projects in 16 countries and four continents, Bridges to Prosperity (B2P) relies on partnerships with bridge engineering experts to develop safe and locally appropriate footbridge technologies. By involving industry experts in both the design process and on-site construction, the result is practical design, feasible construction, and safety best-practices. Cable-supported pedestrian bridges are prototyped and standardized with our industry partners and then openly shared with other organizations and used within B2P training programs.

1.4 Bridging the Gap

Bridging the Gap Africa is dedicated to saving lives and improving the quality of life for rural African families and communities by constructing pedestrian footbridges. Bridging the Gap Africa (BtGA) has actively planned and completed numerous bridges to date resulting in several million safe crossings. BtGA works in the remote areas of Laikipia, Trans Nzoia, Trans Mara, Tsavo East, and West Pokot in Kenya. BtGA has built 50 pedestrian footbridges over eleven different rivers and ravines. These areas are isolated, rugged, and mountainous and are prone to drought and flash flooding. These bridges are saving an estimated 600 lives every year by eliminating drowning, hippo and crocodile attacks for those living in a world where walking is the main mode of transportation.

2. BRIDGE DESIGN FOR RURAL APPLICATION

Rural construction presents an additional set of constraints and challenges. Many of the technologies needed in the developing world have well-documented design approaches for use in developed countries. To make these technologies appropriate for rural applications, modifications must be made for material availability, lowered cost, and limited tools and equipment.

2.1 Design Simplification

The benefits of a standardized bridge design for use in developing countries is three-fold. Simplified and standardized designs lower costs, promote replication, and contribute to ease of construction for rural applications.

B2P focuses on providing a skeleton design, with detail alternatives for varying code requirements and material availability. Each partner project team typically has at least one new design or construction detail that they are responsible for adding or improving. The process of simplification allows the trained engineers to consider many of the same design decisions as other projects working in similar rural contexts, while learning from many of the lessons learned from past projects.
One example of design variations is the tower materials for the cable-supported suspension Bridges to Prosperity projects. Flatiron and McNary Bergeron & Associates have led the effort to develop various alternatives for differing site requirements and local material availabilities. The first design utilized locally available wood telephone poles for the towers. As the towers were to be erected using only pulleys, scaffolding and manual labour, the weight of the wood tower structures limited the allowable span. A next iteration employed steel towers, increasing the viable span from 50 to 80 meters. As Bridges to Prosperity is developing a steel donation program that will provide steel towers at little to no cost, this more costly design alternative could become comparable. A third design alternative, using a reinforced masonry and concrete tower, has also been developed with the first prototype built in Nicaragua in March of 2012. Given these three material options, each community is able to decide the most cost effective and locally appropriate material for their project.
Bridging the Gap Africa also works directly with the local communities to select the location of the bridges and to design bridges that best utilize local materials and labor. BtGA uses modified steel tube towers filled with concrete on their suspended bridges. The steel is obtained from Kenyan sources and BtGA has worked with local craftsmen to set up a fabrication shop (see Fig. 2) providing much needed jobs. Community members work directly with BtGA project managers to provide labor on the jobsite including excavation, quarry work and actual erection of the bridge. (Fig. 3)

![Locals work to build bridges in Kenya (Bridging the Gap Africa)](image)

**2.2 Training and Safety**

Quality training procedures are integral to rural construction. Bridges to Prosperity trains individuals, engineers and organizations in the beneficiary country design and construction techniques, affording opportunities for additional bridge projects in the area. Safety, both during construction and upon completion of the bridge, is of critical importance and also is included in the training. Flatiron Construction worked with B2P to develop training programs and safety procedures specifically designed for the unique conditions presented by rural footbridge projects. These standards will be applied to all of B2P and BtGA project sites.

**3. DESIGN RESOURCE REPOSITORY**

Development projects have the greatest impact when a simplified design approach is supplied in conjunction with a detailed explanation and documentation of design processes and assumptions used. This allows for easy modification by other organizations and communities to better suit their local needs. Bridges to Prosperity has compiled all of their designs and practices, detailing project
feasibility and surveying, materials, technical drawings, construction and quality control, and
maintenance and inspection. These documents, documents from other organizations, and all training
and safety standards are readily available to the public on B2P's website.

Bridging the Gap Africa is also working for the cause to further develop a hybrid steel tower
design solution. BtGA has already prototyped and built this type of tower in over 50 bridges in the last
15 years. BtGA also draws upon the B2P manuals for details that work well in sites within East Africa.
BtGA has adapted the B2P anchors, foundations and decking to best utilize local labor and materials
found in Kenyan terrain. Currently, BtGA is working with a team of volunteer technical advisors that
include US State Bridge engineers, US Peace Corp engineers as well as bridge engineers from industry
participants CH2M Hill, and McCormick Rankin. This team is developing standard design analysis
calculations according to the American Association of State Highway and Transportation Official
(AASHTO) LRFD Bridge Design specifications. These codes are the same required of all federally
funded bridges within the United States and ensure a safe design. The technical advisory board is also
working on developing standard drawings to include BtGA specific details. These documents will be
made available to the public along with B2P’s developed documents.

4. CASE STUDY

In 2010, Harmon Parker, the founder of Bridging the Gap Africa, was honored as a CNN Hero
of the Year. The bridge featured as part of the award is a 40 meter hanging bridge over the Moruny
River in West Pokot, Kenya. (Fig 4) This bridge is a simple, two cable bridge with fabricated steel
towers, concrete anchor blocks and a wood plank hanging deck. The bridge itself cost less than
$10,000 to build and has a simple design and simple construction methods.

Despite its simplicity the bridge has changed the lives of the people in the community. One of
the laborers and community members, David Kakuko, lost his parents when they tried to cross the river
during a flash flood about 13 years ago. He was able to participate in building a bridge that might have
prevented their deaths. The hanging footbridge provides safe passage over the Moruny, which is a
frequently flooded waterway.

The community frequently tried to build bridges with fallen trees, but these types of bridges
were known to be washed away up to seven times each year during floods. The community leaders
contacted Harmon Parker by letter to request a bridge be built. Bridging the Gap Africa responded and
helped the community to raise the needed funds for the bridge. "Before the bridge, there [were] so many people, so many who lost their lives," said Kakuko, 32. "I know, because I have no parents. I have no parents, because this river took them."

The community worked with BtGA to determine the best place for the crossing and helped to organize local labor to build the bridge. Kakuko had no problem with making the commitment to help build the bridge. "It is good for us, because this is our bridge," he said. "It is not for the men who gave it to us. It is ours. So people should guard and watch over it like it is their own." The community takes ownership and responsibility for the upkeep of the bridge after BtGA helps to complete the project.

The bridge not only saves lives, but also provides safe passage to a school, clinic and market. For this particular community, the school enrollment had increased from 250 students before the bridge was built, to 650 students at the present time.

5. TRAINING AND EDUCATION

Bridges to Prosperity's primary strategies recognize the necessity of innovation and education when working with the rural poor. Similarly, Bridging the Gap Africa requires that the community initiate the projects and participate in the construction of the bridges. Both groups emphasize the importance of community ownership of the bridge and strive for the locals to take responsibility of future maintenance and upkeep of the bridge.

Bridges to Prosperity strives to develop and continually improve engineering solutions that benefit rural, isolated citizens and are working hard to become the number one resource for pedestrian footbridge technologies around the world. While the ability to replicate the technology is at the highest level of importance, all bridge designs must allow for flexibility and adjustment, dependent on local conditions and needs. The evolution of the cable-supported suspension bridge design, from wood to concrete towers, allows B2P to present an array of material options and construction techniques at each unique bridge site.

The transfer of technology and knowledge is critical to the mission of B2P. Bridges to Prosperity staff act as on-site trainers, teaching local residents design, construction, maintenance, and safety fundamentals throughout the construction process. Communities are then able to apply these techniques and technical knowledge to other areas of infrastructure development. By creating and sharing a Design Resource Repository, B2P promotes the transfer of technology and knowledge even further, greatly extending their reach. Other organizations and individuals have access to a wealth of engineering solutions that can be replicated and applied to outside projects. In addition to design developments, all training and safety manuals and procedures are openly shared.

6. CONCLUSION

Infrastructure developments will drastically improve the lives of millions of people living in rural, isolated locations. Pedestrian bridges are a catalyst for increasing access and effecting change. The engineering innovations used in rural construction are not new to the engineering industry but require unique modifications and understandings in order to be applied in rural communities. Simplification, standardization, and constructability are all essential characteristics of rural footbridge designs. The sharing of design solutions, safety standards, and training procedures spread locally viable infrastructure development throughout the world. Bridging the Gap Africa and Bridges to Prosperity both strive to work together to provide safe passage over rural rivers all over the world.
7. REFERENCES


