A Suspended Trail Bridge Serving Isolated Communities in Rwanda

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Abstract
In partnership with the NGO Bridges to Prosperity, an international, gender-balanced team from SYSTRA collaborated with local workers to construct an 80-meter-long suspended trail bridge in the Shyagari Valley, Rwanda. The bridge now provides safe, year-round access for over 2,600 residents of Kabare and Nyanza villages, who previously faced hazardous river crossings during seasonal floods. The Gikeri River, prone to rapid flow increases during heavy rains, often isolated the community, preventing access to education, healthcare, and agricultural activities. To address this, the project featured a steel deck supported by four main cables anchored in earth abutments. SYSTRA funded the project and deployed a multidisciplinary team of ten employees from various countries. Over two weeks in November 2022, the team, alongside 36 local workers, manually tensioned cables and installed steel deck panels with precision. The trail bridge remains a testament to how engineering can empower isolated communities and improve lives.

Keywords
Suspended Trail Bridge; Rural Development; Community Impact; Infrastructure Engineering.

Introduction

The Gikeri River (Figure 1) experiences an exponential increase in flow during seasonal rains, posing a serious hazard to the 2,609 residents who need to cross it. As a result, children were unable to attend school on the other side of the river, agricultural workers could not reach the tea plantations, and elderly or sick individuals were deprived of access to the health center.

Figure 1 - The trail bridge over the Gikeri River in the Shyagari Valley

To ensure a safe crossing for the Shyagari Valley residents, the NGO Bridges to Prosperity—which works to improve access to healthcare, education, and economic opportunities through the construction of trail bridges—designed a suspended trail bridge. Spanning 80 meters, the bridge features a steel deck supported by four suspended carrier cables, which are redirected and anchored into earthen abutments (Figure 2).

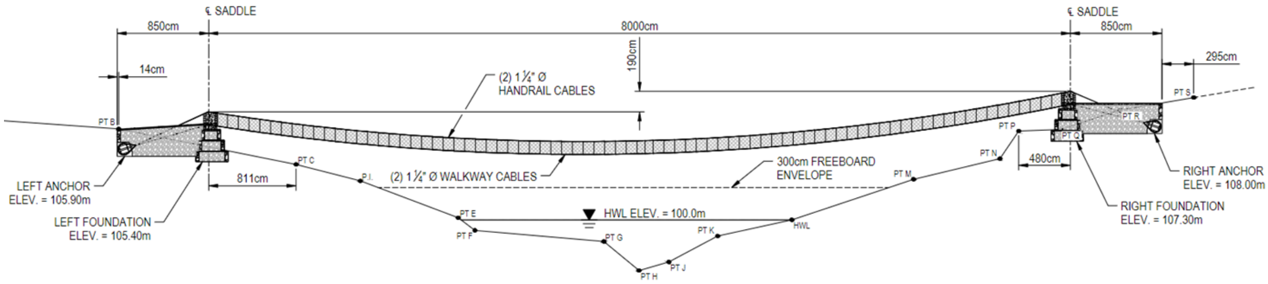

Figure 2 - Elevation view of the suspended trail bridge

At this stage, SYSTRA joined the initiative as a project partner, providing financial support and deploying a team of 10 employees—five men and five women—representing various disciplines and nationalities (Figure 3). Over a two-week period in November 2022, this team collaborated with 36 local workers, under the supervision of a foreman and a site engineer from the NGO, to construct the bridge. SYSTRA's involvement was driven by a commitment to serving local communities, strengthening the connections among its globally distributed teams, and encouraging its employees to engage in solidarity-based projects.

Rôle dans la mission	Nom	Fonction chez Systra	Localization
Project Lead	Philippe BAKHOS	CTO Design & Build	Dubai, UAE
Construction Lead	Houssam MATLI	Senior Bridge Engineer	Paris, FR
Safety Lead	Antoine ROUANET	System Engineer	Paris, FR
Logistics Lead	William BLONDEL	Deployment Manager	Paris, FR
Communications Lead	Giovanna CAMPEDELLI	Bridge Engineer	Sao Paulo, BR
Support Team Members	Mélanie SOREL	Information Manager	Paris, FR
	Franck BUY	CDE Administrator	Paris, FR
	Amanda TRINIDADE	BIM Manager	Belo Horizonte, BR
	Tereza BARROS	Consultant	Belo Horizonte, BR
	Meena JAIN	Environmental Engineer	Faridabad, IN

Figure 3 - The international and multidisciplinary SYSTRA team

Design Concept

Trail bridges provide essential access for rural communities, particularly for pedestrians, animals, motorcycles, and small vehicles. These structures are cost-effective, durable, and easy to construct, making them an ideal solution for remote areas where conventional infrastructure is absent. They are typically built using locally sourced and repurposed materials, ensuring both sustainability and adaptability to local conditions.

Trail bridges typically fall into two categories: suspended and suspension bridges. The suspended trail bridge, based on traditional designs found in Nepal and Peru, uses cables to support the walkway. It is suitable for short to mid spans in gently sloping valleys or longer spans in gorges. The suspension trail bridge, with load-bearing cables above the deck, is ideal for flat river terrains or flood plains. Both designs emphasize ease of construction, allowing for high community involvement (Figure 4).

Figure 4 - Comparison of a suspended bridge (left) and a suspension bridge (right)

For this project, the selected typology is a suspended bridge, chosen due to the location of the structure in a valley, requiring a design capable of spanning the challenging topography.

Structure Description

The Shyagari suspended trail bridge consists of a single 80-meter span (Figure 1). The deck has a usable width of 120 cm and is composed of prefabricated steel panels supported by UPN 100x50x6 crossbeams, spaced one meter apart. These crossbeams are, in turn, carried by four suspended cables (Figure 5). Two of these cables are positioned at the deck level, while the other two are located at the handrail level. Each cable has a diameter of 32 mm and a load capacity of 604 kN.

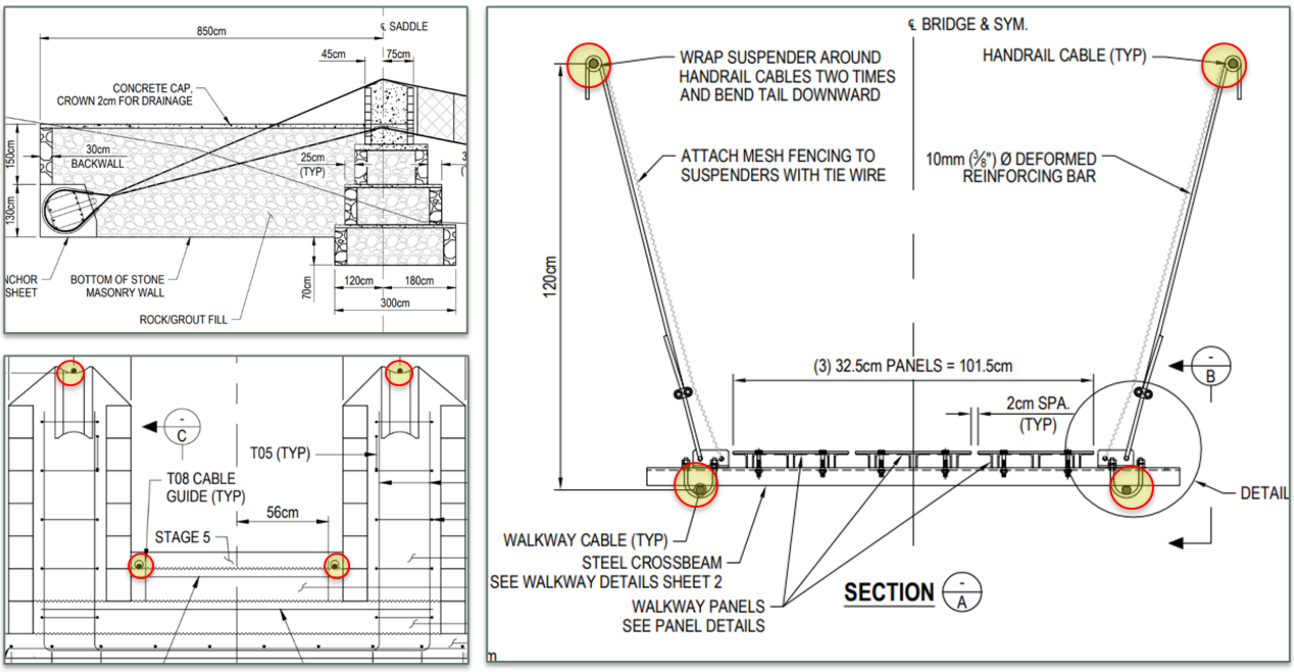

Figure 5 - The deck, cables, and abutments

The cables are redirected over smooth surfaces at the tower supports on both abutments and are anchored into a reinforced concrete anchorage beam within the abutment structure (Figure 5). The lower cables are spaced 120 cm apart from the upper cables and are connected by steel suspenders. Additionally, a steel mesh is attached to the suspenders and cables on either side, serving as a fencing (Figure 6). To enhance lateral rigidity, the deck panels are arranged in a staggered pattern (Figure 6).

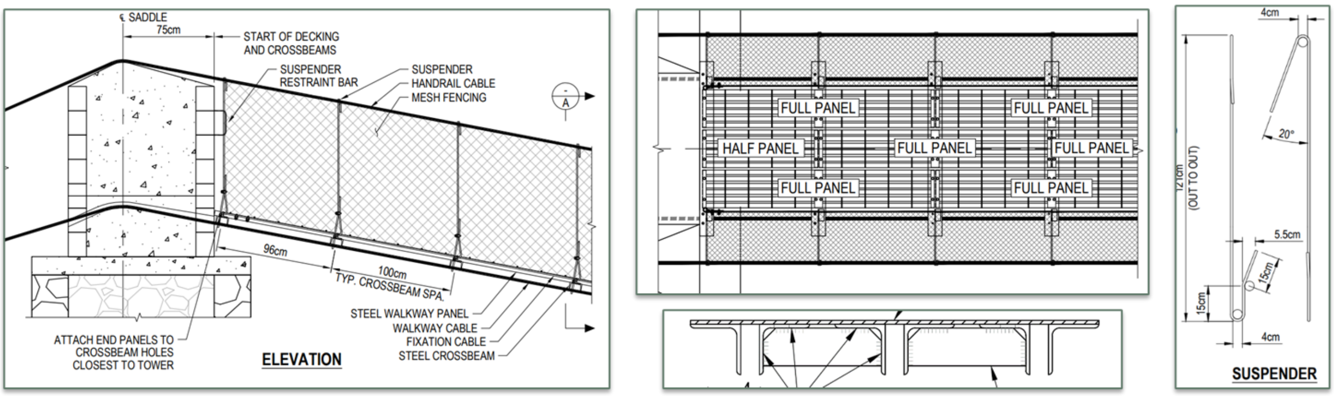

Figure 6 - The crossbeams, deck panels, and suspenders

Traditional Construction Methods: A Typical Workday

The construction site was located in the Shyagari Valley, in the Muhanga region of Rwanda, at an altitude of 1,687 meters. The team was accommodated in the home of a resident from the nearby village of Kabare (Figure 7). A typical workday began at 6:30am with a 10-minute off-road vehicle journey, followed by a 30-minute hike across the Shyagari Valley, as no navigable roads were available for vehicles (Figure 7).

Figure 7 - The house, the road, and a warm-up session on site

Upon arrival at the site, all team members donned their personal protective equipment (PPE) and participated in a warm-up session alongside the local workers (Figure 7). A comprehensive safety briefing was then conducted, followed by an overview of the day's tasks. The workday concluded no later than 5:30 PM, ensuring the team could return to their accommodation before nightfall.

Cable Suspension and Anchorage

Following the excavation and partial construction of the two abutments, the cables were installed and manually tensioned across the river using the combined physical effort of the SYSTRA team and local workers (Figure 8). Precise tension adjustment required millimeter-scale calibration of each cable's sag using an autolevel (Figure 10). This was essential because the cables alternately deviated above and below their theoretical position due to factors such as thermal expansion and frictional relaxation at the anchorages.

Figure 8 - Manual cable tensioning using arm strength

To determine the correct sag, it was necessary to calculate and mark the f-value. The f-value represents the height difference between the lowest point of the cable and the highest point of the tower on the lowest abutment (Figure 9). It is defined as a function of the hoisting height (h_{hoist}) and the height difference between the two abutments of the bridge (Equation 1). The value of h_{hoist}, in turn, is determined by the span of the bridge (Equation 2). The f-value serves as a reference height, marked on the abutment, and is used to adjust the cable's height by aligning it with the autolevel.

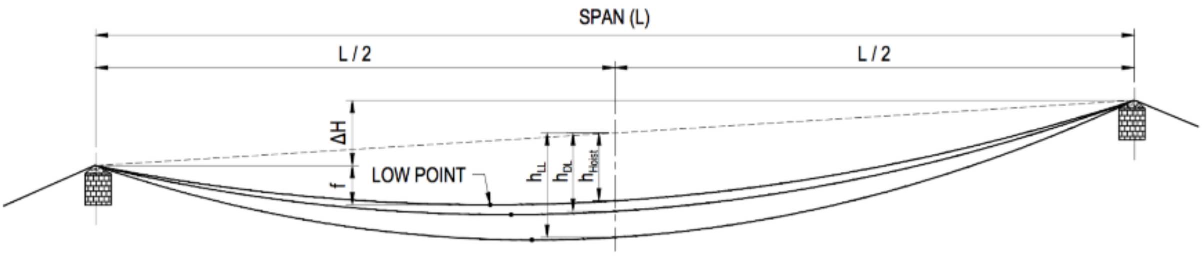

Figure 9 – Calculation of h_{hoist} and f-value for determining the correct cable sag

$$f = \frac{(4 \text{ x } h_{hoist} - \Delta H)^2}{16 \text{ x } h_{hoist}} \tag{1}$$

$$h_{hoist} = 0.046 \; x \; L \tag{2}$$

The manual adjustment method consisted of three cyclical and interdependent steps, repeated until achieving a sag of 3.15 meters (Figure 10). First, partial clamping was applied to temporarily secure the anchorages. This was followed by winching to fine-tune the cable tension when they were positioned too high or too low. Finally, the cables were struck with a wooden beam at the anchorages to release friction within the ducts of the anchorage beam.

Figure 10 - Partial anchorage in the abutments and cable tension adjustment

The three full days dedicated to these adjustments were essential to ensuring the structural stability of the bridge and preventing deformations that could compromise user safety.

Assembly and Launching of the Swings

Simultaneously with the cable adjustments, the 81 deck swings were prefabricated (Figure 11). Each swing consisted of a crossbeam connected on both sides to suspension rods, bolted hooks, and fastening clamps, all of which were shaped and assembled by the team near the two access ramps of the trail bridge.

Figure 11 - Assembly and launching of the swings

The swings were then progressively launched from each end toward the center. Ropes with spacing knots (Figure 11) were used to attach the swings at their final 1-meter spacing. Once secured, teams positioned on opposite sides of the valley pulled the swings toward the center. Effective communication and precise synchronization were crucial to ensuring the success of this stage.

Progressive Installation of the Deck

Following the launching of the swings, the deck panels were progressively installed from both ends of the trail bridge toward the center (Figure 12). The deck consisted of prefabricated steel panels, each 2 meters long, meaning that each panel spanned three crossbeams. The exception was the first central panel at each extremity, which was 1 meter long and spanned the first two crossbeams (Figure 6). This staggered arrangement allowed for an interlocking deck system that increased lateral rigidity.

Two teams, each composed of two people per side, were required to carry out this task safely and efficiently. The panels were bolted onto the crossbeams, starting from the extremities. Each installed panel then served as a platform for securing the subsequent ones until reaching the center. In total, 122 panels were installed over four days.

Additionally, a safety cable was installed above the main suspension cables, allowing workers on the deck to secure themselves and prevent falls into the river or onto the ground in case of an accident (Figure 12).

Figure 12 - Incremental installation of the deck

Painting, Fencing, Final Clamping, and Access Ramps

The trail bridge's handrails consisted of steel mesh panels attached to the suspenders and main cables (Figure 6). Extreme caution was exercised during this phase, which took one full day, to prevent injuries due to the sharp edges of the steel wire (Figure 13). For this reason, protective gloves and safety glasses were always mandatory.

Simultaneously, the cables were permanently clamped and coated with a protective layer inside the abutments. Additionally, the towers at both abutments were painted in the colors of the Rwandan flag (Figure 13).

Figure 13 - Painting of the abutment towers, installation of fencing, and cable coating

The excavated sections of each abutment were then filled with stones, followed by a top layer of unreinforced concrete poured on-site, creating access ramps to the trail bridge on both sides (Figure 14). These final steps took two days to complete, requiring human chains to transport stones and buckets of concrete to the abutments (Figure 14).

Figure 14 - Human chains for filling the abutments and concreting the access ramps

A Local Committee Dedicated to the Trail Bridge

A maintenance and monitoring committee for the trail bridge has been established, consisting of volunteers from the local workers who participated in its construction. The committee's primary mission is to ensure the structural integrity of the trail bridge and carry out minor repairs on non-structural elements, such as the fences or the replacement of suspender cables.

In case of more critical issues, such as significant slippage of the main cables from their reference marks on the towers of the abutments (Figure 15), the committee is responsible for closing access to the trail bridge and directly contacting the NGO Bridges to Prosperity. The NGO will then send specialists to conduct thorough investigations and resolve the issue as quickly as possible.

Figure 15 - Cable slip control marking

The success of trail bridges relies on close collaboration with local communities and governments. Involving local stakeholders from the planning stage ensures the infrastructure meets their needs and priorities. Additionally, the focus on durability and long-term maintenance, with local governments responsible for upkeep, ensures the sustainability of these projects. Trail bridges are designed to withstand time, weather, and heavy use, even in challenging environments.

The Inauguration

The inauguration was marked by a range of emotions, blending intense joy with a sense of sadness (Figure 16). The moment was filled with exuberant joy as the residents of the two villages crossed the trail bridge for the first time, celebrating the arrival of secure and lasting access to schools, healthcare centers, and new employment opportunities. However, this jubilation was tempered by a sense of sadness, as the project was coming to an end, marking the moment when the SYSTRA team had to bid farewell to the local teams. Over the past two weeks, these teams had shared every waking hour of each day, building strong bonds and unforgettable friendships.

The Lasting Impact of the Trail Bridge

Trail bridges generate significant economic benefits. According to Bridges to Prosperity website, in regions such as East Africa, these bridges offer an annual return on investment (ROI) of 49%, driven by improved access to markets, education, and healthcare. In countries like Rwanda and Uganda, ROI can reach up to 158% and 116%, respectively. These high returns underscore the transformative potential of trail bridges in fostering economic growth and improving livelihoods.

According to the impact report published by the NGO, one year after the inauguration, the Shyagari Trail Bridge has had a highly positive effect on the community it serves. Thanks to the bridge, the average household income in both villages increased by 30%. Additionally, 965 children now have safe and uninterrupted access to school, and 271 women have gained access to assisted childbirth.

Figure 16 - Inauguration of the trail bridge with local teams and residents of the served villages

These results underscore the enduring significance of the trail bridge in improving local living conditions. They also reflect the project's substantial contribution to the economic and educational empowerment of the communities, strengthening social bonds and solidarity within the region. The Shyagari Trail Bridge remains a tangible symbol of the fusion between engineering and compassion, working to transform lives and promote sustainable development.

Main Quantities

Suspension cables – 32 mm diameter – 604 kN capacity: 4 cables
Bracing members – UPN 100x50x6: 81 pieces
Prefabricated panels: 122 pieces
Hangers – T10: 162 pieces
Concrete – C10/12: 2.91 m³ per abutment tower
Concrete – C10/12: 5.06 m³ per anchor beam

Conclusion

The construction of the Shyagari suspended trail bridge in Rwanda by an international team from SYSTRA and the NGO Bridges to Prosperity represents more than a technical achievement—it is a vital infrastructure improvement with lasting social and economic benefits. Completed in just two weeks using traditional techniques and manual labor, the 80-meter-long bridge now ensures year-round safe access to medical care, schools, and agricultural markets for over 2,600 residents. One year later, its continued use underscores its critical role in reducing isolation and fostering economic growth. The Shyagari Trail Bridge stands as a testament to how engineering expertise, collaborative effort, and sustainable design can directly improve lives and support long-term community development.

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