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A POLYESTER-ROPE SUSPENDED FOOTBRIDGE IN AIT BAYOUD, MOROCCO: STRUCTURAL ANALYSIS AND KEY DETAILS

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Summary

This paper describes the analysis and structural details for a 64 m span polyester-rope suspended footbridge built in 2013 in rural Ait Bayoud, Morocco to provide members of the community with year-round access to a health clinic, school, and local markets. Polyester rope is an engineered, load rated product designed to endure rough handling and extreme weather. Although this product is frequently used in marine and arboreal applications, it has been rarely used in structural engineering applications. This is the first bridge at a significant scale that uses polyester rope in place of typical steel wire rope.

The first objective is to present the nonlinear static structural analysis of the bridge. Due to polyester rope's viscoelastic behavior lower-bound and upper-bound material stiffness models are considered. No deflection criterion is required in this remote area, so the bridge is theoretically allowed to deflect significantly under full service loads. Practically, these deflections result in onerous walking slopes that are intended to limit the live loads that are ever applied to the bridge at a single time. The second objective is to present the key details at the backstay anchorages and tower saddles. These details take into account large rope elongations that arise during bridge construction and use. Constructability, adjustability, and longevity of these details are discussed.

Keywords: polyester rope; suspended bridge; structural design; structural analysis; geometric nonlinearity; low stiffness

1. Introduction

To demonstrate polyester rope's potential, the first polyester-rope suspended footbridge at a significant scale, 64 m span and 1.02 m width, was built in Ait Bayoud, Morocco in 2013 (Fig. 1). This bridge provides the community members access to the health clinic, schools, and market when the local river experiences perennial flash floods. The U.S. Peace Corps identified the need for a crossing, and collaborated with Engineers Without Borders and community members on the bridge design, construction, and inspection.

The objectives of this paper are to (i) present the nonlinear static structural analysis for this polyester-rope bridge system and (ii) show how backstay anchorage and saddle details are designed and realized to accommodate significant elongations during construction and while the bridge is in service.

Fig. 1. Realized 64 m span polyester-rope suspended footbridge in Ait Bayoud, Morocco

2. Discussion and Conclusions

Accounting for the large geometry changes that occur due to polyester rope's low stiffness was critical in the analysis and to the successful construction of the Ait Bayoud bridge. Polyester rope's low stiffness and the resulting large deflections and elongations are atypical of modern suspended bridges such as the steel-cable structures built by groups including Bridges to Prosperity [1] and Helvetas [2].

Significantly prestressing the suspended ropes allowed the bridge to meet the strength criterion. In the realized design, a novel backstay anchorage accommodated the elongations arising from this prestressing through a set of adjustable links. Even with the stiffness that the ropes gained through prestress, the analysis indicated that the bridge would deflect considerably under the service live load. Accommodating these large deflections was integral to the design concept. As bridge deflections increase, additional people are less likely to step onto the bridge because of the potential discomfort of walking up a steep slope. In this way, deflections are used to manage the live load on the bridge and reduce the likelihood that the full design live load will be applied. Reducing the expected live load increases the bridge's safety. In the realized design, tower saddles are curved to allow for rope angle changes and have protective UHMW-PE tubes for minimizing potential rope abrasion from the rope elongations that accompany the live load deflections.

This paper and the realized Ait Bayoud bridge demonstrate that if polyester rope's low stiffness is considered in the analysis and detailing, then polyester rope has potential in bridge applications. The analyses and physically realized details presented in this paper may be adaptable for other rope structures capable of tolerating large deflections that would otherwise be limited to steel-cable technology such as suspension and cable-stayed footbridges as well as foundation anchorage systems for corrosive environments.

3. References

[1] Bridges to Prosperity, *Bridges to Prosperity Bridge Manual*, 2011.

[2] HMG, TBSSP/Helvetas, *Short Span Trail Bridge Standard: Suspended*, SKAT, 2003.