CAN FOOTBRIDGES BE SMART STRUCTURES?

Authors: María del Mar CORRAL[1], Leonardo TODISCO[2], Hugo CORRES[3]

Affiliation: [1] PhD Student, Univ. Polit. de Madrid, Madrid, Spain – mar.corral.domenge@alumnos.upm.es

[2] Assistant Professor, Univ. Politécnica de Madrid, Madrid, Spain – leonardo.todisco@upm.es

[3] Professor, Univ. Politécnica de Madrid, Madrid, Spain – hugoeduardo.corres@upm.es

Summary

This paper presents a discussion on the design of footbridges as smart structures, with an overview of the design process as well as on the cost implications. The discussion refers to a typology of footbridge consisting of an under-deck externally post-tensioned system. These structures are designed to perfectly counteract a specific loading condition, that generally corresponds to the permanent load distribution. The post-tensioning system inhibits any vertical deflection at the strut location for the considered load condition. For other load conditions, such as live loads, the post-tensioning system still contributes to resist a portion of the loads but its effect is not comparable to that of a fixed support, resulting in a smaller reduction of the maximum bending moment in the deck. As a result, the efficiency of the system decreases for live loads. This reduces the benefits of this structural typology from a structural perspective. This paper introduces the possibility of simulating the effect of a fixed support also for live loads; this behavior can be achieved by using a responsive system which is gradually post-tensioned as the live load increases. This allows to maintain the structural behavior of a continuous beam for any loading condition, resulting in an overall reduction of material. As a first approach, a simple structure is studied (Fig. 1), where the adaptive behavior is materialized through an actuator located between the deck and the under-deck post-tensioning system.

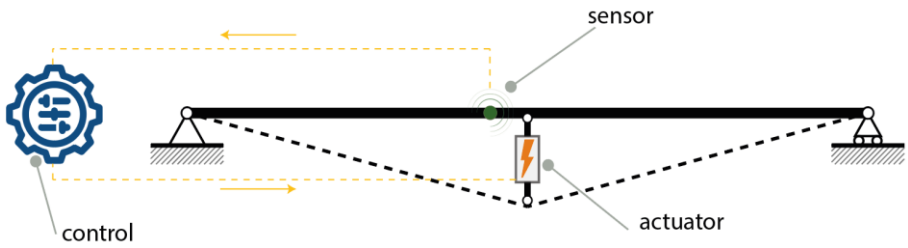

Fig. 1. Responsive externally post-tensioned footbridge.

This paper investigates the effectiveness of this system in terms of material and CO2 savings. This study shows promising results (Fig. 2), revealing savings of up to 13% and 28% in cost CO2, respectively, in comparison to a reference passive system. This motivates future studies in this direction.

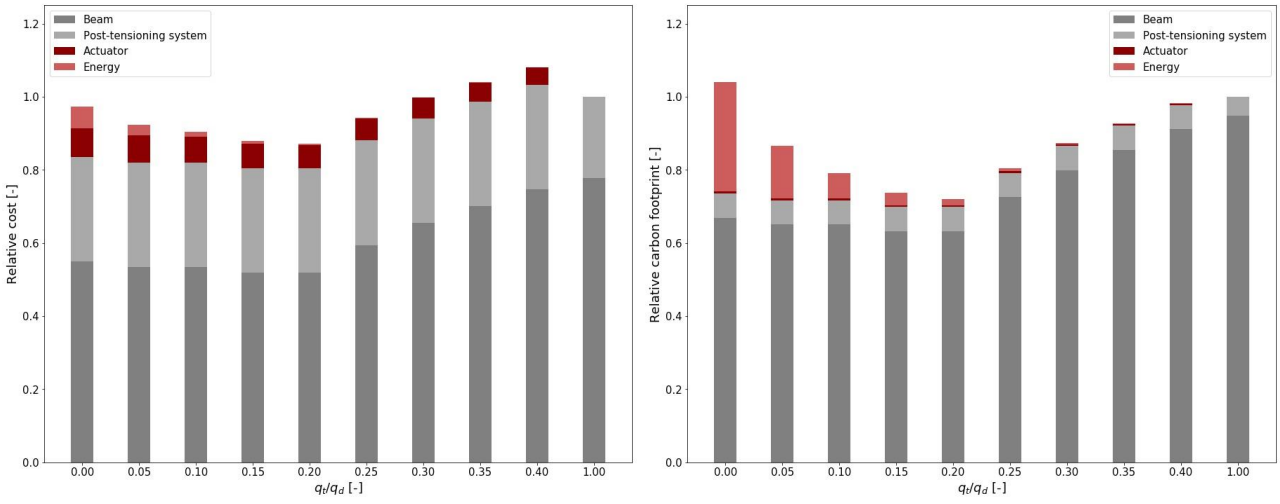

Fig 2. a) Relative cost vs. q_t/q_d. b) Relative carbon footprint vs. q_t/q_d.

Keywords: responsive footbridges; adaptability; external post-tensioning; efficiency; equilibrium; smart structures; responsiveness

https://doi.org/10.24904/footbridge2022.194
Distributed by structurae