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# Investigation of Under-Deck Cable-Stayed Footbridges under Dynamic Pedestrian Loading

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## 1 Abstract

Under-deck cable-stayed (UDCS) footbridges are slender structures that promote the axial behaviour. This allows designers to take advantage of the entire sectional areas and reduce the required construction materials. Besides their high structural efficiency and sustainability, they also possess a number of other advantages such as multiple construction possibilities and strong aesthetic characteristics, therefore becoming an attractive solution in urban infrastructure. However, due to their slenderness, they are more prone to vibrations. Recent closures of footbridges of this typology, indicate that fundamental aspects of their structural response still remained unclear. This paper presents a set of example bridges built with this typology and a detailed investigation of a benchmark case under the dynamic action of pedestrians. Results show that, although ULS is satisfied using a very high deck slenderness (1/100), the SLS of vibrations is the critical design criterion that governs the slenderness of the deck (leading to values of 1/60).

**Keywords:** dynamic response; footbridges; pedestrian loading, under-deck cable-stayed bridges.

## 2 Introduction

UDCS structures are unconventional systems that have been used as road and pedestrian bridges among other applications (i.e. roofs structures). They consists of prestressed cables, with a polygonal layout, located underneath the deck. The cables are self-anchored in the deck and are deviated with the aid of struts (see Figure 1).

These bridges are able to become very slender thanks to the promotion of the axial behaviour. In case of footbridges, due to the relatively small magnitude of the pedestrian actions in comparison to road bridges, they are able to become even lighter. However, that results in a more dynamic, rather than static character of pedestrian actions, making them more prone to vibrations, which are activated due to the dynamic nature of the pedestrian loading.

*Figure 1. Amanenomori footbridge, Japan [1]*

The past few years, significant research has been conducted to investigate structural behaviour of this bridge typology [2, 3, 4, 5, 6, 7]. Nevertheless,

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