# Vibration Control of Simply Supported Beam Bridges Equipped with an Underdeck Adaptive Tensioning System

**Arka P. Reksowardojo, Gennaro Senatore*, Lucio Blandini**

*Institute for Lightweight Structures and Conceptual Design (ILEK), University of Stuttgart, Germany*

**Manfred Bischoff**

*Institute for Structural Mechanics (IBB), University of Stuttgart, Germany*

***Corresponding author:** gennaro.senatore@ilek.uni-stuttgart.de*

## Abstract

External post-tensioning offers significant potential to improve the load-bearing performance of bridges. However, typical external post-tensioning systems are effective for a specific load case. This work investigates the application of an external adaptive tensioning (EAT) system for high-speed railway (HSR) bridges. The design of HSR bridges involves strict acceleration constraints, which typically results in oversizing. The EAT system comprises under-deck cables deviated by linear actuators, which enable controlling the bending moment as the load changes. Simulations are carried out on simply supported beam bridges. Results show that active control through the EAT system allows satisfying vertical acceleration limits for mid-span HSR bridges, which cannot be met otherwise without incurring a weight penalty. In addition, the cyclic stress range is significantly reduced showing the potential for fatigue-life extension.

**Keywords:** adaptive structures; bridge engineering; vibration control.

## 1 Introduction

External post-tensioning is an effective solution to improve the structural performance of beam bridges [1]. The tension force from the external cables is applied eccentrically to the neutral axis through deviators, which produces a bending moment opposite to that caused by the external load. However, passive external post-tensioning systems are effective only under a specific load case. This work investigates the performance of beam bridges equipped with an active external tensioning system comprising under-deck cables that are deviated by vertical compressive struts acting as intermediate supports. Each cable end is anchored to the corresponding end of the beam nearby the support. The structural system comprising beam and cable-strut behaves as an underdeck cable-stayed bridge [2]. However, linear actuators are employed to adjust the length of the struts, which changes the tension in the cables, thus allowing the manipulation of the bending moment as the load changes. This system is referred to as external adaptive tensioning (EAT) system. Previous work has shown that similar external adaptive tensioning systems are effective to reduce the response of beams under quasi-static [3, 4] as well as dynamic loading [5].

The demand for high-speed railways (HSR) is growing since it is considered a strategic and

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