# Damping of long-span suspension bridges with damped outriggers

**Zhanhang Liu, Lin Chen**

*Department of Bridge Engineering, Tongji University, Shanghai, China*

**Limin Sun**

*Department of Bridge Engineering, Tongji University, Shanghai, China*

*State Key Laboratory for Disaster Reduction of Civil Engineering, Tongji University, Shanghai, China*

*Shanghai Qi Zhi Institute, Shanghai, China*

**Contact:** linchen@tongji.edu.cn

## Abstract

Long-span suspension bridges are vulnerable to vortex-induced vibrations (VIVs), e.g., the Humen Bridge and the Xihoumen Bridge in China. This study focuses on a novel strategy by using damped outriggers to control rotations of bridge deck at the junction points between the girder and a bridge tower or pier. A simplified model of a suspension bridge with damped outriggers is used for damping analysis. Considering practical parameter ranges, the maximal damping ratio provided by one damped outrigger to a specific mode is about 1.0%. Influences of bridge boundary conditions, installation position of damped outriggers, and interaction between multiple damped outriggers are studied. When multiple damped outriggers are installed, the damping effects of multiple modes can be further improved. It is shown that damped outriggers are effective in suppressing multimode vibrations of long-span suspension bridges.

**Keywords:** Damping; suspension bridge; damped outrigger; vortex-induced vibration; complex modal analysis.

## 1 Introduction

In the last decades, with the increase of bridge span, the stiffness of the bridge becomes lower. Meanwhile, the frequency and damping decrease, which makes the bridge easier to vibrate under the action of wind and vehicles [1], particularly the vortex-induced vibrations (VIVs). The vibrations could threaten the experience of bridge users, and may even endanger the safety of the bridge structure. Vibration mitigation remains a challenging issue for long-span bridges.

At present, vibration control methods for long-span bridges mainly include aerodynamic treatments, mechanical devices, and structural countermeasures [2]. The commonly used mechanical devices include direct energy dissipation dampers and tuned mass dampers (TMD). TMD can be connected to a structure at an arbitrary position to control the absolute displacement [3]. However, it can only be optimized to a certain vibration mode. Compared with a TMD, direct energy dissipation dampers need to be installed between two points with large relative displacements of the structure to achieve vibration mitigation and energy consumption. The dampers for controlling the vibration of the main girder have been considered between the tower and the girder beam [4]. It is noted that the vertical relative displacements of the bridges at the

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