A longitudinal isolation system with elastoplastic cables for single-tower cable-stayed bridges

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Abstract

For single-tower cable-stayed bridges, a longitudinal isolation system with elastoplastic cables were proposed, and calculation expressions based on dynamic concepts were established for the design of this system. Based on the Jinsha River Bridge, a performance comparison was conducted on the elastoplastic and elastic cable systems. The girder displacements under wind and braking force, as well as the damping effects under earthquakes, were analysed for both systems with the most economical parameters. The results demonstrate that both elastoplastic and elastic cables can effectively reduce the longitudinal displacement of the girder compared to a floating system under normal service conditions. However, elastoplastic cables have a higher material utilization rate, larger restraint stiffness, and a wider range of applicable parameters than elastic cables. In addition, elastoplastic cables can effectively dissipate energy and have a better damping effect.

Keywords: single-tower cable-stayed bridge; longitudinal isolation system; elastoplastic cable.

1 Introduction

Currently, the focus of transportation infrastructure construction in China is gradually shifting towards the central and western regions, which is creating a new demand for bridge construction. Since the local terrain is mostly mountainous and hilly, there is a great need for long-span bridges with a single span of 200m to 400m. Additionally, the central and western regions are prone to frequent strong earthquakes, posing a significant risk of seismic disasters to local bridges. Therefore, the single-tower cable-stayed bridge has become a popular choice for bridges with main spans ranging from 200m to 400m due to its excellent economy, great spanning capability, and good seismic performance.

In high-intensity earthquake areas, cable-stayed bridges typically adopt fully or semi-floating systems where the longitudinal constraint between the tower and girder is released to prevent excessive inertial force of the structure during earthquakes [1]. To control the large seismic displacement of the floating system, additional constraints or energy dissipation devices are often installed between the tower and girder [2-7], and the most commonly used device is the viscous damper [8-14]. For classic two-tower cable-stayed bridges, the floating system with an additional viscous damper is an ideal mechanical system both under normal service conditions and during earthquakes [1]. This is because that it is necessary to release the constraint between the tower and girder to accommodate deformation caused by daily temperature changes and to prolong the structural period to achieve a seismic isolation effect during earthquakes. Additionally, the viscous damper is a type of damping device that does not affect the static stiffness of the bridge but provides effective energy dissipation.

However, for single-tower cable-stayed bridges, it is recommended to use the tower-girder

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