Modal Analysis and TMD Design of the Wing-spread Bridge: A Pedestrian Bridge along the Binjiang Avenue, Shanghai

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Abstract

Wing-spread bridge is an innovative stress-ribbon arch pedestrian bridge expected to be built along Binjiang Avenue, Shanghai, China. Human-induced vibration is an important factor that needs to be considered in the operation period of pedestrian bridges. However, there is a lack of research on this new structure's dynamic characteristics and vibration reduction measures. In this paper, the finite element (FE) model of the Wing-spread Bridge is firstly established, and the modal analysis is conducted based on the FE model. Subsequently, the maximum acceleration of each mode under pedestrian dynamic load is calculated. The result shows that the maximum acceleration of the first-order lateral bending mode exceeds the best comfortable indicator. Finally, two tuned mass dampers (TMD) are designed to be installed at the top of the arches, and the vibration amplitude of the bridge with TMD meets the requirements.

Keywords: stress ribbon arch bridge; FEM; modal analysis; vibration control; TMD.

1 Introduction

Wing-spread bridge is an imaginary 164m stress-ribbon arch bridge built in Shanghai. The arch and the main cable overlap in the middle of the span. A back-cable partial double-layer suspension-arch combination system is proposed in creating the entire bridge, and several innovations are realized. The rigid frame effectively connects the flat arch and the sling in the middle of the bridge. Under the lifting action of the sling, the overall bending moment of the flat arch is improved, the cross-section is lightsome, and the span of the whole bridge is increased. Bridge decks are set on the main arch and suspension belt, and the double bridge decks bring different walking experiences to pedestrians. The tower and foundation are the significant components of the bridge. We adjust the position and the cable force of the back cable, and the cable force of the main cable to achieve better structural performance. In this state, the structure has almost no horizontal thrust on the foundation, and the bridge tower is only subject to axial force under the action of dead load. At the same time, the bridge tower adopts the shape of a

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