The Design of a River-crossing Pedestrian Bridge in Kunming City, China: a New Structure Form for Cable-supported Bridge

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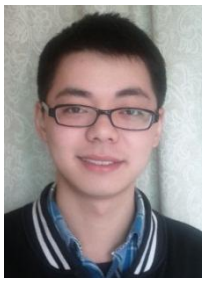

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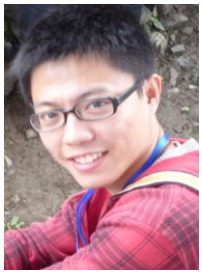

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Summary

Compared with the traditional suspension bridge, the Songhua pedestrian bridge has no hangers, and the cable is under the stiffening girder in the mid-span position. The loads of human groups on the floor system are transferred to the cable by the brace strut of curve shape. This paper mainly introduced the structure design, the related parameters, the construction method , and the static and dynamic analysis. In the static analysis, the cable's internal force and the stress characteristics of the stiffening girder and pylon have been discussed. Regarding the dynamic analysis, this paper compared the bridge's natural vibration characteristics under different boundary conditions of the stiffening girder and the earthquake resistant behaviour and calculated the vertical acceleration by time-history. The results shows that fixing the two end of the stiffening girder can improve the natural frequency efficiently so as to avoid the happening of resonance.

Keywords: suspension bridge; urban pedestrian bridge; dynamic characteristics; vibration induced by human walking; time-history method.

1. Introduction

This Songhua river-crossing suspension bridge in Kunming city of China is a city special pedestrian bridge, while the vehicular bridge located on the side of it. The total length of the main bridge is 73,5m and the full width is 6,25m, with the span arrangement of (12,2+49,1+12,2) m. The effect picture of the Songhua bridge is shown in fig.1. Meanwhile, the central line of the bridge is perpendicular to the river and located in a straight line. As to the substructure, the solid abutment and spread foundation are applied. The design reference period of this bridge structure is 50 years and the 8-degree seismic fortification intensity is adopted. The technical features of this bridge are as follows:

1) The load of human groups on the floor system was transferred to the cable by the brace strut of curve shape instead of hangers.
2) Because the bridge's span is small, live load is large and the stiffness of girder is relatively large, the bridge can be regarded as the combination system of cable and girder.
3) In order to improve the bridge's vibration stiffness and avoid the happening of resonance, the ends of the girder were fixed.

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Fig. 1: Effect Picture of Songhua Pedestrian Bridge

2. Structural Design

Both the stiffness girder and pylon were made up of Q345qD steel and the cable is made up of steel wire rope. For the anchorage, abutment and foundations, C30 concrete is used.
For the cable of each side, two 6×19 round strand steel wire rope (nominal diameter 74mm) of which the nominal tensile strength is 1670N/mm^2 and the minimum breaking force is 3260kN were chosen.

The variable cross-section of steel plate girder is adopted in the stiffening girder. The main girder is composed of two I-beam and connected together by the diaphragms and U-rib stiffeners. Due to the ends of stiffening girder which are fixed and inserted into the concrete, the axial force and moment are great under the external loads especially the temperature action. So the beam height which is in the supporting position is taller than in the mid-span.

The pylons of the pedestrian bridge are designed as two separation steel tower with variable box section in the transverse direction of bridge. As the pylon inclines outwards along the longitudinal direction, the angle between the pylon's central line and horizontal line is 70°. In order to keep its stability, the pylon is also inserted into the anchorage.

3. Structural Analysis

As the new type suspension bridge, the Songhua pedestrian bridge has different internal force distribution in cable and stiffening girder compared to the normal suspension bridge, so that 3 dimension structural analyses are needed to investigate the structural performance of the whole bridge. In the FEM, geometric nonlinearity and initial stiffness of the structure are considered and spatial beam element is adopted for simulating the girder and pylon while the cable is simulated by truss element. The calculated load includes the dead and live load, and the weight of bridge deck pavement and subsidiary facilities are considered in the secondary dead load. According to the local temperature of the bridge, the temperature effect are also included in the FEM. Finally, five typical calculation conditions are considered.

4. Conclusions

The Songhua pedestrian bridge is full of imagination and shaped unique. Its cable is under the stiffening girder in the mid-span position and replaced the hangers with the brace strut of curve shape, which is a kind of innovative design different from the traditional suspension bridge. Through the FEM analysis, both the static and dynamic calculated results satisfied the specifications.