Model experimental research for super-span self-anchored suspension bridge

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Summary

As a part of Wuxi highway, TaoHuaYu yellow river bridge is a super large-span self-anchored suspension bridge with double towers and double cable planes whose span is 160+406+160 m. Experimental model of the whole bridge is designed with a geometric scale ratio of 1/30 and a mechanical scale ratio of 1/1 to analyze the stress states in construction stage and the mechanical properties in serve stage. The researches on the mechanical properties of the bridge have proved the feasibility of the super large-span self-anchored suspension bridge and revealed the variation rules of deformation and stress of the main beams and main cables in whole construction.

Keywords: Super large-span; Self-anchored Suspension Bridge; Model experiment; Mechanical property ; Variation rules.

1. Introduction

TaoHuaYu Yellow River Bridge is a three span anchored suspension bridge with double towers locating ,with a span of 160+406+160 m.. A whole bridge model test for TaoHuaYu Yellow River Bridge are made to analyze the stress state in construction stage and the mechanical properties in serve stage and to verify the feasibility of both the design theory and construction scheme.

2. Design of Test Model

Considering the test content, model material, experimental precision and the test site, the geometric scale of the model is designed to be 1/30 while the mechanical scale is 1/1 to ensure more accurate and ideal experimental data.

3. The Test Scheme

Lever method with a ratio of 1:4 is used for the counterweight of main beam while hanging weight in the corresponding position of the cable clamp is used for the counterweight of main cable and cable clamp.11 displacement measuring points symmetrically arranged along the longitudinal direction of bridge and each section with 1 measuring point. Accordingly, 49 measuring points are also correspondingly set in the cable clamp along the longitudinal direction of bridge to measure the deflection of main cable.11 strain measuring point section of main beam are set along the longitudinal direction of bridge, and there are 6 measuring points in each section.

4. Analysis of Test Results

The test stress of the main beam section matches well with the theoretical one indicating that the model test and theoretical calculation are overall consistent. The stress value in any construction stage is no more than the allowable stress value that in the initial test stage (1th to 8th stage), the main beams are mainly subjected to bending moment without significant change in stress because the self weight of the main beam can be supported enough by temporary piers with only relative small tension from suspender. While from 9th to 17th construction stage, the self weight of main beam gradually transfers to main cable due to the structure system transformation finally a self-

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balance structure is formed that the stress of main beam section changes significantly. After the bridge is completed, the stress of every main beam section in each position are all about -50Mpa showing that the main beam section now is mainly subjected to axial compression without significant bending effect.

In the initial period of suspender tensioning, tension is small and the vertical deformation is not significant with main beam supported on temporary piers. And afterwards, since 11th construction stage, both the value of tension and the number of suspender to be tensioned begin to increase gradually and the system transformation is finally completed through the nonlinear contact between the girder and temporary piers. Therefore, with the transferring of the main beam’s self weight from main beam to main cable due to the tension of suspender, the suspending points are all consistent on the whole with vertical and upward deformation and in this stage the deformation of main beam is extremely significant, and then up to the 17th construction stage, the deformation of main beam tend to turn downward under the second stage load. When suspender tensioning is completed, the results prove that the measured girder curve matches well with the theoretical one and the measured value in the middle section of mid-span is only about 8.5% less than the theoretical one due to the great contribution of stiffener in experimental model.

In the initial period of the test, both the deformation and the tension change of the main cable are relative small while tension in the end of the main cable begins to increase gradually with the increase of both the value of tension and the number of suspender to be tensioned. From the 8th to 13th stage, structure system gradually separates from temporary piers forming a semi elasticity semi-rigid system with suspender combined with temporary pier working together, and then the main beam separates from the temporary supporting thus the tension increase suddenly leading to the sharply increase of the tension in the end of main cable. Afterwards, from the 13th to 15th stage, the main beam has basically separated from the temporary pier and no additional loads are subjected to the bridge so that the suspender tension in the mid-span in this stage is just a internal force redistribution of the structure hence the change of the tension is slight.

In the initial period of suspender tensioning, namely from 1st to 8th construction stage, the tension of main cable is small while the deformation is large which behaves a large displacement nonlinear effect. In the later period, the gravity stiffness of the main cable increases due to the increasing tension so that the deformation caused by suspender tensioning is relatively small with vertical deformation sharply decreased.The effect scope of the suspender tensioning on adjacent suspending point is about 3-5 suspenders’ distance and the displacement weak interference rule is true after the main beam is all off the rack and structure is a self-equilibrium system.

5. Conclusions

1) According to the test results, the mechanical behavior of the main cable and main beam in the model test matches basically well with the theoretical one and behaves the same trends.

2) In the construction process of self-anchored suspension bridge, main beams are constructed first and then the system transformation is completed through suspender tensioning which behaves a large displacement nonlinear effect. With system transformation going on, the gravity stiffness of the main cable increases gradually that the nonlinear characteristics naturally tend to weaken.

3) In the initial period of construction, the section of main beam behaves bending effects due to the self weight, while after the system transformation the main beam is mainly subjected to axial compression with few bending effect due to the transfer of self weight from main beam to main cable.

4) In the process of system transformation, the self weight of the main beam transfers to the main cable due to the suspender tensioning, as a result, the deformation of the main beam turn vertical and upward.

5) In the initial period, the tension of main cable is small with relative large deformation which behaves a large displacement nonlinear effect. While with the increase of tension, the gravity stiffness of main cable increases so that the deformation caused by suspender tensioning is relatively small with vertical deformation sharply decreased .The displacement weak interference rule is true after the main beam is all off the rack and structure is a self-equilibrium system.