Anti-Slip Test of Main Cable Against Saddle of Three Pylon Suspension Bridge

Lin JI
Vice Director
J.P.C.D
Taizhou, CHINA
tzbridge@163.com

Ji Lin, born 1962, received his BS and MS civil engineering degree from Tong Univ. and got his PhD from Hohai Univ.

Ce CHEN
Bridge System Engineer
J.P.C.D.
Taizhou, CHINA
cc808cc@163.com

Chen Ce born 1975, received his BS and MS civil engineering degree from South East Univ.

Zhaoxiang FENG
Bridge System Engineer
J.P.C.D
Taizhou, CHINA
tzbridge@163.com

Feng Zhaoxiang, born 1968, received his BS and MS and PhD from Hohai Univ.

Summary

Taizhou Yangtze River Highway Bridge is proposed to adopt three pylon suspension bridge designs. To figure out slip behavior of main cable against saddle for middle pylon under given circumstance, Jiangsu Provincial Yangtze River Highway Bridge Construction Commanding Department(J.P.C.D.) takes initiative to carry out study on slip resistance of main cable against saddle. This test simulate true contact between strands, wires as well as strand and saddle groove. Moreover, this test uses contact compression stress identical to the actual bridge to truly reflect slip behavior of main cable against saddle for middle pylon in three pylon suspension bridges.

Keywords: three pylon suspension bridges; main cable; middle pylon saddle; slip resistance test;, frictional coefficient.

1. Introduction

Fig. 1: Taizhou Bridge across Yangtze River

Three pylon suspension bridge is a bridge of new structural form(Fig.1). The key element of design of three pylon suspension bridges is determination of middle pylon rigidity. As middle pylon top restraint is much weaker than that of side pylon, when one main span is applied with fully live load and the other main span is applied with empty live load, in case of small rigidity of middle pylon, deformation of stiffening girder will increase twice much as that of single span. In case of large rigidity of middle pylon, flexibility stiffening girder at loaded span is not very large but main cable force has big variation, which might cause slipping of main cable against saddle, resulting larger deformation of stiffening girder. Therefore, it is one of the most important tasks to determine frictional coefficient of middle pylon main cable against saddle during design of three pylon suspension bridges. Due to complexity of force transfer between main cable and saddle, it is very difficult to find out true picture of friction between main cable and saddle by means of theoretical model, therefore, it is necessary to carry out slip test of main cable against saddle so as to figure out frictional coefficient of middle pylon main cable against saddle.

2. Slip Test of Main Cable against Saddle

Model saddle is fixed to test bench by welding to steel plate. No vertical movement or rotation is allowed for saddle. Model saddle (Fig.2) has the same angle as that of the actual bridge. The test simulates theoretical extreme work condition: unsymmetrical work conditions with one full loaded main span and one zero loaded main span. A pressure transmitter is installed at front end of each strand anchorage nut to measure tensile stress of each strand and jack is installed at rear end of

https://doi.org/10.2749/222137908796293631

Fig 2: Saddle and Strand in the Model

pressure transmitter. Strain gauge is installed on tension rod at B end of one strand to measure change of tensile stress during stressing. At clamps of Saddle A (simulated dead load) and B (Simulated dead load + live load at stressing end) ends, indicator is installed to measure slip movement of each strand during stressing. Indicator is installed in front of saddle and close to B end to measure deformation of saddle during stressing.

Main cable strands at both side of model saddle simulates loading of main cable dead load for the actual bridge and figures out 338.85KN for each strand loading and correspondingly 3388.5KN for total load of 10 strands on the condition that compression contact stress of model strand against model saddle is equal to the minimum compression contact stress of actual main cable strand against saddle. During the test, two ends of the strand are stressed simultaneously by jacks to force imposed by dead load and then B end is stressed to force imposed by dead load + live load.

In comparison of multiple strands test results and single strand test results, frictional coefficient of single strand is smaller than that of multiple strands. As above mentioned frictional coefficient calculation formula only takes vertical compression but not side friction of saddle model against strand into account (friction of saddle cover against strand is negligible, because contact area and contact stress of saddle cover against strand is very small), frictional coefficient of multiple strands is comparatively bigger and therefore it is necessary to further analyze side friction of saddle against strand.

3. Test conclusions

Main conclusion is drawn as follows:

(1) Multiple strands slip test results show that frictional coefficient of strand against saddle in three test groups is 0.521, 0.535 and 0.535 respectively. Single strand slip test results show that frictional coefficient of strand against saddle in three test groups is 0.302, 0.326 and 0.391 respectively. In comparison of multiple strands test results and single strand test results, frictional coefficient of single strand is smaller than that of multiple strands. We think the reason is that during multiple strands test, there is not only friction of strands bottom against saddle but also side friction of strands against saddle due to side squeezing and compression, while for single strand test, side friction is not contributing to total friction as much as that for multiple strands test.

(2) Compared with single strand test, contact stress of strands against saddle bottom is relatively bigger. Under high stress, contact area of strands against saddle happens local deformation, which means contact surface is not smooth round arc but becomes accidented, resulting increase of frictional coefficient. After the test, observation of removed pieces justified above deduction.

(3) This test uses galvanized steel wire of the same diameter as actual bridge and simulates true contact between strands, wires as well as strand and saddle groove. Moreover, this test uses contact compression stress which is almost the same as the actual bridge, so work condition of strands against saddle described in multiple strands test model is more closer to true image of the actual bridge.

(4) Considering difference between test model and actual bridge, frictional coefficient obtained from this test shall be properly discounted when it is applied in the actual bridge. In conceptual design of Taizhou Yangtze River Highway Bridge, frictional coefficient (0.2) of middle pylon against saddle is finally adopted.