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Field Observation and Vibration Test of the Tatara Bridge

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Abstract

1. Introduction

The Tatara Bridge, the longest span cable-stayed bridge in the world, has a total length of 1,480 meters and a center span length of 890 meters and is located at the Onomichi-Imabari Route. Such a bridge is tend to appear the sway because of long-span and numbers of long cables and has the possibility to appear complicated behavior, however, there are not enough data for making such behavior clear and verifying the dynamic design. Therefore, it is important to evaluate stability against dynamic loading such as wind and earthquakes in the field investigations. Several field observations and vibration tests have been performed since the beginning of construction. This paper indicates the results of field vibration tests and observations including comparison with ones of theoretical analysis carried out previously.

2. Field Vibration Test

The field vibration test was performed from November to December 1998 on the complete structure including pavements. Two exciters were used in order to vibrate the girder in the vertical and horizontal directions. The horizontal vibration test was the first trial on such a long-span cable-stayed bridge. The situation of the field test is shown in **Photo.-1**.

The dynamic properties (natural frequency, mode shapes and structural damping in logarithmic decrement) of 8 important modes were measured and calculated. The test results are shown in **Table-1** by comparing with ones of the theoretical analysis. It is confirmed that there is only a few differences on the dynamic properties, similarly on the mode shapes.

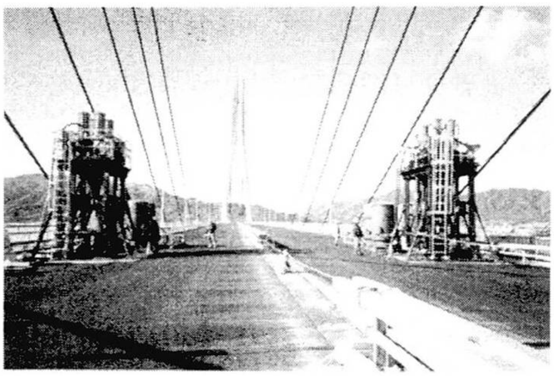

Photo.-1 Situation of the field vibration test

vibration mode		frequency(Hz) messred	frequency(Hz) calcul-ated	log. decrem-ent δ *)	max. amp. (cm)
vertical bending	1st symm.	0.226	0.223	0.024	30.5
	1st asymm.	0.263	0.262	0.018	22.6
	2nd symm.	0.348	0.345	0.007	9.5
torsion	1st symm.	0.497	0.498	0.017	4.8
	1st asymm.	0.831	0.822	0.051	1.6
horizontal bending	1st symm.	0.097	0.094	0.132	9.4
	1st asymm.	0.248	0.249	0.213	4.0
	2nd symm.	0.470	0.494	0.173	1.1

*) : reference data, under investigation

Table-1 Test results

The natural vibration analyses were performed with a three-dimensional frame model of a whole structural system. Each cable models includes 50 nodal points in order to express a coupled vibration between girder and cables.

The structural damping δ in logarithmic decrement in **Table-1** were calculated using the measured free vibration data. The damping is small on the vertical bending and torsional vibrations, however, these are almost same as the wind resistant design code for Honshu-Shikoku Bridge, δ=0.02. On the other hand, the damping is quite large on the horizontal bending vibration. As the reason, it is presumed that the loose-tightened bolts, installed at the edge of girder to fix the attachments such as fairings, have slipped. The free vibration of girder, the slip of fairings and the vibration dependence of damping varies are shown in **Fig.-1**. It shows that slip of fairing has an influence of the structural damping.

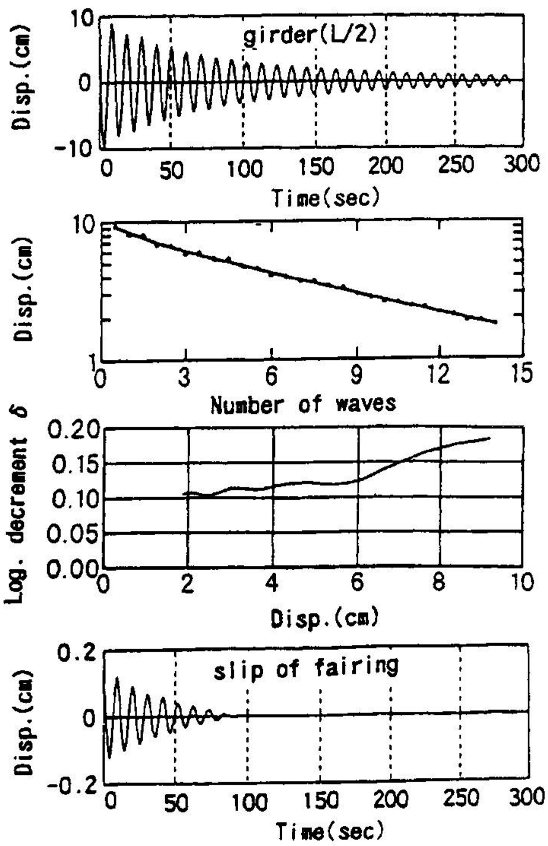

Fig.-1 Free vibration and damping

3. Response Observation in the Strong Wind

The observations of dynamic properties in the strong wind have been performed for about two years from the beginning of the construction to the completion. A vast amount of response data , against strong natural wind such as a typhoon and a seasonal wind, has been stored up. Several important results are as follows;

(1)The maximum gust response of girder was 7□8 cm on both vertical and horizontal vibration against the maximum instantaneous wind speed of the typhoon happened in the situation of almost complete structural system.

(2)The dimple processed polyethylene pipes were developed and used as the countermeasure for rain-vibration. There were no injurious rain-vibrations in the strong wind, therefore the efficiency of this countermeasure was evaluated. Moreover it was confirmed that rubber seals, filled into the entrance of cable in the girder, enabled to prevent vortex-induced oscillation of cables that often had happened under construction.

4. Summary

The field vibration test was performed on the Tatara Bridge and the dynamic properties of important modes, especially structural damping, were measured and calculated for making complicated behavior clear and verifying the dynamic design. With test results, the phenomena of coupled vibrations between girder and cable including non-linear coupled vibration (parametric excitation) and the causes of structural damping were investigated and important data for the future design of long-span cable-stayed bridges was obtained.

On the other hand, the field observations were performed in order to ensure safety under construction, store up the properties of natural wind at the location of this bridge and evaluate the validity of the countermeasure for cable vibration against strong wind. These data are under analysis still now and the new results would be presented in the near future.