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Aerodynamic Stability of Suspension Bridge with Open Grating Deck

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Summary

This paper deals with the aerodynamic stability of super long span streamlined box girder suspension bridge with open grating deck. Two dimensional wind tunnel tests were carried out in order to understand differences in the aerodynamic stability of structures with the different types of grating (wire net or thin perforated plate), and the porosity of these sections. It was shown from wind tunnel test results that the open grating method was effective to improve the characteristics of both the vortex-induced and the compound flutter oscillations.

1. Assumed Suspension Bridge and Wind Tunnel Tests

The effects of grating types and their porosity on aerodynamic stability were examined through wind tunnel tests of section models. Considering a super long span suspension bridge which has center span length of 2500m with two side spans of 1250m each (Fig.1), the cross section of girder and the structural characteristics are shown in Fig.2 and Table I . Table II shows the test cases in this study, where AD is the basic case (without openings), W1L1 is the case in which the parts W1 and L1 are completely open as shown in Fig.2 and Table II. Other cases shown in Table II, W1L1/50G through W1L1/70H are with gratings installed. The porosity of grating is shown by numerals, and letters G and H signified either wire net or thin perforated plate.

2. Wind Tunnel Test Results

2.1 Characteristics of Vortex-induced Oscillation

Fig.3 shows relationships between amplitude of vortex-induced oscillation and angle of attack. In Fig.3, when the angle of attack was 0 degree, with the model configuration W1L1, both the vertical and the torsional vortex-induced oscillations took place, where the maximum vertical amplitude was 100mm, and torsional amplitude was 1.7 degrees. And, the Test case AD demonstrated a vertical vortex-induced oscillation with the maximum amplitude of 500mm at the angle of attack of -3 degrees. At the same angle of attack, the Test case W1L1 showed the maximum of the torsional vortex-induced oscillation of 2.1 degrees. On the other hand, in each case of open gratings, no vortex-induced oscillation was observed at these angles of attack. The open grating method made it possible to suppress the vortex-induced oscillation which appeared in the fully opened case (W1L1) or the fully closed case (AD). However, when the angle of attack was +3 degrees, the torsional vortex-induced oscillation was observed in all cases.

2.2 Characteristics of Compound Flutter

Fig.4 shows relationships between critical wind speed of flutter and angle of attack. Here, the compound flutter speed for all cases of G-series was found to be approximately twice that of AD at the angle of attack of -3 degrees. However, with H-series, it was found that the compound flutter speed varied with the cases tested. In W1L1/50H (the case with porosity of 50%) the compound flutter speed was 90m/s, but the compound flutter speed decreased to approximately 50m/s for W1L1/70H. When the angle of attack was 0 degree, the compound flutter speed varied with each case in both G-series and H-series. In these cases, the compound flutter speeds for W1L1/50G and W1L1/50H were 80m/s and 90m/s, and it could be said that if the porosity of grating was approximately 50%, the aerodynamic stability seemed to be improved best. At the angle of attack of +3 degrees, the compound flutter speed was approximately 40~50m/s in all cases.

3. Concluding Remarks

In this study, concluding remarks are as follows;

(1) The open grating method made it possible to suppress the vortex-induced oscillation which appeared in the fully opened case (W1L1) or the fully closed case (AD) when the angle of attack was -3 or 0 degree.

(2) The aerodynamic stability was improved if the porosity of grating was approximately 50% when the angle of attack was -3 or 0 degree.

(3) It is necessary to study the countermeasures to improve the aerodynamic stability when angle of attack is +3 degrees.

Finally, this paper is offered to examine technical questions in carrying out the project " Aerodynamic Investigation and Research Regarding the Economical Super Long Span Suspension Bridge". We wish to thank the members involved with this project (Public Works Research Institute, Honshu-Shikoku Bridge Authority, Public Works Research Center and 8 companies for steel bridge in Japan including Kawada Industries, Inc.).

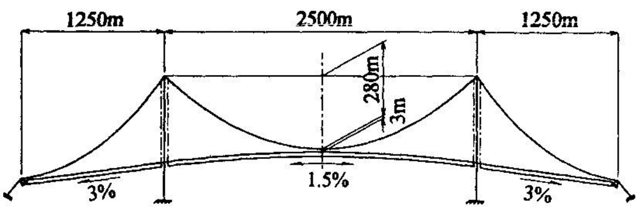

Fig.1 Assumed suspension bridge

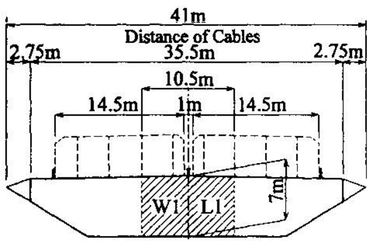

Fig.2 Cross section of girder

Table I Structural characteristics

Span		1250m+2500m+1250m
Sag Ratio		1/9
Distance of cables		35.5m
Allowable stress of cables		100 kgf/mm^2
Dead Weight	Cable	11.0 tf/m/Br.
	Girder	24.0 tf/m/Br.
	Total	35.0 tf/m/Br.
Stiffness of Girder	Vertical	12.0 m^4/Br.
	Horizontal	160.0 m^4/Br.
	Torsional	28.0 m^4/Br.
Polar Moment of Inertia	Cable	350 tf•s^2•m/m/Br.
	Girder	340 tf•s^2•m/m/Br.
	Total	690 tf•s^2•m/m/Br.

Table II Test cases

Case	Pattern
AD	WIND
W1L1	WIND W1 L1
W1L1/50G* W1L1/50H*	WIND W1 L1 ϕ=50%
W1L1/60G W1L1/60H	WIND W1 L1 ϕ=60%
W1L1/70G W1L1/70H	WIND W1 L1 ϕ=70%

* G : wire net
* H : thin perforated plate

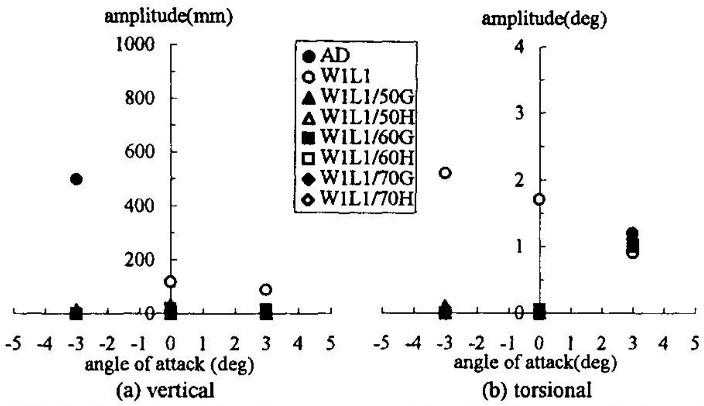

Fig.3 Relationships between amplitude of vortex-induced oscillation and angle of attack

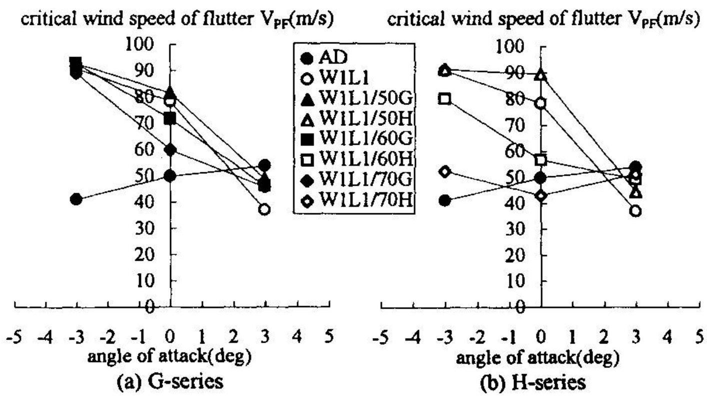

Fig.4 Relationships between critical wind speed of flutter and angle of attack