# Best Cross Stay Location for Super Long Span Suspension Bridge

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## SUMMARY

This paper deals with the best cross stay location for a super long span suspension bridge with a center span of 2,500m. Compound flutter performance is investigated by the direct flutter FEM analysis for 3-D frame model. Both measured aerodynamic forces on the deck and Theodorsen's aerodynamic forces on the flat plate were used for the flutter analysis. From these analytical results, some useful informations for the best cross stay location are obtained in designing a super long span suspension bridge with a center span of 2,500m.

## 1. Analytical study

The following cases were considered to investigate the effects of cross stays on compound flutter speed:
1) Case-S with a pair of cross stays only on the side spans
2) Case-C with a pair of cross stays only on the center span
3) Case-SC with a pair of cross stays in both the side and center spans

In this paper, it is assumed that a pair of cross stays with each cross sectional area of $0.01m^2$ (Young's modulus of elasticity=$1.4 \times 10^7 tf/m^2$) is effective for compression in analyzing each case mentioned above.

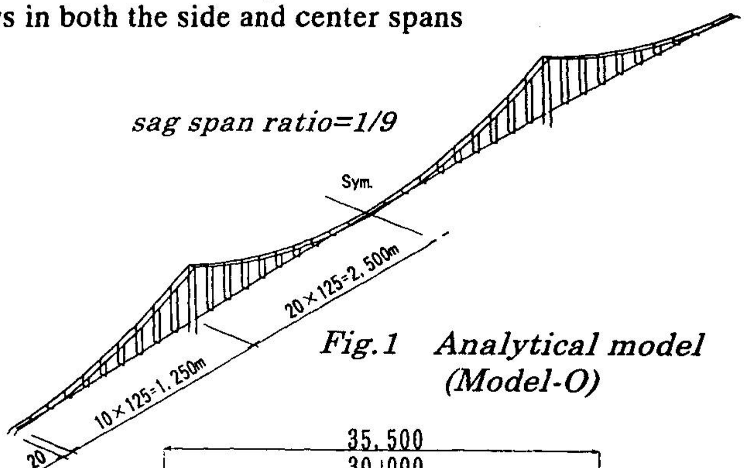


*Fig.1 Analytical model (Model-O)*

## 2. Effects of cross stays on flutter performance

Flutter speeds for the cases described above were computed using Model-O which was idealized as three dimensional frame-work (see Fig.1). Both measured aerodynamic forces on streamlined box girder as shown in Fig.2 and Theodorsen's aerodynamic forces on the flat

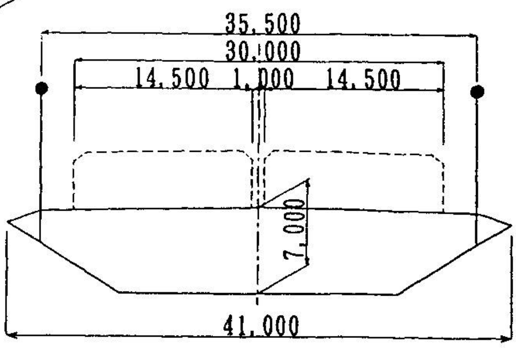


*Fig.2 Section of girder*

plate were used for the flutter analysis. Figs.3 $\sim$ 5 show the analytical results by the direct flutter FEM analysis method. These analytical results are summarized below.

(1) Greatly reduced compound flutter speed have been observed in some cases when the measured aerodynamic forces on the deck were used for the bridge with a pair of cross stay only on the side spans (see Fig.3).

(2) The best cross stay location on the center span is not nearly dependent on different acting aerodynamic forces, and the maximum flutter speed based on the measured aerodynamic forces by the installation of a pair of cross stays in best position $x/L=0.3$ is almost equal to the value based on Theodorsen's aerodynamic forces (see Fig.4).

(3) The flutter speed of a bridge with a pair of cross stays on side spans $x/L_S=0.5$ and on the center span $x/L=0.3$ respectively due to the measured aerodynamic forces is $V_F \fallingdotseq 59.5$m/s( $\delta=0.02$) which is lower than $V_F \fallingdotseq 62$m/s( $\delta=0.02$) with a pair of cross stays only in side spans, $x/L_S=0.5$ (see Fig.5). On the other hand, it was obtained from the flutter analysis based on Theodorsen's aerodynamic forces that flutter speed by the installation of cross stays both at $x/L_S=0.5$ and $x/L=0.3$ is $V_F \fallingdotseq 75$m/s. Hence, it must be emphasized that the flutter analysis based on Theodorsen's aerodynamic forces is not always sufficient for the streamlined box girder suspension bridges with the cross stay system effective for compression.

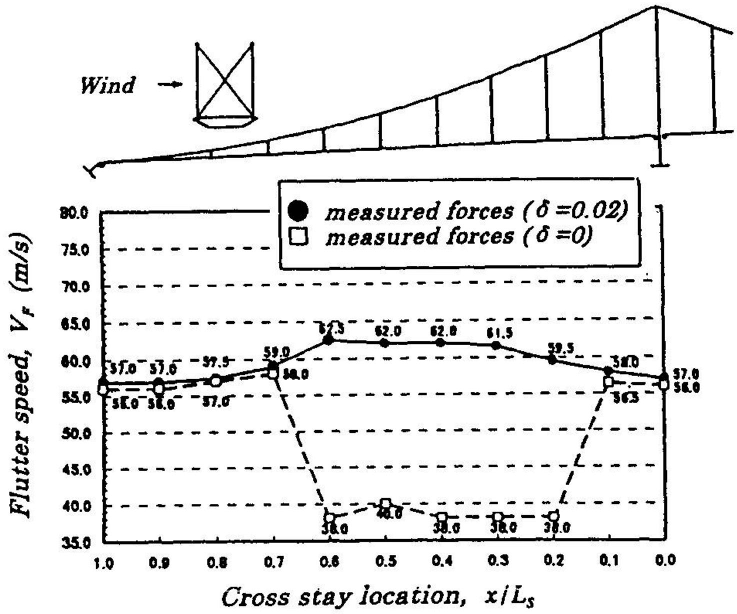


*Fig.3 Effects of cross stays on flutter speed (Case-S)*

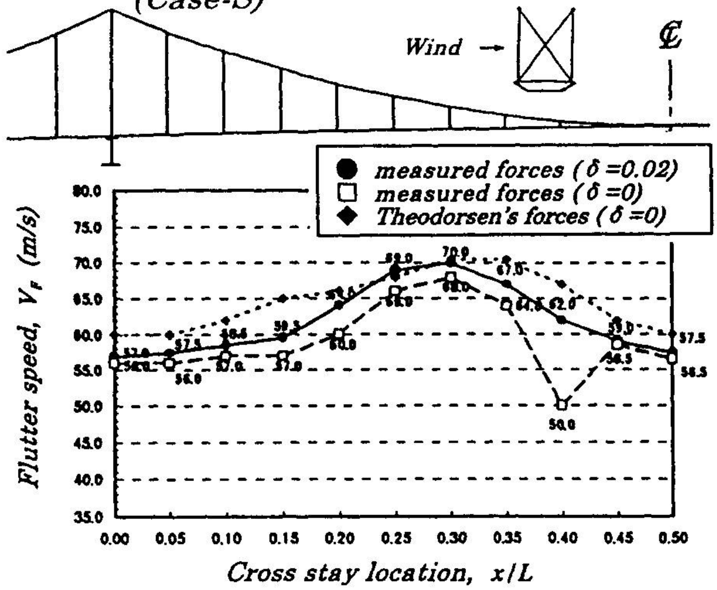


*Fig.4 Effects of cross stays on flutter speed (Case-C)*

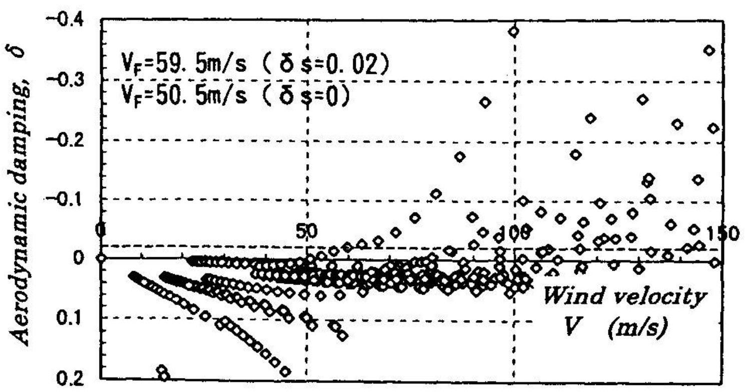


*Fig.5 V-δ curve (Case-SC)*
*(cross stays location ; $x/L_S=0.5$ for side spans, $x/L=0.3$ for center span)*