Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 82 (1999)

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DOI: https://doi.org/10.5169/seals-62132

Aerodynamic Performance of Cable-Supported Bridges with Large Span-to-Width Ratios

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Abstract

Laterally slender bridges seem to be an area which until now has not had very much attention. Therefore, it has been found valuable to carry out a comprehensive study of an important topic related to such bridge structures: the aerodynamic characteristics of long and narrow cable supported bridges.

A primary concern is the study of a proposed spatial cable-stayed bridge, or spatial system, that consists of four inclined cable planes which enable both vertical, lateral and torsional support of the girder. Two bridges of a conventional design are included for comparison. These are a suspension bridge and a cable-stayed bridge of the modified fan type with two parallel cable planes. Such conventional systems offer only vertical and torsional support. However, the suspension bridge is to some extent able to support the bridge deck in lateral direction due to the so-called pendulum effect. The support of the bridge deck in lateral direction becomes increasingly important with increased ratio between the length of the main span and the width of the stiffening girder, the span-to-width ratio.

The three cable supported bridges comprised in the study have an extreme span-to-width ratio of 100, which is almost twice of what is seen in cable supported bridges today. However, both cable-stayed and suspension bridges are being erected with larger and larger span-to-width ratios. The three types are illustrated on the enclosed figure. All bridges chosen for the study have a main span of 800 m and two side spans of 250 m

Two cross-sections of the bridge deck have been studied, namely a streamlined and a bluff section. An extensive test programme was carried out with aeroelastic full bridge models of the three structural systems. The primary concern of the full bridge model tests was determination of stability limits and measurement of buffeting response.

As expected, the spatial system constitutes a promising system due to a significantly smaller lateral response. In the erection stage, the spatial system eliminates the problems of a conventional cable-stayed bridge with excessive lateral deflections. Even mounted with an aerodynamic "unfortunate" bluff section, the spatial system was well-behaved. The observed instabilities of the conventional bridges were one degree of freedom instability (torsional) and there was no coupling of the instability with the lateral degree of freedom.

It is concluded that the proposed spatial cable-stayed bridge in terms of aerodynamic behaviour appears to be very advantageous, especially with a slender girder which can cause problems for

conventional cable supported systems.
The three bridges are illustrated in Figure 1.

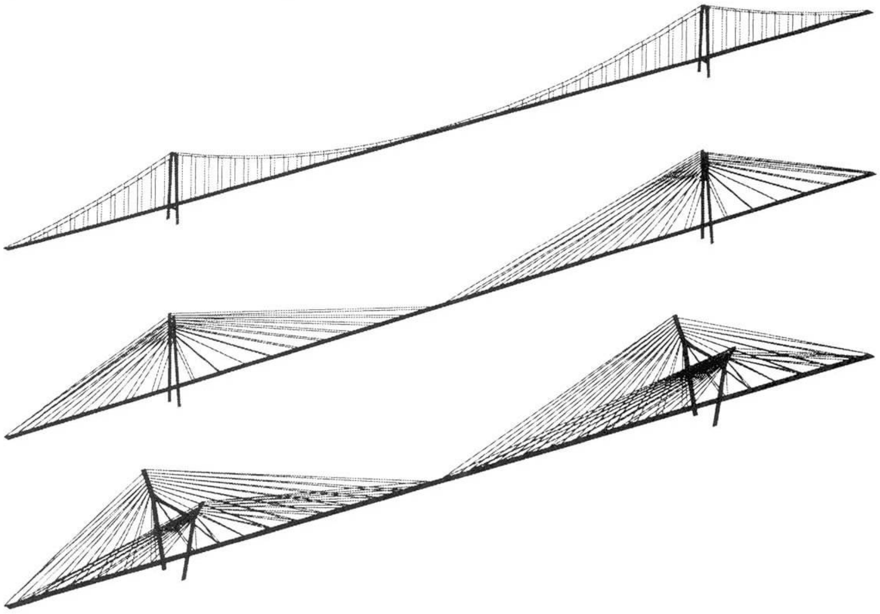

Figure1 *Illustrations of the three cable-supported bridges studied. Upper: suspension bridge, middle: plane (or traditional) cable-stayed bridge, lower: spatial cable-stayed bridge.*

Figures 2 through 4 show photographs of the full bridge models installed in DMI's very wide boundary layer wind-tunnel.

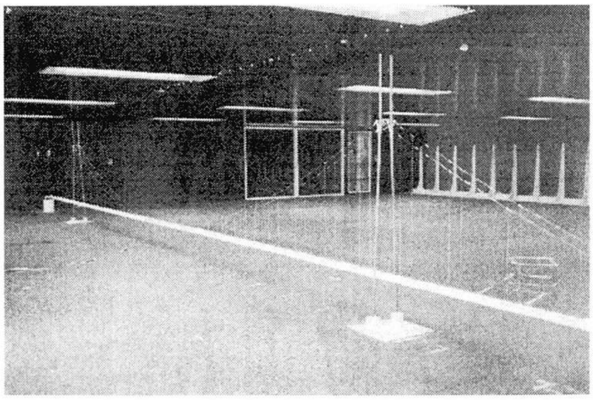

Figure 2 Suspension Bridge Model

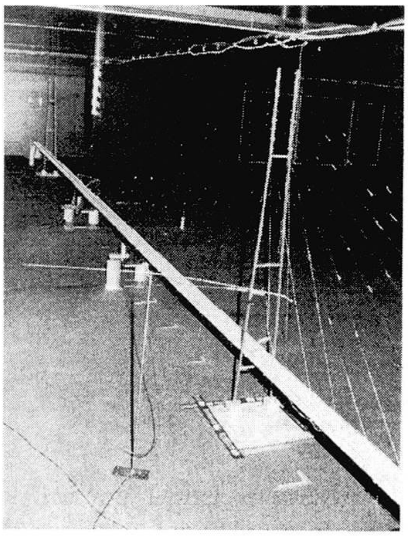

Figure 3 Plane Cable-Stayed Bridge Model

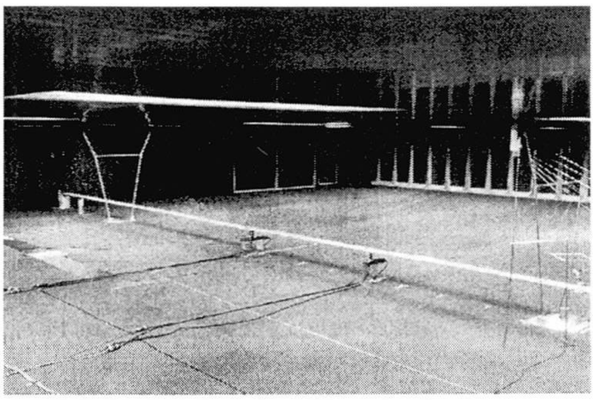

Figure 4 Spatial Cable-Stayed Bridge Model