Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 82 (1999)

Artikel: Experimental analysis of the active tendon control of a large-scale cable-stayed bridge mock-up
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DOI: https://doi.org/10.5169/seals-62161

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Experimental Analysis of the Active Tendon Control of a Large-Scale Cable-Stayed Bridge Mock-up.

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Abstract

Recent improvements in materials led to the construction of progressively longer, structurally more efficient slender bridges. But consequently, structures are more and more flexible. Deck and cable vibrations have become a major issue, particularly in cable-stayed bridge design. The present work concerns the laboratory testing of an active tendon control system for use in a cable-stayed structure. The aim of the active control system is to upgrade the damping of the structure and consequently to mitigate the induced vibration of the stay cables. The study will include an experimental evaluation to be carried out on a large-scale cable-stayed bridge. The proposed design and testing of the mock-up is outlined here.

The bridge mock-up is a cable stayed cantilever beam. The deck, about 30 metres long (which is the maximum dimension allowed in the test laboratory), is mainly composed of two H-beams whose axes are spaced 3.0 meters apart. They are appropriately linked to provide to the whole structure with sufficient transverse stiffness and each H-beam is fixed to a Reaction Wall. The vibration excitation source is anchored at the free end of the deck. Four pairs of parallel stay cables support the deck and a couple of secondary tie-cables are inserted in order to study the control of transverse vibrations of the stay-cables. To give to the stay cables enough sag and consequently reduce their free vibration frequencies, they are heavily overloaded with split steel cylinders in order to increase their average mass.

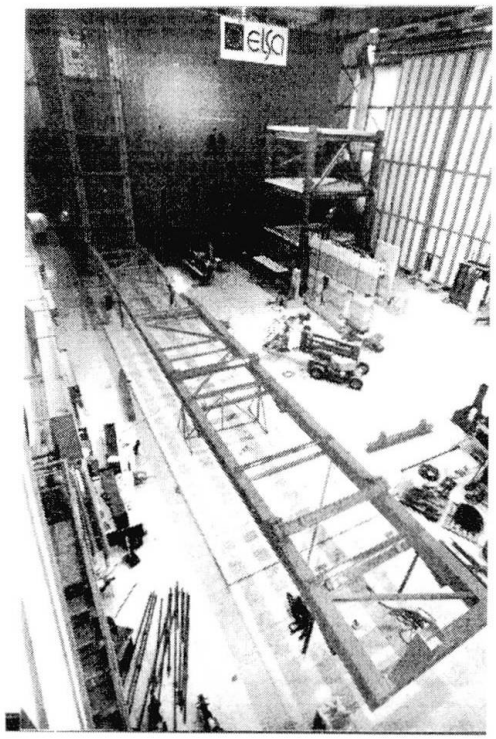
The mock-up will be subjected to forcing functions to improve the understanding of induced vibrations, to validate the numerical tools for prediction of dynamic behavior of cables, to verify the capability of the active control system to mitigate the effects of induced vibrations, as well as to evaluate in detail the performances and the reliability of the whole implementation. This mock-up is a unique large-scale cable-stayed bridge to improve knowledge in stay cable dynamics. While substantial progress has been made in the study of components of active damping systems, little attention has been paid to the overall performance of the system applied to a realistic structure. The structural control system consists of a number of important components such as sensors, controllers, actuators, and power generators that must be part of an integrated system. Moreover, a number of implementation-aspects must be addressed such as intermittent and fail-safe operations, integrated safety, reliability and maintenance. These issues require experimental verification under realistic conditions.

Special care will be assigned to the selection of the most appropriate dynamic testing techniques and to the selection of the transducers, including their conditioning electronics. The tests will be repeated with different loading conditions to provide the reliable data necessary for the validation of a numerical model that includes the structural dynamics, the control system and the actuator dynamics. The deliverables will help the various industrial involved in cable-supported structures to better understand the behaviour of the structures when exposed to vibrations induced by wind, live load, or seismic phenomena.

Forced vibrations in the mock-up will be obtained by means of an electro-hydraulic exciter operating in a frequency sweep excitation manner. This kind of excitation, where the input force can be perfectly monitored and measured, is the most suitable to perform experimental modal analysis. Impulse and free-vibration tests will also be performed.

Measurement equipment will include instrumentation consisting of inductive and laser displacement transducers, accelerometers, strain gauges, and force transducers. To measure tendon vibrations other techniques will be considered such as line-scan camera and laser scanning systems.

Funding under the EC Brite-EuRam programme (Contract No. BRPR-CT97-0402) is gratefully acknowledged. The authors acknowledge the contributions of their colleagues at DERA, Farnborough, UK; BOUYGUES BTP, St Quentin en Yvelines, France; Technische Universität Dresden, Germany; Université Libre de Bruxelles, Belgium.



Large scale cable-stayed bridge mock-up in construction at the JRC - ELSA Laboratory.