Operational Modal Analysis

On a Long-span Cable-stay bridge, using OROS Modal 2

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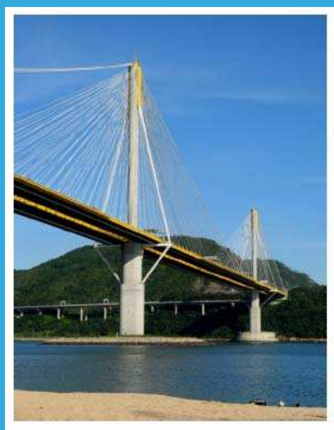
The **Ting Kau Bridge** is a cable-stayed bridge located in Hong Kong. It is shared in two main spans of 475m and 485m respectively.

This structure has been equipped with several sensors fixed inside the bridge for structural health monitoring.



The Ting Kau Bridge

Introduction

Dynamic characterization of civil engineering structures becomes increasingly important for dynamic response prediction, finite element model updating, structural health monitoring, as well as passive and active vibration control of the high/middle-rise buildings, towers, long-span bridges, etc.

Civil engineering structures can be adequately excited by non-measurable ambient, or natural, excitation such as wind, turbulence, traffic, and/or micro-seismic tremors. Ambient vibration test has two major advantages compared to forced vibration test to obtain dynamic characteristics of large civil engineering structures:

- One is that no expensive and heavy excitation devices are required and therefore easy and economic to implement.
- The other advantage is that all (or part) of measurement degrees of freedom can be used as references.

The identification algorithm used for **Operational Modal Analysis** must so be MIMO. The closed-spaced or even repeated modes can easily be handled.

OROS Modal 2

Modern and user-friendly software with specific modules:

- **Geometry building**
- **Operating Deflection Shape in time and frequency domain**
- **Modal Indicator functions**
- **MIMO identifications methods for EMA & OMA**
- **Modal Validation tools (MAC)**

Description

More than 200 sensors including 30 accelerometers are installed.

- 24 accelerometers are placed in 8 sections of the bridge: two in the vertical and one in the transversal direction at each section.
- 4 accelerometers are fixed on the central tower: three in the transversal direction and one in the vertical direction.
- Two accelerometers on the extremity towers: one in the transversal direction on each of these towers.

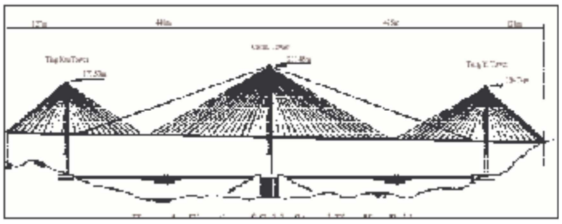
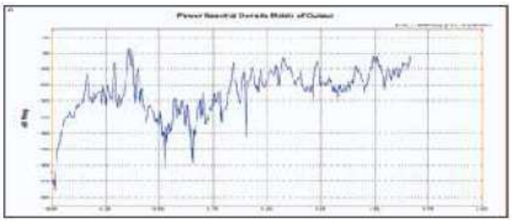
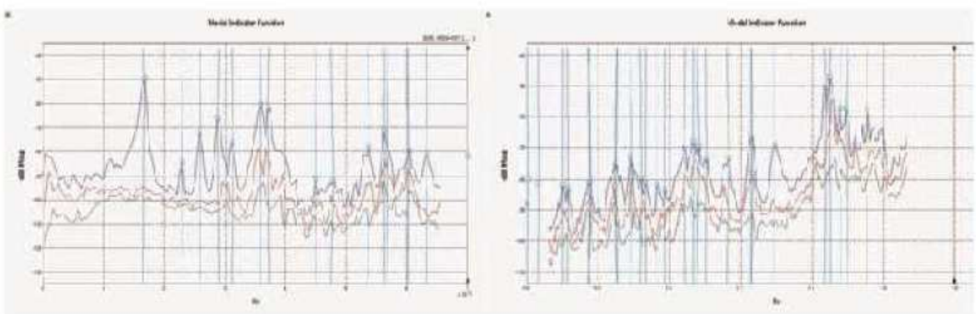


***Fig.1**: Schematic picture of the Ting Kau Bridge*

Data for each channel sampled at a rate of 25.6 Hz are monitored. These data are used to calculate modal parameters with the OMA identification method existing in **OROS Modal 2**. This technique is called Spatial and Frequency Domain Decomposition (SFDD).

Analysis procedure

Responses dues to Ambiant excitation	The responses from the different accelerometers are recorded.
Monitored Power Spectral Density	The first step of this method is to visualize the Power Spectrum Density (PSD) plot. From this graph, shown on figure 2, it is difficult to know how many modes exist in the frequency range of interest.  ***Fig.2**: PSD obtained from monitored response*
Calculated MIF	The second step is to display a graph called Modal Indicator Function. It is based on Singular Value Decomposition (SVD) of the PSD matrix. This tool indicates clearly the structural modes: number and frequencies.  ***Fig.3**: MIF of the Ting Kau Bridge*

Estimated PSD, curvefitting

FSDD identification method estimates theoretical PSD curves to calculate modal parameters.

In this case, favorable enhanced PSD can be obtained for almost all the modes.
Few enhanced PSD plots are shown in figure 4.

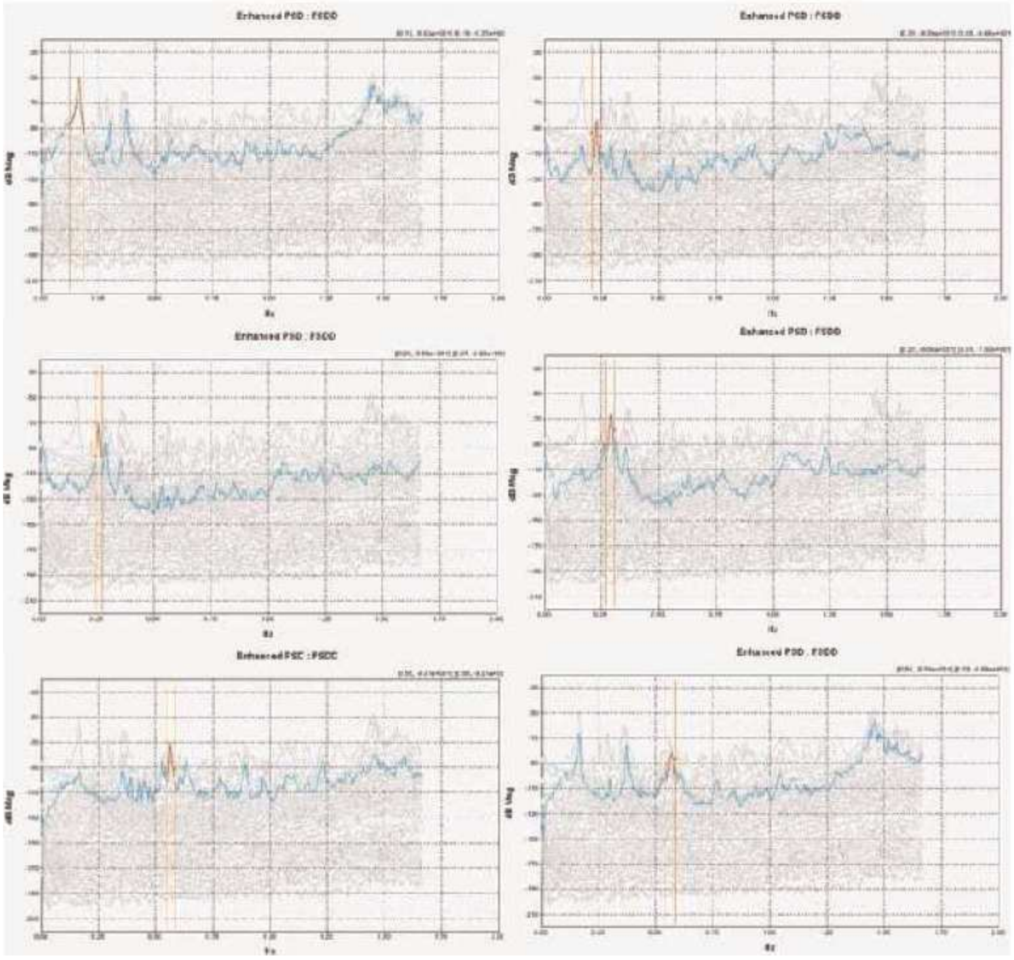


***Fig.4**: Enhanced PSD and curve fitting of the Ting Kau bridge*

Modal parameters :
- frequencies
- damping
- mode shapes

Finally, by using SFDD technique, all together 54 modes are successfully identified from these monitoring data of the bridge under operational conditions. One of the major advantages of SFDD technique is that close-spaced modes, even repeated modes can be dealt with without any difficulty.

OROS, Leadership through Innovation

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Reliability and efficiency are our ambition everyday. We know you require the same for your measurement instruments: comprehensive solutions providing performance and assurance, designed to fit the challenges of your demanding world.

Our Emphasis
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