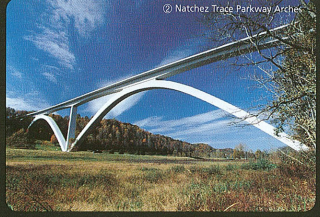
Wind Effects on Bridges

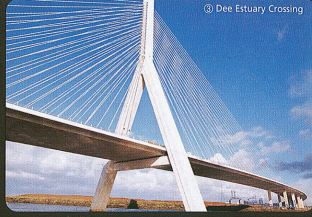
Alan G. Davenport
Wind Engineering Group

The Boundary Layer Wind Tunnel Laboratory

① Sunshine Skyway Bridge



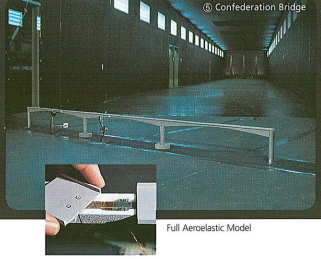
② Natchez Trace Parkway Arches



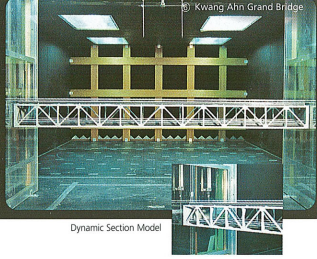
③ Dee Estuary Crossing

'An important measure of the practical value of all model test data is its relation to full-scale experience...the Boundary Layer Wind Tunnel is known for its accuracy and quality of work.'

Taut-Strip Model



Full Aeroelastic Model



Dynamic Section Model

Determining the Effects of Wind

Wind tunnel model testing with the Boundary Layer Wind Tunnel Laboratory is a reliable method of determining wind effects on bridges. Wind tunnel investigations have become the norm for long-span bridges to ensure a safe and economical design. Such studies may, in fact, be desirable for bridges of even moderate span in order to improve the reliability of performance and economy of design.

QUALITY WORK

The Boundary Layer Wind Tunnel Laboratory (BLWTL) is known for its accuracy and quality of work. An important measure of the practical value of all model test data is its relation to full-scale experience. It has always been a priority at the BLWTL that modelling is both accurate and complete. Not only do we use the most advanced technologies available; we are continually making further advancements to our testing and analysis techniques.

BLWTL staff can assist designers with the development of a preferred configuration of bridge deck system. Relying on our experience gained from the range of bridge cross-sections that have been tested over time, we are able to advise on those which have favourable aerodynamic characteristics. Concurrently, a dynamic analysis of the bridge frequencies and mode shapes will assist in the selection of bridge deck systems. BLWTL staff are able to provide a comprehensive dynamic analysis of the bridge if desired.

SECTION MODELS

Once the bridge cross-section has been selected, testing of a section model is usually prescribed. A precisely constructed model is placed in the wind tunnel using a dynamically scaled mounting system. The wind conditions of the site are simulated in our state-of-the-art wind tunnel, using both turbulent and smooth flow. This determines the aerodynamic response characteristics of the bridge section and alerts designers to critical wind speeds at which instabilities, such as vortex shedding or flutter, arise. This BLWTL testing is detailed and thorough in order to provide as complete a picture as possible of the behaviour of the bridge section.

Section model testing provides quick and accurate feedback for an optimum design. An interactive process with the designer can address aerodynamic concerns, such as stability. Modifications to the cross section can easily be made for immediate retesting.

Wind tunnel test results are then combined with the meteorological information for the region in which the bridge is situated. Finally, the resulting predictions are placed into a format suitable for the design engineer, namely, Equivalent Static Loads (ESL).

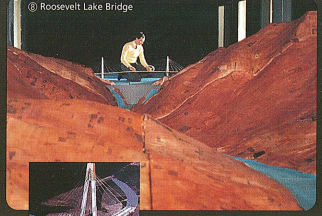
FULL BRIDGE MODELS

For bridges of innovative design, of exceptional size and importance, or of unusual siting, final confirmation of the bridge behaviour can be undertaken on a dynamic (aeroelastic) model of the full bridge. This technique is also used for assessing the behaviour of the bridge during construction. A precisely designed and fabricated model is tested within its surrounding topography. A representative range of wind speeds and directions is used to test key responses such as deck and tower moments, deflections, accelerations and cable tensions.

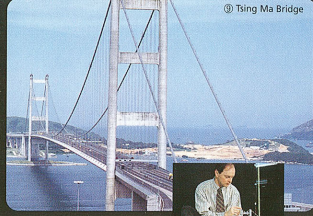
An alternative to the testing of a full bridge aeroelastic model is the use of a taut strip model. This technique provides information on the modal responses of the bridge deck. This data can then be used in further analyses to predict the complete bridge behaviour.


⑦ Ting Kau Bridge

Full Aeroelastic Model


⑧ Roosevelt Lake Bridge

Full Aeroelastic Model with Topography


⑨ Tsing Ma Bridge

Full Aeroelastic Model

EXPERIENCED STAFF

The Boundary Layer Wind Tunnel Laboratory (BLWTL) staff are professional and experienced. Since its inception in 1965, the BLWTL has played an active and leading role in developing the field of wind engineering. We have assisted designers of international renown by establishing wind effects for many of the world's longest and significant bridges.

VALUABLE EXPERTISE

The BLWTL staff capably determine the wind-induced loads and responses of bridges, and where appropriate, arrive at innovative approaches to design challenges.

BLWTL model studies are important:

- to improve the reliability of structural performance and cost-effectiveness
- to ensure an adequate measure of safety against aerodynamic instabilities
- to allow for the proximity to prominent features and other structures
- for bridges located in areas of high incidence of significant wind speeds
- to increase human comfort and safety, as well as driveability, through information on wind characteristics over the bridge as well as overall structural motions

OUR SERVICES

Wind Effects on Bridges

- Predictions of forces, moments, accelerations, deflections, and rotations
- Evaluation of structural requirements to optimize design for the effects of wind
- Development of structural design specification and bridge codes
- Construction stage wind loads and responses
- Advice on optimizing construction sequencing, and measures to ensure safety and integrity during construction
- Cable oscillation problems associated with wake buffeting, vortex shedding, rain/wind interaction, or deck motion
- Advice on additional damping systems to inhibit wind-induced oscillations of bridges, towers and cables, both during and after construction
- Fatigue and load cycle estimation of elements of the deck and cables

Full-scale Monitoring

- Monitoring of wind response of full-scale structures
- State-of-the-art instrumentation can relay data directly and continuously to the BLWTL for analysis

Wind Climate Studies

- Hurricane and severe storm effects
- Monte Carlo simulation of hurricane/typhoon winds
- Influence of large-scale topography on site wind conditions

TIMELY COMMUNICATIONS

An early involvement of BLWTL wind experts results in the greatest benefits. Wind tunnel model studies are particularly valuable if they are carried out at an early stage when design adjustments can still be made. By working closely with our clients on an ongoing basis, we assist in identifying needs in order to provide timely and accurate design information at a reasonable cost.

Alan G. Davenport Wind Engineering Group

The University of Western Ontario, Faculty of Engineering, London, Ontario
Canada N6A 5B9 **Tel: (519) 661-3338** Fax: (519) 661-3339
Internet: www.blwtl.uwo.ca E-mail: info@blwtl.uwo.ca

CREDITS

Cover: Confederation Bridge, Strait Crossing Inc., Photo: John Sylvester Photography, PEI

① Sunshine Skyway, Florida, U.S.A., Figg Engineering Group ② Natchez Trace Parkway Arches, Tennessee, U.S.A., Figg Engineering Group ③ Dee Estuary Crossing, Wales, Gifford Graham & Partners, Photo: Robert Brown A.R.P.S. ④ Storebælt East Bridge, Denmark, COWI Consulting Engineers and Planners AS ⑤ Confederation Bridge, PEI, Canada, Strait Crossing Inc. ⑥ Kwang Ahn Grand Bridge, City of Pusan, Korea ⑦ Ting Kau Bridge, Hong Kong, Schlaich Bergermann und Partner, Hong Kong, Highway Department of the Government of the Hong Kong SAR, Peoples Republic of China ⑧ Roosevelt Lake Bridge, Concrete Alternate, Arizona, U.S.A., Figg Engineering Group ⑨ Tsing Ma Bridge, Hong Kong, Kværner Cleveland Bridge, Ltd., Highway Department of the Government of the Hong Kong SAR, Peoples Republic of China