

Tsing Ma Bridge – Hong Kong (PRC)

Project Description:

The Tsing Ma Bridge (TMB) is the longest suspension bridge (2.2 km) in the world for carrying both vehicle and railway traffic. The TMB is a double deck bridge. The upper deck has two three-lane highways for vehicle traffic. The sheltered lower deck includes two railway tracks and two single-lane emergency roadways for maintenance and ensuring uninterrupted traffic from/to the Hong Kong International Airport during typhoons when wind speed is still within acceptable level. Besides the existing conventional sensors, Fiber Bragg Grating sensors are installed by the Photonics Research Centre of the Hong Kong Polytechnic University to measure vibration, strain distribution and suspension cable tension.

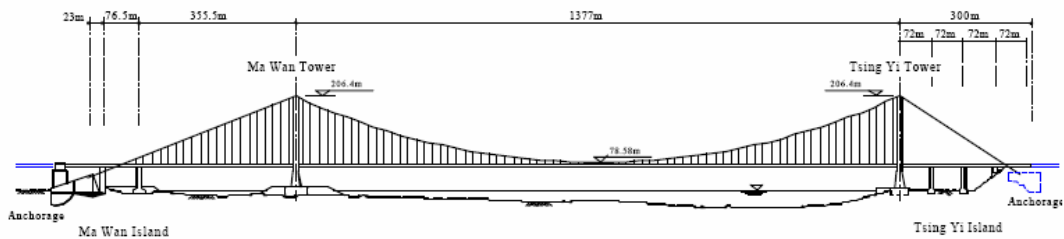


Quick Facts:

- **Name and Location:**, Tsing Ma Bridge, Hong Kong, China
- **Structure category:** Suspension bridge (two main suspension cables)
- **Main span:** 1377 mm (two high-strength concrete towers)
- **Overall length:** 2.2 km
- **Main cable:** 1.1 m in diameter
- **Shipping clearance:** 62 m
- **Number of sensors:** > 350

Description of Structure:

The Tsing Ma Bridge is a double deck suspension bridge having a fully suspended main span supported by two portal-braced, reinforced-concrete towers. The bridge deck is suspended from two main cables passing over the main towers and secured into massive concrete anchorages at each end. The bridge deck section, 41 m wide and 7.5m high, is a hybrid arrangement combining both longitudinal trusses and cross-frames. The main span deck and the Ma Wan side span deck are suspended at 18m intervals by hangers to the main cables, while the Tsing Yi side span deck is supported by three concrete piers spaced at 72m.



(a) Tsing Ma Bridge (TMB)
Tsing Ma Bridge (TMB)

Purpose of Inspection:

The sensors are the early warning system for the TMB and provide the essential information that help the Hong Kong Highways Department to accurately monitor the general health conditions of the bridge, in terms of structural durability, reliability and integrity. The sensors include strain gauges, GPS position sensors, accelerometers, level sensors, temperature sensors and weight-in-motion sensors.

This project is focused on the application of Fiber Bragg Grating for strain measurement and the comparison with conventional strain gauges.

Sensor Details:

Type of sensors	Number	Location
FBG strain sensor	10	Metal structure of Section 23
FBG temperature sensor	1	Metal structure of Section 23
FBG strain sensor	9	Rocker bearing on tower
FBG temperature sensor	1	Rocker bearing on tower
FBG strain sensor	1	Suspension cable

Measurement Equipment and Data Management:

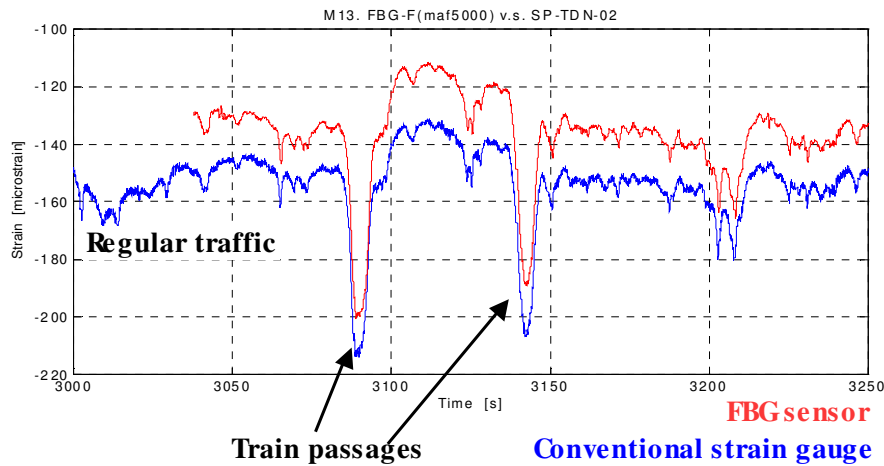
Type of system	Data Management
TNO high-speed dense-channel demultiplexing / interrogation system for FBG sensor array	<ul style="list-style-type: none"> ▪ Data logging ▪ Main analysis (statistic, frequency analysis), graphical presentation and documentation in office

Data Analysis Procedures:

Type of analysis	Software
Statistics, frequency analysis	Self made software

Examples of Outcomes:

The results of the FBG sensor are compared with that of the existing strain gauge. Although the sensors are not located at exactly the same location, great resemblance in the results has been found. Train passages and heavy traffics can clearly be measured.



Comparison of strain measurement between FBG sensor and existing strain gauge.
An artificial off-set is applied to the FBG sensor signal.

Benefits of Using SHM Technologies in the Project:

- Providing information to determine distribution of strains/stresses in critical bridge components
- Documenting abnormal loading incidents such as typhoons, earthquakes, traffic overloads and ship collisions with bridge piers
- Detecting damage or accumulated damage in critical bridge components
- Providing information for a cost-effective maintenance program

References:

CHENG L.K. ET AL., "DYNAMIC LOAD MONITORING OF THE TSING-MA BRIDGE USING A HIGH-SPEED FBG SENSOR SYSTEM", SUBMITTED TO THE 2ND EUROPEAN WORKSHOP ON STRUCTURAL HEALTH MONITORING.

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