



THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學

Case Study – Canton Tower at Guangzhou

Guangzhou, China 2010






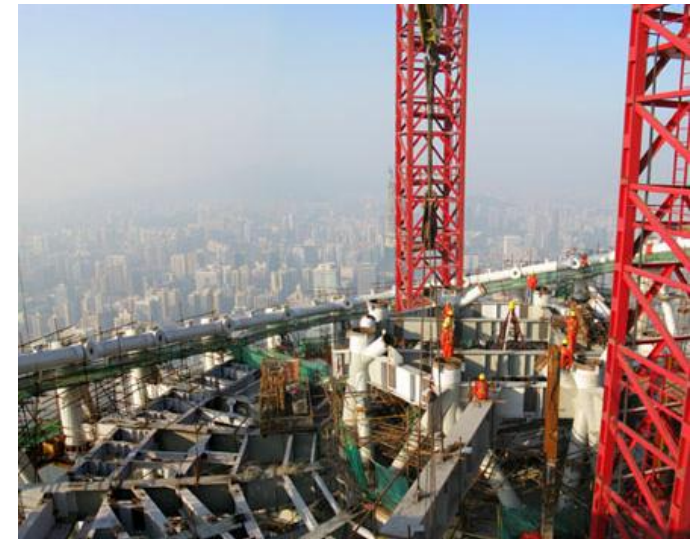
- Worlds tallest broadcasting tower at 610 meters
- Unique design
- Integrated Structural Health Monitoring
- Optical and Electrical sensors integrated into structure
- Reinforced concrete inner tube and steel outer tube with concrete filled tube columns
- Columns interconnected transversely by steel ring beams and bracings
- Hyperbolic shape makes structure attractive but mechanically complex
- 156 meter antenna mast at top of structure



Canton Tower– Structural Health Monitoring System



Aim	Structural monitoring of the new TV tower during construction phase and continuing into the service phase of the structure. Both embedded concrete and steel surface sensors used . Ambitious project in terms of architecture and sensor integration. Sensors output potentially used as input for active vibration abatement system.
Location	Guangzhou, China
System Integrator	Department of Civil and Structural Engineering, Hong Kong Polytechnic University 
Customer	City of Guangzhou
Date	November 2010
Instrumentation	(2) Micron Optics sm130-500 Optical Sensing Interrogator (2) Micron Optics sm041-416 Optical Channel Switch Extension
Sensors	(800) -- Total Optical + Electrical Sensors (399) – Electrical sensors for construction use only 208 Optical Sensors designed for in-service usage (126) Optical Sensors on Tower Body (82) Optical Sensors on Antenna
Project Scope	<ul style="list-style-type: none"> • Construction monitoring of complex structure • In service lifetime monitoring of structural aging • Possible feedback for structural vibration damping mechanism • On-site and remote data retrieval. • Fiber Optic sensors monitor strain, incline and temperatures





- Sensors were installed at five different heights on the outer tube of the tower.
- Monitoring points determined by finite element analysis.
- A total of 208 sensors were installed on tower body and antenna
- Electrical Sensors mostly for construction monitoring, optical sensors for in-service monitoring



- One instrument monitors sensors on body outer tube structure
- Each group of six sensors on body called an array
- Each array monitors one stress area on tower
- 4 arrays in each area on tower (24 sensors)
- 4 FBG's measure strain, 2 FBG's measure temperature in each body array
- Eight arrays of ten FBG sensors used on antenna
- Antenna arrays implemented in response to anomalous readings during construction



“FBG Based Sensors are deployed solely for the purpose of long term in-service monitoring as 399 of the electronic type sensors are not suitable for long term operation and will not be used after completion of the building. A total of 208 FBG based sensors are used for the Structural Health Monitoring System (SHM).¹”



Locations of Sensors on outer tube

453.2 meters
os3100 (16)
os4100 (8)

334.4 meters
os3100 (16)
os4100 (8)

272 meters
os3100 (16)
os4100 (8)

121.2 meters
os3100 (16)
os4100 (8)

32.8 meters
os3100 (16)
os4100 (8)



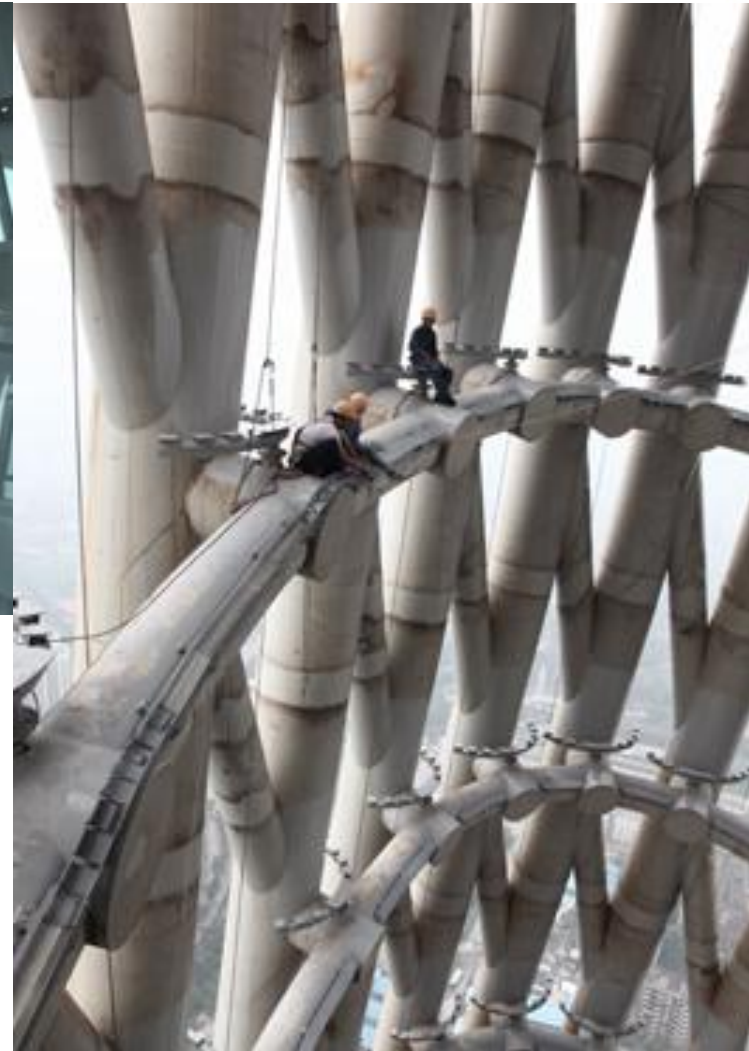
“The monitoring system for GNTVT exercises a pioneering SHM practice that integrates in-construction monitoring and in-service monitoring. Besides detecting any anomalies during construction, the motivation to implement such an integrated monitoring system also lies in (i) facilitating the deployment of the sensors devised for in-service monitoring, (ii) being able to track complete data histories from the onset of construction, and (iii) enabling the establishment of a SHM-oriented baseline model at the completion of structure.²”



**Locations of Antenna Sensors
(note that Antenna is recessed
into the structure).**

454 meters
os3100 (32)
os4100 (8)

448 meters
os3100 (32)
os4100 (8)



- 50 Hertz acquisition speed per channel
- Structure has dozens of vibration modes with modal frequencies under 2 Hertz
- Dozens structural vibration modes measured
- Measures static and dynamic strain responses
- Integral part of building control system

Canton Tower: Sensor Network Configuration



(Antenna Location 1) x 5 groups

Antenna Optical Sensor System



(Antenna Location 2) x 5 groups

Monitoring system housed in secure room or ambient-controlled enclosure



sp130 Controller or Industrial PC for Data Storage



sm130-500, Sensor Interrogator



sm041-416, Sensor Multiplexer



(Tower Location 1) x 8 groups

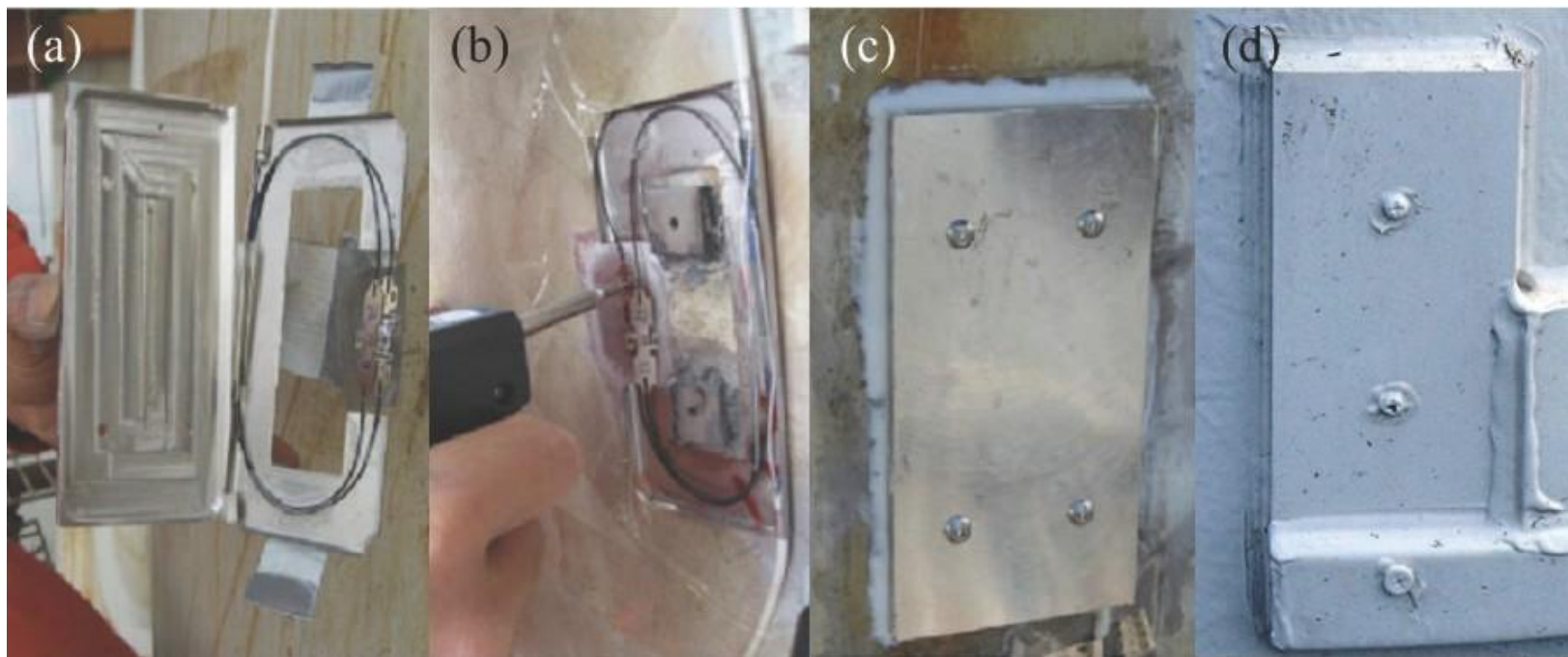
Body Optical Sensor System



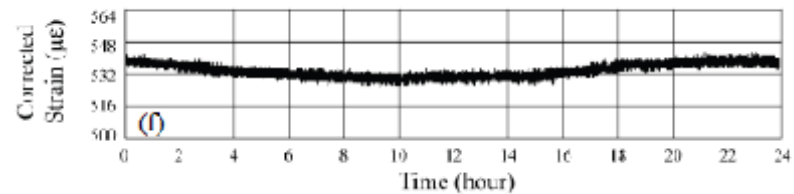
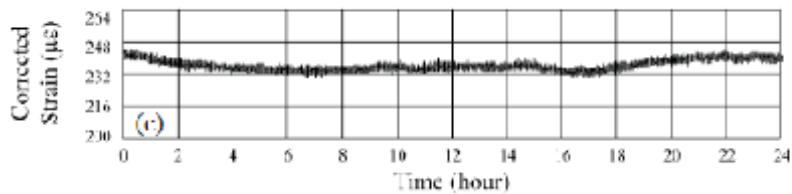
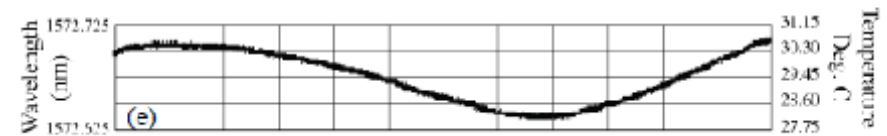
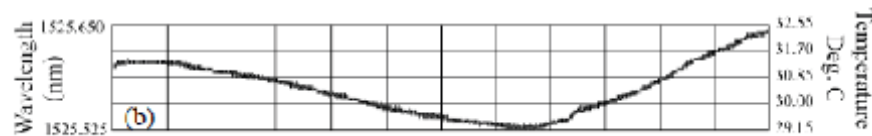
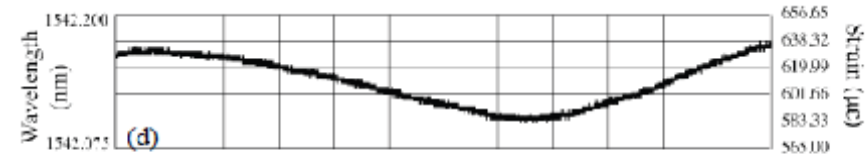
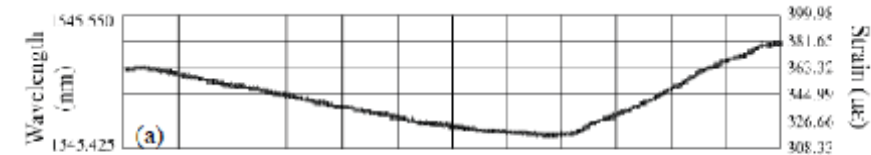
(...) Ch 15 (Tower Location 15)



Ch 16 (Tower Location 16)



- Micron Optics os3100 optical strain gauge / os4100 temperature gauge shown
- Temperature sensors accurate over temperature range of -40C to +120C
- Micron Optics sm130 accurate to +/- 1 $\mu\epsilon$ over +/- 2500 $\mu\epsilon$ strain limits
- Steel packaged optical sensors allow welding to structure
- Sealed in place with cover plate
- Painted for corrosion resistance
- Suitable for long term monitoring of structural health



“These curves are highly correlated, by considering the sensitivity of 27pm/C of the temperature sensors and thermal expansion of the building material at these two measurement points, the temperature effect from the strain sensors are removed and the net strain due to external loadings are depicted in c and f.¹”



- Canton Tower completed for broadcasting for the Asian Games, November 2010
- Sensor system successful in detecting anomalous strain readings
 - This leads to additional Optical Interrogator system being installed to monitor the in-service strain on antenna
- Sensing system operational and reporting data
- Integration of electrical and optical systems successful
- Updated results to be given during invited paper delivered at OFC 2011. Please register and plan on attending presentation given by Hong Kong Polytechnic University, at OFC March 6-10 2011 in Los Angeles. www.ofcnfoec.com



- Acknowledgements

- City of Guangzhou
 - <http://english.gz.gov.cn/>
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- Micron Optics, Inc
 - Tel: 404-325-0005, email: info@micronoptics.com, web: www.micronoptics.com

- References

- 1. Hwa-yaw Tam, H.Y. Au, K.M. Chung, W.Y. Liao, W.H. Chung, S.Y. Liu, C.C. Lai, Y.Q. Ni, A. Csipkes. *Distribution Optical Sensor System on the 610-m Guangzhou New TV Tower*. Invited paper at OFC 2011.
- 2. Yi-Qing Ni, Yong Xia, Wei-Yang Liao, Peng Zhang. *Development of a Structural Health Monitoring System for Guangzhou New TV Tower*. *Advances in Science and Technology* Vol 56 (2008). PP414-419.

