



# Optical Monitoring of Strain and Temperature Within Sprayed Concrete Tunnels

A Case Study

London Underground  
London, England 2013



## The Challenge

- London's Underground network of tunnels covers an area of over 3000km<sup>2</sup>, has nearly 400km of line length and serves 2.5 million passengers every day
- New tunnels are routinely constructed and existing tunnels are continuously being assessed and repaired based on visual inspection, stress in tunnel lining, lining deformation/clearances and track geometry
- Challenge: install a remote monitoring system capable of assessing the structural health of sprayed concrete reinforcement in new and repaired tunnels



## The Solution

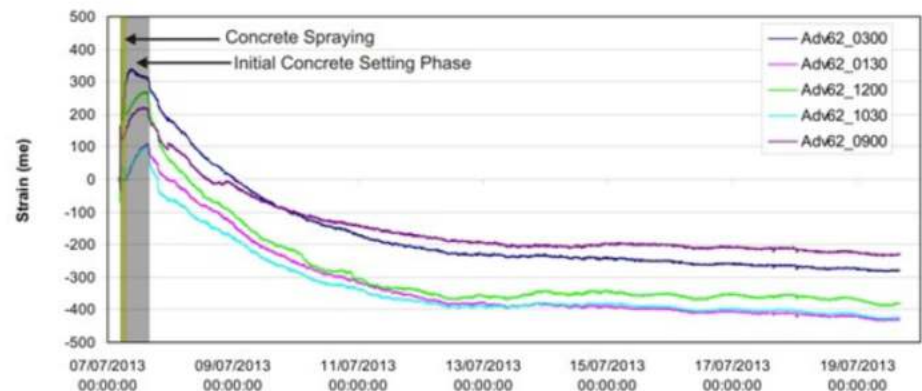
- A fiber optic sensing solution composed of an [sm130](#) Optical Sensing Interrogator from Micron Optics and FBG-based nylon reinforced distributed strain and temperature sensing cables from [Monitor Optics](#)
- Accurate, reliable and robust field-installed system for continuous, distributed strain measurement in new tunnel construction under sprayed concrete
- System designed to maximize construction and repair speed while minimizing risk and enhancing the safety of the structure





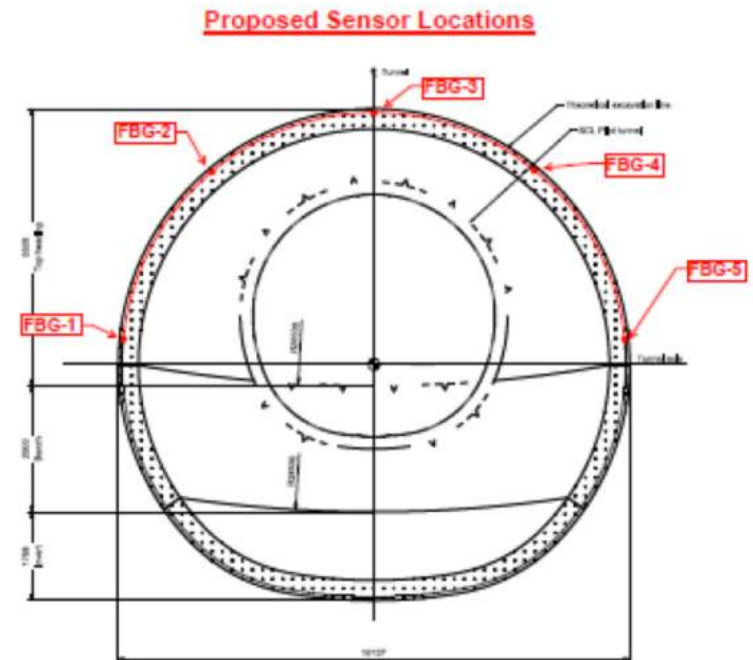
## The Result

- Monitoring commenced in June 2013 and over 150,000 data points have been logged
- The system is enabling data-driven decisions resulting in significant OpEx savings and increased safety
- Based on the success of the deployment there are plans to expand the system into further tunnels
- Never before seen real-time measurement of distributed strains within the reinforcing structures continue to increase the overall efficiency of the construction process





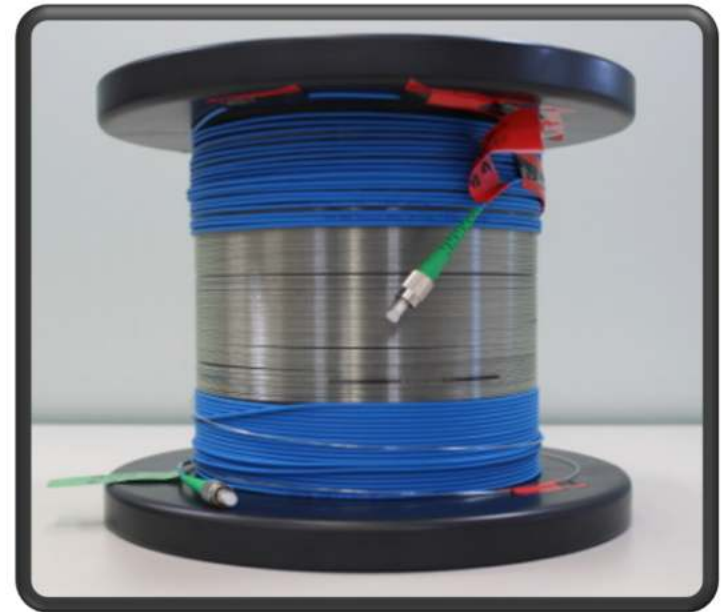
- Two nylon reinforced strain cables installed in the header section of the tunnel
- Each strain sensing cable contains five FBG's equally spaced around the circumference of the tunnel
- The approximate distance between sensors and interrogation unit is 150 m
- Micron Optics [sm130](#) interrogator controlled via a TCP/IP connection running [Enlight software](#) provides measurement and demodulation of the FBG system
- The interrogator and process module are located in a site cabin at the top of a tunnel access shaft
- Data is acquired every second and recorded every minute. This data is then downloaded from the system and sent on to a secure online data server to be used in decision making process



**Monitor Optics sm130 Optical Sensing Interrogator**



- Ideal solution in any application where a high number of sensing points must be installed over long distances
- Strain and temperature on the sensor surface is linearly converted in a wavelength shift in the Bragg grating and this can be very accurately measured using a range of fiber Bragg grating interrogators
- With its rugged design, the cable can be embedded during the construction phase in very harsh environments like concrete structures and asphalt pavements
- All sensing cables employed reinforced accessory components such as splices and connections to guarantee the maximum reliability of the sensing elements



**Monitor Optics FBG based strain sensing cable**



<b>Aim</b>	Enhance the safety and speed of construction of sprayed concrete tunnels in the London Underground train system
<b>Location</b>	London, England, United Kingdom
<b>System Integrator</b>	Monitor Optics, Dublin, Ireland Tel: 44 (0) 7792 650440
<b>Date</b>	Ongoing starting July 2013
<b>Instrumentation</b>	Micron Optics <a href="#">sm130-500 Optical Sensing Interrogator</a>
<b>Sensors</b>	<a href="#">Monitor Optics Strain Sensing Cable</a>
<b>Software</b>	Micron Optics <a href="#">ENLIGHT™ Software</a>



*This work was performed by and special thanks to...*

Monitor Optics Systems Ltd

James Preston, Business Development,  
(+353) 1 492 6281

117 Fortfield Road, Terenure, Dublin 6W, Ireland

[jpreston@monitoroptics.com](mailto:jpreston@monitoroptics.com) web:www.monitoroptics.com