



Tunnel Deformation Monitoring

Project	Installation of OFS system to monitor the movements of a road tunnel during remedial grouting works
Client	Withheld
Date	2005
Location	Spain
Sensors	SmartRod
Attachment	Bolted to tunnel lining
Interrogator	W4
Images	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>SmartRod Installation</p> </div> <div style="text-align: center;">  <p>W4 Interrogator</p> </div> </div>
Results	<p>The Road tunnel in question has been suffering from settlement due to soft ground conditions. During the middle of 2005, contractors entered the adjacent service tunnel and carried out a programme of regrouting works to strengthen the tunnel/soil interface and prevent further settlement.</p> <p>Geotechnical and civil monitoring experts, Sol Data were contracted to instrument the tunnel to measure movements before, during and after the regrouting works using Cyclops, their three axis Theodolite measurement system. Sol Data were partners to the UK project OFSTUNN (2002-2005) in which Smart Fibres developed the SmartRod system for long-term tunnel deformation monitoring and civil structural health monitoring. Also party to the project were the University of Birmingham, London Underground Limited, Metronet SSL BCV Ltd and Tubelines Ltd.</p> <p>It was decided to install a SmartRod deformation system alongside the Cyclops system within the tunnel in order to gain installation experience and validate the SmartRod measurement techniques on a relatively short term campaign, prior to long term deployment.</p>

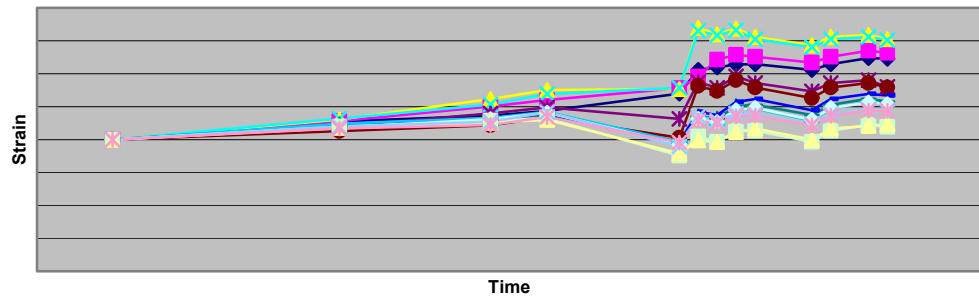
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The zone of the tunnel instrumented with SmartRod was constructed of concrete sections forming an arched roof with an apex approximately 7m above the floor and vertical sidewalls. Two SmartRod sensors were applied, one either side of a joint between sections, each SmartRod containing two channels of multiple Fibre Bragg Grating strain sensors. The rods were fixed to the tunnel wall using rigid clamping plates that ensured no relative movement between adjacent rods – the rod and clamp system extended less than 50mm from the tunnel wall surface. The system was installed using a small ‘cherry picker’ by 2 persons over 2 days.

The Sensor responses were recorded and logged using a W4-5 (4-channel, 1 Hz) FBG Interrogator as the grouting machine advanced towards the instrumented zone, worked within the instrumented zone, and then moved away down the tunnel.

The plot below shows typical measurements from the sensors of one SmartRod section as the grouting works slowly approaches the instrumented zone, then works within the instrumented zone, and then moves away.

Typical Result (full data withheld)



Results

Clearly visible, is the strain slowly building up as the grouting works approaches as the unstable, instrumented section deforms as a result of the works. Then, during the grouting of the actual section there is a significant, permanent strain change reflecting the compression of the tunnel by the grouting. After that, the strain is relatively stable as the machine moves on, suggesting that the instrumented zone is stable and unaffected by the ongoing works.

The typical strain measurements above suggest that the system is working as expected. At the time of writing, the strain data for the complete monitoring campaign is being converted to tunnel displacement data using the proprietary data manipulation routines developed by the OFSTUNN project partners. Further information is not currently available.

Further information

Withheld