



Typical installation shown below of the RST Profile Monitoring System for Tunnel Concrete Segments with an RST flexDAQ Datalogger System.



### > BENEFITS

- |                    |                     |
|--------------------|---------------------|
| ✓ Increase Safety  | ✓ High Accuracy     |
| ✓ High Reliability | ✓ Technical Support |



PRODUCT CATEGORY:  
INCLINOMETERS + TILT SENSORS

# Profile Monitoring System for Tunnel Concrete Segments

The RST Profile Monitoring System for Tunnel Concrete Segments is a series of tilt meters, fixed to the tunnel wall on each of the precast concrete segments erected in place as tunnel lining by a Tunnel Boring Machine (TBM). The system is based on the assumption that each concrete segment is a rigid body and that the complete ring deforms by rotation of the individual segments one relative to the other, and the rotation points are the contact surfaces between adjacent segments. This assumption is very often considered as acceptable by tunnel designers and reasonably close to reality, although spot checks using traditional convergence measurements or surveying methods should be conducted to confirm its validity for each individual tunneling circumstances. This Profile Monitoring System using tiltmeters is a simplified version of the Tunnel Profile Monitoring System (see separate data sheet) and its main advantage is that it can be deployed in the tight space available around the TBM, whereas the Tunnel Profile Monitoring System would be much more difficult to install in the same situation to monitor deformation. A data logging system and Geoviewer software (see separate data sheet) are available to provide near real time displacement and generate a graphical representation of the tunnel convergence.

The Profile Monitoring System consists of a series of precision busbed digital tiltmeters affixed on each of the concrete segments of a segment ring, including the key segment. Each tiltmeter is mounted on a base plate that allows for setting the vertical axis of the tiltmeter so that it will be suitably oriented when mounted on the concrete segment. Spatial displacement of the concrete segments results in changed tilt readings. The data logger system automatically collects the data and transmits it to a computer, either in near real time or by means of manual periodic data transfer using a laptop computer or a memory storage device. The computer then analyzes the data, and calculates the displacement profile for presentation.

The system is available in either open or closed loop configurations. The closed loop method is analogous to conventional closed end survey techniques, while the open loop must be referenced to a known location.

### > APPLICATIONS

Monitor the convergence of precast concrete segments in TBM-driven tunnels during construction for control and safety.

Monitor tunnel deformation due to nearby construction activities.

Monitoring long term deformation and performance of existing tunnels.

### > FEATURES

Very low profile design, suitable for installation in the tight space available around TBMs.

Tiltmeters can easily be redeployed periodically to follow tunnel face progression.

No tunnel traffic interference.

High system accuracy.

Integral transient lightning protection.

Immune to the air density related problems inherent in optical systems.

Compatible with GeoViewer near-real time software with full graphic and alarm capability.

Built in connectors for manual tape extensometer connection to verify operation, and aid in initial installation and commissioning.

On board electronics to minimize electrical noise problems, and permit tilt sensor calibration independent of cable length effects. Cable length may be changed without affecting sensor calibration.

Digital Busbed System: single, interconnected cable from one tiltmeter to the next, to simplify installation and reduce cost.

# Profile Monitoring System for Tunnel Concrete Segments

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## SPECIFICATIONS + ORDERING

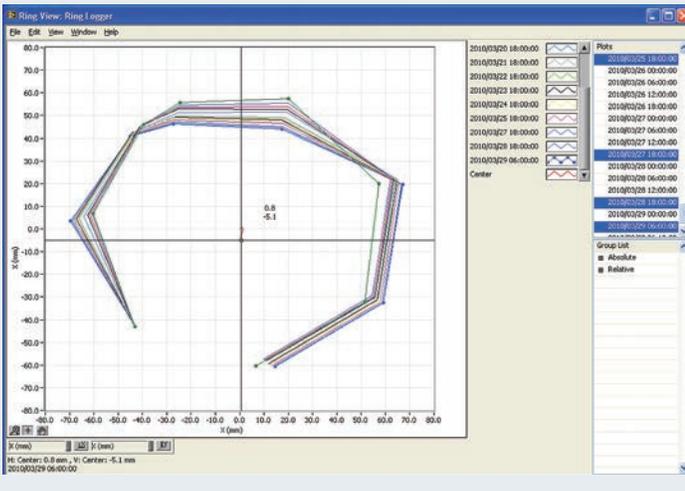
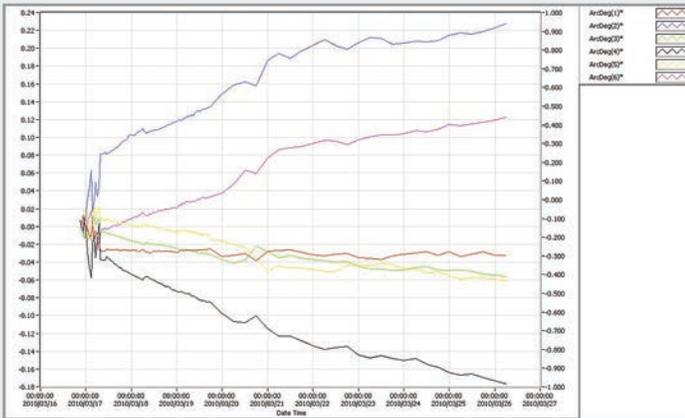
WORKS WITH

# GeoViewer

REAL-TIME MONITORING

The RST GeoViewer program is custom written in both English and the user's language for each site-specific application. GeoViewer will allow the user to retrieve data from the logger in near-real time and process the data.

The XY coordinates and displacement data for each concrete segment is calculated and displayed in a variety of different charts and graphs, displayed graphically, or presented as an image of the tunnel in 3D. Deformation may be animated, time sliced, or rotated as required. An original image of the tunnel may be superimposed with post deformation data to show displacement with time. GeoViewer will automatically collect and process the data to update the screen in near-real time. Alarm functions with user programmable rate/magnitude thresholds are provided. The program format allows data to be imported into outside software programs for further analysis, or will export JPEG images to the Internet. Windows™ XP and Vista operating systems are supported. (Free demonstration software is available, please contact RST for details).



### SENSOR SPECIFICATIONS

TILT SENSOR PARAMETER	SPECIFICATIONS
Range	±15°
Resolution	±2 arc sec. (±0.0006°) (0.01 mm/m)
Non-linearity	±0.0125% F.S. (±0.002°) (0.03 mm/m)
Repeatability	±0.0125% F.S. (±0.002°) (0.03 mm/m)
System Accuracy	1 mm convergence typical
Sensor	MEMS (Micro-Electro-Mechanical Systems) Accelerometer, Digital Bus, Uniaxial
Operating Temp.	-40 to 85°C (-40 to 185°F)

### ORDERING INFO

ITEM	PART #
MEMS Concrete Segment Tiltmeter - Bussed, interconnected cable	ICTCCST
4 conductor, 22 gauge polyurethane jacketed cable	EL380004
Detailed cross sectional drawing of each instrumented segment.	
Plan layout of instrumented segments, and readout location.	
Open or closed loop system.	
READOUTS & DATA LOGGERS	
Ultra Rugged Field PC²	IC32000-AR2-RSTS
GeoViewer Software	ELGL5000
flexDAQ Data Logger System	

WORKS WITH



READY TO RUN  
pre-assembled  
pre-wired  
pre-tested  
pre-programmed

### SYSTEM COMPONENTS

Tilt sensor assembly.
Single interconnected, cable between tilt sensors and to the data logger.
Connectors on each tiltmeter for easy assembly and installation.
Reference pin comes with tape extensometer connector.
Data logger system.
GeoViewer software.
Manual.