
SHAPEARRAY™

Measurand's unique technology, developed over 25 years, makes ShapeArray™ the only patented geotechnical monitoring instrument of its kind.

ShapeArray gives you a more detailed picture of subsurface movement with unparalleled durability relative to deformation.

This automated, inclinometer-style instrument has set a new standard for ease of installation and data collection.

PATENTED PRODUCTS. DATA YOU TRUST.


MEASURAND

SHAPEARRAY

ShapeArray™ is an integrated, inclinometer-style instrument that measures deformation in soil and structures in real-time. This patented shape-sensing, technology can be used vertically, horizontally, or in an arc to automate lateral deformation, settlement, or convergence measurements in tunneling applications.

ShapeArray's design—rigid stainless steel sensorized segments connected by flexible joints—is durable and allows for simple installation from its shipping reel. Every segment of ShapeArray contains a triaxial MEMS tilt sensor, a microprocessor, and digital temperature sensor. ShapeArray data are available in real-time, enabling engineers and designers to reduce risk and save money by making smarter, faster decisions.


MEASURAND


MEASURAND
EASY. RESILIENT. SAAV.

CYCLICAL INSTALLATION

The patented cyclical installation system enables a stable fit into either new or distorted casings. No other inclinometer system is as easy to install or as resilient to deformation.

CASING CAP

The SAAV Casing Cap provides a simple, clean, and efficient way to complete an SAAV installation by holding the SAAV in compression.

EXTENSION TUBES & SILENT SEGMENTS

SAAV is designed to provide maximum flexibility and control. Extension tubes and silent segments place the SAAV's sensorized segments in a zone of interest.

SAAV

The most advanced ShapeArray makes installation even simpler with off-the-reel cyclical installation. Extension tubes and optional silent segments offer flexibility for users to control the location of the sensorized zone.

Segment Length:
250 mm, 500 mm

Installation:
Vertical/Horizontal/
Convergence

Applications:
Permanent/Temporary

PHYSICAL PROPERTIES

SEGMENT LENGTH	250 mm or 500 mm (joint centre to joint centre)
CONDUIT & CASING INSIDE DIAMETERS	27 mm ID, 47 mm to 100 mm
STANDARD LENGTH OF SAAV	Up to 150 m (500 mm segments) Up to 50 m (250 mm) Up to 30 m (convergence installation)
CUSTOM LENGTH OF SAAV	Over standard length, contact Measurand for details
LENGTH OF FIBERGLASS EXTENSION TUBES	1 m to 50 m
LENGTH OF COMMUNICATION CABLE	15 m standard (refer to manual for maximum cable lengths)
SYSTEM PRECISION[123]	± 0.5 mm for 30 m ShapeArray
SEGMENT PRECISION[4]	± 0.0050° (0.09 mm/m)

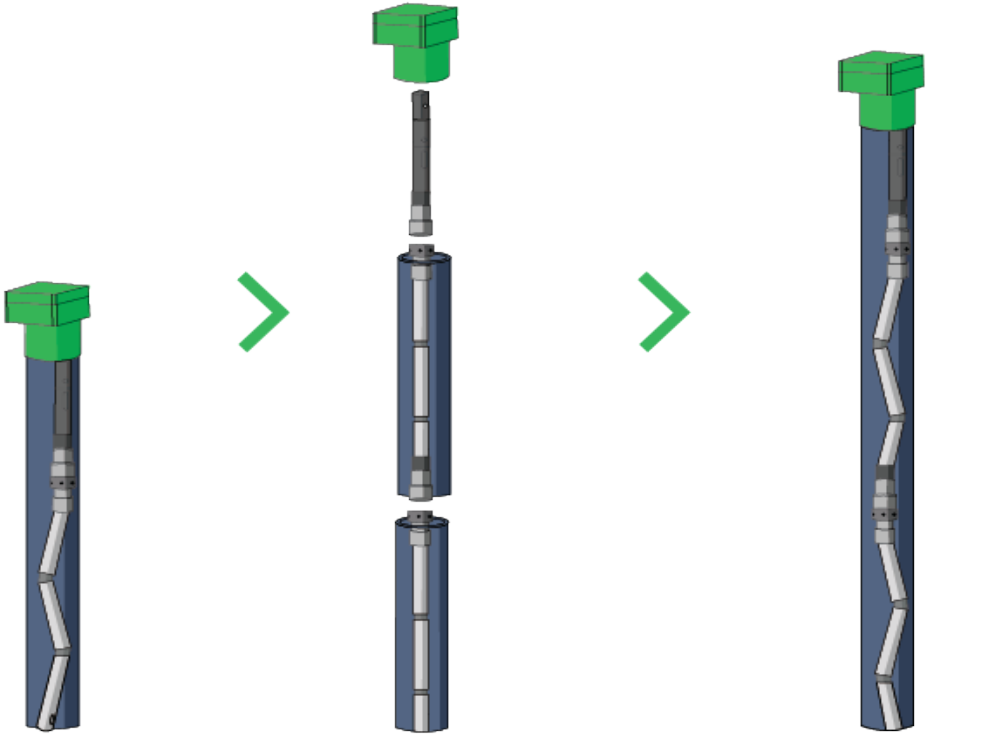
[1] One-sigma value, based on a six-month cyclical installation. Accuracy value is a function of the square root of length.

[2] Value based on Average in Array (AIA) setting of 1000 samples.

[3] Specification is for 3D mode within ± 20° of vertical. Vertical accuracy degrades with angular deviation from the vertical.

[4] Sample size is 540,000 readings. Data was collected for 3 different positions within +/- 10° of the X, Y, and Z axes. Figures provided fall within 99.7% confidence interval (3-sigma value).

CONNECTABLE. SAAV EXTEND.



INITIAL INSTALLATION

RAISE

COMPLETED LIFT

SCALABLE DEFORMATION MONITORING

SAAV Extend is a modular ShapeArray system that scales along with your project's scope.

SAAV Extend includes a top assembly that connects to a base assembly that creates a continuous deformation profile of a borehole.

When the monitored zone of interest grows throughout the lifespan of your project, SAAV Extend Lift Extension segments can be added between the top and base assemblies to increase the total sensorized length.

SAAV Extend's connectors are keyed to ensure azimuth is maintained as Lift Extension segments are added in the field.

SAAV EXTEND

Connect sensorized segments in the field for a continuous deformation profile.

Segment Length:
500 mm

Installation:
Vertical

Applications:
Permanent/Temporary

PHYSICAL PROPERTIES

SEGMENT LENGTH	500 mm (Joint centre to joint centre)
CONDUIT & CASING OUTSIDE DIAMETERS	70 mm or 85 mm inclinometer casing
SAAV EXTEND OUTSIDE DIAMETER	49 mm
MIN. LENGTH OF SAAV EXTEND LIFT EXTENSION SEGMENT	1 m
MAX. COMBINED LENGTH OF SAAV EXTEND	Up to 200 m (500 mm segments)
TENSILE STRENGTH	113 kgf (SAAV joint weakest point) 320 kgf (Connector)
WATERPROOF TO	2000 kPa (200 m Water)
CONNECTOR RATINGS FOR WATER PRESSURE	Mated: 7000 kPa (700 m water) Open face: 1400 kPa (140 m water)
POWER REQUIREMENTS	12 VDC (12–16.5) at 1.8 mA/segment 12 VDC (12–16.5) at 0.4 mA/segment (low power mode)
SYSTEM PRECISION[1][2][3]	± 0.5 mm for 30 m ShapeArray
SEGMENT PRECISION[4]	± 0.0050° (0.09 mm/m)

[1] One-sigma value, based on a six-month cyclical installation. Accuracy degrades as square root of length.

[2] Value based on Average in Array (AIA) setting of 1000 samples.

[3] Specification is for 3D mode within ± 20° of vertical. Vertical accuracy degrades with angular deviation from the vertical.

[4] Sample size is 540,000 readings. Data was collected for 3 different positions within +/- 10° of the X, Y, and Z axes. Figures provided fall within 99.7% confidence interval (3-sigma value).

EXTEND

SAAX

Purpose-built with longer one-metre segments for heavy-duty horizontal installation, including soil settlement, rail-line deformation, and pipeline monitoring.

Segment Length:
1000 mm

Installation:
Horizontal

Applications:
Permanent/Temporary

PHYSICAL PROPERTIES

SEGMENT LENGTH	1000 mm (Joint centre to joint centre)
CASING INSIDE DIAMETERS	27 mm to 54 mm
STANDARD LENGTH OF SAAX	Up to 200 m
CUSTOM LENGTH OF SAAX	Over standard length, contact Measurand for details
LENGTH OF COMMUNICATION CABLE	15 m standard (refer to manual for maximum cable lengths)
SYSTEM PRECISION[1][2][3]	± 0.5 mm for 30 m ShapeArray
SEGMENT PRECISION[3]	± 0.0050° (0.09 mm/m)

[1] One-sigma value based on six-month installation. Accuracy value is a function of the square root of length.

[2] Value based on Average in Array (AIA) setting of 1000 samples.

[3] Sample size is 540,000 readings. Data was collected for 3 different positions within +/- 10° of the X, Y, and Z axes. Figures provided fall within 99.7% confidence interval (3-sigma value).

SAASCAN

Built for rapid deployment and repeated use. The instrument of choice for one-shot verification of the alignment of jet-grouting holes. Thick-walled 500 mm segments provide great spatial detail and resist damage.

Segment Length:
500 mm

Installation:
Vertical

Applications:
Temporary

PHYSICAL PROPERTIES

SEGMENT LENGTH	500 mm (Joint centre to joint centre)
STANDARD LENGTH OF SAASCAN	Up to 50 m
CUSTOM LENGTH OF SAASCAN	Over standard length, contact Measurand for details
LENGTH OF UNSENSORIZED SECTION NEAR-CABLE END	8.2 m standard (Includes 3.3 m Cable Terminator Segment and 7.9 m Hydraulic Hose)
LENGTH OF COMMUNICATION CABLE	15 m standard (refer to manual for maximum cable lengths)
ACCURACY OF ABSOLUTE SHAPE[123]	± 10 mm for 32 m SAAScan
SEGMENT PRECISION[234]	± 0.0050° (0.09 mm/m)

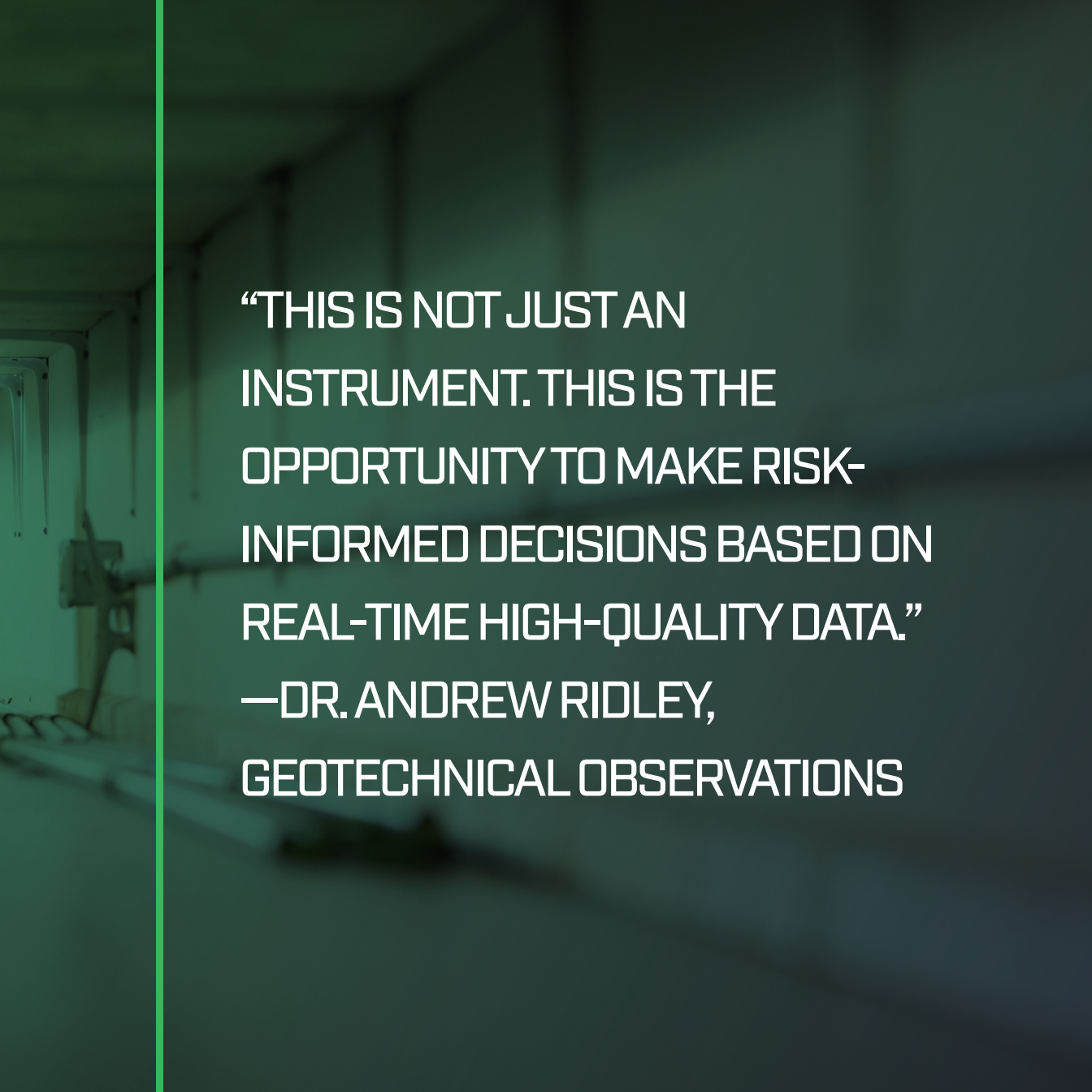
[1] One-sigma value based on six-month installation. Accuracy value is a function of the square root of length.

[2] Value based on Average in Array (AIA) setting of 1000 samples.

[3] Specification is for 3D mode within ± 15° of vertical.

[4] Sample size is 540,000 readings. Data was collected for 3 different positions within +/- 10° of the X, Y, and Z axes. Figures provided fall within 99.7% confidence interval (3-sigma value).

SAASCAN

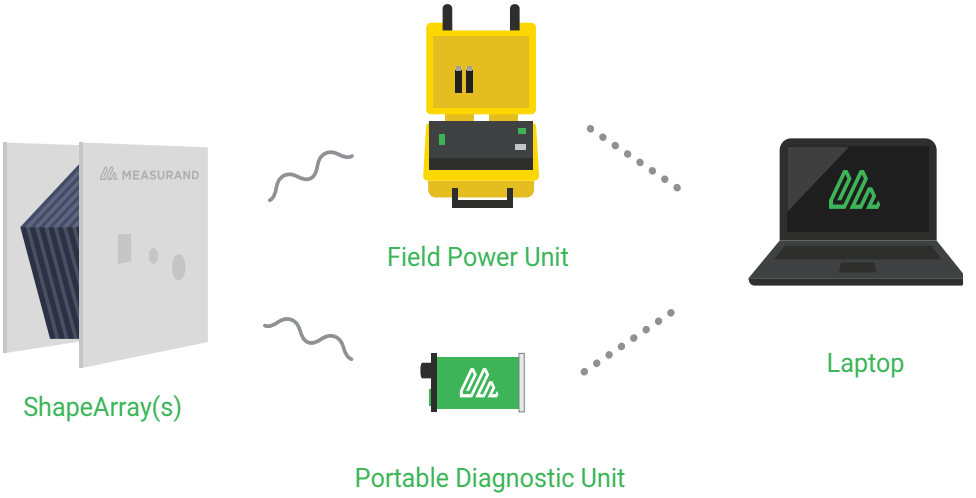

“THIS IS NOT JUST AN INSTRUMENT. THIS IS THE OPPORTUNITY TO MAKE RISK-INFORMED DECISIONS BASED ON REAL-TIME HIGH-QUALITY DATA.”
—DR. ANDREW RIDLEY, GEOTECHNICAL OBSERVATIONS

ARRIVES FIELD-READY. SIMPLE INSTALLATION.

ShapeArray arrives on a reel, pre-calibrated, and ready for installation. Clients can install and configure ShapeArray to collect data in **75% less time** than traditional in-place inclinometer systems.

Measurand offers two interface options to power and communicate with your ShapeArray installations. These devices allow clients to quickly test and verify ShapeArray installations prior to configuration for automated data collection.

Installation verification / Manual data collection



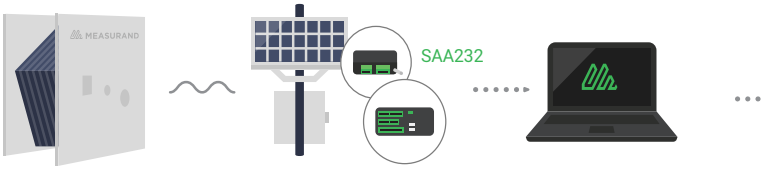
DATA VIEWING AND ANALYSIS

Measurand provides SAASuite—a software package to process, view, and analyze ShapeArray data—at no additional cost. While SAASuite enables the greatest level of functionality and versatility with ShapeArray data, Measurand is committed to an open export policy. SAASuite tools enable automated exports to third party data delivery and viewing software.

Measurand provides cutting-edge technology to the geotechnical industry to automate and modernize their monitoring projects by partnering with industry leaders in wireless connectivity.

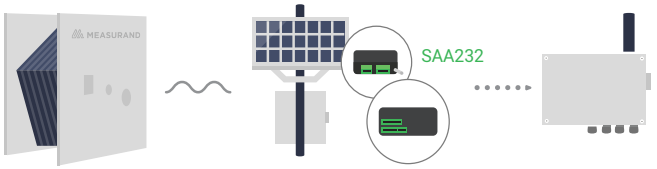
See the full list of automated data collection solutions and third-party integrations at www.measurand.com

Auto Collection / Manual Retrieval



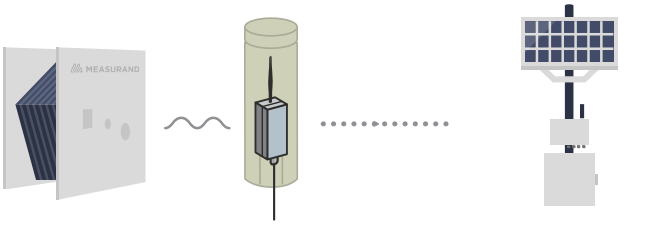
ShapeArray(s) | Data Acquisition System | Data Logger | Laptop

Auto Collection / Retrieval



ShapeArray(s) | Data Acquisition System | Data Logger | Third-party gateway system

Wireless Auto Collection / Retrieval



ShapeArray(s) | Digital node | Data Acquisition System with third–party gateway hub

SAASuite

Open data exports for third-party visualization

INSTALLATION SUPPORT

When complex or uncertain installation conditions face our clients, Measurand is able to assist with technical experts in the field. Measurand believes providing on-site technical advice and training gives your team a solid foundation to get valuable and actionable data from ShapeArray's real-time deformation monitoring.

AFTER SALE SUPPORT

In-house support is provided by technical staff with industry experience, ready to provide assistance with your ShapeArray instrumentation at no additional cost. An online library and support portal make it simple to collect, process, and view your data. For situations that require closer attention, support staff are available via telephone and email.

Reach support at: support.measurand.com


PATENTED PRODUCTS.
DATA YOU TRUST.

"The Yeager Airport project team selected Measurand's ShapeArray sensors to monitor short and long deformation of the retaining wall structure due to a combination of cost, sensor spacing (value of information), installation time, and automation up-time.

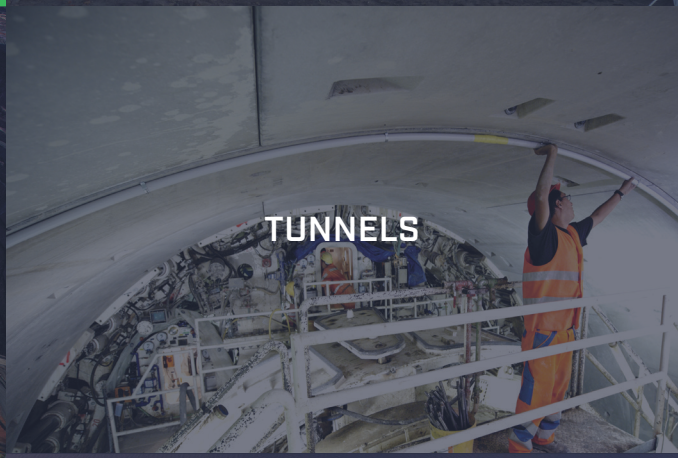
Such value engineering and upfront cost savings were likely considered by the design and construction team when selected shapeArray sensors over other technologies."

–TODD ROBERTS,
DIRECTOR, sensemetrics

SECTORS


URBAN CONSTRUCTION


MINING & TAILINGS PONDS


TUNNELS


GEOHAZARDS


DAMS & LEVEES

US ROUTE 2 LANDSLIDE

Traffic diverted before catastrophic failure

SHAPEARRAYS PROVIDE EARLY WARNING AND THEN SURVIVE MASSIVE SLIDE

Steep river banks and clay soil near highways have led to numerous slide events near Crookston, MN, over the past 50 years. In 2003, a landslide in downtown Crookston caused significant property damage, leading the Minnesota Department of Transportation (MnDOT) to investigate new monitoring solutions. The department had used traditional inclinometers, but were interested in the automation and remote collection of data. MnDOT installed ShapeArrays in two roadway sections on US Route 2 experiencing stress related to erosion and soil instability.

ShapeArray data revealed that soil movements at the Crookston East site were deeper than anticipated. Experts determined that the slope was no longer creeping and a major failure was occurring. The MnDOT closed the westbound lanes of US 2 and detoured traffic on Sept. 15, 2008. Ten days later, a large progressive landslide occurred, dropping a 150-metre section of the highway by three metres. The slide continued over several days. ShapeArray helped engineers ensure that no members of the public were hurt during the sliding event. ShapeArray survived unprecedented deformation during and after the event. The system remains in place and provides valuable data to the MnDOT.

See more project profiles at www.measurand.com

Reference:
Dasenbrock, D. D. (2010) Automated Landslide Instrumentation Programs on US Route 2 in Crookston, MN. *Proceedings of the UMN 58th Annual Geotechnical Engineering Conference*. Continuing Education and Conference Center, St. Paul Campus: University of Minnesota.

YEAGER AIRPORT

Automated backfill deflection monitoring

DEFLECTION MONITORING AFTER AIRPORT RUNWAY SLOPE FAILURE

ShapeArray played an important role in the monitoring strategy of the Yeager Airport runway following a slope failure in 2015 and now, during the project's reconstruction.

The Yeager Airport, approximately 5 km east of downtown Charleston, West Virginia, sits on a hill with steep slopes on several sides. The airport handles over 250,000 passengers per year. When the airport runway's safety overrun collapsed after heavy rains in 2015, the collapse released 288,000 m3 of debris downslope. After the failure, Schnabel Engineering installed two SAAF model ShapeArrays to monitor the slope for further movement.

Construction to rebuild the safety overrun began in spring 2018. Schnabel Engineering installed six additional ShapeArray into soldier piles to monitor deflection during the backfill and anchor stressing stages.

Schnabel Engineering connected the ShapeArrays to sensemetrics' Thread platform, which allowed for the rapid deployment of the monitoring system and access to real-time data within six hours.

See more project profiles at www.measurand.com

ŻELAZNY MOST

Europe’s largest tailings pond demanded deep ShapeArray monitoring

SHAPEARRAY PROVIDES RISK REDUCTION FOR CHALLENGING SOIL FOUNDATION CONDITIONS

With a development capacity of over 1.1 billion cubic metres that accepts 80,000 tonnes of tailings each day, the Żelazny Most Reservoir plays an essential role in Poland's economic activity. When the engineers at the Żelazny Most Reservoir began to suspect that the ground beneath Europe's largest copper tailings pond might be moving, they needed new monitoring solutions.

ShapeArray enabled monitoring at an unprecedented depth, which provided Żelazny Most Reservoir's owners, KGHM Polska Miedz, with a way to monitor slope stability and deformation in the dam foundation.

ShapeArray is part of a monitoring program at the reservoir to accommodate the tailings produced by three copper mines in the area.

See more project profiles at www.measurand.com

RANELAGH SEWER

Effective convergence and settlement monitoring in confined, hazardous space

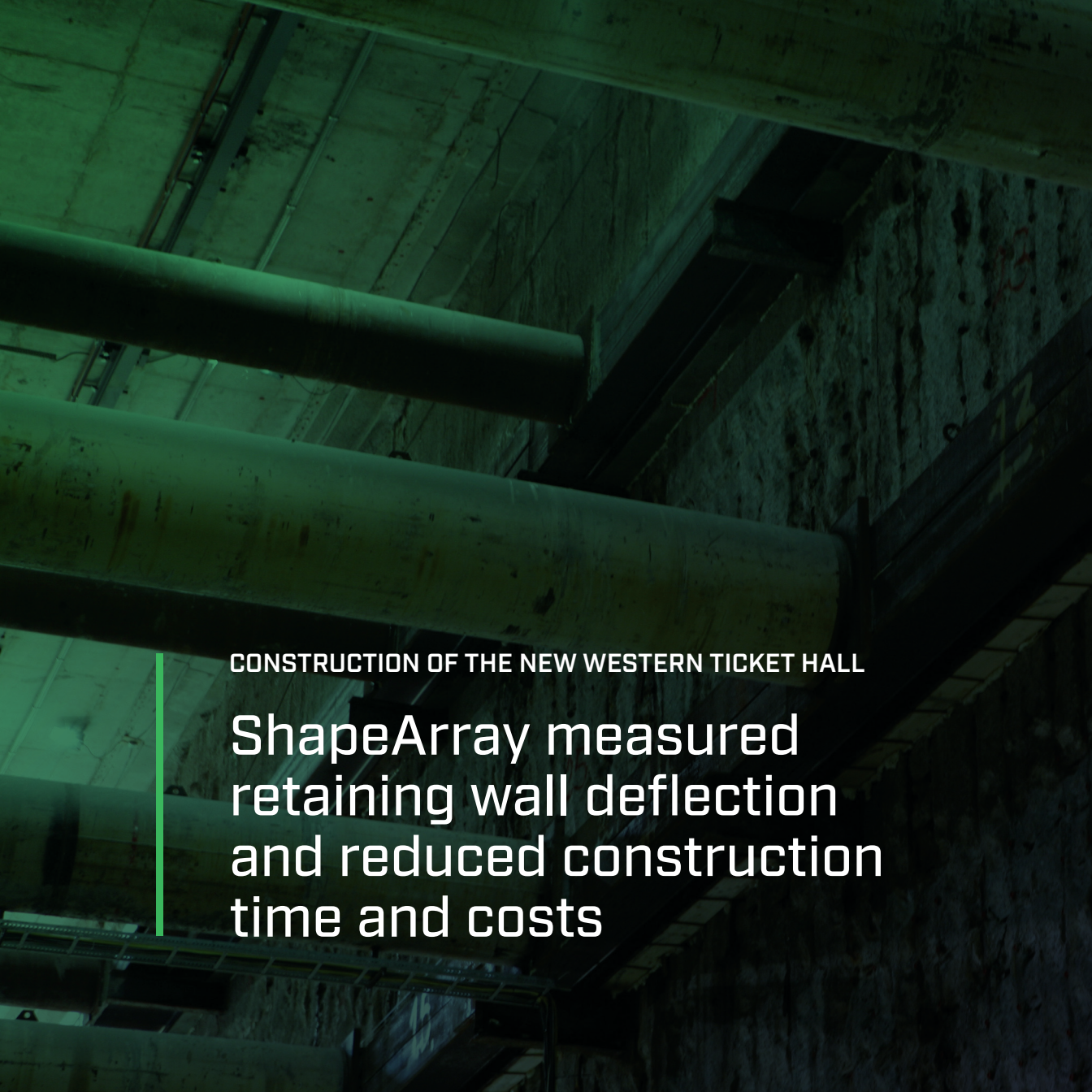
REAL-TIME DATA ALLOWS DESIGN VERIFICATION AND IMPROVES WORKER SAFETY

When designers of a massive rail tunnel underneath London's streets encountered their biggest obstacle, a historic brick sewer, they installed ShapeArray to monitor convergence and settlement. The Ranelagh Sewer, a narrow brick sewer, sat just 4.5 metres over the top of the Tunnel Boring Machine's tunnel drive and was at risk of shifting.

Subsequent discussions with Thames Water determined that standard methods of measuring convergence were an unacceptable risk to workers and not suitable for the application. Designers turned to ShapeArray to provide real-time data on convergence and settlement. Additionally, ShapeArray's low profile would not obstruct the sewer's flow and would eliminate the need for workers to enter the sewer to collect data. ShapeArrays were installed along the tunnel's crown in an arc to measure convergence. An additional ShapeArray, installed along the length of the sewer, measured settlement.

See more project profiles at www.measurand.com

Reference:
Bradley, B., & Garcia, P. G., (2014). The Use of Shape Accel Array for Monitoring Utilities during Urban Tunnel Drives. *Crossrail Learning Legacy.* London, UK. ICE Publishing



CONSTRUCTION OF THE NEW WESTERN TICKET HALL

ShapeArray measured retaining wall deflection and reduced construction time and costs

MEASUREMENT DATA ALLOWS ENGINEERS TO EXECUTE A VALUE ENGINEERING PROPOSAL

As part of a massive construction project on a new £1 billion station on Tottenham Court Road Station in London's West End, engineers planned five levels of temporary props to bolster and stabilize the temporary retaining walls.

Nine ShapeArrays were installed vertically into the retaining walls to measure deflection. Engineers set a number of different alarms to notify staff when movement exceeded their thresholds. The data produced by the ShapeArrays allowed engineers to draft a Value Engineering (VE) proposal to omit a planned propping level. The data showed that forces acting on the retaining walls were within allowable tolerances without the additional prop. The client accepted the VE proposal, which resulted in significant savings to the project and eliminated 26 days of scheduled construction.

See more project profiles at www.measurand.com

Reference:
Thurlow, P., & Lipscombe, R. (2014). The Use of Shape Accel Arrays (SAAs) for Measuring Retaining Wall Deflection. In J. Wolosick, A. Marinucci, S. Ballenger. *Proceedings of the 39th Annual Conference on Deep Foundations.* Atlanta, GA: DFI.

OROVILLE DAM

Spillway reconstruction required fast installation to monitor slope stability

AUTOMATED REAL-TIME MONITORING INSTALLED UNDER BUDGETED TIME

The Oroville Dam, one of the tallest dams in the United States at 235 metres, experienced significant spillway damage in 2017 after a period of prolonged heavy rains, prompting the evacuation of 188,000 people downstream.

Kiewit Construction led the reconstruction efforts, while Terracon was responsible for geotechnical instrumentation and monitoring. Several SAAV model ShapeArrays, along with traditional in-place inclinonmeters, were installed to monitor movement and slope stability during the spillway's reconstruction. The ShapeArrays, connected to the sensemetrics wireless THREAD platform provided project managers with near real-time automated data collection and viewing. According to sensemetrics, the contractor budgeted a three-week period to install and automate the sensored instrumentation, but with the ease of installation and platform integration, the work was completed in three days. The ShapeArrays used on site were installed in a single morning.

Repair construction on the main spillway was completed in October 2018.

See more project profiles at www.measurand.com

GILHUSBUKTA, NORWAY

ShapeArray linked across seabed to create seamless deformation profiles

UNDERWATER INSTRUMENTATION ALLOWS SETTLEMENT MONITORING OF SEABED

The Fjordbyen project, or Fjord City, is a large-scale, multi-year land development and reclamation project in Gilhusbukta, Norway. The project will move 4.8 million tonnes of rock mass into the Gilhuskukta Bay of the Drammmensfjord, allowing the construction of civil infrastructure such as a public transportation hub, a hospital, and housing for 20,000 people. As a busy shipping port, significant amounts of oil, tar, and creosote had leaked into the fjord. In order for the material to be safe for construction, tonnes of rock-fill had to be dredged from the seabed and washed of contaminants before deposit back into the seabed.

To monitor the length of Gilhusbukta Bay, Cautus Geo installed SAAX-type ShapeArray in long trenches dug across the bay in the seabed. The data of three distinct SAAX-type ShapeArrays were combined into a single, seamless profile of the seabed. Three profiles made of nine SAAX-type ShapeArrays in total were trenched into the seabed to establish automated subsidence monitoring before million of tonnes of rock-fill was dumped into the bay. The longest settlement profile out of the three measured 330 metres long. In addition to ShapeArray, Cautus Geo has installed 27 piezometers at nine different locations—the deepest are more than 50 metres below the seabed.

See more project profiles at www.measurand.com

Reference:
A. Karlsvik, "Environmental Dredging: The SeaBed Way," in Seventh International Conference of Remediation of Contaminated Sediments, Dallas, Texas, 2013.


PATENTED PRODUCTS.
DATA YOU TRUST.

TELL US ABOUT YOUR PROJECT

Measurand designs and manufactures superior monitoring products. All ShapeArray instruments are manufactured in Measurand's high-capacity ISO 9001:2015 certified facility.

Measurand's staff of experts is ready to help, from sales to installation to support.

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Technical Support
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