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WORLD TUNNELLING

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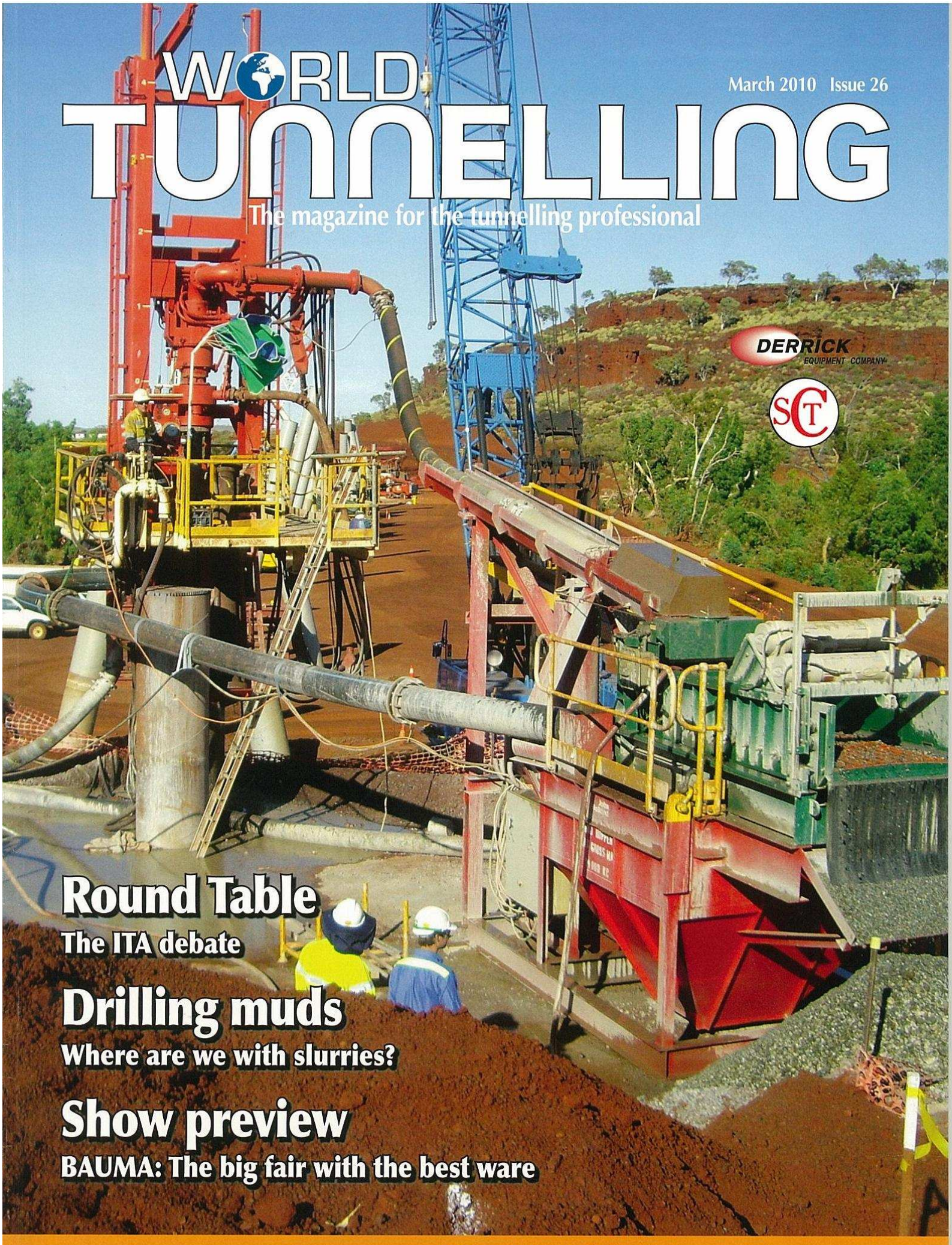

Round Table
The ITA debate

Drilling muds
Where are we with slurries?

Show preview
BAUMA: The big fair with the best ware

www.world-tunnelling.com

PROJECT: Austria

From the ground down

Innovative and patented ground-consolidation technologies were used for a series of structural and waterproofing measures on this tunnel project in Austria

THE new Verona-to-Munich high-speed railway forms a section of the Berlin-to-Palermo rail link of the larger Trans-European Transport Networks (TEN-T). This line will run out of Italy through the Alps and enter the Brenner Base Tunnel (Brennerbasistunnel), currently under construction, before heading into Austria towards Innsbruck.

It is important to note that the Brenner Base Tunnel, with its twin 55km-long tubes, is second in size to the 57km Gotthard Base Tunnel and thus considered one of the most important underground works to be realised.

To manage the design and engineering processes of the works on the Austrian side, the Austrian government formed the Brenner Eisenbahn Gesellschaft (BEG) company. With consulting from ILF-Geoconsult ZT- iC for the geotechnical design and jet-grouting experts at Studio HBPM, BEG drew up a series of projects aimed at minimising the environmental impact on the area adjacent to the line, both during and after construction.

THE STANS TUNNEL

Past Innsbruck, the new line runs parallel to the Inn River, as does the A12 motorway and the railway to Munich. Due to the repeated intersection of the new line with the motorway and existing railway, and the requirement to reduce impact on an area with two existing infrastructures, the engineers designed a set of tunnels which, even at different distances from the riverbed, often pass below the watertable.

During the design phase, they defined methodologies to deal with the diverse situations, and adopted a scheme involving the excavation and covering of trenches or the use of shield tunnel boring machines (TBMs).

At Stans, the short distance of the new line from the bed of the Inn River demanded an alternative solution. At that point, the tunnel passes a motorway viaduct and the existing rail line (both situated a short distance from the river) with a polycentric section of 750m in length, 11.8m in height and 13m in width. The underground works would extend to 30m under the riverbed. To deal with these demanding conditions, an innovative method of consolidation would be necessary.

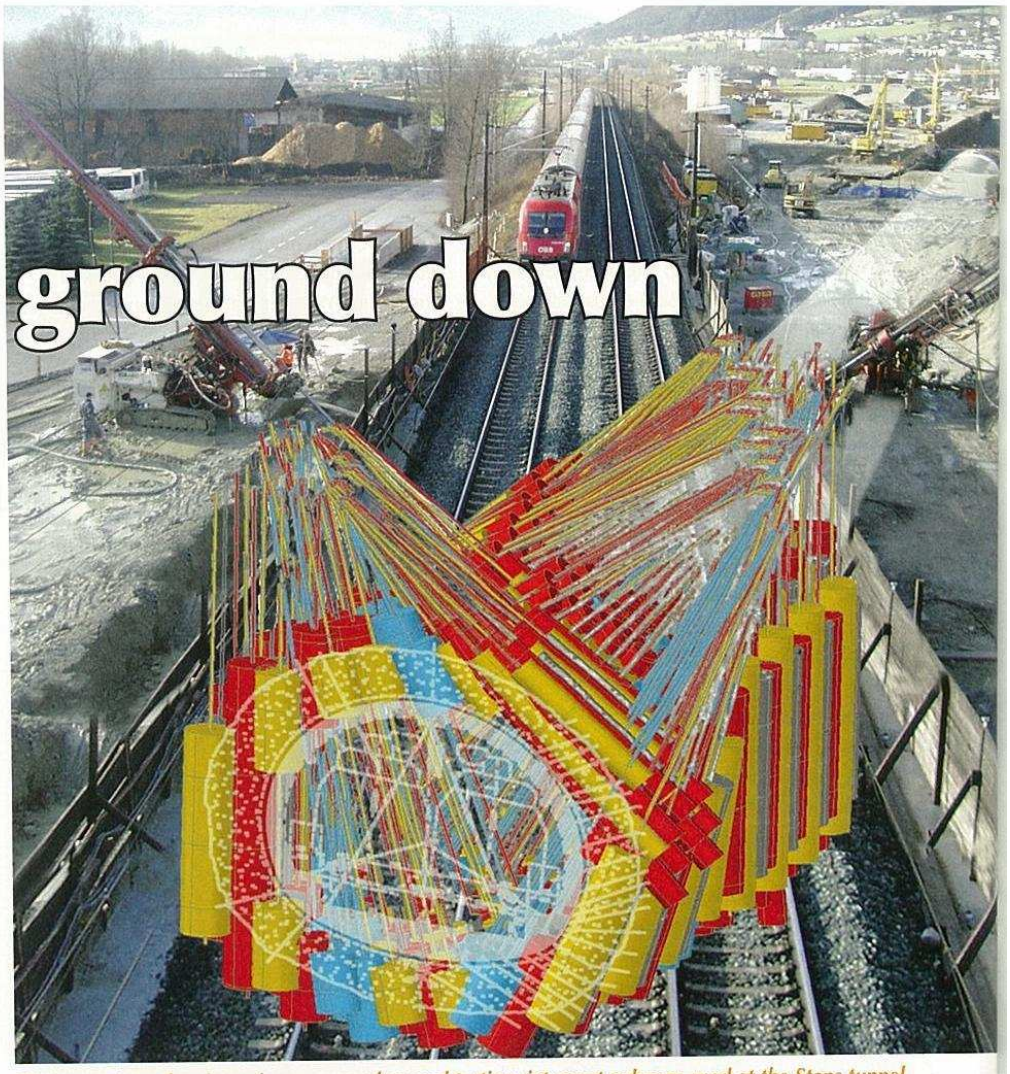

Photo-montage showing primary, secondary and tertiary jet-grout columns used at the Stans tunnel

BEG entrusted the job to the Alpine/GPS Consortium, which then subcontracted foundation specialist Trevi to perform the geotechnical and consolidation work. The geological composition of the soil, including sand, gravel and pebbles below the watertable, made the excavation of a tunnel 30m under the riverbed a challenging process.

BEG provided for the construction of the tunnel under the protection of a waterproof ring of consolidated soil by jet-grouting 2m around the surface to be excavated using compressed air to neutralise any residual permeability. For its part, Trevi implemented a consolidation system to create an outer lining of single and double fluid jet-grout columns. The solution was ideal because it satisfied both a hydraulic and stability function, deemed essential for the tunnel's construction and to guarantee safety.

The jet-grouting mesh prevented seepage and leaks, and therefore allowed workers to operate in an essentially dry environment, while the ring with minimum 2m section made it possible to contain the loads from the motorway, railway and the water pressure of the Inn River.

TREVI'S SOLUTION

Project specifications laid down the conditions for waterproofing (5 litres/sec validated by pumping tests) and structural strength (with minimum values of at least 5N/mm^2) since these were considered vital to safety. Trevi's method ensured these conditions were achieved by creating a mesh composed of three different series of vertical and/or inclined columns, overlapping each other by no less than 100mm at their minimum point of intersection.

The 750m section to be consolidated was divided into 38 compartments, each with a length of 20m. To neutralise leaching of the underground watertable, the most permeable layers of soil were saturated with soil-cement mixes before beginning the jetting process. For each sub-area, an initial series of 'primary' jet-grout columns with a 1.90m diameter was built. When the primary columns were set, a second series of intermediary columns followed.

Guided by the hardened primary columns, the secondary series was contained in the eventual deviations of the perforations in a soil characterised by enormous variations. After the second set of columns were built (1.90m overlapping the first set by a maximum 340mm), the result was a hexagonal cell. After the secondary columns hardened, the third series of columns was created in the centre of the cell, serving to connect the primary and secondary columns. The jetting parameters of these third

columns were lengthened so as to create plugs that sealed any residual imperfections between the primary and secondary columns. Each compartment was separated from the successive one by buffer columns.

The 9,000 perforations led the way for the construction of 6,300 columns in the upper part of the tunnel, the same number in the lower part, and 2,700 at the sides, bringing the total number of columns to 15,300.

The columns reached a maximum depth of 35m and consolidated a total of 120,000m³ of soil through the injection of a total 210,000m³ of soil-cement mix. This type of jetting is particularly suited to soils made up of sand and gravel, which characterise the Stans Tunnel site.

LOGISTICS & QUALITY CONTROL

Construction of the Stans Tunnel was highly complex due to the jet grouting and excavation. Prior to the works, field tests were carried out with the construction of independent, slanted, vertical columns using the single- and double-fluid jet-grouting system and overlapping slanted, vertical columns. The next step was to measure the diameters and evaluate the strength of the columns by removing surrounding soil. Overlap with the adjacent columns and their faithfulness to project requirements were then analysed.

"A mesh composed of three different series of vertical and/or inclined columns, overlapping each other by no less than 100mm"

Each compartment's compliance with waterproofing criteria was verified by leak tests to check that the shell, made up of the tube lining and jet-grout buffers, adhered to the waterproofing level (5 litres/sec per compartment). The resulting values generously fell within this limit.

During tunnelling, compressed air was used to achieve greater overall stability and avoid the seepage of residual water. Pressure was adjusted according to the depth below the watertable. This system requires that the workers and machines go through a decompression chamber to allow them to adapt to the atmosphere above.

As emphasised earlier, the organisation of the site and logistics, as well as the execution of all the works, were of enormous complexity. At some points, the drilling rigs were forced to make the columns at a distance of 1m from the motorway embankment, which required a study of the conditions to ensure operability and safety.

Soilmec CM 40 drilling rigs were assigned to do the jetting, but, in the area abutting the motorway viaduct, micro-drillers were used to allow clearance under the deck. Furthermore, the large quantity of soil-cement mix used (up to 800t/day) required the installation of a production plant that could guarantee output.

Quality control received particular attention, both during the project phase and the execution of the jet-grouting mesh. Before works began, the company devised the Trevi 3D Stans modelling system, which evaluated the overlap of each column with the adjacent one. During the execution phase, the axis of the columns was based on their position using the intermetric system, with its positioning monitored by the Tigor system. All data subsequently flowed into the technical office and to quality control.

These two departments, each operating according to its own protocol, analysed and cross-referenced data from surveys performed in situ, and verified their adherence to project specifications and the 3D modelling. Through the use of the Lutz system, all data regarding drilling and jetting parameters was collected in a database, which served for the representation of the project.

The focus will be on new ways to use its pumps and the latest technology. The firm has announced it will introduce the eagerly-awaited NK 2-22 dewatering pump to the European market for the first time and a GPN-series excavator adaptor for efficient sand-water discharge. Tsurumi will also showcase two of its most renowned pumps: the LSC 'puddle suckers' and LH 675 dewatering pump.

The NK 2-22 is a heavy-duty, high-head, single-phase submersible pump. Its application includes the removal of sand, wastewater and general construction-site drainage.

The 2.2kW motor driving the pump can carry water over a total head of 25m or reach flow capacities of 590 litres/min. It runs off a standard 220V power supply. A high-flow model will also be available, the NK 2-22L, which produces 35% more volume than the standard model.

Other products on display will include several 'puddle sucker' pumps. These LSC residual dewatering pumps are designed to drain large amounts of water down to levels of just 1mm and are among the firm's best-selling ranges.

Hall A6, Booth 322 *www.tsurumi-europe.com*

Soilmec crane control

Soilmec will present a wide range of innovative equipment, technologies and services at Bauma. This includes the SC-65 Foundation Crane, the latest of its heavy-duty crawler cranes and the first Soilmec crane with electro-proportional controls, driven by an electro-hydraulic system, which is designed to give accurate and simultaneous movements.

The crane's maximum capacity is 65.7t with a working radius of about 3.5m. According to the company, the diesel engine power (403kW) and hoisting force (240kN) are greater than those of its main competitors' cranes. Another advantage is the new Soilmec cab, which has been designed to provide improved operator comfort.

Other products on display will include the PSM-5 and PSM-3 Microdrilling Rigs, which allow the group to provide machines of 3-32t. The new PSM-5 is a compact drill rig, weighing 5.5t, available with a combined kinematic mechanism that includes a telescopic arm, a +/- 90°/a1 side traverse and a slewring on mast (standard version).

PSM-3 is a new drilling machine featuring a separate powerpack and the same movements as its elder sister, the PSM-5. Two engine sizes are available: 72kW and 129kW, respectively (diesel and electrical).

The SR-90 TTJ Hydraulic Rotary Rig will be presented in a new configuration and provides a new solution for soil mixing. The line-up will be completed by other rigs, pumps and grout-mixers.

Open-air ground F6, Booth 601/602/1 *www.soilmec.it*

TunnelTec boosts durability

Germany-based TunnelTec will be presenting a variety of tunnel-construction solutions. One of the highlights will be the specialised, robust and low-wear drilling tools aimed at different types of tunnel-boring machine. These tools, which TunnelTec says are characterised by high durability and economic efficiency, are produced independently of TBM manufacturers.

A significant constructional benefit is the fact that these tools can be mounted on existing cutterheads or cutting wheels without any further alteration. TunnelTec claims its tools have shown that the daily headway of the TBM can be increased, with fewer tool changes and less downtime.

The tools on display will be mainly, but not exclusively, for soft ground, and will include bucket scrapers and gauge rippers, as well as scraper, ripper and nose-cone tools for face and central areas of the cutterhead.

TunnelTec also supplies complete cutterheads and equipment for electrical forward monitoring. The company offers various kinds of services for overhauling and refurbishing TBMs, such as the supply of specialised staff, engineering and the delivery of spare parts. Also, full services for tunnel-construction projects, from consulting and project planning up to construction and sale, can also be offered.

Hall C3, Booth 521 *www.tunneltec.com*

VMT guides the way ahead

VMT will be exhibiting as part of the Herrenknecht Group stand. In the 16 years since its inception, VMT has become a leading company, not only in the supply of guidance systems for the full range of tunnel-boring machines but also in fulfilling the metrology needs of modern projects.

On display will be the new Tunnel and Underground Information Software Structure, TunIS. This is the platform on which all VMT guidance systems will now be based to enable the efficient inclusion of enhancements to satisfy the needs of an ever-demanding tunnelling industry.

The main products on show will include: the SLS-SL Guidance system for TBM's; the SLS-LT for pipejacked tunnels that are either curved or of extended distance; plus a comprehensive range of ancillary modules for tasks such as data recording, automatic bentonite lubrication control, monitoring of selected pipe joint gaps, working-face distance measurement on open-face shields, and a video-monitoring facility, as well as remote data transfer.

Also on display will be the Tunnel Construction Information System (CBP) for complete data collection, correlation, evaluation and real-time reporting.

In addition, VMT Process Technology will be showing its Segment Documentation System to ensure comprehensive data acquisition and recording as part of a transparent, and verifiable, quality assurance programme.

The newly-created VMT Geomonitoring will demonstrate its range of monitoring sensors, and its services for geodetic and geotechnical surface and structural monitoring.

Hall C3, Booth 315/512 *www.vmt-gmbh.de*

TunnelTec: refurbished gripper TBM with back-up