GeoDrilling International

ESTABLISHED 1993

Drilling in extremes

Just how do you meet the challenge of drilling on Mars?

Rotary drilling

The latest trends and new developments in the rotary drill sector

Borehole logging

Examining the latest technology and options for borehole logging

ISSN 0969-3769

September 2020 www.geodrillinginternational.com

Find out more about how we can support your work

comacchio.com

PART OF YOUR SUCCESS

At Comacchio we put the customer's needs at the heart of what we do, providing personalized service and developing solid relationships. Our innovative range of drilling equipment and tailor-made solutions is the result of our commitment to continuous improvement and product development, inspired by our clients and performed passionately by our team every day.

COMACCHIO
DRILLING HI-TECH

For sales – rental – parts – service of Comacchio piling equipment in the UK:

NORTH EQUIPMENT LTD
PILING EQUIPMENT

It's nearly business as usual

If this year had not been thrown into turmoil following the global pandemic I, like many in our industry, would be preparing to head to Piacenza, Italy, to attend Geofluid. However, like so much that had been planned for this year, COVID-19 has meant its postponement. Despite the event being pushed back to 2021, here at *GDI* we have not let that stop us from focusing on Italy in this issue.

Taking a close look at the drilling industry in Italy has proven just how resilient the sector is and how despite the challenges presented by the coronavirus driller simply carry on as close to business as usual as they possibly can.

All though it may sound strange, putting this issue of *GDI* together has shown me how some good may just come out of the pandemic. Because of the need for people to work while socially distancing new methodologies are being quickly developed and chief among those is automation. If the drill crew can be distanced from the machinery there is the added bonus of potentially fewer accidents. Of course, in many cases, the introduction of automated processes also increases productivity and reduces downtime.

"Despite the challenges presented by the coronavirus driller simply carry on"

It's just a shame that we will have to wait until next year when, hopefully, the numerous industry events that have been postponed this year will be able to take place and we will all be able to explore the new innovations brought to the fore by COVID-19.

However, there is one thing that you won't have to wait for anymore. This issue of *GDI* sees the title return to both print and digital editions. Just like the rest of the industry when the coronavirus lockdown forced many job sites to close and events to be postponed or cancelled, we were forced to suspend the print edition of the magazine, but now we are back. Happy reading.

DUNCAN MOORE, EDITOR

duncan.moore@aspermontmedia.com
For news and updates, follow me on Twitter: @GeoDrilling

Next issue

Horizontal directional drilling
Auger drilling
Drilling fluids/muds and additives
Africa & Middle East

COVER

Here we have two Fraste FS 500 drilling rigs that were supplied to Europe last July. One to Germany and the other to UK. These rigs include high rates of quality and safety and are destined to perform in many different types of drilling. Construction criteria come from the best manufacturing procedures and excellent component, to give always the best. Fraste since 1964. A lifetime experience is the first guarantee.

Editorial
Editor Duncan Moore
duncan.moore@aspermontmedia.com
Managing editor Richard Roberts
Editorial enquiries +44 20 8187 2330

Social
@GeoDrilling
geodrilling-international-52513999
geodrillinginternational.com

Subscriptions and circulation
+44 (0)20 8955 7050
mining@abacusemedia.com
Aspermont Media Ltd,
21 Southampton Row,
London, WC1B 5HA

Advertising
Head office
Aspermont Media, WeWork 1 Poultry, London EC2R 8EJ, UK.
+44 20 8187 2330

Rest of world **Sales account manager** Gabriella Kiss
+44 20 8187 2324 gabriella.kiss@aspermontmedia.com
North America **Sales account manager** Chad Dorn
+1 720 8553996 cdorn@miningadvertising.com

Italy & Switzerland **Contacts** Fabio Potesta, Daniela Chiusa
T +39 010 5704948 F +39 010 5530088
info@mediapointsrl.it / daniela.chiusa@mediapointsrl.it.com
Media Point and Communications SRL, Corte Lambruschini – C.so Buenos Aires 8- V° piano Int. 7 16129 Genova, Italy.

Digital and creative
Group digital & creative director Abisola Obasanya
Sub editor Woody Phillips
Print management Print.management@aspermontmedia

Executive
Managing director Alex Kent **Chairman** Andrew Kent **Group chief operating officer** Ajit Patel
Group chief financial officer Nishil Khimasia **Chief commercial officer** Matt Smith

Annual subscription – UK and Europe: £95.00 (€160.00 eurozone) Rest of world: US$170.00. Additional current copies are available to subscribers at £12 (US$21) each

GeoDrilling International, ISSN 0969 - 3769 (USPS 001-430), is published monthly, except January and July, which are combined issues (Jan/Feb and Jul/Aug), by Aspermont Media, WeWork, 1 Poultry, London, EC2R 8EJ, UK.

The US annual subscription price is US$170. Airfreight and mailing in the USA by agent named WN Shipping USA, 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA.

Periodicals postage paid at Jamaica NY 11431.

US Postmaster: Send address changes to AirBusiness Ltd, c/o Worldnet Shipping USA Inc, 155-11 146th Avenue, Jamaica, New York NY 11434, WN Shipping USA, 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA.

Subscription records are maintained at Aspermont Media, 21 Southampton Row, London, WC1B 5HA.

Air Business Ltd is acting as our mailing agent.

ISSN 0969-3769

‘High-Tech on Crawlers’ as Hütte launches HBR 710

New requirements regarding safety, handling, versatility and performance have triggered Hütte Bohrtechnik to design its latest drilling rig – the Hütte HBR 710 (patent pending).

The rig’s development, influenced by years of expertise and customers’ experience and demands, is the next step in the evolution of Hütte’s drill rigs – ‘High-Tech on Crawlers’.

A particular feature of the new drilling rig is that it provides a cabin for the operator creating a safer workplace. In addition, all the functions of the rig can be operated easily out of the cabin. In order to boost the flexibility of the rig, all functions can still be radio remote-controlled from outside the cabin, which offers numerous advantages for operating personnel. Besides safety, the cabin also provides protection against all environmental influences. The cabin was moreover designed according to the latest ergonomic requirements and thus ensuring health benefits for the operator.

Designed for the increasingly challenging drilling operations, the new model, powered by a 209kW diesel engine, scores with high performance on the one hand and provides an engine which meets the latest EU and US standards on the other hand.

The HBR 710’s telescopic extendable crawlers ensure a high level of stability, even on rugged grounds.

Offering cutting-edge technology, the drilling rig offers a wide range of uses for customers including anchoring, micropiling etc.

Another outstanding feature of the new Hütte HBR 710 is the kinematic. The combination of turntable and front-the-wall kinematic is unique. The mast movement covers a range of 90° left/right and it can also drill below the surface.

Safety standards and handling facilitations of the drilling rig are increased by the use of a magazine type M3-2 for up to 5m rods and casing in horizontal/inclined/vertical directions. This can also be operated from inside the cabin without any personal intervention at the magazine.

The hydraulic system is equipped with a load-sensing circuit with high-efficiency pumps and distributors. This allows all kinds of applications like double head, vibro or sonic drilling in the field of special foundation engineering.

Hütte Bohrtechnik’s production programme comprises drilling rigs, accessories, spares and service for the foundation industry. All its products inherit cutting-edge engineering solutions, dedicated electronics and innovative and robust design. Hütte Bohrtechnik is proud to sell “ready-to-drill packages” – all from one single source.

Numa adds HDD 80 to product line

Numa, a leading drilling technology provider, has announced the addition of the HDD 80 to its HDD drilling systems product line.

This new product will further extend the range of Numa’s durable and dependable HDD products and provide drillers with more options.

“Numa continues to design new products to tackle the challenges drillers face,” said Numa president, Ralph Leonard. “Our high quality, made in the USA HDD products provide the right balance of performance and dependability without sacrificing tool life.”

The Numa HDD 80 drilling system consists of a variety of HDD components including hammer, bits, side load sonde housing, bent subs, and adaptors which are capable of drilling holes 9-3/4in to 10in (248 to 254mm) in diameter.

Some of the many benefits Numa touts for the HDD 80 hammer include improved steerability, fast penetration rate, simplified field maintenance, reduced air requirements, and lower overall cost per foot.

Numa purposely designed its HDD hammers to drill longer in difficult rock conditions. Furthermore, a single bore design allows for a maximum bore diameter in conjunction with providing optimum life against abrasion.

The full line of Numa’s HDD Drilling Systems is made up of the models below:

- **HDD 35 for drilling holes 3-7/8in to 4in (98mm to 102mm) in diameter**
- **HDD 40 for drilling holes 4-3/4in to 5in (121mm to 127mm) in diameter**
- **HDD 50 for drilling holes 5-3/4in to 6-1/8in (146mm to 156mm) in diameter**
- **HDD 60 for drilling holes 7in to 7-1/2in (178mm to 191mm) in diameter**
- **HDD 80 for drilling holes 9-3/4in to 10in (248mm to 254mm) in diameter**

TEI Rock Drills' success at Colorado manufacturing awards

At the annual Colorado Manufacturing Awards, co-hosted by Company Week and Manufacturers Edge, Montrose-based TEI Rock Drills accomplished a first – winning two categories the same year. TEI's CEO Sue Frank was selected Colorado Manufacturing Woman of the Year by the Colorado chapter of Women in Manufacturing; and the company won the competitive Industrial and Equipment category.

"I'm so proud of the team I have backing me here down in Montrose, Colorado," Frank said. "We've managed to sell and distribute our products worldwide. We're extremely proud that we manufacture everything here in-house and our products support other American-made businesses."

CMA founder and Company Week publisher Bart Taylor commented on the dual wins: "The CMAs are truly a state-wide competition and recognising Sue and TEI Rock Drills in the same year, from Montrose, caps off an exemplary 2020 programme."

ECA's new product service manager and Florida branch manager

Equipment Corporation of America (ECA) has promoted John Hayes to branch manager of ECA Florida and hired Ben Morgan as product service manager with the Bauer Service Team.

Hayes will manage all aspects of ECA's branch in Green Cove Springs, Florida including sales, rental, parts, and service. He has excelled since being hired in 2016 as southeast regional sales manager covering Florida, Georgia, Alabama, and the Caribbean.

He will continue to be active in the deep foundation industry through a variety of trade associations including the Association of Drilled Shaft Contractors, Deep Foundations Institute, Geo-Institute, Design Build Institute of America and the Canadian Geotechnical Society. Hayes has also authored, co-authored, and presented several industry papers to numerous state and federal transportation events.

Morgan brings a unique and valuable perspective to ECA's customers as product service manager. He most recently served in a similar role with Case Foundation Company (now Keller North America).

Based in Chicago, Morgan supports ECA's service technicians and customers with information on the capabilities of foundation equipment, matching rigs and tooling to specific applications; and coordinating logistics.

In Brief

Thames tunnel completed

London's super sewer became one step closer to cleaning up the River Thames when tunnelling machine Charlotte finishing a vital connection tunnel beneath the river.

The 1.1km connection tunnel, created at a depth of around 30m, will take sewage overflows into the main 25km tunnel where it will be transferred to east London for treatment instead of polluting London's waterway.

Easternwell services Newcrest

Easternwell has signed a contract with Newcrest Mining to provide drilling services at its Cadia Valley Operations mine site in NSW, Australia.

The contract involves Easternwell's Rig 103 drilling four directional wells to depths of 1,550m.

Specialising in production and coring wells, the rig is capable of directional and pad drilling, as well as under-balanced air drilling and coring.

Sandvik acquires Allied

Sandvik Mining and Rock Technology has signed an agreement to acquire Allied Construction Products, a US distributor of hydraulic hammers to the construction and mining industries and manufacturer of compactor plates and mounting brackets.

Allied and Sandvik Mining and Rock Technology have had a strategic partnership since 2003, with Allied being the US distributor for Rammer products.

Vermeer's new distribution deal

Total Equipment, Inc., a full-line Vermeer Industrial dealer headquartered in Puerto Rico, has acquired the rights from Vermeer Caribbean to represent the Vermeer Industrial product line in the US Virgin Islands, Haiti and the Dominican Republic.

Under the leadership of Charles de Armas, Total Equipment has represented Vermeer Corporation's sales, service and parts in Puerto Rico since 2014. The dealership will now operate under the brand of Vermeer Total Equipment. The company headquarters will remain in Puerto Rico, while the dealership offers the full line of Vermeer industrial equipment and full-service operations on the island of Saint Thomas, the US Virgin Islands and a commercial office in the Dominican Republic.

"As we expand our representation of Vermeer into new territories, we are excited to continue serving the customers who depend on us today in Puerto Rico, while also partnering with the professionals who are doing the critical work to drive progress in the Dominican, USVI and Haiti," said Charles De Armas, Vermeer Total Equipment dealer principal. "This is an exciting chapter for us as we grow our regional footprint under the Vermeer Total Equipment brand."

Vermeer Caribbean will continue to represent the Vermeer product line across other key Caribbean islands.

"Vermeer Total Equipment and Vermeer Caribbean have been great partners known for providing dependable support to Vermeer customers across the Caribbean islands for some time," said Herb Waldhuetter, managing director of Vermeer Latin America. "With significant infrastructure and natural resource management investments being made across the region, we are excited for what this new alignment and the investments being made across these two dealerships will do to give our customers an even stronger network of Vermeer equipment, service and support."

Komatsu rebrands mining product lines

Signifying the ongoing evolution and rapid transformation of its growing mining product offerings, Komatsu has announced plans to rebrand its underground hard rock equipment, surface wheel loaders and new line of blasthole drills to reflect its united focus on growth in these areas.

The company will retain its iconic P&H and Joy brands for the products longest associated with those names: P&H for its electric rope shovels, hybrid shovels, draglines and 320XPC blasthole drill; Joy for longwall systems, and room and pillar equipment.

Rebranding as Komatsu all surface wheel loaders, new blasthole drills and all underground hard rock equipment, expands the Komatsu brand in mining, while retaining the legacies of its other respected brands, said Jeffrey Dawes, president and CEO of Komatsu Mining.

The first rebranded product, the Komatsu ZT44 track drill, made its debut at CONEXPO-CON/AGG 2020 in Las Vegas this March.

"Building on the growth of our mining portfolio, we're excited to unite more products under the Komatsu brand, while respecting the history and value of the P&H and Joy brands," Dawes said. "As we approach Komatsu's 100th anniversary, it's a great moment to expand the brand in mining and celebrate the growth of these product lines."

The Komatsu ZT44 track drill, made its debut at CONEXPO-CON/AGG 2020

DON'T COMPROMISE. MAXIMISE YOUR POTENTIAL WITH THE DRILLER'S CHOICE.

Complete drill string solutions for every application. Built at state-of-the-art facilities around the world. Supported by local experts who understand your business and listen to your needs. Delivering class-leading efficiency and performance.

www.mincon.com

Mincon™

The Driller's Choice

XCMG Builder of Xcellence to introduce new course module

XCMG Builder of Xcellence to introduce new course module, highlighting field practice and emergency handling

In light of the impact of COVID-19 on long-distance travel, Chinese plant and drill rig manufacturer XCMG is rebranding the fifth season of its renowned Global Excellent Operator Program as XCMG Builder of Xcellence to integrate training resources and upgrade course structures for construction machinery operators in China, technical talents from suppliers and overseas service engineers.

XCMG will host online courses to include troubleshooting case studies and maintenance operations, improving the operators' communication skills and efficiency when they encounter emergency failure problems. The new programme module also increases the proportion of practical on-site operation training with the goal of improving the maintenance and fault handling capabilities of the operators.

In addition to training operator talents in XCMG's headquarter, XCMG Import & Export Company will also be sending technical experts to 11 countries in the second half of 2020 to conduct 14 training sessions, provide field guidance and share experience.

"The programme has accumulated a wealth of teaching and faculty resources as well as an established curriculum which can be optimised to use in future training for overseas service engineers and technical talents from our suppliers. This upgrade has also taken in consideration of the feedback and suggestions from the past participants of the programme to adjust the overall training content and form, further supporting the career development of the trainees and helping them to become the backbone elites of the heavy machinery industry," explained Li Ge, deputy party secretary of XCMG.

In four years, the programme, as part of XCMG's 'For Better Life' global public welfare campaign, has hosted 34 classes in 12 sessions and provided training courses for a total of 708 construction machinery operators and 47 overseas service engineers, playing an active role in the sustainable development of the industry.

Epiroc's sustainability goals for 2030

Epiroc has launched new sustainability goals for 2030 that further advance the Group's ambitions on issues such as climate change and diversity.

Sustainability is already integrated in Epiroc's business operations and this year the Group has established long-term sustainability goals that support the Paris Agreement and the UN 2030 Agenda for Sustainable Development. The new sustainability goals for the next decade include halving CO_2 emissions from operations, transport and major suppliers, as well as from customers' use of Epiroc equipment.

"Since the majority of the CO_2 emissions occur in the use phase of our products, it is crucial that we not only limit our own emissions in operations and transport but also take on the greater challenge to reduce the emissions when the products are in use," said Helena Hedblom, Epiroc's president and CEO.

The new generation of battery-electric mining machines, which is generating strong interest from customers globally, is one example. Epiroc's package of digital solutions, 6th Sense, including automation, also goes a long way to reduce customers' environmental impact as well as to improve health and safety conditions.

"With the new sustainability goals for 2030 we are taking our ambitions in this area to a new level," Hedblom adds. "Epiroc is proud to help to make the mining and infrastructure industries as sustainable as possible."

Africa's groundwater potential: new insights and opportunities

Currently, hundreds of millions of people in Africa depend on groundwater for their basic needs. Farmers, communities, industries and towns will increasingly rely on this resource. Sean Furey explains how it is managed and shared in the future will be central to securing people's lives and livelihoods

From 2013 to 2020 researchers, citizens, governments, the private sector and NGOs from Africa and beyond came together in a UK-funded research programme called UPGro, which set out to Unlock the Potential of Groundwater for the Poor.

UPGro researchers investigated the age of groundwater in sub-Saharan Africa. They also looked at historical groundwater level and rainfall data. They found that in wetter areas recharge happens every year, but in dryland areas substantial recharge takes place less regularly, often just once or twice a decade.

Climate change is expected to make rainfall in sub-Saharan Africa even more variable. The frequency and intensity of floods as well as the frequency and duration of droughts are expected to increase. UPGro research shows that this intensification may favour the recharge of groundwater.

Groundwater can provide vital year-round water supplies and is a lifeline for livestock when ponds and rivers are dry. In dry periods, handpumps are often the only water source available. Handpumps used by rural communities do not withdraw a lot of water, and the shallow aquifers that they rely on, generally receive enough recharge.

Groundwater needs protection from pollution and water quality needs to be monitored. UPGro research found that during the dry season in rural Malawi, Uganda and the Ethiopian Highlands: 72 per cent of working handpumps provided good quality water, 21 per cent of the working pumps were affected by bacteria and nine per cent by chemicals, including nitrate pollution and naturally occurring fluoride and arsenic. In many African cities, groundwater is becoming polluted – often heavily.

At the scale of the African continent, UPGro research has shown that there has been no substantial decline in the volume of water stored in the major aquifer basins over the last 15 years. However, local contexts do differ, and in some African cities, groundwater levels have fallen because of large scale localized pumping.

In 2010, less than four per cent of cultivated land in sub-Saharan Africa relied on groundwater for irrigation – but doing so improves agricultural production, reduces the risk of crop failure and helps to increase household incomes.

Meanwhile, across rural Africa, men and women need water for their differing livelihoods, their health and wellbeing. When water becomes scarce, tensions can arise. This can lead to competition, between men and women as well as conflict in communities and even within families. During such times, women often have less access to water, which limits their livelihood activities. Improved understanding and management of groundwater can help to reduce tensions and ensure that essential activities can continue.

Sean Furey

It is also essential to build trust and connections between local authorities and local people. Within UPGro, an approach called Transition Management has empowered people to engage in constructive dialogue with institutions, NGOs and private companies. Transition Management has enabled sustainable solutions for water-related problems to be developed jointly.

Elsewhere, weekly radio programmes were aired, covering topics such as rainfall, local market information and groundwater. Farmers and community members determined the content of the radio shows, and experts responded to their questions. As a result, people formed a better understanding of groundwater and its management. Communication, when done the right way, can reduce vulnerability.

Looking ahead, groundwater will play an ever-greater role in providing safe and secure water supplies. Research shows that groundwater can contribute to people's resilience and their ability to adapt to climate change. Understanding groundwater opens up economic opportunities and enables costly mistakes to be avoided. However, the nature of groundwater recharge means that long-term thinking and planning are essential.

With determination, perseverance and by working together groundwater, alongside other water resources can be understood and managed. The UPGro community believes that the potential of groundwater can be unlocked and its benefits widely shared.

Historic Fort Bovisand redevelopment facilitated by CAN

Soil nailing a steep rockface on the Devon coast creates challenges that were met by CAN Geotechnical using in-house developed technology to suspend drill rigs on winches

"Drill rigs were suspended from high-capacity Tirfor winch cables"

Fort Bovisand is a heritage structure dating back over 170 years, which is in need of serious renovation as part of a major sympathetic and sustainable development. When completed, it will include an events space, a bistro, a visitors' centre and 81 apartments/houses. The company behind the development, Fort Bovisand Developments Ltd, is chaired by Greg Dyke – former director-general of BBC TV in the UK – who has broad leisure and hospitality experience in the region.

The main access road into the fort complex runs above coastal cliffs made up of rock of the Staddon Formation, soils of the Periglacial Head and raised beach deposits. Gullies cut into the cliff – in some places as near as just a few metres from the road - have undergone significant erosion due to the coastal weather, threatening the stability of the only access route into the site.

A critical element to the overall redevelopment project, therefore, was making safe the two gullies where the road runs immediately adjacent to the cliff face, with each location requiring specialist equipment and work at height experience, hence CAN Geotechnical Ltd was recruited to undertake the work.

CAN used its in-house designed 'A-frame' cliff-mounted drill rigs for a soil nailing job at Fort Bovisand in Devon
Photo: Breakwater Productions

SOIL NAILING

Specifically, stabilisation measures were required to the Periglacial Head deposits, utilising an array of soil nails with a high tensile wire mesh and erosion control matting facing. The eastern gulley required 195 R32 nails installed in a grid pattern over the upper slope and cliff face, with 8m deep inclined drains installed to control water levels. The stainless steel (specified due to coastal corrosion) soil nails installed range from three to 12m deep into the face. Additionally, around the perimeter of the 460m^2 area of the slope, 40 x 1.5m deep dowels were required to fix the netting and erosion matting facing system in place – secured to the dowel plate heads. Similarly, the western gulley required 127 R32 nails drilled up to 12m depth, with 29 inclined water relief drains across the 440m^2 area of the gulley that required stabilising.

CAN's approach was to use an excavator-mounted hydraulic drill rig to install the upper dowels of the netting system and to drill the uppermost rows of soil nails in the face of the cliff. Temporary anchor points were then installed to suspend CAN's in-house designed 'A-frame' face-mounted drill rigs.

The drill rigs were suspended from high-capacity Tirfor winch cables, allowing them to be moved around on the rock face while carrying a fully hydraulic drill mast with Eurodrill top hammer drill head – all powered by umbilical cables from a diesel-hydraulic powerpack situated at the crest. This enabled the drill crews to move the rigs to each soil nail location – which they accessed by using IRATA rope access techniques, abseiling down on to the cliff face, and working suspended from ropes.

ENVIRONMENTAL CONTROLS

As the work was being undertaken on sea cliffs, strict environmental controls were essential. Ecological inspections took place, and the appropriate MMO licence was obtained. Water reached the base of the cliffs only at very high tide but even so, the soil nail drilling was carried out using air flush, so that grouting could be more closely controlled – minimising the risk of grout run-off reaching the intertidal zone.

On completion of CAN's soil nailing and facing system installation, both gullies were hydra seeded, with a coastal seed mix designed to promote re-vegetation.

Following on from CAN's work, a marine contractor will install a rock protection system at the base of the cliffs to protect from future wave action. This includes layers of 3t – 6t block laid against the toe of the slope, to dissipate wave energy in one of the gullies and repair of an existing masonry toe wall facing and placing of rock fill on the lower slope of the other.

Following the stabilisation of both gullies, the access road is now safely stabilised, the weight limit can be removed, and other contractors involved with the main redevelopment can begin their work.

Eijkelkamp GeoPoint
SoilSolutions

BC100 Boxed CPT Crawler

NEW GENERATION CPT MACHINES

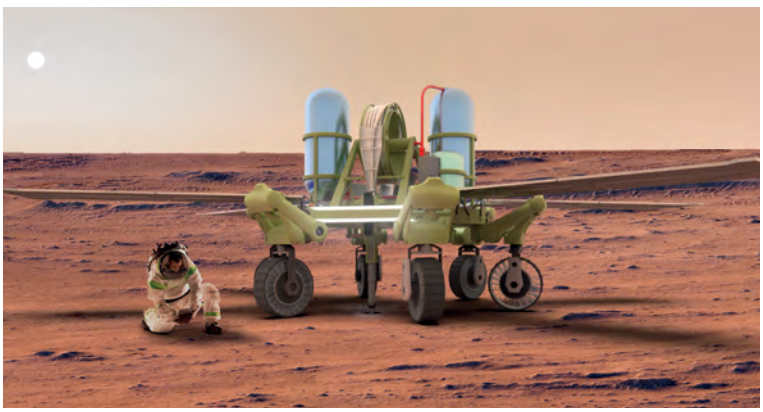
- BC100 weight 10-15 ton
- Diesel Engine (EPA Stage 5)
- Hybrid optional
- Hydrogen optional
- Hydraulic or mechanical CPT clamp
- SonicCPT
- Railway wheels
- Eijkelkamp Service Assistance

Meet the difference

Eijkelkamp GeoPoint SoilSolutions
T +31 (0) 71 301 9251
E info@eijkelkamp-geopoint.com
W www.eijkelkamp-geopoint.com

Drilling for signs of life in Mars' subsurface

Limited power, unnegotiable mass restrictions, and delayed data transmission, drilling on Mars is a task that requires not just meticulous preparation but also extra-terrestrial patience. Signe Hansen talks to the scientists behind the technology that will take humans – or at least their robotic extensions – not just onto the surface of Mars, but below it



To penetrate through Mars' 20m of regolith and extract water from the planet's ice deposits, HoneyBee Robotics has developed the Red Water
Photo: Jetportal

While increasingly advanced drilling technologies have left a diminishing section of Earth's subsurface inaccessible to humankind, the surface of Mars has barely been scratched. This does not mean that the surface drillings (1-7cm depths) of past and present missions have not provided substantial information about the planet; much has been learned about its history and geology. But due to the planet's high level of radiation and the oxidation of its surface, it is unlikely that such drillings will ever conclusively detect any existing signs of life, past or present.

Brian Glass, the principal investigator of NASA's Atacama Rover Astrobiology Drilling Studies (ARADS) project, aimed at designing tools for detecting life on Mars, explains: "Certainly, the Curiosity team would be happy to run over a fossilized stromatolite, but that's unlikely. I think we have a better chance of finding evidence of residual complex organics and biomarkers if we can drill down a metre or two, away from surface irradiation and desiccation."

But, it is, he adds, not an easy task. "To drill on Mars, you have to be willing to drill fully automated, hands-off, blind into unknown materials, with very low power and no casing. In addition to that, there're the low pressures and cold temperatures and getting there… including complete system heat sterilization and cleaning before launch."

Despite the challenges, both NASA and the European Space Agency (ESA) have designed and tested extra-terrestrial drills capable of drilling into the subsurface of Mars, retrieving, and in-situ analysing samples for organic molecules.

Pietro Baglioni leader of ESA's ExoMars Rover team, which is due to have its first rover on Mars in 2023, says: "With the drill unit we have onboard, we want to go down to a maximum depth of at least 2m and collect samples of the subsurface."

ESA's ExoMars drill and the Rosalind Franklin rover carrying it are set to leave Earth in the second half of 2022 and arrive on Mars in the spring or summer of 2023.

PATIENCE AND PREPARATION

When landing on Mars in 2023, the ExoMars drill unit will be operating in an extremely dry environment with low pressure, carbon dioxide atmosphere and a range of low temperatures averaging -80C. But despite the extreme conditions, scientists working for NASA and ESA agree that the main challenges are not the environment, but the limited power supply, the lack of real-time communication, and the mass restrictions on the system.

Kris Zacny, vice president of exploration technology at Honeybee Robotics, which has in partnership with NASA developed the drill for the ARADS project, says: "From a drilling standpoint, Mars is very similar to Earth. But we're very constrained by energy.

"Curiosity and Perseverance [NASA's previous and coming rover on Mars] use multi-mission radioisotope thermoelectric generators which provide 2kW of heat but only 100W of electrical power. This is used to charge the rover's batteries. But while you can use 1kW [or more] to power a drill from onboard rechargeable batteries, all you'll get is around 2.4kWh of energy per day [1kW for 2.4 hours, 500 watts for 4.8 hours etc.]. However, a significant fraction of this 2.4kWh has to be used for housekeeping purposes, running computers, thermal system, communication etc. That's why everything on Mars takes a long time."

While the ExoMars rover and drill use solar cells to generate electrical power, it will also

operate under tight energy restrictions with the rotary drill, rod assembling mechanisms, external sensors and spectrometers all having to operate with around 50-80W.

"To get a sample from 1m down may take a full day, it's not fast. To get a sample from a depth of two metres might require several days, and in that case, we'll have to decide if we can leave the drill inside the terrain through the night," explains Baglioni.

Should the drill freeze or otherwise get stuck, the drill unit carries a spare drill, meaning it can detach and continue the mission. In a worst-case scenario, the entire drill box can detach allowing the rover to continue its mission.

AUTONOMOUS DRILLING

Slowing things further, is the fact that all communication to and from Earth can only be received and sent – with 10-20 minutes delay - during two short daily intervals in the morning and evening (determined by the planets' alignment). This means any drill on Mars will need to operate largely autonomously without real-time human input.

"Light takes 10-20 minutes to get between the planets, but a drill can get into trouble in a few seconds," says Glass. "Artificial intelligence techniques like model-based reasoning, machine learning and pattern-matching are all used by our controls in watching and predicting the drill unit's performance. The automation will shut down and save the unit if it sees a problem, then recover and restart drilling if safely possible."

As with previous surface drills (by NASA), the drilling sites of ESA's ExoMars drill will be chosen from Earth, based on the survey made by the rover's cameras and a subsurface sounding radar providing data on the composition of the subsurface, specifically the possibility of underground water, ice, or rock formations.

"We operate with pre-set sequences with different drilling modes, and once the drill starts, it operates automatically all the way to the retrieval of the sample. But then we can monitor what happens and give step-by-step instructions; usually the window of communication in the morning is used to give instructions and the evening to send back data to the ground," explains Baglioni.

TWO DRILLS, TWO MISSIONS

While the exobiology technologies deployed by NASA and ESA have many similarities (some are indeed shared), the drills are based on slightly different approaches.

The drill carried by ESA's ExoMars rover consists of a 700mm long rotary drill tool equipped with the sample acquisition device and the Mars multispectral imager for subsurface studies (Ma-Miss), which is a miniaturised IR spectrometer devoted to the borehole exploration. With three extension rods of each 500mm and an automatic engage-disengage mechanism for the rods, the drill will be able to sample from up to four depths in one borehole of a maximum of 2m. The drill unit is supported by a positioning system, capable of deploying it from its storage position on the front of the rover to its operational position, orthogonally to the terrain, and to allow the delivery of the acquired soil sample to the rover's suite of analytical instruments.

"The capability of the drill is to penetrate the terrain with up to 110megapascal (MPa) of compressive strength," explains Baglioni. "We studied the possibility of having a percussive feature implemented, but it was too complex, or rather the advantage did not compensate for the extra trouble – we're not interested in drilling in very hard basaltic rocks as information on the presence of water or past life is more likely to be found in sedimentary layers".

Zacny, who has developed the rotary percussive drill tested in the

ARADS successfully demonstrated drilling to 1m from a 300kg medium rover with augured-up samples robotically and cleanly transferred to three onboard sample analysis and life-detection instruments

Photo: NASA/Ames Research Center/ Dominic Hart

ARADS project explains: "The only thing we see is stuff above the surface which is sometimes not representative of what's below. So as such, the drill has to be designed to deal with an entire range of materials. Our drill has a single drill string, so no robotics is needed to assemble anything."

Trident, a 1m drill like the one developed for ARADS, will be part of NASA's Viper lunar rover (due to reach the Moon in 2022). The main task of Trident will be to look for volatile deposits like water, something which is also part of the plan for future Mars explorations.

"In addition to Trident, we are also developing a coiled tubing system called Red Water which will enable us to drill 20m plus," explains Zacny. "The idea is to go through 20m of regolith to get to Mars' ice layers, heat up the ice, melt it, and pump the water up to the surface as part of in situ resource utilisation. This water could be used to sustain human presence or be broken down to hydrogen and oxygen to refuel rocket engines to transport humans back to Earth. The same drill could be used by NASA astrobiology missions to look for extant or extinct life."

The success of drilling technologies on Mars will, in other words, determine not just the likelihood of past and present life on the planet, but also the future of human explorations.

What's happening in the world of rotary drilling?

While very little has changed in the rotary drilling market over recent years, *GDI* has spoken to some of the key players in the sector to discover what current trends are

"Connecting the dots between the drilling process and the entire mining value stream"

In Europe the most frequent request from rotary drill rig users in today's market according to Philip Weichbrodt of Nordmeyer GEOTOOL GmbH is for smaller rigs and big power. "We face more and more requests, which respond to limited access drilling and logistic solutions, which do not require big gear such as trucks and multiple cars," he says.

Speaking on behalf of Swedish rig manufacturer Sandvik, Rob Ewanow of Sandvik Mining and Rock Technology, Rotary Drilling Division notes that the primary goal for all customers will always be safety and productivity. "This continues to this day, but now there is a major requirement on connecting the dots between the drilling process and the entire mining value stream from exploration to excavation. As such it is important not only to be able to receive data inputs from production planning solutions, and exporting the information to blasting solutions, it is important to increase data consistency and smoothing out operator variability."

He then goes on to suggest that "one way to increase data consistency is by increasing the capabilities of the technology and automated functionality on rotary drilling rigs, thus increasing operator efficiency and consistency while drilling the blast holes."

In order to provide this increase, Sandvik has designed its iSeries product family to utilise the latest technology throughout the drilling process and to allow it to be scaled to meet the customers' automation needs.

The latest addition to the iSeries range, the DR410i, pushes forward with Sandvik's SICA Control system, which is common to all Sandvik intelligent solutions, both for underground and surface. It makes the DR410i capable of incorporating innovative features developed across the entire Sandvik mining portfolio.

NORTH AMERICA

Providing a North American perspective, Lori Livengood of Geoprobe reinforces the point that safety is now more of a priority than ever. "Site investigation methods vary greatly depending on regulations, subsurface formations, and acceptable practices in the region, but what is standard is the need to complete the job easily, quickly, and most importantly safely.

On the subject of safety, Livengood notes that it goes beyond just having safety E-stops and that it also needs to focus on how the operator uses the rig. To that end, Geoprobe is incorporating well-designed control panels with tactile feel controls grouped by function, electric controls for hands-free rotation and feed to facilitate rock coring and other rotary applications, adjustable positioning to reduce "drillers neck", and passenger-side positioning increase safety for the operator. Livengood also states that "telescoping winch masts reduce the potential for drillers to collide with utility lines when deploying the drill, reducing the number of incidents." She goes on to point out that Geoprobe offers innovative features like rod loaders and indexing racks on its rigs that reduce fatigue, which in turns reduces injury.

Returning to the subject of new industry trends that go beyond safety, Livengood says: "To be successful, drillers require a versatile drilling rig that works well in wide geographic areas. They desire the increased productivity made possible by multi-functional – or combination – rigs built to handle traditional and in situ techniques, such as CPT.

The view on new trends in the rotary drilling sector put forward

Nordmeyer GEOTOOL has created the GTR 1100 in response to customer requests for compact rigs that are easily transported

by Ewanow is that there is an increased demand for technology-enabled connected solutions and automation. "The recent COVID-19 pandemic has pushed many industries to consider alternative methods of operating to, if possible, allow operators the ability to work from remote, controlled locations," he notes.

In response to this, Ewanow says Sandvik is seeing more requests for automated, technology-enabled solutions. "Customers are not only interested in remotely operating or automating solutions, but are also interested in the technologies and integrations to ensure efficiency at reduced costs.

"The ability to deploy automation-capable solutions is more important now than in the past; and customers are looking to implement these technologies at their own pace in line with the capabilities of their operations. They are looking for equipment that has the capability to scale automation in a staged approach so that the automated functionality can be accessed as the operation requires."

COMPACT OPTIONS

Responding to changing customer demands for Nordmeyer GEOTOOL means a move away from traditional rotary rigs as Weichbrodt explains: "The most significant change we are seeing is not having the focus on rotary drilling methods since our main rigs feature drop weights, coring drill heads and hydraulic jackhammers, we developed more and more solutions where rotary drilling can be replaced by direct push or cased sampling.

"Our clients are happy when for small jobs rotary drilling is not necessary. When it comes to geotechnical drilling sampling results are better when not gained by rotary drilling.

"Of course, there are jobs and places where rotary drilling is required. Since rock coring drills designed for limited access have become more and more interesting for small companies. Here we have developed solutions where core drilling is possible with small GTRs while offering still all other soil investigation solutions. Our GTR 1100 is a very fine example of where rotary drilling (air, mud, coring) is combined in a small soil investigation rig, which offers besides rotary drilling all known soil investigation methods."

The evolution of rigs, which has seen them not only become smaller but also offer more variety of operation is a trend that is not only taking place in Europe as Livengood says: "Combination rigs, which can successfully complete a variety of traditional drilling techniques, as well as switch to in situ techniques, are sought to improve productivity and even ►

more importantly increase rig utilisation rates."

She then notes a second trend for compact rigs with a small footprint that allows ease of access in remote areas or inside buildings without sacrificing power and highlights the Geoprobe 3126GT as an example of such a rig. It includes centreline head side-shift using machine hydraulics to slide between hands-free automatic drop hammer, rotary head, CPT push, and GH63 percussion hammer for direct push without moving the drill mast or machine. A separate mud pump hydraulic circuit stabilises mudflow and still leaves plenty of space for accessories and storage. And with taller drill mast and heavier winch options provides pull back needed for drive and wash.

ELECTRIFICATION

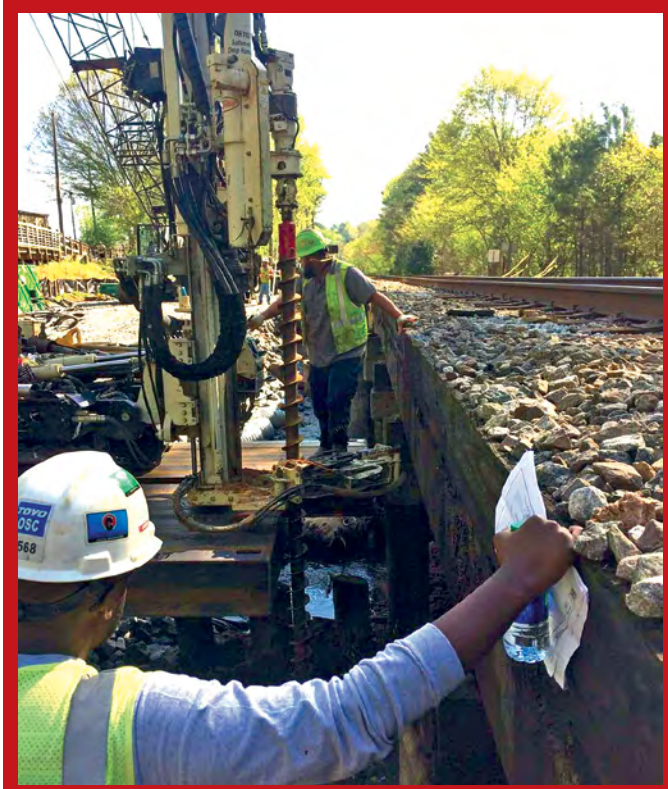
However, regardless of the size of the rig being used or how much automation is being integrated the most significant change in new product development is, like in all areas of mining and construction equipment, a move towards electrification as emission standards tighten making diesel power increasingly less attractive.

A Geoprobe case study

Establishing a strong foothold in the direct push business, Geo Lab Drilling got its start in 1996 as a sampling and on-site lab screening company, using a van-mounted probe and mobile chemistry lab. Growth of the company allowed it to progress from solely a direct push investigation firm into more long-term monitoring and remediation focus. The addition of a 66DT with an auger head opened up more horizons but required some re-education of consultants to teach them that Geoprobe does not mean just direct push.

"Yes, we're going to install hollow stem augered wells, and yes, we're going to do it with a Geoprobe," says owner Brian Strickland. "Environmental services require more than just direct push."

Over the years it has continued to look for ways to stretch its capabilities. "We also purchased conventional drill rigs to broaden our scope of services beyond direct push, only to realise that 7822DT rigs are often preferred for conventional rotary drilling tasks due to their efficiency and mobility," Strickland says.



Dangling auger rods 25ft next to a train trestle to complete Geotech SPT and rock coring with Geo Lab Drilling's Geoprobe 7822DT

Rock coring

In the piedmont of the South, the company is penetrating shallow rock with a downhole air hammer using a large air compressor and a 7822DT. The height of the drill mast accommodates 5ft rods and an air swivel to feed the air hammer. With the addition of the four-speed head, it is now performing mud rotary and NQ wireline rock coring. Active development in Georgia, USA, keeps it busy completing geotechnical investigations which often involve shallow SPT borings to rock with an automatic drop hammer, and then quick conversion to NQ wireline coring for 10 to 15ft of rock core confirmation.

"The 7822DT is very efficient and often outperforms conventional rigs head-to-head. Its agility allows us to complete 80 to 100ft of rock coring in a day," says Strickland. "In a playground dominated by conventional drill rigs, we can come in and show them that Geoprobe rigs core rock well. The efficiency gained allows us to do more linear footage and play ball with the big dogs, and we don't have to concede on rates or production."

Limited access

The 7822DT's tracks and small size also allows the Geo Lab team to stretch into new spaces – off-road, inside buildings, and under canopies. Work on an electrical resistance heading remediation project required drilling and installing supplemental electrodes in and around previously installed electrodes and careful navigation around a mass network of electrical lines.

"No other rig could get into the nooks and crannies and creep over wires without damaging them," Strickland says. "Where others have tried and failed, we succeed."

The team can successfully complete projects that require installing monitoring wells under gas station canopies or foraging through marshland while crossing small creeks to access remote sampling locations.

"Most conventional rigs can't perform low-clearance work under canopies and inside buildings with the nimbleness of a 7822DT," Strickland says. "We have the ability to respond across the board. Name the project and we have a distinct advantage if we can find the unique tool to do it. We know we have the rigs and the operators, which gives us more access and impresses customers."

"There are pros and cons to electrification and not all operations are equipped or ready for the transition," suggests Ewanow. "Electrification throughout a pit requires mining operations to have electrical grids throughout all operational pits. Electrical grids are costly and not quickly established; reducing flexibility and speed when mining new areas.

"Sandvik rotary division understands the need that not all mines are equipped for electrification at this moment so our drive to improve also includes developing solutions with increased fuel efficiency. Our latest development, the DR410i, was designed with fuel efficiency as a key criterion, so far we have seen a significant reduction in fuel requirements with smart hydraulic and compressed air circuit management. Our field testing has seen savings of more than 15 per cent compared to our other models."

Rather than immediately switching to electrification Geoprobe too is pushing the benefits modern diesel rig designs offer by way of cost savings and improved productivity. "Mobilisation costs are minimised via fuel-efficient track-mounted rigs and availability of rigs not requiring a CDL for transport. New advancements such as hydraulic load-sensing systems improve operational fuel efficiency by providing power only when necessary," says Livengood.

"Similarly, advanced cooling systems allow for more efficient completion of high-duty cycle operations – such as coring, augering, or tracking long distances – while operating at elevated ambient temperatures."

The final word on the subject goes to Ewanow, who says: "Overall, electrification is no stranger to Sandvik. We understand the need and are exploring the capabilities leveraging the progress made in our underground market.

"We also understand that the need for fuel-efficient combustible solutions will never go completely away. Operations will always need the flexibility to mine in remote locations or to expand current operations."

Equipped with AutoMine, Sandvik's recently launched and automation-ready DR410i allows for on-board automation that increases drilling efficiency to full autonomous operation while being designed to meet customer needs both now and in the future

Gathering accurate borehole survey information

When undertaking core sampling on mineralisation projects accuracy is of utmost importance, which is why Stockholm Precision Tools considers existing product training and support as important as new product development

Stockholm Precision Tools works with its clients' geological departments to emphasis the correct use of its technologies such as the GyroMaster and Gyro RigAligner

The main objective of mining companies investment in exploration is to obtain core samples and from those samples obtain all the geological and hydrogeological information needed to make an evaluation of the reserve.

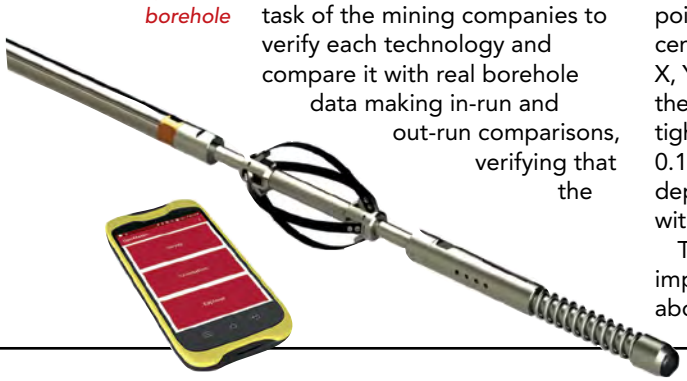
These core samples must be clearly positioned geospatially (X, Y, Z) otherwise they will not have the necessary validity to support any discovery, since they determine the depth and size of the ore body.

Most of the geological programmes undertaken by mining companies are focused on the core orientation, however, that is only 50 per cent of the task.

Stockholm Precision Tools AB (SPT), in Sweden, assists its worldwide clients' geological departments with training courses to teach that the other 50 per cent of the challenge is related to gathering accurate borehole survey information. The training emphasises that the use of correct technology such as SPT's GyroMaster and Gyro RigAligner is extremely important.

Stockholm Precision Tools' GyroMaster measures each data point at each centimetre of depth of a borehole

The best technology is not the one that has the best marketing but the one that complies with standard quality control procedures not only in theory but also in real data comparisons. It is the task of the mining companies to verify each technology and compare it with real borehole data making in-run and out-run comparisons, verifying that the north-seeking gyro matches the land surveyor. But this is usually not a reliable indication of the accurate result. SPT tools, thanks to Navibore Technology, make use of a down-hole autopilot, which is capable of finding and correcting itself along a survey path, eliminating all possibility of drift.



GYROMASTER

The GyroMaster has been accepted as an industry standard and this reputation has been gained due to the excellent results that customers are getting from using it. It is the only north-seeking gyro capable of working in continuous mode from vertical to horizontal.

The big advantage offered by GyroMaster is that each data point is measured at each centimetre providing multiple X, Y and Z values which make the ellipse of uncertainty very tight. The accuracy is less than 0.1 per cent of the total measured depth compared to one per cent with other technologies.

Taking into account the importance of the clarification above, the GyroMaster and the Gyro RigAligner deliver the accuracy and precision needed by SPT's clients exploring and developing gold or other precious mineral reserves in the global mining industry.

Stockholm Precision Tools AB approach is totally different to what its competitors are promoting because its highly focused, in-country support service includes providing the customer with a calibration service that ensures the integrity and reliability of the tool provided in each country.

In addition, the company's remote control and onsite monitoring service of tool parameters from anywhere in the world ensures SPT can address any issues instantly saving time and money by avoiding having to ship tools out of the country or having people travel to the worksite for repairs. This remote backup service is especially important in difficult times when transportation can be a limitation for many mining companies.

RELIABLE TECHNOLOGY

The accurate orientation of drilling rig is a key factor for the

borehole deviation. For the development of mining drilling campaigns, specialised drilling companies are hired. They have their own protocols and procedures for conducting drilling activities but when it comes to the borehole survey it is difficult to control the parameters if reliable survey technology is not available.

This is an area where SPT has dedicated resources and developed a borehole survey gyro technology that has automated internal QA/QC (quality assurance/quality control) procedures ensuring that every borehole meets or exceeds the QC requirements.

Each survey is evaluated automatically by SPT's in-house designed intelligent software application which includes an integrated error model capable of preventing any problems with erroneous data and thus securing the customer's investment. In addition, its portable automatic calibration stand is always available in each county.

As part of the drilling programme, the mining company provides an action plan that includes the starting coordinates of each drilling point. The drilling company must then assign its machine to ensure that it is starting at the exact place that has been assigned according to the plan (Inclination or dip angle, azimuth, and coordinates). This control is as equally important as the well trajectory measurement.

REDUCE INTEGRATION RISK

If the drilling rig does not start with the initial data provided by the mining company, there is a risk of economic loss (loss due to drilling at a wrong point, or additional cost for repeating or reinstalling the machine with the actual data).

The driller operated Gyro RigAligner uses north seeking technology paired with automated software to replace the need for 3rd party surveying services

If the drilling rig starts correctly with accurate information and in the final measurement there is still a difference in angle and/or azimuth, it is an operational or terrain problem.

The approach of SPT is to ensure the SPT Gyro RigAligner works back-to-back to with the GyroMaster providing the client with both technologies calibrated and verified by the same manufacturer thus reducing the risk of any integration problems.

Seeing is believing

GeoDrilling International gets an exclusive first look at Robertson Geo's RGeo-eye – a world-first four-core, high-speed borehole camera system

Above: RGeo-eye is a world-first from Robertson Geo, a slimline, full-colour, downward view camera, operating on a four-core or coax cable at a high transmission rate

RGeo-eye is a slimline, full-colour, downward view camera, operating on a four-core or coax cable at high transmission rate and is fully compatible with existing Robertson Geo winches and surface systems.

Borehole video cameras have a wide variety of applications including borehole and casing integrity inspection; water well monitoring; surveillance of mines, shafts, caverns and voids; pre-logging borehole examination; assessing concrete piles and damage detection in dams, bridges and subsurface structures. Video logs are being used globally across a variety of sectors including the water industry, for geotechnical inspections, in the mining industry and for oil and gas applications.

Video logs are a cost-effective method of inspection, providing data that cannot be obtained by other means and are now being routinely adopted across a variety of sectors in many diverse applications.

"Video logs are a cost-effective method of inspection"

Local and industry regulations often require video inspection of newly installed well casing and many consultants and contractors require verification that the well was installed in compliance with the design criteria of the geologist or engineer. The video log then constitutes part of the permanent record of the well and can be used as an integral component of the contractual acceptance procedure.

A video log can capture the depth of static water level, total depth of the well, joint condition, location of perforated section(s) and detection of any anomalies that could have appeared during installation.

For water wells, downhole video logs are an essential way to monitor the condition of existing or previously used wells and to investigate potential causes of production loss. A video log can collect visual proof of casing condition, downhole pump condition, biological build-up on the well casing and perforated sections, loss of filter pack material and damage to casing which could allow ingress of sediments potentially leading to pump failure.

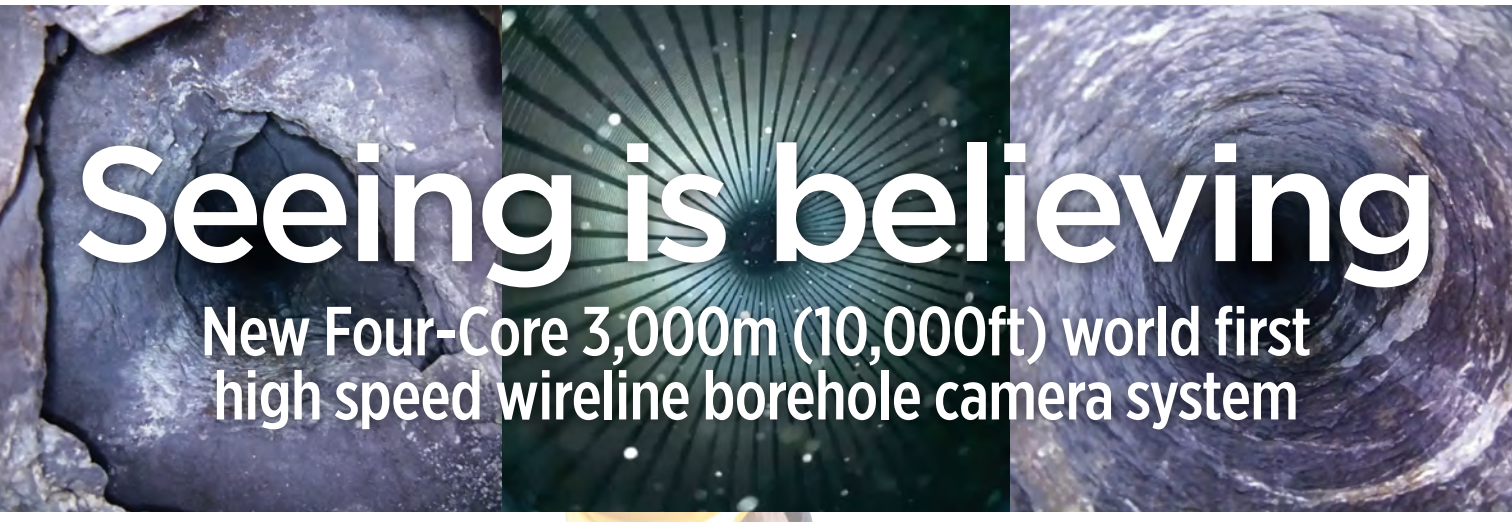
High-quality video data, especially when collected routinely, can be used to identify potential failures before they happen. This ensures that the condition of the well is kept optimised, saving significant costs in well repairs whereby remedial action can be undertaken in a controlled manner avoiding operational crises.

In some instances, maintenance itself may result in damage to a well. The act of removing or installing a pump, treating or attempting to repair casing or attempting to remove a blockage can have unexpected consequences such as pump detachment or damage to the column pipe, well casing or electrical wiring. Videos logs are useful in these instances, as they can identify lost equipment, such as a pump, tools, tremie pipes or drill string rods accidentally dropped down the well. With a diameter of only 43mm the RGeo-eye camera can easily descend past column pipes to view a pump without disturbance.

In the mining industry, video logs are used for the inspection ►

RGeo-eye®

ROBERTSON GEO
Unlocking Your GeoData



Seeing is believing

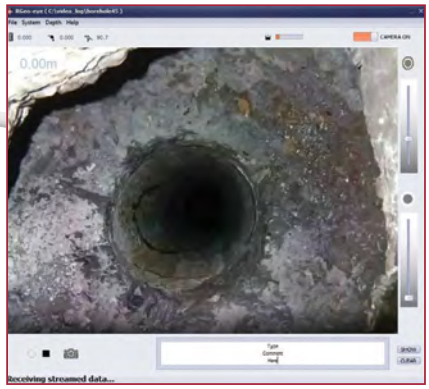
New Four-Core 3,000m (10,000ft) world first high speed wireline borehole camera system

RGeo-eye® is a slimline full colour downward view camera, operating on a 4-core or coax cable at high transmission rate, fully compatible with existing Robertson Geo winches and surface systems.

It offers pressure ratings of 5000psi and a minimum 75°C temperature rating (with 85°C & 100°C versions to be released in Q4 2020 and a 125°C version in development).

The software package provided with the RGeo-eye® camera system allows extensive operator control including – video resolution, frame rate, lighting, white balance, 'snapshot' mode and real time video annotations. Video is recorded in AVI and converted to MP4 for storage and replay.

RGeo-fast® *delivers a world beating 1 Megabit/sec communication speed for high resolution video feed from downhole in air or water filled open or cased boreholes while allowing real-time viewing.*



The acquisition software allows screen shots to be captured and text editing while viewing/recording. Where more detail is required, full colour 'snapshot' images can also be captured at 1600 x 1200.

RGeo-eye at a glance

- The RGeo-eye camera system is a new introduction of a design and build development by the North Wales-based OEM Robertson Geo. It has a deep operating range, operates on industry-standard four-core wireline cable, and offers pressure ratings to 5,000psi and a minimum 75C temperature rating. It is set to lead an exciting and innovative development of downhole camera use for the geophysical data market
- The system incorporates RGeo-FAST delivering one-megabit/sec communication speed enabling the acquisition of high-resolution video feed from downhole (to 3,000m) in air or water-filled open or cased boreholes while allowing real-time viewing for the surface operative
- The camera has autofocus, a frontal LED internal array with adjustable lighting intensity, and a viewing resolution of SVGA (800 x 600) at 25 frames/sec
- The acquisition software supplied with RGeo-eye allows screenshots to be captured and text editing while viewing/recording. Where more detail is required, full colour 'snapshot' images can also be captured at 1,600 x 1,200
- First release of the RGeo-eye camera is rated at 75C with 85C and 100C versions to be released in Q4 2020. A 125C version is also in development for release by mid-2021
- The software package provided with the RGeo-eye camera system allows extensive operator control including – video resolution, frame rate, lighting, white balance, 'snapshot' mode and real-time video annotations. Video is recorded in AVI and converted to MP4 for storage and replay.

The RGeo-Eye is a robust, easy to deploy downhole camera at 1,000 x 43mm and only 5kg

of shafts, drifts, old stopes, risers, roofs or mine workings that may be unsafe to enter.

Videos can also be used to safely inspect flooded underground workings. For flooded workings and for dewatering projects a video log can be used to record water level conditions where they are not continuously monitored. This can help determine if the pumps are working efficiently or if pump capacity needs to be increased.

For exploratory boreholes, prior to geophysical logging, a video log can determine the depth of surface casing, location of lithological contacts, water level and areas of possible blockages or washouts with videos also being an accurate way to detect contact and fault zones. They can be used to identify fractures and locate cascading water entering the borehole above static water level.

In piling applications, video cameras can be utilised for the internal and external assessment of deep concrete piles. When investigating historical piling, where there may be a paucity of information regarding the details of the installation, there is sometimes little choice but to conduct some exploratory drilling.

Boreholes can be drilled into the pile itself and the camera video can then reveal the pile depth, confirming the pile is in the rock socket and to determine the underlying lithology, concrete composition and condition, as well as detecting voids, inclusions, fractures and discontinuities from the concrete pouring process. Where additional proof of compliance to rigorous standards is required, sample piles may be drilled internally and video logged to confirm the integrity of the installation.

For geotechnical applications, videos can be used for dam safety, bridge inspection and underwater pilings. Camera use for reservoir or dam safety includes the inspection of outlet works to identify any evidence of jointing and cracks, or to help detect ingress or egress of water seepage within the works conduit.

Across all sectors, the drilling process itself can sometimes be halted by problems such as loss of drilling fluid circulation, unexpected voids or downhole problems with equipment. In order to first understand and then rectify the problem a video inspection can often be the most cost-effective solution. In many cases the slimline RGeo-eye camera can pass through the drill string and bit without the need to remove the whole drill string.

"A video inspection can often be the most cost-effective solution"

Future developments planned for the RGeo-eye camera include a software facility to extract a 360-degree side view from the data and additional lighting options to provide illumination for voids and caverns and shafts up to 1,000mm diameter

In a world where social, environmental and corporate responsibility are now pre-requisites, the need for robust digital records are essential for conformance to standards across all sectors. Video logs can augment the compliance process by providing an irrefutable image record in a highly cost-effective manner. Seeing can be truly believing.

Borehole logging for engineering projects

When it comes to drilling boreholes for site investigation projects there are many factors that need to be taken into account. Engineers from Socotec provide *GDI* with an insight into the various methods and techniques they use

The aim of borehole logging is to create a record of the in situ ground conditions

Borehole drilling is a highly cost-effective method of ground investigation, particularly when the objectives of the project are clear. Although establishing the overall distribution of materials beneath the site of interest will be common to most projects, detailed objectives will vary depending on the type of project envisaged. For example, projects involving the construction of a multi-storey building, a deep basement, a tunnel or a railway embankment would each have specific requirements that are critical to their design, and a full understanding of these is needed to obtain the best information for the borehole investigation.

The effectiveness of the borehole investigation will be enhanced by a general understanding of the ground conditions likely to be encountered and the suitability of different methods to obtain appropriate information. A variety of drilling techniques have been developed due to the need to manage the vastly different physical characteristics of natural and manmade materials that could be present. Whether the site is underlain by soft alluvial silts, dense river gravel or manmade materials containing buried structures, the success of the project will be reliant on the drilling techniques being suitably matched to the anticipated ground conditions.

The key to a successful borehole investigation is planning, with decisions on the layout, techniques, depths, sampling and testing regimes undertaken by a competent person armed with as much relevant information on the sub-surface conditions and project objectives as possible. Taking care at the design and planning stages will pay dividends in the longer term for controlling risks relating to potential geohazards, with the benefits of undertaking a desk study (and field reconnaissance) likely to be invaluable.

BOREHOLE RECORDS

When undertaking borehole drilling, a comprehensive written record/log of all the pertinent details should be made. Depending on the type of drilling, this may be supplemented by a photographic record of all the soil and rock materials recovered. Generally, the log is the result of a team effort between the drilling crew and one or more loggers, the latter typically being trained geologists or engineering geologists. All those involved should be competent and experienced, with a suitable recognised accreditation or professional qualification. Where the logging process includes ancillary activities such as photographing rotary core or ►

"The key to a successful borehole investigation is planning"

"Describing materials encountered in the ground should address a few basic questions"

the preservation of sections of core selected for laboratory testing, the loggers may be assisted by others.

The information presented in the log should clearly set out the factual details of the drilling process, such as the equipment used, techniques adopted, dates and times of activities to indicate rates of progress, any samples recovered or tests undertaken during the advancement of the hole and any drilling difficulties encountered. It should also include a full description of the nature of the materials encountered at all levels in the borehole. This will present a profile that is as representative as possible of the in situ ground conditions that the borehole has passed through.

As the drilling process imposes a degree of disturbance to the materials it recovers, with some materials lost altogether in difficult ground conditions, the descriptive part of the log requires an element of interpretation that depends on the training and experience of the drillers and loggers involved. A collaborative approach is therefore essential, as a complete and accurate record of the ground will only be possible by combining the first-hand observations of the driller with the detailed assessment of the logger.

SOIL AND ROCK DESCRIPTIONS

The logger is required to carry out a detailed description of all soil and rock samples recovered from the borehole. A systematic approach using standardised terminology is necessary so that all descriptions are meaningful and unambiguous to the reader. Formal guidance is provided in the British Standard BS 5930:2015+A1:2020, *Code of practice for ground investigations*. Although this standard has been used in UK practice for several decades, it is now fully compliant with the information contained in the European Standards EN ISO 14688-1 and EN ISO 14688-2 relating to soil descriptions and EN ISO 14689 relating to rock descriptions.

Describing materials encountered in the ground should address a few basic questions to define the general context of the material.

Firstly, it is important to determine whether the materials have arisen by natural processes or have been placed/disturbed by man. The latter, known as anthropogenic materials (or 'made ground'), is particularly important to identify, as such materials, unless they are selected, placed and compacted in a controlled manner, are typically variable and have unpredictable engineering properties. In some instances, their identification can prove challenging because they may comprise predominantly natural materials with few features of human intervention. Under such circumstances, other evidence can be used, such as materials clearly forming part of an earth structure (e.g. an embankment).

If the materials present are considered to be natural, the next question to be answered is whether they represent soil or rock. While there is usually a clear distinction in terms of geological origin, this can be more problematic for materials where weathering can transform them from rock to soil. The distinction is generally made by the compressive strength characteristics of the material, rocks being stronger than soils.

The majority of soils are made up of inorganic particles (fragments of minerals or rocks), with logging focusing on the particle size, angularity and lithology. The names given to inorganic soils are derived strictly from the particle sizes and include clay (finest), silt, sand, gravel, cobbles and boulders (coarsest).

Most soils comprise a mixture of different grain sizes, with the logger required to apply a series of tests to determine which of those sizes present is the most 'dominant'. This dominance is not based solely on which grain size forms the largest proportion, but rather on which fraction controls the soil's engineering characteristics. The dominant fraction is known as the primary fraction and in a composite soil it will be accompanied by subordinate secondary and tertiary fractions. Having categorised the soil correctly, the logger will focus on such properties as soil strength, fabric and colour, while also aiming to establish which geological unit the soil represents.

Grain/crystal size is a relevant factor in the description of rocks, although the mineralogy and method of formation will also

Observations made by the driller during the boring process can be crucial to accurate logging of samples

NUMA®

MANUFACTURER OF DOWN HOLE HAMMERS AND BITS

The World's Leading Drilling Technology

www.numahammers.com • 800.356.NUMA

UNRIVALED INNOVATION AND CONFIGURATION

Numa offers over 100 hammer and bit models with countless options for drilling holes 3 ½" – 50 ½" (89 – 1283 mm) in diameter. Because all design and manufacturing is done in-house, we are nimble and can adapt to your project needs.

MADE IN THE USA

The widespread availability of mobile devices such as smartphones and tablets enable borehole information to be recorded digitally at the rig side

play an important part in determining the appropriate rock type. The logger will need to incorporate such properties as colour and an estimate of compressive strength into the overall rock description. However, the most important feature influencing the behaviour of a rock mass is the presence of fractures. Detailed descriptions of fractures must be provided, logging properties such as fracture type, inclination, roughness, evidence of weathering and the presence of infill materials.

DRILLER'S OBSERVATIONS

The aim of borehole logging is to create a record of the in situ ground conditions. However, the recovery of material from the ground for inspection at the surface can result in disturbance of the materials, the degree of which will depend on the material type and the drilling method. For example, the dynamic sampling method (window sampling) can produce a continuous series of soil samples, but in a relatively disturbed state. Similarly, rotary coring through difficult ground conditions, particularly in weathered rocks or where there are significant variations in rock strength, can result in sample disturbance. There may also be sections of the soil or rock profile that fail to be recovered at all. In rotary core drilling, poor recovery can result in the erosion of soil or weak rock by the drilling flush, or by sections of core becoming jammed in the core bit. In cable percussion boring, individual samples are taken by the driller, rather than the full soil profile being retained.

Sample disturbance and potential gaps in the soil/rock profile always need to be taken into account by the logger, with observations made by the driller being crucial. In cable percussion boring, the driller is normally better placed than the logger to note the depths of changes between material types, and rotary drillers will be able to indicate probable reasons for any problems with core recovery. The use of drilling parameter recording is beginning to be recognised, providing valuable additional information in these situations.

"The use of drilling parameter recording is beginning to be recognised"

IN SITU TESTING

Although the logging process is primarily focused on the inspection of samples, certain descriptions of the materials encountered will rely on the results of in situ tests that are routinely carried out as part of the drilling process. These may include standard penetration tests (SPT) to determine the relative density of coarse-grained soils, and borehole vane tests to determine the undrained shear strength of soft cohesive soils. Understanding the ground conditions also provides context for the more expensive field tests, such as water pressure (packer) permeability tests and pressuremeter testing.

GROUNDWATER INFORMATION

For many engineering projects, particularly those involving subsurface structures, an understanding of the groundwater conditions beneath the site is critical. Therefore, groundwater observations made during the drilling process form an essential part of the borehole log. The depths at which groundwater is encountered, the observations in respect of groundwater flow into the borehole and the strata in which groundwater may be sealed out of the borehole can represent critical information to be included. This will also enable the subsequent design of groundwater monitoring instrumentation to be suitably targeted.

DIGITAL DATA

While the principles of many drilling methods have remained largely unchanged for many years, the widespread availability of mobile devices such as smartphones and tablets enable borehole information to be recorded digitally at the rig side. This reduces the time and potential errors of a separate subsequent data entry method. Systems can also incorporate data validation and 'sense' checking to minimise incorrect or missing data entry.

The use of a standardised framework for the digital recording, storage and transfer of relevant borehole and logging information was introduced by the Association of Geotechnical and Geoenvironmental Specialists (AGS) and has become an industry-standard extended to cover most aspects of ground investigation, including monitoring, laboratory and specialist field testing. This standardised format has led to the development of software designed to record and manage borehole data, both as in-house systems designed and used by investigation contractors, as well as commercially available systems, representing a substantial step forward in current borehole logging activities.

CONCLUSION

Considering all these factors, it may be concluded that the overall success of borehole logging will depend on the combined skills of the investigation designer selecting the most appropriate techniques, the drilling crew recording as many aspects of the ground conditions as possible and the logger interpreting the findings in the context of these various limitations.

Casagrande's KHD System – Diaphragm wall equipment

For the development of its latest diaphragm wall construction package – the KHD System – Casagrande called upon its half century of experience in specialist foundation construction building

The new Casagrande KHD System is the result of research and innovation based on over 50 years of experience and success by the company in the field of foundations and geotechnical engineering.

Casagrande's new KHD System is a piece of equipment dedicated to the construction of diaphragm walls. Thanks to the compact design and the rotation system, the KHD System is ideal for use in narrow spaces and for producing diaphragm walls with different alignments.

Furthermore, the modularity of the boom makes it possible to pass and build diaphragm walls even below existing structural engineering.

The heavy weight and the clamping force of the hydraulic bucket, the use of a quick free fall winch and the considerable power supplied by the diesel engine of the equipment allow users to successfully build the diaphragm walls even on difficult ground.

The design of KHD System makes it easy to use and comfortable for the operator. The XP series control systems and the precise instruments efficiently govern all machine functions and excavation operations.

PERFORMANCE & PRODUCTIVITY

The Smart Power Management (SPM) is an intelligent engine power management system that improves performances and productivity of the machinery. The SPM system monitors the momentary power flows and immediately allocates the available power to the different jobs, so the operational function always has the maximum power available.

FULL LOAD SENSING

The XP hydraulic power system uses Full Load Sensing (FLS) technology. Unlike the commonly used hydraulic managing systems, the FLS pressurizes only the required amount of oil requested by the users thanks to the back-action between pumps and distributors. It allows the operator to manage the power demands and reduces dissipations, achieving up to 25 per cent fuel saving (calculated on the basis of a theoretical working cycle).

SAFETY & TECHNOLOGY

The equipment used in the KHD System has a very low sound emission level as a result of the of sound-absorbing materials and oil heat exchangers, designed to reduce the overall noise level.

The layout of the machine and the wide openings of the canopy offer comfortable and easy access for inspection and maintenance. The machine conforms to the latest international standards to guarantee the maximum safety of the operators.

FLEXIBILITY

Among the advantages on offer with the XP control system for the operator and the wider supervision of the work is the ability to monitor of all working function, diagnostics of the working systems to ensure the constant monitoring of the status of sensors and components, easy conversion in any drilling arrangement, and the friendly customisation of working functions (e.g. remote rigs assistance, diagnostic, monitoring of working parameters).

VERTICALITY MONITORING

The instrumentation on-board the KHD System records verticality deviations to an accuracy of less than 0.1 per cent. The DIALOG monitoring system includes a depth sensor on the winch and a NEMO sensor fitted on the grab. The NEMO measures verticality along the X- and Y-axis (via two inclinometers) and rotation along the Z-axis (via gyroscope). The sensors transmit their measurements to the DIALOG which displays the trajectory followed by the grab in all three axes. The data is stored for downloading and post-processing.

Casagrande's KHD System in operation fitted to one of the companies B300XP-2 carriers

FOUR Frankfurt project

Franco Cicognani tells *GDI* how Italian underground engineering specialist Trevi faced and won the challenge of carrying out all the foundation works at FOUR Frankfurt, a complex development in Germany

The client decided to build the basements using the top-down construction method

FOUR Frankfurt is a unique high-rise building in the heart of Frankfurt city centre. The purchase in 2015, by real estate business Groß und Partner Grundstücksentwicklungsgesellschaft laid the foundations for the execution of this mega project.

This building development includes four new high-rise buildings on a multi-level and multifunctional construction foundation. Thanks to its 228m high office tower, the building is the highest office space in Germany and, with its slightly shorter 173m high tower, it also ranks as the highest residential tower in the whole of Germany. Parts of the existing buildings will be kept in order to comply with historical preservation requirements; they will be integrated into the new construction.

Due to the simultaneous execution of the works in all areas and the relevant logistical needs, which add to the enormous pressure set by the compliance with the time limit, one of the main challenges of the construction process concerns its position in the city centre.

The four towers of the Frankfurt FOUR project are supported by a base slab and its perimetral walls. Due to space restrictions, the client decided to build the basements using the top-down construction method. This means that, at first, the diaphragm wall and the foundation piles are constructed and then the concrete slab is poured to form the first basement floor.

Subsequently, excavation works take place under that cover and the other basements floors are all built in the same way, while the construction of the building can already start simultaneously.

Since the distance between the opposite walls of the perimeter would span over 100m, prefabricated columns are positioned into the piles to support the slabs. The structural loads of the above-ground structures and of the slabs are thus directly supported by the construction piles through the columns.

The foundation and excavation protection enclosure is carried out using the diaphragm wall method. In this case, two different methods are used.

Generally, the excavation of the panels is carried out using a clamshell. However, due to the strength of the limestone banks, a hydromill is also used, in order to minimise the impact generated by vibrations on the neighbouring structures.

Large diameter bored piles ranging from 1,500mm to 2,000mm are used as foundation elements. In the upper part, a temporary casing is used. Then, in the lower part, uncased drilling is carried out using stabilising bentonite mud, to reach a total drilling length of up to 50m.

After reaching the design depth, the reinforcement cage is installed, then, the concrete is poured into the shaft. Since the working level is significantly higher than the foundation one, the reinforcement cage is placed up to 20m below the working level.

Due to the selected top-down construction method, it is necessary to position the plunged columns in the piles. Since these prefabricated columns are not just temporary supports but are also used as permanent columns in the basement floors, their installation requires meticulous precision.

Therefore, a maximum vertical tolerance of 20mm and a maximum horizontal tolerance of 50mm are allowed. For this reason, an innovative system is adopted for this project. After reaching the design depth of the pile, the reinforcement cage is installed, and subsequently, a collar and a sleeve are positioned around and into the casing. Said sleeve serves to guide the precast column and support its assembly.

In the next step, the position of the sleeve is suitably adjusted by using the adjusting screws on the collar in compliance with the given tolerance requirements. After the adjustment of the sleeve, the pile is backfilled with concrete using a tremie pipe, and then the prefabricated column is installed, guided by the sleeve, inserting it for 3m into the fresh concrete of the pile.

Due to space restrictions on the FOUR Frankfurt project, the buildings' basements are being built using the top-down construction method

Beating bacteria for the Italian 'jobs'

In Italy, Milan-based Millars Products specialises in borehole rehabilitation and remediation, which includes the use of Geoquip's BoreSaver range of water treatment solutions

Among Millars Products customers in Italy is the oil refinery sector, where government regulations insist that hydraulic barriers are in place to contain any potential water leakage around the perimeter of every site. The barriers direct the water into specially drilled wells, situated at every 20-30m, with the express role of stopping it seeping into the aquifer below.

It is imperative that all the pumping equipment within the wells is working to maximum capacity as, if there is a break-down, it could have long-lasting effects on the local environment.

Giorgio Boyd, from Millars Products, explains: "While the spillage remains in the well, the water is then extracted and cleaned before being discharged into the ground.

"It's a critical process as iron bacteria will grow inside the wells very easily and, once it gets established, it can cause massive problems with the equipment and maintenance of the well, so we have to make sure it is in good working order."

To help tackle the problem, Boyd works with UK partner company Geoquip Water Solutions as the exclusive Italian importer of Geoquip's BoreSaver range of water treatment solutions. These are used to treat a cross-section of different types of bacteria, including iron-related bacteria (IRB), iron oxide and manganese oxide deposits.

One of BoreSaver's key benefits is that the treatment can take place while all the equipment is in situ, helping to ensure that downtime is minimal. Boyd says: "The fact there is no need to remove the pump or undertake a mechanical cleaning process is a real benefit as apart from this taking longer, it can also allow air into the well and, of course, the air then helps the bacteria to grow again."

The presence of a marker within the BoreSaver solution also allows Boyd's team to guarantee that no chemical residue is left in the water supply.

One treatment will usually be enough to remove the deposits that have built up and the solution is safe, easy to use and biodegradable.

Another sector where Boyd works with major customers across the country is the geothermal arena.

While introducing a geothermal system into commercial or domestic properties can deliver energy saving benefits of around 30 per cent, this only applies if systems are properly maintained, which means staying on top of potential bacteria growth.

"Like any equipment, if it is fouled through contamination, it will become much less efficient and then the customer is unhappy with how it works. With geothermal, you have water going in and out of the ground to heat or cool the system, so it stands to reason that bacteria can take hold and start to cause problems," he says.

He believes that no matter what section of industry, if there are problems with boreholes or wells underperforming, becoming less efficient, providing lower quantities and quality of water; then bacteria is most likely to be the culprit.

If allowed to go unchecked iron bacteria will grow inside a well very easily and, once it gets established, it can cause massive problems with the equipment and maintenance of the well

TESTING AND INSPECTION

Boyd has a two-pronged plan of attack. The first is to use a biological activity reaction test (BART) kit, which is both simple and cost-effective to use. It involves taking a water sample (container provided) to allow the user to see both if bacteria is present and what type it is – for example, iron-related bacteria, sulphate-reducing bacteria or slime-forming bacteria.

With the tests carried out on-site, over an eight-day period a series of indicators will develop ►

The test vial (centre) once it has been removed from the outer dispenser of the biological activity reaction test (BART) kit

within the sample vial. Typically, these will present as:

- If iron-related bacteria is found, foam will be produced and/or a brown ring develops inside the testing tube
- If sulphate-reducing bacteria is found, foam will again be produced and a black ring may develop around the interior vial of the testing tube.
- If slime-forming bacteria is found, a cloudy or gel-like growth will develop

Identifying the specific bacteria allows the correct treatment solutions to be applied quickly and effectively, flushing out the bacteria and preventing further damage to water quality or corrosion of equipment.

Further testing can then be carried out – both after the treatment and ideally at six-monthly intervals – to ensure the problem has been eradicated.

"These tests can be done quickly and simply, without having to make a major investment, allowing the customer to see if he has a bacteria problem and then look at a treatment and/or a further investigation programme," adds Boyd.

"A critical process as iron bacteria will grow inside the wells very easily"

The second line of investigation will be to use a downhole camera to take a closer look at what is happening underground, helping to rule out external damage or blockages. For this, Boyd uses a Laval R-CAM borehole camera, also from Geoquip. One of the biggest benefits, he says, is that it has a very small diameter, enabling him to use the camera in boreholes without removing the pump.

"Customers are often surprised by what we find – it can be anything from little prawns or frogs to damage caused by previous rough rehabilitation or cleaning; sometimes a well will collapse due to its age and once we surveyed a well which had been damaged by an earthquake."

By using either the BART kits and/or the use of a camera, Boyd says a cleaning, repair and treatment solution programme can be put in place to return the borehole to full capacity.

From then onwards, he recommends putting in an ongoing maintenance programme with regular checks to ensure any future build-ups of bacteria can be identified and treated before they become a major problem.

Facts and figures

The specific capacity (Q/s_w) of a well is the discharge per unit drawdown in the well and is usually expressed in Lpm/m. This is a measure of the effectiveness of a well.

Based on the following:
well diameter 350mm
well depth 160m
well static 80m
pump depth: 120m

Flow prior treatment: 20L/sec.
drawdown: pump in cavitation so at -120m

Flow after treatment: 40L/sec
drawdown: 80-82m

The specific capacity of the well at the beginning prior to treatment was:
20L/sec = 1200Lpm
Drawdown – 80m >> 120m therefore 40m
Specific capacity = 1200 / 40 = 30Lpm/m

The specific capacity of the well at the end AFTER to treatment was:
40L/s = 2,400Lpm
Drawdown – 80m >> 82m therefore 2m
Specific capacity = 2400 / 2 = 1,200Lpm/m

The result shows an impressive 3,900 per cent improvement in the specific capacity of the well.

Case study – a well deep clean doubles water flow

A water well that had effectively been mothballed because of problems with bacteria dramatically reducing its output, has doubled its water flow from 20L/sec to 40L/sec and improved its specific capacity by 3,900 per cent, thanks to a major deep clean project.

A water well, owned by the city's potable water supplier in the Italian region of Lombardy previously provided drinking water to local residents. More recently, however, the loss of flow and water pressure due to problems with bacteria meant it had been consigned to being used only as a back-up source or in the case of an emergency.

When the decision was made to rehabilitate the well, specialist Italian company GN Tecnopompe was brought in to tackle the problem of its restricted flow. Working in partnership with Milan-based Millars Products, the two organisations began a deep cleaning programme using both mechanical cleaning methods and a chemical treatment solution.

Giorgio Boyd, from Millars Products, explains: "An initial inspection revealed that the main problem affecting the well was the growth of iron-related bacteria (IRB), which is a relatively common occurrence if regular treatment is not carried out.

"If allowed to develop unchecked, the bacteria will quickly impact on performance, causing problems with biofouling and clogging of the pumping equipment and potentially damage to the borehole wall and casing."

Made with a carbon steel casing and screen, the borehole was approximately 160m deep, with a static level at around 80m and a diameter of 350mm. At the time the experts were brought in, its maximum output was just 20 litres per second and the pump, installed at minus 120m, often had cavitation problems due to quick dropdown.

The remedial work, which took place in May this year, saw GN Tecnopompe start with a mechanical clean of the well using a piston and brushing method, with an airlift to remove residual deposits.

With the initial clean completed, the next stage was to tackle the bacteria with chemicals and the Millars Products team brought in BoreSaver Ultra C Eco, a specialist treatment solution imported exclusively from its UK partner Geoquip Water Solutions.

An application of over 500kg was inserted into the borehole, using the airlift system to create regular purges to help to circulate the chemical. Over a two-day period, water samples were regularly taken for pH testing and, by the end of the second day, the samples were showing a neutral pH with crystal clear water.

Although the water quality had now dramatically improved, further borehole investigations with a downhole camera revealed that the bottom of the well still contained some residue, and that not all the slots in the casing had fully opened.

The decision was made to apply a second much-smaller BoreSaver treatment, this time using camera technology to ensure it was carefully targeted at the remaining problem areas. By injecting the chemical directly at specific depths and with further piston and brushing combined with a purge using a submersible pump, the remaining residue was successfully cleared.

Tests showed that the well was now producing double the amount of water – 40 litres per second without impacting on the top of the pump, while the water level went down to 120m instead of the previous 80m.

BoreSaver Ultra C is poured into the borehole of a well in Italy that had all but been mothballed due to problems with bacteria dramatically reducing its output

The sample bottle (left) shows how cloudy the water was and demonstrates the mud found in the borehole. The sample (right) was taken one hour later after the mechanical clean but before the chemical treatment

Boyd adds: "We carried out another video inspection and we could see significant improvement on our screens. It was a tremendous result and the quantity and quality of the water now being pumped from this borehole is very impressive. So much so that the well's owners are now ready to treat other wells that have similar problems."

Giovanni Naoni, director of GN Technopompe, says: "We were extremely pleased with the results achieved from the cleaning and treatment process. It was carried out efficiently and with the minimum disruption and we look forward to working with the teams again on future projects."

The BoreSaver range of treatments is designed to tackle different types of bacteria and is easy to use because borehole equipment can stay in place while the treatment takes effect. The presence of a marker within the solution also allows the cleaning team to guarantee that no chemical residue is left in the water supply.

Ongoing maintenance treatments are also recommended to avoid future build-ups of iron contamination.

The Yorkshire Italian job

Since acquiring the Woodsmith polyhalite mine project earlier this year Anglo American has been pressing ahead with the site's development. As part of that work Welltherm Drilling used an MI6 rig from Italian manufacturer Massenza to create a borehole for groundwater monitoring purposes

Top right: With a 56Kn pull-up, 5.20m stroke and a rotary head that can reach 650rpm and 9,630Nm of torque, the MI6 rig was easily able to drill a 200mm diameter well to a depth of 75m

Bottom: The Massenza MI6 drill rig ready to start work in the under-construction mine shaft at the Woodsmith polyhalite mine project

Specialist drilling contractor Welltherm Drilling Ltd has used a Massenza MI6 rig to drill a 200mm diameter well to a depth of 75m at the Woodsmith polyhalite mine project in Yorkshire, UK, one of the most interesting, innovative, and ecologically sensitive mine construction sites in the world.

The work which was undertaken with the MI6 for Anglo American Plc was supervised by UK-based Dunelm Geotechnical and Environmental Ltd.

At the construction site the Massenza MI6, which was supplied by the Italian manufacturer to Welltherm Drilling Ltd, a company specialising in water well, geothermal and site investigation drilling projects, drilled a 200mm diameter well to a depth of 75m, then installed a 125mm wellscreen with filter pack. On completion of the well, a borehole pump was installed and a series of pump and recharge rate tests were undertaken as part of groundwater monitoring within the diaphragm walls of the shaft.

This Massenza MI6 can boast a 56Kn pull-up, 5.20m stroke and a rotary head that can reach 650rpm and 9,630Nm of torque.

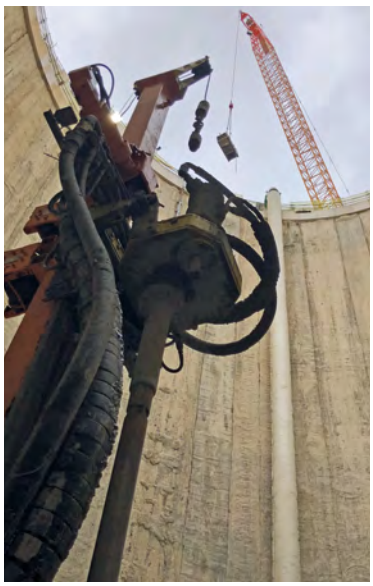
The Woodsmith project is a deep mine and associated transport, processing, and shipping infrastructure development under construction Since 2017 in North Yorkshire, UK.

POLYHALITE

This mine will extract polyhalite, a naturally occurring mineral containing potassium, sulphur, magnesium and calcium, four of the six key nutrients required for plant growth. The polyhalite extracted at the mine will be exported to overseas markets as a low chloride, multi-nutrient fertiliser suitable for organic use that can boost crop yields and aid more sustainable farming.

The relevant fact is that the Woodsmith project area contains the largest and highest-grade resource of polyhalite to be found anywhere in the world, amounting to some 2.69 billion tonnes, giving the mine a potential lifespan of over 100 years.

Polyhalite, indeed, is commonly found at a centimetre scale in mineral deposits throughout the world. But North Yorkshire is the only currently known place where such a thick and high-grade deposit is known to exist.



The Yorkshire polyhalite deposit was formed in the late Permian period, around 260 million years ago, in the southern North Sea basin. What was then the Zechstein Sea periodically evaporated, leaving behind a sequence of mineral deposits including the shelf and basin seams of polyhalite.

In 2017, building work started on a low environmental impact, state-of-the-art mine two miles south of Whitby in the North York Moors National Park. Polyhalite ore will be extracted via two mine shafts and transported outside of the National Park to Teesside on a conveyer belt system in an underground tunnel, avoiding any impact on the countryside above.

Massenza Drilling Rigs is proud to contribute with its technology and experience to what could be a solution to the ever-growing demand for food of the world population, by making cultivation methods and fertilizers more efficient and sustainable.


MASSENZA
DRILLING RIGS
Proudly Made in Italy
Since 1921
www.massenzarigs.it
Drillers' first choice for:
Water Wells
Soil Investigations
Geothermal Applications
Mineral Explorations
Seismic
Foundations
Micro piles and Anchors
UK Sales and Service
Rockbit UK Ltd
www.rockbit.co.uk

Marchi Giorgio - drill on

Since its establishment in 1974, Marchi Giorgio S.r.l. has built a reputation as a company specialising in the distribution of drilling equipment with a focus on tricone bits and mud pumps

Tricone drill bits have been a specialism of Marchi Giorgio since the company was established in 1974

Marchi Giorgio's mission is to provide the highest quality equipment to the drilling industry at the most competitive price possible. With exclusive representative rights for Epiroc/Atlas Copco, Drilcos, CGT, Unidrilltech and Volgaburmash, it is able to challenge the diverse dynamics of drilling operations: oil, gas, water, HDD, etc.

In its warehouse, the continuous availability of an inventory of more 4,000 pieces in an extensive range of equipment includes new tricone bits and drag bits offered in all diameters and sizes, mud pumps, stabilizers and adaptors/subs.

Over the years, through its commitment to the service of the drilling industry, Marchi Giorgio has succeeded in winning as customers some of the most important companies in the business in Italy and internationally as it has made its main focus towards tricone drilling units.

Alongside its specialism in tricone drilling units, Marchi Giorgio has a focus on mud pumps. Laxmi Pumps Private Ltd has been producing submersible pumps exclusively for Marchi Giorgio since its establishment in 1991.

Today, Marchi Giorgio is one of the renowned manufacturers, exporters and suppliers of precision-engineered mud pumps. Its LX-series of mud pumps, sold under the brand name Laxmi, is manufactured in compliance with international standards and are company is ISO 9001:2008 certified.

Developed by a team of highly qualified engineers using computer-aided design and manufacturing technologies, Marchi Giorgio mud pumps are designed to endure high-pressure and high-discharge applications. In addition, they have several in-built design and constructional features that ensure high-efficiency without much electrical input.

The mud pumps are available in various models and can be ordered in bulk. In addition, Marchi Giorgio offers them at very economical prices and provides customised solutions.

The mud pumps are duplex double acting reciprocating type made from a single piece alloy casting capable of handling high discharge and high-pressure applications. These are ideally suited to seismograph survey, water well, oil well, core drilling mud and cement service applications. Moreover, the pumps feature continuous tooth herringbone gears fitted with eccentric for easy economical replacement.

The company offers eight models of pump to choose from.

Marchi Giorgio has the requisite technical and commercial expertise to expand its business to new horizons of growth. The company's main strength is its quality and innovative designs. This is the reason why its products are well established as power saver pumps in the market.

Over the years, Marchi Giorgio has developed an ultra-modern production unit spread over 550sqft of land. It has equipped its unit with the latest technologies and advanced machinery. Backed by these resources, it produces 15 pieces per month.

"An inventory of more 4,000 pieces in an extensive range of equipment"

The Marchi Giorgio timeline

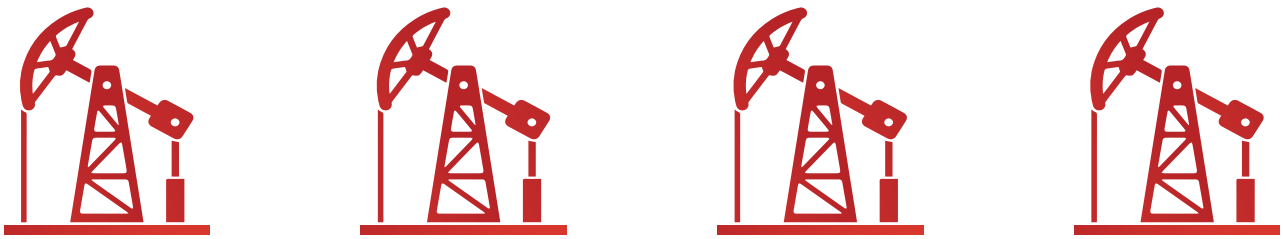
1974 – Marchi Giorgio established.
1988 – A major supplier of new and used drilling equipment in Italy.
2003 – Begins collaboration with Volgaburmash (Russia), a producer of tricone bits.
2005 – Main agent for Volgaburmash in Europe.
2006 – Assists and supports production of Focus RockBits (India), tricone bits and Khalsa (India) drag-bits.
2007 – Europen agent for Focus RockBits.
2010 – Atlas Copco absorbs Focus RockBits and Marchi Giorgio represents both brands.
2011 – Leader in the commercialisation of new tricone rock-bits and tri-blade bits.
2012 – Consolidates strategies with Atlas Copco and appointed European agent for Drilcos Rock Bits (India).
2013 – Starts joint efforts with RockPecker (India) and Cenerg (India).
2015 – Agent for/official partner of AtlasCopco, Drilcos, Cenerg-CGT, Unidrilltech, Volgaburmash and Laxmi Pumps.

MARCHI GIORGIO

DRILLING EQUIPMENT

Established 1974

www.marchigiorgio.com



KEEP CALM AND DRILL ON

PARTNERS

Epiroc · CENERG GLOBAL TOOLS · ROCKPECKER · UniDrillTech · VBN · LAXMI

When quality is the first need Fraste rigs are the preferred choice

The choice by customers in both Germany and the UK to purchase new FS 500 water well drilling rigs from Fraste is a confirmation of how the Italian company's more than 55 years of experience place it among the most trusted rigs manufacturers in the world

During the last days of July 2020, Fraste delivered two powerful, 45t pulling capacity, FS 500 drilling rigs, one of the largest drilling units it produces. The Italian manufacturer describes the FS 500 as one of the most famous rigs in the history of the modern water well drilling industry.

The first of the two large water well drilling rigs was delivered to Eugen Engert GmbH in Germany and the second one in the UK company G Stow Plc. Both of the units are designed to work with a reverse mud circulation system with air lift and can reach depths of 600m in large diameter wells.

Mounted on semi-trailers, the rigs are highly customised according to the customer's needs and are supplied complete with all necessary standard tooling. With the FS 500 safety is not an option, but the base of all construction criteria.

UK and German markets have a long drilling history and knowledge, which can be very challenging for suppliers. However, Fraste is proud to be a partner for the supply of the machines and to offer the best professional support for the rig's lifetime, especially under extreme drilling conditions.

The German customer was searching for a rig to add to its current fleet and with 25 years' experience and technical competence with Fraste's German/Austrian dealer - Becon Anlagenbau GmbH – Andreas Berndl in Austria led Eugen Engert to the choice of Fraste's biggest deepwater well rig: the FS 500.

This version destined for Germany is prepared for reverse circulation drilling of large diameters and deep holes for industrial and private water supply; but other different drilling methods can be used, like direct mud circulation and DTH hammer drilling thanks to a separate mud pump and air compressor that allows the unit to cover a large drilling purposes spectrum.

The German customer has taken the option of full radio-control, too, that allows all the functions of the unit to be radio remote controlled, as well as the installation of a drilling data logger to record all drilling phases and values.

The two latest FS 500 water well drilling rigs from Fraste ready to be dispatched to customers in Germany and the UK

Customer feedback

Upon its arrival in the UK, Fraste's customer had this to say about its new FS 500 rig: "G Stow Plc, a key business within SSI Services (UK) Ltd, which is the infrastructure services business of South Staffordshire Plc, is pleased to announce the arrival of its flagship drilling rig, the Fraste FS 500.

"G Stow operates across the UK with a wide customer base from regulated water companies to businesses within the commercial and industrial sector. We have been drilling and maintaining boreholes for over 100 years.

"We wanted a drilling rig that delivered enhanced safety features and that was capable of drilling flooded reverse and could handle up to 914mm casing - the FS 500 has met all these criteria.

"As the FS 500 is truly a multipurpose drilling rig - we can now offer the following services:

- Large diameter flooded reverse drilling for abstraction boreholes of all sizes.
- De-watering boreholes.
- Drilling of open-loop GSHP borehole from 304mm diameter to 610mm diameter completions
- Conventional mud and air rotary drilling.
- DTH hammer drilling.
- Deep slim water well drilling.
- Mechanical rehabilitation of existing water well where access permits."

In the UK, its sister FS 500 incorporates the original Fraste Munipulator for automatic drill pipes loading that ensures unsurpassable safety for the drilling operators alongside increasing the production time.

Both the rigs were supported by a deep, professional and practical on-site commissioning course held by one of Fraste's lead technical engineers, who train the drilling crews through the world.

Fraste's FS 500 drilling rigs can be supplied with engines ranging in power output from 355 to 800hp; different types of rotary heads up to 4,000daNm torque and 350rpm are available; mast stroke is suitable for 6m and 9m long drill pipes and many options are available for mud pumps, air compressors and other attachments according to the type of drilling to be performed.

Fraste is very proud of the fact that the delivery of the new FS 500 in the UK was via a new business; Eijkelkamp Fraste UK, that started in September 2019 and has continued to operate through the challenges of COVID-19.

Eijkelkamp Fraste UK offers Fraste conventional rigs, Eijkelkamp sonic rigs and CPT units and now has five drilling rigs in its rental fleet and is looking to add more.

The sales and rental activities are carried out with a UK team that offers spares, service and technical support for all UK customers from a first-class facility, centrally located in Bromsgrove.

The business is doing very well and will grow in the years to come thanks to sharing the same commitment to quality and service that Eijkelkamp and Fraste offer; two long-established family businesses, Eijkelkamp since 1911 and Fraste since 1964.

History and structural features

After many years of temporary repair, the decision was made to fully restore the wooden Ponte degli Alpini bridge in the Veneto region of Italy. *GDI* gains in insight into the complexity of the piling work needed as part of the project

Above: A steel frame work was used to support the wooden Ponte degli Alpini bridge while the two underlying bents were completely removed, allowing the construction of the remaining foundation micropiles for the starlings and the installation of the stainless steel truss structure supporting the bents

The Ponte Vecchio (Old Bridge), or Ponte degli Alpini is one of the rare examples of an Italian, fully-covered timber bridge. Located in the town of Bassano del Grappa, in the Veneto region of north-eastern Italy, it was built at the end of the 12th century over the Brenta River and was redesigned in 1567-69 by the famed Renaissance architect Andrea Palladio.

Over its history, it has been repeatedly destroyed and rebuilt, as a result of floods and war. The bridge was sabotaged and collapsed in 1945, during the last weeks of WWII, and then rebuilt in 1948 with the contribution of the Italian mountain infantry corps (called Alpini, hence the name Ponte degli Alpini). Severely damaged by a flood in 1966, it was rebuilt again and continued to undergo reconstruction and repairs, following the original design drawings by Palladio.

The Old Bridge is a timber structure of unique size and complexity at 66m long and 8m wide, it is divided into five 13m long spans. The load of the structure is supported by four timber pile bents and two masonry abutments. Each bent is made of eight oak timber piles, arranged in equal spacing and covered with horizontal timber planks called 'filagne'. The piles are connected on their top by a cap beam that supports the timber columns and struts connected to the bridge superstructure.

Before 1819, the timber piles forming the bents were standing directly in the bed of the Brenta River. The ground beam was a major structural innovation introduced by the post-Napoleonic reconstruction in 1819-21. With the introduction of the 9m long and 60cm wide timber beam, the number of timber piles forming the bent remained unchanged, while the number of piles driven into the riverbed and supporting the ground beam was increased to 15 per each bent.

This foundation concept was preserved over the years (and various reconstructions that involved repair, replacement or addition of the foundation timber piles) until the early 1990s. During 1990 four pairs of 8m deep drilled shafts capped with a stainless steel cover were constructed and connected to the ground beam to support the bridge bents. The load of the bents could thus be partly transferred on the drilled shafts, while part of the load was still supported by the timber poles driven into the riverbed during previous centuries.

Each bent includes one upstream and one downstream starling (rostro in Italian). The rostri are shaped to ease the flow of the water around the bridge, reducing the damage caused by erosion or collisions with flood-borne debris. The starlings are built of timber poles driven into the riverbed, topped by a sloping beam and covered on the sides with filagne to form an organic whole with the bents.

All the starlings were reconstructed after disastrous flooding in 1966, as well as the deck and the wooden superstructure of the bridge. At the same time, one 10.5m deep drilled shaft was constructed just upstream of each bent and connected to the cap

beam on top of the bent piles with two steel tie rods to improve resistance against the strong flow.

Despite all these measures, the horizontal loads of the water flow and the deterioration of the underwater timber elements of the bridge have caused, in recent years, critical deformations of the bridge foundations.

The reinforcing foundation elements introduced from 1965 to 1990 were no longer able to support, through the severely deteriorated timber ground beam, the vertical loads transferred from the four bridge bents.

Starting in 2013, the sinking of the bridge structure became evident. In the summer of 2015, the bridge was sinking by an average of 4-5cm per month, putting the bridge at serious risk. The further collapse of one of the bents in 2018 caused the bending of the bridge. Temporary works were deployed to prevent further damage and avoid the closure of the bridge. Major restoration could no longer be postponed.

THE PROJECT

The project is part of the strategic plan launched by the Italian Ministry of Cultural Heritage and Activities and Tourism in 2015. It is one of the most complex reconstruction projects currently underway in Italy, with a total value of over €6 million (US$7.1 million). It involves the reconstruction of all parts of the Old Bridge, with the focus on the structural aspects.

The goal of the project is not only to guarantee the load-bearing function, but also to obtain an overall improvement in the structural behaviour of the bridge where it is exposed to the stresses of water flow and seismic activity.

Instead of adopting a purely conservative approach, based on the addition and repair or replacement of timber piles, the project has introduced into the bridge's foundations some innovative elements made of state-of-art materials.

The load of the timber bents is now transferred to the ground through an 11.5m long and 1.2m high stainless steel truss structure weighing 7t. The truss rests on top of the eight drilled shafts built in 1990 and on two new concrete plinths supported by micropiles (one upstream and one downstream of each bent). In this new foundation design, the truss replaces the deteriorated 19th-century timber ground beam that lost its load-bearing capacity. Six steel bracing rods that connect the ground beam and the cap beam of the bent piles are added on each side to improve stability of the bents and their resistance.

Further foundation works focus on the starlings: due to the poor state of preservation of the timber piles, they will be replaced by micropiles with permanent stainless steel casings in the upper section. The portion of the starlings above water level will be rebuilt using new timber as well as original timber where possible.

The tie rod connection between the cap beam of the bent piles and the drilled shafts located upstream of each bent will be also be restored with the addition of a steel profile reinforcing the sloping leading edge of the starlings and protecting the tie rods.

The new steel elements introduced by the project will remain under the water level and/or hidden from view thanks to the filagne covering the bents, which will be reconstructed according to original specifications. In this way, the project aims to tackle the structural problems that have endangered the bridge throughout the centuries, while preserving the original form and character of the iconic masterpiece by Palladio.

THE FOUNDATION WORKS

Works for the new bridge foundations began in November 2018 on the east banks of the river. The particular difficulty posed by the engineering works was that they had to be planned, designed, operated and maintained in a challenging fluvial environment located in the historical centre of Bassano. The bridge serves as an essential connection between the west and east ends of the town and is an attraction for tourists from all over the world. It was, therefore, a mandatory condition that the bridge should remain open for pedestrian crossing during the execution of the works, with temporary disruptions kept to a minimum.

"The project aims to tackle the structural problems"

The bridge stands on an alluvial plain, characterised by the predominant presence of gravelly sediments in a sandy matrix with occasional sands and gravels of fluvioglacial origin in the upper layers. Hydrological conditions suggested limiting construction operations time, splitting the schedule in two years.

Construction works in the riverbed were only allowed in the period between December and April, when the water level drops and the risk of flooding is lower. A cofferdam of earth and rock-fill was set up from the banks upstream allowing the river flow to bypass the foundation area. Water was pumped out to create a dry working environment.

The contract for the execution of the foundation works was awarded to Micron Srl, based in the nearby Trentino region. In the first time frame (from December 2018 to April 2019) works were carried out on the two bents of the left bank of the Brenta River.

After temporary works were put in place, the project posed immediately one of its biggest challenges: the construction of a supporting framework for the bridge superstructure. The steel framework permitted to remove the bents for the time needed for

After years of water erosion the bridge's original wooden foundations were so weak the bridge was beginning to sink

After installation, the new steel micropiles were then clad with wood to replicate the look of the bridge's original design

the installation of the new bridge foundations. At the same time, it allowed straightening of the bent bridge, bringing the deck back to its original height.

A series of micropiles with a diameter of 250mm were installed to a depth of 8m to support the steel framework and hydraulic jacks used for the lifting operations. After the steel framework was placed under the bridge deck, the lifting was carried out using 12 jacks. Thanks to electronic control units, the lifting was accurately performed at millimetre intervals, acting simultaneously on two bents in diversified steps.

"The bridge was brought back to its height in February 2019. Lifting operations started on Tuesday morning and were completed Wednesday in the afternoon. These were the only days when the bridge remained closed. The deck could be lifted 28cm on the first bent and 48cm on the second one, causing no damage to the bridge superstructure," says Nicola Capasso, owner of Micron Srl.

RIG CHOICE

With the steel framework supporting the deck, the two underlying bents were completely removed, allowing the construction of the remaining foundation micropiles for the starlings and the installation of the stainless steel truss structure supporting the bents. A total of 50 micropiles cased with stainless steel tube in the upper section were constructed to accommodate the timber poles of the starlings.

"The timber for the reconstruction was partly recovered from the original bridge"

The micropiles were installed using DTH drilling method with a Comacchio MC 22. Double drill strings were connected through a casing top driver on the rotary.

"Our choice fell on this type of rig due to its high production rates," explains Capasso. "A major advantage was given by the patented Comacchio cuttings diverter. Since the space on site was limited and there were many different teams involved at the same time, it was important to ensure that the drilling cuttings were kept under control.

"Obviously, operating in a fluvial environment, you always have to deal with the variability of the river flow. Part of the foundation design was modified after the storms that almost caused a flooding of the Brenta River and lowered the riverbed level in the autumn of 2018. Then, during the execution of the works, the heavy rains in early February 2019 flooded the construction site, just a few days before the date set for the lifting of the steel framework supporting the bridge. The water had to be pumped off-site and the lifting operations were postponed for a couple of days," remembers Capasso.

Once the new foundation elements were installed, the project moved to the next stage: the complete reconstruction of the two timber bents and four starlings.

The timber for the reconstruction was partly recovered from the original bridge elements, while part was supplied new. Parts that were of crucial importance from a structural point of view and/or are very exposed to the water flow and/or difficult to access for maintenance and repair were replaced. The use of new timber elements was kept to a minimum for the parts of the bridge above the water level. To allow this, an extensive survey was carried out by specialised technicians before construction began. It identified the wood species and the resistance class and the degree of humidity of all the timber elements of the bridge, and to map the extent and rate of their degradation.

The second time frame to which foundation works were restricted went from December 2019 to April 2020, involving the two bents on the west bank of the Brenta. Their reconstruction entailed fewer difficulties, thanks to their better state of preservation.

Just as like the year before, a cofferdam was first built in the riverbed upstream of the bridge and the same steel supporting frames were used to remove the bents and install another 50 micropiles, with the same technology adapted the previous year on the east side bents.

The construction works went on during the spring, despite the coronavirus outbreak. New safety protocols were implemented to reduce the risk of infection but work never stopped in the bed of the Brenta River. The temporary restriction of the river flow caused by the cofferdam had to be kept within the established time frame, in order to avoid risks of flooding in case of heavy spring rains.

By mid-May, the bents were completely restored and the cofferdam removed, thus definitively closing the operations in the riverbed. Reconstruction of the deck, of the balustrades, columns and the trusses went on during the summer, working step by step in order to avoid the closing of the pedestrian crossing. The plan is to complete the project by the end of March 2021.

BITS

BOREHOLE PUMPS

GEOQUIP WATER SOLUTIONS LTD Tel +44 (0) 1473 462046
www.geoquipwatersolutions.com. Borehole Pumps, Downhole CCTV, Wellmaster Rising Main, Starter Panels, Compression Fittings

PROQUIP DIRECT LTD Tel: +44 (0)20 8712 5982
www.proquipdirect.com. Franklin Borehole Pumps, SS and PVC Wellheads, I-GON Iron Bacteria Remover, QUAD 4 Joint Kits, BORELINE Flexible Rising Main

CASING & ANCILLARY EQUIPMENT

COLCRETE EURODRILL (see under Drill Pipes, Rods & Tubulars)
MGS +44 (0) 1952-459778

CORE BARRELS & ANCILLARY EQPT

DRILLING FLUIDS

MGS +44(0) 1952-459778

DRILL PIPES, RODS & TUBULARS

DRILL RIGS FOR HIRE

ABI EQUIPMENT LTD +44 (0) 1604 586960 wwww.abi-eqp.com. For ABI and Delmag rigs and attachments (see under Drill Rigs (Rotary))
MGS +44 (0) 1952-459778

DRILL RIG REPAIRS

MGS +44 (0) 1952-459778

EQUIPMENT

GEOTHERMAL EQUIPMENT & MATERIAL SUPPLIES

LOGGING

PUMPS

SITE INVESTIGATION

WELL PACKERS

STAINLESS SCREENS

WELL REHABILITATION

WANTED

DYNAMIC
POWER.

POWER OF KLEMM

KR 704-2E
Electric drive
Engine power: 45 kW
Limited access drilling rig
Radio remote control
Weight: 5.1 t

UNSTOPPABLE!

KLEMM drilling equipment stands for the latest, most sophisticated drilling technologies made in Germany. Because every detail is thought through and designed in a particularly robust way our systems stand for a unique, unstoppable DYNAMIC POWER! Benefit from excellent reliability and performance with the lowest total cost of ownership (TCO). We'll tell you how we can make you unstoppable – give us a call: **+49 2761 705-0**

www.KLEMM-BOHRTECHNIK.de

KLEMM
Bohrtechnik

Experience the Progress.

Liebherr deep foundation machinery

- High availability and long service-life due to robust equipment technology
- Low emission and high efficiency thanks to intelligent drive systems
- Operating comfort through innovative control concept
- Matching working tools ensure excellent productivity
- Optimized construction processes thanks to comprehensive consultation

Liebherr-Werk Nenzing GmbH
Dr. Hans Liebherr Str. 1
6710 Nenzing/Austria
Tel.: +43 50809 41-473
crawler.crane@liebherr.com
facebook.com/LiebherrConstruction
www.liebherr.com

LIEBHERR