Sonic drilling
A new twist on sonic technology is introduced to the construction industry

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Back to the roots

The concept behind sonic-drilling technology was first explored around 100 years ago, but it took many years of research and development, with the torch changing hands on multiple occasions, before it was successfully commercialised. Canadian engineer Ray Roussy of Sonic Drill Corporation (SDC) has been credited with introducing the technology to the drilling industry.

So what makes sonic technology special? It’s known to be an easy, fast, clean, quiet and precise drilling method. But what’s the catch? It can be more expensive than traditional methods when it comes to operation, maintenance and equipment (however, cost-efficiency is often named as a benefit) and, for now, it is not a viable option for depths over 200m (drilling slows down the deeper you get) or large-diameter holes.

With the commercialised technology now out of its teens, one would assume sonic drilling to be fairly widely accepted. While it is in use for various drilling applications around the world, some markets and sectors are still lagging behind.

Introducing new technologies and innovation to the drilling industry can often be a slow process, and most people subscribe to the belief of ‘I need to see it to believe it’. The UK is one example of a region where sonic remains a niche market. The technical manager of Scotland-based drilling contractor GeoSonic Drilling, Andy Condron, told us that there are probably fewer than 20 sonic rigs in the country at the moment. However, with increasing demand for site investigation and geotechnical work, sonic is being requested more often and the technology’s profile might be on the rise.

A specific sector that has yet to properly tap into the potential of sonic is the construction industry. In the January/February 2015 issue of GDI, Roussy told us about some exciting news regarding sonic pile installations that he was planning to announce in the near future. The time has now come to reveal the big secret: SDC has given us an exclusive look at the newly patented sonic pile-anchor method (p11).

Piling is actually not a new application for sonic-drilling technology. In fact, pile driving was one of the earliest uses that sonic drilling was developed for. In the 1960s a sonic pile-driving prototype enjoyed some moderate success; however, development simply ground to a halt. The technology is now returning to its roots – better prepared to tackle the construction industry.

Turn to our sonic feature to read about the new twist to the technology and the basic principles behind sonic drilling, as well as new equipment and application stories.

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**Ausdrill secures Ghana contract**

Mining services company Ausdrill’s subsidiary African Mining Services (AMS) has entered into a contract with Perseus Mining to provide open-pit mining services at its Edikan gold mine’s Eastern Pits operations in Ghana, West Africa.

AMS has been providing mining services to Perseus since 2011. The new contract is for three years with an option to extend for a further two years, and with mining scheduled to commence in Q2 of 2015. The contract is expected to generate approximately US$223 million in revenue over five years.

Ausdrill’s managing director Ron Sayers said: “We are delighted to extend the relationship we have developed with Perseus in Africa. The award of this contract clearly demonstrates the capability of AMS to deliver quality service on schedule.”

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**Norway starts work for 2km-long bridge**

The Norwegian Public Roads Administration has contracted Entreprenørservice to undertake core and hammer drilling as part of preliminary investigations for a 1,960m suspension bridge across the Julsundet strait, which connects the Norwegian Sea to the Romsdalsfjord.

The contract is valued at NK1,639,050 (US$219,735). Project manager Harald Inge Johnsen said: “The core drilling will give us more information about the quality of the rock to plan the foundations and cable anchors. Once this is in place, the pilot project for the bridge can be completed as a good basis for further construction planning and cost assessment.”

The bridge is part of the Romsdalsfjord tunnel. In March, Entreprenørservice was awarded the core-drilling contract for the subsea tunnel under the Romsdalsfjord.

The drilling started at the end of April and will continue until September this year.

A construction road has been built at Julbøen and will be used to deliver equipment. On the other side of Julsundet (Nautneset) a helicopter is needed to deliver the equipment.

The core drilling will be conducted at the waterfront on both sides of Julsundet and where the cable anchorage will be attached to the rock. Five holes will be drilled in Julsundet, with depths between 40m and 80m, from four drill sites. The hammer drilling involves drilling the axis of the tower foundations on both sides of Julsundet and cable anchors on Julbøen.

Six drill holes at 40m to 80m are planned.

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**Gusan drills for the gold**

As part of the preparations for the 2018 Winter Olympics in Pyeongchang, South Korea, a new high-speed railway is being constructed between Wonju and Gangneung.

The line, part of an extensive infrastructure programme, is scheduled for completion by 2017. One of the contractors involved on the Samsung C&T-run project is Gusan Construction. The road bed the company is working on is expected to be completed by November 2016.

A key piece of equipment Gusan Construction has used on the Wonju-Gangneung railway link has been its new Sandvik DT1131i jumbo drill rig, which has been in operation on the project since December 2014.

When the company began work on the project, its drilling jumbos, although performing at reasonable levels, were not deemed to be satisfactory. Gusan wanted to improve drilling speed, rates of advance and drilling accuracy.

After discussions with Sandvik Construction in Korea, Gusan decided to replace the existing jumbo drill rigs with the DT1131i, using RD525 rock drills and Alpha 330 rock tools. The company said the new Sandvik equipment can achieve in 1.5 hours what the previous equipment took 2.5 hours to accomplish.

The DT1131i is a computer-controlled three-boom electro-hydraulic jumbo for tunnelling and cavern excavation of 20-183m² cross-sections, including face drilling, bolt-hole drilling and mechanised long-hole drilling.

Sandvik stated that with the iSURE tunnel-management program, the DT1131i’s iDATA control system, recently launched RD525 rock drills, robust booms and advanced drill-string guides deliver excavation results of the highest quality.
Bauer builds on the Bosphorus

The 5.4-km-long twin-deck Eurasia tunnel, a large part of which will cross the Bosphorus under the seabed, will connect the Asian part of Istanbul with its European part.

Construction work for the new motorway tunnel started at the beginning of 2013. Lead contractors are Yapı Merkezi İnş. Ve San. A.Ş. from Turkey and its Korean partner SK Engineering. A tunnel-boring machine (TBM) is already in operation.

In 2014, Bauer Spezialtiefbau installed a total of 18,900 m² of diaphragm wall with a depth of up to 39 m and a thickness of up to 1.5 m on the European side of the construction site, where the TBM will finally emerge. A Bauer BC 40 trench cutter was used for the installation.

Local ground conditions range from highly porous soil to highly weathered, unstable rock, which initially made the cutting work difficult. In addition, a 35 m-thick solid concrete secant pile wall had to be cut through, which had been constructed beforehand for the operation of the TBM.

Despite these circumstances, Bauer Spezialtiefbau was able to complete its work by December 2014, as planned, without any delay. The tunnel is scheduled for completion by the end of 2016. It is expected to ease the severe traffic congestion in Istanbul, the most populous city in Turkey.

Bauer Spezialtiefbau has installed a diaphragm wall for the Eurasia tunnel
Old gas wells could be key to cheaper geothermal energy

Geothermal Engineering (GEL) has signed a memorandum of understanding with energy company Cuadrilla to look at the feasibility of delivering deep geothermal heat from oil and gas wells in the UK.

The project, backed by the UK Department of Energy and Climate Change, will initially focus on the technical design of the system before considering a potential field trial. This follows on the success of GEL’s field trials of a deep geothermal well in Cornwall in 2014.

The announced project aims to show that geothermal renewable heat can be sustainably delivered from deep wells that were originally drilled for other purposes, such as oil and gas extraction.

By using existing wells, deep geothermal energy costs will be reduced by up to 80%, leading to significantly better economics for the technology. As heat can only be delivered locally, this technique also offers the opportunity for communities to access low-cost heat energy from existing wells.

Dr Ryan Law, managing director of GEL, said: “The successful trial last summer of our equipment in an existing deep geothermal well demonstrated how the technology could contribute to the UK’s energy portfolio. “The possibility of using existing wells enables us to not only deliver renewable geothermal heat at a much lower cost but also to recycle wells that would otherwise be wasted.”

Francis Egan, chief executive of Cuadrilla, said: “We are delighted to support GEL in looking at the feasibility of using one of our exploration well sites to conduct a pilot of a geothermal heat-exchange system. There is still some investigation to be done, but significant potential exits to utilise onshore oil and gas wells, after they have ceased production, to generate low-cost, carbon-free, sustainable geothermal heat energy.

“While we recognise that there will be a big demand for natural gas for decades to come, given that over 80% of UK homes rely on it for heating and cooking, we also support the need to develop other forms of low- or no-carbon energy.”

Ed Davey, UK secretary of state for energy, added: “Geothermal heat could play a huge role in Britain’s low-carbon future, but the cost of drilling coupled with the risks of not succeeding have proved significant barriers.

“If we can develop these technologies so that exhausted shale gas wells can then be used for renewable geothermal heat, we can not only use gas to replace coal, but use shale gas as a bridge to true low-carbon heat.”

Fugro completes seabed investigation for Hornsea wind-farm project

Fugro has successfully completed one of the largest seabed investigation campaigns in the offshore wind industry in preparation for DONG Energy’s 1.2GW Hornsea Project One.

Located 120km off the UK’s Yorkshire coast, the project is scheduled to go into operation by 2020, when it will be able to meet the electricity needs of around 800,000 UK homes.

Søren Egede Johannesen, team lead in DONG Energy’s site-investigation project management, said: “This is the biggest geo-technical campaign we have undertaken and among the largest seabed investigation campaigns the offshore wind industry has seen.

“Fugro used two of the largest and best-equipped geotechnical vessels – MV Greatship Manisha and MV Bucentaur – to undertake the investigation work.”

Fugro was awarded the £13 million (US$20 million) contract in November 2014 following an extremely competitive tender process. As part of the detailed site investigation, its dedicated geotechnical vessels completed close to 2,800m of seabed cone-penetration testing and more than 5,000m of boreholes over a four-month period.

“This campaign is a notable example of the various parties working together to successfully deliver a large-scale project during challenging winter months,” commented Daniel Deen, Fugro’s senior project manager.

“We maintained a high level of performance throughout and fulfilled the objectives.

“The project was completed with no lost-time injuries and minimal equipment downtime, reflecting the diligence of all stakeholders.”
Testing the waters at Sydney Harbour

Geotechnical drilling is currently taking place up to 70m below Sydney Harbour, Australia, to help determine the best location for the new Sydney Rapid Transit railway tunnels.

New South Wales premier Mike Baird commented: “This new rail crossing of Sydney Harbour is the key to increasing capacity on our rail network by 60% – allowing us to move an extra 100,000 people every hour right across Sydney.”

Minister for transport and infrastructure Andrew Constance said surface and underwater drilling is a critical part of the design process and will ensure the city’s brand-new rapid-transit rail network can be delivered as quickly as possible.

“While construction continues apace on the North West Rail Link, we are already preparing for this vital next stage, which will revolutionise the way people get around Sydney,” Constance said.

“From the end of the North West Rail Link at Chatswood, Sydney’s new under-transit network will continue under Sydney Harbour, through new railway stations in the CBD and west to Bankstown with capacity for trains to run every two minutes.”

About 30 boreholes will be drilled as part of the Sydney Rapid Transit geotechnical programme, with roughly half of them beneath Sydney Harbour and the rest on land either side along the tunnel route.

On the harbour, a barge will be towed into position before its four legs are lowered to the seabed as much as 25m below the water surface, then pushed to firm ground on the harbour floor.

The barge will be raised up two metres clear of the water surface to provide a platform unaffected by tides, currents or other water movements.

Boring will then start with a diamond-tipped drill, which takes core samples from depths up to 70m below the bottom of the harbour.

To monitor the barge’s interaction with the harbour floor, divers will also be used as an extra visual check, with a preparation dive already completed on Sydney Harbour.

When the drilling work under the harbour is finished, the holes will be filled with cement to create a permanent seal.

It is anticipated that mostly Sydney sandstone and shale will be found along the Sydney Rapid Transit route and the geotechnical work will help better determine the ground conditions for tunnelling, making sure that the strength of the underlying rock and groundwater conditions are understood.

Geotechnical drilling will also take place at Sydenham, in the Sydney CBD, North Sydney, Crows Nest and Artarmon.

South Australia sets PACE

Multi-commodity explorer Monax Mining has secured funds for a collaborative drilling programme under the South Australian Government’s Plan for Accelerated Exploration (PACE) initiative.

The Adelaide-based company secured funds for its Kimberlite and Punt Hill projects, while its farm-in partners, Western Areas, received funding for the Western Gawler Craton project.

Monax received its full application of A$70,000 (US$55,711) for its kimberlite project, in northern South Australia, and is focused on the Margaret Dam target, where a drilling programme is planned for June/July 2015.

The company is eligible for a further A$75,000 in PACE funding for its Punt Hill IOCG project, which will be used to continue drilling at the Groundhog prospect.

The Western Gawler Craton project is within the Fowler Domain in western South Australia. The Gawler Craton is interpreted to have a geological history analogous to the Thompson Nickel Belt in Canada and the Albany-Fraser Belt in Western Australia.

As project operator, Western Areas is eligible for up to A$100,000 in funding under PACE. Drilling is due to start in the June quarter of 2015 after all statutory approvals are received.

Monax Mining managing director Gary Ferris said: “We are delighted we have been able to secure government funding for three of our projects in South Australia... as it further highlights the perceived prospectivity for these projects.”
**Skelair’s Giraffa gets to work**

The most recent addition to Skelair International’s fleet, the Baby Giraffa, has completed its first commission, rendering the rig fully operational in the UK.

Manufactured by Marini and first showcased at Geofluid 2014, this is the first commission of the rig since its introduction to the Skelair rental fleet. The Baby Giraffa earned its place on a first assignment at Congleton Quarry for the company’s contract-drilling and blasting division. The rig was set up in down-the-hole drilling mode and tasked with drilling 100mm holes from 3m to 6m deep in an area where access was limited.

Steve Lashley, Skelair’s drilling-and-blasting operations manager, said: “The ability of the Baby Giraffa to drill in areas that a normal production rig couldn’t reach made it possible to blast in an area of the quarry where ordinarily other machines couldn’t get to. I’m looking forward to seeing what other difficult tasks it can undertake and testing the machine to its full capabilities.”

John Mayo, managing director of ground-engineering and rock-drilling specialist Skelair, commented: “As a company it’s important that we are able to respond to our clients’ needs with the right equipment exactly when they need it.

“We’re lucky to own one of only two Marini Baby Giraffas in the UK and have received many enquiries since its launch at Geofluid 2014.”

**Set your sights on mining data**

Hexagon Mining has released an upgrade to MineSight 3D (MS3D), the flagship product within its mine-planning product suite.

MS3D visualises output from MineSight products, helping geologists and engineers to create and manipulate 2-D and 3-D data for editing, querying and plotting/display of all types of geology and mining data.

Version 10 of MS3D includes HxM Blast, which, according to Hexagon Mining, revolutionises the design and execution of drill-and-blast plans from within MS3D.

Within a single interface, users will be able to design drill patterns, apply blasting parameters to holes and tie in the shot. The design of the blast makes a difference and HxM Blast will make life easier for the drill-and-blast engineer, Hexagon stated.

Version 10 also includes xViewer, which enables users to display large point clouds, models, surfaces and other large data quickly and in real time. It talks directly to the graphics card to maximise efficiency in display and rendering.

The ability to quickly transform large and high-resolution point clouds into detailed surfaces and solids is realised in the release with the new Point Cloud Mesher. It generates surfaces and solids from a cloud of points by following the trend of the data in three dimensions.

For grade control, Version 10 adds the Digblock Optimiser (DBO) to the operations tool, MineSight Axis. MSAxis-DBO produces economically optimised digblock shapes to be used for grade-control mining.

Hexagon said the product is expected to greatly benefit any mine looking to improve its economic analysis of a deposit.

**Mahmoud is named for top job at Golder**

Golder Associates, a global consulting and engineering firm, has appointed Dr Hisham Mahmoud as its new president and chief executive.

Mahmoud’s career spans some 27 years, the majority of which has been in diversified global engineering and construction companies. He joins Golder from SNC-Lavalin, where he was hired in 2013 as part of the new executive team. There he served in the newly created role of president of the infrastructure group.

Before SNC-Lavalin, Mahmoud worked for AMEC, and URS and its legacy companies Woodward-Clyde and Dames & Moore.

Ian Smith, lead board director at Golder Associates, commented: “Hiring our first external CEO represents a pivotal moment in the history of our great company.

“Hisham has all the attributes we sought to take the business forward. The common feature of his working life has been his ability to drive strategies that add value and generate business growth.”
Atlas Copco invests in training facilities

Atlas Copco Construction and Mining service divisions have invested in a range of new training facilities. These include training simulators, activity-based offices and investment in workshops across the UK and Ireland.

In the mining and construction industries, equipment owners continuously seek to increase the productivity of their machines and are now looking to manufacturers to provide operator and service training to increase performance. In Atlas Copco’s updated service workshops, training is offered to dealers and customers to get the most out of their equipment.

Atas Copco’s mining-service division offers various driller-training programmes. The training for drill-rig operators takes place on a simulator. This means that any mistakes the operator makes while training will have no real-world consequences, and drillers can be trained up to a high standard in a short space of time, before they work on a real rig.

The business line manager for mining service, Peter Haddow, stated: “Advances in technology allow us to train machine operators to a high standard without the need to set foot in the machine. We’ve found our customers like this approach.”

Geo-Foundations wins safety certification

Geo-Foundations, a subsidiary of geotechnical contractor Hayward Baker Canada, has achieved certification for the OHSAS 18001:2007 international standard for workplace health and safety.

The company succeeded in passing the Stage 1 and 2 OHSAS 18001 audits in November and December, respectively. Formal certification for OHSAS 18001 was conferred on Geo-Foundations on January 26, 2015.

This new accomplishment comes on the heels of Geo-Foundations becoming, in October 2013, the first foundation trade contractor in Ontario to achieve COR National Standard certification through the Infrastructure Health and Safety Association of Ontario.

Geo-Foundations is also the first specialist foundation and ground improvement trade contractor in North America to achieve OHSAS 18001 certification.

Todd Edmunds, president of Geo-Foundations, stated: “We are very proud to receive this certification, as it speaks volumes about our long-held core values and genuinely strong safety culture at Geo-Foundations. Leadership in construction workplace safety serves every one of our stakeholders – from our clients and subcontractors to every member of our internal teams.”

Bennett joins Soil Engineering

Geotechnical specialist Soil Engineering Geoservices has appointed Wilton Bennett as regional manager south, working out of the Camberley office in the UK.

Bennett is tasked with the management and development of Soil Engineering’s site-investigation business in the south of England.

Bachy scoops award for employee safety in UK

Bachy Soletanche, a UK geotechnical specialist, has won an international safety award for protecting its employees from the risk of injury and ill health at work.

The award from the British Safety Council highlights the company’s on-going commitment to its employees’ health and safety.

The award highlights the success of a number of different measures put in place by Bachy Soletanche, including its home-safe initiative, which encourages staff to consider all potential risks on a construction site and how to avoid them.

In addition to this, the company has also invested in a group SHEQ (safety, health, environmental and quality) director, Andrew Carpenter, to help drive new initiatives to promote health and safety across the company.

Carpenter commented: “This award demonstrates our absolute commitment to our employees’ well-being, and also highlights our willingness to look at new ways to communicate with our staff to ensure the health-and-safety message is accessible and clear.”
A lesson in sonic

The Drilling Manual by the Australian Drilling Industry Training Committee takes us back to the fundamentals of sonic drilling.

Sonic drilling uses high-frequency, resonant energy to advance a core barrel or casing into subsurface formations. During drilling, the resonant energy is transferred down the drill string to the bit face at various sonic frequencies.

Depending on the size of the sonic head, an even number of counter-rotating, synchronised eccentres (or offset weights) driven by high-speed hydraulic motors provide the drilling power.

With the motors running at several thousand revolutions per minute (rpm), a vibration frequency of around 150Hz is generated in the drill string (and casing). These sonic energy waves (named because 150Hz is within the audible range) are transmitted through the drill string to the end string and then reflected back. This intense vibration causes the drill string to stretch and shorten extremely quickly, and a very thin layer of soil particles directly surrounding the drill string loses its structure. Instead of the stiff mass that requires torque and weight to penetrate, the dry soil behaves like a fluid powder (in an unsaturated zone) or as a slurry or paste (in a saturated zone).

Fluidisation or liquefaction dramatically reduces the friction between the drill string and the surrounding formation; in effect, this allows the drill string to fall into the ground, not unlike a hot knife through butter. This results in rapid penetration of the drill rods with very little weight or rotation.

The stationary soil (i.e. relative to the high-speed movement of the drill rod and sample barrel) prevents the formation from sticking to the wall of the drill rods or the sample barrel, inside or out. This liquefaction and inertia effect enables the collection of long samples in both good ground and in traditionally hard-to-sample formations.

The operator can vary the frequency and bit weight to match the material being drilled, ensuring the best penetration rate and most accurate sampling are obtained.

When the resonant sonic energy coincides with the natural frequency of the drill string, resonance occurs. This results in the maximum amount of energy being delivered to the face. At the same time, any friction in the soil immediately adjacent to the entire drill string is substantially minimised, resulting in very fast penetration.

Because there is no need to overcome the friction between the hole wall and the drill pipe on smaller machines drilling in alluvial-type formations, rotation is required only for rod coupling the drill string.

Sonic drilling technology offers several distinct advantages over conventional drilling in overburden ground. In certain conditions, such as boulder or gravel earth, sonic drilling can succeed where other conventional technologies can struggle. The significant benefits and results of using sonic drilling include:

- Faster drilling;
- The lack of any need to introduce fluid into the hole makes this method an ideal drilling method when contamination is potentially a problem;
- Less mess;
- Wider range of ground can be drilled;
- Smaller footprint;
- No large mud pits or compressor required for cutting removal; and
- Sonic drilling causes minimal disturbance to the surrounding borehole wall, resulting in more efficient performance.

While sonic drilling is used mainly for environmental, geotechnical and mineral applications, the range of tooling options available enables the drilling system to be used not only for sampling but also for those occasions where only the hole is required – that is, when setting piezometers, for seismic shot holes and the geothermal drilling sector.

Like most drilling methods, sonic systems are available in a range of sizes designed to suit...
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SONIC DRILLING

“Standard sonic drilling slows down at depth because the rods must be removed from the hole each time the barrel is emptied”

The clamping system is then operated by the pressurised accumulator activated by the overshot;
▲ This clamp locks it into position;
▲ To retrieve the inner tube, the overshot is lowered;
▲ When it reaches the accumulator, it releases pressure, deactivates the clamp and allows the inner tube to be pulled to the surface; and
▲ A side or front discharge coring shoe is used to prevent core loss or contamination.

DRILLING PRACTICE
Sonic drilling requires the use of resonant energy and/or vibration, and down-pressure to drill a hole. It is vital to monitor downfeed pressure because insufficient down pressure will cause rough vibration, which can break the rods.

Bit plugging is indicated when the holdback and oscillation pressure suddenly drops. If rotation is used (i.e. in harder formations), rotation pressure will rise. To correct this problem, the feed must be slowed down and vibration increased. Drilling fluids are required only in deep holes, hard formations or when advancing casing.

SAMPLING
The main advantage of sonic drilling is obtaining an uncontaminated sample at reasonably high speed. For softer formations, the sample interval must be measured before pulling out of the hole. This is necessary because the core could stretch as it is extruded.

Different manufacturers employ different methods to prevent contamination of the sample when the barrel is lowered back into the hole. With the sonic wireline system, a side discharge core shoe is used to minimise any contamination of the core due to the circulation fluid.

This article is an excerpt from ‘The Drilling Manual, Fifth Edition’ by the Australian Drilling Industry Training Committee Limited, CRC Press, 2015.
Driving innovation

Patented sonic pile-anchors set to revolutionise building foundations, writes Nancy Argyle

It has been a long time coming. In fact, it has taken more than 50 years for sonic drilling research to come full circle – back to one of its earliest uses as a pile driver. Now, however, the technology is far superior and set to transform the piling industry with a just-patented method.

But first, a little history on how we got here. Back in the 1960s, an early sonic pile-driving rig enjoyed a small measure of success using two Second World War army tank engines that generated a whopping 1,000hp, but, despite much effort and a fair bit of money, by the 1980s, sonic pile-driving research had fizzled out with little to show for 20 years of effort.

That is about the time that Ray Roussy, a Canadian engineer, entered the picture. His work on sonic drilling had suddenly ended when his employer, Hawker Siddeley, a British aerospace company, decided to abandon sonic research.

Roussy was convinced the technology was viable – not so much as a pile driver – but, instead, as a drilling rig that could offer faster speeds and the much-appreciated ability to drill through mixed soils where other rigs would jam up. He decided to continue the research but on his own.

Option 3: Sonic pile-anchor (building rests on it and is anchored at same time)
own and with no financing. It was not an easy road but, with perseverance, Roussy patented and successfully commercialised modern sonic drilling technology as we know it today.

After 35 years of effort, Roussy’s award-winning patented technology is now used in almost all drilling applications and around the world on six continents. Drilling three to five times faster through mixed soils, using no drilling mud (so less mess to clean up) and able to provide continuous core samples, sonic drilling technology has been embraced by many industries, including mining, geothermal and environmental.

PILING POTENTIAL
In the coming months, a new twist on this technology will be introduced to the construction industry – a move that has been anticipated for nearly a year but was kept secret until patents could be filed. “It’s been a time-consuming but exciting project to finally realise the piling installation potential in sonic drilling technology,” says Roussy.

Although he spent the better part of his life and career perfecting his sonic drilling technology, it did not stop him from reflecting on its earliest roots in pile driving. “I always believed the sonic drill would, one day, find its original niche in building foundations,” says Roussy.

Roussy, who is president of the Sonic Drill Corporation, which manufactures sonic drill rigs, and Sonic Drilling Ltd, which owns a fleet of sonic rigs that are used for contracting purposes, first used the newly-patented pile-anchor method on his own offices for Sonic Drilling Ltd. “One of the main advantages of using a sonic to install pile-anchors is that it can be done efficiently, with no pounding, in tight spaces and without impacting adjacent structures,” he says. “Plus, on larger piling installations, there’s no need for cranes or heavy equipment, while smaller projects can be quickly and easily completed – lots of opportunity to save on costs.”

Sonic pile-anchors also provide earthquake protection by preventing the building from shifting or separating from its foundation – a significant cause of damage and death in seismic shake-ups and building collapses.

Sonic Drilling Ltd is now actively quoting on pile anchoring projects as word has spread locally about the advantages of the new technique.

In addition, like the adoption of sonic drilling technology in general, it should not take long before this new application is in use around the world.

* Nancy Argyle is an experienced disaster communicator. Based in Calgary, Canada, she is a university lecturer, former print reporter and strategic communications consultant who writes on a variety of topics.
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What prompted the design of the LS250 MiniSonic?
The LS250 MiniSonic was designed to fill a need in the market for a versatile, reliable, compact sonic rig. We leveraged the years of experience our drilling services division has in sonic drilling and our expertise manufacturing sonic equipment and tooling to design and engineer it.

Customers are looking for versatility and reliability in a compact sonic rig – which is exactly what we focused on delivering with the new LS250 MiniSonic.

What applications is the LS250 best suited for?
Due to its innate ability to penetrate fast, produce a nearly undisturbed sample to depth while using little or no fluid, and its unique casing advancement system, the LS250 MiniSonic is a suitable solution for the following market applications:

- The mining industry benefits from sonic’s accurate sampling of unconsolidated formations. Applications include:
  1. Heap leach and tailing pad sampling.
  2. Monitoring well installation and water sampling.
  3. Dewatering applications.

- Sonic drilling can provide continuous, highly representative, relatively undisturbed core samples through any geological formation, including boulders and bedrock.

- Sonic drilling is faster than hollow-stem auger and faster than other drilling methods. The faster drilling rate translates to a much lower per-foot cost compared to other drilling methods.

- Sonic drilling generates considerably less waste than other drilling methods. Waste disposal and clean-up costs can be reduced by up to 80% less than auger, rotary and cable tool methods.

Sonic drilling competes with a number of other drilling techniques for use in the above end-market applications, including hollow-stem auger and air rotary drilling. The main benefits of sonic over these more traditional drilling techniques include:

- Sonic drilling can provide continuous, highly representative, relatively undisturbed core samples through any geological formation, including boulders and bedrock.

- Sonic drilling is faster than hollow-stem auger and faster than other drilling methods.

- Sonic drilling eliminates the risk of cross-contamination and is ideal for environmental and geotechnical work.

- Sonic is useful for infrastructure projects with its ability to drill precise straight holes with minimal deviation at varying angles. In addition, it can be equipped with a standard penetration test (SPT) hammer for added versatility.

“Customers are looking for versatility and reliability in a compact sonic rig – which is exactly what we focused on delivering with the new LS250 MiniSonic”
What are the new rig’s key design features?
Utilising proven technology, the patented MiniSonic head has been used in the field for more than ten years on some of the most technical and difficult projects. The patented airbag system isolates vibration, protecting the rig and directing the energy to the drill string for additional efficiency. For the fastest, easiest and safest way to manipulate the core barrel, the head tilts 28º to the side for sample extraction.

The new rig features a rod presenter where rod and casing can be loaded horizontally, and an actuator then presents the rod and casing vertically to the head. The interlocked rotation barrier slows head rotation when the barrier is open, providing additional operator safety. The LS250 MiniSonic is also available with full CE certification (Machinery Directive 2006/42/EC) according to the latest EN16228 safety standards.

When equipped with the Tier 4i engine package, the LS250 provides an extremely quiet working environment. High idle sound level shows 74dB, while the sound level never exceeds 99dB at full power when drilling.

The LS250 MiniSonic dump mast and wiggle tail offer increased precision drilling and allow for drilling from the ground from vertical to 45º. With the crew working from the ground, safety is enhanced by avoiding stairs and safety rails.

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<table>
<thead>
<tr>
<th></th>
<th>LS250 MiniSonic</th>
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<th>LS600</th>
<th></th>
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<tr>
<td><strong>Metric</strong></td>
<td><strong>Imperial</strong></td>
<td><strong>Metric</strong></td>
<td><strong>Imperial</strong></td>
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<td>5,300lbf</td>
<td>40.5kN</td>
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</tr>
</tbody>
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“When equipped with the Tier 4i engine package, the LS250 provides an extremely quiet working environment.”
How does it compare to the LS600 sonic rig?
The LS250 MiniSonic is much smaller. The main difference is rig size and the depth capabilities and casing length. The LS250 has a dump mast, so the crew works from the ground while the LS600 crew works on a platform.

Where has the rig been field-tested?
The rig has been tested in Poland and Calgary, Canada, and the feedback is very positive. Current field tests comparing productivity with other compact sonic rigs are showing that the LS250 MiniSonic is performing as expected – as productive and, in some conditions, more productive than comparative models.

Some of the feedback from testing has included several observations (see box).

Are customers becoming more aware of sonic technology’s benefits?
While adoption of sonic technology has been slow, that is typical in the marketplace, and we are not surprised by the cautiousness of customers in the fields of mining, environmental, geotechnical and infrastructure.

The challenge is raising awareness and building trust. Our goal is to make the benefits of sonic drilling, as well as all of the possible applications, readily available, and then we can demonstrate the benefits to get buy-in from key decision-makers.

Demand for sonic equipment is increasing. As more of the industry starts to realise the benefits, the more they want to utilise the technology for more projects.

We have already been talking to many customers about the LS250, and it has drummed up a lot of interest. And while we cannot speculate or provide specific numbers on demand, we are very optimistic.

What do you see as the future of sonic technology?
We would not be surprised if the market starts demanding sonic drills capable of deeper, larger-diameter samples and enhanced safety. Safety features are always the first priority across the board with many clients.

Would you like to mention any other developments?
We offer a full line of rods and casing, bits and shoes, accessories and consumables for the LS250. The sonic drill rods, core barrels and casing feature a heat-treated pin and box, increasing wear-resistance and the life of the rods. Our new 10ft upset forged drill rod is made using one piece of metal for stronger rods. Core barrel bits and casing shoes are made using high-grade tungsten-carbide inserts and premium steel for increased durability.

“Current field tests ... show that the LS250 MiniSonic is performing as expected”

“...”

Q: Observations following feedback from testing:

$\checkmark$ The rig is extremely quiet for industrial equipment.
$\checkmark$ The rig is structurally sound and the base of the tower is more structurally sound than other compact sonic models.
$\checkmark$ The rig’s lower profile with the mast down in the travelling configuration is better for manoeuvring and improves the line of sight for the remote operator.
$\checkmark$ With the remote manoeuvring, the operator can reposition the rig from a safe distance, while spotters can also stand well away from the unit while in transit.
$\checkmark$ Articulating the control panel improves operators’ hand positioning and posture.
$\checkmark$ The ability to pull the controls away from the drill lowers the angle the drill operator must twist to see the top of mast.
$\checkmark$ The wide tracks cover more ground, distributing rig weight evenly, and the centre of gravity with the mast down in the travel position is very low.
$\checkmark$ Outriggers/jack legs are better positioned than on comparable sonic rig models – away from crew operating areas.

Q: How does it compare to the LS600 sonic rig?
The LS250 MiniSonic is much smaller. The main difference is rig size and the depth capabilities and casing length. The LS250 has a dump mast, so the crew works from the ground while the LS600 crew works on a platform.

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Riding with the tide

A geotechnical driller in deep water takes advantage of a combination of diamond coring and sonic drilling when substrates need to be characterised in an underwater marine environment, several challenges can emerge versus a more traditional geotechnical project.

First, the soils can change dramatically from the mudline down to bedrock. Additionally, tidal fluctuations complicate the water depth and the depth to which soils and bedrock need to be tested.

However, when soil and bedrock near Prince Rupert in British Columbia, Canada, required investigation for a liquefied natural gas (LNG) marine terminal, Mud Bay Drilling adapted a Terra Sonic diamond coring option to its sonic rig.

According to Gordon Gibbons, Mud Bay president, “the water depths at the work site ranged from 15m to 67m, with 7m of tidal fluctuations over a 24-hour period. The scope of work entailed continuous sonic soil sampling with geotechnical sampling (Shelby piston samples, standard penetration test and cone penetration test in-situ soils investigations) utilising a sonic drill rig mounted on a rubber-tracked carrier”.

The plan was to characterise the soils below the mudline using sonic drilling, then switch to HQ diamond coring for the bedrock.

To avoid having to remove the sonic rig from the barge and replace it with a diamond coring rig, a cost-savings component to the plan was to adapt Terra Sonic’s diamond coring option to the sonic rig. Before the project began, the diamond coring option was installed at the client’s shop location in Surrey, British Columbia. All hydraulic hose connections and quick coupled hydraulic connections were tested at that time. This preparatory work enabled an installation in 15-20 minutes at the project site, and coring began immediately.

PROJECT PROGRESSION

Since no previous drilling was carried out in this area of the Prince Rupert marine environment, bathymetric surveys (marine equivalent to topography) were used to estimate what might exist below the mudline.

To add to the uncertainty, logging operations had existed in the area for over a century, so there was a strong likelihood of drilling into logs, steel cables or sunken boats.

With a plan in place, work began with the sonic drill head. Sonic coring was conducted at depths greater than 200ft (61m) below the mudline. Before bedrock was encountered, where the substrate was not as hard and the wear and tear on the equipment would not be as great, sonic technology was used. Once bedrock was reached, the sonic drill was used to either prove the bedrock, or the diamond coring option was used to HQ core at 10-15m into the rock.

The sonic and diamond coring work resulted in valuable data despite the challenges of the marine environment. It was then decided to expand the initial scope of five holes to ten. The barge company, with its experienced crews, also helped the job go smoothly.

IN COMBINATION

The Prince Rupert project offered a suitable opportunity for combining sonic drilling and Terra Sonic’s diamond coring capabilities. The diamond coring option was best suited for extracting the hard rock cores at greater depths, and unlike speed multipliers used to increase rpm of the sonic head rotation, it consists of a dual-speed motor that operates in the 0-600rpm range with 1,623ft-lb (2,200N-m) of continuous torque and 0-1,000rpm with 811ft-lb (1,100N-m) of continuous torque. When used with a Terra Sonic International sonic drill rig, the coring option also includes a frequency control dial that can be used to fine-tune the rpm of the dual-speed motor.

Sonic drilling is increasingly becoming the methodology of choice for soil characterisation. There are several reasons for this growing trend.
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First, sonic drilling is fast. Depending on the formation, the sonic method can be two to three times faster than conventional drilling. This increased speed is because of the sustained vibratory energy that lies at the heart of the technology. The fluidisation of the soil around the drill bit reduces the amount of friction and thus maximises the speed at which drilling occurs.

A second advantage of sonic drilling over conventional methods is the ability to create continuous core samples. Again, this can in part be attributed to the fluidisation of the soil it creates. Once the formation is fluidised, the sonic drill can pass easily through the substrate and provide a nearly in-situ core sample.

Finally, sonic drilling is advantageous because it increases safety and efficiency. It reduces the amount of investigative derived waste (IDW) by around 80% compared to conventional drilling methods. This not only creates fewer opportunities for accidents, but it also reduces time required for materials handling and associated disposal costs, as well as environmental impact and permitting issues.

Terra Sonic International states that by using its sonic drill rigs there will be fewer equipment breakdown issues, fewer incomplete or defective core samples, and fewer boreholes that fail to meet specifications. The rigs’ design also reduces the number of drillers needed for each project, and the flat platform on the rig creates a sturdy, stable foundation on which the drillers can stand and work.

All told, the combination of sonic technology with the diamond coring option worked well for this project. Gibbons notes: “Everything worked very well and the client was pleased. Good geotechnical soil and rock information was retrieved, and the drilling set-up was efficient, even in the challenging marine tidal fluctuations and water depths.”

Left: core samples obtained from the bedrock beneath the mudline.
In Russian far eastern territories, further east than Siberia, conditions are known to be harsh. In the far-off, isolated region of Kolyma, where temperatures can range from -60ºC to +40ºC, life is often difficult. Here, on an enormous mining concession, mining company Gornaya Kompanija Mayskaya is sampling for gold exploration.

To make the mining activities profitable, the company requires highly accurate mine mapping. The site’s overburden contains permafrost, which causes major problems for conventional drilling systems.

To obtain the data it needs, Mayskaya has elected to use SonicSampDrill’s biggest sonic rig model: the LargeRotoSonic.

**SONIC CHOICE**

In the past, Russian dissidents were banished to the outskirts of the country, to places like Magadan in Kolyma. The town is so far away from everything and everyone else that there was no need for a jail to hold the prisoners.

Today, the biggest challenge for mining companies like Mayskaya is to find a skilled crew willing to work in this harsh environment. It also takes time for provisions and spare parts to reach the job site.

To provide workable conditions for the drill crew, SonicSampDrill, along with its partner Fraste, developed a track-mounted drill rig that is fully covered by a tent: the LargeRotoSonic.

**CUSTOMISED RIG**

SonicSampDrill manufactured a custom-designed drill rig to face the difficult circumstances of Magadan. The LargeRotoSonic Arctic, nicknamed the ‘Beast of the Far East’, consists of two segments:

- The drilling rig, containing the engine, mud pump, MudPuppy mud-cleaning system, drill mast and rod-loading system for both drill pipe and casing.
- A crawler, pulled by the drill rig, with an area for handling and packing the samples.

“Beside sample quality and production speed, we have taken a lot of care with safety and workability when designing this rig,” says SonicSampDrill’s commercial director Huug Eijkamp. “The fully automated rod and casing handler creates a safe environment for the driller. No winch is used in handling the drill tooling. A triple floating foot clamp ensures the driller can break the screw thread on any position.”

In addition, the multifunctional drill rig is built to handle all different formations. If fluids need to be used in the drilling process, the rig contains a MudPuppy 170 series system, which allows it to reuse water in a clean and efficient manner.
Scottish success

Sonic drilling specialist GeoSonic Drilling, which recently celebrated two years of trading, is busy promoting the technology in Europe and further afield.

Helped along by a resurgent infrastructure market and a growing demand for specialist sonic drilling services, Scotland-based contractor GeoSonic Drilling has recorded good results over the past two years and continued to develop the business.

Within its first years of operation, GeoSonic has invested in three new sonic rigs, boosting its fleet to 13; new improved internal training programmes; sonic tooling research and development; and new staff.

Environment, health, safety and quality have also featured heavily in the growing business, with certification to ISO9001 last month and final stage audits for OHSAS 18001 and ISO14001 certifications in June 2015.

SONIC LANDSCAPE

In 2014 GeoSonic went on to form a strategic alliance with the Singapore-based drilling company Indodrill, which can now offer services in its operating territories of south-east Asia.

GeoSonic managing director David Dennis says: “We see huge potential for our business in south-east Asia in response to their rapidly expanding economies, which are predicted to outstrip the year-on-year growth of the EU by greater than two-to-one. More importantly, the prevailing geological conditions are extremely favourable for sonic drilling technologies. Our allegiance with Indodrill gives us a firm foothold in this market.”

On European soil, GeoSonic says demand for its drilling services has increased substantially. This has been driven by a greater acceptance of the technique by ground investigation specialists.

Technical manager Andy Condron explains: “Much of the focus of developing the acceptance of sonic drilling in the UK has been down to an approach of educating our peers on both the advantages and disadvantages of sonic drilling, and when it should or should not be used on a project.

“We then rely on the skills of our drilling teams to take the rigs in the field and positively prove the claims. A project completion rate passing close to three figures per year is proof indeed of the strides forward. We are now seeing an unprecedented volume of large-scale tender specifications with the inclusion of sonic drilling.”

Growth into mainland Europe continues with projects completed as far away as northern Poland as well as a little closer to home in France. The French market continues to be a focus point for the business with a new French entity, GeoSonic France, at the final stages of set-up.

FLEXIBLE APPLICATION

Many of the projects undertaken also highlight the flexibility of sonic drilling when rigs are put in the hands of knowledgeable drillers. The GeoSonic fleet can be found completing sampling disciplines from providing continuous sonic core samples to incorporating thin-walled undisturbed samplers to achieve class 1 samples in cohesive soils, or running large-diameter triple-tube wireline rotary coring equipment in conjunction with sonic drilling.

Drilling is not only restricted to land-based projects, with several offshore marine projects again showing that sonic drilling has its applications in the most challenging of ground investigations.

Above: a recent ground investigation at which GeoSonic advanced boreholes with sonic through dense glacial overburden before converting to wireline GeoborS rotary core tooling or destructive sonic drilling through Sherwood sandstone.

Below: Sonic drilling proves its worth when boreholes need to be advanced to target depth quickly. GeoSonic Drilling drilled to 12-15m at a beach location between tides.
Early unrecorded mine workings still cast their blight across huge swathes of the UK. Expansion of the Industrial Revolution created such a hunger for minerals and ore that landowners barely had time to dig for material let alone provide accurate mapping of their work below ground.

In areas where coal, chalk, limestone and iron ore abounded, especially at shallow depths, the workings still cast a shadow. Hatfield, in Hertfordshire, is one such area scarred by unchecked mine workings, but in recent years the local authority, Welwyn Hatfield Borough Council, has focused on trying to treat its legacy of chalk workings. Funded under the government’s land stabilisation programme, the authority has called on ground engineering specialist contractor BAM Ritchies to plug known workings in the Chantry Lane area south-west of the town.

It is the second such scheme the contractor has carried out for the council, after completing treatment to similar workings near Briars Lane in 2008. Now the BAM Ritchies team is focusing on the area below the houses scattered around Chantry Lane and woodland nearby.

**Project profile**

**Scheme:** Chantry Lane Chalk Mines Treatment, Hatfield  
**Client:** Welwyn Hatfield Borough Council – funded by the Homes and Communities Agency  
**Contractor:** BAM Ritchies  
**Contract value:** £5 million (US$7.5 million)  
**Contract type:** NEC Option B – Bill of Quantities  
**Engineer:** Hyder Consulting  
**Project manager:** Mace

Senior geotechnical engineer Andy Morris is helping deliver a grouting regime that will help relieve the blight the old mine workings place on the area.

“The area has been highlighted as one with a high level of risk associated with chalk mine workings beneath residential properties in a risk assessment carried out across Hatfield. The scheme we are engaged in here will remove that blight from the area’s existing homeowners and those looking to buy in the area,” Morris says.

BAM Ritchies is treating voids and collapsed mine workings through over 900 boreholes, adding up to more than 16km of linear drive.

It is a complicated task; the site rig teams need to drill boreholes under houses and through awkward accesses to reach the treatment areas. Some have been carried out in a small wood and nature reserve, while most are from drill rigs set up in various gardens, driveways and verges.

“A thorough site assessment has already been carried out. On the back of that, there is a treatment regime drawn up by project consultant Hyder,” he explains.

This site assessment identified a number of large open voids near the mine shafts in the south-east corner of the woods. Here the team have drilled and intercepted the voids which generally are 8m long with...
Equipment does the deed

BAM Ritchies is using a variety of its rigs to install the complex grouting regime at Chantry Lane. The team is using a Klemm 701 and a Hutte 203 rig to install most of the boreholes across the project, with two smaller units – R1100 and TD308 restricted-headroom rigs – used for those difficult-to-access areas.

“We are working in the side alleyways and gardens of people’s houses in some cases. There are some difficult access issues here,” explains Morris.

That close proximity will see ‘silent’ plant used where it is demanded, and the team is using other working techniques to keep disruption to residents to a minimum.

All grout is batched off site by supplier Cemex and delivered to holding tanks in the site compound before being pumped to the borehole. Around 30m³ of grout is delivered each day.

150mm-diameter boreholes. The team then filled the voids from the bottom with a 1N/mm² grout mix.

“We bore to an average depth of around 18m below ground level, but obviously this is dependent on the level of the mine workings and the topography of the site,” says Morris.

But it is not just immediate bulk grouting of voids the team is carrying out. There is also a regime of compaction grouting that helps consolidate ground around an underground collapse site.

Here grout is pumped through the grout line to varying pressures, helping force grout between the individual elements of the collapse matrix to strengthen the collapse zone and prevent further problems.

“There is an inflatable packer set to depth on the grout hose,” explains Morris. “This is inflated, which seals the borehole and allows us to grout under the required pressure.”

The 1m-long packer section is set at the required depth around the 50mm-diameter grout lines, which are lifted in 2m stages.

The required pressures are set at a maximum of 10bar where the treatment area is 10m or more below ground level. At shallow treatment depths of below 5m across the site, which features chalk overlaid by glacial tills, that maximum pressure is dropped to 5-10bar.

“The pressure we run to and the amount of grout pumped is all dependent on the nature of the ground at that location. Obviously if we have intercepted a void, then there will be a bigger grout take than was perhaps anticipated, but similarly if the ground is better we might not need as much,” Morris says.

TREATMENT AREAS

Consultant Hyder has designed a borehole grid pattern which sees a primary bore at every 3m. This grid should ensure the BAM Ritchies rig teams manage the coverage across the treatment area, but there are secondary holes planned should the initial grouting pattern not prove itself.

“Testing regime proves the point

The site the Chantry Lane project covers has undergone significant investigation and probing.

Thanks to the comprehensive work carried out before Hyder’s initial design, the site will have been prodded and probed three times, including the borehole and grout injection work itself and the final proofing tests.

The BAM Ritchies team has used the same Rockworks 3-D modelling software used by Hyder in the initial ground investigation and design to plot the grout takes at each borehole and ensure they meet design requirements.

But there is a last round for local residents. The validation work and testing is an essential part of the treatment process and the BAM Ritchies team uses super heavy dynamic probing (DPH) techniques to verify the work. These tests measure the number of blows it takes to drive a 50mm-diameter cone 100mm using a known weight of 63.5kg and known drop height of 760mm.

“It is a standard test used to determine the resistance of soils in situ. Low blow counts could be interpreted as an area still being affected by mine workings, so the higher the better,” says Morris.
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Providing protection

Soil nails help protect residents of Ciudad Bolívar, Colombia, from further landslides.

In the south-west of the Colombian capital of Bogotá, approximately two million people live in the world’s third-largest slum: Ciudad Bolívar. Since its development at the beginning of the 1980s, more and more people have moved to this region every year.

Some areas of Ciudad Bolívar used to be quarries. Even today, the area still has unstable sidehill cuts that are up to 25m high, creating a high risk of rock falls and landslides. The winter of 2011 made the problem significantly worse. Colombia suffered one of the worst rainy seasons in its history, during which a large part of the country was affected by problems with instabilities and flooding.

The Colombian government decided to undertake an extensive effort to stabilise the affected areas. Two different options were reviewed: stabilisation with shotcrete, which is the conventional method in Colombia, and stabilisation with high-strength mesh and GEWI bars. Based on the results of a risk analysis, the latter was chosen as the optimal solution.

ON SITE

Especially in Jerusalén and Canteras – two areas that form part of Ciudad Bolívar – several slopes had to be stabilised. A passive, high-strength spiral rope-net system that was anchored into the stable soil using GEWI soil nails proved to be the best technical and most economical solution (due to significant savings through the use of high-strength steels for the soil nails). Anchored walls were also constructed in the soil, comprising sandy rock material. DSI Colombia supplied approximately 6,000m of 32mm-diameter GEWI bars that were installed in the slopes in lengths ranging from 3m to 8m. They were installed using drills on a platform, which was suspended due to the height and complexity of the slope. The GEWI soil nails are corrosion-protected by an epoxy coating and were supplied by DSI to the job site, including all accessories.

The stabilisation project, which began in January 2014, was successfully completed at the end of last year.

Stabilisation specifics

Owner: Instituto Distrital de Gestión de Riesgos y Cambio Climático (IDIGER), Colombia
General contractor: Consorcio HN Ingeniería, Colombia – construction of all stabilisation measures
Contractor: Warco S.A.S., Colombia – supplier of the high-strength mesh and advice during installation
Consulting engineers: Geocing S.A.S., Colombia – design and advice for construction
DSI unit: DSI Colombia – production, supply, technical support and supervision
Dywidag products: 6,000m of epoxy-coated, Ø32mm GEWI bars, L=3-8m

Below: Ciudad Bolívar in Bogotá, Colombia
Photo: Alison McKellar

Below: a spiral rope-net system was anchored using GEWI soil nails

Below: one of the stabilised slopes in Ciudad Bolívar

Left: a spiral rope-net system was anchored using GEWI soil nails
Under control

Mike Deed, managing director of Geoquip Water Solutions, describes the installation and maintenance of an active groundwater-control system for slope stabilisation.

Castlehaven, on the Isle of Wight, lies within an area considered to be the largest urbanised landslide in western Europe. Known as ‘the Undercliff’, the area fringes the whole south coast of the island and is 12km long, up to 0.6km wide and includes the town of Ventnor and other areas of development. Landslide activity and slope failure at the Undercliff have been an ongoing problem for hundreds of years, promoted by marine erosion at the bottom of the sea cliffs, the geology of the area, high rainfall and high groundwater levels.

A significant landslide during the particularly bad winter of 1994-95 had seriously affected an area up to 400m inland from the coast, and it was acknowledged that the instability at Castlehaven would have to be addressed to reduce the risk to public safety, property and the local infrastructure. An additional issue was that Castlehaven is both nationally and internationally designated and lies within an area that is environmentally sensitive.

It was a challenging brief for the project team as the solution had to prevent erosion, improve stability of the landslide, take into account predicted climate changes and in no way impact on the environmental quality of the area.

The severe limitations placed on the project, which effectively ruled out any ground-improvement construction options, meant the only real option was the installation of a groundwater-con-
control system. The design was further compromised by the amount of landslide debris that had to be penetrated by the wells, the drawdown level required and the economic cost-benefit analyses of all options.

**SIPHON WELLS**

The Isle of Wight Castlehaven Coastal Protection project team chose the siphon drain system, a solution for unstable slopes developed by TP Geo from France, consisting of deep electro-pneumatic and gravity-fed siphon wells.

It had never been used in the UK before but operated successfully at a number of sites in Europe.

Narrow-diameter siphon drains were installed in vertically drilled draining wells, deep enough to achieve the required drawdown. The wells are dewatered using the siphon principle and are able to draw down under the influence of gravity. Siphon tubes were introduced into a permanently water-filled reservoir at the base of the well with an outlet downstream.

If the water level rises in the well, the siphon will flow and abstract water out of the well, until the level falls to the level of the outlet, as long as the flow rate in the siphon is sufficient to keep it primed. As the siphon does not require any source of power to operate, installation and maintenance costs were particularly low. The system was designed to cope with pumping at least double the required rate in 2005 to allow for anticipated increased inflow in the future due to climate change.

Regular monitoring and maintenance schedules were built into the design objectives, and a comprehensive system of instrumentation was installed as part of the construction process.

Of particular importance, and as noted in the paper ‘Castlehaven Coast Protection Slope Stabilisation Works’, Niton, Isle of Wight, UK (S Bomont et al, 2007), was the “monitoring of the possibility of siltation, iron or calcium carbonate encrustation or biofouling, which could impede the long-term performance of the wells”.

**MAINTENANCE PROGRAMME**

The system was completed in 2004 and the Isle of Wight council’s principal coastal engineer Peter Marsden has been looking after the Castlehaven project since. He has implemented a high-level maintenance programme, and part of that programme incorporates BoreSaver from Geoquip Water Solutions, a range of well treatments for systems suffering from or prone to iron bacteria, iron oxide, manganese oxide, calcium carbonate and other minerals.

Approved by the secretary of state in the UK and now used in more than 14 countries worldwide, BoreSaver is safe, easy to use and biodegradable, and so appropriate for an environmentally sensitive area.

It removes deposits and residues that build up and cause blockages in wells, pipes, pumps and other equipment.

Flushed through the Castlehaven system twice a year, BoreSaver allows Mike Lidguard, the contractor, to clean the wells and eliminate any groundwater contamination, thought to occur from septic tanks, which cause bacteria to grow within the wells.

Such was the success of the system and the overall project, the Institution of Civil Engineers and the British Geotechnical Association awarded the project team the Fleming Award in 2005. The Isle of Wight Castlehaven Coastal Protection project team comprised High-Point Rendel, Van Oord UK, TP Geo/Group Ress, Isle of Wight Council, Defra and WJ Groundwater.

Eleven years on, the success of the project has meant that, where other parts of the Undercliff have experienced landslip, most recently at the St Lawrence end of Undercliff drive in February 2014 with sections of the land dropping 5-6ft, the situation in the Castlehaven area has remained stable.

“The severe limitations placed on the project, which ruled out ground-improvement construction options, meant the only option was the installation of a ground-water-control system”

Iron oxide contamination
STABILISATION

**Nailed it**

Vertical Access has been employing TEI mast attachments to complete challenging stabilisation projects in the UK.

**Soil nailing is the preferred method to stabilise embankments because it offers time and cost efficiencies**

Below: overview of the slope stabilisation project at Goytside Farm. Inset, below right: the TEI HEM mast installing soil nails.

**TEI HEM mast specs**

- 24v, on a minimum 20t excavator

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specifications</th>
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<tr>
<td>Operating pressure</td>
<td>172bar</td>
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<tr>
<td>Flow</td>
<td>170-190lpm</td>
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**SOIL NAILING**

- 20m soil nails at 100mm diameter
- 1.5m apart
- 7 rows
- Maccaferri MacMat R erosion-control mat
- Seed layer

Soil nailing is the preferred method to stabilise embankments because it offers time and cost efficiencies. However, one of Vertical Access' main considerations for this job was making sure that all time on site was maximised. In general, Network Rail requires engineering works to take place on Saturday nights, usually due to access restrictions near railway lines. However, Goytside Farm could be accessed via fields near the embankment to carry out work midweek, and Murphy made a track up to the embankment as well as a 4m pad to take the machines' load.

Speaking about the project, Andy Shortt, technical director at Vertical Access, says: "We knew this would be a challenging project for us because of the height and depth we were working to – on this project, we needed to reach up 18m to the..."
This article was written by John Mayo, managing director at ground engineering and rock drilling specialist Skelair International.

VERSATILE HEM

More recently, Vertical Access has used the TEI HEM masts for securing the ground following the Harbury Tunnel landslip – the railway line between Leamington Spa and Banbury in Warwickshire. This was the second time in a year that a landslip had occurred in the area, and it took a while for engineers to be able to gain access because the land continued to move for some time. In total there was 300,000t of soil and rock that required stabilising, so Vertical Access brought in the TEI masts to use on a 67t long-reach and a smaller 20t machine. “This is another example of how versatile these masts are; it was essential that we were able to position them to reach all areas to ensure that another slip doesn’t occur in the near future,” continues Shortt.

A seeded soil layer covers the positioned soil nails and Maccaferri MacMat R.
Safe handling

Klemm Bohrtechnik has released a new drill-tool handling system for mini excavators, which was recently presented to the international trade audience at the Geotherm exhibition in Offenburg, Germany.

To facilitate the safe and easy handling of drill tooling, the use of handling devices in conjunction with mini excavators has today become more common practice.

“In fact, one person is not allowed to carry a weight of more than 25kg,” explains Carl Hagemeyer, Klemm’s managing director, technology division.

“Since more and more workers are aware of this, working with a manipulator is – at least in Germany – a well-known alternative for the mechanised handling of drill rods.

“In comparison to rod loaders, which are attached to or part of the drill rig, this device offers the handling of an unlimited number of rods.

“So the drill rig must not be that big and expensive just because it has to provide enough stability in order to carry the rod loader.”

The handling devices for excavators are equipped with tilt and rotation mechanisms in order to precisely position drill tooling. The energy to power such devices is supplied by a free hydraulic circuit from the excavator. To clamp and hold the drill tools, modified clamping units taken from drill rigs are often used.

Mini excavators are used for drill tool handling as they provide enough stability, manoeuvrability, reach and kinematics for the manipulator.

“Mini excavators are easy to operate and easy to adapt for the Klemm HBR system, which comprises a standardised mechanical and control interface. Many anchor job sites require a mini excavator anyhow for lifting the tendon-stressing equipment and suchlike,” says Hagemeyer.

### Model types HBR 120 and HBR 122

<table>
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<tr>
<th>Handling system</th>
<th>Excavator class</th>
<th>Quick release</th>
<th>Tilt rotator</th>
<th>Adjustment (V or H)</th>
<th>No. of clamps</th>
<th>Rod length (single/double rods)</th>
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<td>HBR 120 60-180 mm</td>
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(*) corresponds to product photo

NEW SYSTEM
Klemm has designed a new modular system to handle tooling. The handling devices, type HBR 120 and HBR 122, comprises gripper jaws, tilt-rotator and electrical control units.

The newly designed gripper jaws are defined through the push-claw kinematic. A large range of diameters are covered without having to change the grippers, and it ensures that the tooling is always concentrically clamped.

The handling device can carry up to three clamping units and can be installed onto different consoles for either horizontal or vertical set-up. The electro-hydraulic parallel control...
unit offers 360° endless rotation, tilt +/- 40°, and clamping of outer casing and inner rods.

The electro-hydraulic valves are positioned in a very compact and protected manner within the tilt-rotator. All clamping units are equipped with load-holding valves. The rod handler is controlled within the excavator through adapted joystick levers and an add-on electronic controller.

The modular system ensures a quick conversion and refitting to the original excavator set-up.

Suitable for different excavator sizes, a range of overload safe-tilt rotators are available. There is also a complete range of quick-change adapters. A patent has been filed for the new handling devices.

The new system differs from previous Klemm devices in that the clamping system is self-centring, so there are no mechanical adaptions necessary, when another diameter has to be clamped. The rod, once it is clamped, cannot fall out of the manipulator.

“Anchor and piling drilling jobs with single and even double-rod/casing drill systems can be carried out with the newly developed Klemm HBR 120 series. At the moment, the modular concept provides a clamping range from 60mm up to 260mm and for rod lengths up to 4m. It also provides a higher level of safety when it is used for the handling of auger rods.

“Even when augers are lighter than 25kg, they are quite dangerous tools and it is a good idea to use this manipulator,” says Hagemeyer.

The system is currently in service on different job sites in Germany, Switzerland and the US. “The customers are very satisfied with the performance and reliability. We also offer this system for a very reasonable price, so the customers do not even think about DIY solutions, which potentially might not comply with the European Machinery Directive 42/2006/EC,” Hagemeyer adds.
Bring to light

German engineering and consulting company DMT’s latest addition to its CoreScan core-logging system is an ultraviolet fluorescence imaging tool, officially launched to market in April.

“The development of the DMT CoreScan UV came about as a result of frequent requests from DMT clients.”

The new DMT CoreScan UV was developed in close co-operation with a number of oil companies and related service providers by DMT in Essen, Germany, which has been developing and manufacturing instruments for the natural resources sector for decades.

The main application of the new UV scanner, which made its recent debut at the GeoConvention in Calgary, Canada, is the imaging of oil-bearing drill core under UV light, a routine core analysis operation in the field of oil & gas exploration. It can, however, also be used in the exploration of fluorescing minerals, such as scheelite and fluorite minerals, as well as salt.

FILLING THE GAP

The new device complements the existing DMT CoreScan system, which comprises the DMT CoreScan3, with its associated analysis software and database DMT CoreBase2. This system, which generates unique 360° or planar images of drill core or core boxes under white light in a resolution comparable to a (non-existent) 140-megapixel camera, is a professional scanning tool for drill core. The brand-new supplement DMT CoreScan UV produces images using UV light, an application that can also be used on whole core, slabbed core or core in core boxes.

This development came about as a result of frequent requests from DMT clients. “Although this kind of core analysis is a standard procedure in oil exploration, there was a distinct lack of professional tools on the market,” explains Jens Wiegand, manager of the DMT CoreScan system.

“Many companies who approached us were working with self-made solutions, and asked if DMT would be interested in designing a CoreScan product for this specific purpose,” he adds. Wiegand and his colleagues spent over two years planning, developing and optimising the new scanner.

IMAGING PROCESS

The maximum image dimensions of the CoreScan UV are identical to those of the main system, namely single cores up to a length of 1.05m and core boxes up to 1.15m x 0.64m.

According to DMT, scanning itself takes a matter of seconds, and since images are taken under white and UV light, mixed images can be produced.

The interactive overlay of the white light and UV light images can be adjusted between 0% and 100%. This allows for a more accurate location of the fluorescence. Based on a special set-up and a combination of different optical techniques, the occurrence of light scattering, artefacts and ghosting under weak UV light is minimised.

Once the CoreScan images have been imported to the analysing software and database, interpretation starts and the results are documented for reference and compliance. Furthermore, all core or well-related data can be integrated into the database or can be exported to other software solutions – for example, 3-D modelling and interpretation software.

The CoreScan UV can be operated as a standalone device or in connection with a CoreScan3. Both devices fit into the same transport box, which acts as a dark chamber for the UV device. It is fully mobile and can be moved to and off site easily. In addition, both devices can be operated using one laptop. All existing CoreScan3 can be upgraded with the new UV scanning tool.

DMT says its geodetic, geophysical and geotechnical measuring systems include a range of efficient and cost-effective borehole logging shuttles for 360° optical scanning and digital documentation, such as the DMT SlimBoreholeScanner or the DMT 3D-Borehole Radar.

Alongside maximum accuracy and data quality, DMT claims, such products are designed with extreme robustness for the often harsh conditions in the field in mind.
Positive vibrations

The vibration-rotary head RHV 2400 developed by German drill-head manufacturer Eurodrill has passed its endurance test, writes Frank Horenkamp

For many years the A9 motorway project in the Swiss Alps has caused problems for the construction companies involved in the works.

In particular, the Riedberg tunnel at Gampel-Steg has posed a real challenge. Here, two tunnel lanes, about 500m long have been planned in an unstable landslide area.

Although starting on the eastern side in 2004, tunnel construction had to be halted temporarily in 2005 due to the increasing ground displacement measured in the tunnel tubes and on the surface. Since then extensive investigations have taken place to identify the best approach to complete the works.

PRE-DRILLING AND GROUTING

As a result of the investigations, soil stabilisation work was initiated at the future western portal of the Riedberg tunnel.

Only after finalising these works could the construction of the tunnel be resumed. The project originally ground to a halt because soil was found to be moving downslope by about an inch every year; at the time the south tube had been bored to a length of 190m, while the construction of the north tube had to be stopped at 140m.

The consolidation work at the western end of the tunnel included backfilling the portal area with about 35,000m³ of material to stabilise the slope. In addition, by means of jet-grouting vertical holes, 20m to 25m-deep cement columns were to be created. At least 2,000 columns were needed to form a cohesive body. The extremely difficult soil conditions meant that all the jet-grouting holes had to be pre-drilled.

The use of a down-the-hole hammer could not be considered for such demanding drilling. Even with other conventional methods, no satisfactory drilling results were achieved. The drilling contractor finally decided to use a vibration-rotary head type RHV 2400 from Eurodrill, a new drill that had already performed well at several construction sites.

Pre-drilling on the jet-grouting holes finally began in September 2013. In all around 40,000m were drilled with the RHV 2400 head. The drill string used here comprised a drill pipe, (152mm in diameter), and a full-faced button bit (200mm in diameter).

During subsequent jet grouting, the holes were injected with a total of 30,000m³ of cement suspension grout.

Jet grouting took place using the simplex method, where cement grout is injected into the soil with high pressure at the monitor.

PROJECT COMPLETION

Eurodrill’s vibration-rotary head RHV 2400 finished its part of the works in February, passing a real endurance test under extreme conditions; however, drilling will continue until the September quarter this year. The opening of this section seems realistic by the end of 2016 or start of 2017.

The entire motorway through the canton of Valais (Wallis) should be completed in 2019, but will not be passable all the way through until 2025.

“Tunnel construction was started in 2004, but had to be temporarily suspended in 2005 due to increasing ground displacement”
What seemed like another Phase II drilling job for the PM Environmental field crew turned into an exercise in patience and skill as they navigated variable geology, an unevenly layered terrain and the very real threat that drilling even a foot too deep would contaminate the artesian water supply of a nearby community park.

The worksite was located in the far north of the state of Michigan, US, and had been occupied by a dry cleaner and a gas station that had five underground storage tanks.

LEAKS AND SPILLS
Both businesses had documented leaks and spills of petroleum and other hazardous chemicals.

The site had been abandoned and the state’s Department of Environmental Quality took over and sent the PM Environmental crew up to drill samples and evaluate the risk of contamination to the community.

The area around the site is known for its artesian spring water, and it is the location for a theme park where visitors can sample the water from fountains fed by the underground aquifer. With the high amount of pressure, the water bubbles up naturally. But this pressure would become a major challenge when it came to digging the site.

CLAY SAMPLES
In late 2014, the three-man drilling team was tasked with
obtaining over 30 soil samples, including from the top and bottom of the water table, as well as from the clay seam below.

Armed with the model 6610DT Geoprobe drill rig, a stainless steel hand auger and Geoprobe DT-22 (dual tube) and SP-22 (screen point) sample tooling, the team had drilled and hit water at five feet (1.5m); however, the bottom of the water table varied. If a cross-section of the terrain looks a bit like a layer cake, this one would have been made during an earthquake.

“We knew the clay was between 20ft and 25ft down, but different spots had different depths and we couldn’t be sure exactly when we would hit clay,” says PM Environmental field scientist Douglas Spencer. “We also didn’t know how thick the clay seam was.”

Spencer and the crew were concerned about the size of the clay seam since directly below it was the high-pressured artesian water spring. They had to drill and take samples of the clay, since dry-cleaning solvents such as tetrachloroethylene, also known as perchloroethylene or perc, tend to settle in clay.

“If we went through the clay seam, we wouldn’t be able to seal the hole due to the pressure, and it would contaminate the spring, park and the wells nearby,” says Spencer.
UNSTABLE BOREHOLES

As they started drilling, the hydraulic pressure as well as the saturated soil made it difficult to descend and get samples.

Even using a dual-rod sampling system, in which a larger outer rod surrounds a smaller inner rod (that is removed and replaced with a sampling core), the soil would ‘heave’, or rush into the empty space of the outer rod as soon as the inner is removed, making it impossible to take a sample.

“Heave adds a lot of time to your job because you have to pull all the tooling back out and start over,” says Spencer.

Spencer and the team decided to hand-auger until they reached the beginning of the water table to overcome the unstable boreholes.

“If we went through the clay seam, we wouldn’t be able to seal the hole due to the pressure, and it would contaminate the spring, park and the wells nearby.”

They took samples and proceeded with the Geoprobe to the bottom of the water table and consequently the top of the clay layer for discreet sampling.

“They traded the standard 5ft increments for 2.5ft ones to make sure they would not pierce the clay layer since, as Spencer notes, “a lot can change in 5ft”.

WORKING BY FEEL

According to PM Environmental field scientist Robert Hikade, the group went largely on feel.

“As we were drilling, we would be paying close attention to whether the probe was descending smoothly or if things got a little harder. If it would kick up a little, we knew we were in clay.”

If they made a mistake and pulled out the rod before reaching clay, the soil/water would rush in and it was back to the beginning.

Thanks to the team’s careful work, all of the sampling work was finished in the allotted four days.

Though the site presented challenges that kept them working later than usual, the decision to hand-augur the top of the site and minimise the drilling increments to 2.5ft kept the artesian water safe and brought the project in on time.
New rigs on the block

Italian drill rig manufacturer Mc Drill Technology (MDT) is now represented in the UK by MDT Sales. GeoDrilling International spoke to the new company’s director, Robin North.

Established in 2006, MDT manufactures an extensive range of equipment in its factories in Venafro and Parma in Italy. The company designs and constructs hydraulic drill rigs for micropiling, anchoring, jet-grouting, piling and geothermal applications.

In early 2012 it acquired Geomeccanica CMV, a large Italian manufacturer of special foundation-drilling machines, adding large-diameter pile, continuous flight auger (CFA) and diaphragm-wall rigs to its product line.

In addition to its Italian sites, MDT runs branches in Brazil and Russia and has numerous international distributors in its partner network. The company is looking to gain a stronger foothold within the UK drilling industry.

The new UK operation was officially launched on April 2 under the banner MDT Sales. Initially, it will introduce MDT products through both sales and the hire market to allow customers to“...
experience the quality and utilisation of the rigs. MDT Sales director Robin North, head of rental company North Equipment and former managing director of Soilmec (UK), says: “The company’s mission will be to provide highly trained staff with particular emphasis on the parts and service, and assisting customers with financing or hire of the MDT equipment, which are quality products within a sensible price range.

“The ability of the MDT factories to support us with technical information on the present range of rigs and the possibility of developing new technology with customer participation are excellent. We’ll also work on customising the equipment for the UK market place.”

UK FLEET
North explains that MDT’s dual-purpose MDT 400 machine, introduced last year, is on a par with similar machines from other well-known manufacturers. The rig can be converted to CFA or rotary mode, or adapted for both purposes, which makes it particularly useful for a rental fleet. In addition to the MDT 400, MDT Sales is bringing a range of minipiling machines across to start with, to build up its rig fleet.

“I think we’ll need to increase our fleet of rigs within a 12- to 18-month period to build up our hire fleet. This will give customers an opportunity to get used to the equipment and make them more known in the market place. This strategy will be combined with the sale of new equipment to UK customers,” says North.

“Regarding the spares and service market, in particular minipiling rig users, there is a tendency for self-service and repair of the rigs. The idea with MDT is not to use too many specialised bespoke spare parts, such as slew rings and gearboxes, which will be standard off the shelf and available commercially. We are trying as much as possible to keep everything standard,” he adds.

MDT Sales is currently operating from Oundle in Northamptonshire, but the company is planning to invest in new, larger premises.
The city of Milan features numerous non-functioning or disused water wells, which are seen as part of the city’s heritage.

In order to preserve them, the company in charge of the city aqueduct, Milan Underground Integrated Water Service, has assigned drilling company Idrogeo, based in Fiorenzuola in Piacenza, to completely restore them. As a result, the wells will be fully functioning once again and maintained to the highest standard.

Many of the wells are currently blocked, and the water cannot permeate from the aquifer into the well pipe. The contractor has to remove the entire pipe column and replace it. The new water-producing area of the column is then reactivated and all other areas are sealed.

The advantages of the project can be summarised as follows:

- Reactivation of a well that is not in use, which is exactly aligned with the old well, without having to set up the new administration of concession procedures;
- Integral renewal of pipes with more resilient material (304 stainless steel);
- Reuse of existing structures; and
- Reuse of the existing water connections.

**CHALLENGING WELL**

One of the wells presented the drillers with technical challenges and the method of replacement had to be well planned. Previous attempts to refurbish it have proven unsuccessful.

The initial step was to inspect the entire column with a video camera to determine the exact depth and structural situation of the well, which is 450/400mm in diameter.

With the support of a Massenza MI4 drilling rig, a specially designed cutting tool was lowered to 106m, and an accurate horizontal release cut was made through the wall of the 219mm steel casing.

The next phase was to establish the construction site to accommodate all the material to be removed and introduced during the refurbishment.

The top section surrounding the well pipe was removed with an auger system, and a new 1,200mm-diameter steel casing was installed to a depth of 13m. The casing ensures the stability of the top section and the following operational phases. This part of the operation was completed using a Geax EK110 drilling machine.

The reverse-circulation (RC) method was used to drill over the old well casing and remove all the debris from the hole.

The remaining operations were completed with a Massenza MI45 drilling rig. The drill pipes and 1,200mm-diameter tungsten carbide insert (TCI) RC bit were designed and manufactured specifically for this application. Quick-connection steel pipes (620mm in diameter) were transformed into RC drill pipes by incorporating separate flow lines for the compressed air and circulation fluid.

The viscosity and density of the bentonite mud was carefully monitored and calibrated throughout the entire operation to maintain the integrity of the borehole, as it had to remain open for several days.

Drilling returns were continually monitored and calibrated.
Installation of stainless steel casings from 66m to 93m depth

Drill pipes and 1,200mm diameter TCI RC bit being lowered into the well

“arried out in excellent condition. A specific ‘fishing tool’ was lowered to approximately 9m inside the 219mm-diameter well casings, and the previous release cut meant that the casings were now detached from the redundant lower section. The pull effort required during this phase was well within the capabilities of the drilling rig; however, it was still substantial as the cementing carried out in the 1990s resulted in the casings being securely fixed both internally and externally. The column was removed in sections, and the height of the drill-rig mast allowed this to be completed in 16m sections.

RECONSTRUCTION PHASES

After the extraction of the columns, normal RC drill techniques were employed with standard phases as summarised below:

- Circulation and reconditioning of the drilling mud with properties suitable for the well’s subsequent completion.
- Supply and installation of 304 stainless steel casings with continuous spiral screens with robust structure, placed from 66m to 93m. Drainage gravel was placed outside the screens.
- Saturation up to ground level of the remaining hole with clay and cement injection.
- Start of well-activation operations with airlift and simultaneous production and Hydropuls development. The operations were carried out for several days with continual testing of the well output, which improved constantly until the well stabilised itself.
- Successful completion of the works with payload tests in steps from 10 to 64L/sec with a submerged pump of 60Cv placed at 36m from ground level.
- Payload measurements were made with a Woltman DN 150 meter, and sand content was monitored and assessed in the settlement tanks. The recorded data has shown good results with almost zero sand content for the duration of the tests.
- When 40L/sec was reached, the specific payload reached was 8.49L/sec/m, which complies with the conditions of the project design.

Installation of stainless steel casings from 66m to 93m depth

Drill pipes and 1,200mm diameter TCI RC bit being lowered into the well

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