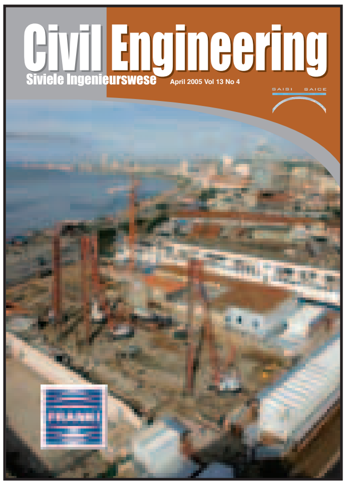
Civil Engineering

Siviele Ingenieurswese

April 2005 Vol 13 No 4

SAISI SAICE



ON THE COVER

Franki Africa devised a pilings and lateral support solution for Torres Atlantico, a twin-tower office and residential complex being built by Angola's three largest oil producers, Sonangol, BP and Exxon. The twin towers will soon soar over Luanda's beachfront and stand as testimony to a burgeoning industry in a country emerging from years of civil war (see article on page 8)

COVER FEATURE

GEOTECHNICAL

FORUM

VIEWPOINT

PROFILE

PRODUCTS AND PROJECTS

SAICE AND PROFESSIONAL NEWS

SAISI SAICE

Civil Engineering
Siviele Ingenieurswese April 2005 Vol 13 No 4

PUBLISHED BY SAICE/SAISI
Block 19, Thornhill Office Park, Bekker Street, Vorna Valley, Midrand
Private Bag X200, Halfway House, 1685
Tel 011-805-5947/48, Fax 011-805-5971
http://www.civils.org.za
civilinfo@saice.org.za

EDITOR
Sarie Moolman
smoolman@netactive.co.za
Tel 012-804-2754, Cell 082-376-2652

EDITORIAL PANEL
Elsabé Kearsley (chair), Irvin Luker (vice-chair), Mike Deeks (president), Wally Burdzik, Johan de Koker, Huibrecht Kop, Jeffrey Mahachi, Eben Rust, Marco van Dijk, Sarie Moolman (editor), Barbara Spence (advertising), Verelene de Koker (secretariat), Dawie Botha (executive director)
dbotha@saice.org.za

ANNUAL SUBSCRIPTION RATE
SA R525,00 (VAT included), International $110,00

ADVERTISING
Barbara Spence, Avenue Advertising
barbara@avenue.co.za
Tel 011-463-7940, Fax 011-463-7939
Cell 082-881-3454

DESIGN AND REPRODUCTION
Marketing Support Services, Menlo Park, Pretoria

PRINTING
Creda Communications, Johannesburg

ISSN 1021-2000

Wanted – at least 100 retired or available civil professionals!

SAICE, FUNDED BY CETA, has been carrying out a major research campaign to determine the number of engineers, technologists and technicians who are operating in the civil engineering field.

In the past, the SAACE and SAFCEC headcounts were normally regarded as being representative of the industry, but civil staff are to be found in all levels of government, parastatals, the supply chain, mining and industrial, academia, home building, etc.

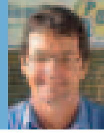
Few sectors or companies do not complain of being short of experienced technical staff. Equally, there are few companies that escape the pleading letters from young students begging for vac work or experiential training.

It is now time to investigate whether there is additional capacity among the ranks of the recently retired and in small companies. ***If you would like to offer your services to mentor or, more correctly, 'knowledge coach' young people, or assist with initiating and managing projects, please submit an abridged CV (not more than two pages) to Allyson Lawless at allyson@ally.co.za.***

The findings and recommendations of the research campaign will be made available in the near future. Watch this space!

Allyson Lawless

Text Boyd Cousins
Pilequip SA



The state of the South African piling nation

OVER THE LAST DECADE the changes in the South African construction marketplace have been dramatic. The impact on the civils industry has been equally affected. Within the civils industry sits the ‘piling contractors market’. This market sector, and its competing contractors, has seen a huge change over the last five years.

The number of market players, the geographic location of contracts, project size and type of piling required have been extremely varied and constantly changing.

The dynamics of this growth has seen the larger contractors moving into Africa and chasing dollar-based contracts; the smaller established contractors have grown in the absence of the larger players; likewise new players have entered the market.

The absence of large civil infrastructure-type projects and the boom in residential projects have given smaller contractors an ideal constant turnover market which has enabled them to expand and equip themselves for bigger projects.

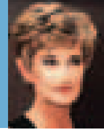
The downside to this change and emergence has been that smaller contractors with less management and lower overhead structures have created a price war among themselves.

Price cutting and counter offers are leading to substandard work and designs are being pushed to the limits. This situation is being exploited by the developers and some professionals with a view to driving down the costs on the project. In this cost-saving drive, quality testing and pile performance testing are being overlooked.

Since piling is still a specialist market, it is clear that this unchecked spiral of pricing cutting and lack of concern for design and pile testing practices must lead to more project delays, deformations/failures and excessive building settlements. The long-term remedial and costly problems for builder and developer will catch up with all parties at some stage, if this practice of poor workmanship and poor pile construction is allowed to continue unchecked by the piling contractors.

It is my strong belief that SAICE or a similar professional body should consider proposals for the formation of a regulating body that can oversee and create a more acceptable work climate within which piling contractors can operate. Disregard of the current situation is definitely leading towards some potentially major structural failures within our domestic market. ◻

Text Lorraine Fourie
lfourie99@telkomsa.net



Giant in geotechnical field retires

After almost forty years of co-piloting the firm of Jones and Wagener, Dr Fritz Wagener has decided to bid farewell to the world of consulting engineers and is thinking about taking up a field that he finds equally absorbing, farming. He says frankly that he finds the thought of retiring from the company that he helped to establish in 1966 and embarking on a somewhat uncertain future path daunting and unnerving. But Fritz von Maltitz Wagener is of Teutonic stock, a youthful 67, and according to his partners and colleagues, an astute businessman with a keen eye for practical solutions – a recipe that spells success. He spoke to Lorraine Fourie on the eve of retirement, reflecting about his contribution to the field of geotechnical engineering and raising some concerns that reach to the core of the engineering profession

THE BOY FROM FICKSBURG

'I've always wanted to go and farm when I retire, but now that it's finally come about, I worry because it's a tremendous change in one's life, especially for my wife, Engela, who's essentially a city girl. It's going to be very challenging indeed.'

The farm in question lies in the eastern Free State, in the Ficksburg district. It has been in the Wagener family for nearly 70 years and Fritz was born there. While he decided to follow a career in engineering, his brother returned to the farm after university to cultivate the land full time, with Fritz becoming the 'Johannesburg partner'. 'I think, however, that I'll remain in Johannesburg for the time being and do consulting work until circumstances for grain producers improve.'

Fritz matriculated from Ficksburg High School, having had very little career advice as a youngster in the mid-1950s. 'A teacher suggested that I should become a scientist, but I don't think I would have been good at that because I like to have answers, and engineering, to me, really is a field which renders answers. In my matric year I read an article on engineering in a career guidance brochure. I remember the picture on the front cover was of an arch dam, and the salary of the director of irrigation was quoted as, I think, 500 pounds a year. So I said, that's me – I'm going to become a civil engineer! Small things like that motivate you as a child, but when I made that decision I knew very little about the profession.'

When Fritz enrolled at Wits for a BScEng degree he knew nothing about geotechnics. Like so many other students who were following the course, he was guided and mentored by the renowned Prof Jerry Jennings. 'We had a very good relationship and later, when I did my master's degree under him, we became close friends.'

Fritz graduated with distinction, the only one in the class of '59. 'I enjoyed my studies tremendously, but I think one excels even more when a person like Jennings is your role model. My parents too were a major influence. We were a close-knit family and they were very proud of their children, giving us all the encouragement we could want.'

The eldest of four children, Fritz retains the close relationship he had with his brothers and sister as well as with his mother's relatives, who still live in the Ficksburg area.

SPREADING HIS WINGS

After obtaining his master's degree in 1961 Fritz spent a year at C A Rigby Consulting Engineers in Johannesburg. 'Rigby did a lot of work on the gold mines in those days and I had a sound introduction to the infrastructural side of gold mining. But then I was invited by my uncle to join his firm of contractors, Dykerhoff and Widmann, in Germany. I spent two years there, at first working in their design office in Munich and then in Bremen and Koblenz. My interest in those days lay in bridges and pre-stressed concrete structures and I had ample opportunity to work on such projects. Even though I changed to geotechnics later on in my career, the time spent in Germany helped me to gain confidence in my field.'

Within three months Fritz could speak German fluently – although he is of German lineage, he grew up in an Afrikaans-speaking home – and he has retained the skill to this day. He also speaks seSotho effortlessly.

When Fritz returned to South Africa, he joined the local branch of Dykerhoff and Widmann (now called DWT because they had gone into partnership with a local civil engineering construction company, James Thompson). 'I was appointed contracts manager with them and that is where I met my future partner, Winston Jones, also a designer and contracts manager.' It was not long before the two started talking about forming their own company, either in contracting or consulting.

Winston was the first to venture out, in

March 1965. 'The idea was that I would join him as soon as enough work had been generated.' Jones and Wagener Consulting Engineers finally opened their offices in Plein Street, Johannesburg, on 1 November 1966, with a staff complement of one draughtsman. Today Fritz leaves behind six partners and a staff of about 70. Winston also retired about a year ago.

Contemplating his 38 years in the business, Fritz regards the extensive work that was done for Iscor at Newcastle in Natal as one of the most interesting and challenging projects he has undertaken. 'Iscor opened a new integrated steelworks there in 1970 and I had the opportunity to handle the geotechnical work for the entire project. Our office also did quite a lot of structural design for them, but I was in charge of all geotechnics.

'I think it is only in a country like South Africa where a young engineer is given the kind of responsibilities I had as a young professional – a situation which continues to this day. Having been part of the engineering arena in Germany I knew for how long I would have had to work there before I was allowed to take on that level of responsibility.

'We worked on the Iscor project for approximately five years and it just about swallowed our entire capacity. But when a proposed steelworks project for them at Rosslyn, Pretoria, was shelved, we had to pursue other avenues.'

DOLOMITE IGNITES A PASSION

Confidence in the work of Jones and Wagener, as witnessed on the Newcastle site, led the chief engineer on that project to introduce Fritz and his company to Anglo American. 'In the second half of the seventies we did several geotechnical engineering projects on Anglo Gold's Vaal Reefs, Elandsrand and Western Deep Levels mines, which was our first exposure to the mining industry. Here we encountered a totally different set of circumstances, centring mainly on dolomite, particularly construction on various types of dolomite. That's where my love for dolomite started.'

Not much was known about construction on dolomite at the time. Building on it was regarded as extremely risky and the precautions which developers adopted were often conservative and costly. Over a period of some ten years (1975–1985) Fritz immersed himself in the field, pioneering investigation and founding methods for dolomitic sites. Much of his experience was gained on the Orkney/Stilfontein gold mines where he led a team which developed appropriate and cost-effective methods for founding all types of structures – from reservoirs to mine headgears, and townships to water-care works – on a wide variety of dolomitic profiles.

His research formed the basis of his doctoral thesis, titled 'Engineering construction on dolomite', for which he was awarded a PhD degree by the University of Natal in 1983. He has published about 50 papers in total, not only on dolomite but also on dams and general problem soils, and feels strongly that one should publish first and foremost in one's own country. 'If you publish a paper at an international conference, it might be one of 1 000 published in five volumes. Very few refer to it again. But if you publish in local publications such as SAICE's Journal, you reach the people that matter. If I can give some advice to young engineers it will be to share their knowledge as widely as possible in their own country before going international. Don't do it the other way round.'

Sharing his knowledge and mentoring young people flow naturally from Fritz's 'amazing ability to get on with people', as colleague and partner Peter Day describes him. 'Fritz has taught me everything I know about fieldwork,' says Peter. 'When I started working with him he spent hours on site with me, teaching me how to profile and introducing me to his clients.'

After years of sanctions against South Africa, which kept Fritz largely homebound, his clients took him as far afield as Malaysia and the Middle East and he became a respected figure on the conference/lecture circuit. In 1984 his contributions were acknowledged by his peers when SAICE's Geotechnical Division presented him with the J E Jennings Award for his work on dolomite. Twelve years later, in 1996, he received the Division's Gold Medal for meritorious contribution to geotechnical engineering in South Africa. And the very next year he joined a select group of engineers on whom the Jennings Award was bestowed twice – this time for the paper that he co-authored on the Merriespruit tailings dam disaster and which he subsequently presented at a conference in Denver, Colorado. Not only was he the leading voice on dolomite, he had also become an expert on tailings dam construction.

SUSTAINABLE DEVELOPMENT

Fritz retained his active interest in dolomite through the years, but the focus of his work shifted in about 1985. 'You really are guided by your clients. At that stage gold was declining and coal mining was up and coming. So Jones and Wagener moved into collieries, at first underground, where we did a number of shafts – incline and vertical – for Trans Natal, Rand Mines and Anglo Coal. Over the next 15 years we were involved largely in water control on opencast mines. We did geotechnical and hydrological investigations as well as the design of slimes dams, slurry ponds, pollution control dams and stream diversions at a number of coal mines – at Rietspruit, Vandyksdrift, Syferfontein, Middelburg, Kriel, Klipfontein and Douglas, as well as at Sasol's Secunda works, to name just a few.'

Because of the nature of their work, at this early stage – before legal controls were introduced – Fritz and his company were already advising their clients to sustain the environment where mining activities were undertaken. 'We always took our responsibilities very seriously and voiced our concern that our mining clients should follow through on their environmental policy and exercise ongoing tight control in their maintenance and rehabilitation programmes.

'Today, of course, many people think we should move away from thermal power and embrace nuclear power on a wider scale. I am one hundred per cent behind this idea because I believe there will be a lot less pollution all round. Apart from noxious gases being emitted into the atmosphere at power stations, you have disturbed terrain at opencast collieries, resulting in water and other pollution. An open-cast colliery, despite sometimes serious efforts, can never be restored to its original pristine state.'

Fritz displays a special enthusiasm for projects where infrastructure had to be created to accommodate the moving of massive machinery. He recalls the challenges that the gigantic draglines (used to excavate the overburden on a mining site) offered. 'These machines have booms the length of a rugby field and weigh between 3 500 and 4 500 tons. To date at Jones and Wagener we have had to design over 200 km of walkway – that is often used only once – to move these machines. So, obviously, the road should not be overdesigned and should be constructed as cheaply as possible, but on the other hand the dragline may not get stuck. Once the dragline has made its way across what used to be, for instance, a maize field, you've got to rehabilitate the land and restore to the farmer a field that will produce the same crop as before the interference.'

The subject of the appointment of consul-

Left: Fritz Wagener (right) and Prof Tony Brink
Middle: Fritz in their Ficksburg wheat field
Far left: Fritz Wagener talking to Peter Day in 1981

tants in a tendering process stirs up another concern. 'The work is often awarded to the consultant who is the cheapest but not necessarily the best in that field,' he says. 'Clients appointing such a firm could end up with a far costlier project, and that after saving a few rand in design fees. When you go to a medical doctor for an operation, you do not call for tenders and select the cheapest. You rather go to the doctor with the expertise in the field.

'A trend in the past few years has been that many clients do not manage their own projects any more but appoint project managers. All that project managers are interested in is time. The sooner a project is completed the more points they score, but the riskier it becomes for the consulting engineer, who is rushed into decisions without studying all alternatives. This is the main reason for the recent spate of collapses of bridges and shopping centres.

'Then there are clients who appoint you to do the design on a project but not the supervision. A design, especially in geotechnical engineering, doesn't stop in an office. It stops on the day you have completed your construction. It is essential that the client should not exclude the supervisory role from your brief.'

Fritz will not be severing ties completely with the profession. He will continue to consult and lecture part time at Johannesburg University and Wits. He loves working with young people. 'I like to teach young graduates the finer points of geotechnical engineering – not so much the scientific facts, which is the lecturer's task, but the field work, the application and problems arising in the field.'

He is concerned because fewer youngsters are entering the engineering profession and many are leaving South Africa. 'My advice to young engineers is to grab the opportunities that this wonderful country offers them. You are entrusted here with responsibilities at a much younger age than would be the case overseas. Don't run away.'

Fritz is facing his new future with the same indomitable spirit. We wish him and his family, 'without whose support,' he says, 'I would not have been able to attain the few accomplishments that have been ascribed to me,' all the best. □

COVER FEATURE

Torres Atlantico

A challenging geotechnical engineering

Geofranki installing the Franki-Titan anchors through the diaphragm wall

EARLY IN 2007, Torres Atlantico, a twin-tower multi-storey office and residential complex, will rise over Luanda's beachfront from driven cast-in-situ piles and lateral support installed by Franki Africa Sucursal Angola, the Angola arm of Franki Africa (Pty) Ltd.

The towers, being built for Angola's three largest oil companies – the Angolan Government Oil Company, (or Sonangol), BP and Exxon – will each soar 16 storeys high, include two basements and five storeys of parking garages, and stand as testimony to the burgeoning oil and gas industry in that country.

In addition to its prominent position and profile, the Torres Atlantico project stands out as one of the most challenging and deepest piling contracts on which Franki Africa has ever installed the Franki-Driven Cast-in-Situ piles.

The soil profile of the low-lying narrow coastal plain that fringes the Bay of Luanda posed a challenge to the project architects, US-based firm EDI, and in June 2000 they called upon Franki Africa to review their professional team's foundation and lateral support proposals.

Having successfully developed techniques to install Franki DCIS piles to depths up to 26 m on the Mozal and Hillside smelter projects, the Johannesburg-based company proposed that large groups of 610 mm diameter Franki DCIS piles be installed as support for the heavily loaded concrete framed structure.

A solution comprising Franki-Titan anchorages installed through a diaphragm wall built several years earlier in the Portuguese colonial era was put forward as a lateral support tie-back solution for the 9 m deep basement excavation envisaged for the project.

GOING TO GREAT LENGTHS ...

In November 2000, the Franki team flew to Houston, Texas, to present their proposed solution to EDI's professional team, the Torres Atlantico project managers and client body.

Soares Da Costa Ltda, a large Portuguese construction company with an operation in Angola, were appointed as the main contractors in September and subsequently appointed Franki Angola to install the piled foundations.

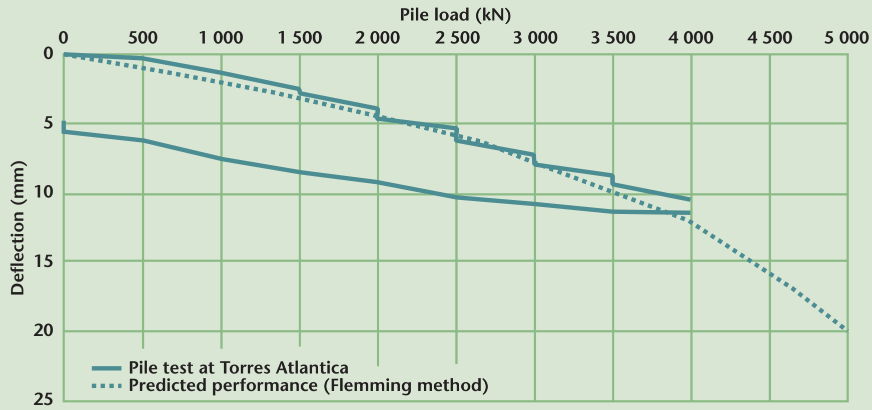
Not only were the site conditions at Torres Atlantico difficult, but working in a country that is recovering from 30 years of civil war also presented its challenges. In addition to the difficulty of clearing customs at Luanda's harbour, spare parts for Franki's specialised equipment are unavailable in Angola and had to be sent from South Africa. In spite of these challenges and the technical complexity of the project, Franki completed the piling operations in December 2004 with only slight delays. Based on the success of this contract, Franki was approached to undertake the design and construction of the lateral support for this project with an estimated completion date of mid-March 2005.

SOIL CONDITIONS

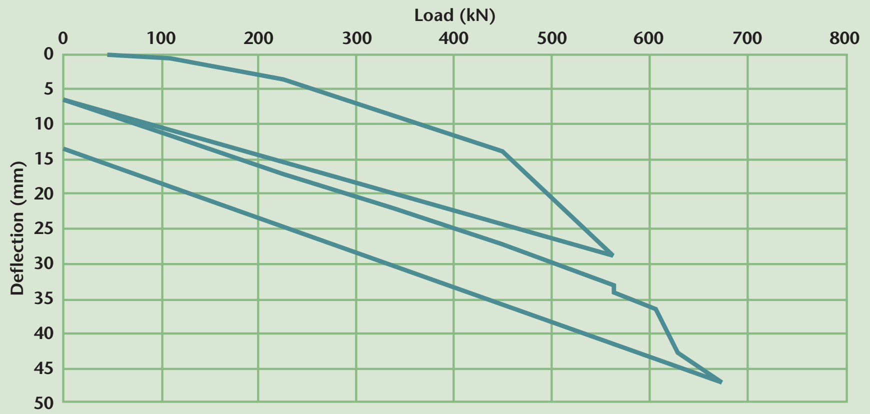
The Bay of Luanda comprises deep marine and alluvial sediments underlain by bedrock deeper than 40 m. Though the soil profile underlying the Torres Atlantico site is

project

610 mm Franki test pile and performance prediction



Franki 450 kN Titan anchor performance



remarkably uniform, the challenge for Franki lay in penetrating the 16 m thick stiff clay horizon and the dense boulder horizon with a driven piled solution and a bored piled solution, respectively. Moreover, the shallow phreatic surface and fragile old buildings surrounding the construction site imposed vibration and movement restraints on both the piled foundation and lateral support contracts.

To support the twin tower block structure, approximately 850 Super Heavy Franki Piles in groups of up to 20 were predrilled through the stiff clay layer and driven onto the very dense boulder horizon at depths of 24 m to 26 m below existing ground level. An enlarged base was installed for the required working load capacity of 2 000 kN with permissible total pile head settlement of 8 mm. Franki DCIS piles were selected for their performance as well as their ability to ensure the load capacity by measuring the basing energy in each pile.

Before the project could begin, a trial programme to demonstrate the load settlement performance of the 610 mm diameter Super Heavy pile had to be completed. To mitigate perceived environmental problems, such as the impact of vibrations, installation techniques and pile load capacity on Luanda's main police station, a building over 200 years old situated on the site's northern boundary, pre-drilling was used optimally.

Measured peak particle velocities of less than 5 mm per second resulted in an uninterrupted contract and the education and awareness programmes developed for the surrounding occupants proved that driven piles remain a viable proposition in city centres.

After Soares Da Costa Ltda's in-house geotechnical contractor experienced difficulties installing and achieving load capacity with post-grouted strand anchorages, the construction company called upon Geofranki to install the Franki-Titan system on the Torres Atlantico site.

The problems that resulted from the unsuccessful installation of the anchors initially installed resulted in construction programme delays and, to make up the lost time, Franki is installing more than four anchors a day, using one machine.

Once again, Franki had to consider the environment while devising the lateral support solution. In very weak ground conditions under old structures that are in a poor state of repair, Franki opted to install approximately 200 No 40/16 Franki-Titan anchors with a 10 m fixed length generating a working load capacity of 450 kN. This facet of the Torres Atlantico project – the anchor installation – is on programme and the scheduled completion date should be achieved.

The success of Franki on the Torres Atlantico project thus far is founded not only on its proven technical proficiency, but also on the support rendered by the main contractors Soares Da Costa Ltda and the professional team on the project.

Contact
Gavin Byrne and Daan Coetzee
Franki Africa (SA) (Pty) Ltd
Tel 011-887-2700
Fax 011-887-0958
E-mail info@franki.co.za

Text Alan Parrock Geotechnical principal
ARQ Consulting Engineers (Pty) Ltd

Interesting geotechnics at Impala Platinum

Impala Platinum has its primary operations concentrated on the western limb of the Bushveld Complex near the towns of Phokeng and Rustenburg in North-West. Expansion of the facilities made it necessary for a headgear with a foundation situated 26 m below surface to be constructed at the proposed site of the new Number 16 Shaft. This article details some interesting aspects of the geotechnics associated with the excavation

GEOLOGY

The geology of the area belongs to the Rustenburg Layered Suite of the Bushveld Complex. According to the 1:250 000 geological map (2526 Rustenburg) the unit present on site is the Pyramid gabbro-norite. This unit comprises gabbro, norite and anorthosite layers that gently dip to the east. To the west and north-west of the site outcrop hills of gabbro-norite are present (2).

TYPICAL PROFILE

At the site a typical profile comprised the following (3):

- 00,0 to 01,3 m — Clay vertisol
- 01,3 to 04,1 m — Completely weathered, very closely jointed very soft rock resembling gravel; norite
- 04,1 to 09,5 m — Medium weathered, closely jointed, medium hard rock; norite
- 09,5 to 18,2 m — Slightly weathered, widely jointed, very hard rock; anorthosite
- 18,2 m + — Slightly weathered to fresh rock, very widely jointed very hard rock; norite

SLOPE DESIGN

The above profile meant that the upper weathered materials to approximately 10 m depth had to be battered back to generate safe slope angles, whilst the lower, less weathered, very hard rock could stand practically vertically. The general layout of the box cut is detailed in three-dimensional format in figure (4).

However, this simplified design profile was complicated because seismic forces induced by blasting generate localised instability of faces. Thus sloping to slightly lower face angles and meshing the faces proved particularly successful, particularly when combined with shotcreting selected noses (5).

3,5 mm φ, 100 mm diagonal mesh was used in conjunction with 1,8 m long split sets to ensure that localised instability would not be problematic as excavation proceeded (6).

WEDGE FAILURE

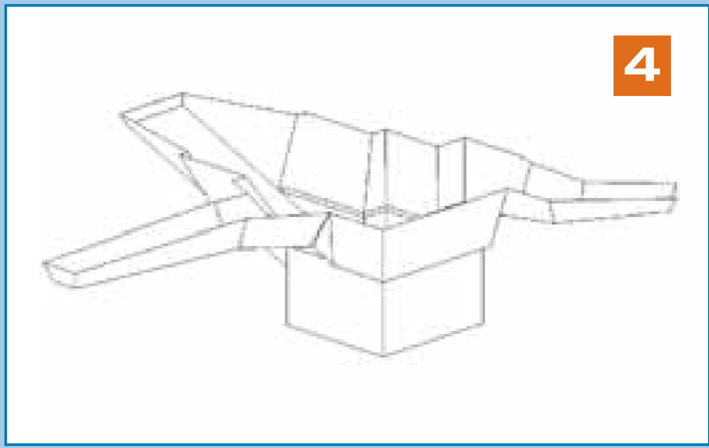
Possible wedge failure was investigated and mitigating remedial measures were designed (7).

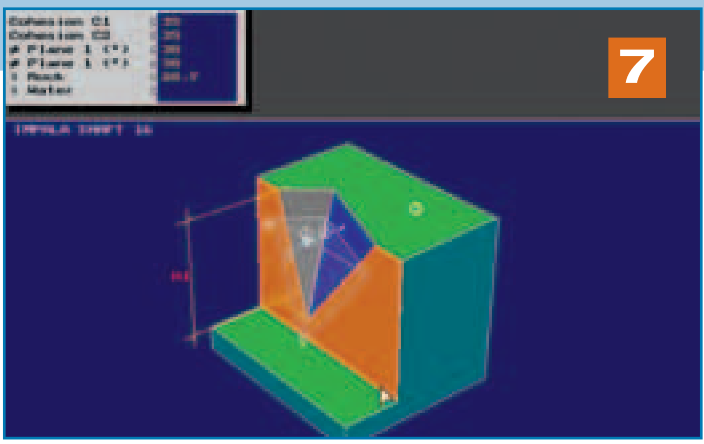
EXCAVATION

Removal of the approximately 30 000 m^3 of blast material was accomplished using steeply sloped access ramps and six-wheel-drive articulated dump trucks (8).

DEWATERING

Although significant quantities of water were predicted to occur from pump tests conducted during the investigation, initially two pumps (and later a single pump) were capable of controlling water during excavation (9).

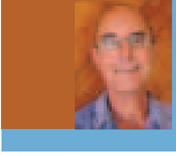
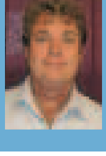




Client
Impala Platinum Ltd

Client alliance partner
Read Swatman and Voigt (Pty) Ltd

Subcontract for box cut design
ARQ (Pty) Ltd

Text Brian Harrison
Principal, Inroads Consulting cc
André Wood
Managing director, TRG International (Pty) Ltd

Horizontal directional drilling and its

HORIZONTAL DIRECTIONAL DRILLING (HDD) is a construction procedure that has been employed internationally for some 25 years. It describes a specific form of trenchless technology that, by definition, enables a variety of underground ducts and pipes to be installed with minimum disruption to the ground surface. The technique combines the steering technology developed in the oil industry with boring methods employed for conventional horizontal trenchless crossings. It requires little, if any, excavation to install pipes and conduits in a range of lengths, sizes and depths along pre-assigned vertical and horizontal alignments.

The technique has gained worldwide acceptance and is considered an established method for installing pipes and ducts ranging in sizes from 50 mm to 1 500 mm beneath large obstructions such as rivers, wetlands, highways, airfields and buildings.

In 2001 it was estimated that there were over 10 000 HDD rigs of various sizes worldwide, yet in South Africa there are probably fewer than ten, suggesting that local application of the system has been limited. No doubt there are many reasons for this, not least of which being the high cost of importing the machinery, tooling and consumables, compounded by the reluctance of clients and consulting engineers to accept an apparently new and untested technology as a viable alternative to conventional construction methods.

APPLICATIONS

As with all trenchless methods, HDD has the advantage of minimising the disruption caused by conventional open cut and cover excavations for service installations, and it improves safety as it eliminates the need to support the sidewalls of deep trenches. HDD has the added advantage of enabling crossings to be constructed beneath large surface obstructions along preset horizontal and vertical alignments where direct, indirect and social costs would otherwise make such an alignment unfeasible if conventional construction techniques were to be employed.

Environmental applications are wide and varied, including limiting surface disruption in sensitive areas such as wetlands. Others include the installation of well screens along horizontal curves within or near a contaminated zone, thereby optimising the efficacy of contaminated water recovery by enabling substantial lengths of screen to be placed in the areas most needed. In addition, HDD offers the ability to enhance bio-remediation of pollutants by the injection of appropriate liquids or gasses. Post-installation of leachate drains in tailings and landfill sites is another application of the technique in the environmental field, as is the sealing off of contaminated areas by horizontal injection of polymers or grouts beneath polluted underground plumes.

HDD can be employed to provide horizontal water extraction wells beneath or within rivers or lakes where, owing to set-up costs over water, conventional vertical boreholes may prove to be too costly.

Another possible application, which requires further study and research, is the use of horizontal guided drilling for site investigations.

THE TECHNIQUE

HDD essentially involves three processes:

- The first stage entails installing a pilot hole drilled from the surface at a pre-determined angle and along a prescribed path. The drill path comprises straight inclined and straight horizontal sections connected to large radii curves. The latter are dictated by the size of the drill string, pipe material and pipe diameter and are formed by a small kink, or bend, in the drill string just behind the drill head, termed a 'bent sub'. Steering is controlled by rotating the drill head to the desired direction and then pushing the drill string forward until the required direction is obtained, after which drilling is continued along the realigned path. The size of the pilot hole is dictated by, among others, soil conditions, the size of the drilling machine and the drilling method. The pilot hole is supported by slurry, consisting of a mixture of water and bentonite, and sometimes polymers.
- The second stage enlarges the pilot hole by reaming to achieve the required size within which the product pipe or duct is to be installed. Typically, the final hole should be between 1,3 and 1,5 times the outside diameter of the product pipe, and for large diameter holes a number of reaming operations may be required. The process is normally carried out by attaching the reamer to the drill string on the side opposite to that of the drill rig, from where it is rotated and pulled back into the pilot hole, which is enlarged by cutters attached to the reamer. Lengths of drill pipe are added to the reamer as it is pulled back to the rig. Slurry is again used to support the hole. Depending on ground conditions, forward reaming can also be carried out. In this process the reamer is thrust forward by the drill rig and guided by the pre-drilled pilot hole.
- The final process entails pulling the product pipe into the pre-drilled hole. The pipe, usually steel or HDPE, is prefabricated to the required length on the side opposite to the drill rig, from where it is connected to the drill string via a pulling head onto which a swivel is attached. The swivel prevents rotation of the pipe as it is pulled by the drilling rig into the hole until the full length of pipe is in place.

EQUIPMENT

The equipment required to carry out HDD work includes the drilling rig, tracking system, mixing and recycling equipment, tooling, including rods, bits and reamers, and consumables such as bentonite

Table 1 Industry classification of HDD rigs

Description	Pipe diameter (mm)	Depth range (m)	Bore length (m)	Torque (Nm)	Thrust/pullback (ton force)	Machine weight (tonne)
Mini	50–250	5 to 10	180	Up to 1 300	Up to 90	8
Midi	250–600	Up to 20	270	1 300 to 9 500	90 to 450	16
Maxi	600 – 1 200	Up to 60	1 500	Up to 108 000	Plus 450	25

Table 2 Typical applications for rig classes

Description	Applications
Mini	Telecommunications, power cables, water, sewerage and gas lines
Midi	Crossings beneath streams, roadways, environmentally sensitive areas such as wetlands
Maxi	Substantial crossings beneath rivers, highways and airfields

and polymers.

Drilling rigs are classified into three groups termed mini, midi and maxi rigs. The type of rig selected depends on the length of pipe to be installed, the hole size, thrust and pullback capacity, torque and depth to be drilled. Table 1 illustrates the industry classification of HDD systems developed in 1994. Since then substantially more powerful rigs have been manufactured, enabling larger, deeper and longer crossings to be achieved, and the classification presented here is probably due for updating.

Mini rigs are typically used for short distances and small-diameter pipes and conduits associated with municipal service reticulation lines. Maxi rigs, on the other hand, are used for longer distances and large diameter pipes, such as for bulk water and sewer, and beneath sizeable crossings. Intermediate distances and pipe diameters require a midi rig, the capabilities of which fall between those of the mini and maxi. Table 2 outlines typical applications for the various rigs classes.

In South Africa there are estimated to be seven mini and three midi rigs, most of which are located in Gauteng. No maxi rigs are available locally, although they can be purchased from overseas suppliers and manufactures.

Tracking systems are required to ensure that the position of the drill head is correctly aligned vertically and horizontally. These include the walkover and wireline steering systems, which provide information on the magnetic azimuth for horizontal control and inclination for vertical control.

The walkover system employs a transmitter, or 'sonde', located near the drill head. When positioned directly above it, a receiver at ground surface locates the position and depth of the drill head. The wireline system consists of a magnetic sensor placed in a non-magnetic bottom hole assembly, which is connected to a computer at the surface by wires which pass through the inside of the drill pipe. Magnetic readouts are interpreted by the computer, providing information on the alignment and depth of the bore.

In South Africa the walkover system is the cheaper and more popular, but it does have its limitations, some of which are discussed below.

Tooling includes drill bits, rods and reamers, the correct choice of which is vital to the successful completion of an HDD project.

Drill bit selection depends on the subsoil conditions and geology and range from duck bill and jetting or shovel bits for soft soils, through to tricone roller bits for stiff and dense clays and sands, and downhole hammer and Tricone bits with mud motor for very dense soil and rock conditions.

Drill rods are typically 127 mm (D150) to 171 mm (D300) OD hollow steel pipes in lengths of 9,1 m. Rod selection is related to the rig specifications, crossing length and product pipe diameter.

Reamers come in a range of sizes and shapes, each selected to suit the soil conditions encountered. They include spiral or fluted reamers, which are the most versatile since they can be used in sands, clays, gravels, cobbles and soft rock. Others include wing or open reamers for stiff clays, barrel reamers for loose sands and mixed soils, blade reamers for soft and firm clays, and rock reamers for rock formations.

Slurry mixing and recycling consists of a chamber for mixing the bentonite, water and additives and a collection pit where the returned mixture with cuttings from the hole are passed through a system of sieves and hydro-cyclones to separate the cuttings, which are disposed of, from the bentonite mixture, which is re-used.

Drilling fluid is one of the most important components of the entire HDD operation since it fulfils a variety of functions, including holding the cuttings in suspension and transporting them to surface, stabilising the hole, lubricating the drill bit and rods, cooling the tooling and preventing loss of slurry through micro-fissures and voids. Polymers and additives are sometimes mixed with the bentonite slurry. These are expensive but they do aid in improving lubrication, controlling fluid loss, enhancing suspension of the cuttings, and controlling viscosity.

SOME HDD PROBLEMS

Proper investigation, planning and the correct selection of equipment and tooling, and the use of experienced operators can overcome many of the problems associated with HDD projects.

Geotechnical conditions underlying the route are probably the most important factors to be considered in any HDD project, as they govern the selection of suitable tooling and provide information for the correct slurry design. Variations in subsoil conditions, both laterally and with depth, the presence of obstructions, the depth to a perched or regional water table and the presence of shallow rock are just a few of the many potential difficulties that may be identified by undertaking a geotechnical investigation before embarking on any HDD project. Potential problems can then be anticipated and addressed at the planning stage before undertaking the work.

Steering problems normally arise when soft clay or loose sand overlies very dense soil, such as pedocretes, or rock, more so at shallow entry angles. Under these conditions the drill head may deflect off the harder underlying material, leading to deviations from the desired route. Pushing the drill rod without rotation may assist in this regard. A similar steering difficulty may be encountered when the drill deflects off boulders occurring within the formation. Very soft low strength clays may also present steering difficulties, as they are unable to offer any significant shear resistance to the steering tool when a change in trajectory is required.

Tracking or locating systems, particularly the walkover system, present problems where metallic objects or magnetic and electrical interferences are present. Such sources include microwave towers, traffic signal loops, power lines and electrified security fences. The walkover system requires the receiver to be located above the transmitter at the drill head, and access to certain areas such as over rivers and wetlands or beneath buildings becomes problematic. The walkover system also has depth limitations. Although more expensive, the wireline tracking system is one method of overcoming some of these difficulties.

Borehole stability is governed by the material through which the hole is advanced and collapse of the hole may lead to numerous difficulties. These include high pullback forces, high torque and surface settlement, which occurs if the hole is large or near to the ground surface. While slurry often addresses potential borehole collapse, excessive use may cause swelling of some active desiccated clays owing to water absorption by the clay. This causes the borehole to slowly close with time, resulting in a hole size smaller than the product pipe. While potentially preventing hole collapse, thicker, and hence more viscous, slurry requires that more torque be applied by the rig.

Slurry loss is not uncommon, particularly in sands and at shallow depths where seepage occurs through permeable material. Hydraulic fracture in fissured clays and jointed weathered rock is another source of fluid loss. Increasing the fluid density and control of drilling pressure can partially assist in reducing these losses.

Drill rod failure occurs when excessive torque and pullback forces are applied to the string by the rig, mainly during reaming. Tensile and bending failure may occur during pullback along sharp curves which induce high stresses in the rods at the bends. Steep entry angles require high pullback forces. The grinding action of abrasive silica rich materials such as quartzite may wear the rod where it rests on the rock, reducing its diameter and hence strength.

LIMITATIONS

HDD is not the panacea for all installation projects and it does have its limitations.

For example, *machine size* limits the length and alignment for a given pipe diameter. Although sizeable projects can be undertaken with smaller rigs, the risks are increased, particularly during reaming and pipe installation. Careful planning, detailed investigation and considerable operator skill are required to undertake an HDD project employing a machine with lower thrust, pullback and torque than that ideally required.

Space limitations may in certain situations obviate the use of HDD, especially in developed urban areas. For a given depth, entry angle, pipe size and material type, the drilling rig must be set back to a predetermined entry point. If obstructions such as buildings and roads prevent this, then HDD is not feasible at the location intended. Similar requirements are necessary at the exit point. Space is also required for the rig, slurry mixing and recycling plant, disposal and for storage of the tooling and consumables.

Pipe type and diameter place limitations on the radii within which the pipe can be installed. Sharp curves with small radii place undue stresses on the drill rod during pullback, and both tensile and bending stresses on the pipe itself. Large pipes require large bend radii with concomitant large set-back distances requiring additional space, which, if at a premium, makes the technique unviable.

Buried obstructions such as boulders can seriously effect steering, as discussed above. Fill areas containing large blocks of reinforced concrete rubble are even more problematic. Not only does this affect steering, but the steel interferes with the tracking system and severely wears the drill bit.

PROJECTS

A few projects that were undertaken recently are described below, together with the problems encountered and the methods employed to overcome them.

- A 200 m long crossing beneath a river underlain by alluvial deposits comprising cobbles and sand was undertaken in the Eastern Cape. A 315 mm HDPE pipe was installed after pilot boring with a Trihawk and roller-cone drill bit and staged reaming with hole openers. Problems were encountered in penetrating the dense tightly packed cobbles, which may have been overcome had a deeper bore been designed and a mudmotor employed, as originally proposed. Owing to limited funds, a shallower depth was selected and an alternative drilling technique to that ideally required was used.

- A 284 m long crossing beneath a river underlain by silt and silty sand was undertaken in Mozambique. A 200 mm steel pipeline placed within a 315 mm HDPE sleeve was installed after the pilot bore had been enlarged to accommodate the sleeve.
- Two 200 mm diameter HDPE pipe ducts for electric cables were installed beneath a railway line, a road and a stormwater channel, over a distance of some 150 m and within residual granite comprising uniform clayey sand of stiff consistency. The crossings were located near to a substation and beneath a railway line where high electromagnetic fields were generated, leading to problems with the walkover tracking system. This was overcome by utilising a dual frequency sonde.
- Numerous HDPE sewer pipes, ranging in size from 200 to 315 mm, were installed over a total distance of some 1 200 m to depths of the order of 4 to 5,5 m in a busy urban area. Variable ground conditions were encountered, ranging from transported silty sands through to clayey silt, residual andesite, residual shale gravel and dense sand, and residual sandstone. Tracking was carried out with Digitrak locating systems and a Magenta 0,1 % drilling sonde, which enabled drilling to the tight tolerances required for the sewer lines.
- A number of crossings for a gas line were installed in soils ranging from fill, alluvial gravels and cobbles, expansive clay and residual sandstone, to quartzite and dolerite. Pipes consisted of bitumen-coated steel of 204 mm OD. Tooling included a standard jetted system, mud motor, directional air hammer and hole openers. All bores were designed and logged and the final 'as-built' bore installation with details and drawings provided.

  The main problem was the variable geotechnical conditions at each of the crossings. No information was provided prior to establishing on site and ground penetrating radar was used in an attempt to estimate the in-situ density of the soils, and by inference consistency, and to locate services.

  The bitumen-coated cover to the pipe also created some difficulties, particularly in areas underlain by weathered rock, as the gravel-sized particles tended to adhere to the coating, necessitating large pullback forces to overcome the increased frictional resistance. Care had to be taken to ensure that all gravel and sand suspended in the bentonite was removed before installation of the pipe was attempted.

  In some locations the underlying active clays were dry and stiff. When slurry was introduced, they expanded, resulting in some difficulties in installation. Slightly larger holes were reamed where these conditions occurred. Loss of slurry through fissures, which are common in these clays, particularly in the upper horizon, also occurred when crossings were too close to the ground surface.
- A 450 mm diameter 74 m long HDPE sewer pipe was installed in dense ferricrete in a township. Very few problems were encountered on this contract. Laying out the product pipe before installation did interfere with access to driveways and some roads, but the local residents were informed of this beforehand and were very accommodating.
- A 137 m long crossing beneath a road and located in rock was undertaken employing a 25 ton midi rig and a directional air percussion hammer. Because of space constraints and other restrictions the rig was set up on a platform some 4 m above the road level. Complex curves were required and continual directional changes had to be made throughout the bore, together with allowances for bend radii of the drill rod, sleeve pipe and the product line. Rock hole openers were used to enlarge the bore diameter to the required size before it was finally cleaned and the sleeve pipe installed.
- In Saudi Arabia, a maxi rig was used to install two crossings, one a 406 mm diameter 1 000 m long steel pipeline located beneath a 167 m high sand dune. No problems of any significance were encountered except that of designing a facility capable of pumping and recycling 2 000 ℓ/min of slurry down the hole during the reaming stages. The second installation consisted of a 610 m long 762 mm diameter steel pipeline placed beneath a highway interchange. Sandy clay and sandstone were encountered in the bore. The only available water in the area was saline, which required a special blend of drilling fluids. Of the few problems encountered, one was that the viscosity of the drilling fluids increased from 40 to 120 seconds owing to the sandy nature of the material. An additive and water were used to constantly adjust the fluid mixtures. Buoyancy of the pipe was calculated and adjusted throughout the pulling process. The entire installation was completed in 17 days.

CONCLUSIONS

HDD is a useful and internationally accepted technique for the installation of pipes and ducts covering a range of sizes and lengths in areas of surface and buried obstructions. It has applications in many fields, including civil infrastructure, water abstraction and environmental monitoring and remediation.

The method requires fairly sophisticated equipment and tooling and the experience of skilled operators. While it has its advantages, there are limitations for which the technique is suitable and it can be fraught with problems if undertaken by inexperienced contractors or with inadequate equipment.

Since it was first implemented, a great deal of research has been undertaken and significant developments have been made in the machinery, tooling, tracking equipment and slurry design, and HDD has now reached a level of advancement that makes it a viable, competitive and cost-effective alternative to conventional subsurface installation methods. Projects can now be undertaken which, for social, environmental or financial reasons, would not otherwise have been possible.

For various reasons the method has yet to receive sufficient recognition and application in South Africa, which has placed limitations on the number of contractors carrying out HDD work, and on the number and size of drilling rigs and tooling available. ◻

Text **Dr G V Price** Terreco Consulting East London
N North-Coombes Goba Moahloli Keeve Steyn (Pty) Ltd Durban
R Damhuis South African National Roads Agency Port Elizabeth

Special thanks to the South African National Roads Agency for permission to publish this article

Innovative solution for fracturing rockmass

SLAKING AND DISINTEGRATION in Karoo Mudstones is a well known, extensively documented geotechnical problem, especially when ongoing disintegration in rock cuttings results in undermining of more resilient overlying sandstone, with concomitant crashing of these onto the roadway. Recent investigations into continuous ravelling and loose rock falling onto National Route N2 in the Kei Cuttings of the Eastern Cape have resulted in innovative and cost-effective methods of stabilising rockmass exposures susceptible to this mode of failure.

DISINTIGRATION IN MUDROCK

One of the major engineering problems associated with the rapid weathering of mudrock surface on exposure is when disintegrating or slaking rock in cuttings is overlain by more resilient rock such as siltstone or sandstone. Over time, cavities expand beneath competent rock until a vertical joint is intersected, or until the cantilever strength of the overlying rock is breeched, at which time catastrophic failure occurs and masses of rock plummet down to the road. There is usually very little warning and the condition is always potentially life-threatening.

CONCHOIDAL FRACTURING IN SANDSTONE

Conchoidal fracturing in sandstones of the Adelaide Subgroup; Beaufort Group; Karoo Sequence, is a phenomenon observed in the field by the authors, and appears to be particularly prevalent in the Border and former Transkei areas of the Eastern Cape. Yet the phenomenon is poorly referenced. A literature survey has provided only one reference, namely from Brink (1983), in which he refers to work by Haughton (1969) that 'certain sandstones in the lower Beaufort Group are also liable to disintegrate with a small-scale spheroidal type of pattern'. Haughton suggests, in one oblique reference, that 'both the lower beds of the Beaufort and the underlying Ecca sediments contain bands of spheroidally-weathering greenish or bluish sandstones, greenish flagstones, and calcareous concretions'. Important here is not so much the 'spheroidal' reference, but rather the stratigraphic locality, that is, as 'lower' Beaufort, placing these particular sedimentary units in the Border and former Transkei areas.

Dr G V Price, investigating reasons for a large sandstone rock collapse in the Barberskrans area of the N10 near Cradock, discovered that certain sandstones – on weathering – produced not 'small-scale' spheroidal fracturing as suggested by Brink, but relatively large-scale arcuate or ellipsoid fracturing which Price has termed conchoidal fracturing of weathered sandstone. Further investigations in the Kei Cuttings of the N2 reveal the problem to exist there, too. Here, newly exposed sandstone in certain rock cutslopes indicate rock to be initially free of any visible deformation, yet in time dark lines appear on the rock surface, which lines appear to demarcate planes of weakness along which moisture is being absorbed and lost. In time relatively large-scale breakup of the rock occurs along these, now elliptical lines, to produce a smooth curved fracture – hence the term 'conchoidal fracture'.

GEOTECHNICAL ANALYSES

Investigations into rockmass cutslopes in the Kei Cuttings reveal moderately to slightly weathered, grey, pale yellow and brown, closely jointed sandstone with minor intercalations of olive brown mudstone in some cuttings. In others, mudstone occupies the entire cutslope. Mudstone rock disintegrates on exposure, with continuous accumulation of gravel/pebble-sized fragments of mudstone in the side drain creating an ongoing maintenance problem. Exposed sandstone, on the other hand, undergoes conchoidal fracturing, which could give rise to large-scale, even catastrophic, rockmass failure, although measured failures to date have been relatively small. This problem is exacerbated by a joint pattern capable of localized toppling and wedge failure. Scaling by barring down loose material has improved stability but this is only a temporary measure since ongoing disintegration and conchoidal fracturing upon exposure will create the same poor rockmass conditions over and over.

Long-term, more permanent solutions, such as battering back, topsoiling and vegetating the slope, or stabilising with rockbolts, mesh and shotcrete, are either impractical or too costly. Cutslopes are high and extensive, which would require excavating half the mountainside in the former, and the latter, besides being aesthetically unattractive and environmentally intrusive, would be prohibitively expensive. A more innovative and cost-effective solution was required, leading to the installation of a 'cable-mesh anchorage' trial section on one of the larger cutslopes in the Kei Cuttings.

CABLE-MESH ANCHORAGE – THE SYSTEM

The use of rockfall netting fixed to cutslopes has seen widespread use internationally, particularly in mountainous countries where rock failures are prevalent. Here in South Africa, rock catch-fences and meshnet stabilisation have been successfully utilised, notably along Chapman's Peak Drive. However, to the authors' knowledge, this is the first application of rockfall netting specifically to control near-vertical disintegrating/conchoidally fracturing mudstone and sandstone rockmasses.

Cable-mesh anchorage comprises a system of mesh and cables anchored into the rock face and revolves around three major elements, namely mesh, cabling and anchorage pins.

DESIGN AND CONSTRUCTION

Geotechnical investigations required for the design include joint surveys to determine the extent of any rockmass instability plus estimates of strength/disintegration and fracturing of the rock substance. The kinematic instability is estimated based on stereographic projections and stability analyses determined from these projections.

The cable-mesh anchorage system installed in the Kei Cuttings at N2 Section 17, km 1.2 (immediately north of Kei Bridge) comprises the following components:

- *Mesh:* 2,7 mm diameter hot-dip galvanised and uPVC-coated, hexagonal woven double-twisted wire mesh, with 80 mm x 100 mm mesh openings, installed in 2 m widths hung off the summit cable and tied to the base cable. Mesh laced together along all joints, using 2,2 mm diameter uPVC-coated binding wire.

Before

During

After

- *Cables:* 10 mm woven steel cables strung diagonally across the face of the cutting, connected to 12 mm horizontal cables installed at the summit of the cutting and 2,5 m above the toe (height chosen to discourage theft of mesh).
- *Anchors:* 16 mm diameter galvanised and threaded gewi bar dowels, grouted 500 mm into the rock face in pre-drilled holes, with 1 200 mm long bars installed above the summit to anchor the top cable. Rock face anchors installed at a bi-directional grid spacing of 5 m, with diagonal cables strung through them and secured to top and bottom cables. Note that anchorage dowels can also perform a stabilising function and be designed as rockbolts where appropriate.
- *Summit drainage:* Desirable, but not provided in this case, due in part to the difficult terrain and in part to the presence of existing established vegetation. The binding effects of existing root systems and the water attenuating effects of the vegetative cover were deemed to be integral to the stability of the summit area and were therefore not compromised. In addition the contributing flow from the summit catchment is relatively small.
- *Catchwall:* Desirable where the possibility of larger boulders slipping through the bottom of the mesh is high – not required or provided in this case.

CONCLUSION

The cable-mesh anchorage system has been implemented and tested in the Kei Cuttings with outstanding results. Rock debris alongside the road has been reduced to virtually zero with most of the loose rock trapped by the mesh. A small quantity of finer fragments slip down the face and onto the toe verge, where they are removed as necessary. There is therefore also a maintenance cost benefit. A significant bonus has been the 'greening' effect in the exposed rock face. Debris accumulation acts as a filter with larger fragments trapping smaller ones and resulting ultimately in localised islands of soil where vegetation has established. This will result in partial revegetation of even very steep slopes and with it, added stability and a boon to environmental aesthetics. Indeed, proprietary eco-friendly filter fabrics can be installed below the mesh to mitigate the erosive effects of wind and water and to accelerate the greening of the slope.

Cable-mesh anchorage is not, however, the panacea for all ills. It requires a specific geological set of mudstone/siltstone and sandstone assemblages; state of weathering is fundamental; and is more applicable to areas of existing road located immediately adjacent to the road verge where space for alternative measures is limited. The rockmass must be largely homogenous, whether it be sandstone or mudstone, and large ledges of unweathered rock undermined by rapidly slaking mudstone would, for example, not be an appropriate condition. An excessively weathered rockmass would also not be appropriate as at some point the rockmass stability defining characteristics – discontinuity relationships; joint condition; hardness; rock disintegration; etc – are superseded by the rock substance properties which revolve around soil mechanics characteristics such as shear strength; presence or absence of moisture, and so forth.

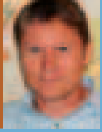
These apart, the use of cable-mesh anchorage for disintegrating or fracturing rock is a very viable tool of rockmass support. Conchoidal fracturing of sandstone rockmasses in the Eastern Cape – and possibly elsewhere – is a relatively poorly known mechanism of rockmass instability, with little documentation yet there is, as shown, substantive proof and recognition of this malady, which has potential for large scale mass movement. Cable-mesh support has in the meantime proved capable of supporting such rockmass. The method is innovative, economically sound, aesthetically enhancing, and environmentally effective.

References

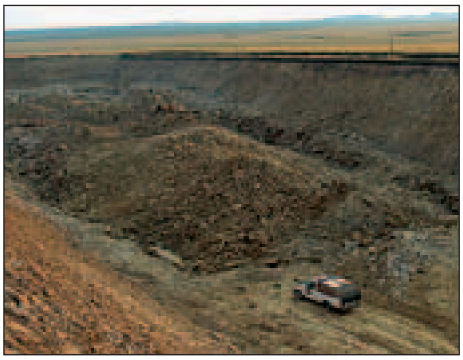
Brink, A B A 1983. *Engineering geology of southern Africa; Volume 3; The Karoo Sequence*. Pretoria: Building Publications.

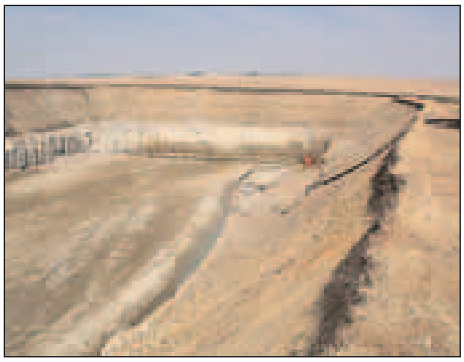
Haughton, S H 1969. *Geological history of southern Africa*. Cape Town: Geological Society of South Africa.

Venter, J P 1980. The engineering properties and road-building characteristics of mudrocks with special reference to southern Africa. DSc thesis, University of Pretoria.



Text Pieter Oosthuizen
ARQ Consulting Engineers (Pty) Ltd





Geotechnical aspects of the development of the Sigma MOOIKRAAL UNDERGROUND COLLIERY

Sigma Colliery has been the sole supplier of coal to Sasol Infrachem Industries (SII) in Sasolburg since 1952. Several alternatives to this supply have been investigated and having natural gas piped from Mozambique is probably the most viable long-term solution. Coal, however, is still required to produce the steam that is needed for the SII processes. The current coal reserves of Sigma Colliery in Sasolburg are not sufficient to supply needs in the long term and several other alternatives were investigated. The most viable solution to supplying SII with coal was to establish a new operation, Sigma Mooikraal Underground, in the Block 13 portion of the Sigma Colliery reserves

GEOLOGY

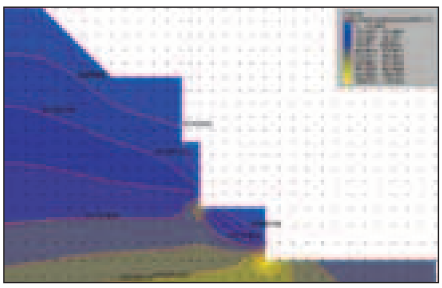
The general area of the proposed mining development is along the eastern flank of a major area of geological upheaval known as the Vredefort Dome Impact site. The Vredefort Dome was formed an estimated 2 000 million years ago when an asteroid some 10 km in diameter hit the earth close the where the town of Vredefort is situated today. The area is primarily underlain by sedimentary lithologies of the Ecca Group of the Karoo Supergroup, particularly those associated with the Vryheid Formation. Dolerite intrusions in the form of sills are generally present in the upper horizons of the Karoo Sequence. The Block 13 coal deposits cover an area of approximately 12 km from north to south and 10 km from west to east.

INITIAL INVESTIGATIONS

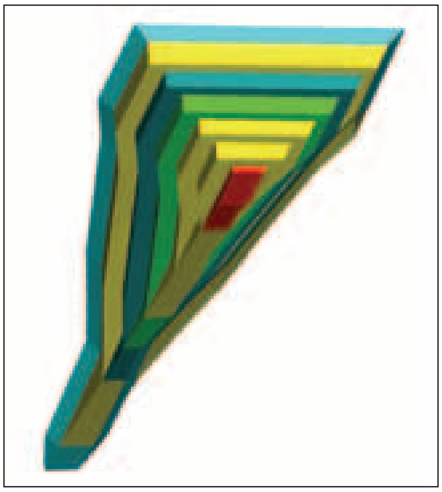
ARQ Consulting Engineers undertook a geotechnical investigation of various aspects of the proposed development at the feasibility stage. This included general infrastructure such as offices, change rooms, stores, water handling dams, storage silos and some 18 km of conveyor route. In addition, the mine entrance area was investigated by drilling rotary core boreholes as well as percussion boreholes logged by traditional and geophysical methods. Based on the findings of this investigation, recommendations were formulated on the most appropriate way to access the coal reserves.

ADIT EXCAVATION

Sasol decided that an open-voided, adit excavation was the most cost effective and practical means of accessing the coal reserves. The initial plan was to excavate a 500 m long decline at a slope of 8 degrees to terminate at a square base 52 m below ground level. An extensive geotechnical investigation into the feasibility and detail design of the various components of the access route to the coal was undertaken by means of geo and hydro exploratory rotary core boreholes supplemented by an extensive programme of geophysical probe logging. Two-dimensional finite element software was used to model stresses and deformations of actual and planned excavations.

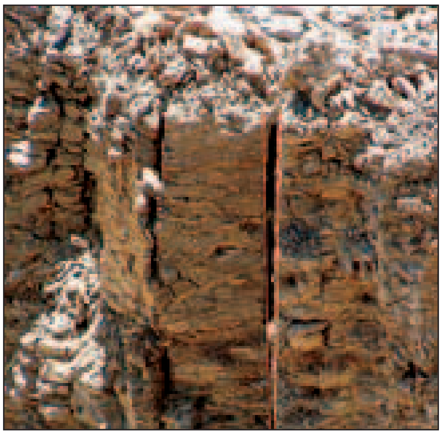


Assessment of stresses and strains in rock mass by finite element methods



Three-dimensional view of a digital terrain model used in the planning stages of the adit excavation

The layout of the adit excavation, blasting patterns and required lateral support were greatly influenced by the highly weathered and fractured nature of a near surface, hard rock dolerite sill (UCS around 200 MPa) characterised by steeply dipping discontinuities that opened up very soon after excavation. This problem was solved by trimming back cut slopes excavated into the dolerite sill to 45 degrees and in this process removing most steeply dipping discontinuities, thus drastically minimising the propensity for toppling failure.

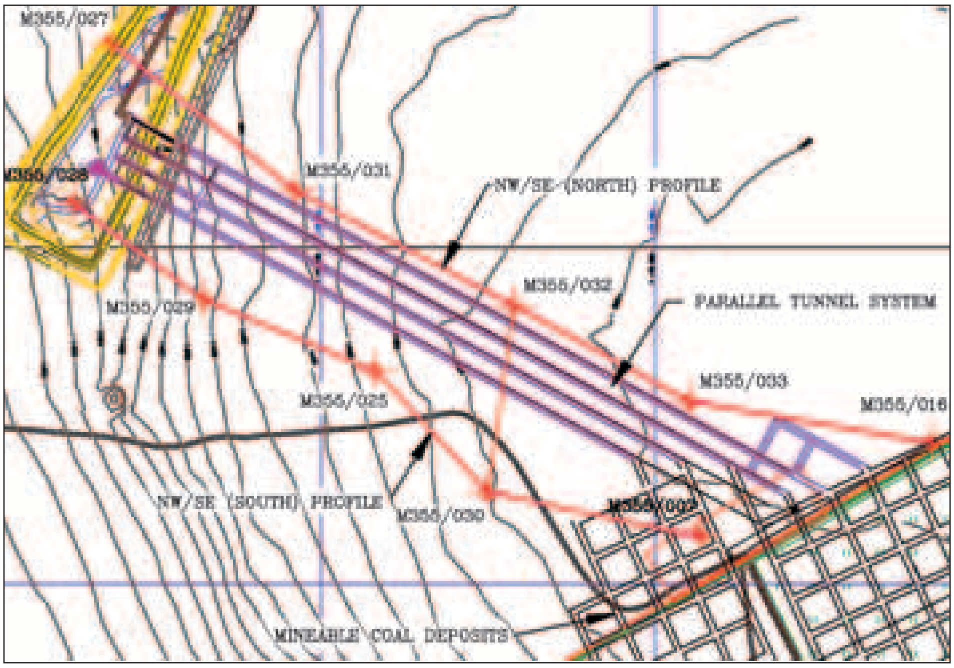


Excavation through the upper, hard rock dolerite sill produced many challenges

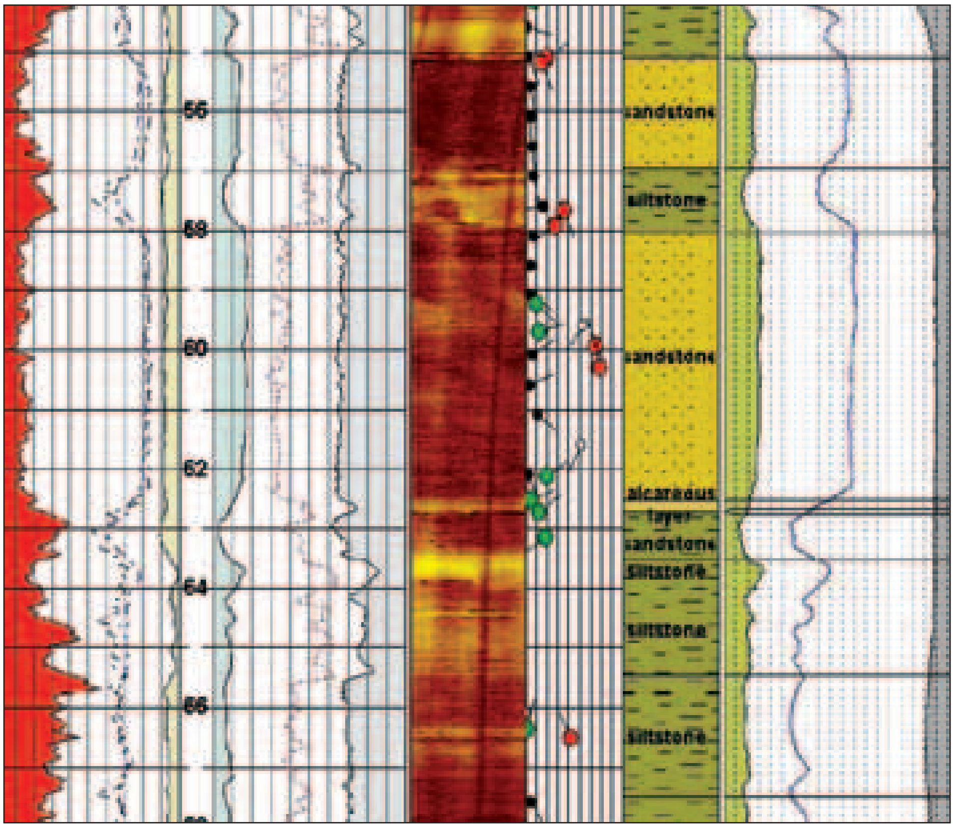
That problem having been circumvented, the underlying sandstone formations proved equally problematic. The exposed sandstone was much softer (UCS around 20 MPa) and more friable than expected and degraded rapidly on exposure to atmospheric conditions. Great difficulty was experienced in drilling the pre-split holes into this material. A decision was taken to use a tracked excavator to remove as much as possible of the soft, overlying sandstone, mostly in the form of loose sand.

Pre-split and bulk blasting drilling into sandstone soon commenced. Owing to the softness of the sandstone, the first blast caused large-scale damage to the rock face to such an extent that it was decided to abandon the deepening of the adit excavation. The deepening of the adit excavation was subsequently terminated at a final depth of approximately 22 m below surface.

Extensive damage to sandstone rock after pre-split and bulk blasting



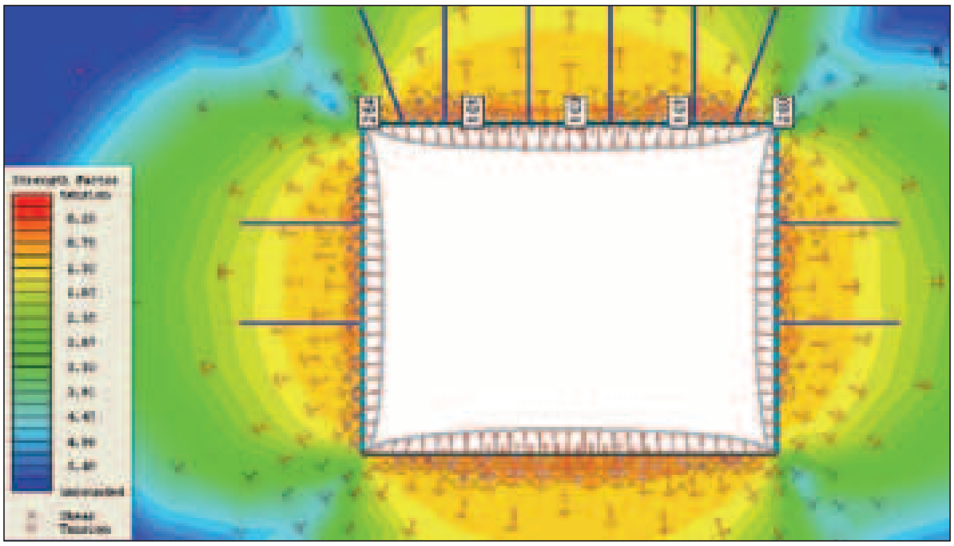
Layout of the four parallel access tunnels relative to the adit excavation and mineable coal deposits



An example of a portion of a geophysical log giving rock type, rock hardness, spacing and inclination of discontinuities. An acoustic scanner image of the borehole wall is included

Sector No	CH along c/l of tunnel (m) Start	End	Rock	Discontinuity spacing	Average dip (degrees below horizontal)	Average dip direction(s)
1	0	150	Sandstone	Slightly to moderately fractured	17 to 24	120 and 260
2	150	185	Siltstone/shale	Moderately to highly fractured	38 to 42	130 and 190
3	185	234	Sandstone	Moderately fractured	22	90 and 270

Typical summary of information gathered from the results of the geophysical logging



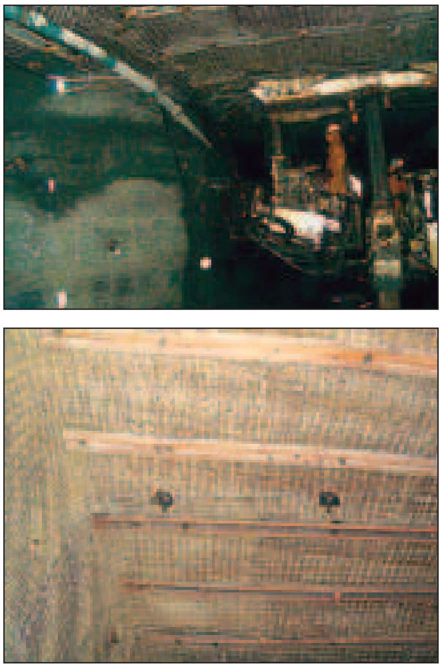
Typical output from a plastic analysis undertaken of an access tunnel indicating expected deformations, contours of strength factors and failed elements

ACCESS TUNNELS

Sasol Mining has extensive experience in the underground mining of coal in the Mohlolo underground section of Sigma Colliery. Based on this experience and because similar rock conditions were expected at the new site, a preliminary layout of tunnel dimensions and spacing, rock bolt spacing and other rock support measures were proposed for the new tunnels. ARQ was approached to undertake an independent assessment of the proposed support measures based on existing information and the drilling of additional rotary core boreholes and geophysical logging along the proposed route. Data gathered during the geophysical probing of the boreholes was used to assess the quality and cutability of the rock material along the route of the tunnels.

The assessment of the proposed support measures was undertaken with the Phase2 software platform; an elastic and plastic, finite element program for calculating stresses and displacements around underground or surface excavations. Various rock support types and configurations as well as liner supports were incorporated into the models.

One of the four parallel tunnel entrances at the base of the adit excavation



Rock support during and after installation

Movement along discontinuity in exposed rock face

FINAL REMARKS

At present the excavation of the access tunnels is ongoing. Although large volumes of groundwater and soft rock conditions have been encountered in certain areas, only isolated and small instabilities have been recorded. All is on track for the first extraction of coal from the newly developed mine in September 2005. ◻

TRENCH SHORING

Prefabricated shoring systems

ONE OF THE MAJOR DILEMMAS on a construction site, in particular where the work involves excavations, is achieving optimum production without in any way compromising the safety of workers. Shoring a trench or excavation in South Africa usually means installing timber planks and props in the excavation. This is a time-consuming process and is extremely limiting, as it involves working within a congested timber-propped excavation.

In Europe, the USA and Middle East, timber shoring has, for many years now, been replaced by prefabricated, portable and re-usable trench-shoring systems. These systems not only vastly improve safety on construction sites, but achieve substantial increased productivity.

Time saved for completion of a shored trench installation using prefabricated shoring systems is at least three-fold. For example, a 100 m length of 4 m deep pipe installation in a timber-shored trench could take 15 days to complete, whereas the same job shored with prefabricated trench boxes could take five days.

Krings Verbau, of Germany, pioneered an excellent range of prefabricated shoring systems some 30 years ago. These shoring systems are designed to stringent European safety standards and for ease of use. Krings produces a wide range of shoring elements suited to different excavation applications, ranging from lightweight systems to withstand earth pressures of 17 kPa and depths of 1,5 m, to systems withstanding earth pressures of 120 kPa and depths of 5–7 m. Corner elements for pit shoring and adaptations for manhole widenings on pipelines also form part of the range. These trench-shoring products have re-use factors of 250 and more.

Transportation to site is on a flat-bed truck and assembly is undertaken with a site excavator or TLB. The installation procedure comprises an initial shallow excavation followed by the insertion of the shoring elements, followed by further excavation and pushing downward on the elements until final depth is reached. Extraction of the shoring system is undertaken while backfilling is in progress.

The timber-shoring system currently used in South Africa requires that the construction worker must enter the previously excavated trench or pit to install the shoring elements, thus working in a dangerous situation to make the trench or pit safe. By contrast, the Krings shoring systems are installed during excavation and extracted during backfilling, and thus the worker never enters an excavation which is not shored.

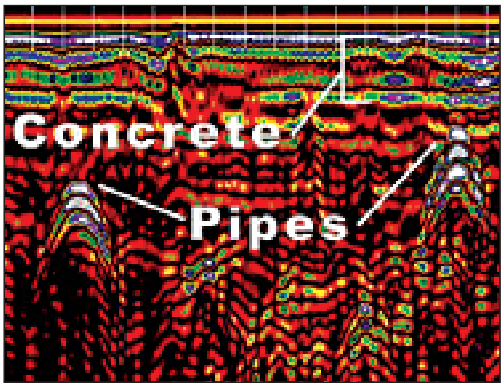
The South African civil engineering construction industry should be looking to achieve the same safety and productivity advantages offered by prefabricated shoring. The promulgation of the new Construction Regulations in July 2003 now require that an engineer-designed shoring system must be used to make safe all man entry excavations deeper than 1,5 m below ground level. The new regulations also place a large degree of responsibility for ensuring safety on site on the client, and therefore on the professional team employed by the client.

Krings shoring products may be purchased or rented in South Africa through Aject Africa (Pty) Ltd. In order to optimise the use of the trench-shoring systems, Aject Africa and Krings Germany offer a design service to ensure the client gets the right product for the job.

Contact
Hugh Feely
Adject Africa
hugh@ajectafrica.co.za


Text Terry Odgers
Red Dog Scientific Services

GPR technology in concrete and road structure inspection and



RADAR'S EVOLUTION FROM RESEARCH TOOL TO MAINSTREAM APPLICATIONS

Ground penetrating radar (GPR) systems have been in use for over 30 years, most commonly in geophysical applications, such as mapping bedrock layers and water tables. Because of advances in electronics and software, GPR has rapidly evolved into a valuable investigative tool for mainstream applications. Today GPR is used to study, evaluate and solve a wide range of infrastructure problems such as locating and mapping buried utilities; determining road layer thickness, material characteristics and sub-base and sub-grade conditions; assessing the magnitude and location of deterioration inside reinforced concrete structures; and investigating the condition of railway track systems and components. Such GPR-based information can be used to provide an efficient and effective method of identifying infrastructure problems.

Although early GPR systems were complex and required an experienced operator to collect and interpret data, current systems employ advanced analysis software and improved user-interfaces, making them significantly easier to operate. Radar is no longer just a tool for researchers. It is an accurate, cost-effective and non-intrusive tool that is practical for mainstream maintenance and inspection.

A BRIEF REVIEW OF THE TECHNOLOGY

A GPR system emits a pulse of electromagnetic energy into a surface and measures the energy reflected from any buried targets within that structure. As the system is moved across the surface, a series of reflected signals are used to create a profile image of the sub-surface. Collecting multiple parallel profile lines allow the creation of 3D images. The total power of transmitted pulses during system operation is only about 1/1 000th that of a mobile phone, so GPR poses no adverse health problems for the user or interference with existing communications systems.

A typical GPR system consists of a control unit, antenna and survey cart. The control unit contains electronics that produce and regulate the pulse of radar energy that the antenna sends into the ground, and record and store the data. Antenna frequency is a major factor in depth penetration and target resolution, and should be selected based on the application. A higher frequency antenna will locate smaller targets, but will not penetrate as far into the surface, while a lower frequency antenna will penetrate deeper, but will have lower resolution.

GPR APPLICATIONS FOR UTILITY DETECTION

Speed and accuracy are critical in locating or mapping underground utilities. Simply marking known utilities from as-built maps is often a risky approach, as many of these documents are incomplete or outdated. Since the consequences of making an error are potentially huge – ranging from the financial costs of interrupting communication or electrical services to loss of life – professional locating contractors are being called upon with increasing frequency to verify what lies below the surface. GPR offers superior ability to determine the location and depth of utilities and identify voids and buried objects. Unlike other locating technologies such as radio frequency identification, GPR can detect utilities of all material types, including PVC, and enables the user to map closely spaced utilities in 3-D. When integrated with GPS technology, an accurate map of the area can be produced and archived for future reference.

GPR APPLICATIONS FOR CONCRETE STRUCTURE INSPECTION

In many situations, inspection of concrete structure using traditional non-destructive testing (NDT) methods such as acoustic emission and radiography (X-ray) is not practical. The processes can be time-consuming to complete, require evacuation of the area being tested, and demand considerable set-up time before the inspection can even begin. All of these factors can be unappealing to customers who need a fast, reliable, unobtrusive method.

GPR quickly and accurately locates rebar, tension cables, plastic conduits and voids to a depth of 40–50 cm in existing concrete structures (for example tunnels, walls, floors, slabs, decks, balconies and garages). In addition, it is used to detect and map the relative condition of concrete so that rehab projects can be prioritised and planned more effectively. For QA on new concrete structures, radar is used to inspect and measure slab thickness.

GPR APPLICATIONS FOR ROADWAY INSPECTION

GPR systems are now able to collect roadway information at speeds up to 100 km/h so that traffic flow is minimally affected. A high scan rate permits imaging of small voids and pipes underneath the road. Concrete roadway (up to 40 cm) and bituminous/asphalt roadway (up to 90 cm) can both be surveyed with a high degree of accuracy.

On new projects, accurate roadway thickness profiles collected continuously along roadways provide an excellent method of verifying adherence to QC/QA specifications. Roadway thickness accuracy is critical for establishing valid load capacities – a factor that greatly enhances the life of any roadway network. The digital 'infrastructure profiles' can be archived for immediate access, and can facilitate the planning of long-term maintenance programmes.

Radar is ideal for the identification and inventory of older roadway systems whose construction history is often unknown. Lack of good data presents an expensive challenge in determining whether to spot repair a stretch of roadway or to partially or fully reconstruct it.

GPR APPLICATIONS FOR BRIDGE DECK INSPECTION

GPR can be used on overlaid and bare concrete decks reinforced with longitudinal and transverse steel (upper and lower mesh) to identify deterioration quantities (delamination, punky concrete, corroded rebar) and their locations on the deck structure.

As in other applications, radar can also be used for QC/QA verification on new bridges. If there is not enough rebar coverage, the concrete can wear away, leaving the reinforcements accessible to the elements, for example salt and moisture can cause corrosion, degrade the integrity of the concrete, and lead to unscheduled and costly repairs. An excessive amount of rebar coverage can have a negative impact, as excessive surface cracking can result. Accurate measurement of concrete cover (depth of rebar from exposed concrete or asphalt surface) on new construction allows engineers to better predict the service life of a bridge deck, reducing the likelihood of future problems.

In bridge maintenance, radar complements and enhances traditional engineering evaluations. Radar-imaged deterioration maps can be used to guide the optimal use of corrosion potential testing, chloride testing and coring – minimising the deck area required for sampling. The resulting data provides an accurate overall deterioration threshold, which separates critical maintenance zones from areas not requiring immediate attention.

CONCLUSION

GPR technology continues to evolve and improve, offering benefits in a wide range of practical NDT investigation and damage prevention applications. It has proven to be one of the most efficient and accurate methods available to the marketplace. ◻

Female engineer
heads up geoscience consultancy

TERRATEST, THE GEOTECHNICAL and environmental consulting firm established in 1990, has undergone significant changes in 2005. Mrs Jan Norris, who joined the company in 1996 as a geotechnical engineer and became a director in 2004, has now been appointed managing director and Professor Deneys Schreiner, formerly dean of the Faculty of Engineering at the University of KwaZulu-Natal, took over as head of geotechnical engineering as from 1 March 2005. Peter Waldron, the project leader of the very successful Schools Play-pump Programme (which recently received the SAACE commendation for Engineering Excellence for projects with a value of less that R5 million) continues at head of the earth sciences section.

With a professional team of engineers, environmental scientists, hydrogeologists, geophysicists, geologists, project managers and GIS specialists, Terratest provides a unique service to the industry.

'Terratest's strength lies in the synergy between our environmentalists, geohydrologists and geotechnical specialists,' says Norris.

'The integration of our services allows us to view each project holistically and provide optimum solutions to our clients, which include municipalities, consulting engineers, the mining sector and developers.'

The firm is involved in a variety of projects, including the implementation of the Zululand Groundwater Supply Programme, for which an average of 20 boreholes are being drilled every week. The programme has been carefully planned, with input from a variety of sources, including the Zululand District Municipality's planning division, groundwater consultants, engineering consultants, local government structures and community representatives. This is a rudimentary programme which is not seen as the final method of water delivery to the local communities, but rather as an interim measure to supply water quickly, cost-effectively and efficiently to recipients who will receive bulk water only several years from now.

A recent challenging geotechnical project was a large lateral retaining wall on the North Coast Road, Durban, undertaken for Ethekweni Municipality City Engineers Unit. Owing to the widening of this road the existing Metro rail line had to be supported in a complex and unstable geology. The solution involved ground anchors, piles, and rock bolts, and on completion, great emphasis was placed on the aesthetic appearance of the area. A terrace block wall, planted with indigenous vegetation, was erected, and on the upper slope a terracotta pigmentation were used in the schokcrete to create an environmentally appealing look.

Terratest is also busy with the strategic environmental assessment (SEA) for the Abaqulusi Municipality in the Vryheid area. An SEA aims to integrate natural environmental concerns into the planning process at the same level at which social, economic and institutional considerations are addressed. It serves as a tool for the practical translation of the idea of sustainability into programmes and projects in the integrated development planning (IDP) process.

JAN NORRIS

Jan Norris was born in Liverpool in 1965. After completing her B(Eng) Hons in civil engineering at Birmingham University in 1989 she spent a year working in Zimbabwe as a site agent for the construction of earth embankment dams throughout the country.

She returned to England the following year and joined Thames Water in their geotechnical division. Most of her time there was spent on the geotechnical investigation for the London Water Ring Main – a large 3,5 m diameter, 80 km long tunnel 50 m underground.

Thames Water sponsored her part-time MSc studies in geotechnical engineering at Surrey University, from which she graduated in 1994. She was then promoted to Thames Water's head office in Reading to join the project management team (their engineering discipline was 500 strong). It was during this time that she met her husband, Craig, and moved to South Africa.

In 1996 she joined Terratest as a geotechnical engineer. She was promoted to associate in 2000 and executive associate in 2002, and appointed a director of the firm in 2004.

She regards herself as 'lucky' to have been involved in a diverse array of projects – embankments over highly compressible clays, lateral support design, constructions over old landfill sites in Ireland, and (as part of the independent engineers team) the recent rehabilitation of Chapman's Peak Drive.

Jan became a member of the Pietermaritzburg SAICE branch committee in 2003, was elected chair in 2004, and is now responsible for the branch's continued professional development portfolio.

PROFESSOR DENEYS SCHREINER

After 20 years as an academic, including five years as dean of the Faculty of Engineering at the University of KwaZulu-Natal, Professor Deneys Schreiner is re-establishing himself in the consulting fraternity. In March this year he took on the role of head of geotechnical engineering at Terratest.

Schreiner believes that engineers can find technical solutions to any foundation problem. The challenge, as he sees it, is to marry the technical solution to the financial viability of the project, thus providing the most cost-effective solution for the client.

'There is little benefit in providing a cheap solution which will lead to significant maintenance costs in the future,' he says.

'Likewise there is little to be gained from a solution so expensive that the client's project becomes unprofitable. Equal attention must be paid to the three key requirements of adequate strength, continuing functionality and economic viability.'

Schreiner has spent most of his working life alternating between the UK and South Africa. After obtaining his MScEng in geotechnical engineering under Ken Knight at the University of Natal in 1976, he worked as a soils engineer for Des Webb with extensive service on the Sasol 2 piling project. In 1979 he was awarded the Confederation of British Industry Scholarship and left for the UK to work on the construction of an earth dam in Yorkshire and then on the analysis and design of piled and gravity base foundations for offshore oil platforms. In 1980 he returned to Johannesburg where he joined Ove Arup & Partners as a geotechnical engineer. He soon moved to their Durban office, becoming the associate responsible for foundation engineering in that region, dealing with various projects such as the Playhouse Theatre and the Marine office block. In 1983 he was enticed back to Britain by McClelland Limited to continue his work on offshore foundations but in 1985, frustrated by an industry slow-down, he resumed his studies and obtained his doctorate under John Burland at Imperial College, London, studying the effects of expansive soils beneath African roads. He has published a number of conference and journal papers on this and other geotechnical engineering topics.

In 1991, encouraged by the political changes in South Africa and wanting to be part of the reconstruction process, Schreiner returned to take up a post as senior lecturer in the Department of Civil Engineering at the University of Natal. He quickly moved up the academic ladder to become full professor and dean of the Faculty of Engineering in 2001. His deanship ended in 2004 with the merger of the engineering faculties from the universities or Natal and Durban-Westville.

YGEC 2005

YOUNG GEOTECHNICAL ENGINEERS CONFERENCE

ENVIRONMENTAL GEOTECHNOLOGY – A CONTRADICTION IN TERMS?

A conference organised by the SAICE Geotechnical Division in collaboration with SAIEG, GIGSA & SANIRE

WHEN?

13–15 June 2005

WHERE?

Aventura Swadini, Mpumalanga. Swadini is situated in the Drakensberg, on the banks of the Blyde River in the Blyde River Canyon Nature Reserve (www.aventura.co.za/swadini/swadini.htm)

HOW DO I GET THERE?

The resort is situated 35 km from Hoedspruit in Mpumalanga and is readily accessible by car, or by plane via Hoedspruit Airport

CONTACT

Lesley Stephenson
Tel 011-717-7031, Fax 011-339-7853
E-mail stephensonl@ebe.wits.ac.za

THE GEOTECHNICAL DIVISION OF SAICE has been hosting local YGE conferences since the 1980s. The 1st International Young Geotechnical Engineers Conference (iYGEC) was held at the University of Southampton in the UK in 2000. At this event young engineers from around the globe gathered to experience an international conference, share their knowledge and experiences, and build lasting friendships. In 2003 the division obtained the approval of our international body (the International Society for Soil Mechanics and Geotechnical Engineering, ISSMGE) to host the 1st African Regional YGE Conference (aYGEC) in Swakopmund, Namibia. This was followed later in the same year by the 2nd iYGEC in Romania.

This event is aimed at bringing together young engineers and scientists working or studying in Africa in the fields of soil mechanics, geotechnical engineering and geology and to provide an opportunity to

- experience a conference of international standards, in a friendly environment, amongst his/her peers
- submit a technical paper for peer review and to present this paper before an audience of his/her peers
- get feedback and positive criticism from the conference 'Godfather' (a senior and well-respected member of the South African geotechnical community) and
- be eligible for the best paper and best presentation awards, which involves sponsorship to attend and represent South Africa at the next International YGE gathering in Osaka, Japan, in September 2005

Local and International Conferences and Symposiums 2005

LOCAL

Young Geotechnical Engineers Conference, YGE 2005
Swadini, Mpumalanga
13–15 June 2005

Contact
Lesley Stephenson
Tel 011-717-7031, Fax 011-339-7853
E-mail stephensonl@ebe.wits.ac.za

INTERNATIONAL

2nd International Conference on Problematic Soils
Malaysia
27–29 April 2005

Contact
The Secretariat
Tel +65 733 2922, Fax +65 235 3530
E-mail cipremie@singnet.com.sg
www.cipremier.com

International Conference on Deep Mixing Best Practice and Recent Advances
Stockholm, Sweden
23–25 May 2005

Contact
Conference Secretariat Deep Mixing
Tel +46 13 20 18 00, Fax +46 13 20 19 14
E-mail secretariat@deepmixing05.se
www.deepmixing05.se

International Symposium on Geology and Linear Infrastructures, GEOLINE 2005
Lyon, France
23–25 May 2005

Contact
Patrick Ledru
E-mail geoline2005@brgm.frgeoline2005.brgm.fr

5th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground
Amsterdam, The Netherlands
15–17 June 2005

Contact
Conference Secretariat
KIVI Congresorganisatie
Att J van der Kamp
Fax +31 (0) 70 391 98 40
E-mail tc28@kivibur.nl
www.tc28-amsterdam.org

11th International Conference of the International Association of Computer Methods and Advances in Geomechanics
Prediction, Analysis and Design in Geomechanical Applications
Torino, Italy
19–24 June 2005

Contact
E-mail iacmag@iacmag2005.it
www.iacmag2005.it

2nd International Conference on Geo-Environmental Engineering
United Kingdom
22–24 June 2005

Contact
The Secretariat
Tel +65 733 2922
Fax +65 235 3530
E-mail cipremie@singnet.com.sg
www.cipremier.com

6th International Conference on Ground Improvement Techniques
Coimbra, Portugal
18–19 July 2005

Contact
The Secretariat
Tel +65 733 2922
Fax +65 235 3530
E-mail cipremie@singnet.com.sg
www.cipremier.com

International Symposium on Geotechnics in Cities
Lille, France
27–29 July 2005

Contact
GeocityNet 2005
Tel +33 (0)3 20 43 45 66
Fax +33 (0)3 28 76 73 31
E-mail cipremie@singnet.com.sg
www.cipremier.com

2nd International Symposium on Identification and Determination of Soil and Rock Parameters for Geotechnical Design, PARAM 2005
Paris, France
20–21 August 2005

Contact
Francoise Bourgain
Tel +33 (0)1 44 58 28 22
Fax +33 (0)1 44 58 28 30
E-mail bourgain@mail.enpc.fr

16th International Conference on Soil Mechanics and Geotechnical Engineering
Geotechnology in harmony with the global environment
Osaka, Japan
12–16 September 2005

Contact
Chairman: Prof Toshihisa Adachi
Tel +81 3 3251 7661
Fax +81 3 3251 6688
E-mail 16ICSMGE@jiban.or.jp
www.jiban.or.jp/~16ICSMGE

Please refer to the GeoDiv website at www.up.ac.za/academic/civil/geodiv/ for more information

Installing sheetpile cofferdam for deep liftshaft pit (Durban Point area)

Trench support for 1 800 mm dia stormwater pipe. Depth of excavation 5,5 m (Ballito, KwaZulu-Natal)

TRENCHING AND EMBANKMENT SUPPORT MADE EASIER AND SAFER

WORKING INSIDE DEEP TRENCHES and at the foot of steep embankments and cuttings has now been made easier and safer with the availability of light interlocking sheetpiles and easy-to-use excavator-mounted vibratory hammers which both install and extract the sheetpiles.

These products have now been launched in South Africa by geotechnical supplier Pilequip SA.

Boyd Cousins, owner of Pilequip SA, identified the need for a shoring/trenching system that was safe yet affordable to the South African market. The first excavator mounted vibrator – an ICE EM328 – was landed here in April 2004.

The Dutch manufacturer ICE BV ranks among the largest in the world and operates in 45 countries. South Africa is seen as a potential growth market and hence Pilequip was signed up as its southern African agent.

The light sheetpiles needed to complement the vibrator arrived in August 2004 from world sheetpile leader Arbed (Luxembourg). The potential of the system was soon recognised and taken up by specialist civils contractor Leomat plant hire and construction, who has been involved with deep excavations for ewer and water services as well as deep structures for over 2015 years.

According to Arnaldo Corbella (director of Leomat Durban), working with the excavator-mounted vibratory unit took about a week to master, and now deeper excavation trenching solutions can be offered without having to call in specialist piling contractors with large crane units.

The Arbed PU 6 sheetpiles – in lengths of 6,0 m and 4,0 m – are relatively light (75 kg/m^2) yet surprisingly strong. They can support embankments of up to 2,5 m without props and simple propping for depths up to 4,0 m. The interlock makes for added strength and very good water retention in wet conditions. 'The sheets are robust and since they are vibrated into the ground we do not damage them like an impact hammer does,' says Corbella.

Leomat are confident that they will get more than ten re-uses from a single set of PU 6 sheets, which makes the PU 6 solution quite affordable.

MAINTENANCE CONTRACT FOR AFRICA'S GIANT EYE AWARDED

THE SOUTH AFRICAN ASTRONOMICAL OBSERVATORY (SAAO) has chosen ApplyIT's Aurora-Maintenance software to manage the maintenance of the Southern African Large Telescope (SALT) which, once complete in July 2005, will be the largest single optical telescope in the southern hemisphere.

Also known as Africa's giant eye, SALT is under construction in Sutherland in the Karoo, the SAAO's main astronomical observation site renowned for its clear weather and dark, cloud-free, unpolluted skies. The US$30 million telescope is a modified version of the Hobby-Eberly telescope in Texas. It is owned by the SALT Foundation, an international consortium initiated by the National Research Foundation, which through South Africa's Department of Science and Technology, owns approximately 30 % of the shares. Partners in the project include academic institutions from Germany, New Zealand, Poland, the UK and the US.

Aurora-Maintenance, which is used extensively in the process manufacturing industry, focuses on ensuring safe, reliable operations by supporting preventative and reactive maintenance strategies, including the automated scheduling of routine inspections and maintenance tasks.

The Aurora maintenance management system, which will go live at SALT at the end of January, includes integrated modules for equipment management, work order management, scheduled maintenance and spares management.

'SALT's maintenance requirements are not unlike those of the process manufacturing industry. The difference is that we don't manufacture widgets, we process digits,' says James O'Connor, Sutherland operations manager. 'The data we gather from our studies of the night sky is crucial for astronomical research around the world and as such, our margin for error is extremely narrow. Anything less than 100 % accuracy is simply not good enough. To achieve this standard, our equipment needs to be well monitored and maintained at all times.'

O'Connor says the SAAO's choice of maintenance software was based on a number of factors. 'The performance of the chosen system had to match the highest international standards of maintenance software. It was an added bonus for us that the Aurora suite has been locally developed and as such, was priced competitively for us as a non-profit research organisation,' he says.

The higher the capital investment in equipment, the greater the emphasis that needs to be placed on maintaining equipment effectively through the implementation of correct procedures, notes Gavin Halse, MD of ApplyIT.

'Of equal importance is the appropriate automated monitoring and management of the condition of equipment, reducing management's dependence on human interaction and ensuring consistent levels of control,' says Halse.

Once the Aurora system has been rolled out for SALT, the SAAO intends in time to implement the software across all the telescopes stationed on the Sutherland site.

EXPLORING NEW AVENUES

TO MANY, LAKE MICHELLE is probably one of the most beautiful places in the world. Set amidst Noordhoek's tranquil wetlands, this incredible lakefront development has inspired numerous investors to create breathtakingly magnificent homes. The R200 million residential initiative has been ongoing for the last eight years, presenting many interesting challenges.

Lake Michelle's heart is a salt marsh lake with indigenous fauna and flora. The area is home to over 126 species of birds and other fauna like the rare leopard toad and an extensive variety of ducks and fish. 'Our greatest challenge in this five phased project was to ensure that the venture remain eco friendly. This required us to engage in many long discussions with environmental bodies like The Noordhoek and District Civil Association, The Developers of the Environment for the Western Cape and the Noordhoek Environmental Action Group,' says Peter Wium, senior partner at De Villiers Sheard Consulting Engineers.

Although the project started eight years ago, it was suspended temporarily until a Cape Town developer bought the ground and resumed the venture at its full pace. The delay placed tremendous time constraints on the team. They subsequently approached Knowledge Base Software to help with the preliminary designs, feasibility studies and DTM, extending into the final designs for the roads, services and pond structures. 'It was comforting to know that we were receiving help from the Civil Designer software experts and we acquired a great deal of knowledge during this period. Knowledge Base provided us with two technicians for a month and we were able to meet our deadline in time,' notes Peter.

Besides the actual environment, the design itself was equally challenging. 'We were given specific requirements for the design of the sewer systems, being so close to the water body and with a ground surface that was very flat. In addition, certain zones were restricted and we found ourselves having to work around these environmentally sensitive areas.'

In order to maintain the quality and aesthetics of the estate, the landscape guidelines specified that stormwater pass through reeded channels to aid the water purification process before entering the lake. These reeded links form access points via bridges and paths, leading residents onto decks, board walks, jetties and bird hides.

Info
Yolanda Desai, Knowledge Base
021-701-1850, yolanda@knowbase.co.za.

ROCKFALL PROTECTION

ROCKFALL PROTECTION SYSTEMS ARE A KEY ELEMENT in the design and maintenance of infrastructure networks and have a direct impact on safety. The word 'system' correctly embraces the different structural components that should be considered when taking on a problem of this kind.

A key distinction should be made between active and passive protection systems. *Passive systems* do not affect the process of the rock detaching, but focus, rather, on containing falling debris, thereby averting danger to the infrastructure and its users. These systems include drapery wire mesh, rockfall protection barriers, and rockfall protection embankments. *Active systems,* on the other hand, act on the rock-detachment process. One example is armoured mesh, where different kinds of metal wire and cables form a mesh which is then anchored to the rock slope.

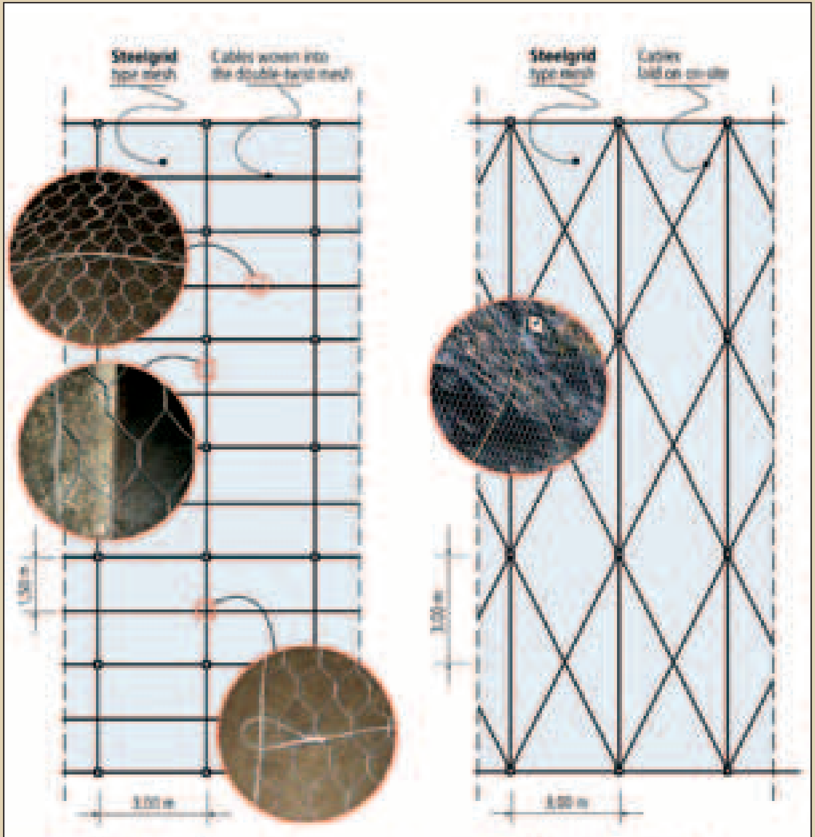
Marco Pauselli, technical manager of Maccaferri / African Gabions, says that Maccaferri's concept behind a protection system is a combination of good planning and the correct choice of system components which depend primarily on the stresses the system will have to withstand. The concept is one of 'minimum energy level', that is, a response proportionate with the problem, thereby avoiding overdesign and unnecessary costs.

Take for example the most basic of passive systems, a drapery of wire mesh nets. Here the nets are anchored at the top of the cliff and left unanchored on the rockwall, allowing rocks to fall to the foot of the cliff, in a contained fashion. Until recently, the mesh drapery and the steel cable used for anchorage were installed in two separate processes, clearly a time-consuming exercise.

Maccaferri has developed a product midway between a cable-reinforced mesh and a cable panel surface revetment known as 'Steelgrid'. This system is typically applied to rock masses whose surface can break down into fragments not smaller than the apertures in the mesh, and in any case not larger than 0,5 m in diameter.

Steelgrid encompasses the flexibility of the double-twist mesh with the strength of the steel cable by having the steel cable intrinsically woven into the double-twist mesh. However, the great economic bonus of Steelgrid comes from the fact that two different products can be installed at the same time (mesh and steel cables).

Maccaferri have developed and perfected a host of systems, both for the passive and active cases. These innovations extend to the 250 kJ to 3 000 kJ rockfall barrier systems capable of covering a wide range of energy spectrums, rockfall embankments and steel cable panels. □



Steelgrid-type mesh facing

Steelgrid-type mesh facing and holding cables

RECIPIENTS OF HONORARY FELLOWSHIPS

ALEC HAY

It is with great pleasure that the South African Institution of Civil Engineering confers an honorary fellowship on a stalwart of the civil engineering profession and of this institution – Alexander James Hay, better known to most of us as Alec.

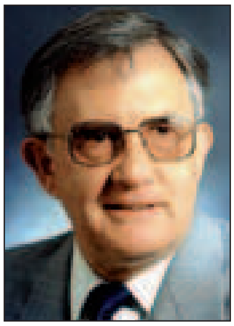
As a young man Alec joined the Johannesburg City Engineer's Department as a trainee civil engineering assistant, but soon attended the University of the Witwatersrand, from where he graduated in 1969. He remained with the City Engineer's Department until 1991, rising from an assistant resident engineer on the South-Eastern Outfall Sewer to assistant city engineer in 1983 at the age of 36 and to deputy city engineer in 1987. As deputy city engineer he headed both the Design and the Road Planning and Traffic Engineering branches of the Johannesburg City Council.

His career highlights while he was with the Johannesburg City Council included involvement in the design of the Diepsloot arch bridges, which were to carry the Diepsloot Outfall Sewer, the investigation into aggregate alkali reaction, which had affected certain structures on the Johannesburg motorway and which led to, for example, the reconstruction of a portion of a portal on the double-decker section of the M1 in 1991. Alec was involved with the design of many reservoirs to meet the requirements laid down by Rand Water, which at the time doubled the storage capacity of Johannesburg. With the advent of implosions of buildings in South Africa, led the team that formalised this method of demolition with a new chapter in the National Building Regulations.

At the end of 1991 the City Engineer's Department ceased to exist, ending the first half of Alec's professional career. At the time the industry was in the deepest recession it had ever experienced, so that two difficult years followed before he was appointed assistant chief civil engineer at Rand Water, where he assumed responsibility for the administrative management of the Civil Engineering Design Section of Rand Water.Major projects that were being undertaken included elements of the '1992 Scheme', a project that enhanced supply capacity to the Gauteng Region in conjunction with the Lesotho Highlands Water Transfer Scheme.

Alongside his successful professional career, Alec contributed enormously to SAICE from 1978, when he became secretary, and later chairman, of the then Municipal Engineering Division. In 1987 he was elected to Council and in 1996 became president of the Institution. In the years since his presidency Alec has remained a trusted and valued member of various SAICE committees. His involvement over the years with ECSA Council and committees, such as the Central Registration Committee, the Registration Committee for Professional Engineers, the Professional Advisory Committee for Civil Engineers, and the International Committee, in many instances as chairman, as well as his contribution to the Engineers Mobility Forum and the establishment of agreements of mutual recognition with sister engineering bodies overseas, has greatly benefited the institution and the profession.

BINGLE KRUGER



It is an honour for the South African Institution of Civil Engineering to confer an honorary fellowship on Pieter Willem Bingle Kruger.

Bingle Kruger originally intended to become a sheep farmer, but in 1959 was one of the first nine graduates from the newly established engineering faculty at the University of Pretoria. He furthered his education at the University of California in Berkeley, where he obtained his master's (in 1962) and doctorate (in 1964) in transportation and traffic engineering. The University of Pretoria honoured him with the TuksAlumni Laureatus Award in 2000 and a DEng (Honoris Causa) in 2003. He was invited by the engineering institutions to deliver the 2000 Hendrik van der Bijl Lecture at the University of Pretoria.

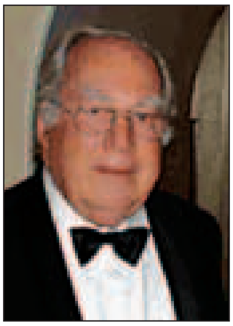
In 1965 Dr Bingle co-founded the consulting engineering firm Bruinette, Kruger, Stoffberg and Hugo, later known as BKS. For many years he was responsible for the technical management of the firm's work in the field of transportation engineering. With his managerial skills and expertise in this field, which includes traffic engineering, road and airport planning and design, public transport, and comprehensive transport planning, Dr Bingle was instrumental in his company's international operations in more than 20 countries and contributed to projects of national importance, such as the Mohale Dam and roads on the Lesotho Highlands Water Project, toll road studies and the planning of several toll roads, industrial complexes, large sports stadia, the National Water Resource Strategy, the South African Large Telescope, the Nelson Mandela Bridge, and the Sasol gas pipeline from Mozambique to Secunda. Dr Bingle acted as expert witness for a large number of township board hearings on matters concerning the traffic implications of proposed large development schemes such as Menlyn Shopping Centre in Pretoria and Sandton City in Johannesburg. He has been a member of the PWV (now Gauteng) Transportation Consortium since 1973 and is still the chairman.

Not surprisingly, in 1989 Dr Bingle was appointed by the Minister of Transport to the South African Roads Board, the Toll Roads Committee and the Urban Transport Planning Committee. The eight-member South African Roads Board is responsible for the direction and approval of all national road projects. The Minister also appointed him to the Civil Engineering Advisory Council, of which he was acting chairman in 1998/99. He served on the steering committee of the former National Institute of Road and Transportation Research of the CSIR for a time. As a member of the South African Association of Consulting Engineers he served on the National Liaison Committee between SAACE and the Department of Transport for several years as well.

Dr Bingle's involvement with SAICE is closely linked to his leadership and management skills, and his interest in transportation. In 1988 he was the chairman of the organising committee of the Eighth Quinquennial Convention for SAICE in conjunction with the Annual Transportation Convention, which was held in Pretoria. He was the honorary treasurer and chairman of the Finance and Administration Committee from 1989 to 1994. In 1995 he served SAICE as its president.

Although Dr Bingle has now retired, he remains active, notably as the president of the multi-disciplinary South African Academy of Engineering, which has a membership of around 100 eminent engineers. The academy aims to serve the nation at policy decision-making level through the application of engineering and technology in its broadest sense. It is fitting that a civil engineer of the dignified and professional stature of Dr Bingle Kruger is leading the way.

ROSS PARRY-DAVIES



It is with great pleasure that the South African Institution of Civil Engineering confers an honorary fellowship on an individual who is a unique combination of distinguished academic, leading contractor and consultant, having spent 40 years in the contracting industry and 20 years as a consultant – Dr Ross Parry-Davies.

Ross Parry-Davies graduated from UCT in 1945, and spent the next nine years contracting, mainly on water supply projects and dams, before he worked for two years with F E Kanthack & Partners on the design of the Kafue hydroelectric project, which incorporated dams, tunnels, penstocks and underground power stations. In 1956 he joined the Cementation Company and was initially involved in aspects of the Kariba scheme where he began developing techniques for the stressed strengthening of dams, which he later applied at 13 dam sites in southern Africa, using anchors up to 6 000 kN capacity.

He returned to the Cape to build the Apostles Tunnel and various harbour works, but at the same time he was working on innovative techniques, such as vibroflotation, dynamic consolidation, specialised grouting and ground improvement techniques. He was the first person in the world to use ground anchors to provide lateral support for basement excavations, which were initially used on the SA Mutual basement in Port Elizabeth. His subsequent work with Ruben Stander, in which grout jacking was used for the first time to provide a lateral support system for the Trust Bank basement excavation in Johannesburg, at the time the deepest in the world, won wide acclaim. He used soil nails to reinforce slopes on De Waal Drive in Cape Town, 20 years before the 'new' techniques of soil nailing were claimed, and built a unique through-flow rockfill dam in Lesotho.

In 1970 he created Ground Engineering, which he sold to LTA in 1974, Here he became involved with, among other projects, the Drakensberg Pumped Storage scheme and the Huguenot Tunnel, where ground-freezing techniques smoothed the way for construction.

Since his retirement from LTA in 1987 he has been involved with consulting on mainstream engineering projects, has appeared as an arbitrator and expert witness, and has been a specialist consultant on the acclaimed rehabilitation of Chapman's Peak Drive.

In 1991, when he was well into his sixties, he was awarded a doctorate from the University of Pretoria.

Dr Ross Parry-Davies served on the SAICE Council for six years. His mission was to unify the profession by incorporating all members of the civil engineering industry, including professional technologists and technicians, into SAICE. He was chairman of the sub-committee that updated the South African Code of Practice for Lateral Support, for which he received the Jennings Award and the Geotechnical Medal for meritorious service. In 2002, with Brenda Sudano, he organised the funding and publication of the book *The Romance of Cape Mountain Passes* by Graham Ross, making possible a splendid tribute to South African engineering.

Dr Ross Parry-Davies has brought distinction to the profession of civil engineering. He has been a leading contractor, distinguished academic and consultant, a loyal servant of the profession, and a definitive example of the species *ingenior* and the innovators who makes things happen and solve problems through bright ideas and lateral thinking. ◘

CSIR RESEARCHER WINS BEST PAPER AWARD AT WEDC CONFERENCE

At the awards ceremony: Mr Bouathong Vong Lorkham (Acting Minister of Communications, Transport, Ports and Construction), Kevin Wall and Mr Somphone Dethoudom (Director-General of the Department of Housing and Planning)

KEVIN WALL FROM CSIR Building and Construction Technology won a joint award for the best paper presented at the Water, Engineering and Development Centre (WEDC) Conference in Vientiane, Laos, South East Asia. Kevin's paper is entitled 'An investigation of the franchising option for water services in South Africa'.

The WEDC has for the last three decades been organising international conferences on the provision of infrastructure services for low- and middle-income countries. These have grown in stature, and are now regarded by developing countries' water and sanitation services practitioners and advisers as 'the' conferences to attend. The conference location alternates each year between Africa and Asia, and is jointly organised by staff from WEDC and a local organising committee.

The 2004 conference took place in Laos (more correctly 'the Lao People's Democratic Republic'), a country of six million people that is bordered by Vietnam, Cambodia, Thailand, Myanmar (formerly Burma), and China. The capital, Vientiane, is on the Mekong River, which fortunately has very broad shoulders and can accept the pollution from this city of 800 000 people

The 2005 conference will be held in Kampala, Uganda. ◻

DIARISE THIS!

Event	Date	Venue	Contact
Business Finances for Built Environment Professionals	9–10 June	SAICE National Office Thornhill Office Park Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
Coastal Engineering and Management Course	18 & 19 April 21 & 22 April	Cape Town Saldanha	Lungelwa Lamani Tel 011-805-5947, Fax 011-805-5971 llamani@saice.org.za
Handling Projects in a Consulting Engineer's Practice	4–5 August 2005	SAICE National Office Thornhill Office Park Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011- 805-5971 llamani@saice.org.za
Technical Report Writing	21 & 22 April 4–5 July 13–14 July 11–12 August	SAICE National Office, Midrand Cape Town SAICE National Office Durban	Lungelwa Lamani Tel 011-805-5947, Fax 011- 805-5971 llamani@saice.org.za
Concrete Technology (C&CI Level 3)	3–7 October 2005	Contest Concrete Technology Services Westmead, Pinetown, Durban	Antoinette Marais Tel 031-700-9394 antoinettem@contest.co.za
Concrete Practice (C&CI Level 2)	31 May – 3 June 2005 15–18 August 2005	Contest Concrete Technology Services Westmead, Pinetown, Durban	Antoinette Marais Tel 031-700-9394 antoinettem@contest.co.za
Introduction to Concrete (C&CI Level 1)	6–7 June 2005 5–6 September 2005 7–8 November 2005	Contest Concrete Technology Services Westmead, Pinetown, Durban	Antoinette Marais Tel 031-700-9394 antoinettem@contest.co.za
South African Society for Intelligent Transportation Systems SASITS Conference 2005	10–13 May 2005	Cape Town International Convention Centre, Cape Town	Carla de Jager Tel 011-805-5947, Fax 011- 805-5971 cdejager@saice.org.za
EcoSan 2005 Third International Conference on Ecological Sanitation	23–27 May 2005	International Convention Centre, Durban	Carla de Jager Tel 011-805-5947, Fax 011- 805-5971 cdejager@saice.org.za
Mortars Plaster and Masonry	24 May 2005 20 October 2005	Contest Concrete Technology Services Westmead, Pinetown, Durban	Antoinette Marais Tel 031-700-9394 antoinettem@contest.co.za
Young Geotechnical Engineers Conference YGE 2005	13–15 June 2005	Swadini, Mpumalanga	stephensonl@ebe.wits.ac.za
Concrete Repairs	14 June 2005	Contest Concrete Technology Services Westmead, Pinetown, Durban	Antoinette Marais Tel 031-700-9394 antoinettem@contest.co.za
Obtaining Environmental Authorization: A Strategy	13–14 July 2005	Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011- 805-5971 llamani@saice.org.za
Assertiveness and Conflict Resolution for Managers	2–3 August 2005	Midrand	Lungelwa Lamani Tel 011-805-5947, Fax 011- 805-5971 llamani@saice.org.za