Profile of Prof Eben Rust

Focus on Geotechnical Engineering

- Centrifuge installed at UP
- Load-testing of DUKTUS pile
- Specifications for geosynthetics
TITAN DRILL AND INJECTION ANCHORS
the new way in Anchor-Technique

TITAN Grouted Micropiles – Our System

The load carrying member of TITAN grouted micropiles is a hollow threaded bar which simultaneously acts as sacrificial drill rod, injection pipe and reinforcing steel (3 in 1).

Opposite to the already known applications to DIN 4128 to secure the bore hole with a casing against collapsing as occurring in loose soil or rock formations, the Ischebeck system secures the stability of the bore hole with grout during flushing – additional stabilisation with casings is not required. This saves several steps in the installation process and in most cases leads to a drastic improvement in the installation speed in comparison to traditional systems. A further advantage is the continuous dynamic pressure grouting right after drilling with the stabilising flushing grout.

Without casing the grout penetrates and locks into the soil. This improved surface friction results into a settlement of the pile head of such non tensioned micropiles in the range of a few millimeters, and consequently these settlements are similar to post tensioned anchors to EN / BS 1537. Therefore TITAN grouted micropiles can be an equivalent and economic alternative to post tensioned permanent anchors when considering the load-transfer diagram.

Depending on the application TITAN grouted micropiles can be called tension piles, anchor piles or soilnails.

A unique feature is the drill steel use as the tension-and/or compression member.

Sole Importer and Distributor of TITAN Anchors for the Sub Sahara Region

The company, Titan Geotechnical System (Pty) Ltd, was established in 2002 as a joint venture between G Bartkowiak, J Bartkowiak and Friedr. Ischebeck GmbH Germany. Titan Geotechnical System (Pty) Ltd is the Sole Importer and Distributor of TITAN Anchors for the Sub Sahara Region. For trade enquiries please contact:

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Website www.titangeo.co.za | Email info@titangeo.co.za

Range of Available Anchors

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I FIND RECENT calls for Benni McCarthy and Siyabonga 'Bhele' Nomvetha to be part of the national football team again, quite interesting. Their recent performance records at Orlando Pirates and Morocco Swallows have shown their spectacular abilities. McCarthy’s goal, a classic overhead kick, against Maritzburg United in the PSL recently tells you that the old dog still has vooma. In my opinion, he is still South Africa’s most lethal striker in the 18-yard area. Veteran striker Nomvetha continues to run circles around younger players and penetrate defence lines with the same alertness and pace he possessed ten years ago.

The invitation of older players to re-join the national team is evidence of the lack of foundational level development; which includes proper resources, administrative structures and systems that give focused attention to the development of young talent.

This succession planning challenge is not uncommon to civil engineering. As part of the integrated improvement of the civil engineering pipeline, and with the absence of middle management engineers, young engineers are required to develop in unconventional ways. While we harness the wisdom of retired engineers, and seek other formal avenues of training like the SAICE Candidate Academy, and consultant specific development programmes, graduate engineers are required to go the extra mile to ensure their professional and personal development. Relying on the Monday to Friday, 9 to 5 day is not going to cut it anymore.

I am aware that training of young engineers is an on-the-job activity, under the wisdom of an experienced and registered engineer, and for this to happen we need government to roll out more projects. And yes, it is true that this is not happening as efficiently as it should be. Organisations who ply their trade in the mining sector, for example, and not the government market, seem to be achieving training and development goals quite successfully.

I imagine several business directors and CEOs piously claiming they already have training programmes, and some have taken awards in this arena, but I wish to ask how many engineering professionals, principals, directors and shareholders have your training programmes produced? Does the development of graduate engineers feature as high as shareholder interest in your organisation?

When Toyota announced in 2009, just before the world financial crisis took hold, that it had made a loss of $4.4 billion and that the outlook for the next fiscal year was also looking grim, they also announced that Toyota would not retrench or fire staff, would reduce dividend payouts to shareholders and investors, would continue to invest in staff development and training during the lean times ahead, and would study and improve existing systems and processes. Enough said!

I wish to turn my attention back to the graduate engineers; all businesses operate on the model $P = I – E$ in order to maximise Profit, minimise Expenditure and maximise Income. Corporate governance, organisational culture, training and development, social investment, and so on, all happen in the context of generating profit for shareholders, no matter which way one spins the business lingo.

Bearing this is mind, graduate engineers need to ensure that they join organisations where they will participate in a formal training programme with a view to register as a professional over a minimum period of three years. This is priority number one – do not settle in an organisation until you are certain of this experience. The programme should include working closely with a professionally registered engineer and coach or mentor that takes you successfully through the steps required for professional registration with the Engineering Council of South Africa. It is imperative that you receive design, construction and project management experience.

Next, ensure that you enter into the working environment with enthusiasm, a positive attitude, confidence and willingness to do any engineering work. This includes playing secretary from time to time, and washing the cups. Lack in confidence and the inability to ask questions, will see you fall behind. If you have identified your lack of self-confidence, ask your coach, mentor or boss to send you on a personal development programme.

Finally, ensure you are earning a competitive, market-related and fair salary. There are excellent salary surveys – some are freely available on the internet. Familiarise yourself with the going rates. Remember that as a young engineer you need to budget for accommodation, a car and day-to-day necessities.

Remember also that you are an engineer, albeit an inexperienced one, and that you are a sought after commodity, so be aware of the job hopping disease. Job hopping ultimately has the impact of pricing you out of the market while restraining your professional development. Stay in an organisation for at least three to five years.

The signs show that the infrastructure market will be thriving, especially in the second half of the current decade. This forecast implies that it is the present graduate engineers who will be enjoying the markets then. It follows that present graduate engineers need to immerse themselves in training and development, in preparation of the good times ahead. More than this, they need to be proactive, vigilant and self-reliant – this is the sign of shouldering responsibility sooner than expected.
Esorfranki Geotechnical has successfully completed one of the biggest micro-piling projects ever conducted in South Africa – a R38.3 million contract which called for the stabilising of a retaining wall on the road between Ncembu Plateau and Langeni Sawmill some 50 km from Mthatha in the Eastern Cape.
## IN BRIEF

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- Red Cap Kouga Wind Farm - geotechnical study
- New accessories for ACIP and CFA pile installation monitoring
- Paramesh – Maccaferri’s flexible retaining wall solution
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- Restructured MBSA appoints Executive Director

## SAICE AND PROFESSIONAL NEWS

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ESORFRANKI GEOTECHNICAL has successfully completed one of the biggest micro-piling projects ever conducted in South Africa. The R38.3 million contract was awarded by the Eastern Cape Department of Roads and Public Works in February 2011 and called for the stabilising of a retaining wall on the road between Ncembu Plateau and Langeni Sawmill, some 50 km outside of Mthatha.

The micro-pile design was carried out by HHO/Camdecon JV and the engineer for the contract was Terence Bergman, assisted on site by Rey Farrugia.

The project commenced in May 2011 and was completed in November of that year. It is the fourth undertaking that Esorfranki Geotechnical has completed in the area in recent times, the other three being foundation piling for the Joza Police Station in Grahamstown, lateral support for a bridge over the Mthatha River in Mthatha, and lateral support and foundation piling for a new VW/Audi dealership in East London.

The retaining wall project became necessary after investigations revealed that the slope on which the mechanically stabilised earth retaining structure had originally been constructed was moving on a deep-seated shear surface, well below the natural ground level, requiring stabilisation.

The original retaining wall, completed in early 2008, varies in height from eight to twelve metres and is reinforced with steel strips. Towards the end of the original construction period, the wall settled by 250 mm and additional stabilising fill was placed at the toe of the slope. Subsequent subsurface investigations were carried out and seven inclinometers were installed at the site.

During the 2008/9 and 2009/10 rainy seasons the wall moved by 50 mm and 60 mm respectively, resulting in further subsurface investigations and another inclinometer installation in 2010.

SUBSOIL CONDITIONS
Subsoil conditions at the base of the retaining wall comprise up to three metres of quarried dolerite rock fill, primarily made up of very hard rock dolerite boulders between 300 mm and two metres in diameter, as well as some shale and siltstone layers.

The rock fill is underlain by a very hard talus boulder layer up to 14 m thick in a soft to stiff, moist clayey silt matrix down to about 24 m, with completely weathered siltstone beneath. Underneath the siltstone is a hard dolerite layer which served as the founding zone for the vertical piles, with a four metre toe.

The groundwater level rises into the talus during summer rainfall and the pile installation was therefore undertaken below groundwater level.

WORKS
The Esorfranki Geotechnical team appointed subcontractors Roberts Brothers Construction to construct the pile caps, and Rumdel Construction to remove the existing access ramp and carry out the associated earthworks.

Due to the nature of the subsoil conditions and the fact that no water or drilling fluids could be used, DTH percussion drilling was the only method suitable for installing the micro-piles, and as the work needed to be carried out in a constrained working area, it was necessary to use light and compact drilling rigs. Three different Casagrande drill rig models were used – C4, C6 and C8.

The design to support the subsurface failure called for the installation of 573 (number) 165 mm diameter inclined
piles and 446 (number) 225 mm diameter vertical piles tightly spaced and all acting together, with the construction of three pile caps of five metres wide, 50 m long and one metre deep. The depth range of the piles varied from 18 to 25 m. Pile positions varied between 35° and 60° to the horizontal plane, and rigs therefore had to be kept stable on a tight platform.

The work also included the installation of six inclinometers between 25 and 30 m deep, a mass concrete infill between the earth wall and the pile caps, and removal and reconstruction of V-drains.

Two inclined and two vertical verification test micro-piles were installed and tested before the installation of the working piles commenced. Thereafter, random working piles were subjected to proof testing. The micro-piles were permanently cased one metre into the talus and fully grouted. The reinforcement for the inclined micro-piles was galvanised.

CHALLENGES
One of the highest rainfall figures in years was experienced throughout the duration of the project, as well as occasional snowfalls, both of which significantly challenged work progress. The rain caused a high water table, making it difficult to drill the moist clay with an air-driven down-the-hole hammer. In addition, the presence of large boulders in the talus layers prevented the use of a clay cutter or drag bit to drill, which also slowed progress.

To meet the programme schedule it was necessary to have six drilling rigs, three grouting stations and seven high-pressure compressors on site, which caused its own problems due to the restricted access and confined nature of the site. The larger drilling rigs had to be offloaded from the lowbed trailers approximately four kilometres from the site and then had to move to the site under their own steam.

The remoteness of the site presented real challenges regarding the transportation of necessary materials, as large trucks could not travel through the forested mountain slope. The Esorfranki Geotechnical team therefore had to offload pallets of cement and steel from the trucks further down from the site and repack the materials onto a smaller truck. However, during the heavy rains it was impossible to even drive a bakkie onto the site.

STRENGTHS
Esorfranki’s many years of experience in the piling industry, coupled with highly experienced personnel, proved to be primary strengths on this project. The project was completed to the client’s satisfaction, and with only one instance of time lost due to injury.

Offering a full design and construct service, Esorfranki Geotechnical is a “one-stop geotechnical shop” — the largest specialist geotechnical contractor in South Africa, and the most established in the sub-Saharan Africa region.
Thousands of engineering firms, transportation authorities, mining houses, and government agencies around the world trust gINT® for their reporting and enterprise data management needs. Now infrastructure professionals in South Africa can take advantage of this powerful geotechnical and geoenvironmental software to collect, validate, organise, and access subsurface data, ultimately turning it into intelligent information.

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- Nine different log and report styles
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AN ACTIVE CHILDHOOD

The scope of Eben’s compulsive energy is well summed up by his wife Jeanne: “My dad used to say in the days when Eben often went out into the field, ‘You must miss him a lot when he’s gone because he fills up the entire house’ – and he does. He’s always active; to take him along on a cruise ship holiday would drive him and everybody around him nuts.”

Eben spent his first eight years in the former Northern Rhodesia where his dad was involved in road building, at one stage in his career joining forces with Alwinus van Niekerk in what would later become the firm of Van Niekerk, Kleyn & Edwards (VKE). When the family returned to South Africa in the early 1960s, the contact with VKE resumed and a construction contract landed them in the small Karoo town of Calvinia, where the four English-speaking Rust children stuck out like sore thumbs amongst the local Afrikaner kids. “We were regarded almost as aliens from outer space,” Eben says laughingly.

Further contracts took the family to even smaller places, such as Nieuwoudtville, Carnarvon and Britstown. By the time they were stationed in Cathcart, Eben was in Standard 9 (Grade 11) and he was sent to Afrikaans Hoër Seunsskool in Pretoria. “All in all, I attended ten schools. I did the normal stuff that kids do, but because I was small and light I also took up gymnastics. And I did boxing, from primary school – when the gloves were bigger than me – through to matric. I always made sure the other boys knew I was a boxer; I found this to be a good strategy.”

What he also did from early childhood was to learn about civil engineering from his father. “I couldn’t wait to join him on site after school. I knew about road pavements, I watched him in his lab, I helped him (though I was probably more in the

The winner of SAICE’s Geotechnical Gold Medal for 2011 has an overriding mission in life: to produce, in South Africa, geotechnical engineers of a quality and quantity that can compete with and also surpass the best of their breed in the world. With consummate keenness, Prof Eben Rust (Geotechnical Engineering) of the University of Pretoria and owner of Osimo cc, has throughout his professional career applied his varied talents to achieve this goal.
way than anything else), I sat with him throughout the night watching how the deck of a bridge was being poured, and I enjoyed every minute. My dad set his faith on me being a civil engineer one day.”

Eben fulfilled that ambition: he went on to do his BSc and Honours degrees in Civil Engineering, as well as his MSc (cum laude) in Geotechnical Engineering at the University of Pretoria. For his PhD (Geotechnical Engineering) he went to the University of Surrey in the UK, submitting his thesis on *The interpretation of incomplete dissipation tests* (1997).

**EARLY DAYS OF THE PIEZOCONE**

He started his career with VKE in Pretoria, where, on his very first day he came into contact with something that would change his life. “I walked into the office of my boss Dr Gary Jones, and on his desk was a drawing of some cylinder with a sharp point at one side.” Being naturally inquisitive, Eben asked what it was. “He told me it was an instrument he was working on that measured soil strength by determining the resistance to penetration, but it involved all kinds of electronics of which he didn’t have enough knowledge to take it further. The concept originated in Holland and Belgium in the early 1900s, but it was mechanically driven. The Scandinavians then took it to the electronic level, but it was now at the point where electronics started to go miniature,” Eben explains.

Eben had always been very interested in electronics. He’d been making his own PC boards and building amplifiers and speakers for his hi-fi systems since school days. “It was touch and go whether I’d study electronic or civil engineering when I went to university.” Eagerly he said to Jones, “Give it to me to sort out.” It was the first step of Eben’s lifelong involvement in the development of the piezocone and the start of a longstanding relationship with Gary Jones who, Eben says, “forged my early career”. They did their first cone penetration testing at the Bafokeng mine, Rustenburg, in November 1977.

Of the many geotechnical investigations he did in that phase with VKE he highlights a project between Illovo and Amahlongwana on the Natal south coast, where he did the design of a stage-construction programme for embankments across five floodplains with soft recent clays. When Jones left VKE for Steffen Robertson and Kirsten (SRK), he handed the piezocone over to Eben, but within a few
months Eben also joined SRK. By that time the Dutch had got to know about the South Africans’ developments on the piezocone. “They are pre-eminent in the world as far as cone penetration testing is concerned, and we had now gone past them,” Eben says excitedly. He was part of a four-man mission from SRK who visited Delft LGM in 1982 to show them the advancements that had been made in South Africa.

**NOVEL THINKING ON ELECTRONICS**

The USA had also taken note of the progress, and they wanted assistance with piezocone testing at their Gas Hills tailings dam reclamation project in Wyoming – but as in immediately. As the consultant on *in situ* testing, Eben, supported by SRK’s Andy Robertson and Dirk van Zyl, flew out to assist in the field work, interpretation of the results and the final designs. “The first Apple and Sharp PCs had just come out, but I couldn’t get the data into my PC because it couldn’t read the piezocone,” Eben relates. “So I took one of the I/O (in/out) cards, tied it to two analogue-to-digital converters, put the signal from the cone through the A-to-D converters so that it was now digital, and then wrote the interface for the computer, whereupon I could store the data. This procedure would have developed in due course, but I would like to think that it was early thinking on my part,” he says with pride. The undertaking had a humorous touch, which Eben recounts: “I told nobody but Gary about my experimenting and that I would only know for sure whether the PC would work on site. He was very supportive, saying: ‘If all else fails, you’ll have the backup of your analogue system.’ When we arrived at Gas Hills, Wyoming, we were very uncommunicative about the equipment in the back of the transport truck and wouldn’t allow anybody near it.” Suffice it to say, it worked. Similar piezocone testing and interpretation was done a year later at the Urvan hazardous waste disposal site in Colorado. “It was the first time ever that our peers in the USA were exposed to this type of testing. It was a real turning point,” says Eben.

At that stage Eben had only a B-degree and he resigned from SRK to enrol for his Masters studies while also lecturing in soil mechanics at the University of Pretoria. Once again, the piezocone accompanied him to UP where he continued his research, notably on the re-assessment of the tests and designs carried out at floodplains on the Natal south coast, to enable better performance predictions for future construction.

Throughout his academic career he has continued to act as specialist geotechnical consultant to a range of consultancies.

**BREAKING GROUND IN VIETNAM AND SOUTH AFRICA**

Among the major projects that he worked on during the early 90s, a US$15 000 million (1993 value) project at Haiphong in northern Vietnam gets him talking animatedly, not only because of its sheer size, but also because of the scenic beauty of the country and the phenomenal work ethic of the people. Haiphong lies inland of the Red River Delta where farmers have been cultivating their rice paddies for ages. “An area of 1 000 ha was earmarked for an export processing zone which was to include a port, rail line, roads, and an entire city with factories of every possible kind, hotels, golf courses, you name it,” Eben explains. “The site was underlain by 45 m of soft, compressible clays, and our investigation included piezocone testing, laboratory testing and drilling, followed by the analysis of the results, settlement predictions and foundation recommendations.” On one occasion Eben and his team were visited on site by Duong Moi, Secretary-General of the Communist Party (the equivalent of the president of a country), after which details of their involvement in the development of the country were broadcast on Vietnamese television.

To his mind, the biggest research project on the settlement of embankments on soft alluvial soils ever carried out anywhere was done here in South Africa. “It incorporated 15 embankments, with the sites extending from Richards Bay in KwaZulu-Natal to Bot River in the southern Cape. The aim of the research, which was done by Gary Jones and myself for the former Transvaal Roads Department in 1990, was to establish a better design and prediction model for settlement of these soft clays,” he continues. The results later formed the nucleus of Jones’s PhD thesis.

**GOING ALL-OUT TO GENERATE TOP PhDs**

Eben regards all the highlights in his life up to that point as small fry compared to what was to follow. He continues: “When I started at UP it was put to me that I should not only teach; I should also do research and publish, and in the process produce PhD graduates of note. But I felt myself at a dead end: I had limited resources; I didn’t even have a PhD myself. How could I produce world-class geotechnical engineers in the circumstances? So I thought, either I go for it in a big way or I simply go with the flow and teach undergraduates.” He took the high road, asked for six months’ sabbatical leave and, accompanied by Jeanne, left for the UK, funding all expenses out of his own pocket. He was intent on enrolling at the University of Surrey in Guildford and doing his PhD under the direction of Prof Noel Simons, ex-graduate of the University of Natal and by then a renowned geotechnical engineer in the UK. “I thought I’d just knock on his door, play on his goodwill towards South Africa and see if we can come to an arrangement.” Everything panned out smoothly, but for one drawback: Simons would shortly be retiring as head of department. His successor was the rapidly-rising Prof Chris Clayton, with whom Eben completed his PhD and struck up a lasting friendship.

Eben now set out to use his close ties with the University of Surrey to the benefit of his home university. “I wanted my best students to do their PhDs there, to expose them to the resources, the tutors, the way of thinking and working at Surrey, because it broadens the scope tremendously and makes a huge difference to one’s life.” When Clayton later moved to the University of Southampton, the academic interaction expanded to that campus. “Then other universities, such as Cambridge, started to take note of what we were doing,” Eben continues. “I later met Prof Robert Meir, head of department at Cambridge, and we developed a good working relationship beneficial to both universities, and several of my ex-students completed their PhDs there. I totally re-hashed the postgraduate programme at UP to educate as many students in geotechnical engineering as possible.” Many of his students have completed their PhDs and Masters here, as well as in the United Kingdom. Among them are his son Martin and daughter-in-law Michelle, both of whom studied under Clayton at the University of Southampton. “These students are my living legacy; I am immensely proud that I can be instrumental in shaping their futures,” he says with feeling.
PROVINCIAL TREASURY

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(Branch: Governance and Asset Management)

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- Guide and drive the attainment of quality financial governance, accounting, asset, supply chain and financial systems management within both the provincial and local government environment;
- Develop, review and implement as applicable the relevant national, provincial and local legislation, standards and prescripts relating to the former, inclusive of effective internal controls;
- Monitor, evaluate and promote financial propriety by ensuring compliance with proper recordkeeping, reporting and financial transaction administration and management standards;

Competencies:

- Well-developed conceptual, and formulation skills required; Excellent networking, network formation and leadership skills with demonstrable experience in problem identification and solving; Strong analytical thinking, teambuilding and good interpersonal skills with a client orientation/focus and excellent communication abilities.

Applications are to be submitted on fully completed Z83 forms obtainable from any government department or www.westerncape.gov.za/eng/jobs/ clearly indicating the position being applied for and reference number. Applications must include a current CV (5 pages maximum) together with certified copies of ID, driver’s licence, Matric Certificate and Academic qualifications. Appointment is subject to security clearance and vetting checks as prescribed. Candidates will be required to undergo competency assessments/tests of 1½ days duration on a date and time determined by the department. No late, faxed or e-mailed applications will be accepted.

Forward your application to Judy Johnstone, Ayanda Mbanga Response Management, PO Box 833, Green Point 8051 or place in the Ayanda Mbanga Response Management Job Application box located at 1 and 4 Dorp Street, Ground floor, Cape Town. Applications not submitted via Ayanda Mbanga will not be considered.

If you have not received a response from the Department within 3 months of the closing date, please consider your application as unsuccessful.

The WCG is guided by the principles of Employment Equity. Disabled candidates are encouraged to apply and an indication in this regard would be appreciated.

Closing Date: 11 May 2012
WORLD-CLASS LAB AT UP

There were more ideas germinating in Eben’s fertile mind. On one of his visits to Clayton he was completely bowled over by the work done by a company called Surrey Geotechnical Consultants (SGC). “Clayton had started SGC in partnership with Hardev Sidhu, and whilst they did consulting in the early years they basically set out to do the best geotechnical laboratory testing that you’ll find anywhere in the world. When I saw their facilities I immediately asked Chris to help me create a quality lab like that at UP,” Eben says. Established with private funding, and carrying the blessing of the dean of the civil engineering faculty, the Advanced Soils Laboratory came into being at UP.

“The first few projects, including Maguga Dam, were run for us by Hardev Sidhu. He would fly out and we would do the testing for the rock-fill and the clay core to be used in the construction of the dam. But that was not sustainable in the long run, so when Gerhard Heymann, who had been doing his PhD on small strain laboratory testing under Clayton, returned to South Africa, I asked him to take over the lab and he has been developing it ever since. The degree to which our expertise has expanded over the past ten years is simply amazing,” Eben says excitedly.

“Over and above the initial in situ testing and lab testing we now have capabilities in seismic testing and, our new toy, the centrifuge.” This came about through another of Eben’s students, SW Jacobsz, who had done his PhD at Cambridge on the centrifuge and whom Eben had been constantly nagging to join UP. SW finally relented, but told Eben that if he wanted him to do research, they “would have to buy him a centrifuge”. Eben takes up the story: “Setting up such a facility at UP had been my ambition for years – imagine having a centrifuge right here in Pretoria; wouldn’t it be fantastic? So Prof Elsabe Kearsley and SW applied for scarce equipment funding; it was approved, and with a lot of goodwill from industry this multi-million rand equipment is now in the final phase of being installed. It’s the biggest centrifuge in the southern hemisphere with a 3 m radius and 150 G-ton acceleration,” he exclaims with glee.

ONE MORE DREAM BEING REALISED

Eben’s latest baby, which is in the process of being perfected, is a piezometer that measures itself. “It’s always been a problem to monitor and take measurements on remote sites: personnel need to visit the terrain regularly and travel back and forth to have the results assessed. I’m experiencing this myself at present on two project sites in northern Mozambique and Ghana. So I’ve had this idea that technology must be able to produce an invention that is stable and self-sustainable for many years, which you can programme to SMS you at regular intervals with the pressure readings of all the piezometers installed on a specific site.” Eben’s alpha prototype consists of ...
a modem that runs off lithium batteries, 12 A-to-D converters, and a circuit board that he designed and built himself. “You tell the PC board to read the piezometers in a certain sequence, you put the results into the SMS, again in a certain sequence, and you SMS it to yourself with a stamp of its identity, date and time. On receipt, it will be automatically dispatched to the right data base from where you’ll have updated graphs all the time.”

NEVER A DULL MOMENT
All piezocone testing is done through Eben’s company Osimo cc, named after a small town in Italy to which he and Jeanne took a fancy. “I started the business originally under my own name, but settled on a more generic name when I decided to expand my operations and also route Jeanne’s consulting work through the company.” Jeanne is a computer consultant to several large concerns, but also lends a hand with Eben’s programming, in addition to being an enthusiastic co-traveller on his regular trips into the wild, flying with him in a micro-light or gyrocopter, and employing her skills at homemaking and decorating. “She is the glue that holds together all my ventures and stuff,” he says.

Currently, Eben has four CPT rigs operating on sites in Africa and South Africa. He has also turned his hand to designing and building his own rigs, right up to the cylinders, which are lighter than those normally used. His latest rig is designed to install both piezometers and piezocones, containing the most modern technology. “The piezocone still looks the same as the very first version – the outside geometry is specified; it must be 36 mm in diameter – but it’s on the inside where the electronic revolution has taken place. Where, in the old days the sensor was huge and clumsy, now it’s about the size of a sugar grain but it’s hugely sensitive. The purpose-built logger records everything that happens with all the instrumentation at 200 millisecond intervals so you know to a fraction of a millimetre where you are with the probe.”

Always striving for quality, Eben also turned his attention to SAICE’s technical journal. As chairman of the Geotechnical Division in the late 90s he saw the need to revamp the journal and turn it into a flagship publication for the civil engineering society. After presenting a comprehensive strategic and business plan to bring the journal on par with international standards and trends, he was elected chairman of the editorial panel assessing papers, ensuring quality and, eventually, after ten years of hard work from him and his team, receiving international ISI accreditation. “If you want to get recognition at UP you have to publish in an ISI-accredited journal. In the civil engineering fraternity we could never publish in South Africa, and now we can.” He has since resigned as chairman, but remains a member of the editorial panel. “You can’t keep striking the same anvil for ever; once you’ve done your thing you need to stand back and let others take over.”

To round out his 24-hour days, Eben has a variety of pastimes: 4x4 trips to the most untamed areas on the map, skin diving, spear fishing, flying, fine music, cherry farming, cooking, wine collecting and photography are all on the menu – but that’s a story for another time.
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A centrifuge for TUKS

IN THE APRIL 2011 edition of the SAICE magazine (Civil Engineering April 2011 p 46) we reported on the successful funding application that the Department of Civil Engineering at the University of Pretoria (UP) had made to the National Research Foundation for a geotechnical centrifuge. Now, one year later, we are pleased to report that the geotechnical centrifuge has been delivered, installed and commissioned in the civil engineering laboratories at UP, or TUKS, as the university is popularly known.

The purpose of a geotechnical centrifuge is to accelerate small-scale soil models to high accelerations to create a realistic stress distribution within the model that is analogous to the full-scale situation. For example, a model with a scale of 1:50 needs to be accelerated to 50 times earth’s gravity, or 50G. These requirements necessitate a powerful centrifuge. The TUKS centrifuge is the first geotechnical centrifuge in sub-Saharan Africa and is currently the largest in the southern hemisphere.

The centrifuge obtained by TUKS is referred to as a 150G-ton instrument, which means that it is capable of accelerating a model weighing up to 1 ton to 150 times earth’s gravity. The centrifuge was manufactured by the French company Actidyn, located just outside Paris.

The centrifuge model platform measures 0.9 m x 0.8 m with unobstructed headroom of 1.3 m. The radius, measured from the centrifuge axis to the model platform, is 3 m. This means that, at an acceleration of 150G, the model will be travelling in a circular orbit at 240 km/h! The model is counterbalanced by an automatically adjustable counterweight, which shifts to ensure that the machine remains in perfect balance during testing. Fine-tuning the balance of the centrifuge is accomplished by sliding weights located in the centrifuge arms.

The centrifuge was transported from France by sea and was delivered to Durban harbour from where it was transported to Pretoria by train. From the freight depot it was transported to TU, or TUUKS, as the university is popularly known.

The reinforced concrete chamber was designed by Jones & Wagener Consulting Civil Engineers and was constructed by Stefanutti Stocks at no cost to the university. In addition, the reinforcement steel was donated by Steeldale Reinforcing, the special shuttering by Wiehahn Formwork and Scaffolding, and the special high-slump concrete by Lafarge (an impressive cube strength of 70 MPa was measured at 28 days!).

The electricity supply to the centrifuge was designed by Claassen Auret Incorporated, and the cooling system by Spoormaker & Partners. The Department of Civil Engineering would like to express its sincere gratitude to these companies for their tremendous support of this venture.

The purpose of this door is to complete the circular circumference of the centrifuge chamber, and its function is therefore primarily aerodynamic in nature. Due to its light construction, a second steel-reinforced containment wall was constructed outside this door to ensure the safety of persons working in the...
centrifuge laboratory. A roller shutter door prevents access to the main centrifuge door during operation.

The centrifuge is powered by two electric motors with a combined maximum power consumption of 120 kW. As all the heat from the drive motors will be released in the centrifuge chamber during operation, a cooling system of equal capacity was installed. Cold air is introduced to the centrifuge chamber via a circular opening in the roof, and air is extracted from the floor of the chamber before being cooled and circulated back into the chamber.

Testing of soil models on the geotechnical centrifuge is accomplished with the aid of remote-controlled actuators, and observations are made using a state-of-the-art data acquisition system. The centrifuge is equipped with electric slip rings, as well as hydraulic and pneumatic lines, via a slip ring stack rated to 10 bar. This can be used to control various types of actuators to carry out many kinds of experiments during physical model studies on the centrifuge.

The data acquisition system was developed and manufactured by the Centre for Offshore Foundations Systems located at the University of Western Australia in Perth. The system has a total of 24 channels, which can log a variety of instrument types up to a frequency of 1 MHz for short periods. Data logged at slower frequencies, or data from, for example onboard cameras, can be streamed in real time via a fibre-optic rotary network connection or a standard wireless link to the data acquisition computers located in an adjacent control room.

The control room is equipped with two relatively high-specification personal computers for data acquisitioning and image processing, as well as a standard computer from which the centrifuge is controlled. A 42” video monitor is also available from which events within the centrifuge model can be observed, in addition to a video projector which can be used to project images against a large screen in the main centrifuge laboratory for teaching purposes.

The total floor space of the centrifuge laboratory amounts to approximately 250 m², of which the centrifuge takes up around 30%. A model preparation room, equipped with an independent dust extraction facility and a height-adjustable sand hopper, is also available. A press for
The consolidation of clay samples is currently being obtained.

The primary aim with the centrifuge laboratory is to provide a research tool which will be used for model studies by staff and students of the university. Collaboration with the Departments of Geology and Mining Engineering (and others) is envisaged. Two Masters students and a number of undergraduate final year students are currently in the process of designing centrifuge models which will be tested as part of their research.

Projects which are currently in the planning phase include the following:

- the modelling of a soil-nail retaining wall, investigating the mobilisation of nail forces as excavation progresses, and the effect of moisture ingress behind the shotcrete face;
- studies into the behaviour of thin-walled large-diameter pipes; and
- a study to investigate the degrading of small-strain soil stiffness to obtain the correct stiffness for the design of conventional spread footings.

It is hoped that the facility will help to attract graduate students interested in carrying out model testing as part of their research during Masters and PhD studies. In addition, collaboration with other universities and other institutions, e.g. the CSIR and the Council for Geoscience, will be encouraged.

The geotechnical centrifuge will also be available to companies who would like to carry out testing of physical models for commercial purposes. Persons interested in more information are welcome to contact Prof SW Jacobsz at the Department of Civil Engineering (sw.jacobsz@up.ac.za).
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Safe, fast and simple: the DUKTUS pile is load-tested in South Africa

THE DUKTUS DUCTILE CAST IRON PILE SYSTEM
This piling system has been in existence for over 30 years during which time over four million linear metres of ductile cast iron piles have been installed into the ground around the world.

The system comprises 5 m long pre-fabricated pile sections manufactured in the DUKTUS factory in Hall near Innsbruck, Austria. The quality of the prefabricated piles is very high as they are manufactured in a strictly controlled factory environment using advanced technology. This allows a unique specialised jointing system to be formed during manufacture, which, combined with a specialised treatment process applied to the ductile cast iron material itself (DUKTEC), is the key to the success of the system (see Figure 1).

DUKTEC MATERIAL ADVANTAGES
The ductile cast iron pile material is strong and robust, making handling and installation fast and simple and eliminating durability and corrosion concerns.

The unique patented ‘Plug and Drive’ pile jointing system, in combination with a pile shoe, ensures a watertight core which is easily filled with concrete in a controlled manner to create a high-quality composite pile, with the concrete core surrounded by the high-quality ductile cast iron pile outer shell.

The Eurocodes, now also used in South Africa, recognise these advantages in terms of higher quality control from both the piling methodology and the materials, the combination of which eliminates the risk of pile contamination. The Eurocodes therefore use lower partial factors of safety on the composite pile materials, making the DUKTUS ductile cast iron pile system very efficient in terms of materials. For example, a 170 mm diameter DUKTUS ductile cast iron pile enjoys the same permissible design load capacity as a 520 mm diameter cast-in-situ pile.

As well as being very simple, the unique pile jointing system enables pile installation rates of up to 500 m per day per piling machine. The piling system and methodology require only a standard

Introducing modern technologies into an existing market can be a challenge, but most would agree that the recipe for success must bring together simplicity, technical performance, time savings, high safety and quality standards, and cost savings. Pursuing these goals, piling contractor GeoPile Africa (Pty) Ltd has sourced and introduced into the local market the DUKTUS ductile cast iron pile system under an exclusive licence agreement.
Due to the unique DUKTUS ‘Plug and Drive’ piling system, pile head trimming works are included in the piling scope of works, which brings further time and cost savings to the activities of the general contractor whose work follows the piling contractor. All of this contributes to deliver a project ahead of schedule and within budget.

In summary – less pile materials, combined with less site resources for installation, with significantly faster piling production rates, plus no pile trimming for the main contractor, plus no spoil or wastage from piling activities all combine into time and cost savings for the client. Smaller diameter piles require smaller pile caps to be constructed by the general contractor, which offers the client further time and cost savings.

A high ground water table and unstable soils constitute problems for most piling systems and result in reduced productivity, requiring more resources such as bentonite and/or the use of temporary casings, all of which increase costs. The DUKTUS piling system is unaffected by these challenges. Regardless of whether the soils are saturated and unstable, this piling system requires no additional resources. High productivity can therefore be maintained. Costs are unaffected and high safety and quality standards remain assured.

**PROVING THE PERFORMANCE OF THE PILES**

Ductile cast iron piles have already been introduced and used in Africa, the closest location being in Angola. However, because ductile cast iron piles have not yet been introduced into South Africa, it was decided that the technical performance of the piles should first be proved using static load testing. This was achieved with the assistance of the University of Pretoria.

**SOILS INVESTIGATION**

Initially, three dynamic penetrometer (DPSh) tests were performed and a rotary core borehole was sunk at the university’s experimental farm in Lynnwood, Pretoria. Interestingly, the three penetrometers reached refusal at about 16 m depth, giving initial indications that this was the rock head depth. However, this was misleading, because the subsequent borehole proved bedrock to be at 34.5 m depth, with firm to stiff clay overlying the bedrock.

The soil profile comprised a firm, silty clay from reworked residual shale to a depth of 15 m. This was followed by sandy...
clay from reworked residual andesite to 29 m. The consistency of this material varied fairly randomly between firm to stiff, with occasional soft inclusions. Below 29 m the residual andesite became intact and weathering reduced with depth. Intact highly weathered soft rock andesite was encountered at 34.5 m.

The soils investigation revealed the soil profile to be much deeper than anticipated. However, this meant a conservative profile in which to test the piling system, as longer piles would tend to be more prone to problems like lateral deflection and buckling under load than shorter piles. Results from pile tests in such a profile should therefore be conservative.

**INSTALLATION OF TEST PILES AND ANCHOR PILES**

Two test piles and eight reaction anchor piles were installed. The total installed pile length amounted to 200 linear metres and was accomplished within only one and a half day’s work in early November 2011. The time spent installing the DUKTUS ductile cast iron piles included four hours for the installation of strain gauges inside hollow test pile TP2. The local excavator operator had never been introduced to this piling method before. The test piles are respectively referred to as TP1 and TP2 in this article. A DUKTUS pile being installed using a standard excavator fitted with a breaker hammer is illustrated in Figure 2.

During installation, it was decided to terminate TP1 into the stiff clay at a pile toe depth of 30 m, some 4.5 m above the rock head level determined from the adjacent borehole. TP2 was driven to 27.5 m depth, terminating about 7 m above the expected rock head level. It is uncertain by how much the depth to bedrock varies on the test site, as only one borehole was drilled.

Both test piles were instrumented with four levels of weldable strain gauges to measure the axial load distribution in the piles during the load tests. The load was applied to a 300 ton load cell located on top of each pile, and was electronically recorded to provide a continuous load record for each test. Pile displacements were recorded using dial gauges, complemented in the final test by electronic displacement transducers.

Each of the eight anchor piles was driven using a special oversize shoe to 15 m depth into clayey material (residual shale). During driving, the annular space between the pile and soil was filled with 10 MPa mortar in order to improve the shaft capacity of the piles. GEWI bars of 50 mm diameter were placed into the core of the eight anchor piles and these were filled with 10 MPa mortar. The central core of TP1 was also filled with mortar while TP2 was not filled. The pile plan layout is presented schematically in Figure 3.

Two decisions were deliberately taken in order to obtain ‘worst case’ static load test results. First, the test piles were terminated several metres above the expected rock head. Second, a relatively weak 10 MPa hand-mixed mortar was deliberately selected for all pile filling.

It was decided to perform a static load test based on aiming for a permissible...
design load capacity of 1 200 kN on the mortar-filled TP1. In the case of TP2, the central core was left hollow and it was decided to aim to perform a static load test on this test pile to prove a permissible design load capacity of 900 kN.

**METHOD OF INSTALLATION OF DUKTUS PILES**

DUKTUS piles were supplied in standard 5 m prefabricated lengths. A 30 tonne excavator with hydraulic booms and hammer, capable of reaching the necessary height required to drive each 5 m pile section, was used. The installation methodology is described below:

1. The first pile section was lifted from a horizontal storage position on the ground into a vertical position by the excavator operator using a standard sling.
2. The tapered spigot toe of the first section of the pile was then lowered to fit snugly onto the pile shoe, which had been placed at the pile position as surveyed.
3. The excavator operator then guided the hydraulic hammer and pile adaptor pin into the socket at the top of the pile section.
4. The banksman checked the pile verticality using a spirit level, and the excavator operator then activated the hydraulic hammer (breaker hammer) to drive the pile section into the soil.
5. After the first pile section had been driven to ground level, the excavator operator lifted a second pile section and lowered the tapered spigot toe into the socket at the top of the first pile section.
6. The unique design of the patented DUKTUS ‘Plug and Drive’ jointing system ensures (i) that a pile section aligns with the preceding pile section, and (ii) that the structural rigid connection joint between the two pile sections is completed after ongoing pile driving, forming a cold weld to fuse together the two pile sections, and (iii) that the joint between the pile sections is as strong as the individual pile sections themselves.
7. Steps 5 and 6 were repeated until the pile was driven down to reach the chosen founding level where the pile was driven to a predetermined set.
8. The pile was then marked at the final cut-off level and cut off using a simple angle grinder.
9. The off-cut pile section was then used as the starter pile section on the next pile installed (see step 1 above), thereby avoiding any material wastage.

After completion of driving, the inner core of the DUKTUS pile remains dry, due to the DUKTUS design of the watertight pile joint and shoe. This permits physical measurement of the depth of every pile installed, giving added quality assurance and peace of mind to all parties concerned. After final inspection and measurements, the installed piles can easily be filled with concrete. A 170 mm external diameter DUKTUS pile requires only 18 litres of concrete per linear metre. Therefore, 300 m of pile installation per day (for example, 20 piles to 15 m depth) will only require a single ready-mixed concrete truck to be delivered per day towards the end of the day’s piling work.

The next day the general contractor has no pile trimming to carry out, and minimal cleaning up is required, enabling immediate commencement of steel fixing and shuttering for pile cap works.

**STATIC LOAD TESTS**

**Compression Test**

The jack and reaction beams and load testing equipment were set up on site and the relevant zero readings were taken.

<table>
<thead>
<tr>
<th>Test pile reference</th>
<th>Test pile details</th>
<th>Load (kN)</th>
<th>% of Permissible design working load</th>
<th>Gross settlement (mm)</th>
<th>Residual settlement after unloading (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1 30 m depth (4.5 m above rock head)</td>
<td>mortared core</td>
<td>1 200 kN</td>
<td>100%</td>
<td>18.43</td>
<td>4.12</td>
</tr>
<tr>
<td>TP2 27.5 m depth (7 m above rock head)</td>
<td>hollow core</td>
<td>900 kN</td>
<td>100%</td>
<td>9.61</td>
<td>3.76</td>
</tr>
<tr>
<td>TP2</td>
<td>27.5 m depth (7 m above rock head)</td>
<td>hollow core</td>
<td>1 350 kN</td>
<td>150%</td>
<td>17.27</td>
</tr>
<tr>
<td>TP2</td>
<td>27.5 m depth (7 m above rock head)</td>
<td>hollow core</td>
<td>1 800 kN</td>
<td>200%</td>
<td>32.25</td>
</tr>
</tbody>
</table>
The 30 m deep mortar-filled test pile TP1 was statically load-tested in two cycles, first up to 1 200 kN (the idealised permissible design-safe working load) and then up to 1 500 kN (125% of the idealised permissible design-safe working load). A further load cycle was not carried out due to a problem with the reaction system.

The 27.5 m deep hollow core test pile TP2 was then statically load-tested in three cycles of 900 kN (100% of idealised permissible design-safe working load), 1 350 kN (150% of idealised permissible design-safe working load) and then up to 1 800 kN (200% of the idealised permissible design-safe working load).

The results of the load tests are summarised in Tables 1 and 2 and the load-displacement curves for the first load cycle on each pile are shown in Figure 4. Most of the pile head settlement could be attributed to elastic deformation of the piles as illustrated by the small residual settlement values upon unloading. The maximum settlement under working load amounted to 18 mm and 10 mm for the grouted and hollow piles respectively, while the residual settlement after removal of the working loads amounted to only about 4 mm for both the grouted and hollow piles.

**Tension Test**

Following the compression tests, tension tests were carried out on two of the 15 m long anchor piles by jacking the reaction beam using pile TP2 as reaction. A maximum tensile load of 600 kN was applied to each of the reaction piles, mobilising on average 51 kPa of shaft friction (based on a 15 m pile length and pile diameter of 170 mm with a 40 mm wide grouted annulus around the pile). This was accompanied by only between 1 mm and 2 mm upward displacement at pile head level, which was nearly fully recovered upon unloading, leaving a residual upward displacement of only approximately 0.5 mm. It was not possible to exert larger tensile loads given the rated capacity of the GEWI bars connecting

A 170 mm external diameter DUKTUS pile requires only 18 litres of concrete per linear metre. Therefore, 300 m of pile installation per day (for example, 20 piles to 15 m depth) will only require a single ready-mixed concrete truck to be delivered per day towards the end of the day’s piling work.

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the reaction system to the piles. The tensile test clearly illustrates excellent shaft capacity around the mortar-filled perimeter of the piles, confirming that the DUKTUS system has potential to also perform well in soil conditions where sound end-bearing capacity is not guaranteed.

SUMMARY

Two pile load tests, carried out on approximately 30 m long DUKTUS piles in a firm clayey soil profile underlain by competent bedrock, illustrated excellent load bearing characteristic with settlements of only 19 mm and 10 mm respectively under working load. Between 70% and 80% of this settlement resulted from elastic compression of the piles, as illustrated by the small residual settlement upon unloading.

The soil profile in which the piles were tested is deeper and softer than what would typically be encountered in South African conditions. It is approximately twice the depth in which the DUKTUS piles would typically be recommended. The results obtained are therefore deemed to be conservative. The relatively soft clay provided adequate lateral support to ensure a high axial capacity, not only arising from end-bearing, but also very good shaft resistance.

Due to its simplicity and efficiency, the DUKTUS piling system has numerous advantages:

- Piles are rapidly and easily installed using locally available resources – a standard hydraulic excavator and hammer, as well as local excavator operators who may have no prior piling experience.
- The system offers a high standard of safety and quality. Very few site personnel and very little equipment are required on site for piling works to be carried out. This dramatically reduces site congestion and conflict with other activities on site. Piles are prefabricated in the quality-controlled environment of the DUKTUS factory and each pile is supplied with quality certification in compliance with European Standards.
- Pile installation is rapid, generally averaging 250 to 300 linear metres per excavator per day. The DUKTUS pile, being a driven displacement pile, is a direct replacement for the driven cast-in-situ pile, for which a typical production per piling rig is generally around 50 linear metres per day.

As an example, a small piling site such as a three-storey low-rise office or apartment block or car park might require, say, 100 piles to 15 m depth. Piling would take a single driven cast-in-situ piling rig approximately five weeks to install, after which the general contractor would be unable to commence pilecap construction until around week seven of the construction programme.

He would first have to trim the piles to the final cut-off level and tidy up the site after the piling contractor has left. In comparison, the DUKTUS piling system would require just over one week to complete the entire piling installation, inclusive of the pile trimming, with minimal site disturbance and no wastage of piling materials whatsoever. This enables the general contractor to commence pilecap construction immediately after the piling works in week two of the construction programme. On larger projects, that five week time saving would be further amplified due to the use of multiple piling machines.

Less equipment and manpower resources on site, in combination with a rapid production rate of pile installation, result in a clean and safer construction site with less congestion. More working space is freed up for the general contractor to proceed more effectively. Furthermore, due to the simplicity of the segmental installation process, the DUKTUS piling system is versatile and flexible in terms of variable pile depth requirements.

The results of the strain gauge measurements installed by the University of Pretoria at different levels along the length of the test pile shafts, as well as the data from other instrumentation used in the test arrangement will be presented in a future technical paper.

Figure 4 Load-displacement curves for the first load cycles on the grouted and hollow test piles
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<tr>
<th>Product</th>
<th>Description</th>
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<tr>
<td>DatumMate</td>
<td>WGS 84 Datum Conversion of Drawings</td>
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<tr>
<td>WaterMate</td>
<td>Water Reticulation Design and Static Analysis and Time Simulation</td>
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<td>AutoTurn</td>
<td>Vehicle Manoeuvre Simulation/Analysis</td>
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<td>RoadMate</td>
<td>Urban/Rural Road Design</td>
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<td>SurfMate</td>
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<td>PipeMate</td>
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<td>AutoCAD Civil 3D</td>
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<td>RebarMate</td>
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<td>Aircraft Movement/Space Analysis</td>
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<td>ParkCAD</td>
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Slope Stabilisation along National Route N12 Section 18

**DESCRIPTION OF THE PROJECT**

Part of the brief from the client (SANRAL, i.e. the South African National Roads Agency Limited) required analysis and evaluation of the stability of the cuttings along National Route 12 Section 18 near Alberton, between the Reading Interchange and the Elands Interchange (SANRAL chainage 11 400 and 17 000 m). This article describes the measures taken to reduce the risk and probability of slope failure in these cuttings, thereby ensuring driver safety. A solution was also required to allow for drainage and easy maintenance of these cuttings.

Four existing cuttings were widened along this stretch of the route – three on the eastbound carriageway (referred to as Reading West, Reading East and Elands Eastbound), and one on the westbound carriageway (referred to as Voortrekker Westbound). Designs were required to ensure the long-term stability of these widened cuttings.

**METHODOLOGY AND DESIGN APPROACH**

The geotechnical investigations were carried out by ARQ (Pty) Ltd intermittently from 2010 to 2011, as the different cuttings became available. The typical geology of the material encountered in the cuttings was quartzite interlayered with quartzitic conglomerate of the Central Rand Group. The investigation was aimed at supplying information in terms of:

- the joint condition, spacing, and hardness of the rock
- the overall stability
- localised areas of instability, and
- design recommendations to ensure the long-term safety and stability of the cuttings.

The investigations commenced with field mapping of the cuttings. The faces of the cuttings were mapped in the vertical and horizontal planes. Vertical mapping made use of abseiling techniques and crane baskets, as the cuttings ranged in height from 7 – 26 m, and was conducted at intervals of approximately 20 m along the length of the cuttings. Horizontal mapping was conducted along the length of the cuttings at approximately eye level from the base of the cutting. Visual observations and photographs were also used to identify and record any salient features encountered, as well as features that required special attention, and that had not been covered by the mapping.
Stereographic analysis of the field mapping allowed clusters of joints and joint sets to be identified for each cutting. These joint set orientations, together with the shear strength parameters determined for the rock mass using the RocLab software, made an evaluation of the overall slope stability possible. This was done using the Prokon geotechnical suite which was, in turn, verified by hand calculations. The kinematics of the interaction between joint sets were also analysed to evaluate localised stability and potential rockfall. Using this information, the cuttings were evaluated for different failure modes, including wedge, planar and toppling failure along various joint planes. The overall slope stability of each cutting was assessed for circular failure in the case of multiple joint sets. Water and seismic effects were also taken into consideration during the slope stability analysis. From this assessment, the cuttings presented global stability, but localised stability remained a concern.

IMPLEMENTATION

Following the evaluation of the cuttings, the corrective measures listed below were deemed necessary to ensure the stability of the cuttings:

- To reduce the risk of rockfalls, the cuttings were first cleared of all loose rocks and material using a long-reach excavator and rope access methods. Loose rubble and rock debris on top of the slope were also removed to a minimum of 2 m behind the crest of the cuttings.
- Due to the jointed nature of the rock mass, water is able to move along joint planes causing hydrostatic forces, and is able to lubricate and destabilise parts of the rock mass. Drainage of the cuttings was therefore required to stabilise the slopes as a whole. Perforated PVC drains, lined with geosynthetics to prevent the migration of fines (which could...
Gabions provided this multifunctional solution. However, for steep slopes at the crest, a low, nominally-reinforced shotcrete wall was used to deflect water away from the crest of the cuttings. Gabions were specifically used at the base to act as a barrier to loose rocks rolling and spilling onto the road.

For the other cuttings, where localised areas of highly fractured rock were present, draped rockfall netting systems were used on the face of the slope to slow down and redirect any small falling blocks. This netting was used where the joint spacing was too small to successfully make use of rock bolts or anchors. Rockfall netting is typically ended two metres above the road level for two reasons – firstly, to prevent theft of the netting, and secondly, to allow the easy clearing away of small blocks from the base of the cutting during regular maintenance.

As a final precaution, rock bolts and anchors were used on large blocky areas, either to stabilise portions of the cuttings when large blocks were encountered, or to intercept and contain intermediate discrete blocks of rock.

Clearing was carried out and drainage was installed on all four cuttings. The design for Reading West, Reading East and Voortrekker Westbound cuttings was done by ARQ. This incorporated gabions, shotcrete panels and walls, draped rock-fall netting and rock bolts. The design for Elands Eastbound cutting was conducted by Melis & Du Plessis – the design incorporated gabions at the crest and base of the slope, rock-fall netting pinned to a systematic pattern of anchors, and rock bolts.
SPECIALISED CONSTRUCTION METHODS AND EQUIPMENT EMPLOYED

Sanyati Piling and Geotechnical were awarded the contract to carry out the specialised work at height. The company made use of specialist contractors WEPEC cc and GUNCRETE. The need to undertake most of this work at height presented significant challenges to the engineer who needed to make detailed assessments of the conditions, and the contractor who was required to install the netting using specialised equipment and techniques. The following brief notes give an idea of the challenges involved:

- Drilling and installing the rock bolts for the netting was extremely difficult due to the highly fractured rock and the 89 mm anchor hole size.
- Excavators fitted with hydraulic drifters were used for drilling, and a crane with a basket-mounted drifter was used to drill the more inaccessible anchor holes.
- In areas where spot bolts were required, a rope-suspended drill rig (spider) was used for the drilling operation.
- All the installation of the rock bolts and netting was done by rope technicians.

CONCLUSION

The Gauteng Freeway Improvement Project, implemented by SANRAL, is set to ensure a world-class, well-maintained and upgraded road network. Innovative designs and construction techniques are required to achieve this. The successful completion of this project will ultimately improve the driving experience for all motorists in Gauteng. The measures carried out over this portion of the route, as described in this article, will no doubt contribute to the goals of SANRAL, ensuring driver safety by reducing the risk and probability of slope failures.
“Congratulations to the Reading Interchange team on their successful completion of the ROCKFALL MITIGATION PROJECT”

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An investigation into the stability of the Ring Road lateral support system adjacent to the construction of UCT’s new engineering building

INTRODUCTION

In 2010 the University of Cape Town (UCT) embarked on a three-year capital expenditure programme valued at nearly R1 billion. A considerable component of this expenditure programme was the construction of the New Engineering Building (NEB), on the slopes of Devil’s Peak, which commenced in January 2011. The NEB was to replace the structure housing the Civil Engineering Department laboratories. This project required a multi-staged demolition of the structure, in conjunction with the initiation of construction. Furthermore, extensive bulk excavations were required in order to accommodate the proposed basement level of the NEB earmarked for the new Civil Engineering Department laboratories.

The bulk excavations for the basement level raised slope stability concerns relating to the site’s western boundary. The western boundary of the site supports Ring Road – a busy internal road of UCT – by means of a tapered gravity retaining wall. The wall supports a 6.3 m backfill at its highest point. During the planning and design phase of the NEB it was established that the stability of this retaining structure would be undermined by the excavations extending 3.3 m below the toe of...
this structure. Hence, an additional lateral support system was
designed and constructed by Esorfranki before excavations took
place, in order to provide the required stability to the slope once
excavations commenced.

These slope stability concerns led to an independent inves-
tigation, led by the University of Cape Town’s Civil Engineering
Department and centred on good excavation practice, to assess
the performance of the Ring Road lateral support system in
stabilising the western boundary. This was carried out in light
of the growing need for sustainable land use, whereby the ex-
pansion of underground space is regarded as a suitable solution
(Goddard 2004). Furthermore, recent excavation failures, such
as the collapse of Singapore’s Nicoll Highway in 2004, formed
the setting to the investigation into the NEB earthworks’ influ-
ence on the neighbouring lateral support system. Extensive
research into excavation failures, especially by Sowers (2004),
Chen et al. (2000) and Gue & Tan (2004), found that inadequacy
in design was the main contributing factor to excavation
failures. This emphasised the importance of using thorough
design and analysis techniques during the design of excavations
in order to prevent failure. It is against this backdrop that the
investigation into the performance of the Ring Road lateral sup-
port system adjacent to the NEB was launched.

The primary objective of this study was to provide insight
to the question, “How was the stability of the NEB site’s
western boundary affected by the excavation works?” This
was assessed by a slope stability analysis using (1) limit equi-
librium (LE) techniques, and (2) the Shear Strength Reduction
(SSR) technique. The SSR method involves the systematic use
of Finite Element (FE) analysis to determine a Shear Strength
Reduction Factor (SSRF), or factor of safety which brings the
slope to the verge of failure (Hammah et al. 2005). This is done
by reducing the strength of respective materials of the slope
by the SSRF until the FE analysis does not converge – giving
the critical SSRF, which is effectively regarded as the global
factor of safety for the respective slope.

The SSR technique was used to supplement and provide
insight into the output given by the conventional LE tech-
niques, especially with regard to the stress-strain behav-
iour of the respective materials. The necessary modelling
was carried out using two software packages developed
by Rocscience, under licence from Kantey and Templer
Consulting Engineers. Slide was used to conduct the LE
slope stability analysis. This is a powerful slope stability
package, capable of assessing numerous material models, as
well as structural elements such as ground anchors and re-
taining walls. Phase2 – a two-dimensional FE program – was
used to supplement the output given by the LE analysis. This
was done in order to assess the material behaviour and its
subsequent response to the ongoing excavations and loading.
The stability of the Ring Road lateral support was assessed
by comparing the stability of the system before and after
excavations took place. This resulted in a thorough geotech-
nical analysis, which is outlined in the sections to follow.

SITE CHARACTERISATION

Geological conditions

Based on published geological data, the area is known to be
underlain by a varying thickness of transported material
emanating from the slope to the west, followed by residual
Malmesbury Group shales of the Tygerburg Formation (Brink
1985). This geological information was confirmed upon
sub-surface investigation by Kantey and Templer Consulting
Engineers (2010). A geotechnical investigation was conducted
by drilling four boreholes across the site and assessing the
substrata by means of Standard Penetration Tests (SPT) and
core-logging. Three distinct material profiles were found,
namely, (1) fill, (2) transported material and (3) residual
Malmesbury Group material. The description of these layers
is summarised in Figure 2.

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Brief Description</th>
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<tbody>
<tr>
<td>0.5</td>
<td>Fill material, consisting of sand and brick fragments. Sign of feruginisation – highlighting seepage from the slopes to the west of the site. [FILL]</td>
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<tr>
<td>1.47</td>
<td>Colluvial material, consisting of sandstone boulders supported in sandy silt matrix. Medium dense to dense with depth. [TRANSPORTED]</td>
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<td>16</td>
<td>Reworked weathered Malmesbury Group material – fissured clayey silt (ML). Stiff to very stiff with depth. [REWORKED RESIDUAL]</td>
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<tr>
<td>19.7</td>
<td>Intact weathered Malmesbury Group material – clay silt (ML). Very stiff. [RESIDUAL]</td>
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Figure 2 Summary of material profile

<table>
<thead>
<tr>
<th>2011</th>
<th>Jan</th>
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<th>Apr</th>
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<th>Jun</th>
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<td>Anchored Soldier Pile Wall Installation</td>
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<td>Pile Installation</td>
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<td>Casting of Capping Beam</td>
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<tr>
<td>Ground Anchor Installation</td>
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<tr>
<td>Bulk Excavations</td>
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Figure 3 Bulk excavation programme
Staging of excavation process

The NEB complex was to be constructed on the same footprint as the former Civil Engineering Department laboratories. This required the demolition of the respective buildings before excavation could commence. Furthermore, based on the findings of the geotechnical site investigation, the western boundary required additional lateral support. The details of these processes are presented below, and the bulk earthworks programme is given in Figure 3.

Demolition of Civil Engineering Department laboratories and site clearance

The first stage of construction involved the demolition of the Civil Engineering Department’s laboratories. This process took approximately 5 months to complete, and involved the following:
- Demolition of the Civil Engineering Department’s laboratories and the foundations
- Removal of all rubble from the site
- Removal of former stormwater drainage systems located on the site
- Relocation of trees
- Establishment of an initial ground level (IGL) of 121.65 m above mean sea level (AMSL)

Installation of additional lateral support on western boundary

The installation of the additional lateral support on the western boundary was a three-month process, beginning in June 2011. An anchored soldier pile wall was deemed the most appropriate retaining system for the NEB site by the design consultants. This included the following components:
- 750 mm diameter, 17.0 – 20.0 m long cased auger piles
- 300 mm diameter, 7.75 m rotary percussion piles
- 1.0 m wide, 1.2 m deep capping beam
- 16.5 m Titan 52/26 permanent ground anchors
- Steel mesh and gunite arch system

The piles were arranged with sets of three 300 mm diameter piles in-between pairs of 750 mm diameter piles. The 750 mm diameter piles were used to support 5 MN column working.
loads. These piles were modelled in Plaxis, by Esorfranki, and sized according to a 2.5 MN load supported by each 750 mm diameter pile. Although designed primarily as load bearing, the 750 mm diameter piles provided considerable stiffness to the lateral support system, which ultimately allowed the use of the 300 mm diameter piles.

The initial design of the lateral support system actually comprised 600 mm diameter continuous flight auger (CFA) piles and 750 mm diameter cased auger piles, with alternating pairs. However, upon the commencement of boring, it was found that CFA piles were not suitable, due to the frequent occurrence of extremely large boulders. This resulted in the set of three 300 mm diameter rotary percussion piles replacing the pair of 600 mm diameter CFA piles in-between the 750 mm diameter piles.

Once the installation of the piles was complete, the capping beam was constructed to provide extra rigidity to the soldier pile wall, and it provided a base upon which ground anchors could be stressed (Figure 4). The ground anchors were installed to minimise the deflection of the pile wall. This was deemed necessary to minimise the possibility of eccentric loads forming at the column-capping beam interface, and to reduce the bending stresses in the soldier piles. The installation of the ground anchors began once the capping beam had reached sufficient strength to resist the ground anchor stresses.

Steel mesh gunite arches were adopted to retain the soil in-between the soldier piles. Wick drains were installed behind these arches to convey seepage to a drain at the basement floor slab level. The gunite arches were constructed after the anchors had been installed and the necessary excavations completed.
Bulk excavations

The bulk excavation process involved the establishment of two platforms – Platforms 1 and 2 – over a period of four months. The two platforms were established at different levels in order to accommodate basement levels and the pad footings upon which the NEB was to be founded.

The excavation works were carried out by Caterpillar 330C excavators. Platform 2 was excavated first as these excavations did not interfere with the installation of the additional lateral support to the western boundary. Excavation processes were carried out on portions of Platform 1, but Platform 1 was only completed after the ground anchors had been installed. Figure 5 illustrates the completed bulk earthworks.

**SELECTION OF MATERIAL PARAMETERS**

The material parameters used to conduct the relevant modelling in this study are illustrated in Table 1. It should be stressed that this investigation was independent of previous design and planning processes conducted by the consulting engineering teams. Therefore, the soil parameters listed below were derived during this investigation, and were not necessarily the same parameters used by the design engineers. The bulk density of all three materials was derived from laboratory testing. The Mohr-Coulomb shear strength parameters for the colluvial material were determined through back-analysing an exposed cutting on the site. The Mohr-Coulomb shear strength parameters for the reworked and intact weathered Malmesbury Group material were determined from relevant literature and case studies, with considerable reference to Brink (1985) and Parrock & Du Plessis (2010). The elastic material parameters were derived from relevant literature, with special reference to Sabatini et al (1999) and Kulhawy & Mayne (1990).

**RESULTS**

Table 2 gives the slope stability results from the different methods of analysis conducted on the Ring Road lateral support. These results are summarised and shown graphically in Figure 6. It is evident from these results that the system was sufficiently safe both before and after excavation. This is based on factor of safety and SSRF values greater than 1.50. Furthermore, the stability improved with the construction of the tied back wall and excavation of the respective soil.

On a qualitative level, the importance of the pile wall was illustrated by this analysis. The circular shear failure results indicate that the overall failure mode was critical. However, the analyses conducted using non-circular shear surfaces show that the most likely mode of failure was through the ground anchor. An important observation of this was the shear surfaces extending below the pile wall despite breaching the ground anchor. This highlighted the importance of the pile wall in maintaining stability. This also emphasised the increased stability of the system by displaying that a failure of the soil body through the anchor was more probable than an overall failure of the system.

The circular and non-circular shear failure surfaces were superimposed onto the FEM SSR results as illustrated in Figures 7 and 8 by a red and orange dashed line respectively. This was done in order to compare the FEM SSR results directly to the minimum shear surfaces discovered during the LE analysis. Figure 8 shows the development of two distinct shear strain zones. The most prominent shear strain zone coincided closely to the non-circular slip surface yielded by the LE analysis. The circular shear surface also followed a band of less prominent shear strain recognised by the FEM SSR analysis. Furthermore, Figure 8 depicts the effect of the pile with significant shear strain in front of the pile wall, but a reduced area of shear strain behind the toe of the wall. This demonstrates the mobilisation of the shear stress by the pile wall and how this stress is transferred to the soil in front of the wall.
The FEM SSR results illustrated the effectiveness of this technique, especially when combined with conventional LE methods. With reference to Figure 6, the LE result showed an improved factor of safety with the construction of the pile wall, but the FEM SSR results did not. The decrease of SSRF values between the two cases is likely to be due to the increased surcharge loading behind the wall as a result of a construction crane. The benefit of the FEM SSR technique is given here, as the results demonstrated the behaviour of the material behind the lateral support system in response to the increased surcharge loading from the retained soil and crane loading. This was important, as it illustrated the system’s stability as a function of its geometry, strength parameters and loading, in terms of the material’s response to stress. The FEM SSR technique essentially modelled a progressive failure of the slope, and in doing so, highlighted key weaknesses in the material which arose from the system’s geometry and loading. Such an analysis is not possible to model using LE techniques, as inter-particle material interactions are not assessed. Furthermore, LE methods are unable to model the interaction between structural elements, such as the anchored soldier pile wall and the supported soil. FEM methods can, and are able to accurately predict the structural elements’ interaction with the retained material, including key parameters such as anchor forces, deformation, shear, bending and axial stresses.

CONCLUSIONS
The analyses conducted on the western boundary of the NEB bulk excavations found the Ring Road lateral support system to be stable. This conclusion was derived from slope stability analyses, using numerical methods, conducted on the Ring Road lateral support system. The Ring Road lateral support system formed the western boundary to the NEB site.

The slope stability analysis conducted on the Ring Road lateral support system showed that the system was stable, based

<table>
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<th>Table 2 Slope stability results</th>
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<td><strong>Analysis</strong></td>
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<td>Simplified Bishop</td>
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<td>Spencer</td>
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<td><strong>Average</strong></td>
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<td><strong>SSRF‡</strong></td>
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‡ Circular Shear Failure Analysis | † Non-circular Shear Failure Analysis | • Shear Strength Reduction Factor

![Figure 6 Comparison of slope stability results](image)

![Figure 7 FEM SSR slope stability results - after demolition, but before excavation](image)

![Figure 8 FEM SSR slope stability results - after excavation](image)
At the heart of every Atlas Copco DrillAir™ compressor is the new DrillAir™ screw element. Driven with a ultra-low friction gearbox, the new compressor units consume less energy.

DrillAir™. The largest air volume with the highest air pressure in the portable compressor industry.

ACKNOWLEDGEMENTS
The help of all the personnel from Kantey and Templer Consulting Engineers is greatly appreciated, especially with regard to lending the software and access to resources that made this investigation possible. Furthermore, sincere gratitude to the firms which provided crucial information regarding this project, especially, Sutherland Consulting Engineers, KFD Wilkinson Consulting Engineers and Esorfranki Geotechnical.

NOTE
The list of references is available from the editor.

The analyses conducted on the western boundary of the NEB bulk excavations found the Ring Road lateral support system to be stable. This conclusion was derived from slope stability analyses, using numerical methods, conducted on the Ring Road lateral support system. The Ring Road lateral support system formed the western boundary to the NEB site.
BACKGROUND
The government of Botswana in recent years has undertaken major dam construction to address the rapidly growing demand for water. This culminated in the construction of three major dams with a combined capacity of about 530 million m³, almost doubling existing surface water capacity to 939 million m³. Construction of the Dikgatlhong Dam commenced in March 2008, followed by the Lotsane Dam in April 2009 and the Thune Dam in April 2010. Dikgatlhong and Lotsane Dams are substantially complete. Dikgatlhong is the largest dam in Botswana with an active capacity of 400 million m³, while the Thune Dam, which is still under construction, will be the fourth largest dam, with a full supply capacity of 90 million m³ upon completion.

During excavation of the cut-off trench, potholes were encountered. The occurrence, intensity and size of these potholes puzzled many, and various theories were postulated on the origins of these potholes.

PROJECT DESCRIPTION
Thune Dam is situated on the Thune River in the northeastern part of Botswana, 120 km southeast of Selebi Phikwe in the Bobirwa District.

The zoned earth-fill dam, composed of central clay core with gravelly sandy shell protected by upstream rip rap and downstream gravel, has an embankment height of 34.5 m above river bed level, and an earth-fill volume of 1.12 million m³ for the 1 670 m long dam wall. The mass concrete spillway weir is 28.5 m high and 115 m long, and is contained between mass retaining walls.

The outlet works comprise a 30 m high reinforced concrete intake structure in the retaining wall, and a DN 1 500 mm outlet pipe leading to the valve chamber. The water is intended for potable water supply and irrigation to neighbouring villages.

Construction of the dam is in progress, and completion stands at about 45%. The dam is scheduled for completion in April 2013.

GEOLOGICAL SETTING
The dam site and the greater part of the dam basin are underlain by sedimentary strata of the Lebung Group, within the upper Karoo Super Group, which is Triassic to Jurassic in age. The lithology
in general comprises orange, red or white sandstone, locally calcareous, with reddish siltstone increasingly common downwards. Younger Karoo basalts lie immediately to the north of the dam site.

The dam site falls within the Limpopo Mobile Belt, the oldest known mobile belt in the world, with rocks varying in age from 2 700 million to 3 700 million years. The Limpopo Mobile Belt separates the Zimbabwean craton in the north from the Kaapvaal craton in the south. In broad terms, the cratons comprise large stable masses of crystalline rock, mainly granites and metamorphic rock. The mobile belts have a history of major deformation associated with igneous activity and metamorphosis. The metamorphic rocks are, in turn, overlain by younger sedimentary and igneous rocks. Despite the tortured history, the younger Karoo sediments are relatively undisturbed and are essentially horizontally bedded.

The area has been intruded by younger dolerite dykes, which, on a regional scale, commonly strike either in E-W or ENE-WSW directions. Regional-scale faulting is uncommon, but an NE striking fault which traverses the dam’s left flank has been mapped. The entire area is now covered by aeolian Kalahari sands.

CHALLENGES ENCOUNTERED WITH POTHOLES

One of the more unusual features exposed during foundation excavations was a section of the sandstone bedrock where the relatively smooth, albeit irregular, rock surface was intensely potholed. The potholed section was only approximately 220 m in length, predominantly between Ch 200 and Ch 420; potholes were not...
The sandstone within this zone was relatively massive. Jointing was not well developed, and was in fact largely absent. Generally the potholes were up to 500 mm in diameter, although some were in the range of 1 m to 2 m diameter, while a few were between 3 m and 4 m. The inner surface of the potholes was characterised by a hardened ‘skin’ of sandstone, which appeared cemented by iron oxides. This oxidised zone extended several millimetres into the sandstone rock material, becoming progressively less oxidised with increasing depth, and changing in colour from dark, rusty brown to orange and then again to the whitish colour of the unaltered bedrock.

The potholes were typically filled with a slightly ferruginised, i.e. slightly cemented sand, which was noticeably more dense than the overlying, loose aeolian Kalahari sands.

At first glance the potholes appeared randomly distributed across the sandstone surface, but in fact there was a higher pothole concentration associated with sandstone bands coloured with a faint reddish brown, in contrast to the whitish coloured sandstone. These bands were, however, not representative of the sub-horizontal sandstone beds, as they rather appeared as sub-vertical bands of discolouration.

**Likely origins**

Conventional understanding of potholes links their development to turbulent water currents, and erosion along some predetermined weakness, aided and accelerated by a more resistant boulder or cobble. Certainly, in places, potholes exposed on the palaeo-surface were seen to contain a harder cobble / boulder which could be considered to support this view. This view, however, was challenged by potholes exposed within the rock mass after the upper 1.5 m sandstone had been removed by blasting as part of foundation treatment.

Blasting revealed numerous ‘potholes’ within the rock mass, all without apparent openings to the surface or connections to one another. These closed ‘potholes’ further occurred within the massive sandstone rock mass which was almost entirely free of jointing, banding, or other weakness. These features were filled with the slightly cemented sand, and were further characterised by the presence of abundant roots, this within a rock mass which appears to have almost no joints that could allow root penetration.

Clearly these features, entirely within the sandstone rock mass, could not have originated due to erosion caused by turbulent water currents.

One possible explanation for the origin of these features may be linked to biological activity. Some species of bacteria are capable of ‘consuming’ siliceous minerals. The sandstone basins might also be ‘sealed’ by mats of cyanobacteria, fungi, algae, and fine sediment. This surface ‘biofilm’, along with subsurface ‘endolithic’ cyanobacteria (within-rock organisms), prevents water from soaking into the otherwise porous sandstone. Organisms on and within the rock represent a ‘weathering front’ wherein water is retained, and along which the pothole is enlarged by a combination of biological and physical means (Utah Geological Survey).
Terry Kabell, client dam expert, in consultation with Tim Broderick, a geologist with vast local and regional experience, had a different view. “Nobody that I know has encountered anything like these potholes before. Tim and I both believe that the potholes represent the remains of trees. The supposition is that there was a grove of trees long ago (palaeolithic), and that they became covered by aeolian sand — perhaps a relatively quick event. The trees died and rotted, and the sand became compacted to form the present sandstone. Over later years the area was covered by colluvial soils — your overburden material of 1 m to 2 m depth. This theory is supported by the circular shape of the holes and the dark staining seen around their perimeter."

Detailed observations of these potholes reveal smooth bulbous bases, however, which do not appear to be consistent with the theory that large trees were responsible. The large-tree theory would also have difficulty explaining the ‘pothole’ features buried entirely within the rock mass.

A more plausible explanation may be found in research on rock doughnut and pothole structures in the equivalent upper Karoo Clarens Formation sandstones, which are comparable to these upper Karoo Lebung Group sandstones, and which related similar features to venting of hydrothermal fluids, created by Jurassic fluid seepage (Grab & Svenson 2011), possibly relating to the intrusive dolerites of that age.

**Treatment of the potholes**

Two major options were considered. One option was to fill up the potholes with dental concrete, and the other to excavate them out. However, to avoid fracturing of the sandstone foundation, the specification did not allow blasting of the cut-off trench. The blasting option would therefore require specification relaxation, and could inevitably also attract potential for a claim. Excavation by alternative methods, other than drilling and blasting, was not considered viable. Backfilling of the potholes with dental concrete required massive handwork, and getting workers inside the deep potholes was not considered safe.

A trial blast was carried out on a 20 m section to evaluate the effects of blasting. Staggered holes 1.5 m apart were drilled and lightly charged with a powder factor of 0.5 kg/m³. Results of the trial blast exceeded expectations, with no damage to the underlying rock. Consequently it was decided that controlled blasting was the best way of dealing with the potholes. The blasting was undertaken to a depth of 1.5 m resulting in removal of about 80% of the potholes. Deeper potholes were then cleaned out and backfilled with dental concrete.

Potholes within the dam footprint, which had not been exposed by excavation, were considered a potential risk to the stability of the embankment should they be filled with collapsible material. A test was carried out to determine the collapse potential of the aeolian Kalahari sands. A pond was constructed on a section with deep sand, filled with water, and left to drain. Grid levels taken after the pond had drained were compared with datum grid levels before the pond had been filled with...
water. The test results proved that the sand was not collapsible, and hence no treatment other than normal dam foundation treatment was necessary.

Consolidation and curtain grouting were undertaken as was required for the cut-off trench. The pothole area had grout takes considerably lower than other areas of the cut-off trench, an indication that the sandstone in the pothole area was generally massive and intact and free of potential seepage paths.

OTHER GEOTECHNICAL FEATURES ENCOUNTERED
On the left bank cut-off trench, beyond the pothole area, three major features were exposed during excavation of the foundation. The V-shaped features, most likely negatively-weathered dolerite dykes filled with alluvial sand, pinned out about 5 m below design invert. The cut-off trench was extended to the bottom of the features. More dolerite dykes were encountered on the right bank. In addition to consolidation and curtain grouting, all these features were stitch-grouted.

CONCLUSION
No detailed studies have been conducted on the pothole features encountered, and no hypothesis on their origin could be conclusively proved.

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REFERENCE

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Environmental Consultants Water Resources Consultants
in association with ILISO Consulting
Main Contractor Zhong Gan Engineering Construction
Subcontractors Dura Soletanche Bachy, Emblem Investments (Pty)
INTRODUCTION
Aquarius Platinum South Africa (AQPSA) is planning the expansion of their Everest Platinum Mine located approximately 30 km west of Lydenburg in Mpumalanga. The proposed expansion will include the addition of two new decline box-cuts, a tailings storage facility and a new road connecting this infrastructure. This extension of the infrastructure will provide access to additional ore-body that will increase the life of the mine.

ARQ Consulting was responsible for conducting and supervising the geotechnical fieldwork, the interpretation of results and several analyses, including finite element analyses, in order to produce detailed designs for certain components of the proposed surface infrastructure.

GEOLOGY AND TOPOGRAPHY
The Everest Platinum Mine is located between Lydenburg and Dullstroom in some of the most picturesque and steep landscapes in the country. The Groot Dwars River, near which the box-cuts are located, is in a valley approximately 850 m below the adjacent mountains.

![Figure 1  Proposed developments at the Everest Platinum Mine](image)
The steep site terrain made the field investigation challenging, particularly the road centreline (RCL) investigation, with a change in elevation of approximately 450 m between the existing surface infrastructure and the proposed box-cut sites.

According to published geological maps, the mine is underlain by rocks of the Rustenburg Layered Suite, including norite. This is consistent with the soil conditions encountered during the test pit and drilling investigations. In some areas of the site, residual norite soils were found to have particularly poor engineering properties, which caused some difficulties during design.

In Figure 1 the various components of the proposed surface infrastructure can be seen on an inclined Google Earth image with the proposed RCL shown by the yellow line.

**PROPOSED TAILINGS STORAGE FACILITY**

The Everest Platinum Mine is currently utilising a tailings storage facility (TSF) to house the waste material produced by the processing plant. The capacity of the existing TSF will not be able to accommodate the additional volume of tailings which will be produced when the proposed infrastructure is brought into operation. For this reason an area of approximately 80 ha has been earmarked for the new TSF site. The geotechnical investigation for this area comprised excavator test pits and both disturbed and undisturbed soil sampling. Consolidated drained triaxial testing was undertaken on the undisturbed samples at carefully selected confining stresses to gather information that would allow for an accurate design. The proposed TSF footprint can be seen in Figure 2 with the test pit locations overlain. The TSF is to be placed on top of a disused portion of the Transvaal Kiwi Orchard which can also be seen in the figure.

Detailed test pit profiles and soil test results were provided to specialist tailings dam design consultants who will be responsible for further feasibility studies and designs.

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**Dynamic and Static Penetrometer Testing**
The proposed TSF will require a large quantity of cohesive soil material for the construction of the starter wall. In an attempt to minimise environmental impact and construction cost, the option of sourcing this material from within the footprint of the TSF site is being considered. This proposal is subject to on-going EIAs (Environmental Impact Assessments) and other studies, and has not yet been finalised. The new tailings storage facility will have enough capacity for the extension phase of the mine.

**ROAD CENTRELINE**

The expansion of the mine will require the construction of a new road which will link the proposed box-cut developments down in the valley with the existing mining infrastructure 450 m higher up. The distance between these points is approximately 3.5 km in a straight line. However, due to the steep and uneven nature of this region, 8.6 km of road will be required. This rather indirect route is necessary as vehicles responsible for personnel transport and general deliveries will not be able to safely negotiate steep slopes and sharp bends.

It was initially envisaged that the 8.6 km of road centreline would be investigated by the excavation of test pits at regular intervals of 500 m, utilising a 30 ton excavator. Subsequent to ARQ's first inspection of the proposed RCL it soon became apparent that this method of investigation would not be possible. The steep slopes and rocky outcrops would not allow machine access to test positions. The investigation method was revised to include hand-excavated test pits and dynamic cone penetrometer (DCP) tests where access was not possible with the excavator.

As can be seen in Figure 3, a cream-coloured residual norite layer was often encountered near the surface. The properties of this material were found to be highly variable. Residual norite may manifest as a gravelly soil, in which case good shear strength and CBR values can be expected. On the other hand, when the residual norite manifests as a silty or clayey material, low CBR values and high PIs are to be expected. The gravelly residual norites make for good road building materials, whereas the silty or clayey materials do not. The RCL will be...
vertically aligned to accommodate the adverse soil conditions.

The possibility of utilising rock produced from blasting operations during the construction of the box-cuts has also been considered as a source of high quality construction material for the road. This rock, once blasted, can be passed through a multiple-stage crushing and screening plant. After this process, it is surmised that material with a quality very close to that required for G1 will be generated. In addition, the same procedure may be used to generate the aggregate source for the asphalt surfacing.

In devoting substantial attention to material balance studies, the need to either import construction material or stockpile excess material produced on the mine, will be minimised.

**BOX-CUTS**

Two decline box-cuts have been proposed to provide access to further ore. The proposed box-cuts will be excavated on the mountain slopes on either side of the Groot Dwars River. The natural slopes on
which the box-cuts will be excavated can be described as steep, with average slopes in the order of 25°, and localised areas where the slopes are steeper.

The drilling rigs, which were used to drill four boreholes on each box-cut site, were established by helicopter as no other means of establishment was feasible. Figure 4 shows the approximate centreline of the Waterfall box-cut on the steep natural slope, and Figure 5 demonstrates the soil and rock profile generated from the core drilling.

The cores drilled on the proposed box-cut sites provided a good indication of the soil and rock profiles that could be expected. The upper layer, consisting of completely weathered norite-containing boulders and core stones, was the main concern when considering lateral support. This layer was found to be up to 14 m thick on the Waterfall box-cut site.

When considering a slope angle for the upper residual norite layer, it is important to note that the natural slope of the mountain is approximately 25°, and that the footprint of the box-cut becomes excessively large if a near vertical lateral support design is not implemented. This large footprint is undesirable from both a financial and environmental point of view and was thus avoided.

The lateral support technique of choice was determined to be soil nails, shotcrete and mesh. Soldier piling and mechanically stabilised earth walls (MSEW) were considered but found to be unfavourable. The soldier piling option was not well suited to this site, due to the presence of rock.

CONCLUSION
Through a well planned and executed geotechnical investigation it was possible to accurately assess the conditions present on site. The certainty with which parameters could be estimated allowed for the generation of an optimal and cost-effective design solution.

It is for this reason that a thorough geotechnical investigation is encouraged for mining projects during the feasibility phase, which could result in major cost savings for the construction phase of the project.

Figure 6  Example of an FEA model (finite element analysis)
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INTRODUCTION

South African mining companies are becoming increasingly involved in operations throughout the world, particularly in other parts of Africa, while international mining companies are extending their operations into South Africa. South African mining and construction companies have therefore become subject to international standards for the planning, design, construction, operation and closure of mine residue storage facilities. Often the standards imposed in jurisdictions such as Canada, Australia, the USA and European countries differ from those that have commonly been applied in South Africa. As regulators and the public worldwide pay increasing attention to sustainability, environmental, health and safety issues, the international standards themselves are becoming far more onerous on the owner, designer and operator of these facilities than has previously been the case.

At the International Conference on Mining Waste held in Rustenburg in March 2008, the authors presented a paper on South African mine residue disposal practices in a global context. In this article we look at recent developments in some important aspects of the design, operational management and closure of tailings facilities as currently applied in South Africa.

BACKGROUND TO SOUTH AFRICAN PRACTICE

Most of southern Africa experiences a subtropical climate, ranging from arid to moist, with evaporation exceeding precipitation almost everywhere, and no winter freeze. The population over much of the land is relatively sparse, though in recent years there has been increasing urbanisation in the principal mining areas. The availability of sufficient water of acceptable quality for all uses is becoming increasingly problematical. Hence mine developments are being required to limit the quantity of water they draw for their operations, and at the same time to prevent the discharge of contaminated water back to the environment, either on surface or through seepage into the ground. Groundwater is seldom a significant source of water for the mines and continues to be used mainly for agricultural purposes.

South Africa and its immediate neighbours are situated in an area of low seismicity. This has led to the common practice of upstream construction of tailings containment walls using the tailings themselves as construction materials. Elsewhere, however, mine residue facilities may be subject to significant seismic risk and high rainfall, which strongly affects the methods of construction and operation of tailings storage facilities required to ensure adequate stability.

Only in the last 15 years or so has the closure of mine residue deposits been considered to be an integral part of the up-front design and operation of the facility.

Although political and social considerations have become increasingly important in mine operations generally, they are less directly relevant to tailings management.

REGULATORY FRAMEWORK, DESIGN LIFE

The principal government departments that regulate mine waste disposal in South Africa are Mineral Resources, Water Affairs and Environmental Affairs, and all three need to be independently

The design life for operation of a mine waste facility is generally taken as no more than 20 years, sometimes less, irrespective of the mineral or resource reserve available. It is unrealistic to forecast the economic viability of a mine beyond a 20 year horizon. However, mine owners cannot escape liability for the impacts of their residue storage facilities after closure and for the long-term future. In that respect, international standards look towards a 1 000 year horizon.

Companies based in Canada, Australia or the USA may well insist that mines owned by them anywhere in Africa are designed and operated in line with the standards applicable in their home countries.

**WATER MANAGEMENT**

In South Africa, the common approach is to minimise the quantity of water held on a tailings storage facility, though this policy is not always observed, sometimes with severe consequences (such as the failure of the Merriespruit tailings dam in 1994). Nevertheless, it is not unusual to utilise tailings dams also as water storage dams, and in such cases the impoundments need to be designed and operated so as to comply with the dam safety requirements laid down for water storage dams.

Water management on mines in South Africa is governed by regulation GN R77 (more usually referred to under its previous designation GN R704) under the National Water Act, and regulation GN R577 under the Mineral and Petroleum Resources Development Act. Although the two sets of regulations are generally complementary, certain specifications differ, in particular regarding the design storm – 50 years in GN R704 and 100 years in GN R577.

This applies to the minimum freeboard to be provided on the tailings facility: GN R704 specifies a minimum of 0.8 m above the water level reached in the 1 in 50 year 24 hour storm, while GN R577 specifies a minimum of 0.5 m above the water level reached in the 1 in 100 year 24 hour storm.

Other important restrictions imposed by GN R704, largely related to environmental protection, include the following:

- Clean water systems should not spill into any dirty water system, or vice versa, more than once every 50 years. Process water should be recycled as far as practicable.
- No mining and no activity associated with mining that is likely to cause pollution may take place within the 50 year flood line or within 100 metres of any watercourse. In certain instances, such as chromite mining, no activity may encroach within the 100 year flood line.
- All water conveyances should be designed to operate satisfactorily for flows arising from the 50 year recurrence interval rainfall event of 24 hours duration.
- Access to tailings storage facilities, return water dams or any other activity should be restricted and warning signs must be placed at prominent locations. It is striking that the South African requirements are so much less stringent than the 1 in 100 year 72 hour event stipulated in Australia and the 1 in 500 or 1 in 1 000 year events mandated in North America.

Increasing attention is being paid to the protection of groundwater. In the past, little consideration was given to prevention of seepage into the groundwater; indeed, until forty years ago, seepage was considered to be beneficial in that it improved the stability of the tailings deposit. Old tailings deposits were hardly ever lined, while more recently natural clay liners have been favoured. Synthetic geomembrane liners would not normally be considered under tailings except in special circumstances, though in recent years they have often been used to line return water reservoirs.

**STABILITY**

In South Africa it is common to design for a minimum factor of safety (FoS) of 1.3 against slope failure under static conditions while the facility is in operation and under regular surveillance, increasing to 1.5 after closure. For transient or seismic conditions, a minimum FoS of 1.1 is usually specified, but may be modified under particular circumstances, particularly if it can be shown that deformations are likely to be small.

These criteria are not out of line with generally accepted international standards. In most of South Africa, however, the climate is temperate semi-arid to arid, and seismic risk is generally low, which means that the required FoS can be achieved with simpler methods of construction than in regions with significantly higher rainfalls, more extreme temperatures and higher seismic risk. In southern Africa it is common to use upstream construction methods, where the tailings containment wall is raised by placing more tailings in a controlled manner on top of the existing tailings.
beach. Where the tailings might be subject to liquefaction, upstream construction is considered unacceptable and an earthfill or rockfill embankment is required instead of a tailings wall.

The design basis earthquake for seismic loading is not mandated in SA. Internationally, the seismic loading is commonly based on the peak ground acceleration for a 475 year (or 950 year) event, equivalent to a 10% chance of exceedance in 50 (or 100) years.

Consideration also needs to be given to the maximum credible earthquake, with a return period of maybe 1 in 10 000 years.

Deposition procedures commonly practised in South Africa are suited to controlling the location and extent of the water pool and to building up the containment wall around the perimeter of the deposit. Thus single point open-ending is not common. The ring paddock system is common on gold tailings dams on relatively flat ground, while spigoting is more usual for other minerals, and cycloning of the tailings to obtain more competent material for wall building is sometimes used. To date, central discharge of highly thickened or paste tailings has rarely been applied in South Africa.

Although international practice forbids any penetration of the lining or containment wall, it is common in South Africa for the decant pipeline and filter drain outlet pipes to pass through the perimeter wall. Pumped systems would only be used in South Africa where this could be shown to be advantageous for other reasons.

CLOSURE
The main long-term objectives of mine closure are to stabilise the geochemical and geotechnical conditions of the disturbed mining areas and to prevent any on-going environmental degradation. The mine and tailings dam closure process in South Africa is regulated by the Department of Mineral Resources, with strong input from the Department of Water Affairs with respect to the post-closure impacts on water resources. No closure certificate will be issued unless and until all organs of State responsible for administering the environment have confirmed in writing that the provisions relating to health and safety and management of potential pollution of water resources have been addressed.

A mine permit holder remains responsible for any environmental liability, pollution or ecological degradation until the Minister has issued a closure certificate. Application for a closure certificate must be accompanied by a Closure Plan, as well as an Environmental Risk Report, which in turn must include financial provision for long-term maintenance and monitoring programmes. Even after formal closure, the mine permit holder cannot simply walk away. Indeed, there is...
no time frame stipulated in the Water Act for post-closure responsibility.

CONCLUSION
As a whole, design standards and criteria used internationally are becoming far more onerous on the owner, designer and operator of mine waste facilities than has previously been the case. In the long term the adoption of these criteria in new African mining developments can only benefit the mining industry and environment. However, it is important that overseas or first world standards be implemented judiciously, and that they be applied in a manner appropriate to the particular situation.

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Specifications for geosynthetics in South Africa: from ISO to SABS

GIGSA ORIGINS

GIGSA, the Geosynthetics Interest Group of South Africa, is a non-profit organisation dedicated to the scientific and engineering development of geosynthetics and associated technologies in South Africa.

GIGSA was founded in 1994 by a group of suppliers, installers, consultants, a regulator and an academic at the Faculty of Engineering of the University of the Witwatersrand. The founding of GIGSA coincided with the publication of the first edition of the Minimum Requirements series by the then Department of Water Affairs and Forestry. The intention of the Minimum Requirements was to regulate waste management as a whole, but also waste disposal by landfill in South Africa, which made the use of geomembranes mandatory. This reinforced the need for an organisation like GIGSA, as geosynthetics were largely unknown construction materials at that time.

GIGSA was furthermore founded as the South African Chapter of the International Society of Geosynthetics (IGS). The IGS was established in 1984 with, in broad terms, the same objectives as GIGSA. The IGS became the first non-founding member of the Federation of Geo-Engineering Societies (FedIGS) in 2011. The founding members of the FedIGS are the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the International Society of Rock Mechanics (ISRM) and the International Association for Engineering Geology and the Environment (IAEG). The aim of the FedIGS is to facilitate collaboration and provide means of structured and formal communication between the organisations.

INTRODUCTION TO GEOSYNTHETICS

Geosynthetics have been in use around the world for more than four decades, and by no means form a new category of construction materials. Geosynthetics are, however, not on par with other construction materials such as steel, concrete and soil in terms of standardisation or availability of up to date national specifications.

Geosynthetics can be defined as a planar product manufactured from polymeric material for use with soil, rock or earth in civil engineering applications. Geosynthetics can be divided into a number of categories that include:

- Geocells
- Geofoam
Geosynthetics consist predominantly of polymers (i.e. plastics) and could have been described more accurately as geopolymers. The word geosynthetics, however, took hold before this realisation was made.

Geosynthetics are used to preform seven major functions:
- Filtration by inhibiting the internal migration of soils
- Drainage by creating a preferential internal flow path
- Containment by the provision of a barrier
- Reinforcement by providing additional internal strength to soils masses
- Erosion control by inhibiting the surface migration of soil
- Separation by acting as divider at interfaces
- Protection by acting as a cushion layer

Geosynthetics are used in many of the civil engineering fields, of which the following are the most prominent:
- Soil reinforcement in retaining walls, embankments, foundations, road pavement layers and erodible surfaces such as coastal shores and riverbeds
- Lining and capping systems for waste disposal sites, but also for other structures such as reservoirs, tanks, dams and tunnels

Geosynthetics are characterised by mechanical and endurance characteristics much like concrete and steel. What sets geosynthetics apart, however, is the fact that plastic deformation or creep is substantial and governs the design process. As an example, where material factors for steel and concrete are often set marginally above unity in the Limit State Design framework, material factors for geosynthetics or polymers can be as high as three. Many other factors also play a part, such as installation damage of a relatively fragile polymeric product, and physical degradation of a product that, as an organic compound, is highly susceptible to UV and elevated temperatures. These specific characteristics require a good understanding of geosynthetics to apply them correctly,
but also the need for rigorous testing and the associated materials specifications to provide proper design input.

GEOSYNTHETICS STANDARDS AND SPECIFICATIONS IN SOUTH AFRICA

Geomembranes

The SABS (South African Bureau of Standards) established a working group in 2002 that investigated the adoption of the Geosynthetics Research Institute (GRI) set of material test methods to serve as a basis for a South African National Standard. SANS 1526:2003 Thermoplastics sheeting for use as a geomembrane was subsequently published with GRI-GM13 for HDPE, GRI-GM17 for LLDPE and GRI-GM18 for fPP as the base. The test methods are based on ASTM and are considered the normative standard for geomembranes worldwide. SANS 10409:2005 Design, selection and installation of geomembranes was also published and provided standards beyond the materials specification that is contained in SANS 1526. While this set of national standards is deemed to be largely up to date and sufficient at present, further detailed development is envisaged and will be carried out by the ‘SABS Sub-Committee 59J: Geosynthetics’.

Geotextiles

The standards and specifications for geotextiles in South Africa are limited and out of date. A SABS code of practice for the testing of geotextiles exists (SANS 10221:2007), which lists five in-isolation tests and serves as a means to classify geotextiles. The code defines a list of geotextile grades, but does not provide input into the actual design process, nor does it consider the geotextile soil interface. TRH15:1994 Subsurface Drainage for Roads and COLTO 1998 Section 2100 – Drains aim to address some of the design inputs that are required. These specifications may be deemed to follow most of the design requirements, but fall short as they do not reflect the current state of practice nor the possible performance of geotextiles. As an example of the shortcomings one should note that the geotextile strengths are specified at 10% elongation, while geotextiles are known to function beyond this limit and are particularly of benefit where large deformations must be accommodated.

In view of these shortcomings, the intention is to adopt international specifications rather than trying to update existing specifications. SABS is a participating body of the International Organisation for Standardisation (ISO). This provides the opportunity to adopt ISO standards and provide them as South African National Standard (SANS) at relatively small cost. SABS has recently formed ‘Working Group 5: Geotextiles’ under ‘Sub-Committee 59J: Geosynthetics’ to investigate the ISO standards and to adopt them in a structured fashion.

For the sake of this discussion standards can be divided into three main components, namely definitions, test methods and guidelines (relating to design and use that may also be described as a product specification). The intention is to investigate the ISO standards in this order.

In the year 2000, ISO established a technical committee for geosynthetics, TC221, which works in close contact with the European Standards Organisation (CEN) ‘Technical Committee 159: Geosynthetics’. ISO has developed 32 geosynthetics-related standards and is actively updating and revising these to reflect the latest research and development in geosynthetics. These standards are divided into 11 product specifications (related to applications) and test methods. The 11 applications are roads, railways, earthworks/foundations/retaining walls, drainage systems, erosion control works, reservoirs and dams, canals, tunnels, solid waste disposal, liquid waste containment, and lastly asphalt reinforcement.

The first two standards developed by TC 221 are ISO 10318: Geosynthetics – Terms and definitions, as well as ISO 9862:2005 Geosynthetics – Sampling and preparation of test specimens. These two standards have recently been proposed to SABS by the working group to be adopted, and it is believed that they will become national standards within a period of 12 months. The working group focus is currently shifting to the actual test methods that serve as input to application standards or product specifications. Once a basic set of test methods have been agreed upon the focus will shift to the guideline or product specifications.

Other Geosynthetics

SABS has also formed working groups that are investigating the development and adoption of national standards for geogrids and GCLs.
CONCLUDING REMARKS
GIGSA is actively involved in the development of geosynthetics specifications within the working groups of the SABS sub-committee on geosynthetics with the ultimate goal to provide a complete set of national standards. This will aid in standardising the specification and use of geosynthetics in South Africa. Given that the use of geosynthetics is likely to increase significantly with the promulgation of the National Standard for Disposal of Waste to Landfill, expected during 2012, such standardisation will be beneficial to clients, engineers, suppliers and installers involved in geosynthetics projects.

NOTE
References are available from the authors on request.
A geosynthetic alternative to traditional sand filter drains in a piggy-back tailings storage facility

INTRODUCTION

The processing of most mined metal ores results in waste commonly known as tailings. The sheer volume of tailings and their potential environmental impact necessitate engineered disposal techniques and storage facilities. The dam walls for third and fourth generation type facilities are constructed using the tailings themselves for cost effectiveness. These facilities can follow three main construction methods, namely upstream, centreline or downstream development of the walls. Irrespective of the construction technique utilised, the principle is to create a consolidated stable outer annulus to contain the inner saturated, often under-consolidated, core. Creating the consolidated outer annulus is facilitated by the inclusion of filter drains – often called under drains – around the perimeter to draw down and control the phreatic surface emanating from the flow or seepage of pore water from the saturated core. Apart from the aesthetic aspects and their impact on the environment, tailings dams are often extensive in area, sterilising valuable land. Consequently, it is becoming increasingly difficult to license new tailings storage facilities (TSFs).

Piggy-back TSFs aim to reduce the footprint of the tailings facility by building ‘up’ rather than ‘out’. They are constructed on top of existing tailings dams. Some old tailings dams may not have had any under drains, or may just be too high or old for the original ground level filter drains to be effective in controlling the phreatic surface within the piggy-back tailings to be deposited on top. Regardless of the method employed to construct these facilities, the piggy-back deposit requires under drains of some form to maintain a low phreatic surface in the dam to facilitate consolidation and improve stability of the dam wall, and to reduce the recharge to the underlying tailings, which could otherwise cause seepage and instability in the hitherto stable old slopes. These drains are typically constructed using selected filter sand, clean single-sized stone, and slotted pipes. Transporting this material to the top of an existing dam that may still be operational, can be onerous and can also cause disruptions to the normal operations of the facility, as surfaces need to be allowed to dry and consolidate for loaded construction equipment to gain access to place the sand and stone.

GEOSYNTHETICS

As defined by the International Geosynthetic Society: geosynthetics are planar, polymeric (synthetic or natural) material, used in contact with soil, rock and/or any other geotechnical material in civil engineering applications.

![Typical design of conventional filter drain](image)
In the early 1970s Bidim® geosynthetic filter fabric was introduced to the South African civil engineering industry. After the first earth dam was constructed using geotextiles in 1970, at Valcros in France, many designers adopted a simpler drain design wherein the filter fabric replaced many layers of the natural filter material. Since 1975 geotextiles have been used successfully in large dams in South Africa, including the 51 m high Kilburn Dam, the 56 m high Mokol Dam and the 43 m high Kwena Dam, amongst others. The geotextiles were used downstream of the chimney drain, as a supplement to the granular filter system on either side of the clay core, beneath rip-rap, surrounding toe drains and blanket drains.

Considering the escalating cost, increased scarcity and effort required when using natural material for the construction of filter drains, an opportunity was identified to develop a composite geosynthetic filter drain which does not require any natural filter sand or stone.

**CHEMWES AND CROWN TSF - PROBLEMS EXPERIENCED**

The Chemwes No 5 TSF, on the West Rand, was an existing operational facility being developed at a relatively high rate of rise (ROR) of 3 m/yr. An extension of the life and expansion of the operation called for an interim tailings disposal solution requiring an 8 m/yr rate of rise. The high rate of rise dictated the use of cyclones to deposit an outer wall which, due to its inherent higher permeability, required under drains to control the seepage, thus preventing the development of excess pore pressure.

Many difficulties were experienced while trying to install the filter drains, due the facility being operational at the time. The natural drain materials, sand and stone, had to be transported up to the top of the existing dam to sections where the tailings had to be allowed to dry for weeks to achieve the required minimum bearing capacity to carry the fully loaded trucks. It was this experience that highlighted the need for an alternative system of under drains that did not require any natural filter material.

The Crown TSF had previously retro-fitted geotextile-wrapped ‘sausage’ drains, comprising perforated collector pipes encased in stone, to control slippages. These have been used with sustained success, indicating the durability of the geotextile against acid attack and clogging.

**BRAKPAN TSF**

Brakpan TSF handles gold tailings from the Ergo complex. Tailings usually fall within the 60 micron to 300 micron particle size bracket, corresponding to a fine to medium sand fraction, and are typical of Witwatersrand gold tailings underflow. A piggy-back TSF of 40 m high was required to be built on top of the existing 80 m dam, but the designers were reluctant to repeat their experience on the Chemwes site. A solution was required that would not necessitate stone being transported to the top of the existing dam, and that could be installed with little effort, while making minimal use of earthwork equipment. The success of the Crown ‘sausage’ drains pointed towards developing a composite geosynthetic filter drain.

**Tailings/geotextile compatibility**

Before the composite geosynthetic drain could be assembled, the tailings from the Brakpan TSF had to be evaluated with regard to compatibility with the candidate geotextile filter. This was required to ensure that the geotextile would not blind or clog, and that piping would not occur. These are the main mechanisms of failure of geotextiles and have resulted in some problems.

The cost comparison showed a 20% saving in the cost of the composite geosynthetic filter drain compared to the conventional sand/stone filter drain. This did not account for escalation over the 20 months between the pricing exercises which could have increased the savings in real terms. An additional and decisive factor that should be borne in mind was the ease of installation with minimal disruption to the on-going tailings deposition on other parts of the dam, improving quality control on the drain installation and minimising the risk substantially on the deposition operation.

**Figure 2** Detail of composite geosynthetic drainage system
engineers being circumspect about the use of geotextiles as filters. Such a failure could have a severe effect on slope stability and could limit the maximum height of the dam. These conditions are influenced by the apparent opening size (AOS) of the pores in the geotextile in relation to the material being retained. This is a function of the approximate size of the largest particle that will pass through the geotextile. The permeability of a geotextile filter can be significantly reduced over the lifetime of the installation. For this reason a geotextile with permeability ($k_p$) of at least 10 times the permeability of the base soil ($k_s$) should be specified.

**Long-term gradient ratio (LTGR) test**

The LTGR test, which is based on the gradient ratio test (ASTM D 5101), uses a customised permeameter fitted with stand-pipes to measure the changes in hydrostatic head across a soil sample and the geotextile interface below. Water is passed vertically through the sample of soil to be drained on site and the candidate geotextile as setup in the permeameter. Changes in flow rate and standpipe readings are taken periodically. Using Darcy’s equation the permeability of both the soil and the soil/ geotextile interface can be calculated.

After performing a desktop analysis based on the particle size distribution of the Brakpan TSF tailings, two grades of non-woven geotextile were chosen for testing. The choice of these grades was based on an optimisation of the filtration characteristics influenced by the thickness and number of constrictions of the geotextile.

The nonwoven geotextile selected for use in the trial section maintained a higher flow rate, indicating higher permeability with a gradient ratio (GR) of around 1.4. A GR between 1 and 3 indicated that the soil sample was stable and the geotextile was working satisfactorily. A GR of >3 indicates a clogging potential, whereas a GR value of <1points to a piping problem. The 6% of clay and silt size particles in the sample led to a small amount of piping, which was reflected in the conductivity readings. Once these fines had migrated through the geotextile, a more open filter bridge was developed and stability was achieved.

The nonwoven geotextile selected also satisfied the conditions of the desktop analysis, having an $O_{wv}$ = 100 μm and a permeability of $k_s$ = $4.8 \times 10^{-3}$ m/s more than 900 × the permeability of the soil $k_p$ = $5 \times 10^{-6}$ m/s.

**Composite geosynthetic drainage system**

The proposed composite geosynthetic drainage system consisted of two 170 mm high Megafl oTM panel drains installed vertically next to one another to maximise compression resistance against the increasing overburden pressure. These drains were supplied pre-wrapped in a nonwoven geotextile and had a combined width of 100 mm. A cuspated solid sheet geospacer, ZipcoreTM, formed the base of the drainage system. Made from a sheet of HDPE this formed a cut-off barrier and conduit to contain and direct all the moisture that was collected by the drain to the Megafl oTM collector pipes. The geospacer was laid with a slight fall towards the panel drains. A high-strength slit-film woven tape geotextile, Kaytape® S270, was laid directly onto the geospacer to act as a bridging medium over the 8 mm high cuspatations. This allowed for a high confining pressure to be accommodated by the drain without a loss in lateral flow capacity. The nonwoven geotextile was then laid on top and acted as a filter, as depicted in Figure 2.

This innovative composite geosynthetic system facilitated the quick and easy installation of the drain with minimal earthworks and no imported filter sand or stone. The tailings were deposited directly onto the drain.

**Cost analysis**

The cost comparison showed a 20% saving in the cost of the composite geosynthetic filter drain compared to the conventional sand/stone filter drain. This did not account for escalation over the 20 months between the pricing exercises which could have increased the savings in real terms.

An additional and decisive factor that should be borne in mind was the ease of installation with minimal disruption to the on-going tailings deposition on other parts of the dam, improving quality control on the drain installation and minimising the risk substantially on the deposition operation.

**Test section – Brakpan TSF**

A 40 m long, 5 m wide section of the composite geosynthetic filter drain was installed at the Brakpan TSF. Paddock walls lined with HDPE were constructed around the test panel to allow the filter to be covered in four 1 m layers of tailings in a relatively short period of time to simulate the intermittent but progressive development of a tailings dam. An outflow pipe from the test panel was installed to enable the measurement of the outflow rates from the drain. The drain’s ability to withstand the intended 40 m overburden stress was also assessed.

The measured flow rates as shown in the graph in Figure 3 demonstrate an initial surge when the tailings were deposited, then a gradual decrease in flow until the next layer had been deposited. The fact that the flow rates surged each time a new layer of tailings was added indicates that the drains had not been compromised and that the geotextile filter had not blinded or clogged. The lower peaks and the sustained

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![Figure 3 Flow measurements from outlet pipe](image-url)
longer continuous flow are indicative of the greater depth of tailings deposited over the drain with each cycle.

**CONCLUSION**

Based upon the cost effectiveness, installation advantages and the positive test results, 8.5 km of composite geosynthetic drains are being installed on the Brakpan tailings storage facility. These benefits of the composite geosynthetic drainage system have led to the same system being implemented on two new TSFs on ground level at two chrome mines, with a third currently under design.

Nonwoven continuous filament filter fabrics have been successfully utilised in the South African civil engineering industry for more than 40 years. Over this time there has been evidence that not all tailings are compatible with geotextile filters, but this project has shown that, with the correct laboratory testing, desktop analysis, specifications and field trials, geosynthetics can be used to great effect in facilitating the drainage of tailings deposits.

**REFERENCE**


No tailings facility, irrespective of size, location or geometry, should be designed in an off-the-shelf manner. Each tailings facility, and the operator/owner of that facility, deserves a design that is an appropriate reflection of the prevailing site conditions and the breadth of potential operating constraints to which the facility will be subjected. Any lesser design stewardship is deficient (Martin et al 2002)
THE GEOTECHNICAL DIVISION of SAICE organised the 8th Young Geotechnical Engineers Conference (YGEC) on the African continent. This conference was held at the Berg and Dal Camp site in the Kruger National Park from 31 August to 2 September 2011. The two-and-a-half day conference is held every three years for engineers younger than 35 years.

At the conference 28 papers were presented under the following categories:
- Site investigation and testing
- Piling and lateral support
- Mining and environmental
- Analyses and modelling
- Construction and case studies

The conference was overseen by godfather Dr Gary Jones who gave us valuable feedback on the papers that had been presented. He challenged us as young engineers in many ways about our future and the future of our profession, and about how we are going to make a difference. We are very thankful to him and his wife Wendy for their time and input into making this venture such a success.

Needless to say, the social activities were great fun as usual, such as an entertaining team-building evening, and a night drive which included a bush braai where the only protection from wild animals was a game ranger plus a rifle.

The YGEC is always loads of fun, where new acquaintances are made, where young people learn from one another and where an environment is provided that allows speakers to present to a more forgiving audience.

The Division would like to congratulate Jacobus Breyl and Gerrit Smit for winning the best presentation and best paper award respectively. They will be attending the international YGEC in Paris, France, in 2013 (lucky fellows!).

The Division would also like to thank the organising committee, which comprised young people from industry, for their time and effort, as well as RCA conference organisers for all their hard work in making this event such a success.

Finally, the Geotechnical Division of SAICE sincerely thanks the following companies for their sponsorships:
- Aveng Grinaker-LTA Ground Engineering (Platinum sponsor)
- GAST (Gold sponsor)
- SRK Consulting (Gold sponsor)
- Stefanutti Stocks Geotechnical (Bush braai evening)
- Gundel GeoSynthetics
- Kaytech
- Maccaferri
- Veka VKE
- ARQ
- BKS
- Jones & Wagener
- Gauteng Piling
- Sanyati Piling
- GETS
- GIGSA
- GeoExplore Store
THE SAICE GEOTECHNICAL DIVISION held its Annual General Meeting (AGM) on 24 November 2011. The AGM is an excellent opportunity for like-minded professionals from the industry to meet on an informal level. The successes of the previous years are remembered proudly and the highlights of the coming year are outlined.

At the AGM, chairman Dr Eduard Vorster, summarised the Division’s 2011 activities. He highlighted:

■ The 9th Jennings lecture by Professor Rodger Frank on Eurocode 7
■ The Young Geotechnical Engineers Conference (see article on page 68)

The strengths and successes of the geotechnical engineering industry in South Africa would not be what they are today if not for the men and women who had the courage to step up to the plate. Recognition is given to these leaders in our industry through various awards. Seetella Makhetha, 2011 SAICE President, delivered his Credo in a riveting speech, after which the winners of the 2011 SAICE Geotechnical Awards were announced. We would once again like to congratulate the following individuals:

■ Hendrik Steenkamp of the University of Pretoria received the award for his final year project titled Embedment of dynamically loaded foundations. The award is presented annually to the author of the best final year dissertation on a geotechnical topic at a South African university.
■ Michelle Theron, Fritz Wagener and Phillip Steenkamp received the Jennings Award for their paper, Seismic stability assessment of the raising of the Geita tailings storage facility, Tanzania. The award is presented to members of the Geotechnical Division who author meritorious publications in geotechnical engineering in South Africa or elsewhere. The award is made in honour of Professor JE Jennings, who is widely regarded as the pioneer of modern soil mechanics in South Africa.
■ Professor Eben Rust, who was awarded the SAICE Geotechnical Gold Medal. The South African Geotechnical Medal was instituted by the Geotechnical Division in 1989 to honour members of SAICE who, in the unanimous opinion of the Division Committee, have made a significant contribution to geotechnical engineering in South Africa.

For a full history of previous recipients, and more information on the various awards, please visit the Geotechnical Division website at the following address: www.geotechnicaldivision.co.za

The Geotechnical Division Committee would like to thank Dr Eduard Vorster for his excellent work as chairman for the past two years. His efforts are greatly appreciated. The Committee would also like to congratulate our new chairperson, Dr Michelle Theron. We wish her all the best with the enormous task ahead.

During 2012 we look forward to presenting one-day short courses which will mostly be aimed at the younger engineering generation. Possible topics include foundation design, lateral support and geotechnical site investigations. In order to receive information on upcoming events, evening lectures and the like, please register on the Geotechnical Division website (www.geotechnicaldivision.co.za) and subscribe to the newsletter.

In addition to the Barry van Wyk, Jennings and Gold Medal Awards, the Geotechnical Division wishes to invite nominations for Fellowship of SAICE. Fellowship of SAICE is awarded to members of SAICE who have inspired and motivated others within the industry through their dedication and contribution towards the civil engineering profession in South Africa. Nominations forwarded to the Geotechnical Division will be specifically for persons working within the field of geotechnical engineering.

The Division is also looking forward to receiving nominations for the 2012 awards, so please forward all nominations to Gerrit Smit (gerrits@leoconsult.co.za).
IN BRIEF

BRIDGE PROVIDES PENGE COMMUNITY WITH SAFE ACCESS TO SCHOOL

A NEW SINGLE-LANE vehicle bridge over the Olifants River that will connect the Penge community in the Limpopo Province with the Mankele Primary School has been completed and was officially opened to the public on 14 February 2012. The much-anticipated opening was attended by local and district mayors, Mr David Magabe and Mr NJ Mahlake respectively; MEC for Roads and Transport, Ms Pinky Kekana; as well as the premier of the province, Mr Cassel Mathale. The school was previously only accessible across the river bed or via a home-made cable and pulley system over the river when it rained, a dangerous practice claiming several lives in the past few years. Following the go-ahead from the Roads Agency Limpopo, the bridge was constructed by UMSO Construction, Paramount Construction and Terra Strata.

As the main contractor, UMSO Construction, a black-empowered civil engineering company with specific expertise in the construction of roads, water and sewer reticulation, concrete structures, bridges and box culverts, undertook all steelwork as well as the road across the bridge, which is a prefabricated modular steel Acrow bridge, similar to a Bailey bridge.

Geotechnical contractors Terra Strata were appointed to undertake all the piling for the project. A ‘new kid on the block’, Terra Strata specialises in auger piling, although the company’s portfolio includes other types of piling services to the building and construction industry, including CFA piling, percussion piling, limited headroom piling, hollow bar piling, dolomite and specialist grouting, lateral support to excavations, as well as geotechnical investigation.

Dolomite under-ream piling was used for the foundations for the Penge Bridge, reaching depths of 36 m – some of the deepest dolomite under-ream piling in South Africa. “We converted one of our Casagrande B125 auger rig drills to act as a hammer to drive the holes required for the two-part 6 m steel casings, which were welded together using a combination of welding techniques for proper penetration and fusion,” says Terra Strata site agent William du Toit. “We used three 1000 CFM 25 bar compressors to blow the chip out of the holes, and a Tremie pipe connected to a Putzmeister concrete pump to pump concrete into the pile. Sonic logging tubes were installed into the deep piles to test the integrity of the concrete,” says du Toit.

In total, 48 piles were ‘socketed’ at a depth of 1.5 m into the rock; 16 of these were raked at an inclination of 126-128°, while the rest were vertical. Du Toit comments that, despite the challenging depth of the piling, the project was completed without any complications in a relatively short period of time, having started at the end of August 2011 and completing all work by 9 December.

Civil engineering company Paramount Construction stepped in after the piling was completed to excavate around the piles and to strip the piles to the underside of the bases to riverbed level. “We were responsible for the substructure of the bridge, including the bases, piers and abutments, and handed the project over to UMSO Construction on 8 February 2012,” says Richard Hein, commercial manager at Paramount Construction. UMSO finished the jacking on 9 February, with the bridge deck plated on 13 February, ready for the public to cross the Olifants River safely for the first time on 14 February 2012.

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RED CAP KOUGA WIND FARM - GEOTECHNICAL STUDY

IN DECEMBER 2011, ground engineering, environmental and geohydrology consulting firm Terratest was retained by Cape Town-based Red Cap Kouga Wind Development Company for the purpose of undertaking a detailed geotechnical investigation at Oysterbay in the Eastern Cape. The project feasibility engineering was undertaken by Afri-Coast Engineers, with drilling services being performed by Diabor, DPSH testing by Algoa Cut & Core and laboratory testing services by Labco, Civilab, RockLab and Talbot & Talbot.

The geotechnical survey was one of a number of specialist studies being undertaken at the site, including botanical, archaeological, noise impact, visual, ornithological, as well as other ecological surveys. “Long-term meteorological monitoring had proven the area to possess an exceptional wind resource,” says Operations Director from Red Cap Investments, Lance Blaine.

The geotechnical investigation comprised the mobilisation of five rotary-core diamond-bit drill rigs to accommodate the tight time frames associated with the required work of investigating 35 proposed turbine positions. Boreholes penetrated to depths of 30 m each, with associated SPT and undisturbed sample retrieval. Groundwater sampling was also conducted at each borehole and submitted for steel and concrete chemical aggression testing. In addition extensive trial pitting was performed to five metre depths within the turbine footing, as well as density testing in the form of DPSH and DCP probes, and seismic surveys at selected positions. Electrical resistivity testing had been performed as part of a preliminary geotechnical investigation.

“The geology of the area is an interesting example of sedimentary folding,” says Terratest Senior Engineering Geologist Richard Fyvie. “The site spans a wide geographical area that is underlain by a significant anticlinal structure, with Goudini, Cedarberg and Peninsula Formations being found within the investigation boundary. The Peninsula Formation comprises the oldest and most prominent formation on site, being easily recognisable in outcrops of...”
NEW ACCESSORIES FOR ACIP AND CFA PILE INSTALLATION MONITORING

PILE DYNAMICS, Inc. has released new accessories and software for its Pile Installation Recorder (PIR). Debuting are the PIR Viewer and a new version of the PIRPLOT data processing and reporting software.

The Pile Installation Recorder is an automated monitoring equipment piece that records and displays grout volume versus depth, along with other parameters that aid in the installation of augered cast-in-place (ACIP) and continuous flight auger (CFA) piles. Even before its new enhancements, the PIR had won awards (Ohio New Product Award in 2000) and praise. Jason Matthew Crisp, Project Superintendent of HJ Foundation in Miami had the following to say in December 2011:

“Even though I have been installing auger cast piles for almost 20 years, there comes a time where I have to work in a region of the country which requires me to use local union help. My last project was in Syracuse, NY. We had to install 200 CFA piles of 16 inch diameter up to 80 feet deep. When you are working in NY, you need to use NY licensed operators. Qualified operators they were, but they lacked the technical knowledge needed to successfully drill and pull a CFA pile properly. Who steps in? Pile Dynamics with their PIR. With the new colour screen and simple user-friendly controls, my green operator was pumping piles out like a seasoned operator, making my job easier and more productive.”

The PIR Viewer will make Jason even more productive, as it is a handheld Wi-Fi device that allows a supervisor or inspector to see, in real time, the information that the PIR is displaying to the operator in the crane cab. This enables the supervisor to stop the crane operator sooner in case there is a concern. In the past, the pile had to be completed and a summary report generated before an inspector could review the installation details. The user of the PIR Viewer pushes a button to flag when grout return occurs, and may use a logging feature to manually count grout pump strokes. Once the pile has been completed this information may be compared to the PIR summary report. Post-processing with PIRPLOT generates quality tables and graphs that can be customised for presentation.

In addition to the PIR, Pile Dynamics produces several other quality assurance and quality control products for the deep foundations industry. Its products are recognised throughout the world as the ultimate solutions for the testing and monitoring of deep foundations. The company is based in Cleveland, Ohio, and has commercial representatives worldwide.
Forces imposed by the tipper trucks, over a restricted area pre-determined by a portable bridge ramp, required the design to accommodate 250 kPa of pressure. The flexibility of the Paramesh system allowed for the settlement and consolidation associated with forces of this magnitude, without major deformation or any structural implications.

Since all the soils utilised in the construction of the Paramesh structure consisted of overburden coal residue, the design of the wall had to allow for differential settlement and high pH’s which are associated with chemical attacks and environmental degradation. Galfan coating of the wire, instead of traditional galvanising, provided the required corrosion control for the harsh soils, while the PVC coating provided additional protection against the degradation of the wires resulting from environmental factors. The Paralink™ consists of a core of high-tenacity polyester yarn tendons encased in a polyethylene sheath, which makes it unsusceptible to degradation.

The poor in situ foundation material of the site raised concerns of bearing failure due to imposed loads from the new structure. Maccaferri’s analysis showed that, by lengthening the Paralink grids and thus evenly distributing the high, imposed loads, the bearing pressures were substantially contained. Utilising this method, instead of a traditional rock-fill pioneer layer, as had been suggested initially, reduced the excavation and rock-fill over the entire structure footprint by 3 000 m³.

As this was a high-risk Category 3 wall, Maccaferri’s specific quality control procedures were followed on site by Civcon and managed on a daily basis by Exxaro Resources to ensure that the structure was built in accordance with the design and drawings.

The G6, free-drainage, non-cohesive backfill material was available on site and was compacted with light equipment up to 2 m from the face of the wall, and with heavy rollers thereafter, which was in line with Exxaro’s health and safety requirements.

It took 21 weeks to fill 1 426 m³ of rock into the single-skin gabion cladding, commencing in March 2011 and completing in August. When Civcon’s team, comprising 32 local, mostly unskilled labourers, were packing in full force, they achieved 120 m³ of rock-fill per week, whilst simultaneously backfilling and compacting material to 95% MOD AASHTO.

The project was successfully achieved within budget. Teamwork between Exxaro, LSL, Maccaferri and Civcon, as well as specialist consultants Aurecon and ARUP, ensured that the Paramesh retaining wall was constructed safely, efficiently and to the highest quality standards.

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**MAPEI HELPS DOLLY UP CAPE TOWN THEATRE, WITHOUT THE DRAMA**

THE RECENT RENOVATION of the Fugard Theatre’s nineteenth century façade needed to be perfect. That is why one of Cape Town’s foremost construction companies used the Mapei Primer 3296 to consolidate old plaster between brickwork,
leaving the building’s appearance rusticly authentic, manicured and beautiful.

Mapei South Africa, a subsidiary of the global Mapei Group and a leading cement technology company in South Africa, supplied the Primer 3296, which now protects the theatre against Cape Town’s climatic attacks of rain, humidity, heat and sunlight. “Our product achieves this by deeply penetrating the surface of the brickwork, reducing the formation of pinholes, and preventing the product from drying too quickly. This greatly improves the bonding properties of the substrate,” says Paul Nieuwoudt, product manager for Building Systems Mapei South Africa.

The fine particles of Primer 3296 give the acrylic polymer-based water-dispersion product its penetrative characteristics, even soaking into cementitious surfaces that are by nature not very porous. The Primer 3196 is also relatively easy to apply with a traditional garden sprayer, a roller, or a brush – depending on the size of the surface to be treated. “If a surface is particularly absorbent, several coats can be applied at intervals of a few minutes between each application. However, two or three coats are generally sufficient,” says Nieuwoudt.

The Fugard Theatre, named after one of South Africa’s most prized dramatists, Athol Fugard, is situated in the District 6 region of Cape Town. The theatre was formed by merging the Sacks Futeran Warehouse with the Buitenkant Congregational Church, and now seats an audience of 270.

**RESTRICTED MBSA APPOINTS EXECUTIVE DIRECTOR**

ITUMELENG (TUMI) Dlamini has been appointed Executive Director of Master Builders South Africa (MBSA) – the first woman, and first black person, to become executive head of MBSA in its 108 year history.

She joined MBSA on 1 March 2012 as part of MBSA’s new strategic restructuring plan which involves the appointment of an Executive Director as the executive head of the organisation, and the creation of the new post of Operations Director, which will be filled by Pierre Fourie, former CEO of MBSA.

Tumi holds a BSc. Sci degree with majors in Industrial Sociology and African Politics, as well as an LLB degree, both from the University of Cape Town. She joins MBSA with an impressive and diverse career history. She is an admitted attorney of the High Court of South Africa and was the first black female partner at international law firm, Bowman Gilfillan, where she practised corporate and commercial law.

After ten years in legal practice, which included time at the firm’s London offices, she joined the 2010 FIFA Soccer World Cup Organising Committee South Africa, where she held various key senior positions, including Manager in the Office of the CEO where she was responsible for organisational and executive management, as well as operational planning.

She later served as the Head of African Legacy and Strategic Stakeholders, also part of the 2010 FIFA Soccer World Cup project. In this position she engaged, networked and negotiated with key national and provincial government leaders, as well as business leaders in South Africa and Africa. She was also responsible for facilitating private and public partnerships for the delivery of the 2010 FIFA Soccer World Cup Legacy projects, one of which was the development of SMMEs to unlock and apply participation by SMMEs in the procurement spend of the World Cup projects.

Danie Hattingh, President of MBSA, comments: “We are delighted about Tumi Dlamini’s appointment to our organisation. Her appointment marks the implementation of the next phase of Master Builders South Africa’s strategic plan and will strengthen the organisation’s liaison with government and industry stakeholders. She will be responsible for implementing the new growth strategy adopted by the MBSA Board. Over and above her leadership and executive management role, Tumi’s main focus will be to cultivate and strengthen strategic relationships with national and provincial governments, as well as key industry role players, to unlock investment and development within the building industry.”

The new MBSA Executive Director says she is looking forward to working with MBSA and achieving its strategic goal. “I will use my accumulated experience to lead the organisation towards the advancement of its priorities for the greater good of the industry.”
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- repair mortar

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Mapenet 150
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In answer to demand for more hands-on courses for young graduates, a number of new courses have been added to the Candidate Academy line up. The first of these will be “Getting Acquainted with Concrete” and “Getting Acquainted with Concrete Durability, Deterioration and Repair”. As with all Candidate Academy courses, the many exercises in the work-book will challenge delegates to solve real-world problems and develop appropriate specifications. The courses will cover the subject of “applied concrete technology” or how to specify and use concrete to achieve the highest economy and quality of structure possible.

ASSIGNMENTS AND FOLLOW-UP SUPPORT
The services of Bruce Raath, the Education and Training Director of Letaba Management Services, have been harnessed. As with all Academy courses the option of doing additional assignments and accessing project support in the workplace is also available. Bruce is well known in the field and, although retired from the C&CI (Cement & Concrete Institute), continues to advise on issues of materials and structures, “because that is where the technology breaks down, right between inadequate specification and what the contractor is deemed to know.”

<table>
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<tr>
<th>Candidate Academy Courses April - July 2012</th>
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<tr>
<td><strong>Course</strong></td>
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<tr>
<td>R2R for Candidates (1 day – 1 CPD)</td>
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<td>R2R for Mentors, Supervisors &amp; HR (1 day – 1 CPD)</td>
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<td>Getting Acquainted with GCC (2 days – 2 CPD)</td>
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<td>Basic Pressure Pipeline Design (2 days – 2 CPD)</td>
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<td>Getting Acquainted with Water Reticulation Design (2 days – 2 CPD)</td>
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<td>Getting Acquainted with Sewer Design (3 days – 3 CPD)</td>
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<td>Getting Acquainted with Concrete (2 days – 2 CPD)</td>
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<tr>
<td>Getting Acquainted with Concrete Durability, Deterioration and Repair (1 day – 1 CPD)</td>
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HELPING HAND
The Academy is an initiative of SAICE Professional Development and Projects (SAICE-PDP) and Consulting Engineers South Africa (CESA) to improve the numbers and quality of engineering graduates eligible to register with the Engineering Council of South Africa (ECSA). Courses include guidelines on how to register, and introductory practical training in a range of disciplines aimed at offering graduates the opportunity to solve typical practical problems encountered in the workplace, under the guidance of experienced and passionate professionals.

Although many technical courses are available through the range of Voluntary Associations and commercial training organisations, most are aimed at enhancing the skills of experienced professionals needing to continue their development and earn CPD points. The “getting acquainted” series has been designed to allow young graduates to deal with their first tasks in the workplace with reduced input or support from their supervisors, who generally have limited time to devote to skills transfer.

SUPPORT FOR SMALL CENTRES
The first three months of 2012 have seen another ‘first’ for the Candidate Academy in the running of courses in many small and/or rural centres, traditionally considered not viable for training, including Nelspruit, Secunda, Umtata, Polokwane and Mthatha. Such has been the success that further courses will be offered later in the year as per the schedule alongside.

FUTURE COURSES
Please see the table on p 76 for courses planned for the next four months.

IN-HOUSE COURSES
There has been an increasing demand for in-house courses. If you have large numbers who require training, let us customise a course to suit your needs.

CONTACT DETAILS
For more details or to book on one of the courses, contact SAICE or CESA:

- For SAICE-arranged courses, contact
  Marthelene on saice@ally.co.za
- For CESA-arranged courses, contact
  Mary on sce@cesa.co.za

For more information, go to www.civilsmasakheni.co.za and click on the Candidate Academy button.

Call for Volunteers
As many of our members are aware, most of the ECSA committees function only because of a substantial commitment by volunteers from the recognised Voluntary Associations like SAICE.

The largest group of SAICE members are those involved in the peer-review process for registration of professional engineers. The number of applications per year is rising steadily, and this does increase the workload on those existing hardworking members who are currently involved.

The Professional Advisory Committee (PAC) Civils in ECSA is responsible for considering applications for registration as professional engineers from persons who are civil engineers. To assist the PAC, the PAC has a panel of reviewers who are appointed to carry out the professional review function which is a part of the registration process. SAICE is part of the administrative function for registration, as it arranges the professional reviews for the PAC. Senior SAICE members are also called upon to be appointed by ECSA to serve on an appeal panel, when such need arises.

A critical function that SAICE must fill, is to identify persons who are willing and able to fulfil these functions for the profession and to propose these members to the PAC and ECSA for appointment.

Many of our long-standing reviewers have now retired, and the increase in workload due to the number of applications being received by ECSA, is making the process more and more challenging. SAICE now urgently needs to recruit more reviewers to assist with the reviewing process.

The task is not as daunting as some may imagine, as the development of the skills for the task of assessing applicants for registration can be a progressive process, with a member first serving as a reviewer, paired with an experienced reviewer. Once experienced, the next step can be to serve as a PAC member and then later as an appeal panel member.

If you have been registered as a professional engineer for at least ten years and would like to volunteer to serve as a reviewer, a potential member of the PAC, or to be available to serve on an appeal panel, please advise Dawn Hermanus (dawn@saice.org.za) so that SAICE can continue providing this valuable service for the profession. Kindly also include your area of expertise in civil engineering with your application. Reviewers currently receive an honorarium from ECSA.

Call for Arbitrators and Mediators
For many years senior members of SAICE have formed the backbone of the Arbitration and Mediators Panel for Civil Engineering Contract disputes in not only South Africa, but most of southern Africa.

Each year, as the need for arbitrators and mediators grows, the number of members involved diminishes. We are looking for new, younger members who would like to participate in this extremely challenging field. The opportunity to participate and gain experience in this area of our profession will also provide valuable experience for the individual in his or her own career.

The over-arching and co-responsibility to complete contracts in a fair and equitable manner is an essential component in the relationship between clients, consulting engineers and contractors. The role of the arbitrator and mediator is to ensure that this relationship remains consistent, dependable and has the trust of everyone working in the civil engineering profession.

Do you want to be one of these people? If you answered yes, then please contact Dawn Hermanus (dawn@saice.org.za) who will provide you with further information in this regard.
Transportation users and professionals are all the poorer for the passing of Ivan Douglas Speed in September 2011. Ivan was a major contributor to the evolution and modernisation of both private and public transport in the City of Cape Town over the past fifty years.

Ivan matriculated from Diocesan College (Bishops) in Cape Town in 1949, and graduated from the University of Cape Town (UCT) in 1953 with a BSc (Eng) in Civil Engineering. In 1954 he joined the then Cape Roads Department in the road design office, but was soon after transferred to a roads camp just outside Port Elizabeth as Resident Engineer. In 1956 he moved to the UK for further studies at the University of Durham, from where he graduated with a Diploma in Highway Engineering and Traffic Studies. To help fund his overseas studies he applied for and obtained Fellowships from both the International Road Federation (IRF) and the South African Road Federation (SARF). He was the second South African to be awarded an IRF Fellowship and the first person resident in the Cape Province to receive a SARF Fellowship.

On his return to South Africa Ivan joined the City Engineer’s Department of the City of Cape Town where he was to work for nearly 40 years. While with the City, he held many senior positions. He was Chief Town Planner from 1973 to 1982 and the first Director: Metropolitan Transport Planning, which post he held for 12 years until his retirement in 1994.

To ensure that he had the qualifications to match his belief in integrated urban planning, Ivan obtained the degree of Master of Urban and Regional Planning (MURP) in 1969 from UCT. This interest, and later total commitment to integrated planning, saw Ivan being professionally registered with both the Engineering Council of South Africa (in 1971) and the South African Council for Town and Regional Planners (later the SA Council for Planners) (in 1985). He was also a Fellow of SAICE, having joined as a member in 1957, and a Member of the SA Institute of Town and Regional Planners from 1971. Ivan was very active in SARF throughout his career and this was recognised by making him an Honorary Life Member. He was also an Associate Member of the Institution of Highway Engineers (IHE) in London.

Ivan played an active role in all the major road, transport and land use developments in Cape Town over his more than 50 year career. In addition he participated in the formulation of a registration act for town and regional planners and served on sub-committees of the Committee of Urban Transport Authorities (CUTA). He chaired working groups on the establishment of a metropolitan transport authority.
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Summary of Strengths

- 3 times faster than conventional construction
- Completely eliminates wet trade on site
- Twice the shear strength of double skin clay brick
- SANS 10400 and 10400 XA compliant
- Lightweight concrete panel with fiber cement sheeting finishes
- Strong, durable and robust panels
- Rapid installation with less labor and less technical skills required for erection
- Easily transportable panels on and off-site
- Fixed cost to most sites
- Termite, pest and rot resistant
- Better thermal ratings than clay brick
- Acoustic attenuation comparable to double clay brick plastered
- Superior quality and finishes
- Takes all decorative treatments from cladding to chemical paint with no need for plastering or rhino lighting
- Environmentally friendly construction material
- Excellent fire resistant qualities with twice minimum SA requirements for internal and external walls that are fire rated and load bearing
- Installation training available using local unskilled labor and trade

Contact Details

Cel: 082 868 7475
Tel: 011 695 4800
Fax: 011 805 9948
Web: www.mibt.co.za

celcirose@mweb.co.za

Ivan Speed (far left) at the SARF National AGM in Cape Town in October 2010 – with him in the picture are, from left, Cecil Rose, SARF President Mutshutshiu Nxumalo, Kate Gregg, Dr Graham Ross, Hannes Wael and John Sponneck

Ivan Speed (far left) at the SARF National AGM in Cape Town in October 2010 – with him in the picture are, from left, Cecil Rose, SARF President Mutshutshiu Nxumalo, Kate Gregg, Dr Graham Ross, Hannes Wael and John Sponneck.
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<td>Theuns Eloff</td>
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<td>Keith Mackie</td>
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<td>Les Wiggill</td>
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Engineering the perfect balance

If managing a diverse range of major infrastructure projects appeals to you, then seriously consider moving to Australia to join Toowoomba Regional Council’s professional engineering team. As a valued team member you will enjoy an exciting career reaping quality outcomes every day. The Toowoomba Regional Council, 130 kilometres west of Queensland’s capital city Brisbane, administers a dynamic region rich in resources and opportunities.

Responsible for a 10,000 kilometre road network, significant drainage networks and other transport infrastructure, council’s Infrastructure Services Group (ISG) plays a vital role in an organisation with total assets exceeding $3 billion, an annual budget of over $600 million and 1,758 dedicated staff.

At the end of the day you will have the time to appreciate the quality lifestyle choices the Toowoomba region offers - inner city, suburban or rural living, superb cultural facilities, vibrant festivals and events, tertiary education, public and private schools and a full range of sporting and recreational venues.

Exciting career, relaxed lifestyle – the perfect balance.

Principal Engineer - Transport
You will lead a team of engineers and technical officers responsible for transport infrastructure planning, program development, design and pre-construction delivery.

Principal Engineer – Road Operations
You will lead a team of engineers and technical officers responsible for corridor management, traffic and traffic signals, parking, street lighting and road safety.

Principal Engineer – Asset Management
You will lead a team of engineers, surveyors and technical officers responsible for the asset management of urban and regional transport and drainage networks.

Phone Rod Betts on +61 7 4688 6729 for more information on the above positions.

Principal Engineer – Construction & Maintenance x 2
You will lead a team of engineers and technical officers with day labour teams responsible for preparing and delivering road and drainage construction and maintenance programs.

Coordinator – ISG Programs
As an experienced programmer, you will oversee the development and delivery of ISGs annual design, capital and maintenance works programs.

Please phone Ian Slader on +61 7 4688 6391 for more information on these positions.

Other engineering vacancies include:

- Senior Engineer – Drainage Network Modelling
- Coordinator – Traffic Systems
- Environmental Engineers x 2
- Engineer – Drainage Design
  Phone Rod Betts on +61 7 4688 6729
- Technical Officers – Design x 3
  Phone Gary Natalier on +61 7 4688 6798
- Coordinator ISG Quality Systems
  Phone Ian Slader on +61 7 4688 6391
- Coordinator Project Management
  Phone Gavan Scheiwe on +61 7 4697 0239
- Engineer Project Management
  Phone Gavan Scheiwe on +61 7 4697 0239
- Engineer/Technical Officer – Construction and Maintenance x 3.
  Phone Lee Busby on +61 7 4698 3813 or David Pascoe on +61 7 4688 6559
- Senior Engineer – Development Assessment
- Graduate Engineer – Development Assessment
- Technical Officer – Development Assessment
  Phone Danielle Fitzpatrick on +61 7 4688 6741

Closing Date: 5pm Monday 30 April 2012. All positions listed in this advertisement are permanent full-time positions. To find out more about these exciting Engineering careers please visit our website - www.toowoombaRC.qld.gov.au/jobs
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